PROJECT MANUAL FOR:
CP170621 - SCHOOL OF MUSIC NEW BUILDING
CP172801 – GENERAL SITE: SCHOOL OF MUSIC EXTENDED UTILITIES

AT:
UNIVERSITY OF MISSOURI
COLUMBIA, MISSOURI

FOR:
THE CURATORS OF THE UNIVERSITY OF MISSOURI

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CP172810
VOLUME 3
VOLUME 4 OF 4
**PROJECT MANUAL FOR:**
**CP170621 - SCHOOL OF MUSIC NEW BUILDING**
**CP172801 – GENERAL SITE: SCHOOL OF MUSIC EXTENDED UTILITIES**

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SECTION 220500 - COMMON WORK RESULTS 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. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Mechanical sleeve seals.
   5. Sleeves.
   7. Grout.
   8. Coordination drawings.
  10. Trenchings, excavating and backfilling.
  11. Plumbing demolition.
  12. Equipment installation requirements common to equipment sections.
  13. Painting and finishing.

1.3 DEFINITIONS

A. 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.

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

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

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

E. 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.

1.4 SUBMITTALS

A. Product Data: For the following:
1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

1.5 QUALITY ASSURANCE

A. 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. Any additional costs as a result of these modifications shall be borne by the Contractor. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

B. Plumbing work to comply with International Plumbing Code (IPC) as listed on Drawings and General Conditions.

1.6 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. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

1.7 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 Division 08 Section "Access Doors and Frames."

D. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

E. Coordinate connection of plumbing systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Sequence, coordinate, and integrate removal of existing equipment and material as required to maintain services for existing building and for portions of remodeled areas at all times.
1.8 SCHEDULING AND PHASING

A. All plumbing work shall be scheduled to meet project completion date. Plumbing work shall be phased for projects requiring phasing of work. Install additional fittings, valves, caps as required to support phasing. Refer to phasing schedule on drawings.

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

E. 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.

2.4 TRANSITION FITTINGS

A. Acceptable Manufacturers:

3. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
4. JCM Industries.
5. Smith-Blair, Inc.
6. Viking Johnson.

B. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

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. Acceptable Manufacturers:
   1. Capitol Manufacturing Co.
   2. Calpico, Inc.
   3. Epco Sales, Inc.
   5. Lochinvar Corp.;

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

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.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

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 deg F.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Acceptable Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.

   2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

   3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. 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.

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.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated or rough brass.
D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.
E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.
2.10 COORDINATION DRAWINGS

A. The contractor shall prepare CAD generated drawings (min. ¼” scale) showing following systems/items as a minimum:
   1. Plumbing piping routing including locations of valves, drops to fixtures, risers, etc.
   2. Plumbing equipment locations and clearances required.

B. The contractor shall submit the CAD generated drawings to mechanical contractor for coordination with other trades. The drawings shall be submitted either in electronic format or printed copies as requested by HVAC Contractor.

C. The contractor shall participate in coordination meetings when requested by HVAC Contractor.

2.11 PROJECT RECORD DRAWINGS

A. Drawings shall be furnished in electronic-media (CD-Rewritable type) and at least one hard copy prints.
   1. Format: Same CAD program, version and operating system as the original Contract Drawings.
   2. Incorporate changes and additional information previously marked on Record prints. Delete, re-draw and add details and notations where applicable.

B. Identify and date each drawing and include the designation “PROJECT RECORD DRAWING” or “AS-BUILT DRAWING” in a prominent location.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
   1. Piping to be Removed: Removed portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material. Generally remove piping up to existing mains or valves.
   2. Piping to be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material. Cap behind walls, chases, or shafts or flush with floor. Patch surfaces to match existing adjacent surfaces.
   3. Equipment to Be Removed: Disconnect and cap services and remove equipment from project site.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 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 minimum 8 inches above accessible ceilings to allow sufficient space for ceiling panel removal and service access. In general install piping tight to slab, beams, joists and structural members if possible.

F. Install piping to permit valve servicing.

G. Install piping at indicated 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 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. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   g. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
   h. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw or spring clips.
   i. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   j. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
   k. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

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

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

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.
a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

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 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. 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.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. 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.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

T. Verify final equipment locations for roughing-in.

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

V. Draining and Refilling of Systems: Provide all shutoff valves, drain valves, pipe, fittings, and miscellaneous material required to drain each existing system as required for new work. After new work is completed, tested, and found tight, refill each system as required. Time for shutting down existing system for draining shall be coordinated with all other work and with Owner’s representative. Cost for all chemicals and additives for refill shall be borne by the Contractor.
3.3 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.


F. 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.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 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 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. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.5 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.
3.6 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

3.8 GROUTING

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

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout around anchors.

G. Cure placed grout.

END OF SECTION 220500
SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING 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.
5. Iron, grooved-end butterfly valves.
8. Iron, grooved-end swing check valves.
10. Iron gate valves.
13. Chainwheels.

B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

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 B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF-372 (lead free) for valve materials for potable water service.

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 valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than 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 ten (10) 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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Crane Co., Crane Valve Group
   2. Hammond Valve.
   4. NIBCO Inc.

B. Class 125, Bronze Angle Valves with Bronze Disc:
   1. 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.

C. Class 150, Bronze Angle Valves with Bronze Disc:
   1. 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.
2.3 BRASS BALL VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
5. Jamesbury; a subsidiary of Metso Automation.
7. NIBCO INC.

B. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:

1. 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: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.4 BRONZE BALL VALVES

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

1. American Valve, Inc.
2. Conbraco Industries, Inc.; Apollo Valves.
3. Crane Co.; Crane Valve Group; Crane Valves.
5. Milwaukee Valve Company.
6. NIBCO INC.
7. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Lead Free Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.
2.5 IRON, SINGLE-FLANGE BUTTERFLY VALVES

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

2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
4. DeZurik Water Controls.
5. Hammond Valve.
7. NIBCO INC.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless Steel Disc:

1. 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: 316 Stainless Steel.

2.6 BRONZE SWING CHECK VALVES

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

1. American Valve, Inc.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Crane Co.; Crane Valve Group; Jenkins Valves.
4. Crane Co.; Crane Valve Group; Stockham Division.
5. Hammond Valve.
7. NIBCO Inc.
8. Powell Valves.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Bronze Swing Check Valves with Bronze Disc:

1. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:

1. Description:
2.7 IRON SWING CHECK VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Jenkins Valves.
3. Crane Co.; Crane Valve Group; Stockham Division.
5. Milwaukee Valve Company.
6. NIBCO Inc.
7. Powell Valves.
8. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Iron Swing Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:

1. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 500 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.

2.8 IRON, CENTER-GUIDED CHECK VALVES

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

1. Anvil International, Inc.
2. DFT Inc.
3. Hammond Valve.
4. Metraflex, Inc.
5. Milwaukee Valve Company.
7. NIBCO INC.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Description:
   b. CWP Rating: 200 psig.
   d. Style: Compact wafer.
   e. Seat: Bronze.

C. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Description:
   b. CWP Rating: 300 psig.
   d. Style: Compact wafer.
   e. Seat: Bronze.

D. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Description:
   b. CWP Rating: 200 psig.
   d. Style: Compact wafer.
   e. Seat: EPDM or NBR.

E. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Description:
   b. CWP Rating: 300 psig.
   d. Style: Compact wafer.
   e. Seat: EPDM or NBR.

2.9 BRONZE GATE VALVES

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

1. American Valve, Inc.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Crane Co.; Crane Valve Group; Jenkins Valves.
4. Crane Co.; Crane Valve Group; Stockham Division.
5. Hammond Valve.
7. NIBCO Inc.
8. Powell Valves.
9. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, NRS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 125, RS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

D. Class 150, NRS Bronze Gate Valves:

1. 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.

E. Class 150, RS Bronze Gate Valves:

1. Description:
   a. Standard: MSS SP-80, Type 2.
2.10 BRONZE GLOBE VALVES

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

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Crane Co.; Crane Valve Group; Stockham Division.
3. Hammond Valve.
5. NIBCO Inc.
6. Powell Valves.
7. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

B. Class 125, Bronze Globe Valves with Bronze Disc:

1. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

C. Class 125, Bronze Globe Valves with Nonmetallic Disc:

1. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

D. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. 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.

2.11 CHAINWHEELS

A. Acceptable 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 valve stems.
   3. Sprocket Rim with Chain Guides: Ductile iron of type and size required for valve. Include zinc coating.

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 valves 6 inches 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, gate, or plug valves.
3. Throttling Service: Globe or angle, ball, or butterfly valves.
4. 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 for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.
   c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

B. Pressure ratings for valves shall not be less than as required by system pressures.

C. 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.

D. 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 and Larger: Flanged ends.
3. For Steel Piping, NPS 2 and Smaller: Threaded ends.
4. For Steel Piping, NPS 2-1/2 and Larger: Flanged ends.

3.5 DOMESTIC, HOT- AND COLD-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 or Class 150, bronze or nonmetallic disc.
3. Ball Valves: Two piece, full port, brass or bronze with brass, bronze, stainless-steel trim.
4. Bronze Swing Check Valves: Class 125 or Class 150, bronze or nonmetallic disc.
5. Bronze Globe Valves: Class 125 or Class 150, bronze or nonmetallic disc.

B. Pipe NPS 2-1/2 and Larger:

1. Bronze Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
3. Bronze, Grooved-End Butterfly Valves: 175 or 300 CWP.
4. Bronze Swing Check Valves: Class 125 or Class 250, metal seats.
5. Bronze, Center-Guided Check Valves: Class 125 or Class 150, compact-wafer, metal or resilient seat.
6. Bronze Gate Valves: Class 125 or Class 250, NRS or OS&Y.
7. Bronze Globe Valves: Class 125 or Class 250.

3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 125 or Class 150, bronze or nonmetallic disc.
2. Ball Valves: Two piece, full port, brass or bronze with brass, bronze, stainless-steel trim.
3. Bronze Swing Check Valves: Class 125 or Class 150, bronze or nonmetallic disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Swing Check Valves: Class 125, metal seats.
   2. Iron, Grooved-End Swing Check Valves: 300 CWP.
   3. Iron Gate Valves: Class 125, NRS or OS&Y.

END OF SECTION 220523
SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING 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 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Pipe positioning systems.
8. Equipment supports.

B. Related Sections include the following:

1. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.

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.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Powder-actuated fastener systems.
4. Pipe positioning systems.
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. Acceptable 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. Acceptable Manufacturers:
   2. Carpenter & Paterson, Inc.
   3. Empire Industries, Inc.
   5. Grinnell Corp.
   6. GS Metals Corp.
   8. Piping Technology & Products, 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 METAL FRAMING SYSTEMS

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

B. Acceptable Manufacturers:
   2. GS Metals Corp.
   4. Thomas & Betts Corporation.
   5. Unistrut Corp.; Tyco International, Ltd.
C. Coatings: Manufacturer's hot dipped or galvanized finish unless bare metal surfaces are indicated.

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

2.5 THERMAL-HANGER SHIELD INSERTS

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

B. Acceptable Manufacturers:

1. Carpenter & Paterson, Inc.
2. PHS Industries, Inc.
3. Pipe Shields, Inc.
5. 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.

2.6 FASTENER SYSTEMS

A. 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. Acceptable Manufacturers:

b. Empire Industries, Inc.
c. Hilti, Inc.
d. ITW Ramset/Red Head.
e. MKT Fastening, LLC.
f. Powers Fasteners.

2.7 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.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
2.8 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 or insulated stationary pipes, NPS 1/2 to NPS 8.
   8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 8.
   9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated or insulated 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.

I. 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.

J. 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 mechanical-expansion anchors instead of building attachments where required in concrete construction.

O. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.
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. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

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

E. 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.

F. 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 Division 07 Section “Roof Accessories” for curbs.

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

H. Install hangers and supports to allow controlled thermal 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. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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: 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.

5. Insert Material: Length at least as long as protective shield.
6. 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.

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. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

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SECTION 220553 - IDENTIFICATION FOR PLUMBING 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 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Pipe labels.
   3. Stencils.
   4. Valve tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
C. Valve numbering scheme.
D. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 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, 1/16 inch thick, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

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 partially cover 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: At least 1-1/2 inches high.

2.3 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

2.4 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 wire-link or 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.

1. 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 Section "Interior Painting".

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

C. 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 and within mechanical rooms, boiler rooms, chiller rooms, etc.
7. On piping above removable acoustical ceilings.

D. Pipe Label Color Schedule:

1. Domestic Water Piping:
   a. Background Color: Blue.

2. Sanitary Waste and Storm Drainage Piping:
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 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 similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

2. Valve-Tag Color:
   b. Hot Water: Natural.

3. Letter Color:
   b. Hot Water: Black.
SECTION 220700 - PLUMBING INSULATION

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. Flexible elastomeric.
      b. Mineral fiber.
      c. Molded Close Cell.
   2. Insulating cements.
   3. Adhesives.
   5. Lagging adhesives.
   7. Factory-applied jackets.
   8. Field-applied jackets.
   10. Securements.
   11. Corner angles.

B. Related Sections include the following:
   1. Division 23 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).

B. Shop Drawings:
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   3. Detail removable insulation at piping specialties, equipment connections, and access panels.
   4. Detail application of field-applied jackets.
   5. Detail field application for each equipment type.
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 E84, 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.

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 Division 22 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. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 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.

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

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products of one of the following:
      a. Aeroflex USA Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. NOMACO Insulation.

   2. Thermal Conductivity: Not exceeding 0.25 BTU-in/hour sq. ft. °F at 75°F mean temperature.

G. Mineral-Fiber, Preformed Pipe Insulation:
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Knauf Insulation.
      c. Manson Insulation Inc.
      d. Owens Corning Fiberglas Corp.

   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

   3. Thermal Conductivity: Not exceeding 0.23 BTU-in/hour sq. ft. °F at 75°F mean temperature.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corp.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Manson Insulation Inc.
      e. Owens Corning Fiberglas Corp.

   2. Density: 2.5 lbs/cu. ft.
   3. Thermal Conductivity: Not exceeding 0.27 BTU-in/hour °F at 75°F mean temperature.

   1. Acceptable Manufacturers: Subject to compliance with requirements provide product by IFS Corporation; Truebro.
2.2 INSULATING CEMENTS


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

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aeroflex USA Inc.
   b. Armacell LCC.
   c. Foster Products Corporation, H. B. Fuller Company.
   d. RBX Corporation.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW.
   b. Foster Products Corporation, H. B. Fuller Company.
   c. ITW TACC, Division of Illinois Tool Works.
   d. Marathon Industries, Inc.
   e. Mon-Eco Industries, Inc.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW.
   b. Foster Products Corporation, H. B. Fuller Company.
   c. ITW TACC, Division of Illinois Tool Works.
   d. Marathon Industries, Inc.
   e. Mon-Eco Industries, Inc.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dow Chemical Company (The).
   c. P.I.C. Plastics, Inc.
   d. Speedline Corporation.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

   1. Childers Products, Division of ITW.
   3. ITW TACC, Division of Illinois Tool Works.
   4. Marathon Industries, Inc.
   5. Mon-Eco Industries, Inc.

C. Vapor-Barrier Mastic: Water or solvent based; suitable for indoor and outdoor use on below ambient services.

   1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.05 perm at 43-mi dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

   1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 200 deg F.
   3. Solids Content: 63 percent by volume and 73 percent by weight.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

   a. Childers Products, Division of ITW.
b. Foster Products Corporation, H. B. Fuller Company.
c. Marathon Industries, Inc.
d. Mon-Eco Industries, Inc.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.

4. Service Temperature Range: Minus 50 to plus 180 deg F.


2.6 SEALANTS

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

1. Childers Products, Division of ITW.
3. Marathon Industries, Inc.
4. Mon-Eco Industries, Inc.
5. Pittsburgh Corning Corporation.

B. Joint Sealants for Cellular-Glass:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW.
   b. PABCO Metals Corporation.
   c. RPR Products, Inc.

   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Avery Dennison Corporation, Specialty Tapes Division.
   2. Compac Corp.
   4. Venture Tape.

B. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
6. **ASJ Tape Disks and Squares**: Precut disks or squares of ASJ tape.

C. **FSK Tape**: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. **Width**: 3 inches.
2. **Thickness**: 6.5 mils.
3. **Adhesion**: 90 ounces force/inch in width.
4. **Elongation**: 2 percent.
5. **Tensile Strength**: 40 lbf/inch in width.
6. **FSK Tape Disks and Squares**: Precut disks or squares of FSK tape.

### 2.10 SECUREMENTS

A. **Bands**:

1. Stainless Steel: ASTM A 167 or ASTM A 240, Type 304; 0.015 inch thick, 1/2 inch wide with wing or closed seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.

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.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

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

### 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.

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.

a. 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 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 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

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

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

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

1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive 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."

3.5 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 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.

3.6 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturers’ recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 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.

3.8 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. Secure with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

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

B. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one (1) location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
   2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three (3) locations of straight pipe, locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
   1. NPS ½” through 6": Insulation shall be the following:
      a. Flexible elastomeric: 1/2 inch thick.

B. Domestic Hot and Recirculated Hot Water:
1. NPS 1-1/4” and smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   b. Flexible elastomeric: 1/2 inch thick

2. NPS 1-1/2” and larger:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   b. Flexible elastomeric: 1 inch thick

C. Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 3/4 inch thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE
   A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
   B. If more than one material is listed, selection from materials listed is Contractor’s option.
   C. Equipment, Concealed:
      1. None.
   D. Equipment, Exposed:
      1. None.
   E. Piping, Concealed:
      1. None.
   F. Piping, exposed in mechanical room piping that is within 6 ft. of the floor.
      1. Aluminum, Smooth: 0.016 inch thick.

END OF SECTION 220700
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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. Aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
      2. Encasement for piping.
      4. Flexible connectors.
      5. Escutcheons.
      6. Sleeves and sleeve seals.
      7. Wall penetration systems.

1.3 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.
   B. Field quality-control reports.

1.4 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.

1.5 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 Architect no fewer than seven (7) days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Architect's written permission.

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 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. Grooved-Joint Copper-Tube Appurtenances:
      a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Anvil International.
         2) Shurjoint Piping Products.
         3) Victaulic Company.
      b. Copper Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.
      c. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

2.3 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.

2.4 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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
C. Dielectric Flanges:

1. 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. 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. 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. Description:

   a. Electroplated steel nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Male threaded or grooved.
   d. Lining: Inert and noncorrosive, propylene.

2.5 FLEXIBLE CONNECTORS

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

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex-Weld, Inc.
4. Hyspan Precision Products, Inc.
5. Metraflex, Inc.
6. Unaflex, Inc.
7. 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.

2.6 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.


D. One Piece, Stamped Steel: Chrome-plated finish with setscrew.

E. Split Casting, Cast Brass: Polished, chrome-plated 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.

2.7 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. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

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 setscrews.

2.8 SLEEVE SEALS

A. Acceptable 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.

2.9 WALL PENETRATION SYSTEMS

A. 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.

2.10 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 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 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 "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

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

D. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

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

I. Install piping to permit valve servicing.

J. 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.

K. Install piping free of sags and bends.

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

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

N. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

O. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

P. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

3.2 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. 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.
G. 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.

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

3.3 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "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 Division 22 Section "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 Division 22 Section "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 Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

3.4 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.

3.5 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 unions couplings.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "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.

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

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

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

   1. NPS 3/4 and Smaller: 60 inches with 3/8-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.

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

F. Install supports for vertical steel piping every 15 feet.

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

3.7 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.
3.8 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, stamped steel with set screw.
   5. Bare Piping in Equipment Rooms: One piece, stamped steel with set screw.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.9 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 Division 07 Section "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 Division 07 Section "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: Steel pipe.
   2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
      a. Extend sleeves 2 inches above finished floor level.
      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 Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   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: 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. 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. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.10 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.

3.11 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.

3.12 IDENTIFICATION
   A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.
   B. Label pressure piping with system operating pressure.

3.13 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 to stand 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.

3.14 ADJUSTING

A. Perform the following adjustments before operation:

   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
      a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide 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.

3.15 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. Prepare and submit reports of purging and disinfecting activities.
C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.16 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. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought- copper solder-joint fittings; and brazed or soldered joints.
E. Aboveground domestic water piping, NPS 2-1/2 and larger, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper solder-joint fittings; and brazed or soldered joints.
   2. Hard copper tube, ASTM B 88, Type L or; grooved-joint copper-tube appurtenances; and grooved joints.

3.17 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.

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

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 domestic water piping specialties:
   1. Vacuum breakers.
   2. Backflow preventers.
   3. Strainers.
   4. Hose bibbs.
   5. Drain valves.
   6. Air vents.

B. Related Sections include the following:
   1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
   2. Division 22 Section "Domestic Water Piping" for water meters.
   3. Division 22 Section "Emergency Plumbing Fixtures" for water tempering equipment.
   4. Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.4 SUBMITTALS

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

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

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties 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.

B. NSF Compliance:
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

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

1. Conbraco Industries, Inc.
2. FEBCO; SPX Valves & Controls.
4. Toro Company (The); Irrigation Div.
7. Zurn Industries, LLC; Wilkins Div.

B. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Inlet and Outlet Connections: Threaded.
5. Finish: Chrome plated.

C. Hose-Connection Vacuum Breakers:

2. Body: Bronze, nonremovable, with manual drain.
4. Finish: Chrome or nickel plated.

D. Laboratory-Faucet Vacuum Breakers:

2. Size: NPS 1/4 or NPS 3/8 matching faucet size.
4. End Connections: Threaded.
5. Finish: Chrome plated.

2.2 BACKFLOW PREVENTERS

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

1. Conbraco Industries, Inc.
2. FEBCO; SPX Valves & Controls.
3. McDonald, A.Y. Mfg Co.
6. Zurn Industries, LLC; Wilkins Div.

B. Reduced-Pressure-Principle Backflow Preventers:
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
4. Size: To match pipe size.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

C. Hose-Connection Backflow Preventers:
   2. Operation: Up to 10-foot head of water back pressure.
   3. Inlet Size: NPS 1/2 or NPS 3/4.
   5. Capacity: At least 3-gpm flow.

D. Backflow-Preventer Test Kits:
   1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.3 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations, unless otherwise indicated.
   5. Perforation Size:
      a. Strainers NPS 2 and Smaller: 0.020 inch.
      b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
      c. Strainers NPS 5 and Larger: 0.10 inch.

2.4 HOSE BIBBS

A. Hose Bibbs:
   4. Supply Connections: NPS 1/2 threaded or solder-joint inlet.
   5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.5 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
   2. Pressure Rating: 400-psig minimum CWP.
   4. Body: Copper alloy.
   5. Ball: Chrome-plated brass.
   8. Inlet: Threaded or solder joint.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   3. Do not install bypass piping around backflow preventers.

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

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
3.3 LABELING AND IDENTIFYING

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

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
5. Dual-check-valve backflow preventers.
6. Reduced-pressure-detector, fire-protection backflow-preventer assemblies.
8. Water pressure-reducing valves.
10. Primary, thermostatic, water mixing 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 Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

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

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

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 221119
SECTION 221316 - SANITARY WASTE AND VENT 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. This Section includes the following for soil, waste, and vent piping inside the building:
      1. Pipe, tube, and fittings.

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

1.4 SUBMITTALS
   A. Product Data: For pipe, tube, fittings, and couplings.
   B. Field quality-control inspection and test reports.

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

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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS
   A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.
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. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.


2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Section "Common Work Results for Plumbing" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:

1. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:

1. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

D. Underground, soil, waste, and vent piping shall be any of the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
3.3 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

D. Install underground, steel, force-main piping.

E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.


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

H. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

I. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

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

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

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


L. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

M. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."


C. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

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

E. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

F. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.

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

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   1. Horizontal Piping: Horizontal backwater valves.
   2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Install individual, straight, horizontal piping runs according to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.
B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.

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

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 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: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.

3.7 CONNECTIONS

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

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

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

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

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

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unenclosed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.9 CLEANING

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.

END OF SECTION 221316
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

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 sanitary drainage piping specialties:
   1. Metal cleanouts.
   2. Floor drains.
   3. Through-penetration firestop assemblies.
   5. Flashing materials.

B. Related Sections include the following:
   1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 SUBMITTALS

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

B. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.5 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 METAL CLEANOUTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Josam Company; Blucher-Josam Div.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.

B. Exposed Metal Cleanouts:

1. Standard: ASME A112.36.2M for cast iron/ASME A112.3.1 for stainless steel for cleanout test tee.
2. Size: Same as connected drainage piping
3. Body Material: As required to match connected piping.
4. Closure: Raised-head, brass or cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Metal Floor Cleanouts:

1. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
2. Size: Same as connected branch.
3. Type: Heavy-duty, adjustable housing.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Required.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Heavy Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
14. Size: Same as connected branch.
15. Housing: Stainless steel.
17. Riser: Stainless-steel drainage pipe fitting to cleanout.

D. Cast-Iron Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: As required to match connected piping.
4. Closure: Raised-head, brass or cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Floor Drains:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Josam Company; Blucher-Josam Div.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zum Industries, LLC; Light Commercial Operation.
   g. Zum Industries, LLC; Specification Drainage Operation.
2. Standard: ASME A112.6.3.
4. Seepage Flange: Required.
5. Clamping Device: Required.
6. Outlet: Bottom or Side.
10. Top or Strainer Material: Gray iron/Nickel bronze/Stainless steel.
12. Top Shape: Round.
13. Dimensions of Top or Strainer: Minimum 8 inch diameter.
16. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet. Trap-seal primer valve connection where shown on drawings.
17. Trap Material: Cast iron.
19. Trap Features: Cleanout.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
   2. Size: Same as connected soil, waste, or vent stack.
   3. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
   5. Special Coating: Corrosion resistant on interior of fittings.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. 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.
      a. NPS 2: 4-inch- minimum water seal.
      b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

B. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.
   5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

C. Sleeve Flashing Device:
   1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will
extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.

2. Size: As required for close fit to riser or stack piping.

2.5 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft. thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft.
2. Vent Pipe Flashing: 8 oz./sq. ft.

C. Fasteners: Metal compatible with material and substrate being fastened.

D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

E. Solder: ASTM B 32, lead-free alloy.

F. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. 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.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

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

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
   a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
   b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
   c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

G. Install deep-seal traps on floor drains and other waste outlets, if indicated.

H. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

I. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

J. Install wood-blocking reinforcement for wall-mounting-type specialties.

K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

L. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 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 equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

   1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
   2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

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

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.5 FLOOR DRAINS SCHEDULE

A. Floor Drains Schedule:

1. Unfinished Areas on Grade:
   b. Top of Body and Strainer Finish: Gray iron.
   c. Strainer Material: Gray iron.
   d. Top Loading Classification: Extra heavy duty.
   e. Integral Tray and Cleanout: Required.
   f. Backwater Valve: Required.

2. Unfinished Areas above Ground:
   b. Top of Body and Strainer Finish: Gray iron.
   c. Top Loading Classification: Extra heavy duty.
   d. Strainer Material: Gray iron.
   e. Integral Trap and Cleanout: Required.

3. Finished Areas on Grade:
   b. Top of Body and Strainer: Nickel bronze.
   c. Top Loading Classifications: Light duty.
   d. Integral Trap and Cleanout: Required.
   e. Backwater Valve: Required.

4. Finished Areas above Grade:
   c. Top Loading Classification: Light duty.
5. Mechanical Rooms on Grade:
   b. Top of Body and Strainer Finish: Gray iron.
   c. Top Loading Classification: Extra heavy duty.
   d. Strainer Material: Gray iron.
   e. Trap and Cleanout: Required.
   f. Backwater Valve: Required.
   g. Sediment Bucket: Aluminum.
   h. Drain with 9" deep sump.

6. Mechanical Rooms above Grade:
   b. Top of Body and Strainer Finish: Gray iron.
   c. Top Loading Classification: Extra heavy duty.
   d. Strainer Material: Gray iron.
   e. Sediment Bucket: Aluminum.
   f. Drain with 9" deep sump.

7. Funnel Floor Drains: Same as floor drains specified above, but with elongated 8x3 funnel.

END OF SECTION 221319
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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. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
7. Grout.
8. Coordination drawings.
9. Project Record Drawings.
10. HVAC demolition.
11. Equipment installation requirements common to equipment sections.
12. Painting and finishing.
13. Concrete bases.

1.3 DEFINITIONS

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

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

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

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

E. 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.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.
G. The following are industry abbreviations for rubber materials:

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

1.4 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

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. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. Any additional costs as a result of these modifications shall be borne by the contractor. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

D. HVAC work to comply with International Mechanical Code (IMC) as listed on Drawings and General Conditions

1.6 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.

1.7 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 Section "Access Doors and Frames."

D. Sequence, coordinate, and integrate installations of HVAC materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

E. Coordinate connection of HVAC systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Sequence, coordinate, and integrate removal of existing equipment and material as required to maintain services for existing building and for portions of remodeled areas at all times.

1.8 SCHEDULING AND PHASING

A. All HVAC work shall be scheduled to meet project completion date. HVAC work shall be phased for projects requiring phasing of work. Install additional fittings, valves, caps, and dampers as required to support phasing. Refer to phasing schedule on drawings.

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

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

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

E. 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.

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

2.4 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. Acceptable Manufacturers:
   1. Capitol Manufacturing Co.
   2. Capico Inc.
   3. Epco Sales, Inc.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

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.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

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 deg F.

2.5 MECHANICAL SLEEVE SEALS

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

   1. Acceptable Manufacturers:

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

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. 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.

2.6 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.

2.7 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated or rough brass.
D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated.
E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.
2.9 COORDINATION DRAWINGS

A. The contractor shall prepare CAD generated overall coordination drawings (min ¼” scale) to coordinate HVAC systems installation with other trades. Following systems/items shall be indicated and co-coordinated, but not limited to, with each other based on input from installers of these systems:

1. Ceiling layout.
2. Sheet metal ductwork including locations of boxes, diffusers, grilles/registers, duct risers, fire/smoke dampers, etc.
3. HVAC piping routing including locations of valves, expansion loops, risers, etc.
4. Fire suppression piping mains, sprinkler heads, flow switches, etc.
5. Plumbing piping routing including locations of valves, drops to fixtures, risers, etc.
6. Electrical systems including locations of light fixtures, routing of main feeders/conduits larger than 3” dia., routing of cable tray, etc.

B. Contractor shall obtain information of other systems from General Contractor, Electrical Contractor, Fire Suppression Contractor, Plumbing Contractor and others as required for incorporation in the coordination drawings.

C. Contractor shall arrange coordination meeting with other contractors, whose systems need coordination, to resolve conflicts.

2.10 PROJECT RECORD DRAWINGS

A. Drawings shall be furnished in electronic-media (CD-Rewritable type) and at least one hard copy prints.

1. Format: Same CAD program, version and operating system as the original Contract Drawings.
2. Incorporate changes and additional information previously marked on Record prints. Delete, re-draw and add details and notations where applicable.

B. Identify and date each drawing and include the designation “PROJECT RECORD DRAWING” or “AS-BUILT DRAWING” in a prominent location.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material. Generally remove piping up to existing mains or valves.
2. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material. Generally remove ducts up to existing mains or shut-off dampers.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.
3.2 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 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 minimum 8 inches above accessible ceilings to allow sufficient space for ceiling panel removal and service access.

F. Install piping to permit valve servicing.

G. Install piping at indicated 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 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. Insulated Piping: One-piece, stamped-steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
   g. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type.
   h. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw or spring clips.
   i. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
   j. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
   k. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

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

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

O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   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 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

   1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. 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.

R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. 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.

S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

T. Verify final equipment locations for roughing-in.

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

V. Draining and Refilling of Systems: Provide all shutoff valves, drain valves, pipe, fittings, and miscellaneous material required to drain each existing system as required for new work. After new work is completed, tested, and found tight, refill each system as required. Time for shutting down existing system
for draining shall be coordinated with all other work and with Owner’s representative. Fill glycol system with type and percentage solutions as directed by Owner.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 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.


F. 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.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 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 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. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.5 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.

3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."
8. Concrete base for pumps shall be a minimum of 5x the pump weight.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, hot dip galvanize or cold galvanize and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

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

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.
3.10 GROUTING

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

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 230500
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. All motor shall meet minimum ASHRAE energy efficiency requirements.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Motors ½ HP and Larger: Three phase, unless shown otherwise.

B. Motors Smaller than ½ HP: Single phase, unless shown otherwise.

C. Frequency Rating: 60 Hz/

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
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: Separate winding for each speed.


F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F unless otherwise noted.

I. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer’s standard starting characteristic.

J. 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.
   5. Motors under 100 hp – Provide Aegis shaft grounding ring on either the drive end or non-drive end of the motor in accordance with manufacturer’s recommendations.
   6. Motors 100 hp and above – Provide ceramic bearing or bearing journal on non-drive end of the motor and Aegis shaft grounding ring on the opposite end in accordance with manufacturer’s recommendations.
2.5 SEVERE-DUTY MOTORS

A. General: Severe-duty motors are required wherever indicated in other Division 23 Specifications, or where noted on the Drawings, or as listed here:

1. Primary Heating Water Pumps.
2. Secondary Heating Water Pumps.

B. Specification Requirements: Comply with all requirements of polyphase motors specified elsewhere in this Section, except where more stringent requirements are necessary to meet IEEE-841 and as further specified below.

C. Type: Totally enclosed fan-cooled (TEFC) horizontal and vertical single speed, squirrel cage, polyphase induction motors; meeting all severe-duty requirements of IEEE-841.

D. Design Characteristics: NEMA MG 1, Design B, unless otherwise indicated. Degree of protection shall IP55. Motor bearings shall have a degree of protection of IP56 via the use of non-contact bearing isolator.

E. Service Factor: All motors shall be rated for 1.15 service factor but shall be selected so that the scheduled duty point is at or below 1.00 service factor.

F. Service Conditions: Motors shall be rated for continuous-duty operation without de-rating under the following service conditions:

1. Exposure to ambient temperatures from -25°C to 40°C.
2. Exposure to altitudes up to 1000 meters (3300 feet).
3. Rated for use in indoor or outdoor applications involving sever duty conditions such as high humidity or chemical-laden, corrosive, or salty atmospheres.
5. Variable Frequency Drive (VFD) or full-voltage, across-the-line starting.
7. Voltage unbalance at the motor terminals up to 1%.
8. Temperature rise of the stator winding up to 80°C when operated at rated horsepower.

G. Insulation: Non-hygroscopic, chemical and humidity-resistant insulation system with rating of Class F or better insulation and Class H spike-resistant wire.

H. Airborne Sound: Motor sound power level when measured at a no-load condition shall not exceed 90 dBA when determined in accordance with NEMA MG 1-1998 Part 9.

I. Vibration: Motor vibration measured in any direction on the bearing housing shall meet the levels listed below when tested per Part 7 of NEMA MG 1-1998:

1. Unfiltered vibration at rated voltage and frequency shall not exceed 0.08 in/s peak velocity for 4-pole motors.
2. Filtered vibration shall not exceed 0.05 in/s peak velocity at twice line frequency.
3. Unfiltered axial vibration shall not exceed 0.06 in/s peak velocity on bearing housing.

J. Manufacturer’s Special Warranty: Provide written warranty, signed by manufacturer, agreeing to repair or replace motors that fail in materials or workmanship within specified warranty period. Special warranty specified in here shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

1. Warranty Period: Manufacturer’s standard, but not less than five (5) years after date of Substantial Completion for sine-wave power motors, and not less than three (3) years after date of Substantial
Completion for motors powered through variable frequency drives. Warranty must include parts, labor, shipping and handling charges, and applicable taxes.

2.6 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
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 Include:
   1. Pipe bends and loops.
   2. Alignment guides and anchors.

1.3 DEFINITIONS
A. BR: Butyl rubber.
B. Buna-N: Nitrile rubber.
C. CR: Chlorosulfonated polyethylene synthetic rubber.
D. CSM: Chlorosulfonil-polyethylene rubber.
E. EPDM: Ethylene-propylene-diene terpolymer rubber.
F. NR: Natural rubber.
G. PTFE: Polytetrafluoroethylene plastic.

1.4 PERFORMANCE REQUIREMENTS
A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.
B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.5 SUBMITTALS
A. Product Data: For each type of product indicated.
B. 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.

C. Welding certificates with picture ID.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing, LLC.
   b. Flex-Hose Co., Inc.
   c. Flexicraft Industries.
   d. Hyspan Precision Products, Inc.
   e. Metraflex, Inc.
   f. Piping Technology & Products, Inc.
   g. Senior Flexonics, Inc.; Pathway Division.

2.2 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36.

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.

F. Concrete: Portland cement mix, 4500 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. 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.

PART 3 - EXECUTION

3.1 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.

3.2 SWING CONNECTIONS

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

   B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

   C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE INSTALLATION

   A. Install guides on piping adjoining pipe expansion fittings and loops.

   B. Attach guides to pipe and secure to building structure.

3.4 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 or compensators are indicated.

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

END OF SECTION 230516
SECTION 230519 - METERS AND GAGES 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes meters and gages for mechanical systems and water meters installed inside the building.

B. Related Sections include the following:
   1. Mechanical equipment Sections that specify meters and gages as part of factory-fabricated equipment.

1.3 SUBMITTALS

A. Product Data: Include scale range, ratings, and calibrated performance curves for each meter, gage, fitting, specialty, and accessory specified.

B. Shop Drawings: Include schedule indicating manufacturer's number, scale range, fittings, and location for each meter and gage.

C. Product Certificates: Signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and compliance with specified requirements.

D. Shop Drawings: For brackets for duct-mounting thermometers.

E. Maintenance Data: For meters and gages to include in maintenance manuals specified in Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Dial Type Thermometers:
      b. Ernst Gage Co.
      c. Marsh Bellofram.
      d. Trerice: H. O. Trerice Co.
      e. Weiss Instruments, Inc.
   2. Pressure Gages:
b. Ernst Gage Co.
c. Marsh Bellofram.
d. Trerice: H. O. Trerice Co.
e. Weiss Instruments, Inc.

2.2 THERMOMETERS, GENERAL

A. Scale Range: Temperature ranges for services listed are as follows:

1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
2. Hot Water: 30 to 300 deg F, with 2-degree scale divisions.
3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.
4. Steam and Condensate: 50 to 400 deg F, with 5-degree scale divisions.

B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 DIAL TYPE THERMOMETERS

A. Description: ASTM E 1.

B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, minimum 2” diameter, maximum 5” diameter, accurate to within 1% of full scale.

C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Tube: Red or blue reading, organic-liquid filled with magnifying lens.

E. Scale: Satin-faced nonreflective aluminum with permanently etched markings.

F. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.4 SEPARABLE SOCKETS

A. Description: Fitting with protective socket for installation in threaded pipe fitting to hold fixed thermometer stem.

2. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation. Omit extension neck for sockets for piping not insulated.
3. Insertion Length: To extend to one-third of diameter of pipe.
4. Cap: Threaded, with chain permanently fastened to socket.
5. Heat-Transfer Fluid: Oil or graphite.

2.5 THERMOMETER WELLS

A. Description: Fitting with protective well for installation in threaded pipe fitting to hold test thermometer.

2. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation. Omit extension neck for wells for piping not insulated.
3. Insertion Length: To extend to one-third of diameter of pipe.
4. Cap: Threaded, with chain permanently fastened to socket.
5. Heat-Transfer Fluid: Oil or graphite.

2.6 DUCT THERMOMETER SUPPORT FLANGES

A. Description: Flanged-fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.
   1. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of exterior insulation.
   2. Insertion-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation lining.

2.7 PRESSURE GAGES

A. Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; dry type, unless liquid-filled-case type is indicated.
B. Case: Drawn steel, brass, or aluminum with 4-1/2-inch- (115-mm-) diameter, glass lens.
C. Connector: Brass, NPS 1/4 (DN8).
D. Scale: White-coated aluminum with permanently etched markings.
E. Accuracy: Grade A, plus or minus 1 percent of middle 50 percent of scale.
F. Range: Comply with the following:
   1. Vacuum: 30 inches Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).
   2. Fluids under Pressure: Two times the operating pressure.

2.8 PRESSURE-GAGE FITTINGS

A. Valves: NPS 1/4 (DN8) brass or stainless-steel needle type.
B. Syphons: NPS 1/4 (DN8) coil of brass tubing with threaded ends.
C. Snubbers: ASME B40.5, NPS 1/4 (DN8) brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

PART 3 - EXECUTION

3.1 METER AND GAGE INSTALLATION, GENERAL

A. Install meters, gages, and accessories according to manufacturer's written instructions for applications where used.
3.2 THERMOMETER INSTALLATION

A. Install thermometers and adjust vertical and tilted positions.

B. Install in the following locations:

1. Inlet and outlet of each hydronic coil in air-handling units systems.
2. Inlet and outlet of each steam-to-hot water converters.
3. Chilled water supply and return mains at building entrance.

C. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending to one-third of diameter of pipe.
2. Fill sockets with oil or graphite and secure caps.

D. Install thermometer wells in vertical position in piping tees where test thermometers are indicated.

1. Install with stem extending to one-third of diameter of pipe.
2. Fill wells with oil or graphite and secure caps.

3.3 PRESSURE-GAGE INSTALLATION

A. Install pressure gages in piping tees with pressure-gage valve located on pipe at most readable position.

B. Install dry-type pressure gages in the following locations:

1. Discharge of each steam or water pressure-reducing valve.
2. Inlet and outlet of each condensate pump.
3. Inlet and outlet of domestic water heaters.
4. Inlet and outlet of hot water heat exchangers.
5. Supply and return header of chilled water system.

C. Install liquid-filled-type pressure gages at suction and discharge of each pump.

D. Install pressure-gage needle valve and snubber in piping to pressure gages.

1. Exception: Install syphon instead of snubber in piping to steam pressure gages.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Install meters and gages adjacent to machines and equipment to allow service and maintenance.
2. Connect flow-measuring-system elements to meters.
3. Connect flowmeter transmitters to meters.
4. Connect thermal-energy-flowmeter transmitters to meters.

B. Make electrical connections to power supply and electrically operated meters and devices.

C. Install electrical connections for power and devices.

D. Electrical power, wiring, and connections are specified in Division 26 Sections.
3.5 ADJUSTING AND CLEANING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjust faces of meters and gages to proper angle for best visibility.

C. Clean windows of meters and gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 230519
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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes general duty valves common to several mechanical piping systems.

B. Related Sections: The following Sections contain requirements that relate to this Section:
   1. Special purpose valves are specified in Division 23 piping system Sections.
   2. Valve tags and charts are specified in Division 23 Section "Mechanical Identification."

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

C. Maintenance data for valves to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.4 QUALITY ASSURANCE

A. Single-Source Responsibility: Comply with the requirements specified in Division 1 Section "Materials and Equipment," under "Source Limitations" Paragraph.

B. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.5 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 globe and gate 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 indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use a sling to handle large valves. Rig to avoid damage to exposed parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Gate Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.

2. Ball Valves:
   a. Conbraco Industries, Inc.; Apollo Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.

3. Butterfly Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Grinnell Corp.
   c. Milwaukee Valve Company, Inc.
   d. NIBCO Inc.
   e. Stockham Valves & Fittings, Inc.

4. Swing Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.

5. Lift Check Valves:
   a. Bonney Forge.

6. Globe Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Milwaukee Valve Company, Inc.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.
2.2 BASIC, COMMON FEATURES

A. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.

B. Sizes: Same size as upstream pipe, unless otherwise indicated.

C. Operators: Use specified operators and handwheels, except provide the following special operator features:
   1. Handwheels: For valves other than quarter turn.
   2. Lever Handles: For quarter-turn valves 6 inches (DN150) and smaller, except for plug valves, which shall have square heads. Furnish Owner with 1 wrench for every 10 plug valves.
   3. Chain-Wheel Operators: For valves 4 inches (DN100) and larger, installed 96 inches (2400 mm) or higher above finished floor elevation.
   4. Gear-Drive Operators: For quarter-turn valves 8 inches (DN200) and larger.

D. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

E. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.


   1. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F (450 deg C) for gate, globe, and check valves; below 421 deg F (216 deg C) for ball valves.

2.3 GATE VALVES

A. Steam Distribution (15 – 65 psig) – Gate Valves, 2” and Smaller: Threaded outside screw and yoke, Class 800 ASTM A105 forged steel body and bonnet, stainless steel wedge disc and seat; and with cast iron handwheel. Valves 2½” and larger, flanged, forged steel, outside screw and yoke, 150 lb. class.

B. Steam (below 15 psig in building) – Gate Valves 2” and Smaller: 150 lb. rising stem gate valves. Union shall not be integral to the valve. Valves 2½” and larger shall be flanged ends, outside screw and yoke, Class150.

2.4 BALL VALVES

A. Chilled Water and Hot Water - Ball Valves: MSS SP-110, 150 lb., 2” and smaller, ASTM B 584 bronze body and bonnet, 2-piece construction; stainless steel ball, full port blowout proof; stainless steel stem; Teflon seats and seals; soldered end connections, NIBCO T-595-Y, NIBCO S-595-Y or equal:
   3. Memory Stop: For operator handles.
2.5 GLOBE VALVES

A. Chilled Water and Hot Water - Globe Valves, 3 Inches (DN65) and Smaller: MSS SP-80; Class 125, 200-psi (1380-kPa) CWP, or Class 150, 300-psi (2070-kPa) CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or Teflon disc, silicon bronze-alloy stem, Teflon-impregnated packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

2.6 BUTTERFLY VALVES

A. Chilled Water and Hot Water - Butterfly Valves: MSS SP-67, 200-psi (1380-kPa) CWP, 150 psi maximum pressure differential, ASTM A 126 cast-iron full lug body and bonnet, extended neck, 316 stainless-steel stem, field-replaceable EPDM sleeve and stem seals, Grinnell Series 8000 or equal:

1. Disc Type: 316 stainless steel.
2. Operator for Sizes 2 Inches (DN50) to 5 Inches (DN150): Lever handle with latch lock with memory.
3. Operator for Sizes 6 Inches (DN200) to 24 Inches (DN600): Gear operator with position indicator with chain 6'-0" A.F.F.
4. Operator for Sizes 6 Inches (DN200) and Larger, 96 Inches (2400 mm) or Higher above Floor: Chain-wheel operator with chain 6'-0" A.F.F.

2.7 CHECK VALVES

A. Swing Check Valves, 2 Inches (DN65) and Smaller: 150 lb.; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, soldered connections, NIBCO T-433 or equal:

B. Swing Check Valves, 2-1/2 Inches (DN80) and Larger: MSS SP-71, Class 125, 200-psi (1380-kPa) CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged end connections, NIBCO F-918 or equal.

C. Lift Check Valves (Pump Discharge): Class 800, forged steel ball type check valve, with bolted bonnet, male-female joint, spiral wound gasket made in F316L/graphite. Valves shall conform to MS-SP-118 and ASME B16.34 and shall be tested according to API 598.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. 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.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.
F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer’s written instructions.

B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

D. Locate valves for easy access and provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the center of the pipe.

F. Install valves in a position to allow full stem movement.

G. For chain-wheel operators, extend chains to 60 inches (1500 mm) above finished floor elevation.

H. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Swing Check Valves: Horizontal position with hinge pin level.
   2. Lift Check Valve: With stem upright and plumb.

3.3 SOLDERED CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder melts on contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends and proximity of valve internal seat or wall to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.
D.  Assemble joint, wrench tight.  Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.5 FLANGED CONNECTIONS

A.  Align flange surfaces parallel.

B.  Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible.  Use suitable lubricants on bolt threads.  Tighten bolts gradually and uniformly with a torque wrench.

C.  For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.6 VALVE END SELECTION

A.  Select valves with the following ends or types of pipe/tube connections:

1.  Copper Tube Size, 2-1/2 Inches (DN65) and Smaller:  Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
2.  Steel Pipe Sizes, 2-1/2 Inches (DN65) and Smaller:  Threaded.
3.  Steel Pipe Sizes, 3 Inches (DN80) and Larger:  Flanged.

3.7 APPLICATION SCHEDULE

A.  General Application:  Use gate, ball, and butterfly valves for shutoff duty; lubricated plug cocks, and balancing valves for throttling duty, and butterfly valves on pump discharge.  Refer to piping system Specification Sections for specific valve applications and arrangements.

B.  Heating and Chilled Water Systems:  Use the following valve types:

1.  Ball Valves (up to and including 2"):  
2.  Butterfly Valves 3" and Larger:
3.  Bronze Swing Check:  Class 150, with composition seat.
5.  Balancing valves:  Bell and Gossett CBV or Armstrong Flowsetter ΔP type

C.  Low-Pressure Steam and Condensate Return Systems (Inside Building):  Use the following valve types:

1.  Gate Valves (2" and smaller):  150 lb., rising stem.
2.  Gate Valves (steam supply 3" and larger):  150 lbs, OS&Y.
3.  Globe Valves:  Class 150, bronze body with Teflon disc (ahead of pressure gauges).

D.  Steam and Condensate Return Distribution Systems:  Use the following valve types:

1.  Gate Valves (Steam Supply 2½" and Smaller):  Threaded OS&Y, 800 lb.
2.  Gate Valves (steam supply 3" and larger):  Class 150, flanged cast steel body.
3.  Globe Valves:  Class 150, cast steel body with Teflon disc (ahead of pressure gauges).
4.  Check Valves:  Class 800, forged steel ball check.
3.8 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

END OF SECTION 230523
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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. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment supports.
B. Related Sections include the following:
   1. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
   2. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   3. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
   4. Division 23 Section(s) "Metal Ducts" and "Nonmetal Ducts" 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 and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS
A. Product Data: For the following:
1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Powder-actuated fastener systems.

B. Welding certificates with picture ID.

1.6 QUALITY ASSURANCE

A. 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. Acceptable 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. Acceptable Manufacturers:

2. Carpenter & Paterson, Inc.
3. Empire Industries, Inc.
5. Grinnell Corp.
6. GS Metals Corp.
8. Piping Technology & Products, 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 METAL FRAMING SYSTEMS

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

B. Acceptable Manufacturers:
   2. GS Metals Corp.
   4. Thomas & Betts Corporation.
   5. 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.

2.5 THERMAL-HANGER SHIELD INSERTS

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

B. Acceptable Manufacturers:
   1. Carpenter & Paterson, Inc.
   2. PHS Industries, Inc.
   3. Pipe Shields, Inc.
   5. 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.

2.6 FASTENER SYSTEMS

A. 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. Acceptable Manufacturers:
2.7 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. Acceptable Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

   2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   3. 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. Bases: One or more plastic.
   2. Vertical Members: Two or more protective-coated-steel channels.
   3. Horizontal Member: Protective-coated-steel channel.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes and then hot dipped or cold galvanized.

2.9 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.

I. 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.
J. 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 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. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. 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.

F. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

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

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes and then hot dipped or cold galvanize.

I. 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.

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

K. 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.

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

M. 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.

N. 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. Cold galvanize 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 stick to comply with ASTM A 780.

END OF SECTION 230529
SECTION 230548 - VIBRATION CONTROLS 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Freestanding and restrained spring isolators.
4. Housed spring mounts.
5. Elastomeric hangers.
7. Spring hangers with vertical-limit stops.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
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.
   a. Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

B. Welding certificates with photo ID.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.
1.5 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   3. Mason Industries.
   4. Vibration Eliminator Co., Inc.
   5. Vibration Isolation.
   6. Vibration Mountings & Controls, Inc.

B. Pads Type A.1: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene or rubber.

C. Mounts Type A.2: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Spring Isolators Type B.1: Freestanding, laterally stable, open-spring isolators.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolators Type B.2: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

F. Housed Spring Mounts Type B.3: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.

2. Base: Factory drilled for bolting to structure.

3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

G. Elastomeric Hangers Type B.4: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

H. Spring Hangers Type B.5: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

I. Spring Hangers with Vertical-Limit Stop Type B.6: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Thrust Limits – Type C.1: Combination coil spring and elastomeric insert with spring and insert in compression with a load stop. Include rod and angle-iron brackets for attaching to equipment.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of ¼-inch movement at start and stop.

K. Pipe Riser Resilient Support: - Type D.1: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch-thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 VIBRATION ISOLATION EQUIPMENT BASES

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   3. Mason Industries.
   4. Vibration Eliminator Co., Inc.
   5. Vibration Isolation.
   6. Vibration Mountings & Controls, Inc.

B. Steel Base – Type E.1: Factory-fabricated, welded, structural-steel bases and rails.
   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.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars comply with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

   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.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. 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.

2.3 FACTORY FINISHES

A. Finish: Manufacturer’s standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

A. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

B. 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.

C. 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.

D. 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.

3.4 FIELD QUALITY CONTROL
   A. Perform tests and inspections.
   B. Remove and replace malfunctioning units and retest as specified above.
   C. 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 air-spring leveling mechanism.
   D. Adjust active height of spring isolators.

3.6 VIBRATION ISOLATOR SCHEDULE FOR SLAB ON GRADE LOCATED EQUIPMENT

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Mounting</th>
<th>Size</th>
<th>Base Type</th>
<th>Isol. Type</th>
<th>Static Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal fans</td>
<td>Floor</td>
<td>Up to 60 HP</td>
<td>E.1</td>
<td>A.2</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>75 HP and above</td>
<td>E.1</td>
<td>B.1</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td></td>
<td>Suspended</td>
<td>Up to 40 HP</td>
<td>E.1</td>
<td>A.2</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All sizes</td>
<td>--</td>
<td>B.5</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>Inline fans</td>
<td>Floor</td>
<td>Up to 40 HP</td>
<td>E.1</td>
<td>A.2</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td>Suspended</td>
<td>All sizes</td>
<td>--</td>
<td>B.5</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>Utility sets</td>
<td>Floor/Roof</td>
<td>All sizes</td>
<td>--</td>
<td>A.2</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td>Suspended</td>
<td>All sizes</td>
<td>E.1</td>
<td>B.4</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>Air Handling units</td>
<td>Floor</td>
<td>Up to 5&quot; SP</td>
<td>--</td>
<td>A.1</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>Above 5&quot; SP</td>
<td>--</td>
<td>A.1</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td>Suspended</td>
<td>All sizes</td>
<td>--</td>
<td>B.5</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>Centrifugal Pumps</td>
<td>Floor</td>
<td>Up to 50 HP</td>
<td>E.1</td>
<td>A.2</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td></td>
<td>Floor</td>
<td>Above 50 HP</td>
<td>E.2</td>
<td>B.1</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td></td>
<td>Suspended</td>
<td>All sizes</td>
<td>--</td>
<td>B.5</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>Piping – Horizontal</td>
<td>Suspended</td>
<td>All sizes</td>
<td>-</td>
<td>B.4</td>
<td>0.25&quot;</td>
</tr>
<tr>
<td>Piping – Vertical</td>
<td>Floor</td>
<td>All sizes</td>
<td>--</td>
<td>D.1</td>
<td>0.25&quot;</td>
</tr>
</tbody>
</table>

Notes: 1. The table indicates minimum static deflection for the isolator. The Contractor shall provide isolators with
        proper deflection, for equipment furnished, as recommended by the isolator manufacturer.
2. Provide C.1 type (thrust limits) isolators for all fans, air handling units rated for more than 5" total static
   pressure.
3. Isolators indicated for horizontal piping is only for three (3) hangers on discharge/outlet and three (3)
   hangers on suction/inlet pipes for pumps, air compressors, vacuum pumps, and equipment mounted on
4. Fans within air handling units, equipped with internal vibration isolators, shall not require isolation for fans as indicated in table above.

### 3.7 VIBRATION ISOLATOR SCHEDULE FOR EQUIPMENT LOCATED ABOVE GRADE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Mounting</th>
<th>Size</th>
<th>Base Type</th>
<th>Isol. Type</th>
<th>Static Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline Fans</td>
<td>Floor</td>
<td>Up to 40 HP</td>
<td>E.1</td>
<td>B.1</td>
<td>1.0”</td>
</tr>
<tr>
<td></td>
<td>Suspended</td>
<td>All sizes</td>
<td>--</td>
<td>B.6</td>
<td>1.0”</td>
</tr>
<tr>
<td>Air Compressors</td>
<td>Floor</td>
<td>All sizes</td>
<td>E.2</td>
<td>E.2</td>
<td>1.0”</td>
</tr>
<tr>
<td>Piping – Horizontal</td>
<td>Suspended</td>
<td>All sizes</td>
<td>--</td>
<td>B.4</td>
<td>0.25”</td>
</tr>
<tr>
<td>Piping – Vertical</td>
<td>Floor</td>
<td>All sizes</td>
<td>--</td>
<td>D.1</td>
<td>0.25”</td>
</tr>
</tbody>
</table>

**Notes:**

1. The table indicates minimum static deflection for the isolator. The Contractor shall provide isolators with proper deflection, for equipment furnished, as recommended by the isolator manufacturer.

2. Provide C.1 type (thrust limits) isolators for all fans, air handling units rated for more than 5” total static pressure.

3. Isolators indicated for horizontal piping is only for three (3) hangers on discharge/outlet and three (3) hangers on suction/inlet pipes for pumps, air compressors, vacuum pumps, and equipment mounted on type “B” isolators. Remaining piping does not require isolation.

4. Fans within air handling units, equipped with internal vibration isolators, shall not require isolation for fans as indicated in table above.

END OF SECTION 230548
SECTION 230553 - IDENTIFICATION 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 SUBMITTALS

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

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 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. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS
A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
C. Background Color: Red.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
F. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.
2.3 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 partially cover 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: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.


C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.


H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard or metal.

2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.
2.6 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 wire-link or 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.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches.
   2. Fasteners: Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

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 Section "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.
C. 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, within mechanical rooms, boiler rooms, chiller rooms, etc.

D. In general follow Pipe Label Color Schedule as shown below, unless the Owner has different schedule standards in which case the Owner’s schedule shall be followed:
   1. Heating Water Piping:
      a. Background Color: Orange.
   2. Low-Pressure Steam Piping:
      a. Background Color: Yellow.
   3. High-Pressure Steam Piping:
      a. Background Color: Yellow.
   4. Steam Condensate Piping:
      a. Background Color: Yellow.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system. Reduce intervals to 25 feet in areas of congested piping and equipment, within mechanical rooms, etc.
3.5 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; 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 similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   d. Low-Pressure Steam: 1-1/2 inches, round.
   e. High-Pressure Steam: 1-1/2 inches, round.
   f. Steam Condensate: 1-1/2 inches, round.

2. Valve-Tag Color:
   b. Hot Water: Natural.
   c. Low-Pressure Steam: Natural.
   d. High-Pressure Steam: Natural.
   e. Steam Condensate: Natural.

3. Letter Color:
   b. Hot Water: Black.
   c. Low-Pressure Steam: Black.
   d. High-Pressure Steam: Black.
   e. Steam Condensate: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553
SECTION 230593 - TESTING, ADJUSTING AND BALANCING 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 DESCRIPTION OF WORK

A. This scope of services specified the requirements and procedures for mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results. The test and balance work will be performed by the Owner's personnel. It is the Contractor's responsibility to assist as outlined below.

B. Test, adjust and balance the following mechanical systems which are shown in the construction documents.

1. Exhaust air systems.
2. Hydronic systems.
3. Steam distribution systems.
4. Verify temperature control system operation.

C. The contractor's responsibilities are as follows:

1. Notify the Owner's Representative fourteen (14) days prior to the schedule date for balancing the system.
2. Schedule a two (2) week allowance for the testing and balancing firm to complete the testing and balancing work when scheduling completion of all work required of the Contractor by the contract documents.
3. Cooperate with the testing and balancing firm and shall make all necessary preparations for the TAB efforts.
4. Complete the following work prior to requesting the TAB effort.
   a. Clean and flush all piping systems.
   b. Leak test and make tight all piping systems.
   c. Fill all piping systems with clean water.
   d. Clean and seal all ductwork systems.
   e. Service and tag all equipment.
   f. Set and align all motors and drives.
   g. Start up and prove all equipment and systems.
   h. Make preliminary settings on all control devices and have all systems operational.
   i. Operate all systems successfully for twenty-four (24) hours minimum.
5. Lubricate all motors and bearings.
6. Check fan belt tension.
7. Check fan rotation.
8. Patch insulation, ductwork and housing, using materials identical to those removed.
9. Seal ducts and piping, and test for and repair leaks.
10. Seal insulation to re-establish integrity of the vapor barrier.
11. Attend a coordination meeting prior to the balancing of the system and a coordination meeting following the balancing of the system.
12. Provide a complete set of as-built drawings prior to the TAB effort.
13. Provide craftsmen of the proper trade to work with the TAB firm to make adjustments and installation changes as required.
14. Change out fan sheaves when and if required by the TAB firm.
15. Dedicate the resources to accommodate all changes identified by the test and balance firm in a timely manner.
16. If a significant rebalance (Owner’s determination) of the HVAC system is required due to the Contractor’s failure to properly install and check out the HVAC system, the cost of rebalancing the system shall be borne by the Contractor.

1.3 PRE-BALANCING CONFERENCE

A. Prior to beginning of the testing, adjusting and balancing procedures, a conference with the Owner’s Representative, Engineer and the Test and Balance Agency’s representative will be held. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting and balancing.

1.4 SEQUENCING AND SCHEDULING OF SERVICES

A. Test, adjust and balance the air conditioning systems during summer season and heating systems during winter season. This includes at least a period of operation at outside conditions within 5 deg. F wet bulb temperature of maximum summer design condition, and within 10 deg. F dry bulb temperature of minimum winter design conditions. Take final temperature readings during seasonal operation.

PART 2 - PRODUCTS (Not applicable)

PART 3 - EXECUTION (Not applicable)

END OF SECTION 230593
SECTION 230700 - HVAC INSULATION

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. Flexible elastomeric.
   b. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
7. Sealants.
8. Factory-applied jackets.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.

B. Related Sections:

1. Division 22 Section "Plumbing 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).

B. LEED Submittal:

1. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

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.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

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 Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. 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.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

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

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

   a. Aeroflex USA Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. NOMACO Insulation.

2. Thermal Conductivity: Not exceeding 0.25 BTU-in/hour °F at 75°F mean temperature.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Manson Insulation Inc.
   e. Owens Corning Fiberglas Corp.

2. Density: 1.9 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.25 BTU-in/hour sq. ft. °F at 75°F mean temperature.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Manson Insulation Inc.
   e. Owens Corning Fiberglas Corp.

2. Density: 3.0 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.30 BTU-in/hour sq. ft. °F at 100°F mean temperature.

I. 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 ASJ. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Manson Insulation Inc.
   e. Owens Corning Fiberglas Corp.

2. Density: 3.0 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.23 BTU-in/hour sq. ft. °F at 75°F mean temperature.

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning Fiberglas Corp.

2. Density: 2.5 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.27 BTU-in/hour sq. ft. °F at 75°F mean temperature.

K. Mineral-Fiber, Preformed Pipe Insulation:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Knauf Insulation.
   c. Manson Insulation Inc.
   d. Owens Corning Fiberglas Corp.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.
   3. Thermal Conductivity: Not exceeding 0.23 BTU-in/hour sq. ft. °F at 75°F mean temperature.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corp.
   b. Johns Manville.
   c. Knauf Insulation.
   d. Manson Insulation Inc.
   e. Owens Corning Fiberglas Corp.

2. Density: 2.5 lbs/cu. ft.
3. Thermal Conductivity: Not exceeding 0.27 BTU-in/hour sq. ft. °F at 75°F mean temperature.

2.2 INSULATING CEMENTS


2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA Inc.
      b. Armacell LCC.
c. Foster Products Corporation, H. B. Fuller Company.
d. RBX Corporation.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).


1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW.
   b. Foster Products Corporation, H. B. Fuller Company.
   c. ITW TACC, Division of Illinois Tool Works.
   d. Marathon Industries, Inc.
   e. Mon-Eco Industries, Inc.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dow Chemical Company (The).
   c. P.I.C. Plastics, Inc.
   d. Speedline Corporation

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
2.5 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. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. P.I.C. Plastics, Inc.
   c. Proto PVC Corporation.
   d. Speedline Corporation.

2. Adhesive: As recommended by jacket material manufacturer.


4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Products, Division of ITW.
   b. PABCO Metals Corporation.
   c. RPR Products, Inc.

   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
2.6 TAPES

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

1. Avery Dennison Corporation, Specialty Tapes Division.
2. Compac Corp.
4. Venture Tape.

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

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

C. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

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

2.7 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240, Type 304; 0.015 inch thick, 1/2 inch wide with wing or closed seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.

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.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

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.

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, ducts and fittings, 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, duct system, 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. 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.
   a. 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 duct and pipe flanges and fittings.

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

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

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

O. 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 PENETRATIONS

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

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

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive joint sealers.

D. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Mineral Fiber, Pipe and Tank 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 adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. 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.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from galvanized steel or aluminum, at least 0.040 inch thick.
3. 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.

3.6 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:

### 3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

**A.** Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

**B.** Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

**C.** Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

**D.** Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

### 3.8 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.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg 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 2 times the insulation thickness but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg 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 2 times the insulation thickness but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.9 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.

3.10 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.11 FINISHES

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

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
3.13 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor equipment in paragraphs below that is not factory insulated.

C. Heat-exchanger (steam to hot water) insulation shall be one of the following:
   1. Mineral-Fiber Board: 3 inches thick.

3.14 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.15 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

B. Chilled Water:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Flexible Elastomeric: 1 inch thick.

C. Heating-Hot-Water Supply and Return:
   1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
   2. NPS 1-1/2 and larger: Insulation shall be one of the following:

D. Low Pressure Steam, Low and High Pressure Steam Condensate, Condensate Pump Discharge, Condensate Pump Receiver Vent to 7 ft., Flash Tank Vent to 7 ft., Steam Relief Vent:
   1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inch thick.
2. NPS 1-1/2 and larger: Insulation shall be one of the following:
   a. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.

E. High Pressure Steam (above 15 psig):
   1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 2-1/2 inch thick.
   2. NPS 1-1/2 to NPS 3: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches thick.
   3. NPS 4 and larger: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe, Type I or II: 4 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Equipment, Heating Hot-Water Convertors:
   1. Embossed Aluminum Jacket.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed to view in occupied area and within 6'-0" of finished floor:
   1. PVC Jacket.

E. Piping, Exposed in mechanical rooms except steam & steam condensate:
   1. Aluminum Jacket.

F. Steam & Steam Condensate Piping, Exposed in mechanical rooms:
   1. Aluminum Jacket.

END OF SECTION 230700
SECTION 230900 - CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. University of Missouri Controls Specification.

B. This section contains requirements for electrical and digital control systems as indicated on the contract drawings.

C. Contractor is responsible for providing, installing and connecting all sensors, control valves, control dampers, electrical components and all interconnecting pneumatic tubing and electrical wiring between these devices and up to the Direct Digital Controllers (DDC).

D. DDC controllers consist of Johnson Controls METSYS controller, type NAE, DX, FEC, ION, AHU, VAV, VMA, or UNT controllers. Owner will provide Johnson Control METSYS controllers for the contractor to install.

E. After all equipment has been installed, wired and piped, Owner will be responsible for all termination connections at the DDC controller’s and for checking, testing, programming and start-up of the control system. Contractor must be on site at start-up to make any necessary hardware adjustments as required.

F. Once each mechanical system is completely operational under the new control system, contractor shall make any final connections and adjustments. For controls renovation jobs, contractor shall remove all unused sensors, operators, panels, wiring, tubing, conduit, etc. Owner shall have the option of retaining any removed pneumatic controls.

1.2 RELATED SECTIONS

A. Drawings and general provisions of Contract, including General and Special Conditions apply to work of this section.

1.3 QUALITY ASSURANCE

A. Contractor's Qualifications:

1. Contractor shall be regularly engaged in the installation of digital control systems and equipment, of types and sizes required. Contractor shall have a minimum of five years experience installing digital control systems. Contractor shall supply sufficient and competent supervision and personnel throughout the project in accordance with General Conditions section 3.4.1 and 3.4.4.

B. Codes and Standards:

1. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.

2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.

3. NFPA Compliance: Comply with NFPA 90A “Standard for the Installation of Air Conditioning and Ventilating Systems” where applicable to controls and control sequences.

4. NFPA Compliance: Comply with NFPA 70 “National Electric Code”.

1.4 SUBMITTALS

A. Shop Drawings: Submit shop drawings for each control system, containing the following information:

B. Product data for each damper, valve, and control device.

C. Schematic flow diagrams of system showing fans, pumps, coils, dampers, valves, and control devices.

D. Label each control device with setting or adjustable range of control.

E. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Provide details of faces on control panels, including controls, instruments, and labeling.

G. Include written description of sequence of operation.

H. Provide wiring diagrams of contractor provided interface and I/O panels.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Conduit and Raceway:

1. Electrical metallic Tubing: EMT and fittings shall conform to ANSI C80.3.
2. Surface Metal Raceway and Fittings: Wiremold 500, Ivory, or approved equal.
3. Flexible Metal Conduit: Indoors, per National Electric Code for connection to moving or vibrating equipment.
4. Liquidtight Flexible Conduit: Outdoors, per National Electric Code for connection to moving or vibrating equipment.

B. Control Valves: Provide factory fabricated electric control valves of type, body material, and pressure class as indicated on the drawings. Butterfly style control valves are not acceptable except for two position applications. Equip control valves with proper shutoff rating for each individual application.

1. Steam and Hot Water:
   a. Manufacturer do not allow KMC valves and actuators.
   b. Water Service Valves: Equal percentage characteristics.
   c. Steam Service Valves: Equal percentage characteristics.
   d. Single Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on “top and bottom” guided plugs.
   e. Valve Trim and Stems: Polished stainless steel.
   g. Control valves should have a minimum 100 psi close-off rating for chilled water applications.

2. Hydronic Chilled Water and Heating Water:
   a. Hydronic control valves shall be pressure independent. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valve shall accurately control the flow from 1 to 100% full rated flow.
   b. The valve bodies shall be of cast iron, steel or bronze and rated for 150 psi working pressure. All internal parts shall be stainless steel, steel, Teflon, brass or bronze.
c. Valves shall be DeltaP Valves manufactured by Flow Control Industries, Belimo P Series, Danfoss AB-QM Series, or approved equal. Belimo EV050 Series is not acceptable.
d. The valves shall have pressure taps across the valve for measuring the pressure drop across the valve. The pressure taps shall have ½-inch extensions for accessibility.
e. Control valves shall be installed with unions or flanges as necessary for easy removal and replacement.
f. Valve Tag shall include the model number, AHU being served, design flow, and maximum flow for that valve.
g. The control valves shall be delivered preset to the scheduled design flow and should be capable of reaching 110% of the design flow to allow for field adjustment for capacity changes.

C. Control Dampers: Ruskin CD-50 or approved equal.
   1. Provide dampers with parallel blades for 2-position control.
   2. Provide opposed blades for modulating control.
   3. Dampers shall be low leakage design with blade and edge seals.
   4. Provide multiple sections and operators as required by opening size and sequence of operations, as indicated on the contract drawings.

D. Electric Actuators: Johnson Controls, Bray, Belmo, TAC or approved equal, KMC actuators are not approved. Size electric actuators to operate their appropriate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified. If mixed air AHU has return air, exhaust air and outside air dampers that are not mechanically linked then static safety switch must be installed and wired to safety circuit. Spring return actuators should be provided on heat exchanger control valves or dampers or as specified on the drawings. Control signal shall be 0 to 10 VDC unless otherwise specified on drawings. Actuators with integral damper end switch are acceptable. For VAV reheat valves, actuators shall have a material override capability to aid in system flushing, startup and balancing.

E. Air Temperature Sensors:
   1. All electronic temperature sensors shall be compatible with Johnson METASYS systems.
   2. Sensors shall be 1,000 ohm platinum, resistance temperature detectors (RTDs) with two wire connections. Duct mounted sensors shall be averaging type. Contractor may install probe type when field conditions prohibit averaging type, but must receive permission from Owner’s Representative.
   3. Coordinate thermowell manufacturer with RTD manufacturer. Thermowells that are installed by the contractor, but are to have the RTD installed by owner, must be Johnson Controls Inc. series WZ-1000.

F. Electronic Temperature Sensors and Transmitters:
   1. Chilled Water, Heating Hot Water, and Steam Temperature Sensors:
      a. General: The RTD/Temperature Transmitter/Thermowell assembly shall come as a complete assembly from a single manufacturer. The Assembly shall be suitable for use in the accurate measurement of Chilled Tower/Dual Water temperature in a mechanical room environment.
      b. Calibration: Each RTD must be match calibrated to the Transmitter via NIST traceable calibration standards. Results are to be programmed into the transmitter. Results are to be presented on report as after condition at the specified calibration points. Assembly shall not be approved for installation until Owner has received all factory calibration reports.
      c. RTD:
         1) RTD type: 2-wire or 3-wire 100 ohm platinum class A.
         2) Outside Diameter: 0.25 inch.
         3) Tolerance: +/- 0.06% Type A.
         4) Stability: +/- 0.1% over one year.
         5) TCR: 0.00385 (ohm/ohm/°C).
6) RTD shall be tip sensitive.
7) Resistance vs. Temperature table for the RTD must be provided to the Owner.

d. Transmitter:
1) Transmitter shall be match calibrated to the RTD and assembled as a matched pair.
2) Type: 2 wire (loop powered).
3) Input: 2 or 3 wire 100 ohm platinum class A or class B RTD.
4) Output: Output shall be a 4-20 mA signal linear to temperature.
5) Calibrated Span:
   a) Chilled Water: 30°F to 130°F.
   b) Hot Water: 100°F to 250°F.
   c) Steam: 150°F to 450°F.
6) Calibration Accuracy, including total of all errors, of the Transmitter & RTD matched pair over the entire space shall be within +/- 0.2% of the calibrated span or +/- 0.18°F, whichever is greater.
7) Supply Voltage: 24 VDC
8) Ambient Operating Temp: 32 to 122°F
9) Epoxy potted for moisture resistance.
10) Mounting: Transmitter shall be mounted in the RTD connection head.

e. Thermowell:
1) Thermowell shall be suitable for immersion in chilled, hot water and steam.
2) Thermowell shall be reduced tip.
3) Thermowell shall be one piece stainless steel machined from solid bar stock.
4) Thermowell shall have ½” NPT process connection to pipe thread-o-let.
5) Thermowell Insertion depth shall be ½ the inside pipe diameter but not to exceed 10”.

f. Assembly:
1) Assembly configuration: Spring loaded RTD with thermowell-double ended hex-connection heat.
2) Connection head shall be cast aluminum with chain connecting cap to body, have ½” NPT process and ¾” NPT conduit connections, and a sealing gasket between cap and body.

g. RTD/Temperature Transmitter/Thermowell assembly shall be the following or approved equal:
1) Manufacturer: Pyromation, Inc.
2) Chilled Water: RAF-185L-S4C[length code]08-SL-8HN31, TT440-385U-S (30-130)°F with calibration SMC (40,60)°F.
3) Hot Water: RAF 185L-S4C[length code]08T2-SL-8HN31, TT440-385U-S (100-250)°F with calibration SMC (140,180)°F.
4) Steam: RAT185H-S4C[length code]08T2-SL-8HN31, TT440-385U-S (150-450)°F with calibration SMC (300,350)°F.

G. Occupant Override: Provide wall mounted occupant override button in locations shown on drawings.

H. Low Limit Controllers: Provide unit-mounted low limit controllers, of rod-and-tube type, with an adjustable set point and a manual reset. Capillary shall be of adequate length to horizontally traverse face of cooling coil every 12”. Multiple low limit controllers may be required for large coils. Controller shall have an extra set of contactors for connection to control panel for alarm status. Locate the thermostat case and bellows where the ambient temperature is always warmer that the set point.
1. Freeze Stats: Johnson Controls model A70HA-1 or approved equal.

I. Humidistats: Humidistats must be contamination resistant, capable of ± 2% RH accuracy, have field adjustable calibration and provide a linear proportional signal.
   1. HD20K-T91 or equivalent.

J. Humidity High Limit:
   1. Multi-function device that can function as a high limit or proportional override humidity controller, as stand-alone proportional controller, or a stand-alone two-position controller.
      a. Johnson Controls TRUERH HL-67N5-8N00P or approved equal.

K. Carbon Dioxide Sensor:
   1. Wall Mount: ACI Model ESENSE-R.
   2. Duct Mount: ACI Model ESENSE-D.

L. Fan/Pump Status: Status points for fan or pump motors with a VFD must be connected to the terminal strip of the VFD for status indication. Current switches: Current switches are required for fan and pump statuses that are not connected to a VFD. The switches must have an adjustable trip setpoint with LED indication and be capable of detecting broken belts or couplings. Units shall be powered by monitored line, UL listed and CE certified, and have a five year warranty.
   1. Kele, Hawkeye or approved equal.

M. Relays Used for Fan and Pump Start/Stop: Must have LED indication and be mounted externally or starter enclosure or VFD.
   1. Kele, RIBU1C or approved equal.

N. Power Supply Used to Provide Power to Contractor-Provided Control Devices: Shall have adjustable DC output, screw terminals, overload protection and 24 VDC and 24 VDC output.
   1. Kele, DCPA-1.2 or approved equal.

O. Pressure Differential Switch:
   1. Fans: NECC model DP222 or approved equal.

P. Differential Pressure Transmitter: Provide units with linear analog, 4-20 mA output proportional to differential pressure, compatible with the Johnson METASYS Systems.
   1. Water: Units shall be wet/wet differential pressure capable of a bi-directional pressure range of +/- 50 psid. Accuracy shall be +/- 0.25% full scale with a compensated temperature range of 30 to 150 deg F and a maximum working pressure of 250 psig. Install transmitter in a pre-manufactured bypass valve assembly with shut-off valves, vent valves and a bypass valve, all enclosed in a NEMA 1 enclosure.
      a. Setra model 230 with Kele model BVA-5 bypass valve assembly, or approved equal.
   2. Air: Units shall be capable of measuring a differential pressure of 0 to 5 in. WC. Accuracy shall be +/- 1.0% full scale with a compensated temperature range of 40 to 149 deg F and a maximum working pressure of 250 psig.
      a. Setra model 267, or approved equal.
b. Shall be installed in control panel and piped 2/3 down the duct unless shown otherwise or approved by Owner’s Representative.

Q. Building Static Pressure: Transducer shall utilize a ceramic capacitive sensing element to provide a stable linear output over the specified range of building static pressure. Transducer shall be housed in a wall-mounted enclosure with LCD display. Transducer shall have the following capabilities:

1. Input Power: 24 VAC
2. Output: 0-10 VDC
3. Pressure Range: -0.25 to +0.25 inches w.g.
4. Display: 3-1/2 digit LCD, displaying pressure in inches w.g.
5. Accuracy: +/- 1.0% combined linearity and hysteresis.
6. Temperature Effect: 0.05% / deg C.
7. Zero Drift (1 year): 2.0% max.
9. Operating Environment: 0 to 140 deg F, 90% RH (non-condensing).
10. Fittings: Brass barbs, 1/8” O.D.
12. Outdoor Sensing Tube Enclosure: UV stabilized thermoplastic or aluminum “can” enclosure to shield outdoor pressure sensing tube from wind effects.
13. Transducer shall be Veris Industries Model PXPLX01S, equivalent from Setra, or approved equal.

R. High Static Pressure Limit Switch: Provide pressure high limit switch to open contact in fan circuit to shut down the supply fan when the inlet static pressure rises above the set point. Provide with an adjustable set point, a manual reset button, 2 SPST (normally closed) contacts, and ¼” compression fittings.

1. Kele model AFS-460-DDS, or approved equal.

S. Airflow/Temperature Measurement Devices:

1. Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.
2. The measurement device shall consist of one or more sensor probe assemblies and a single, remotely mounted, microprocessor-based transmitter. Each sensor probe assembly shall contain one or more independently wired sensor housings. The airflow and temperature readings calculated for each sensor housing shall be equally weighted and averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable. Vortex shedding flow meters are not acceptable.
3. All Sensor Probe Assemblies:
   a. Each sensor housing shall be manufactured of a U.L. listed engineered thermoplastic.
   b. Each sensor housing shall utilize two hermetically sealed, bead-in-glass thermistor probes to determine airflow rate and ambient temperature. Devices that use “chip” or diode case type thermistors are unacceptable. Device that do not have two (2) thermistors in each sensor housing are not acceptable.
   c. Each sensor housing shall be calibrated at a minimum of 16 airflow rates and have an accuracy of +/- 2% of reading over the entire operating airflow range. Each sensor housing shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).

1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
   d. The operating temperature range for the sensor probe assembly shall be -20°F to 160°F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).
e. Each temperature sensor shall be calibrated at a minimum of three temperatures and have an accuracy of +/-0.15°F over the entire operating temperature range. Each temperature sensor shall be calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).

f. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g. Each sensor assembly shall not require matching to the transmitter in the field.

h. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.

4. Duct and Plenum Sensor Probe Assemblies:

a. Sensor housings shall be mounted in an extruded, gold anodized, 6063 aluminum tube probe assembly. Thermistor probes shall be mounted in sensor housings using a waterproof marine grade epoxy resin. All wires within the aluminum tube shall be Kynar coated.

b. The number of sensor housings provided for each location shall be as follows:

<table>
<thead>
<tr>
<th>Area (sq. ft.)</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>4</td>
</tr>
<tr>
<td>2 to &lt;4</td>
<td>6</td>
</tr>
<tr>
<td>4 to &lt;8</td>
<td>8</td>
</tr>
<tr>
<td>8 to &lt;16</td>
<td>12</td>
</tr>
<tr>
<td>&gt;=16</td>
<td>16</td>
</tr>
</tbody>
</table>

c. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

1) Insertion mounted through the side or top of the duct.
2) Internally mounted inside the duct or plenum.
3) Standoff mounted inside the plenum.

d. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5. Fan Inlet Sensor Probe Assemblies:

a. Sensor housings shall be mounted on 304 stainless steel blocks.

b. Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.

c. Mounting feet shall be constructed of 304 stainless steel.

d. The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.

6. Transmitters:

a. The transmitter shall have a 16 character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics. Configuration settings and diagnostics shall be accessed through a pushbutton interface on the main circuit board. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.

b. The transmitter shall be capable of independently monitoring and averaging up to 16 individual airflow and temperature readings. The transmitter shall be capable of displaying the airflow and temperature readings of individual sensors on the LCD display.

c. The transmitter shall have a power switch and operation on 24 VDC (isolation not required). The transmitter shall use a switching power supply fused and protected from transients and power surges.
d. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

e. The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be protected from weather and water.

f. The transmitter shall be capable of communicating with the host controls using one of the following interface options:

1) Linear Analog Output Signal: Field selectable, fuse protected and isolated, 0-10 VDC and 4-20 mA (4-wire).
2) RS-485: Field selectable BACnet-MS/TP, ModBus-RTU and Johnson Controls N2 Bus.
3) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, ModBus-TCP and TCP/IP.
4) LonWorks Free Topology.

g. The transmitter shall have an infra-red interface capable of downloading individual sensor airflow and temperature data or uploading transmitter configuration data to a handheld PDA (Palm or Microsoft Pocket PC operating systems).

7. The measuring device shall be UL listed as an entire assembly.

8. The manufacturer’s authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer’s placement requirements.

9. Manufacturer:

a. Primary, flow elements, sensors, meters and transducers shall be EBTRON, Inc. Model GTx116-P and GTx116-F or approved equal.

b. The naming of any manufacturer does not automatically constitute acceptance of this standard product nor waive their responsibility to comply totally with all requirements of the proceeding specification.

T. Electrical Requirements: Provide electric-pneumatic switches, electrical devices, and relays that are UL-listed and of type which meet current and voltage characteristics of the project. All devices shall be of industrial commercial grade or better. Residential types will be rejected.


2. Relays: Relays shall have a LED status indicator, voltage transient suppression. Closed-Open-Auto switch, plastic enclosure, and color coded wires. Kele model RIBU1C or approved equal.

U. Magnetic Flowmeter for Chilled Water, Heating Hot Water and Make Up Water:

1. The Magnetic Flowmeter flow tube and computer/transducer shall come as a complete system assembled by a single manufacturer. The flowmeter shall be suitable for use in the accurate measurement of chilled water flow, Cooling Tower Water fl, or Make Up water flow for process control and/or utility metering, in a mechanical room environment, with a Johnson Controls EMCS system.

2. The flowmeter shall consist of a pulsed DC electromagnetic coil incorporating Faraday’s Law utilizing the flowing water as the conductor. The flowmeter shall provide proper grounding for use in Schedule 40 steel pipe, Schedule 10S stainless steel pipe, or copper pipe as application requires.

3. The flowmeter element should be sized to maintain maximum accuracy over the flow range of the application while keeping flow tube velocity below 15 fps at max flow. The flowmeter element shall be the flow tube, spool piece type with a non-conductive lining and no intrusions into the flow path. The flowmeter flow tube shall be suitable for direct mounting to standard ANSI flanges.

4. The flowmeter shall have a local LCD display that indicates flow in GPM and/or total gallons from the totalizer. The flowmeter shall be programmable/configurable via local push buttons. The flowmeter computer/transducer shall be remote mounted. The flow tube shall have a direct mounted junction box for wiring connections.
5. The flowmeter shall have the capability to be calibrated in situ to verify proper operation and accuracies.
6. The flowmeter shall also meet the following specifications:
   a. Measure bi-directional flow.
   b. Zero-point stability.
   c. Flow tube can withstand a full vacuum on an intermittent basis.
   d. Normal obstructions, partially opened valves, 90° or 45° elbows, and pump discharges shall require no more than 5 pipe diameters upstream and 3 pipe diameters downstream of straight run for specified performance.
   e. Auto-restart after electrodes have lost wetness.
   f. Computer/transducers shall be interchangeable to multiple flow tubes without affecting the published accuracies of the meter.
   g. Computer/transducer internal electronic components, including power supply and output boards, shall be field interchangeable/exchangeable.
   h. Calibration: NIST Traceable, certificate provided with each meter.
   i. Electrode Pressure Rating: Equivalent to flow tube flange rating.
   j. Minimum Conductivity: 5 S/cm for fluid to be measured.
   k. Transmitter Ambient Temp.: 122°F.
   l. Flow Tube Process Temp.: 32°F to 140°F for chilled water applications.
   m. Flow Tube Process Temp.: 32°F to 140°F for make up water applications.
   n. Flow Tube Process Temp.: 32°F to 311°F for hot or dual water applications.
   o. Flow Range: +/- 0 to 30 fps.
   p. Accuracy (velocity <= 1.0 fps): +/- 0.5% of reading or +/- 0.005 fps.
   q. Accuracy (velocity > 1.0 fps): +/- 0.5% of reading.
   r. Analog Output: 4-20 mA, linear to flow in GPM.
   s. Analog Output Accuracy: +/- 0.05% of span.
   t. Repeatability: +/- 0.1%.
   u. Stability: +/- 0.1%.
   v. Ambient Temperature Effect: <1% per 100°F.
   w. Vibration Effect: 0.1% (remote mounted transducer).
   x. Low Flow Cutoff: Settable to 0.04 fps or lower.
   y. Low Flow Cutoff Analog Output: Analog output shall be 4.0 mA at flows below the low cutoff.
   z. Humidity Limits: 5-90% RH.
   aa. Power Supply: 115 VAC.
   ee. Flanges: Carbon steel, ANSI Class 150#.
   ff. Electrodes: Corrosion resistant Alloy C.
   gg. Cable Length: As required per plans.
   hh. Cable shall be capable of empty pipe detection.
   ii. All cable shall be provided by the meter manufacturer.

7. The flowmeter shall be Siemens Magflo Mag 6000 with Mag 5100W or approved equal.
8. Bids/Submittals: All bids and/or submittals must include published specifications, specific model number configurations, and operation and maintenance manuals.
9. Warranty: All parts and components as needed for the specified operation and performance shall be covered under warranty for a period of not less than two years.

V. Steam Swirl Flow Meter:
1. The University of Missouri Columbia has standardized on FSS Swirl Flowmeters as manufactured by ABB Inc., Warminster, PA and Supertrol II flow computers as manufactured by KEP Inc., Eaton Town, NJ. Substitutes will not be accepted.
2. As these meters will be used to measure building steam usage for utility billing purposes, the meter shall be carefully sized considering the design of the building envelope, HVAC and process equipment, projected building utilization and diversification. Consultant is to provide Project
Manager with GSF of facility and a steam usage estimate. All capacities and selections must be verified with ABB and approved by the Project Manager before completing final selection.

3. Steam Meter:
   a. Meter shall be Swirl Flowmeter Model FSS430Y0R1F0(____)R0A1A1B1H5L2SPOR5TC1M5. No substitutions accepted.

4. Flow Computer:
   a. KEP Flow computer model ES7490O1(3-MOD-IP)P with enclosure model MS811NEMASTAX1HT. No substitutions accepted.

5. Pressure Transmitter:
   a. ABB Model 261GSDKBNS1 pressure transmitter or approved equal. Pressure range 0-145 psig. Process temperature range of -58 to 248 °F. ½” NPT process connection. Pressure transmitter shall have ½” pigtail siphon and ½” forged steel gate valves before and after installed pigtail siphon.

6. RTD:
   a. ABB Model V10186-LT2T (____) 3S3A10 or approved equal. RTD assembly shall include a spring loaded, three-wire platinum 100 ohm RTD. Aluminum connection head, 316 stainless steel union and nipple inserted into a 316 stainless steel thermowell. Process connection shall be ¾” NPT.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details shown on drawings.

B. Raceway: Raceway is to be installed in accordance with the National Electric Code. Use of flexible metal conduit or liquidtight flexible conduit is limited to 36” to connect from EMT to devices subject to movement. Flexible raceway is not to be used to compensate for misalignment of raceway during installation.

C. Control Wiring: Install control wiring in raceway, without splices between terminal points, color-coded. Install in a neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.

1. Install circuits over 25-volt with color-coded No. 12 stranded wire.
2. Install electronic circuits and circuits under 25-volts with color-coded No. 18 stranded twisted shielded pair type conductor.
3. N2 communications bus wire shall be 18 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, described as 18-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.
   a. Metastat wiring shall be minimum 20 AWG, plenum rated, stranded, 8 conductor stranded wire.
4. FC communications bus wire shall be 22 AWG, plenum rated, stranded twisted shielded, 3 conductor, with blue outer casing, described as 22-03 OAS STR PLNM NEON BLU JK distributed by Windy City Wire, constructed by Cable-Tek, or approved equivalent.
a. Network sensor wiring (SA Bus) shall be 22 gauge plenum rated stranded twisted wire, 4 conductor.

5. All control wiring at control panel shall be tagged and labeled during installation to assist owner in making termination connections at control panel. Label all control wires per bid documents.

D. All low voltages electrical wiring shall be run as follows:

1. Route electrical wiring on concealed spaces and mechanical rooms whenever possible.
2. Provide EMT conduit and fittings in mechanical rooms and where indicated on drawings.
3. Low voltage electrical wiring routed above acoustical ceiling is not required to be in conduit, but wire must be plenum rated, but wire must be plenum rated and properly supported to building structure.
4. Provide surface raceway, fittings and boxes in finished areas where wiring cannot be run in concealed spaces. Route on ceiling or along walls as close to ceiling as possible. Run raceway parallel to walls. Diagonal runs are not permitted. Paint raceway and fittings to match existing conditions. Patch/repair/paint any exposed wall penetrations to match existing conditions.

E. All devices shall be mounted appropriately for the intended service and location.

1. Adjustable thermostats shall be provided with base and covers in occupied areas and mounted 48” above finished floor to the top of the device. Tubing and/or wiring shall be concealed within the wall up to the ceiling where ever possible. Surface raceway may only be used with approval of Owners Representative. Wall mounted sensors such as CO₂, RH, and non-adjustable temperature sensors shall be mounted 54” above finished floor. Duct mounted sensors shall be provided with mounting brackets to accommodate insulation. Mounting clips for capillary tubes for averaging sensors are required.
2. All control devices shall be tagged and labeled for future identification and servicing of control system.
3. Preheat and mixed air discharge sensors must be of adequate length and installed with capillary tube horizontally traversing face of coil, covering entire coil every 24 inches bottom to top.
4. All field devices must be accessible or access panels must be installed.

F. Install magnehelic pressure gage across each air handling unit filter bank. If the air handling unit has a prefilter and a final filter, two magnehelic pressure gages are required.

G. Steam Swirl Flow Meter:

1. Installation of steam meter and associated wiring, pressure transmitter and RTD assembly, shall be in strict accordance with manufacturer’s printed instructions and recommendations, applicable BOCA requirements, and as detailed on drawings.
2. Swirl meters shall be installed in a horizontal position with a minimum of five straight pipe diameters upstream and five straight pipe diameters downstream. Meter head shall be installed in the horizontal place or facing down as detailed in instructions for high temperature applications.
3. Swirl meter shall be installed prior to all steam pressure reducing valves and modulating control valves.
4. Swirl meter transmitter shall be located in an accessible location to permit ease of reading and service of transmitter.
5. Low-voltage wiring to the steam meter and flow computer shall be made in coordination with Owner’s Representative as shown in 336333 ABB Swirl Meter Wiring Diagram drawing.

3.2 ADJUSTING AND START-UP

A. Start-Up: Temporary control of air handling units shall be allowed only if approved by the owner’s representative to protect finishes, etc., AHUs may be run using caution with temporary controls installed by contractor early in the startup process. All safeties including a smoke detector for shut down must be operational. Come means of discharge air control shall be utilized and provided by the contractor such as a temporary sensor and controller located and installed by the Contractor.
B. The start-up, testing, and adjusting of pneumatic and digital control systems will be conducted by Owner. Once all items are completed by the Contractor for each system, Contractor shall allow time in the construction schedule for Owner to complete commissioning of controls before project substantial completion. This task should be included in the original schedule and updated to include the allotted time necessary to complete it. As a minimum, the following items are required to be completed by the Contractor for Owner to begin controls.

1. Process Control Network:
   a. The control boards and enclosures need to be installed in the mechanical rooms.
   b. The fiber optic conduit and box for the process control network needs to be installed. Once in place, Owner needs to be contacted so the length of the Owner-provided fiber cable can be determined and ordered, if required. Coordinate with Owner to schedule the pull in and termination of the fiber cable. Power should be in place at that time. (Fiber for the process control network is required to allow metering of utilities prior to turn on).

2. Heating System:
   a. Pumps, heat exchangers, steam pressure reducing station, piping, control valves, steam and/or hot water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The housekeeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, steam regulators set to required pressure, condensate pumps operational, heating system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.

3. Cooling System:
   a. Pumps, heat exchangers, piping, control valves, chilled water meter, feeder conduit and wire, VFDs, control panels and control wiring installed in the mechanical room. The housekeeping pads must be poured before pump operation. All must be in place in working order (pumps aligned, VFDs set up by vendor, motors checked for rotation, cooling system ready to circulate (all piping pressure tested, flushed, and insulated) with differential pressure sensors in place.

4. Steam Swirl Flow Meter:
   a. The final wiring connections to the swirl meter, pressure transmitter and RTD will be made by Owner.
   b. Steam will not be turned on by Owner until the steam meter is fully installed and operating satisfactorily and the downstream steam piping is successfully leak tested and secure.
   c. Only Owner personnel will be authorized to turn steam service on or off.

5. Exhaust and Energy Recovery Systems:
   a. Exhaust fans need to be operational and under control before labs can be commissioned.

6. Some balance work can be done alongside the control work as long as areas are mostly complete and all diffusers are in place.

3.3 CLOSEOUT PROCEDURES

A. Contractor shall provide complete diagrams of the control system including flow diagrams with each control device labeled, a diagram showing the termination connections, and an explanation of the control sequence. The diagram and sequences shall be framed and protected by glass and mounted next to controller.
B. Contractor shall provide as-built diagram of network bus routing listing all devices on bus, once wiring is complete prior to scope completion.

END OF SECTION 230900
SECTION 232113 - HYDRONIC 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.

1.2 SUMMARY

A. This Section includes piping systems for hot water heating and chilled water cooling systems; makeup water for these systems; blow-down drain lines; and condensate drain piping. Piping materials and equipment specified in this Section include the following:

1. Pipes, fittings, and specialties.
2. Special-duty valves.
3. Hydronic specialties.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. General Sections "Firestopping" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
2. General Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
3. Division 23 Section "Basic Mechanical Materials and Methods" for general piping materials and installation methods.
4. Division 23 Section "Valves" for gate, globe, ball, butterfly, and check valves.
5. Division 23 Section "Meters and Gages" for thermometers, flow meters, and pressure gages.
6. Division 23 Section "Hangers and Supports" for pipe supports.
7. Division 23 Section "Mechanical Identification" for labeling and identifying hydronic systems.
8. Division 23 Section "HVAC Pumps" for pumps, motors, and accessories for hydronic systems.
10. Division 23 Section "Testing, Adjusting, and Balancing" for hydronic system adjusting and balancing.

1.3 SYSTEM DESCRIPTION

A. Hydronic systems are chilled water and hot water heating, forced, recirculating systems.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, accessories, and installation instructions for each hydronic specialty and special-duty valve specified.

1. Submit flow and pressure drop curves for balancing valves, based on manufacturer's testing.
C. Shop Drawings detailing pipe anchors, special pipe support assemblies, alignment guides, and expansion joints and loops.

D. Field test reports indicating and interpreting test results for compliance with performance requirements specified in Part 3 of this Section.

E. Maintenance data for hydronic specialties and special-duty valves to include in the operation and maintenance manual specified in Division 1.

1.5 QUALITY ASSURANCE

A. ASME Compliance: Comply with the following provisions:

1. ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

2. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

3. Welding Standards: Qualify welding processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."

1.6 COORDINATION

A. Coordinate layout and installation of piping with equipment and with other installations.

B. Coordinate pipe sleeve installation for foundation wall penetrations.

C. Coordinate pipe fitting pressure classes with products specified in related Sections.

D. Coordinate size and location of concrete housekeeping pads. Cast anchor-bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

E. Coordinate installation of pipe sleeves for penetrations in exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Firestopping" for fire and smoke wall and floor assemblies.

1.7 EXTRA MATERIALS

A. Maintenance Stock: Furnish a sufficient quantity of chemicals for initial system startup and for preventive maintenance for one year from Substantial Completion.

PART 2 - PRODUCT

2.1 MANUFACTURERS

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

1. Balancing Valves:

   a. Armstrong Pumps, Inc.
   b. Bell & Gossett.
   c. Nibco
   d. Tour & Anderson.
2. Pressure-Reducing Valves (Make-up water for hot and chilled water systems):
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Grinnell Supply Sales Co.
   d. ITT Hoffman; ITT Fluid Handling Div.
   e. Bell & Gossett.

3. Safety Relief Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Conbraco Industries, Inc.
   d. ITT Fluid Technology Corp.; ITT McDonnell & Miller.
   e. Bell & Gossett.

4. Compression Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT Fluid Technology Corp.; ITT Bell & Gossett.
   d. Taco, Inc.
   e. Bell & Gossett.

5. Air/Dirt Separators:
   a. Spirotherm.

6. Air Purgers:
   a. Amtrol.
   b. Bell & Gossett.
   c. Taco.

7. Suction Diffusers:
   a. Bell & Gossett.
   b. Armstrong.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3 "Pipe Applications" Article for identifying where the following materials are used.

B. Steel Pipe, 2-1/2-Inch NPS (DN50) and Smaller: All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

C. Steel Pipe, 3- to 12-Inch NPS (DN65 to DN300): All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

1. Steel Pipe Nipples: ASTM A 106 or ASTM A 53, Schedule 40, carbon steel, seamless for 2-inch NPS (DN50) and smaller and electric-resistance welded for 2-1/2-inch NPS (DN65) and larger.

D. Steel pipe, 14- to 18-inch NPS (DN 350 to DN 450): All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

E. Contractor may, at his option, use Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) for chilled and hot water heating piping 2-1/2" and below.
2.3 FITTINGS

A. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125.

B. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

C. Cast-Iron Threaded Flanges: ASME B16.1, Classes 125 and 250; raised ground face, bolt holes spot faced.

D. Wrought-Steel Fittings: ASTM A 234 (ASTM A 234M), Standard Weight.

E. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

2. End Connections: Butt welding.
3. Facings: Cast iron with flat faced flanges, 125 lb. valves.

F. Wrought-Copper Fittings: ASME B16.22.

G. Wrought-Copper Unions: ASME B16.22.

2.4 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

B. Brazing Filler Metals: AWS A5.8, Classification Bag 1 (silver).

C. Welding Materials: Comply with Section II, Part C of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

D. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15 Section "Valves."

B. Refer to Part 3 "Valve Applications" Article for specific uses and applications for each valve specified.

C. Balancing Valves (2" and Under): 200-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature, bronze body, balancing valve with combination shutoff capability. Balancing valves shall have memory stop and pressure/temperature metering taps, with wheel handle and indicator. Furnish with portable test kit. Quarter turn valves will not be acceptable.

D. Pressure-Reducing Valves: Diaphragm-operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

E. Safety Relief Valves: Brass or bronze body with brass and rubber, wetted, internal working parts; according to ASME Boiler and Pressure Vessel Code, Section IV. See schedule on drawings for sizes.
2.6 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig (1035-kPa) working pressure, 225 deg F (107 deg C) operating temperature; ½ ball valve.

B. Pre-pressurized Expansion Tanks: Welded carbon steel for 125-psig (860-kPa) working pressure, 240 deg F (191 deg C) maximum operating temperature. Provide taps for tank and drain fitting; tanks shall be vertical or horizontal as indicated on drawings. Tanks shall be furnished with heavy duty butyl diaphragm and charging valve. Factory test tank with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C. Air & Dirt Separator: Furnish and install coalescing type air eliminator and dirt separator on the heating and chilled water systems. Pipe size is not a factor and all units shall be selected at the point of peak efficiency per the manufacturer's recommendations. All combination units shall be fabricated steel, rated for 150 psig working pressure with entering velocities not to exceed 4 feet per second at specified GPM. Units specifically designed for high velocity systems may have an entering velocity of up to 10 feet per second. Units shall include an internal bundle filling the entire vessel to suppress turbulence and provide high efficiency. The bundle must consist of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminant from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valve side top to flush floating dirt and liquid and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connection an equal distance for dirt separation. Air eliminators shall be capable of removing 100% of the free air, 100% of the entrained air and up to 99.6% of the dissolved air in the system fluid. Dirt separator shall remove at least 80% of all particle 30 micron and larger within 100 passes. Separator shall be furnished with removable bottom. Equipment shall be Spirotherm or approved equal, type "VDT".

D. Balancing Valves (2-1/2" and Larger): 175 psi working pressure, 250 deg F maximum operating temperature, heavy-duty, cast iron flanged, valves 2-1/2-3" size shall have brass ball with glass and carbon filled TFE seat rings. Valves 4" to 8" shall be fitted with bronze seat, replaceable bronze disc with EPDM seal insert and stainless steel stem. Valve shall have pre-set capability.

E. Y-Pattern Strainers: 125-psig (860-kPa) working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for 2-1/2-inch NPS (DN65) and larger, threaded connections for 2-inch NPS (DN50) and smaller, bolted cover, perforated Type 304 stainless-steel basket, and bottom drain connection.

F. Basket Strainers: 125-psig (860-kPa) working pressure; high-tensile cast-iron body (ASTM A 126, Class B), flanged end connections, bolted cover, perforated Type 304 stainless-steel basket, and bottom drain connection.

G. Automatic and Quick-fill Station: Furnish and install for hot water system, 1/2" Bell & Gossett or Taco relief valve on hot water system, set for 100 p.s.i. Extend line from each relief valve to nearest floor drain and turn down. Provide 1/2" Bell & Gossett or Taco pressure regulating valve with strainer for each system set to maintain not less than 10 p.s.i. at high point in each piping system. Mount each valve and strainer assembly approximately 36" above floor in accessible location. Provide 4-1/2" pressure gauge with globe valve on low pressure side of each regulating valve.

H. Suction Diffuser: Angle pattern 175-psig (1204-kPa) pressure rating, cast-iron body and end cap, pump inlet fitting; with bronze startup and stainless-steel permanent strainers; stainless-steel straightening vanes; drain plug; and factory-fabricated support.
PART 3 - EXECUTION

3.1 PIPE APPLICATIONS

A. Hot Water and Chilled Water: 2-1/2"-inch NPS (DN50) and Smaller: Steel pipe with threaded joints.
B. Hot Water and Chilled Water: 3-Inch NPS (DN65) and Larger: Steel pipe with welded and flanged joints.
C. Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
   1. Shutoff Duty: Use ball (up to 2-1/2") and butterfly valves (3" and larger).
B. Install shutoff-duty valves at each branch connection to supply mains, at supply connections to each piece of equipment, and elsewhere as indicated.
C. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.
D. Install center-guided check valves on each pump discharge and elsewhere as required to control flow direction.
E. Install safety relief valves on hot water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements.
F. Install pressure-reducing valves set in quick and automatic fill system on hot water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

A. Install piping according to Division 23 Section "Common Work Results for HVAC."
B. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
C. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4-inch NPS ball valve, and short 3/4-inch NPS threaded nipple and cap. Install manual air vents at all high points.
D. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
E. Install branch connections to mains using tee fittings in main with takeoff out bottom of main, except for up-feed risers with takeoff out top of main line.
F. Install unions in pipes 2-inch NPS and smaller, adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated. Unions are not required at flanged connections.
G. Install flanges on valves, apparatus, and equipment having 2-1/2-inch NPS and larger connections.
H. Install strainers on supply side of each control valve, pressure-reducing valve, pressure-regulating valve, solenoid valve, in-line pump, and elsewhere as indicated. Install 3/4-inch NPS nipple and ball valve in blow-down connection of strainers 2-inch NPS and larger.

I. Provide temporary caps and covers over piping to prevent collection of dirt and debris during construction.

J. Anchor piping as required to ensure proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. General: Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Conform to requirements below for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) in length.
   2. Adjustable roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal runs 20 feet (6 m) or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
   7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
   8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
   9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.
  10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.
3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in system, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install combination air/dirt separator in hot water pump suction lines. Run piping to compression tank with a 2 percent upward slope toward tank. Install blow-down piping with ball valve; extend to nearest drain.

C. Install shot-type chemical feeder in hot water system where indicated; in upright position with top of funnel not more than 48 inches (1200 mm) above floor. Install feeder with connections on each side of the hot water pump discharge valve. Pipe drain, with ball valve, to nearest equipment drain.

3.7 FIELD QUALITY CONTROL

A. Testing Preparation: Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Flush system with clean water. Clean strainers.
   4. Isolate equipment that is not subjected to test pressure from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Flanged joints where blinds are inserted to isolate equipment need not be tested.
   5. Install relief valve set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Testing: Test hydronic piping as follows:
   1. Acceptance Testing: Perform hydrostatic tests on the hydronic piping in accordance with ANSI B31.9 and as follows:
      2. Notify Owner’s Representative 24 hours before required testing. All tests shall be conducted in the presence of the Owner’s Representative.
      3. Flush system with clean water. Clean strainers.
      4. Minimum test pressure shall be 100 PSIG.
      5. Pressure gauge shall be min. 4" dia. Face, 0-160 PSIG, and shall be calibrated within 1 year of test date.
      6. Test pressure shall be held for 1 hour.
      7. Prepare reports for all tests and required corrective action.
      8. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
      9. System shall be operated for a minimum of 24 hours to demonstrate to the Owner’s Representative that system is complete and operational.

3.8 ADJUSTING AND CLEANING

A. After completing system installation, including outlet fittings and devices, inspect finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Flush hydronic piping systems with clean water. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

C. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.
3.9 COMMISSIONING

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that system is completely full of water.

C. Perform these steps before operating the system:

1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Lubricate motors and bearings.

END OF SECTION 232113
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 categories of HVAC pumps for hydronic systems:

1. End-suction pumps.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 23 Section "Meters and Gages for HVAC Piping" for thermometers and pressure gages, connector plugs, and devices.
2. Division 23 Section "Common Motor Requirements for HVAC Equipment" for pump motors.
3. Division 23 Section "Vibration Control" for inertia bases, isolation pads, spring supports, spring hangers, and flexible pipe connectors.
4. Division 23 Section "Instrumentation and Controls for HVAC" for interlock wiring between pumps, and between pumps and field-installed control devices.
5. Division 26 Sections for power-supply wiring, field-installed disconnects, required electrical devices, and motor controllers.

1.3 PERFORMANCE REQUIREMENTS

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data including certified performance curves and rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.

C. Shop drawings showing pump layout and connections. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.

D. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating between manufacturer-installed wiring and field-installed wiring.

E. Product certificates signed by manufacturers of pumps, certifying accuracies under specified operating conditions and compliance with specified requirements.
F. Maintenance data for pumps to include in the operation and maintenance manual specified in Division 1. Include startup instructions.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9 "Building Services Piping" for piping materials and installation.
2. Hydraulic Institute's "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.
3. UL 778 "Standard for Motor Operated Water Pumps" for construction requirements. Include UL listing and labeling.
4. NEMA MG 1 "Standard for Motors and Generators" for electric motors. Include NEMA listing and labeling.
5. NFPA 70 "National Electrical Code" for electrical components and installation.

B. Single-Source Responsibility: Obtain each category of pumps from 1 source and by a single manufacturer.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. Extended Storage Longer than 5 Days: Dry internal parts with hot air or vacuum-producing device. Coat internal parts with light oil, kerosene, or antifreeze after drying. Dismantle bearings and couplings; dry; coat with acid-free, heavy oil; tag; and store in dry location.

E. Comply with pump manufacturer's rigging instructions.

PART 2 - PRODUCT

2.1 MANUFACTURERS

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

1. Separately Coupled, Vertical, In-Line Centrifugal Pumps:
   b. ITT Fluid Technology Corp.; Bell & Gossett Div.
   c. Peerless.

2.2 PUMPS, GENERAL

A. General: Factory assembled and tested.
B. Types, Sizes, Capacities, and Characteristics: As indicated.

C. Factory Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

D. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

2.3 SEPARATELY COUPLED, VERTICAL, IN-LINE CENTRIFUGAL PUMPS

A. Description:

1. Single stage, single suction type, vertical inline design pump with integrated controls.
   a. Seals: Split-coupled serviceable without disturbing motor or piping connections.
   b. Include casing drain plug and ¼ inch suction and discharge ports.

B. Design Criteria:

1. Design pump for variable volume applications and selected for hydraulic design conditions and minimum pressure.
2. Meet or exceed requirements of ASHRAE 90.1

C. Pump Construction:

1. Casing: Cast iron to ASTM A48, Class 301.
   a. Test casing to 150% maximum working pressure.
   b. Ensure casing is radially split to allow for removal of rotating element without disturbing pipe connections.
   c. Drill and tap casing for gauge ports on both suction and discharge connections.
   d. Drill and tap casing on bottom for drain port.

2. Impeller: To ASTM B584, bronze, fully enclosed and dynamically balanced to ANSI G6.3 and fitted to shaft with key.
   a. Use two-plane balancing when installed impeller diameter is less than 6 times impeller width.

3. Pump Shafts:
   a. Split Coupled: Stainless steel to ASTM A582/A582M, Grade 416.
   b. Shaft Sleeves: Stainless steel to ASTM A582/A582M, Grade 416.

4. Coupling: Rigid spacer type, high tensile aluminum.
   a. Design coupling for easy removal on site to reveal space between pump and motor shaft.
      1) Ensure revealed space is sufficient for removal of mechanical seal components without disturbing pump or motor.
   b. Include coupling guard.
   c. Include lower seal chamber throttle bushing to ensure seals maintain positive cooling and lubrication.
5. Flanges: To ANSI/ASME B16.5, Class 125.
8. Mechanical Seal: Shall be stainless steel multi-spring outside balanced type with Vitron secondary seal, carbon rotating face and silicon carbide stationary seat. Provide a 316 stainless steel gland plate. Provide factory installed flush line with manual vent to purge air prior to pump start-up. Inside seal is not acceptable.

D. Motor: Single speed, with ball bearings, unless otherwise indicated; rigidly mounted to pump casing with lifting eye and supporting lugs in motor enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment".

E. Capacities and Characteristics as scheduled on drawings:

2.4 PUMP SPECIALTY FITTINGS

A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and 50% min. open area, 5/32" perforations, stainless steel permanent strainers; bronze or stainless steel straightening vanes; drain plug and factory-fabricated support.

2.5 GENERAL-DUTY VALVES

A. Refer to Division 23 Section "Valves" for general-duty gate, ball, butterfly, globe, and check valves.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting performance of pumps.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 CONCRETE

A. Install concrete inertia bases and concrete pads for pumps. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 23 Section "Basic Mechanical Materials and Methods."

3.3 INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that piping is not supported by pumps.
D. Set base-mounted pumps on concrete inertia bases. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.

2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."

D. Alignment Tolerances: According to manufacturer's recommendations.

3.5 CONNECTIONS

A. General: Install shutoff valve and strainer on pump suction and cushion check valve and cutoff valve on pump discharge, except where other arrangement is indicated.

B. Connect piping to pumps as indicated. Install valves that are the same size as piping connecting to pumps.

C. Install suction and discharge pipe sizes equal to or greater than the diameter of pump nozzles, sizes as noted on drawings.

D. Install thermometers where indicated.

E. Install pressure gages on pump suction and discharge. Install at integral pressure gage tappings.

F. Install temperature and pressure gage connector plugs in suction and discharge piping around each pump.

G. Install electrical connections for power, controls, and devices.

H. Electrical power and control wiring and connections are specified in Division 26 Sections.

3.6 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Clean strainers.

C. Set pump controls.
3.7 COMMISSIONING

A. Final Checks Before Startup: Perform the following preventive maintenance operations and checks before startup:

1. Lubricate bearings.
2. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.
3. Check that pumps are free to rotate by hand. Pumps for handling hot liquids shall be free to rotate with pump hot and cold. Do not operate pump if it is bound or even drags slightly until cause of trouble is determined and corrected.
4. Check that pump controls are correct for required application.

B. Starting procedure for pumps with shutoff power not exceeding safe motor power:

1. Prime pumps, opening suction valve, closing drains, and preparing pumps for operation.
2. Open cooling water supply valves in cooling water supply to bearings, where applicable.
3. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.
4. Open circulating line valves if pumps should not be operated against dead shutoff.
5. Start motors.
6. Open discharge valves slowly.
7. Check general mechanical operation of pumps and motors.
8. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

B. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except that discharge valves are opened sometime before motors are started.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION 232123
SECTION 232213 - STEAM AND CONDENSATE HEATING 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.

1.2 SUMMARY

A. This Section includes steam and condensate piping and specialties for building HVAC and domestic water heating systems, including pipes, fittings, special-duty valves, and specialties.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 23 Section "Basic Mechanical Materials and Methods" for general piping materials and installation methods.
2. Division 23 Section "Valves" for general-duty gate, globe, ball, and check valves applicable to this Section.
3. Division 23 Section "Meters and Gages" for thermometers, flow meters, and pressure and vacuum gages.
4. Division 23 Section "Hangers and Supports" for pipe supports.
5. Division 23 Section "Mechanical Identification" for labeling and identifying steam and condensate piping systems.
6. Division 23 Section "Instrumentation and Control for HVAC" for temperature-control valves and sensors.

1.3 SYSTEM DESCRIPTION

A. Steam and condensate for this Project is obtained from the campus existing steam and condensate distribution system. Medium pressure steam will be extended from the campus distribution system into the new building. Steam-to-Hot water heat exchangers will be utilized for generating heating hot water for the new building.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data including rated capacities where applicable, furnished options and accessories, and installation instructions for safety relief valves, pressure-reducing valves, and steam traps.

C. Shop Drawings detailing cooling pipe assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

D. Maintenance data for steam and condensate specialties and special-duty valves to include in the operation and maintenance manual specified in Division 1.

E. Field test reports indicating and interpreting test results relative to compliance with specified requirements.
1.5 QUALITY ASSURANCE

A. ASME Compliance: Comply with the following provisions:

1. ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
2. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
3. Welding Standards: Qualify welding processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications."

1.6 COORDINATION

A. Coordinate layout and installation of piping and flash tanks with steam and condensate equipment and with other installations.
B. Coordinate pipe sleeve installation for foundation wall penetrations.
C. Coordinate installation of equipment supports, and roof penetrations.
D. Coordinate pipe fitting pressure classes with products specified in related Sections.
E. Coordinate size and location of concrete housekeeping pads. Cast anchor-bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.
F. Coordinate installation of pipe sleeves for penetrations in exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in General Section "Firestopping" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCT

2.1 MANUFACTURERS

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

1. Safety Valves:
   b. Spence Engineering Co., Inc.
2. Pressure-Regulating Valves:
   a. Spence Engineering Co., Inc.
3. Steam Traps:
   b. Mepco.
   c. ITT Hoffman; ITT Fluid Handling Div.
   d. Watson-McDaniel Co.
4. Air Vents and Vacuum Breakers:
b. ITT Hoffman; ITT Fluid Handling Div.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3 pipe application articles for identifying where the following materials are used.

B. Steel Pipe, 2-Inch NPS and Smaller: All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

C. Steel Pipe, 2-1/2- to 12-Inch NPS: All steel pipe shall be ASTM A53, Grade B, Type E. Welded fittings shall be the same material as the pipe.

1. Steel Pipe Nipples: ASTM A 106 or ASTM A 53, Schedules 40 and 80, carbon steel, seamless for 2-inch NPS (DN50) and smaller and electric-resistance welded for 2-1/2-inch NPS (DN65) and larger.

2.3 FITTINGS

A. Malleable-iron fittings: Class 300 type.

B. Schedule 40 fittings: Wrought steel welding type fittings.

2.4 JOINING MATERIALS

A. Welding Materials: Comply with Section II, Part C of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

B. Gasket Material: Flexitaulic or equal, thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

C. Bolting: ASTM A193, Grade B7 alloy steel stud bolts with heavy hex nuts, ASTM A194, Grade 2H.

2.5 VALVES

A. Gate and check valves are specified in Division 23 Section "General Duty Valves for HVAC Piping."

B. Refer to Part 3 "Valve Applications" Article for specific uses and applications for each valve specified.

2.6 SAFETY VALVES

A. Furnish ASME, Underwriters-approved steam relief valve on low side of each medium pressure to low pressure regulating valve. Relief valves shall be set to relieve at 15 p.s.i.

B. Connect each relief valve with vent pipe, extend vent pipe and terminate as indicated on drawings. Provide float and thermostatic drip trap for each relief valve, extend drip line from drip trap and end over floor drain.

C. Relief valves shall have enclosed springs with side outlets. Valves 2" and below shall be Kunkle Fig. No. 6010 or equivalent Longergan, Consolidated or approved equal manufacture, bronze, screwed, with stainless steel springs and seats. Valves 2-1/2" and larger shall be Kunkle Fig. No. 252 or equivalent Longergan, Consolidated or approved equal manufacture, iron body, bronze fitted, stainless steel springs and seat, flanged, side outlet. Submit shop drawings of all valves for approval of Architect.
2.7 PRESSURE-REGULATING VALVES

A. All pressure regulating valves shall have capacity and pressure range shown on drawings. Valves 2-1/2" and above shall be equipped with flanged ends, 2" and below with screwed ends and unions. Provide uniflex gasketed unions on screwed valve PRV stations. Valves shall be designed for working pressure of 125 p.s.i. Each valve shall be installed with 3-valve bypass.

B. Valves shall be Spence pilot type, single seat pressure reducing valves with semi-steel bodies, stainless steel trim, stainless steel diaphragms, guide bushings, springs, seats and stems. Provide steam type strainer on inlet to each valve. Install valves as recommended by valve manufacturer. Provide valved control line connection installed to meet requirements of valve manufacturer. Provide external adjusting stem on valves if required for proper operation on light load. Valves shall be designed for quiet operation, and valve manufacturer shall be responsible for selecting proper size for quiet operation. Provide muffling orifice for each PRV.

C. Furnish and install 4-1/2" pressure gauge with brass cutoff cock and siphon on each side of each pressure reducing valve with operating pressure at the midrange of the gauge. Gauges shall be of type hereinbefore specified. Submit shop drawings of pressure regulating valves for Architect's approval. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

D. Contractor shall provide Spence Type E full port regulator with both a Type D5 pilot for pressure control and a Type VH210 for temperature control. Pilot valves will be mounted in series with the VH210 pilot (first) feeding the Type D5 pilot (second) which in turn operates the main valve. The VH210 temperature control pilot shall accept a 0-10Vdc signal from the building automation system for temperature control.

2.8 FLOAT AND THERMOSTATIC TRAPS (LOW PRESSURE STEAM)

A. Furnish and install 250 lb. class, cast iron, heavy duty combination float and thermostatic traps at all points where steam drip traps are required or shown on low pressure steam return piping for main drips, humidifiers, coils, unit heaters and miscellaneous equipment. Minimum size trap acceptable shall have a capacity base on SHEMA rating of 100# per hour with 1/2# differential. Furnish and install 15 degree check valve in 1/2" line around steam trap on each steam coil with automatic control valve for vacuum breaker. Traps with built-in vacuum breakers will not be acceptable. Note: All coils handling all outside air shall be equipped with not less than two (2) traps full capacity of each coil. Set traps on all outside air coils at least 16" below coil outlet.

B. Floats in all traps shall be made of stainless steel. All seats shall be stainless steel.

C. Each float and thermostatic trap shall be equipped with dirt pocket and external angle type strainer ahead of each trap, full size of trap opening. Each trap shall have union on trap inlet and union and shutoff valve on trap outlet unless shown otherwise on drawings. Mount float and thermostatic traps at least 8" below coil outlet.

2.9 INVERTED BUCKET TRAPS (MEDIUM PRESSURE STEAM)

A. All low points in 60 psi. steam piping and all points where condensate lifts are required shall be dripped through cast iron inverted bucket traps. All bucket traps shall be provided with shutoff valves, unions, integral monitoring device, and external steam type "Y" strainer. Traps shall be designed for 250 lb. class, cast iron. Traps shall be designed to handle the load with 15# differential. Provide check valve on discharge of each trap. Size of traps shown on drawings is minimum; increase size of traps where required to meet above requirements.
2.10 STRAINERS

A. Basket Strainers: Strainers for condensate return pumps shall be Crane, Mueller, Spence or McAlear, basket type with stainless steel water strainers with bolted top, full size of piping served, 800 lb. class water pressure, with valved drain piped and turned down over floor drain or sump. Openings in strainers shall be 1/8" in diameter. Area of openings in strainers shall be at least 3 times area of pipe connection.

B. “Y” Type Strainers: Provide steam strainer ahead of each automatic control valve and steam trap. Steam strainers shall be full size of pipe served, Crane, Mueller, Spence or McAlear "Y" type, complete with perforated stainless steel cylinders, 800 lb. class, with 3/4" pipe extension and shutoff valve for blowing out strainer.

PART 3 - EXECUTION

3.1 PIPE APPLICATIONS INSIDE BUILDING

A. Steam Piping (includes steam vent piping), 2-Inch NPS (DN50) and Smaller: Schedule 40 steel pipe with threaded joints and Class 300 malleable-iron fittings.

B. Steam Piping (includes steam vent piping), 2-1/2- to 12-Inch NPS: Schedule 40 steel pipe with welded joints, Schedule 40 wrought-steel welding fittings, and Class 150 wrought-steel flanges.

C. Condensate Piping, 2-Inch NPS and Smaller: Schedule 80 steel pipe with threaded joints and Class 300 malleable-iron fittings.

D. Condensate Piping, 2-1/2- to 12-Inch NPS: Schedule 80 steel pipe with welded joints.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the valve types as specified in Section 15100.

B. Install shutoff-duty valves at each branch connection to supply mains, at inlet connection to each steam trap, and elsewhere as indicated.

C. Vacuum Breakers Less than 15 psig (100 kPa): Class 150 bronze swing check with composition seat.

D. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

E. Install swing check valves as required to control flow direction and to serve as vacuum breakers, except where noted.

3.3 STEAM-TRAP APPLICATIONS LESS THAN 15 PSIG (100 kPa)

A. Float and Thermostatic Traps: Flash tanks, heat exchangers, and coils.

3.4 STEAM-TRAP APPLICATIONS UP TO 125 PSIG (860 kPa)

A. Inverted Bucket Traps: Steam main and riser drip legs.

B. Traps installed in steam trenches shall be provided with a cooling/storage chamber.
3.5 PIPING INSTALLATIONS

A. Install piping according to Division 23 Section "Common Work Results for HVAC."

B. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4-inch NPS ball valve, and short 3/4-inch NPS threaded nipple and cap.

D. Install steam supply piping at a uniform grade of 0.2 percent downward in direction of flow.

E. Install condensate return piping at a uniform grade of 0.4 percent downward in direction of flow.

F. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

G. Install branch connections to steam mains using 45-degree fittings in main with takeoff out top of main. Use of 90-degree tee fittings is permissible where 45-degree fittings are impractical. Where length of branch takeoff is less than 10 feet, pitch branch line down toward mains at 0.4 percent slope.

H. Install unions or flanges adjacent to each valve, at final connections to each piece of equipment, and elsewhere as indicated.

I. Install strainers on supply side of each control valve, pressure-regulating valve, solenoid valve, traps, and elsewhere as indicated. Install 3/4-inch NPS nipple and ball valve in blow-down connection of strainers 2-inch NPS and larger. Match size of strainer blowoff connection.

J. Anchor piping to ensure proper direction of expansion and contraction.

K. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, control valves, isolation valves, pipe bends, and expansion joints.

1. Size drip legs at vertical risers full size and extend beyond rise. Size drip legs at other locations same diameter as main. Provide 18-inch long drip leg for steam mains smaller than 6-inch NPS. In steam mains 6-inch NPS and larger, provide drip legs 2 pipe sizes smaller than main, but not less than 4-inch NPS.

2. Equip drip legs, dirt pockets, and strainer blow-downs with gate valves to allow removal of dirt and scale.

3. Install steam traps close to drip legs.

L. Do not lift condensate piping that is gravity fed.

3.6 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations close to connected equipment, maximum 48 inches.

1. Unless otherwise indicated, install gate valve, strainer, and union upstream from trap; install union, check valve, and gate valve downstream from trap.

3.7 PRESSURE-REDUCING VALVE INSTALLATIONS

A. Install pressure-reducing valves as required to regulate system pressure, in readily accessible location for maintenance and inspection.

B. Provide bypass between multiple parallel reducing valves, with gate valve equal in size to area of reducing valve seat ring.
C. Install gate valves and unions around each reducing valve. Unions may be omitted for reducing valves with flanged connections.

D. Install pressure gages on low-pressure side of each reducing valve and ahead of shutoff valve, plus one downstream for shutoff valve.

E. Install strainers upstream for each reducing valve.

F. Install safety valves downstream from each reducing valve station.

3.8 SAFETY VALVE INSTALLATIONS

A. Install valves according to ASME B31.1. Pipe discharge to atmosphere outside building, without stop valves. Comply with ASME Boiler and Pressure Vessel Code installation requirements.

3.9 HANGERS AND SUPPORTS

A. General: Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Conform to requirements below for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.
   2. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal runs 20 feet or longer, supported on a trapeze.
   3. Spring hangers to support vertical runs.

C. Install hangers with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 9 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 9 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/2: Maximum span, 12 feet; minimum rod size, 3/8 inch.
   4. NPS 2: Maximum span, 13 feet; minimum rod size, 3/8 inch.
   5. NPS 2-1/2: Maximum span, 14 feet; minimum rod size, 3/8 inch.
   6. NPS 3: Maximum span, 15 feet; minimum rod size, 3/8 inch.
   7. NPS 4: Maximum span, 17 feet; minimum rod size, 1/2 inch.
   8. NPS 6: Maximum span, 21 feet; minimum rod size, 1/2 inch.

D. Support vertical runs at each floor.

3.10 PIPE JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for joint construction requirements for threaded, welded, and flanged joints.

3.11 HEAT EXCHANGER CONNECTIONS

A. Piping size for supply and return shall be minimum size as equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment – offset traps to move out from under the heat exchanger as indicated on the sketch of connections.

C. Set regulating valve for each heat exchanger furnished under temperature control heading.
D. Provide combination float and thermostatic trap on drip from heat exchanger with 1/2" check valve vacuum breaker piped to return main.
E. Install pressure gages at coil inlet connections.
F. Furnish and install UL approved relief valve on shell side of heat exchanger, set for 125 psi. Extend lines from relief valves and turn down over floor drain.

3.12 FIELD QUALITY CONTROL

A. Testing Preparation: Prepare steam and condensate piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Flush system with clean water. Clean strainers.
   3. Isolate equipment that is not subjected to test pressure from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Flanged joints where blinds are inserted to isolate equipment need not be tested.
   4. Install relief valve set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Testing: Test steam and condensate piping as follows:
   1. Acceptance Testing: Perform hydrostatic tests on the steam and condensate piping in accordance with ANSI B31.1 and as follows:
      2. Notify Owner’s Representative 24 hours before required testing. All tests shall be conducted in the presence of the Owner’s Representative.
      3. Flush system with clean water. Clean strainers.
      4. Minimum test pressure shall be 150 PSIG.
      5. Pressure gauge shall be min. 4” dia. Face, 0-160 PSIG, have a current calibration within 1 year of test date.
      6. Test pressure shall be held for 1 hour.
      7. Prepare reports for all tests and required corrective action.
      8. Clean and flush steam piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing steam piping system, but before balancing, remove disposable fine mesh strainers.
      9. System shall be operated for a minimum of 24 hours to demonstrate to the Owner’s Representative that system is complete and operational.

3.13 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Flush steam and condensate piping with clean water. Remove, clean, and replace strainer screens.
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 steam pressure-powered steam condensate pumps.

1.3 SUBMITTALS
A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Include receiver capacity and material.
B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Source Limitations: Obtain steam condensate pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of steam condensate pumps and are based on the specific system indicated. Refer to Division 1 Section “Product Requirements.”

C. ASME Compliance: Fabricate and label steam condensate pumps to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.5 DELIVERY, STORAGE, AND HANDLING
A. Manufacturer’s Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
B. Store steam condensate pumps in dry location.
C. Retain protective covers for flanges and protective coatings during storage.
D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
E. Comply with pump manufacturer’s written rigging instructions.
PART 2 - PRODUCTS

2.1 PRESSURE-POWERED STEAM CONDENSATE PUMPS
   A. Acceptable Manufacturers:
      1. Johnson
      2. Spirax Sarco, Inc.
      3. Armstrong
      4. Watson McDaniel
   B. Description: Factory-fabricated, pressure-powered pumps with mechanical controls, valves, piping
      connections, factory and accessories suitable for pumping steam condensate using steam.
   C. Configuration: Quadplex pump with float-operated valve control.
      1. Pump Body: Cast iron.
      2. Piping Connections: Threaded; for steam condensate, operating medium, vent, and indicated
         accessories. Provide extensions to accommodate 1½” factory insulation.
      3. Level Gage: Glass site gage with shutoff cocks.
      4. Valves: Manufacturer's standard check valves on inlet and outlet.
      5. Strainers: Wye pattern strainers on pump inlet piping.
      6. Internal Parts: Stainless-steel float, springs, and actuating mechanism.
      7. Valve Seals: Replaceable from exterior.
      8. Receiver: Cast iron, factory mounted on steel supports; with water-level site glass and threaded
         piping connections. Maximum inlet height on receiver above the housekeeping pad shall be 62”.
      9. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106; Schedule 80; seamless steel.
      12. Insulation: Factory insulate with 1½” thick glass fiber insulation with aluminum jacket.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation
      tolerances and other conditions affecting performance of work.
   B. Examine rough installation of steam condensate piping.
   C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install pumps to provide access for periodic maintenance including removing accessories.
   B. Support pumps and piping separately so piping is not supported by pumps.
   C. Install thermometers and pressure gages.
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. Install steam supply for pressure-powered pumps as required by Division 23 Section "Steam and Condensate Piping."

D. Install gate and check valves on inlet and outlet of pressure-powered pumps.

E. Pipe drain to nearest floor drain for overflow and drain piping connections.

F. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

3.4 STARTUP SERVICE

A. Verify that steam condensate pumps are installed and connected according to the Contract Documents.

B. Complete installation and startup checks according to manufacturer's written instructions.

C. Clean strainers.

D. Set steam condensate pump controls.

E. Perform the following preventive maintenance operations and checks before starting:
   1. Test pump controls and demonstrate compliance with requirements.
   2. Replace damaged or malfunctioning pump controls and equipment.
   3. Verify that pump controls are correct for required application.

F. Place condensate pumps in operation according to manufacturer's written startup instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION 232223
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. Section Includes:
      1. Single-wall rectangular ducts and fittings.
      2. Single-wall round and flat-oval ducts and fittings.
      4. Sealants and gaskets.
      5. Hangers and supports.
   B. Related Sections:
      1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS
   A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
   B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
   C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS
   A. Product Data: For each type of the following products:
      1. Sealants and gaskets.
   B. Shop Drawings:
      1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
      2. Factory- and shop-fabricated ducts and fittings.
      3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
      4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Coordination Drawings: CAD generated plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

7. Refer to Section “Common Work Results for HVAC”.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE


B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653.

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.
2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 3 inches.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. 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.

D.溶剂型接缝密封胶:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   7. Mold and mildew resistant.
   8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   9. VOC: Maximum 395 g/L.
   10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
   11. Service: Indoor or outdoor.
   12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

   2. Type: S.
   3. Grade: NS.
   5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
   1. Seal shall be rated for 10-inch wg static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.
E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts before external insulation is applied. Provide adequate sealing as required to meet duct leakage requirements.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.

C. Hanger Spacing: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts, for 24 inches length, that are visible through return and exhaust registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:


2. Maximum Allowable Leakage: Duct system leakages shall not exceed 5% of design air flows. When systems are leak tested in section, the total cumulative leakage of the system shall not exceed 5%.

3. Test the following systems:

   a. All supply air ducts and sections from air handling unit to terminal units.
   b. All return air ducts and sections from grilles/registers to return/relief air fan.
   c. 10% of supply air ductwork downstream of boxes, but not less than two systems.
   d. Two exhaust air duct systems.

4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

5. Test for leaks before applying external insulation.

6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

7. Give seven days' advance notice for testing.
C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
   1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
   2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
   7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
   1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel.

B. Supply Ducts:
   1. Ducts Located within Mechanical Equipment Rooms:
      a. Pressure Class: Positive 4-inch wg.

C. Exhaust Ducts:
   1. General Exhaust System Ducts:
      a. Pressure Class: Negative 2-inch wg.

D. Outdoor-Air Ducts:
   1. All Ducts:
      a. Pressure Class: Positive or negative 1-inch wg.

E. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

F. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
      a. Velocity 1000 fpm or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm:
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:
   1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to-Diameter Ratio: 1.5.

   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.
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. Section Includes:
   2. Fire dampers.
   3. Combination fire and smoke dampers.
   4. Flange connectors.
   5. Turning vanes.
   6. Duct-mounted access doors.
   7. Flexible connectors.
   8. Duct accessory hardware.

B. Related Sections:
   1. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

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

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      c. Control damper installations.
      d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
      e. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.
1.4 QUALITY ASSURANCE


B. Comply with AMCA 500-D testing for damper rating.

1.5 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed, but not less than two.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653.

2. Exposed-Surface Finish: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480, Type 304, and having a No. 2 finish for concealed ducts and D4 finish for exposed ducts.

D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Manual Volume Dampers:

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

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. McGill AirFlow LLC.
d. METALAIRE, Inc.
e. Nailor Industries Inc.
f. Ruskin Company.
g. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
   a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness, or 0.10 inch aluminum sheet channels.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 0.064 inch thick, or roll-formed aluminum 0.10 inch thick.

7. Bearings:
   a. Molded synthetic or Stainless-steel sleeve.
   b. Dampers shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel/Aluminum.

2.3 FIRE DAMPERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. Arrow United Industries; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   5. McGill AirFlow LLC.
   6. METALAIRE, Inc.
   7. Nailor Industries Inc.
   8. Ruskin Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 inch thick and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.


2.4 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
4. Nailor Industries Inc.
5. Ruskin Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.


G. Smoke Detector: Integral, factory wired for single-point connection.

H. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Leakage: Class I.

J. Rated pressure and velocity to exceed design airflow conditions.

K. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

L. Damper Motors: Modulating or two-position action.

M. 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 23 Section "Instrumentation and Control for HVAC."

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 24V, single phase, 60 Hz.

N. Accessories:

1. Remote mounted momentary test switch. Provide with pushbutton and lights (red for closed damper, green for open damper).

2.5 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.6 TURNING VANES

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. METALAIRE, Inc.
4. SEMCO Incorporated.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.7 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
5. Greenheck Fan Corporation.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Ventfabrics, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Doors close when pressures are within set-point range.
5. Hinge: Continuous piano.
7. Seal: Neoprene or foam rubber.
8. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.8 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

   1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
   2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
   3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.9 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
   1. Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.
D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire and smoke dampers according to UL listing.

G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream and downstream from turning vanes.
   9. Upstream or downstream from duct silencers.
  10. Control devices requiring inspection.
  11. Elsewhere as indicated.

H. Install access doors with swing against duct static pressure.

I. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

J. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment.

L. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

M. Connect flexible ducts to metal ducts with draw bands and adhesive plus sheet metal screws. Do not use flexible ducts through walls, partitions.

N. Install duct test holes where required for testing and balancing purposes.

O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300
SECTION 233413 – MIXED-FLOW HVAC FANS

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. Mixed-flow fans.

1.3 PERFORMANCE REQUIREMENTS
   A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
   B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS
   A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
      1. Certified fan performance curves with system operating conditions indicated.
      2. Certified fan sound-power ratings.
      3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
      4. Material thickness and finishes, including color charts.
      5. Dampers, including housings, linkages, and operators.
      6. Fan speed controllers.
   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. 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.
   C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
   D. Field quality-control test reports.
   E. Operation and Maintenance Data: For axial fans 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.
   B. AMCA Compliance:  Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
   C. NEMA Compliance:  Motors and electrical accessories shall comply with NEMA standards.

1.6 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 final locations, according to manufacturer's written instructions.
   C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION
   A. Coordinate size and location of structural-steel support members.

1.8 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. Belts:  One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MIXED-FLOW FANS
   A. Acceptable Manufacturers:  Subject to compliance with requirements, provide products by one of the following:
      1. Loren Cook Company.
      2. Greenheck.
   B. Description:  Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive, and accessories.
   C. Housings:  Steel or Aluminum.
      1. Inlet and Outlet Connections:  Outer mounting frame and companion flanges.
      2. Guide Vane Section:  Integral guide vanes downstream from fan wheel designed to straighten airflow.
D. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Shaft Bearings: Radial, self-aligning ball or roller bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
   b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
   c. Extend lubrication lines to outside of casing and terminate with grease fittings.

F. Accessories:

1. Mounting Clips: Clips welded to fan housing, of same material as housing.
2. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.

G. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

H. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Epoxy/Phenolic/Powder-baked enamel as indicated.

   a. Apply to finished housings.
   b. Apply to fan wheels.

I. Capacities and Characteristics as indicated on drawings.

2.2 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install axial fans level and plumb.

B. Support suspended units from structure using threaded steel rods. Vibration-control devices are specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment."

C. Install units with clearances for service and maintenance.

D. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.
B. Adjust belt tension.

C. Lubricate bearings.

END OF SECTION 233413
SECTION 233723 - HVAC GRAVITY VENTILATORS, LOUVERS AND VENTS

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 fixed extruded aluminum louvers and wall vents.

B. Related Sections include the following:
   1. Division 23 Section "HVAC Power Ventilators".

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.

C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

D. Storm-Resistant Louver: Louver that provided specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Intake and relief ventilators shall be capable of withstanding the effects of gravity loads, wind loads, seismic loads, and thermal movements without permanent deformation of components, noise or metal fatigue, or permanent damage to fasteners and anchors.


C. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft., acting inward or outward.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, over-stressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range): 120 deg F ambient; 180 deg F material surfaces.
E. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer’s stock units identical to those provided, except for length and width according to AMCA 500-L.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
2. Show mullion profiles and locations.

C. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain ventilators, louvers and vents through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

B. Product Options: Information on Drawings and in Specifications establishes requirements for system’s aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods including preconstruction testing, field testing, and in-service performance.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators, louvers, vents and are based on the specific equipment indicated. Refer to Division 01 Section “Product Requirements.”

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect’s approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.


1.7 COORDINATION

A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.
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. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653, G90 zinc coating, mill phosphatized.

D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.

   1. Use types and sizes to suit unit installation conditions.
   2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
   3. For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
   4. For color-finished louvers, use fasteners with heads that match color of louvers.

E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.3 FABRICATION, GENERAL

A. Fabricate frames, including integral bases and sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

B. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

C. Fabricate supports, anchorages, and accessories required for complete assembly.

D. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

E. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolts assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.

   1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated.
   2. Horizontal Mullions: Provide horizontal mullions at joints unless continuous vertical assemblies are indicated.
F. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

G. Include supports, anchorages, and accessories required for complete assembly.

H. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches o.c., whichever is less.

1. Full Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.

2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.

3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.

4. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.

I. Provide subsills made of same material as louvers or extended sills for recessed louvers.

J. Join frame members to each other and to fixed louver blades with fillet welds concealed from view unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.4 FIXED, EXTRUDED-ALUMINUM LOUVERS

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

1. Ruskin Company; Tomkins PLC.
2. Greenheck Fan Corporation.
3. Louvers and Dampers, Inc.

B. Horizontal, Drainable-Blade Louver:

1. Louver Depth: 4 inches.
2. Frame and Blade Nominal Thickness: Not less than 0.080 inch for blades and 0.080 inch for frames.
3. Mullion Type: Exposed.
4. Louver Performance Ratings:
   a. Free Area: Not less than 54% for 48-inch- wide by 48-inch-high louver.
   b. Point of Beginning Water Penetration: Not less than 873 fpm free-area velocity.
   c. Air Performance: Not more than 0.15 inch wg static pressure drop at 873-fpm free-area velocity.

5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.5 LOUVER SCREENS

A. General: Provide screen at each exterior louver.
1. Screen Location for Fixed Louvers: Interior face.
2. Screening Type: Bird screening except where insect screening is indicated.

B. Secure screen frames to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
   1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
   2. Finish: Same finish as louver frames to which louver screens are attached.
   3. Type: Rewirable frames with a driven spline or insert.

2.6 BLANK-OFF PANELS

A. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver.
   1. Thickness: 1 inch.
   2. Metal Facing Sheets: Aluminum sheet, not less than 0.032-inch nominal thickness.
   3. Insulating Core: Rigid, glass-fiber-board insulation.
   4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer’s standard extruded-aluminum-channel frames, not less than 0.080-inch, with corners mitered and with same finish as panels.
   5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
   6. Panel Finish: Same type of finish applied to louvers, but black color.
   7. Attach blank-off panels with sheet metal screws.

2.7 FINISHES, GENERAL

A. Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Finish louvers after assembly.

2.8 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designation aluminum finishes.

B. High-Performance Organic Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Fluoropolymer Two-Coat Coating System: Manufacturer’s standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight, complying with AAMA 605.2.
      a. Color and Gloss: As selected by Architect from manufacturer’s full range of colors and glosses.

C. Finish shall match color of architectural metal attic panels.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION
A. Install louvers plumb and at indicated alignment with adjacent work.
B. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
C. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.
D. Label intake and relief louvers according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."
E. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
F. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
G. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
H. Form closely fitted joints with exposed connections accurately located and secured.
I. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 07 Section "Joint Sealants" for sealants applied during louver installation.

3.4 CONNECTIONS
A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

3.5 ADJUSTING AND CLEANING
A. Adjust damper linkages for proper damper operation.
B. Clean exposed surfaces of louvers that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.

C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

D. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with factory-applied finish coating.
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SECTION 235700 - HEAT EXCHANGERS FOR HVAC

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 shell-and-tube heat exchangers for HVAC applications.

1.3 SUBMITTALS
A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
B. Maintenance Data: For heat exchangers/pump package to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE
A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Other manufacturer’s products with equal performance characteristics may be considered. Refer to Division 1, Section “Substitutions”.
B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, “Pressure Vessels”, Division 1.

PART 2 - PRODUCT

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Shell-and-管 Heat Exchangers:
      a. Armstrong.
      b. Bell & Gossett.
      c. Mepco.
      d. Taco.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS
A. Shell and tube heat exchangers.
2. Shell and Head Materials: Steel shell and cast-iron head.
3. Tube and Tube Sheet Materials: Seamless, 18 BWG, 3/4-inch (20-mm) OD copper tubes with steel tube sheets.
5. Tubes on water side shall be designed for 125 psi operation.
6. Shell on steam side shall be designed for 150 psi at 375 degrees F operation with 1/16” allowance for corrosion.
7. Heat exchanger shall be ASME rated and labeled.
8. Furnish heat exchanger with ASME and UL approved relief valve set for 100 psi.
9. Heat exchanger shall be rated for full capacity as scheduled on drawings with the design parameters as scheduled, based on a shell side steam pressure of 0.5 psig.

PART 3 - EXECUTION

3.1 EXECUTION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Maintain manufacturer’s recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
C. Install piping with threaded or flanged connections of heat exchangers.
D. Install shutoff valves at heat exchanger inlet and outlet connections.
E. Install ASME UL approved relief valves on heat exchanger heated-fluid connection.
F. Install vacuum breaker at heat exchanger steam condensate outlet connection – see sketch of connections on drawings.
G. Provide valved drain from heat exchanger piped to floor drain and turned down.
H. Pipe outlet from relief valve to floor drain and turn down.

3.3 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.4 COMMISSIONING

A. Verify that heat exchangers are installed and connected according to the Contract Documents.
B. Adjust flows and controls to deliver specified performance.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 DEMONSTRATION

A. Start-Up: Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain heat exchangers as specified below:

1. Train Owner’s maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining heat exchangers.
2. Review data in maintenance manuals. Refer to Division 1, Section “Contract Closeout”.
3. Review data in maintenance manuals. Refer to Division 1, Section “Operation and Maintenance Data”.
4. Schedule training with Owner, through Architect, with at least seven (7) days advance notice.

END OF SECTION 235700
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. MU Division of IT Telecommunications Construction Standards and Specifications apply to this section. The Contractor shall obtain the latest revision of document and install all cables, pathways, boxes, equipment, and hardware in a manner to conform with MU Standards and Specifications.

1.2 SUMMARY

A. Section Includes:
   1. Electrical equipment coordination and installation.
   2. Sleeves for raceways and cables.
   3. Sleeve seals.
   5. Coordination drawings.
   6. Project record drawings.
   7. Trenching, excavating and backfilling.
   8. Electrical demolition.
   9. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

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.

B. All equipment furnished shall be U.L. Listed and labeled or equivalent approved.

C. Comply with NFPA 70.

D. Equipment Selection: Equipment of larger physical dimensions, higher capacities or ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical/electrical services are appropriately modified. Any additional costs as a result of these modifications shall be borne by the Contractor.
1.6  DELIVERY, STORAGE, AND HANDLING

A. Deliver raceways in clean condition. Store to prevent entrance of dirt, debris and moisture.

B. Protect stored raceways, wires, and connectors from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

1.7  INTERPRETATION OF THE DRAWINGS

A. The drawings indicate diagrammatically the conduit runs and the apparatus served in a general way. No attempt has been made to show exact location of every box, fitting or conduit offset. Such items are to be provided and all wiring connections and home runs are to be made as required. Where conduit runs are shown terminating in arrows, such conduit runs shall be extended to panels/boards or other equipment. Where equipment is specified to be wired, make connections as shown on approved equipment wiring diagrams. Consult equipment approved shop drawings for location of outlets and for miscellaneous controls. Where wire sizes are shown on drawings, the wire size for each circuit shall be for the entire circuit.

B. Where conduit is shown without wiring symbols, install one (1) hot (phase) wire, one (1) neutral wire, and one (1) ground wire.

C. Provide full size neutral for each circuit.

D. No more than three circuits shall be installed in a conduit.

1.8  TEMPORARY POWER

A. The contractor shall make all provisions for and furnish and install all necessary conduit, wire, and distribution equipment for a complete temporary wiring system for use during construction of the building. Temporary wiring shall include a system of temporary lights and power distribution. Refer to Division 01.

1.9  COORDINATION

A. Coordinate arrangement, mounting, and support of electrical 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 raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

E. Coordinate electrical testing of electrical, mechanical, and architectural items, so equipment and systems that are functionally interdependent are tested to demonstrate successful interoperability.
F. Coordinate rough-in connections to pre-manufactured headwall systems including power for lighting, receptacles; connections for nurse call, voice/data outlets and TV interface.

1.10 LOCATION OF OUTLETS

A. Outlets are only approximately located on the construction drawings and great care must be used in the actual location of outlets by consulting architectural drawings and details and the various fixture drawings and by securing definite locations from the Architect.

B. At various places where outlets are shown below exposed pipes or ducts, Contractor shall set outlet box to clear same by at least 12”. Where outlets are installed over piping or ducts, outlets shall be moved so as to clear piping and ducts at no additional cost, using approved conduit and conduit fittings.

C. Switch outlets shall generally be located on lock side of door. Check the latest general drawings on job for door swings before roughing in for switches.

D. Check height of tile or similar wainscots and set switch outlet boxes so that same will clear top of wainscot or will come entirely within the wainscot.

E. Wall outlets installed flush shall be provided with device (plaster) covers set to come flush with the finished surface.

F. For electric water coolers, install box in accordance with manufacturer’s shop drawings so that receptacle will be concealed by unit housing.

G. For other equipment, provide electrical rough-in in accordance with the equipment installation instructions and architectural drawings.

H. Do not use through-the-wall and back-to-back boxes.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe,” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. 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.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 COORDINATION DRAWINGS

A. The contractor shall prepare CAD generated drawings (min. ¼” scale) showing following systems/items as a minimum:
   1. Electrical equipment locations and clearances required.
   2. Routing of main feeders and conduits (3” dia. and larger), cable trays and bus ducts.
   3. Locations of items in ceiling such as light fixtures.

B. The contractor shall submit the CAD generated drawings to the contractor for coordination with other trades. The drawings shall be submitted either in electronic format or printed copies as requested by the contractor.

C. The contractor shall participate in coordination meetings when requested by the contractor.

2.5 PROJECT RECORD DRAWINGS

A. Drawings shall be furnished in electronic-media (CD-Rewritable type) and at-least one hard copy prints.
   1. Format: Same CAD program, version and operating system as the original contract documents.
   2. Incorporate changes and additional information previously marked on record prints. Delete, redraw and add details and notations where applicable.

B. Identify and date each drawing and include the designation “PROJECT RECORD DRAWING” or “AS-BUILT DRAWING” in a prominent location.

PART 3 - EXECUTION

3.1 TRENCHING, EXCAVATING AND BACKFILLING

A. Excavate to required dimensions and depth. The trench excavation shall be in open cut from surface and shall be minimum width necessary to permit the placing of the pipe as required. Excess excavation shall
be backfilled with crusher run rock. Such rocks shall be placed at the Contractor’s expense. Lines shall be used to lay out trenches.

B. All excavations shall be properly protected by the necessary bracing and timbers, to prevent any cave-ins or injury to adjacent improvements. The sides of the excavations shall be securely held by bracing or sheathing, which bracing or sheathing shall not be removed until the level of the backfill has reached the point where such removal can be safely carried out. Where adjacent improvements might be injured by the removal of such bracing, the braces shall be left in place to prevent such injury. The thickness of the sheathing and the dimensions of the cross braces, shoes and miscellaneous supports to be used by the Contractor shall be of type required to properly protect the sides of the trench and to prevent injurious cave-ins or erosions.

C. The Contractor shall do all pumping and bailing necessary to keep all excavations free of water and shall provide for the uninterrupted flow of the surface water adjacent to the line of the work during the progress of the work. The Contractor shall inspect the ground where excavation is required to ascertain the structure of the soil. Additional consideration will not be allowed for encountering rock, stone, old foundations or other unfavorable excavating conditions.

D. In cases where existing sewer or other piping are encountered, they shall not be displaced or disturbed. All sewer lines damaged or disturbed in the construction shall be replaced or required at the Contractor’s expense, unless, in the opinion of the Architect, such damage was caused through no fault of the Contractor.

E. Contractor shall provide all temporary steel plates, barricades, and such other signs and signals by day as shall be necessary to warn the public of and protect the workers from the danger caused by excavations and other obstructions, day and night.

F. The backfilling of trenches shall be carried out as rapidly as the testing and acceptance of the finished sections of the installation will permit. The trench shall be backfilled in layers of not to exceed eight inches (8”) with good selected clean earth, thoroughly tamped with mechanical tamper to a 95% optimum compaction. Density shall be tested by an approved laboratory, using a standard method. Tests shall be made of each 2 ft. depth on the basis of one test per 1000 sq. ft. of fill area. Last 12” of backfill shall be made with good clean top soil. Contractor shall obtain and pay for tests. Submit five (5) copies of tests for approval. Note: Broken stones, cinders, wood and rubbish are not acceptable for backfilling. Backfill all street cuts in a manner meeting the approval of the Architect.

G. In spaces between walls and line of excavation, fill with thin layers of selected clean earth; thoroughly tamp in eight inches (8”) thick layers and bring up to a finished level of established grades. All wood and foreign material shall be removed from excavation prior to backfilling.

H. After backfilling, all surplus excavated materials shall be removed from the property.

I. The work shall be executed so that any existing permanent structure along and adjacent to the new work are properly protected. Any damage occurring to these structures shall be repaired by the Contractor at his own expense.

J. The Contractor shall make field inspection of the location along which the underground conduit is to be routed, and note all obstructions and improvements at the surface which may affect the method of operation in the construction of these conduits. Such underground pipes or conduits which may exist, or which may be encountered, shall be protected by the Contractor during this construction. Any expense or inconvenience caused by their existence and the necessary protection for utilities adjacent thereto shall be considered as covered and included in the contact, without additional cost to the Owner.

3.2 ELECTRICAL DEMOLITION

A. Refer to Division 02 Section “Selective Demolition” for general demolition requirements and procedures.
B. Disconnect, demolish, and remove electrical systems, fixtures, devices, and components indicated to be removed. In general, remove all fixtures, raceways, cables, junction boxes, and equipment not utilized in new construction. For circuits disconnects, remove raceways and cables all way to the source. Label breakers switches from where circuits have been removed as “SPARE”.

C. Protect existing electrical equipment and installation indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

D. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

E. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish. Raceways shall not be abandoned within walls.

F. Remove demolished material from Project site.

G. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

H. Remove equipment to be salvaged, disconnect from power, and deliver to Owner as directed.

3.3 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

F. In general install raceways and boxes minimum 8” above hung ceiling. All raceways, boxes and equipment shall be independently supported from structure. Do not support from ductwork or piping.

G. Where new devices are added to existing circuits, take readings prior to adding new devices, and submit to Architect for review. Do not proceed with new work until approved by Architect.

H. All low voltage devices (including but not limited to voice/data communication; nurse call; master antenna television; patient monitoring; telemetry, etc.) that are installed in patient care areas or patient rooms or procedure rooms shall have their conduit extended out to above accessible ceiling space in adjacent corridor. Terminate conduit with a bushing.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
B. 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.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. 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.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping." For communications cable penetrations, comply also with requirements in Division 27 Section "Common Work Results for Communications."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."
END OF SECTION 260500
SECTION 260505 – ELECTRICAL TESTING

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 general requirements for electrical field testing and inspecting. Detailed requirements are specified in each Section containing components that require testing. General requirements include the following:

1. Suitability of test equipment.
2. Calibration of test instruments.
3. Coordination requirements for testing and inspecting.
4. Reporting requirements for testing and inspecting.

B. Emergency systems shall be tested as specified herein.

1.3 QUALITY ASSURANCE

A. The Electrical Contractor shall completely test and inspect all systems in accordance with the specifications and drawings. The Electrical Contractor shall certify that all systems are in complete working order prior to turning over the Owner.

B. Except as modified by governing codes and by the contract documents, comply with the latest applicable provisions and latest recommendations of the following:

1. NFPA.
2. NEMA.
3. NEC.
4. IEEE.
5. IPCEA.
6. ANSI.
7. UL.
8. NECA.
9. Local Fire Department.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING

A. It shall be the responsibility of this Contractor to furnish all testing instruments/equipment, materials and labor necessary to perform the following tests.
1. After wires or cables are in place, but before being connected to devices and equipment, the system shall be tested for shorts, opens, intentional and unintentional grounds by means of wires in conduit that are shorted or unintentionally grounded shall be replaced.

2. Voltage drops for panel and large feeders shall not exceed 3% hence the total voltage drop for a feeder and any branch circuit shall not exceed 5% of the service voltage. The test shall be made under design load or its' equal.

3. Any wiring device or electrical apparatus in this contract, if grounded or shorted on an integral "line" part, shall be removed and the problem rectified.

4. When required, complete test and inspection records shall be made and incorporated into a report for each piece of equipment tested. All readings taken shall be recorded. Four (4) copies shall be submitted to the Architect for approval.

5. Notify the Architect, with minimum seven (7) days notice, about testing schedule.

3.2 WIRING TEST

A. The wiring and cable tests shall be made before any circuits, main switches, motors, transformers or feeders are energized.

B. Tests shall be made for continuity, identification and absence of shorts and grounds for each conductor. Both ends of a given conductor shall be identified alike. Before circuit terminal connections are made, continuity and identification of wiring shall be checked by means of a DC test device using a bell, light, meter, or buzzer.

C. Insulation Resistance (IR) test shall be made using meggers at the following values:

   1. 208Y/120 Volt wiring at 500 Volts DC.

D. Insulation resistance between phase conductors and neutral, phase conductors and ground shall not be less than the minimum requirements of 2000 meg-ohms.

   1. Wire terminations shall not be made to equipment (motors, MCCs, but ducts, etc.), until that piece of equipment has been tested and verified as specified in this section.

   2. Test motor feeders with motors disconnected, but with circuit breakers, switches or starters in the circuit opened so as to include only that portion of the feeder, required to be tested.

   3. Test lighting feeders with the circuit breakers and panelboards connected but with lighting branch circuit breakers or switches open so as to include only the branch circuit to be tested.

   4. Contractor shall correct or replace any circuit which is defective or grounded and shall correct all other problems encountered by these tests. All defects whether due to faulty workmanship or material furnished by the Contractor shall be corrected under this section at the Contractor's expense.

3.3 LIGHTING TEST

A. Check all lighting fixtures for proper operation. All Contractor supplied fixtures shall be 100% operable at no additional cost to the Owner. Repair cost to Owner-supplied fixtures shall not be the responsibility of the Contractor unless otherwise stated.

B. Verify operation of Lighting Control Systems. Program time clocks per client's requirements, including holiday setbacks.

3.4 MOTOR TEST

A. Perform motor tests in coordination with fire suppression, plumbing and HVAC contractors for motors furnished with their equipment.
B. All 208/120V motors shall be “spot tested” with 500V DC in a similar manner. The minimum resistance to ground shall be 2000 meg-ohm (corrected to 20 degrees C). The Contractor shall record the ambient temperature of the motor and submit this value along with insulation resistance value. For motors from 7-½ to 20 HP, Contractor shall submit Dielectric Absorption Ratios. For motor above 20 HP, the Polarization Indexes of the motor shall also be submitted.

C. Make the following checks on all motors prior to start up.
   1. Check motor nameplates for HP, speed, phase and voltages. Verify proper voltage available for terminal wiring.
   2. Check shaft for freedom of rotation.
   3. Verify that the motor is properly lubricated prior to energizing.

D. Contractor shall furnish a proper sized heater for each overload relay.

E. Make the following tests on all motors during or immediately after start-up:
   1. Check for proper shaft rotation.
   2. Check motor for smooth operation (vibration).
   3. Take a current reading using a clamp-on ammeter. (Record no-load readings and loaded readings).

3.5 PANELBOARD TESTS
A. Test all equipment to be operated on the 208/120V system at 500V DC prior to connecting feeders. A minimum insulation resistance of 2000 meg-ohms shall be obtained between all phases and between phase and neutral, and phase and ground.

3.6 SPOT TEST
A. “Spot Test” mentioned in this section shall be interpreted as the specific test method of obtaining insulation resistance by applying indicated test voltage for 60 seconds to the equipment or wiring being tested.

3.7 CONTROL WIRING/OUTLET TEST
A. Control wiring shall perform the function as noted in operation methods and/or included schematics and single line diagrams.

B. All 120-volt outlets shall be tested with a Daniel Woodhead Cat. No. 1750 and 1760 tester. Minimum acceptable tension is 10 oz. for receptacles.

END OF SECTION 260505
SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

B. Pre-wired systems such as type AC (armored cable), type MC (metal-clad and type NM (nonmetallic-sheathed cable) shall not be used. (Exception: MC may be used for lighting fixture whips up to 6'-0" long. They must be dedicated, not daisy chained together).

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

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 NFPA 70.
D. All conductors and cables shall be UL labeled.

1.6 COORDINATION
A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
B. Coordinate layout and installation of conductors and cables with other trades.

1.7 DELIVERY, STORAGE AND HANDLING
A. Delivery conductors and cables according to NEMA WC 26.
B. Protect stored conductors and cables from moisture and dirt. Do not store outside, exposed to elements. Elevate above grade. Do not exceed structural capacity of floor, when stored inside.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES
A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Encore Wire and Cable.
   2. Senator Wire & Cable Company.
B. Copper Conductors: Comply with NEMA WC 70.
C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.
D. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC or mineral-insulated, metal-sheathed cable, Type MI with ground wire.

2.2 CONNECTORS AND SPLICES
A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AFC Cable Systems, Inc.
   2. AMP Incorporated/Tyco International.
   4. O-Z/Gedney; EGS Electrical Group LLC.
   5. 3M; Electrical Products Division.
   7. Tyco Electronics Corp.
B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

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

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
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.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL AND SIZE APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Conductors smaller than No. 12 AWG shall not be utilized anywhere, unless specifically noted on drawings.

D. The minimum conductor size for branch circuits shall be #12 AWG copper. To compensate for voltage drop, where branch circuit lengths are between 100 and 150 feet, use #10 AWG copper. For branch circuit lengths exceeding 150 feet, use #8 AWG copper.

E. Wire size ampacity shall equal or exceed its overload protective device. Where wire sizes shown on the drawings are greater than the apparent ampacity requirements, the size shown shall prevail to compensate for voltage drop. In no instance shall conductors be installed that are less than required by NEC.
3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THWN, single conductors in raceway or Type XHHW, single conductors in raceway. Mineral-insulated, metal-sheathed cable, Type MI where specifically indicated on drawings.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

D. Feeders at all other locations: Type THHN-THWN, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits at all other locations: Type THHN-THWN, single conductors in raceway.

H. Class 1 Control Circuits: Type THHN-THWN, in raceway.

I. Class 2 Control Circuits: Type THHN-THWN, in raceway.

J. Fire Alarm Circuits: Refer to Section 280513 “Conductors and Cables for Electronic Safety and Security”.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal conduits in finished walls, and above ceilings, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed conduits parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support conduits according to Division 26 Section “Hangers and Supports for Electrical Systems.”

F. Identify and factory color-code conductors and cables according to Division 26 Section “Identification for Electrical Systems.”

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. 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.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:
   1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
   2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. 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.

F. Cut sleeves to length for mounting flush with both wall surfaces.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space
between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section “Penetration Firestopping.”

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and branch circuit conductors for compliance with requirements.
   3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
      a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of final acceptance.
      b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test Reports: Prepare a written report to record the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519
SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. MU Division of IT Telecommunications Construction Standards and Specifications apply to this section. The Contractor shall obtain the latest revision of document and install all cables, pathways, boxes, equipment, and hardware in a manner to conform with MU Standards and Specifications.

1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

B. This Section includes grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other Sections of these Specifications.

C. Related Sections include the following:

1. Division 26 Section 260519 “Low-Voltage Electrical Power Conductors and Cables” for requirements for grounding conductors.

1.3 SUBMITTALS

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

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:

1. Ground rods.

C. Qualification Data: For testing agency and testing agency's field supervisor.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For grounding to include the following in operation and maintenance manuals:

1. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NFPA 70B.
   a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
   b. Include recommended testing intervals.
1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

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 UL 467 for grounding and bonding materials and equipment.

D. Communications Grounding shall comply with BICSI Telecommunications Distribution Methods Manual (TDMM) and BICSI Information Transport Systems Installation Methods Manual, latest editions.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches in cross section, unless otherwise indicated; with insulators.

1. Telecommunications Ground Busbar (TGB) shall have industry-standard 2-hole pattern, and be 4 inches wide, as manufactured by CPI # 40153-012 or approved equivalent.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.
2. Telecommunications Grounding Connector Lugs: Irreversible compression type, 2-hole lug, for connection to TGBs. Approved manufacturers: Burndy, Panduit, Thomas & Betts.
C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions. All concealed terminations to the grounding electrode shall be made using exothermic welds.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch diameter by 10 feet in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 4/0 AWG minimum.
   1. Bury at least 24 inches below grade.

C. Grounding Bus: Install in electrical and telecom equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

D. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. Armored and metal-clad cable runs.
C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 3/0 AWG minimum insulated grounding conductor in raceway from electrical service entrance grounding busbar to nearest Telecom room TGB.

1. Telecom Rooms: Terminate grounding conductors on a 1/4-by-4-by-12-inch minimum Telecommunications Grounding Busbar (TGB).
2. Bond each TGB to:
   a. Equipment ground bus of nearest electrical branch circuit panel board, via No. 6 AWG grounding conductor for distances up to 100 feet, No. 3/0 AWG grounding conductor for distances greater than 100 feet. Grounding conductor shall be insulated and routed in raceway.
   b. Nearest building steel when available, via No. 6 AWG grounding conductor for distances up to 100 feet, No. 3/0 AWG grounding conductor for distances greater than 100 feet.
   c. Nearest section of Cable Tray via No. 6 AWG grounding conductor.
   d. Metal conduits and sleeves entering the Telecom Room, via No. 6 AWG grounding conductor.

G. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 INSTALLATION

A. Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.

B. Electrical Room Grounding Bus: Space 1 inch (25 mm) from wall and support from wall 6 inches (150 mm) above finished floor except as otherwise indicated.

C. Grounding Conductors: Route along shortest and straightest paths possible, minimizing direction changes and utilizing wide-radius bends where direction changes are necessary, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

E. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

G. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building’s main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

H. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

I. In addition to bonding the water service, effectively grounded building steel or rebar of reinforced concrete columns, driven ground rods outside or buried electrode shall be provided and interconnected.

J. Provide a copper ground cable from the above main service ground bus to building steel, driven ground rods outside or buried electrodes.

K. The Main service neutral shall be bonded to the main service ground.

L. Bond all interior metallic water, gas and other metallic lines.

M. The complete metal conduit system shall be used for the equipment grounding system. Conduit systems and associated fittings and terminations shall be made mechanically tight to provide a continuous electrical path to ground and shall be safely grounded at all equipment by bonding all metallic conduit to the equipment enclosures with locknuts cutting thru paint of enclosures. Bond all conduits entering primary switchgear, unit substations and secondary switchboards with a ground wire connecting the grounding type bushings to the equipment ground bar. Conductors shall be sized per NEC.

N. In addition to using the conduit system for grounding, a complete auxiliary green wire equipment grounding system shall be installed, continuous from main ground, through distribution and branch circuit panelboards and paralleling all feeders and branch circuit wiring. The minimum size shall be #12 copper except #14 on control circuits. This shall apply to all circuits rated 100 volts or more above ground potential.

O. Bond all communications conduit systems to ground.

P. Connect ground terminal on wiring devices to auxiliary green wire equipment grounding system.
Q. Motor frames shall be bonded to the equipment grounding system by an independent green wire, sized as shown.

R. System neutral connections shall be insulated from metal enclosures except at the neutral of the service entrance equipment. Connections to the main switchboard enclosure shall be by means of bonding jumpers.

S. The building neutral shall be identified throughout with white conductors.

T. Steel frame buildings and metal exterior coverings on buildings that are not effectively grounded shall be grounded thru a low resistance grounding system whether or not a lightning protection system is required.

U. Ground metal exterior coverings and metal roofs with minimum #4 copper conductor at a minimum of two points, intervals not exceeding 100 feet.

V. Ground steel frame buildings at each corner with maximum of every 60 ft. around the outside perimeter by cadwelding #2/0 (#4/0 for buildings over 75 ft. tall) copper conductor to steel columns and extending below ground to driven ground rods; top of 0.625 inch x 10 ft. ground rod shall be minimum of 12 inches below finished grade and 3 ft. out from building foundation. Bond the water service, street side of water meter, to the adjacent perimeter steel column with #4/0 insulated copper conductor. Sleeve all concrete foundations and masonry walls with PVC sleeve.

W. Earth metal exterior coverings and metal roofs with minimum #4 copper conductor at a minimum of two points, intervals not exceeding 100 feet.

X. Connections to driven ground rods or other such electrodes shall be a minimum of three feet from the foundation wall or beyond the roof drip line, whichever is greater. Do not install ground rods in backfill.

Y. The electrodes (driven ground rods) of the electrical grounding system shall not be used for the electrodes for the lightning protection system, and vice versa. However, these two systems shall be bonded together at one point.

Z. Wiring devices shall be connected with grounding jumper from ground pole on device to grounding screw in the outlet box.

AA. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

BB. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

3.4 CONNECTIONS

A. General: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells. Complete with manufacturer’s written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding-Wire Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: Where metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.

E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer’s published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.

F. Compression-Type Connections: use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

G. Moisture Protection: Where insulated grounding conductors are connected to grounding rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

B. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system. The maximum ground-resistance level shall not exceed 5 ohms.
   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.
3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System: 5 ohms.
D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526
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. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.
B. All conduit shall be supported from the building. Attachment to other pipes, conduits, ductwork, etc. will not be allowed.

1.3 DEFINITIONS
A. EMT: Electrical metallic tubing.
B. IMC: Intermediate metal conduit.
C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS
A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS
A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.
B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze hangers. Include Product Data for components.
   2. Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components.
4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 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.

B. Coordinate installation of equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

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.

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

   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. ERICO International Corporation.
   d. GS Metals Corp.
   e. Thomas & Betts Corporation.
   f. Unistrut; Tyco International, Ltd.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

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

   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. Fabco Plastics Wholesale Limited.
   d. Seasafe, Inc.
2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainles steel.
4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. 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.

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

      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.


2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.
PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. 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 communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
   6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
   7. To Light Steel: Sheet metal screws.
   8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

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

B. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529
SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. MU Division of IT Telecommunications Construction Standards and Specifications apply to this section. The Contractor shall obtain the latest revision of document and install all cables, pathways, boxes, equipment, and hardware in a manner to conform with MU Standards and Specifications.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. All empty conduit shall be furnished with a pull string.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metal conduit.

F. LFNC: Liquidtight flexible nonmetallic conduit.

G. RNC: Rigid nonmetallic conduit.

H. RMC: Rigid metal conduit (rigid steel conduit).

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

   1. Custom enclosures and cabinets.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Source quality-control test reports.

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.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Republic Conduit.
3. Western Tube and Conduit.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

E. EMT: ANSI C80.3.

F. FMC: Zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket.

H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Fittings for EMT: Steel or die-cast, compression type, and rated for ground connection.
2. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.
2.2 NONMETALLIC CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. CANTEX Inc.
6. Lamson & Sessions; Carlon Electrical Products.
7. Manhattan/CDT/Cole-Flex.
8. RACO; a Hubbell Company.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

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

1. Cooper B-Line, Inc.
2. Hoffman.
4. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 3R, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type. Flanged-and-gasketed type where shown on drawings.

E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
7. RACO; a Hubbell Company.
8. Thomas & Betts Corporation.

B. Pull and junction boxes shall be minimum 4" x 4".

C. Communications back-boxes for outlets shall be 4" x 4", 2-1/2" depth, with 2" x 4" single-gang reducer for single-gang faceplate mounting. Joint/shared boxes for power and Communications are not allowed.

D. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

E. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.

F. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

G. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, with gasketed cover.

J. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

K. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

2.5 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.6 SLEEVE SEALS

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

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
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.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit or IMC.
2. Concealed Conduit, Aboveground: Rigid steel conduit or RNC, Type EPC-80-PVC.
3. Underground Conduit: RNC, Type EPC-80-PVC, direct buried.
4. Within Underground Duct Banks: RNC, Type EPC-40-PVC.
5. Underground Conduit: RNC, Type EPC-40-PVC, when encased in minimum 3” thick concrete.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
7. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
8. EMT is not allowed to be used outdoors.
9. Rigid metal conduit shall be used for all conduit that exits the building. At least 5 feet of horizontal run out from the building shall be rigid metal conduit to allow for building settlement.
10. Elbows for rigid metal conduit, 3 inches and larger, shall be either plastic coated or tape coated (for corrosion control) rigid metal conduit to prevent damage from pulling ropes.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Physical Damage: Rigid steel conduit or IMC. Includes raceways in the following locations:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Electrical rooms.
   e. Stainwells.
   f. Within block or masonry walls.
3. Concealed Above Hung Ceilings and Within Interior Sheet Rock Walls and Partitions: EMT.
4. Underground Conduit: Rigid steel conduit or IMC, below concrete. Conduit is not allowed within poured concrete.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations. Length not to exceed 6 ft.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway or EMT.
8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
C. Concealed: FMC ½” inch – only in specific locations, in existing areas, within existing walls to remain. Utilize only between box in wall to junction box above ceiling. Junction box shall be located within 12” above hung ceiling. FMC, within walls, not acceptable in other locations.

D. Minimum Raceway Size: 3/4-inch trade size, except for Communications cabling which shall be minimum raceway size 1-inch.

E. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
   2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

F. Install raceways underground or below floor only for locations indicated on drawings.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping. Do not install horizontal raceway directly and parallel under cold water or chilled water pipes. In general, install raceways as high as possible, closer to underside of structure. Install horizontal raceways minimum 8 inches above ceilings.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Install temporary closures to prevent foreign matter entering the raceways.

F. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

G. Install no more than the equivalent of three 90-degree bends in any conduit run.

H. Conceal conduit and EMT within finished walls and ceilings, unless otherwise indicated.

I. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
   1. Run parallel or banked raceways together on common supports.
   2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

J. Join raceways with fittings designed and approved for that purpose and make joints tight.
   1. Use insulating bushings to protect conductors.

K. Utilize compression fittings only with suitable tools.

L. Raceways embedded in slabs is not allowed.

M. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

P. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with one (1) locknut, use two (2) locknuts: one (1) inside and one (1) outside the box.

Q. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

S. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. Raceway shall be sized to include minimum 33% spare cable capacity for future adds.
2. 1-Inch Trade Size and Larger:
   a. Install raceways in maximum lengths of 150 feet.
   b. Install with a maximum of three 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements.
   c. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

3. Conduits shall not be daisy-chained together.
4. Conduit inside bend radius must be:
   a. 2" Trade size and smaller conduit: minimum bend radius of six times the conduit inside diameter.
   b. Larger than 2" Trade size conduit: minimum bend radius of 10 times the conduit inside diameter.

5. Conduit fill limits in terms of maximum number of Category 6 cables shall be as follows:
   a. 1" Conduit: 5 cables
   b. 1-1/4" Conduit: 8 cables
   c. 1-1/2" Conduit: 11 cables
   d. 2" Conduit: 20 cables
   e. 3" Conduit: 47 cables
   f. 4" Conduit: 84 cables

6. Maintain following minimum clearances from cable pathways, to avoid electromagnetic interference, from the following:
   a. Motors and transformers: 4-feet
   b. Conduit and cables used for electrical power distribution: 1-foot
   c. Fluorescent lighting: 5-inches

7. Pull boxes shall be placed directly after a bend where possible, or sized accordingly if the pull box is located at the bend.
8. 1-inch minimum conduit shall extend from outlet backbox, to above accessible ceiling with minimum 12-inches clearance above ceiling, turn 90-degrees, and be reamed and installed with a
nylon insultated bushing to avoid damage to cables. This conduit must terminate before passing 
through a fire rated wall.

9. When using architect- and owner- approved surface mount raceway, a Wiremold # 5744S outlet 
box or approved equal shall be provided. Dual channel raceway such as Wiremold 4000 shall use 
a V/G4007C-1 device plate.

T. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed 
sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover 
plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the 
following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

U. Expansion-Joint Fittings: Install UL approved expansion fittings in each run of aboveground conduit that is 
located at building expansion joint. Length of fittings shall not exceed 6 inches.

V. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit from junction boxes to 
recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or 
movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Flexible conduit from light fixture to lighting fixture not allowed.

W. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install 
box flush with surface of wall.

X. Set metal floor boxes level and flush with finished floor surface.

Y. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

Z. All raceways terminating a junction boxes, located above ceiling shall be provided with color coded vinyl 
tape indicating the service. Color coding tape shall be applied next to the junction box. Tape color shall 
match junction box cover color.

AA. The height of the center of outlets above the finished floor, if not otherwise specified or shown on 
drawings, shall be as following:

<table>
<thead>
<tr>
<th>Type of Outlet</th>
<th>Height Above Finished Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting Brackets</td>
<td>As indicated on drawings</td>
</tr>
<tr>
<td>Switch Outlets</td>
<td>3'-10&quot; to centerline</td>
</tr>
<tr>
<td>Convenience Receptacle</td>
<td>1'-6&quot; (1'-3&quot; to bottom of box) *</td>
</tr>
<tr>
<td>Telephone Outlet</td>
<td>1'-6&quot; (1'-3&quot; to bottom of box) *</td>
</tr>
<tr>
<td>Data Outlet</td>
<td>1'-6&quot; (1'-3&quot; to bottom of box) *</td>
</tr>
<tr>
<td>Wall Telephone Outlet</td>
<td>3'-10&quot; to centerline **</td>
</tr>
<tr>
<td>Fire Alarm Manual Pull Stations</td>
<td>3'-10&quot; to centerline **</td>
</tr>
<tr>
<td>Audio /Visual Alarms</td>
<td>6'-6&quot; to bottom of device ***</td>
</tr>
</tbody>
</table>

* Minimum height of 1'-3" to meet ADA Standards
** Mount at 5'-6" in Mechanical Rooms
*** Maximum of 6' below finished ceiling whichever is least unless shown or indicated otherwise

Note: Where receptacles are shown installed above countertops, mount receptacles no less than 6" 
centerline above tops of splash back. See architectural elevations case work shop drawings for 
determining exact heights.
3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section “Common Work Results for Electrical”.

2. Install backfill as specified in Section "Common Work Result for Electrical".

3. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.

   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

5. Warning Tape: A red plastic tracer tape is to be buried 12” above conduit in all installations.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. 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.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:

   1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.

   2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.

E. 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.

F. Cut sleeves to length for mounting flush with both surfaces of walls.

G. Extend sleeves installed in floors 2 inches above finished floor level.

H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."

3.5 SLEEVE-SEAL INSTALLATION

A. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.7 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.8 CLEANING

A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes. Remove burrs, dirt, and construction debris.

END OF SECTION 260533
SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Identification for raceways.
   2. Identification of power and control cables.
   3. Identification for conductors.
   5. Warning labels and signs.
   6. Instruction signs.
   7. Equipment identification labels.
   8. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.


D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

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

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding of Conductor Tape: All service, feeder and branch circuit conductors, rated for 600V or less shall be factory color-coded as specified herein. Field applied labels, tapes or bands not acceptable.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
2.5 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 WARNING LABELS AND SIGNS


B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.7 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Minimum 0.0625 inch thick adhesive backed, with white letters on a black background. Minimum letter height shall be 3/8 inch.

2.9 JUNCTION/PULL BOX COVER IDENTIFICATION

A. Paint all junction and pull box covers to identify service and voltage as follows:

1. 120V Normal power – Green.

B. All covers shall identify circuit numbers, panel designation, voltage and service. Identification shall be done by black magic markers.

2.10 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.

B. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS
A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Verify identity of each item before installing identification products.
B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
C. Apply identification devices to surfaces that require finish after completing finish work.
D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas, within mechanical rooms, chiller rooms and boiler rooms.
G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.
H. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.
3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for All Service, All Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label or self-adhesive vinyl tape applied in bands. Install labels at 20-foot maximum intervals. The identification will include source board/panel and target board/panel. Use black letters on orange background.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box as specified herein.

C. Power-Circuit Conductor Identification, 600 V or Less: Factory color-code conductors as listed below:

1. Colors for 208/120-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
   e. Ground: Green.
   f. Switch Legs: Pink.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels or Baked-enamel warning signs or Metal-backed, butyrate warning signs.

2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.
J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:
   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label or Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label 4 inches high.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   d. Unless provided with self-adhesive means of attachment, fasten labels with
   e. Use appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
   f. The label shall include voltage, phases, number of wires, and board/switchgear/equipment served from. (Example: Panelboard BL-20-LN; 120/208 volts, 3 phase, 4 wire, served from board DP-B1-HN).

2. Equipment to Be Labeled:
   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Switchboards.
   e. Enclosed switches.
   f. Enclosed circuit breakers.
   g. Enclosed controllers.
   h. Push-button stations.
   i. Contactors.
   j. Remote-controlled switches, dimmer modules, and control devices.
   k. Battery-inverter units.
   l. Monitoring and control equipment.
SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY AND ARC FLASH HAZARD ANALYSIS

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 computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study. The study shall include short circuit evaluation, device evaluation, device coordination and arc flash evaluation.

B. The Owner shall be furnished short-circuit and protective device coordination studies as prepared by contractor.

C. Contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current issue of NFPA 70E – Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 – 2002, the IEEE Guide for Performing Arc-Flash Calculations.

D. The scope of the studies shall include the electrical distribution equipment shown on the plans.

E. Service Entrance Equipment:

1. All overcurrent protective devices installed in service entrance panels.

F. Feeder Circuits:

1. All three (3) phase feeder circuit protective devices installed with a rating equal to or greater than 30 amps.

G. Branch Circuits:

1. All three (3) phase branch circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
2. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

H. A preliminary study has been performed by the consultant. This preliminary study will be made available to the contractor.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
C. Qualification Data: For coordination-study specialist.

D. The studies shall be submitted to the Owner and Engineer for review and approval prior to final completion.

E. A preliminary Arc Flash Hazard Analysis shall be submitted to the Owner’s Representative and Engineer with new electrical equipment submittals. Equipment submittals will not be reviewed without the study specified herein.

F. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of two (2) bound color copies of the complete final report shall be submitted. Electronic PDF copies of the report shall be provided. Two (2) CDs containing all study files, including all device curves shall be provided (use the SKM “Project-Backup” command).

G. The report shall include the following sections:
1. Executive Summary including introduction, Scope of Work and Results/Recommendations.
2. Short-Circuit Methodology, Analysis Results and Recommendations.
3. Short-Circuit Device Evaluation Table.
4. Protective Device Coordination Methodology Analysis Results and Recommendations.
5. Protective Device Settings Table.
7. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.
8. Arc Flashing Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
9. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, devices numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.

H. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital form.
1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.
4. Setting report.
5. Arc flash calculations and report.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer. Submitted study shall bear the seal of the professional engineer.

C. The Registered Professional Electrical Engineer shall be an employee of the approved firm providing the study.
D. The Registered Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies.

E. The approved firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.

F. The engineering firm shall have a minimum of ten (10) years of experience in performing power system studies.

G. The study shall include the stamp or seal and signature of the preparing engineer and shall be reviewed and approved by the Engineer of Record.

H. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

I. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Acceptable Computer Software Developers: Subject to compliance with requirements, provide products by SKM Systems Analysis, Inc. only. The study shall be performed using the latest version of SKM Systems Analysis Power Tools of Windows (PTW 32).

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

   a. Arcing faults.
   b. Simultaneous faults.
   c. Explicit negative sequence.
   d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.

B. Proceed with coordination study only after relevant equipment submittals have been assembled.
3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Impedance of utility service entrance.

3. Electrical Distribution System Diagram: In two (2) hard-copy and two (2) CD electronic-copy formats, PDF submittals, showing the following (use SKM ‘project Backup’ command):
   a. Circuit-breaker and fuse-current ratings and types.
   b. Relays and associated power and current transformer ratings and ratios.
   c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   d. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
   e. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Ratings, types, and settings of utility company's overcurrent protective devices.
   e. Special overcurrent protective device settings or types stipulated by utility company.
   f. Time-current-characteristic curves of devices indicated to be coordinated.
   g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   i. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchgear and switchboard bus.
2. Motor-control center and starters.
3. Distribution panelboard.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Utilize approved computer software program. Include studies of system-switching configurations and alternate operations that could result in maximum fault including arcing fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141 and IEEE 242.

1. Transformers:
   a. ANSI C57.12.10.
   b. ANSI C57.12.22.
   c. ANSI C57.12.40.
   d. IEEE C57.12.00.
   e. IEEE C57.96.

4. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
2. Show momentary (1/2 cycle), interrupting (5-cycle), 30-cycle fault-current values for 3-phase, 2-phase and phase-to-ground faults and time-delayed currents (6 cycles and above) on medium-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY


1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
3. Calculate the maximum and minimum ground-fault currents.

B. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.

C. Include on each TCC graph, a complete title with descriptive device names.

D. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

E. Identify the device associated with each curve by manufacturer type, function, and if applicable, tap, time delay, and instantaneous settings recommended.

F. Plot the following characteristics on the TCC graphs, where applicable.

1. Electric utility’s overcurrent protective device.
2. Low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands.
3. Low voltage equipment circuit breaker trip devices, including manufacturer’s tolerance bands.
4. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
5. Ground fault protective devices, as applicable.
6. Pertinent motor starting characteristics and motor damage points, where applicable.
7. The largest feeder circuit breaker in each motor control center and applicable panelboard.

G. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

H. Provide the following:
1. A one-line diagram shall be provided which clearly identified individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus.
2. A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
3. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
4. The study shall include a separate, tabular printout containing the recommended settings of all adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram
5. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
6. Contractor shall notify Owner in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.

I. Comply with IEEE 141 and IEEE 242 recommendations for fault currents and time intervals.

J. Transformer Primary Overcurrent Protective Devices:
1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

K. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

L. The protective device settings must address the need to minimize arc flash hazards while maintaining proper coordination.

M. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
   a. Device tag.
b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

N. Completed data sheets for setting of overcurrent protective devices.

O. Main service entrance switch shall be set to coordinate with utility company.

3.5 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer’s Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of overcurrent protective devices within equipment.

B. Testing: Perform the following device setting and prepare reports:

1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

   a. Verify that overcurrent protective devices meet parameters used in studies.
   b. Adjust devices to values listed in study results.

2. Adjust devices according to recommendations in Chapter 7, “Inspection and Test Procedures”, and Tables 10.7 and 10.8 in NETA ATS.

3.6 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA 70E-2009, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis and the protective device time-current coordination analysis.

B. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, starters, panelboards) where work could be performed on energized parts.

C. The analysis shall be based on the specific devices installed and include (but not be limited to) the following:

1. Service Entrance Equipment:

   a. All overcurrent protective devices installed in service entrance panels.
2. Feeder Circuits:
   a. All three (3) phase feeder circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.

3. Branch Circuits:
   a. All three (3) phase feeder circuit overcurrent protective devices installed with a rating equal to or greater than 30 amps.
   b. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

4. Motor Control Centers:
   a. All motor circuit overcurrent protective devices for motors with a rating equal to or greater than 10 horsepower.

D. Working distances shall be based on IEEE 1685. The calculated arc flash protection boundary shall be determined using these working distances.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

F. The short-circuited calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

1. The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Alternative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault coordination from motors should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 5 cycles.

H. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear, and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment’s main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.

I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to complete the incident energy for the corresponding location.
K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 Section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

L. Provide the following:
   1. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
   2. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
   3. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

M. Settings shall minimize arc flash risk while maintaining coordination.

N. No location shall be greater than 8 cal.

3.7 FIELD ADJUSTMENT
   A. The contractor shall adjust relay and protective device settings according to the recommended setting table provided by the coordination study.
   B. The contractor shall make modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
   C. The Arc Flash Hazard Analysis shall be reviewed and updated to reflect any changes and corrections to conductor length within one week of the final electrical walk through for punch list.

3.8 ARC FLASH LABELS
   A. Contractor shall provide a 4.0 in. x 4.0 inc. thermal transfer type label of high adhesion polyester for each work location analyzed. The labels shall be waterproof.
   B. The labels shall be designated according to the following standards:
      2. ANSI Z535.4 – Product Safety Signs and Labels.
      3. NFPA 70 (National Electric Coe) – Article 110.16.
   C. The label shall include the following information:
      1. System Voltage:
         a. Flash protection boundary.
         b. Personal Protection Equipment category.
         c. Arc-Flash Incident energy value (cal/cm²).
         d. Limited, restricted and prohibited Approach Boundaries.
            1) Study report number and issue date.
   D. Labels shall be printed by a thermal transfer type printer, with no field markings.
E. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:

1. Floor Standing Equipment: Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.

2. Wall Mounted Equipment: Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.

   a. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

F. Owner and engineer approved Arc Flash Hazard warning labels shall be furnished and installed by the contractor prior to project completion.

END OF SECTION 260573
SECTION 260923 - LIGHTING CONTROL DEVICES

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 lighting control devices:

1. Indoor occupancy sensors.
2. Lighting contactors.

B. Related Sections include the following:

1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

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

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product 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 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.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY SENSORS

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

1. Hubbell Lighting.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Sensor Switch, Inc.
5. TORK.
6. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, 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 1 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-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
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.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot-high ceiling.

D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch-high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch-high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot-high ceiling in a corridor not wider than 14 feet.

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.

2.2 LIGHTING CONTACTORS

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

2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
4. GE Industrial Systems; Total Lighting Control.
5. Grasslin Controls Corporation; a GE Industrial Systems Company.
6. Hubbell Lighting.
7. Lithonia Lighting; Acuity Lighting Group, Inc.
9. Square D; Schneider Electric.
10. TORK.
11. Watt Stopper (The).

B. Description: Electrically operated and mechanically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less 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 with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.

2. Control: On-off operation.
2.3 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "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 Division 26 Section "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 Division 26 Section "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 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.

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 Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.
3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of final acceptance by Owner, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923
SECTION 262416 - PANELBOARDS

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. Lighting and appliance branch-circuit panelboards.

B. Load centers are not allowed.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Short-circuit current rating of panelboards and overcurrent protective devices.

5. Include evidence of NRTL listing for series rating of installed devices.

6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

7. Include wiring diagrams for power, signal, and control wiring.

8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

9. Equipment submittals will not be reviewed without study specified within Section 260573.

C. Field Quality-Control Reports:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
D. Panelboard Schedules: As indicated on drawings.

E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 104 deg F.
   b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Architect's written permission.
3. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of final acceptance by Owner.

1.10 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. Keys: Two spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

2. Front: Secured to box with screws or bolts. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

4. Finishes:
   a. Panels and Trim: Steel or galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: Same finish as panels and trim.


B. Incoming Mains Location: Top or bottom.

C. Phase, Neutral, and Ground Buses:
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material and sizes.
   2. Main and Neutral Lugs: Compression type.
   3. Ground Lugs and Bus-Configured Terminators: Compression type.
   5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Panelboards rated 240 Vac or less shall be equipped with bolt on branch circuit breakers, panelboards shall have short circuit ratings as shown on the drawings or as herein scheduled, but not less than 10,000 amperes RMS symmetrical.

G. Size and location of panels shall be as shown on drawings. In general, all panelboards shall be 42 circuits capacity unless noted otherwise.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.3 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

2.4. ENERGY MONITORING: Provide and install an energy meter for each panelboard indicated on project electrical drawings.

A. Manufacturers: Subject to compliance with requirements, provide the following products:
1. E-Mon Energy Monitoring Products – Class 5000 Smart Meter

B. Meter shall be fully electronic with 4 line LCD display showing kwh.

C. Meter shall utilize 0-2 volt AC output current sensors to allow paralleling and/or mounting up to 500 feet from the meter. Sensors shall be of split-core configuration to allow installation without disconnecting cabling, etc. Sensors shall be available from 100 amp to 3200 amp. Sensors shall be optionally available in solid-core configuration (100 & 200 amp.)

D. Meter shall provide current sensor installation diagnostics indicator, phase error indicator and phase angle diagnostics on display.

E. Meter shall be field programmable for meter date/time, IP address and ID code for communication options.

F. Meter shall be enclosed in a NEMA 4X polycarbonate enclosure (standard) with padlocking hasp & mounting flanges for indoor/outdoor installation (stand alone) with one 1 1/16” KO on bottom of enclosure. Optional heavy duty JIC steel enclosure available for indoor installation.

G. Meter shall be UL/CUL Listed to latest applicable standards for safety.

H. Meter shall meet or exceed ANSI C12.20 accuracy standards.

I. Meter shall provide non-volatile memory to maintain reading during power outages.

J. Meter shall store interval data for kW and kVAR for up to 72 days in first-in first-out format.

K. Meter works as a master device on BACnet MS/TP.

L. Meter shall provide optional 5th & 6th channel for logging inputs from third-party metering devices (gas, water, BTU, etc.) Both channels provide interval data logging that can be read via E-Mon Energy software and Modbus.

M. Meter shall be capable of daisy-chain or star connection using RS-485 communications in combinations of Class 3200s, 3400s, 5000s, IDR-8s, IDR-16s not to exceed 52 devices. Cabling shall be through RJ-11 modular jack (4-conductor) or terminal block (3-conductor), 18-26 AWG, up to 4,000 cable feet total.

N. Meter shall be MV-90 compatible.

O. Meter shall provide real time kw data via BacNET.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Mount top of trim 74 inches above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges in accordance with coordination study.

F. Install filler plates in unused spaces.

G. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

I. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner’s final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
   c. Instruments and Equipment:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports; including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated in Division 26 Section "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   1. Measure as directed during period of normal system loading.
   2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416
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SECTION 262726 - WIRING DEVICES

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. Receptacles, receptacles with integral GFCI, and associated device plates.
      2. Twist-locking receptacles.

1.3 DEFINITIONS
   A. EMI: Electromagnetic interference.
   B. GFCI: Ground-fault circuit interrupter.
   C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
   D. RFI: Radio-frequency interference.
   E. TVSS: Transient voltage surge suppressor.
   F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
   C. Field quality-control test reports.
   D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE
   A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
   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 NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
   1. Cord and Plug Sets: Match equipment requirements.

1.7 EXTRA MATERIALS

A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Floor Service Outlet Assemblies: One for every 10 installed, but no fewer than one.
   2. Receptacles: One for every 20 installed, but no fewer than two.
   3. Snap Switches: One for every 20 installed, but no fewer than two.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers' Names: Subject to compliance with requirements, provide products by one of the following:
   1. Wiring Devices (Receptacles, Switches):
      a. Cooper Wiring Devices.
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Mfg. Company Inc.
      d. Pass & Seymour/Legrand; Wiring Devices Div.
   2. Occupancy Sensors:
      a. Cooper Industries, Inc.
      b. Hubbell Incorporated.
      d. Pass & Seymour/Legrand.
      e. The Watt Stopper.
   3. Poke-Through and Floor Service Outlets:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Pass & Seymour/Legrand; Wiring Devices Div.
      c. Square D/Groupe Schneider NA.
      d. Thomas & Betts Corporation.
      e. Wiremold Company (The).
   4. Multioutlet Assemblies:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Wiremold Company (The).
2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498, and FS W-C-596.

1. Description: Grounding system shall be all brass and integral to the wrap around mounting strap (single-piece with no rivets or mechanical connections in the primary path between the point of ground wire termination and ground blades). NOTE: specific catalog numbers are not listed below. This product description (or similar verbiage) must be highlighted in the submittal documents to confirm this performance requirement has been satisfied.

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A.

2.4 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.5 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A.

C. Switches shall be heavy-duty, quiet type.

D. Pilot Light Switches, 20 A:

1. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

E. Key-Operated Switches, 120/277 V, 20 A:

1. Description: Single pole, with factory-supplied key in lieu of switch handle.

F. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

G. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
2.6 OCCUPANCY SENSORS

A. Wall-Switch Sensors:
   1. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

B. Wall-Switch Sensors:
   1. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

C. Long-Range Wall-Switch Sensors:
   1. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft.

D. Long-Range Wall-Switch Sensors:
   1. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft.

E. Wide-Range Wall-Switch Sensors:
   1. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft.

2.7 WALL PLATES

A. Single and combination types to match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.8 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.
   1. Wiring Devices: Ivory or White or As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 APPLICATION

A. Wiring devices, on emergency power circuits, shall be red in color.
B. All wall plates within a room or area shall be same type – thermosplastic. Mix matching of wall plates shall not be acceptable.

3.2 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail, or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:
   1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
   10. Install devices and assemblies level, plumb and square with building lines.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles at top, and on horizontally mounted receptacles to the right.
   2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
   3. Install ground pin of vertically mounted receptacles, located more than 60” above floor, at bottom.
F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
   1. Install dimmers within terms of their listing.
   2. Verify that dimmers used for fan speed control are listed for that application.
   3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

J. Install GFCI receptacles as shown on drawings and within 60 inches of water source.

3.3 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
   1. Receptacles and Switch Wall Plates: Identify panelboard and circuit number from which served. Use engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 5 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 262726
SECTION 262813 - FUSES

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. Cartridge fuses rated 600-V ac and less for use in enclosed switches, panelboards, switchboards, enclosed controllers and motor-control centers.

2. Spare-fuse cabinets.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.

   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.


4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.

2. Current-limitation curves for fuses with current-limiting characteristics.

3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

4. Coordination charts and tables and related data.
1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

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

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.7 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
2.3 PLUG FUSES
   A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.4 PLUG-FUSE ADAPTERS
   A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

2.5 SPARE-FUSE CABINET
   A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
      1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
      2. Finish: Gray, baked enamel.
      3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
      4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
   B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
   C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
   D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
   E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS
   A. Cartridge Fuses:
      1. Service Entrance: Class L, fast acting.
      2. Feeders Rated for More than 600 Amps: Class L, fast acting.
      3. Feeders Rated Less than 600 Amps: Class J, time delay.
      4. Motor Branch Circuits: Class RK1, time delay.
      5. Other Branch Circuits: Class RK5, non-time delay.
      6. Control Circuits: Class CC, fast acting.
   B. Plug Fuses:
      2. Other Branch Circuits: Edison-base type, dual-element time delay.
3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.

C. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

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 SUMMARY

A. Section Includes:
   1. Fusible disconnect switches.
   2. Nonfusible disconnect switches.
   3. Receptacle switches.
   4. Shunt trip switches.
   5. Molded-case circuit breakers (MCCBs).
   7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.
B. NO: Normally open.
C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of NRTL listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.

C. Field quality-control reports.
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

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

1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's written permission.
4. Comply with NFPA 70E.

1.7 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
1.8 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2. General Electric Company.
3. Square D; Group of Schneider Electric.

2.2 FUSIBLE DISCONNECT SWITCHES

A. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position. Furnish and install an operator override to allow the door to be opened without having to open the switch.

B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Lugs: Compression type, suitable for number, size, and conductor material.

2.3 NONFUSIBLE DISCONNECT SWITCHES

A. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Lugs: Compression type, suitable for number, size, and conductor material.
2.4 RECEIPTACLE SWITCHES
   A. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 600-V ac, 60 A and smaller; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
   B. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.5 SHUNT TRIP SWITCHES
   A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
   B. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
   C. Control Circuit: 120-V ac; obtained from a control power source of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
   D. Accessories:
      1. Oiltight key switch for key-to-test function.
      2. Oiltight red ON pilot light.
      3. Isolated neutral lug; 100 percent rating.
      4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
      5. Form C alarm contacts that change state when switch is tripped.

2.6 MOLDED-CASE CIRCUIT BREAKERS
   A. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
   C. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
      1. Instantaneous trip.
      2. Long- and short-time pickup levels.
      3. Long- and short-time time adjustments.
      4. Ground-fault pickup level, time delay, and I^2t response.
   E. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
   F. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
H. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

I. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.7 MOLDED-CASE SWITCHES

A. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

B. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.

2.8 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 12.
2. Outdoor Locations: NEMA 250, Type 3R.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
D. Install fuses in fusible devices.
E. Comply with NECA 1.
F. Circuit breakers and switches installed in existing switchgear and switchboard shall have interrupting capacity to match interrupting capacity of switchgear, switchboard, panelboard in which they are installed.

3.3 IDENTIFICATION
A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL
A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
C. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.
D. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".
SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable frequency controllers.

1.2 REFERENCE STANDARDS


B. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives; National Electrical Manufacturers Association.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association.


1.3 SUBMITTALS

A. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

B. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Test Reports: Indicate field test and inspection procedures and test results.

D. Manufacturer’s Instructions: Indicate application conditions and limitation of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

E. Manufacturer’s Field Reports: Indicate start-up inspection findings.

F. Operation Data: NEMA ICS 7.1: Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

G. Maintenance Data: NEMA ICS 7.1: Include routine preventive maintenance schedule.

1.4 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five years documented experience and with service facilities within 200 miles of Project.
C. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer’s written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Toshiba, Model Q9 or Model FS1: www.toshiba.com.


C. Yaskawa; Model Z1000: www.yaskawa.com.

2.2 DESCRIPTION

A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified feature and options in accordance with NEMA ICS 3.1.

1. Employ microprocessor-based inverter logic isolated from power circuits.
2. Employ pulse-width-modulated inverter system.
3. Include a DC link reactor for reduction of harmonic distortion.
4. The controller, and all associated components, shall be supplied by a single vendor.
5. The controller will be operating a variable volume fan motor, or water pump motor for HVAC application.
6. System voltage shall be indicated on front of ASD, using minimum of 1-inch high letters.

B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public. No disconnects in VFD cabinet. Disconnect must be in separate enclosure.

2.3 OPERATING REQUIREMENTS

A. Rated Input Voltage for Motors Rated below 40 HP: 200 volts, three phase, 60 Hertz, with a voltage tolerance of +/- 10% and a frequency tolerance of +/- 2 Hz.

B. Rated Output: Output frequency shall vary between 0.1 Hz and 400 Hz. Frequency resolution shall be 0.01 Hz digital and 0.03 Hz analog with an accuracy of +/- 0.2% of maximum frequency at 25 degrees Celsius. Maximum voltage frequency shall be adjustable from 25 Hz to 400 Hz. Voltage boost shall be adjustable from 0% to 30% with starting frequency adjustable from 0 Hz to 10 Hz. The output current shall be 100% continuous and 110% for 60 seconds, based on NEC Table 430-150 (Full-Load Current, Three-Phase Alternating Current Motors) for 200 volts or 460 volts.

C. The drive shall be rated to run continuously at the connected motor FLA without being in the service factor.
D. The controller shall contain three critical frequency jump points with individual bandwidth. Upper and lower frequency limits shall be capable of being varied.

E. The PWM carrier frequency shall be adjustable from 5000 Hz to 15000 Hz.

F. The drive shall contain two separate acceleration/deceleration times (0.1 to 6000 seconds) with a choice of linear, S or C curves. The drive shall have a standard dynamic electric braking for motors rated 30 HP or below. The drive shall restart into a rotating motor by sensing the coasting motor speed and matching that frequency. The drive shall have adjustable soft stall (10%-150%) and adjustable electronic overload protection (10%-100%).

G. The drive shall have external fault input, be capable of re-setting faults remotely and locally.

H. Input Signal:
   1. 0 to 10 v DC.
   2. 0 to 5 v DC.
   3. 4 to 20 mA DC.

I. Manual bypass is not required on VFD unless indicated on bid documents.

2.4 COMPONENTS

A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current, output power (kw), and motor RPM.

2.5. ENERGY MONITORING: Provide and install an energy meter for each Variable Frequency Drive indicated on project electrical drawings.

A. Manufacturers: Subject to compliance with requirements, provide the following products:
   1. E-Mon Energy Monitoring Products – Class 5000 Smart Meter

B. Meter shall be fully electronic with 4 line LCD display showing kwh.

C. Meter shall utilize 0-2 volt AC output current sensors to allow paralleling and/or mounting up to 500 feet from the meter. Sensors shall be of split-core configuration to allow installation without disconnecting cabling, etc. Sensors shall be available from 100 amp to 3200 amp. Sensors shall be optionally available in solid-core configuration (100 & 200 amp.)

D. Meter shall provide current sensor installation diagnostics indicator, phase error indicator and phase angle diagnostics on display.

E. Meter shall be field programmable for meter date/time, IP address and ID code for communication options.

F. Meter shall be enclosed in a NEMA 4X polycarbonate enclosure (standard) with padlocking hasp & mounting flanges for indoor/outdoor installation (stand alone) with one 1 1/16" KO on bottom of enclosure. Optional heavy duty JIC steel enclosure available for indoor installation.

G. Meter shall be UL/CUL Listed to latest applicable standards for safety.

H. Meter shall meet or exceed ANSI C12.20 accuracy standards.

I. Meter shall provide non-volatile memory to maintain reading during power outages.

J. Meter shall store interval data for kW and kVAR for up to 72 days in first-in first-out format.
K. Meter works as a master device on BACnet MS/TP.

L. Meter shall provide optional 5th & 6th channel for logging inputs from third-party metering devices (gas, water, BTU, etc.) Both channels provide interval data logging that can be read via E-Mon Energy software and Modbus.

M. Meter shall be capable of daisy-chain or star connection using RS-485 communications in combinations of Class 3200s, 3400s, 5000s, IDR-8s, IDR-16s not to exceed 52 devices. Cabling shall be through RJ-11 modular jack (4-conductor) or terminal block (3-conductor), 18-26 AWG, up to 4,000 cable feet total.

N. Meter shall be MV-90 compatible.

O. Meter shall provide real time kw data via BacNET.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NEMA ICS 7.1, manufacturer's instructions, and per drawings.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Provide engraved plastic nameplates; refer to Section 260553 (16075) for product requirements and location.

D. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

E. When remote service disconnect is required, provide with auxiliary contacts hardwired to VFD safety circuit to shut down VFD, if disconnect is opened.

3.2 FIELD QUALITY CONTROL

A. Prior to initial energization, provide the service of the manufacturer's field representative to prepare and start controllers.

3.3 MAINTENANCE

A. Furnish two extra of each air filter.

B. Provide service and maintenance of controllers for one year from Date of Substantial Completion.

END OF SECTION 262923
SECTION 265100 - INTERIOR 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 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections include the following:

1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. BF: Ballast factor.
B. CRI: Color-rendering index.
C. CU: Coefficient of utilization.
D. HID: High-intensity discharge.
E. LER: Luminaire efficacy rating.
F. Luminaire: Complete lighting fixture, including ballast housing if provided.
G. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
5. Life, output, and energy-efficiency data for lamps.
6. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

   a. Photometric data shall be certified by a qualified independent testing agency.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

C. Coordination Drawings: Reflected ceiling plan(s) 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. Lighting fixtures.
   2. Suspended ceiling components.
   3. Structural members to which suspension systems for lighting fixtures will be attached.

D. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

G. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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 NFPA 70.

D. FMG Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

   1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of final acceptance by Owner. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
B. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Electronic Ballasts: Five years from date of final acceptance by Owner.
2. Warranty Period for Electromagnetic Ballasts: Three years from date of final acceptance by Owner.

C. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.

1. Warranty Period: Two year(s) from date of final acceptance by Owner.

1.8 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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2. Troffers:
   a. Columbia Lighting; Division of Hubbell Lighting.
   b. LSI Midwest Lighting.
   c. Metalux.
   d. H. E. Williams Inc.
3. Strip Fluorescent Fixtures:
   a. Columbia Lighting; Division of Hubbell Lighting.
   b. Lithonia Lighting.
   c. LSI Midwest Lighting.
   d. H. E. Williams Inc.
4. Exit Signs and Emergency Lighting:
   a. Dual-Lite; Division of Hubbell Lighting.
   b. Emergi-lite; Division of Thomas and Betts.
c. Failsafe; Division of Cooper Lighting.
d. Hubbell Lighting, Inc.
e. Lithonia Lighting.
f. Prescolite; Division of Hubbell Lighting.
g. Surelite; division of Cooper Lighting.

5. Downlighting (Recessed, Surface, HID):
   a. Edison Price Lighting.
   b. Halo; Division of Cooper Lighting.
   c. Hubbell Lighting, Inc.
   d. Infinity Lighting.
   e. The Kirlin Company.
   f. Kurt Versen Co.
   g. Lithonia Lighting.
   h. Lightolier; Division of Genlyte Thomas Co.
   i. Prescolite; division of Hubbell Lighting.
   j. Rambusch Lighting.

C. In order to create a controlled, competitive bidding climate, the Lighting Fixture Schedule, as indicated on the drawings, was developed around the manufacturer listed in the schedule. Equal products from the manufacturers listed will be acceptable. In limited circumstances, for various reasons, certain fixtures were deemed to be proprietary. In these cases, the language, “No substitutions”, is intended to provide the electrical distributors bidding the job with the ability to assemble the most competitive lump sum price for the lighting fixture/lamp package. The electrical distributor, therefore, has the authority to require unit pricing from the manufacturer’s representatives for those products so specified.

D. Light Fixture Schedule as indicated on drawings.

E. Lamps: Subject to compliance with requirements, provide products by one of the manufacturers specified.
   2. Philips Electronics.
   4. Osram Sylvania.
   5. Westinghouse Corporation.

F. Ballasts: Subject to compliance with requirements, provide products by one of the manufacturers specified.
   1. Advance; Division of Philips Electronics.
   2. General Electric Company.
   3. Lutron Products.
   4. Osram Sylvania.
   5. Universal.

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

H. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

I. 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: At least 0.125 inch minimum unless different thickness is indicated.
   b. UV stabilized.
2. Glass: Annealed crystal glass, unless otherwise indicated.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. Electronic Ballasts: Comply with ANSI C82.11; instant-start type, high frequency 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. Plug in type disconnect and end of life sensor. Ballast shall be Class “P” and CSA Certified and shall comply with FCC and NEMA limits governing electromagnetic and radio frequency interference.

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: 20 kHz or higher.
5. Lamp Current Crest Factor: 1.7 or less.
6. BF: 0.85 or higher.
7. Power Factor: 0.95 or higher.
8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

B. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 and the following:

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: 0.95 or higher.
C. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.


D. Single Ballasts for Multiple Lighting Fixtures: Factory-wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

E. Ballasts for Low-Temperature Environments:

1. Temperatures 0 Deg F and Higher: Electronic or electromagnetic type rated for 0 deg F starting and operating temperature with indicated lamp types.
2. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.

F. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.

G. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

1. Dimming Range: 100 to 10 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.

H. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
   a. High-Level Operation: 100 percent of rated lamp lumens.
   b. Low-Level Operation: 50 percent of rated lamp lumens.
2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
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: 0.95 or higher.
10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
2.5 EMERGENCY FLUORESCENT POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate 1 fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Night-Light Connection: Operate one fluorescent lamp continuously.
3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Night-Light Connection: Operate one fluorescent lamp in a remote fixture continuously.
5. Housing: NEMA 250, Type 1 enclosure.
6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.6 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
   a. Battery: Sealed, maintenance-free, nickel-cadmium type.
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.
   c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
   g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

3. Master/Remote Sign Configurations:
   a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
   b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.7 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.
2.8 FLUORESCENT LAMPS

A. 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.

B. T8 rapid-start low-mercury lamps, rated 31 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 80 (minimum), color temperature 3500 K, and average rated life 20,000 hours, unless otherwise indicated.

C. T8 rapid-start low-mercury lamps, rated 25 W maximum, nominal length of 36 inches 2,000 initial lumens (minimum), CRI 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

D. T8 rapid-start low-mercury lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours, unless otherwise indicated.

E. T5 rapid-start low-mercury lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 20,000 hours, unless otherwise indicated.

F. T5HO rapid-start, high-output low-mercury lamps, rated 54 W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 20,000 hours, unless otherwise indicated.

G. Compact Fluorescent Lamps: 4-Pin, low mercury, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated. Note: Two (2) pin lamps are not acceptable.

1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
6. 55 W: T4, triple tube, rated 4300 initial lumens (minimum).

H. Headwall System: Provide lamps for patient light fixtures provided by the headwall manufacturer. The lamps shall be T8, rapid start, 32W for 4 ft. lamps and 25W for 3 ft. lamps. Coordinate type and quantity with headwall system manufacturer.

2.9 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.


E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.10 DIMMING CONTROL DEVICES

A. Dimming Controls: Sliding-handle type with on/off control; compatible with ballast and having light output and energy input over the full dimming range.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Lighting Fixtures 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 fixture. Locate not more than 6 inches from lighting fixture corners.
   2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
   4. Install at least two independent support rods or wires from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 265100
SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Protecting existing vegetation to remain.
   2. Removing existing vegetation.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Disconnecting, capping or sealing site utilities.
   7. Temporary erosion- and sedimentation-control measures.

1.2 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

B. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   1. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

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.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

F. The following practices are prohibited within protection zones:
   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 “Earth Moving.”
   1. Obtain approved borrow soil material off-site when satisfactory soil material is 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 identify trees, shrubs, and other 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 erosion- and sedimentation-control drawings and requirements of authorities having jurisdiction.
B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site.
B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Design Professional.

3.4 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
   1. Arrange with utility companies to shut off indicated utilities.
B. Interrupting 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 Design Professional not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Design Professional’s written permission.
3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
   2. Use only hand methods for grubbing within protection zones.

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, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. 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.

B. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavation for paving and grading.
   2. Excavation for Site structures.
   3. Site filing and backfilling.
   4. Drainage course for slabs-on-grade.
   5. Consolidation and compaction.
   7. Consolidation and compaction of bedding under utilities.
   8. Rough grading.

B. Related Sections:
   2. Section 311000 – Site Clearing.
   3. Section 331100 - Water Utility Distribution Piping

1.2 DEFINITIONS

A. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials, and bottom of over excavation areas if required by the contract document.

B. Subbase Course: Aggregate layer placed between the subgrade and hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

E. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill, when sufficient approved soil material is not available from excavations.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated, regardless of the character and density of materials, including reuse or disposal of materials removed.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Design Professional. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
   2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Design Professional. Unauthorized excavation, as well as remedial work directed by Design Professional, shall be without additional compensation.

G. Fill: Suitable materials used to raise existing grades.

H. Finish Grade: The top surface of sod, top surface of topsoil where sod is not indicated or exposed rock surface where indicated on the drawing.

I. Trench 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.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.3 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: For each type of material indicated in Part 2 of this section.

C. Contract Closeout Submittals: Submit in accordance with Division 1.

1. Project Record Documents.
   a. Accurately record location of underground utilities remaining, rerouted utilities, and new utilities by horizontal dimensions from above grade permanent fixtures, elevations or inverts, and slope gradients.

1.4 QUALITY ASSURANCE

A. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following:
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

B. Testing Agency: A qualified independent geotechnical engineering testing agency shall classify proposed on-Site and borrow soils to verify that soils comply with specified requirements and to perform specified field and laboratory testing.

C. Pre-excavation Conference:
   1. Convene pre-excavation conference under provision of Division 1, one week prior to commencing Work of this Section.
   2. Contractor shall be presiding officer at conference.
   3. Conference shall be attended by Contractor, Owner's Representative, testing agency, and earthwork subcontractor.
   4. Purpose of conference will be to review contract requirements and discuss schedules, work procedures, acceptable materials specified under this Section, locations where specified materials may be incorporated, and quality control.

1.5 PROJECT CONDITIONS

A. Existing Conditions:
   1. Locate existing underground utilities in areas of excavation Work.
      a. Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by Owner's Representative and then only after acceptable temporary utility services have been provided.
      b. Provide not less than 72 hours notice to Design Professional and Owner's Representative and receive written authorization to proceed before interrupting any utility.
1.6 MAINTENANCE

A. Where settling is measurable or observable at excavated areas during correction period required by General Conditions, remove surface (pavement, lawn, or other finish), add backfill material, compact as specified in this Section for location of material, and replace surface treatment.
   1. Restore appearance, quality, and condition of surface or finish to match adjacent materials.
   2. Eliminate evidence of restoration.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. Provide approved borrow soil materials from off-Site when sufficient approved soil materials are not available from excavations, at no increase in Contract Sum or extension of Contract Time.
   2. Dispose of any excess materials legally off site at no increase in contract sum or extension of contract time. On site disposal of suitable materials may only be permitted where shown on the drawings.
   3. Fill and backfill materials shall be subject to the approval of testing agency and the Owner’s Representative.
   4. For approval of fill and backfill materials, notify testing agency and Owner’s Representative at least 5 working days in advance of intention to import material.
      a. Designate proposed borrow area and excavate test pits to permit testing agency to sample as necessary from borrow area for the purpose of making acceptance tests to confirm quality of proposed material.

B. General Fill Materials
   1. Definition: That material used to obtain finish subgrade levels at locations specified under this section.
   2. Acceptable material: Excavated on-Site material or off-Site borrow material which is free from debris, organics, decomposable, and corrodible materials, and containing the proper moisture content, liquid limit, and plasticity index to obtain specified compaction requirements.
      a. Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.

C. Low Volume Change Material:
   1. Definition: That material used to obtain the upper 12 inches of finish subgrade beneath pavement areas, and material used as trench backfill material in pavement areas.
   2. Acceptable material:
      a. On-site or Off-Site borrow material which is free from debris, organics, decomposable, and corrodible materials with a liquid limit of less than 50 percent and a plasticity index less than 30, or another material acceptable to the testing agency.
         1) Existing on-Site material proposed for reuse, and off-Site borrow material shall be approved by testing agency.
      b. A granular fill containing sufficient fines to exhibit a definite moisture/density relationship.

D. Granular Fill:
   1. Definition: Free-draining granular base used beneath building slabs-on-grade and used as backfill behind foundation and retaining walls.
   2. Acceptable materials: Clean crushed stone or gravel, free of Shale, clay, friable material, and debris, complying with ASTM C33 Size No. 67.

E. Pavement Subbase Course:
   1. Definition: Granular base used beneath concrete pavement and other pavements indicated on Drawings.
   2. Acceptable materials: Comply with APWA Street Construction and Material Specifications, Division II.
F. Crushed Limestone Fill Material:
   1. Definition: That material used at trench backfill under pavements, at locations specified under this Section, and at locations indicated on Drawings.
   2. Acceptable materials: Comply with APWA Street Construction and Material Specifications, Division II.

G. Bedding Materials: Type 1 aggregate per MoDOT Standard Specification for Highway Construction, Section 1007.

H. Trench Backfill Materials:
   1. Slab on grades: Low volume change materials per this section.
   2. Pavement areas: Low volume change material per this section.
   3. Other areas: General Fill Material or other materials specified under this Section at locations specified or indicated on Drawings.

I. Backfill Material
   1. Definition: Material requiring placement and compaction with manual procedures because of restricted spaces or new construction.
   2. Acceptable materials: Either General Fill Material, Granular Fill Material, or other materials specified under this Section at locations specified or indicated on Drawings.

J. Suitable Soils: Suitable soils within 36 inches of finished grade in lawn and planter areas shall be cohesive soils in Soil Classification Groups ML, CL, CH or a combination thereof, free of rock or gravel greater than one (1) inch in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter.

K. Unsuitable Material
   1. Definition: That excavated material which does not meet the consistency requirements of any other defined materials in this Section, including muck, frozen material, organic material, top soil, rubbish, and rock within the limits defined for General Fill Material
   2. Dispose of unsuitable material off-Site, at no increase in Contract Sum or extension of Contract Time.
      a. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Verify location and elevations of existing building foundations.
   2. Verify location and elevations of existing underground utilities.
   3. Verify erosion control systems are in place.
   4. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection:
   1. Protect trees, shrubs, lawns, other plant growth, and other features indicated on Drawings to remain.
   2. Protect bench marks, monuments, existing structures, existing fences, existing roads, existing sidewalks, existing paving, and existing curbs from damage caused by settlement, lateral movement, undermining, washout, and other hazards caused by Work of this Section.
      a. If damaged or displaced, notify Owner’s Representative and correct defects as directed by Owner’s Representative.
   3. Protect above and below grade utilities which are to remain.
4. Protect adjacent and downstream properties from pollution, sedimentation, or erosion caused by the work of this Contract.

B. Precautions:
1. Use all means necessary to control dust on and near the Work, and on and near off-Site borrow storage, and spoil areas, if such dust is caused by performance of the Work of this Section, or if resulting from the condition in which Project Site is left by Contractor.
2. Moisten surfaces as required to prevent dust from being a nuisance to the public, neighbors, and concurrent performance of other Work on Project Site.
3. Identify required lines, levels, contours, and datum.
4. Identify above and below grade utilities.
5. Provide and maintain positive surface drainage.

3.3 WATER CONTROL
A. Provide berms or channels to prevent flooding of subgrades.
B. Prevent infiltration of water into excavations from whatever sources as may exist.
C. Prevent ponding of water on finish subgrades.
D. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
E. Prevent flooding of Project Site and surrounding areas.
F. Promptly remove water collection in depressions.
   1. Provide and maintain ample means and devices with which to remove and dispose of water entering excavations.
   2. Ensure dry excavations and preservation of final lines and grades of bottoms of excavations.

3.4 EXCAVATION, GENERAL
A. Use of explosives is not permitted.
B. Excavation above subgrade as defined in paragraph 1.2 of this section is unclassified and includes excavation of any material encountered regardless of its character including rock, soil materials, debris, and other obstructions and shall be included in the base bid.
C. Perform excavation to the lines and grades indicated on Drawings within a tolerance of 0.10 foot.
   1. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections.
D. Perform Excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) “Construction Standards for Excavations, 29 CFR Part 1926”.
E. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into excavations.
F. Protect subgrades and foundation soils against freezing temperatures and frost.
   1. Provide protective insulation materials as necessary.
G. When excavating through roots, perform Work by hand cutting roots with sharp axe.
H. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.
EARTH MOVING

PROJECT MANUAL FOR
CP170621 - SCHOOL OF MUSIC NEW BUILDING
CP172801 - GENERAL SITE: SCHOOL OF MUSIC EXTEND UTILITIES

I. Machine slope banks to comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   1. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in excavations regardless of time period excavations will be open.
      b. Extend shoring and bracing as excavation progresses
   2. Control surface drainage down slopes.
   3. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.

J. When materials encountered at subgrade are determined to be unacceptable for use by testing agency, remove such material to depths and limits determined by testing agency.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.

K. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency, at no increase in Contract Sum or extension of Contract time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

L. Backfill and compact over-excavations and unauthorized as specified for the area at which it occurs, at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

M. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradation.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.

N. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.

O. Hand trim excavations.
   1. Remove loose matter.

P. Excavation for Footings and Foundations:
   1. Do not disturb bottom of excavation.
      a. Excavate by hand to final grade immediately prior to placement of concrete reinforcement.
      b. Trim bottom of excavations to required lines and grades to leave solid base to receive other work.
   2. Drill probe holes at exposed bottom of excavations as directed by testing agency.

3.5 TRENCH EXCAVATIONS

A. Use of explosives is not permitted.

B. Trench excavation is unclassified and includes excavation to required exposed subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.

C. Excavate trenches to gradients, lines, depths, and elevations indicated on Drawings, within a tolerance of 0.10 foot.
D. Perform excavation Work in compliance with applicable requirements of authorities having jurisdiction, including United States Department of Labor, Occupational Safety and Health Administration (OSHA) "Construction Standards for Excavations, 29 CFR Part 1926".

E. Do not perform trench excavation in areas to receive fill until fill operations are complete to an elevation of not less than 24 inches above the top of the proposed pipe or conduit for which the trench is to receive.

F. Perform Work in a manner and sequence that will provide drainage at all times and that will prevent surface water from draining into trenches.

G. Protect subgrades against freezing temperatures and frost.

H. Provide protective insulation materials as necessary.

I. When excavating through roots, perform Work by hand cutting roots with a sharp axe.

J. Excavation cut shall not interfere with normal 45 degree bearing splay of foundations.

K. Excavate trenches to uniform width, sufficiently wide to enable installation of utilities and to allow safe inspection of installed utilities.

L. Excavate trenches 6 inches deeper than bottom of pipe elevation to allow for bedding course
   1. Hand excavate for bell of pipe.
   2. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
   3. Comply with local codes, ordinances, and requirements of agencies having jurisdiction.
   4. Provide materials for shoring and bracing.
      a. Maintain shoring and bracing in trenches regardless of time period trenches will be open.
      b. Extend shoring and bracing as excavation progresses.
   5. Control surface drainage down slopes.
   6. Cover slopes to prevent loss of moisture content of soil and to prevent raveling.
   7. Hand trim trenches.
      a. Remove loose matter.

M. When subgrade materials are encountered which testing agency determines to be unacceptable for use, remove such material to depths and limits determined by testing agency:
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material.
   2. Removal and replacement of unacceptable material will be paid on basis of Unit Prices included in the Contract Documents.

N. Where depressions result from, or have resulted from the removal of surface or subsurface obstructions, open depressions to equipment working width, and remove debris and soft material as directed by testing agency at no increase in Contract Sum or extension of Contract Time.
   1. Backfill with material acceptable to testing agency and compact to density equal to the specified requirements for subsequent fill material, at no increase in Contract Sum or extension of Contract Time.

O. Stockpile excavation material which testing agency has approved for reuse.
   1. Stockpile soil materials without intermixing soil materials with different consistencies and gradations.
   2. Place, grade, and shape stockpiles to drain surface water.
   3. Do not stockpile within drip line of trees which are to remain.
   4. Cover stockpiles to prevent wind-blown dust.

P. Remove unacceptable excavation material from Site, at no increase in Contract Sum or extension of Contract Time.
   1. Submit an acceptable agreement with the property owner on whose property the unsuitable material is placed.
3.6 SUBGRADE PREPARATION AT PAVEMENTS

A. General:
1. Excavation for subgrade preparation is unclassified and includes excavation to required subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, debris, and other obstructions.
2. Testing agency shall be present to observe proof-rolling of subgrades in pavement and sidewalk areas prior to placement of fill and shall be present during placement and compaction of fill materials in pavement and sidewalk areas. Testing agency shall also be present to observe proof-rolling of finished subgrades prior to installation of pavement and sidewalk sections.
3. Fill material shall not be placed, spread, or rolled while the material is frozen or thawing, or during unfavorable weather conditions.
4. Moisture condition or dry fill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by diskin, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
9. In excavations where testing agency determines that subgrade material is unacceptable, remove unacceptable material and backfill in accordance with procedures determined by testing agency.
10. Minimize construction traffic, including foot traffic, from pavement finished subgrades in order to prevent unnecessary disturbances of subgrade materials.
   a. If testing agency determines that finished subgrades have been disturbed, remove disturbed areas and replace and recompact to required density as directed by testing agency.
   b. If testing agency determines that rutting has occurred, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
   c. Testing agency shall be present during compaction of material.

B. In cut areas below pavements requiring less than 12 inches of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, excavate existing material to a depth of not less than 6 inches below bottom of pavement subbase course.
1. Proof-roll subgrade and repair as required in paragraph 3.6.E below, then scarify to a depth of 6 inches to result in a surface free from ruts, hummocks, and other uneven features which, in the opinion of the testing agency, would prevent uniform compaction by the equipment proposed for use.
   a. Moisture condition subgrade to achieve moisture content specified in this section.
   b. Compact to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. After scarifying, moisture conditioning, and recompacting, backfill areas using approved materials placed in loose lifts not exceeding 8 inches.
   a. Compact each lift to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
3. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.
4. Maintain subgrade moisture content within specified range until pavements are installed.
a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
b. Recompact and retest until required density and moisture content is obtained.

C. In areas below pavements requiring 12 inches or more of fill to obtain finish subgrade elevations, and a lateral distance of 5 feet outside pavement areas, proofroll existing subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.

1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

2. After proofrolling operations are performed and observed soft areas repaired, place approved material in loose lifts not exceeding 8 inches.
   a. Compact each lift to a minimum of 95 percent of the material's maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3. Fill operations shall continue in compacted layers until finish subgrade elevations have been obtained.
   a. Compact each lift to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
      1) Field density tests shall be taken after the compaction of each layer of fill by testing agency.
      2) When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

4. Protect excavations from excessive wetting and drying during construction.
   a. Remove water entering excavation, and remove disturbed or softened soil.

5. Maintain subgrade moisture content within specified range until pavements are installed.
   a. Rework non-complying area as required to achieve specified requirements as directed by testing agency.
   b. Recompact and retest until required density and moisture content is obtained.

D. Tolerances

1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

E. Immediately prior to placement of pavement subbase course and pavements, proofroll subgrade in presence of testing agency using a fully loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of 20 tons.

1. Remove soft areas as directed by testing agency and recompact in loose 9 inch lifts to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

3.7 GENERAL SITE FILL

A. General:

1. Testing agency shall be present during placement and compaction of fill material.
2. Fill material shall not be placed, spread, or rolled while the material is frozen of thawing, or during unfavorable weather conditions.
3. Moisture condition or dry fill material as required to obtain specified moisture limits.
4. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by dishing, harrowing, or pulverizing.
5. Place fill material using spreading equipment capable of obtaining uniform loose lift thickness.
6. Compact fill material using equipment appropriate to the material being compacted, as determined by testing agency.
7. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed fill area is as specified.
8. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.

B. Perform grading to the contours and elevations indicated on Drawings:
1. Uniformly grade areas to a smooth surface, free from irregular surface changes.
2. Provide a smooth transition between existing adjacent grades and new grades.

C. Place general fill material in systematic and uniform horizontal lifts not exceeding the following loose-depth-measurements:
1. For fill material to be compacted with heavy compaction equipment: 9 inches.
2. For fill material to be compacted with hand operated tampers: 4 inches.

D. Under sidewalks and ramps compact each lift of material to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
1. In other areas, compact each lift of material to a minimum of 90 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework on-complying area as required to achieve specified requirements.

E. Bench existing slopes horizontal sections equal in width to equipment used.

F. Where embankments, regardless of height, are placed against hillsides or existing embankments having a slope of steeper than 1 vertical to 5 horizontal, bench or step existing slope in approximately 24 inch rises:
1. Place fill in lifts not exceeding 9 inches in loose-depth-measurement.
2. Compact material bladed out, bottom area which was cut to form benches, and fill material being placed, to a minimum of 95 percent of the material’s maximum Standard Proctor dry density with a moisture content between 0 and +4 percent above optimum moisture content in accordance with ASTM D698.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

G. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
1. Submit an acceptable agreement with the property owner on whose property the material is placed.

H. Tolerances:
1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.
2. Top surface of finish subgrade under unpaved surfaces: Plus or minus ½ inch from required elevations.

3.8 INSTALLATION OF GRANULAR FILL

A. Immediately prior to placement floor slab granular base, testing agency will evaluate subgrade to determine whether moisture content is within specified range, and whether subgrade has been disturbed.
1. In areas where testing agency determines subgrade is not within specified moisture content range, remove non-complying areas and replace and recompact to required density, within specified moisture content range, as directed by testing agency.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When test indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.
2. If testing agency determines that rutting has occurred or other detrimental conditions exist, excavate 6 inches, or other depth as directed by testing agency, of subgrade material and recompact as specified for affected area.
   a. Field density tests shall be taken after the compaction of each layer of fill by testing agency.
   b. When tests indicate that any layer of fill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

B. Place granular fill in equal continuous layers not exceeding 6 inches.
   1. Compact granular fill using heavy vibrating equipment, in 3 passes, to achieve a total compacted thickness of 4 inches in presence of Owner’s representative or testing agency.
   2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and “wacker” compaction equipment.

C. Tolerances:
   1. Top surface of finish subgrade under slabs-on-grade: Plus or minus ¼ inch from required elevations.

3.9 INSTALLATION OF PAVEMENT SUBBASE COURSE

A. Place pavement subbase course in equal continuous layers not exceeding 6 inches.
   1. Compact granular fill for pavement and sidewalk subbase course to a minimum of 95 percent of the material’s maximum standard proctor dry density in accordance with ASTM D698.
   2. Compact granular fill in confined areas using a combination of manually operated vibratory plates and “wacker” compaction equipment.
   3. Qualitative tests shall be taken after the compaction of each layer of fill by testing agency.

B. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.

3.10 BEDDING

A. Place and compact bedding course on trench bottoms and where indicated on Drawings.
   1. Install materials in continuous layers not exceeding 6 inches compacted depth.

B. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Install bedding to a depth of 6 inches below bottom of pipe bell or conduit, to an elevation of 6 inches above pipe or conduit.

D. Compact bedding materials by slicing with a shovel and compacting with vibratory plates and “wacker” compaction equipment.

E. Support pipe and conduit during placement and compaction of bedding fill.

3.11 INSTALLATION OF BACKFILL

A. Backfill excavations promptly, but not before completion of the following:
   1. Surveying location of underground utilities for Record Documents
2. Testing, inspecting, and approval of underground utilities
3. Removal of concrete forms
4. Removal of lumber, rock, paper, and other debris from areas to be backfilled
5. Removal of temporary shoring, bracing, and sheeting

B. Backfill areas to contours and elevations indicated on Drawings, using unfrozen backfill material
1. Do not backfill over porous, wet, frozen, thawing, or spongy surfaces
2. Do not backfill during unfavorable weather conditions
3. Moisture condition or dry backfill material as required to obtain specified moisture content limits
   a. Material which is too wet to allow proper compaction, as determined by testing agency
4. Place backfill material using equipment capable of obtaining uniform loose lift thickness
5. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency
6. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed backfill areas is as specified
7. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
8. Compaction in lawn and planter areas is 85% maximum.

C. Backfilling of curbs, slabs-on-grade, and other structures whose foundation is unprotected from water shall be accomplished as soon as forms are removed, to eliminate possibility of softening of subbase below structure

D. Backfill foundation walls with granular material, not less than 24 inches in width, to an elevation of 2 feet below finish grade.
1. Backfill simultaneously on each side of unsupported foundation walls.
2. Backfill upper 2 feet using General Fill Material.

E. Backfill trenches to contours and elevations indicated on Drawings, using unfrozen backfill material.
1. Do not backfill over porous, wet, frozen, or spongy surfaces.
2. Do not backfill during unfavorable weather conditions.
3. Moisture condition or dry backfill material as required to obtain specified moisture content limits.
   a. Material which is too wet to allow proper compaction, as determined by testing agency, may be spread and permitted to dry assisted by disk ing, harrowing, or pulverizing.
4. Place backfill material using equipment capable of obtaining uniform loose lift thickness.
   a. Employ a placement method of backfill operations which does not disturb or damage utilities in trenches.

F. Backfill trenches that carry below or pass under footings and that are excavated within 18 inches of footings with concrete.
1. Place concrete to elevation equal to bottom of footings.

G. Compaction of General Backfill
1. Maintain optimum moisture content of backfill materials to attain required compaction density.
2. General Fill Materials used for backfill shall be placed in lifts not exceeding 9 inches in loose-depth-measure and compacted as specified for General Site Fill
3. Granular Fill Materials used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted as specified for Granular Fill.
4. Field density tests shall be taken after the compaction of each layer of backfill by testing agency.
   a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

H. Compaction of Trench Backfill
1. Compact backfill material using equipment appropriate to the material being compacted, as determined by testing agency.
2. Maintain optimum moisture content of backfill materials to attain required compaction density.
3. When Work is interrupted by rain, do not resume Work until testing agency indicates that moisture content and density of previously placed backfill area is as specified.
4. Where soil has been softened or eroded by flooding or placement during unfavorable weather conditions, remove damaged areas and recompact to required density.
5. General Fill Material used for backfill shall be placed in lifts not exceeding 4 inches in loose-depth-measure with each lift compacted as specified in this section.

6. MoDOT Standard Specification for Highway Construction Type 5 aggregate used for backfill shall be placed in lifts not exceeding 6 inches in loose-depth-measure and compacted to a minimum of 97 percent of the material's maximum Standard Proctor dry density with a moisture content near optimum in accordance with ASTM D698.

7. Field density tests shall be taken after the completion of each layer of backfill by testing agency.
   a. When tests indicate that any layer of backfill or portion thereof does not meet the required compaction density or moisture content, rework non-complying area as required to achieve specified requirements.

I. Slope grade away from building not less than 12 inches in 10 foot for a distance of not less than 6 feet outside of building lines.
   1. Make grade changes gradual.
   2. Blend slopes into level areas.
   3. Remove surplus materials from Site, at no increase in Contract Sum or extension of Contract Time.
   4. Submit an acceptable agreement with the property owner on whose property the material is placed.

J. Tolerances:
   1. Top surface of finish subgrade under paved areas: Plus or minus ¼ inch from required elevations.
   2. Top surface of finish subgrade under unpaved areas: Plus or minus ½ inch from required elevations.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

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 when approved by Geotechnical Engineer.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 6938, 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 one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
   3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.13 PROTECTION

A. Protect newly graded areas from freezing and erosion.

B. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.
1. Testing agency shall be present during compaction of material.
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 paving.
   2. Asphalt traffic-calming devices.
   3. Asphalt surface treatments.

B. Related Requirements:
   1. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
      a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
      b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include technical data and tested physical and performance properties.
   2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or Missouri Department of Transportation (MoDOT).

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MoDOT for asphalt paving work.
   1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.
1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Prime Coat: Minimum surface temperature of 60 deg F.
   2. Tack Coat: Minimum surface temperature of 60 deg F.
   4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
   5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. Aggregate base for asphaltic pavements shall be a granular compacted crushed limestone with a gradation and quality conforming to the requirements of MoDOT Standard Specification 1007 for either Type 1 or Type 5 aggregate.

B. The maximum lift thickness for granular base shall be 4 inches.

C. Granular base thickness in excess of 4 inches shall be placed in multiple lifts with each lift being of approximate equal thickness.

D. Granular base shall be compacted to at least 100% of Standard Proctor Compaction (ASTM D-698)


G. Mineral Filler: ASTM D 242, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320, PG 64-22.

B. Asphalt Cement: ASTM D 946/D 946M for penetration-graded material.

C. Cutback Prime Coat: ASTM D 2027, medium-curing cutback asphalt, MC-30 or MC-70.

D. Tack Coat: ASTM D 977 emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

E. Water: Potable.

F. Undersealing Asphalt: ASTM D 3141/D 3141M; pumping consistency.

2.3 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by MoDOT; 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 with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
   1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
   2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Testing Agency, and replace with compacted backfill or fill as directed.

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

3.2 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. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
   1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
   2. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
   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.

3.3 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in 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. Place hot-mix asphalt surface course in single lift.
   3. Spread mix at a minimum temperature of 250 deg F.
   4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
   5. 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 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. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course before placing asphalt surface course.

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.

3.4 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. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to Al MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.5 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.
1. Complete compaction before mix temperature cools to 185 deg F.

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 the following density:
1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927 or AASHTO T 245, but not less than 94 percent or greater than 100 percent.
2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

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.
A. Construct hot-mix asphalt speed bumps, humps, cushions, and tables over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F.
   1. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
   2. Asphalt Mix: Same as pavement surface-course mix.
   3. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of 1 inch from top of pavement to a clean, rough profile.

B. Place and compact hot-mix asphalt to cross section indicated, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.7 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Base Course: Plus or minus 1/2 inch.
   2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
   1. Base Course: 1/4 inch
   2. Surface Course: 1/8 inch.
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

C. Asphalt Traffic-Calming Devices: Compact and form asphalt to produce the contour indicated and within a tolerance of plus or minus 1/8 inch of height indicated above pavement surface.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.
   1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
      a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
      b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.9 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION
SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.

B. Work in public right-of-way: All work in public right-of-way shall be performed per City Standards and Specifications.

1.2 ACTION SUBMITTALS

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

B. Samples: For each exposed product and for each color and texture specified.

C. Other Action Submittals:
   1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
   2. Aggregates: Aggregates must be supplied from a source previously tested and certified by MoDOT as meeting "Aggregates for Concrete" requirements in Section 1005 of MoDOT Standard Specifications. Aggregate shall be sound and durable and meet ASTM C586.

1.3 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with ACI 301 unless otherwise indicated.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT


B. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.

C. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A; coated, deformed.

D. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60 plain-steel bars.
E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI’s “Manual of Standard Practice” from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified.

2.2 CONCRETE MATERIALS AND MIXTURES

A. Portland cement concrete shall conform to MoDOT 501 and 1005 with the following modifications:
   1. All portland cement concrete shall be air entrained with 6% (± 1%) minimum air content.
   2. The use of calcium chloride is not permitted.
   3. The allowable slump shall be not more than 4 inches.
   4. The minimum 28-day compressive strength shall be 4,000-psi.
   5. Aggregate:
      a. The combined maximum weight of flint and chert shall be 1% of the weight of coarse aggregate.
      b. The maximum weight of lignite shall be 0.07% of the weight of the fine aggregate.

2.3 CURING MATERIALS

A. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

2.4 RELATED MATERIALS

A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.5 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete.
   1. Dowels: Galvanized steel, 3/4 inch in diameter, 10-inch minimum length.
   2. Adhesive: As recommended by wheel stop manufacturer for application to concrete pavement.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

C. Prior to concrete paving, Contractor shall prepare mockup for concrete pavement and sidewalks. Mockup to include a minimum of 100 square feet of paving. Mockup may be installed “in-place” and must demonstrate the proposed joint types, reinforcement, sealant, and saw-cutting. Prepare mockup for Owner review and approval, prior to concrete paving.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides 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.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.

B. Comply with ACI 301 requirements for measuring, mixing, transporting, placing, and consolidating concrete.

C. 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.

D. Screed paving surface with a straightedge and strike off.

E. 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.

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 COLD AND HOT WEATHER CONCRETE PLACEMENT

A. Cold Weather Concrete:
   1. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontin-
      ued when the descending air temperature in the shade and away from artificial heat reaches thirty-
      five (35°) degrees F. Concrete operations may be resumed when the ascending air temperature in
      the shade and away from artificial heat reaches thirty five (35°) degrees F.
   2. When concrete work is authorized during cold weather, the concrete may be heated in accordance
      with ACI specifications. The temperature of the concrete shall be not less than sixty (60°) degrees
      F and not more than eighty (80°) degrees F at the time of placement in the forms.
   3. No concrete shall be placed on frozen subgrade. Sudden cooling of concrete shall not be permit-
      ted. Concrete exposed to frost action or freezing weather shall be removed and replaced at the
      Contractor's expense.
   4. A sufficient supply of approved blanketing material shall be provided and placed on all concrete
      placed between November 1 and April 1 and at other times when the ambient air temperature is
      expected to drop below forty (40°) degrees F. Blanketing materials shall protect the concrete and
      maintain a minimum temperature of forty (40°) degrees F in the concrete as measured on the sur-
      face. Concrete shall be covered for at least four days.

B. Hot Weather Concrete:
   1. The provisions of this section shall apply to all concrete work, which is done when the air tempera-
      ture is above eighty (80°) degrees F at the time of placement. The temperature of the concrete,
      when placed, shall not be high enough to cause excessive loss of slump, flash set or cold joints.
      Forms, reinforcing and sub-grade surfaces against which the concrete is to be placed shall be wet-
      ted down immediately before placement. In no case shall the temperature of the concrete, when
      placed, exceed ninety (90°) degrees F.
   2. When the air temperature exceeds ninety (90°) degrees F and as soon as practicable without caus-
      ing damage to the surface finish, all exposed concrete shall be kept continuously moist by means
      of fog sprays, wet burlap, cotton mats, or other means acceptable to the Engineer at no expense to
      the Owner. This cooling with water shall be in addition to the initial sealing by membrane curing
      compound.
   3. No concrete shall be placed when the air temperature is above ninety-five (95º) degrees F.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions
   cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according
   to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but
   before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by curing compound.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:
   1. Elevation: 3/4 inch.
   3. Surface: Gap below 10-foot-long, unleveled straightedge not to exceed 1/2 inch.
4. Joint Spacing: 3 inches.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.

3.10 WHEEL STOPS

A. Install wheel stops in bed of adhesive applied as recommended by manufacturer.

B. Securely attach wheel stops to paving with not less than two [galvanized]-steel dowels located at one-quarter to one-third points. Install dowels in drilled holes in the paving and bond dowels to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Design Professional.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

3.12 FIELD QUALITY CONTROL

A. Delivery Tickets: For each load delivered, submit 3 copies indicating quantity, mix identification, admixtures, design strength, aggregate size, design air content, and design slump at time of batching.

B. Tests: Owner will retain the services of an engineering inspection and testing firm. Contractor will be responsible for coordinating and scheduling inspection. Tests will include the following: strength, air entrainment, temperature, and slump tests. Test results will be specified to be sent directly to the Contractor, Engineer and Owner’s representative.

1. Testing agency shall perform sampling and testing of concrete specified in ACI 301 Sections 16.3, 16.4, and as follows:
   a. Test data from concrete cylinder breaks will be evaluated using procedures of the American Concrete Institute (latest edition of ACI 214) to determine if the compressive strength of the concrete tested is acceptable.
   b. Concrete will be tested at the minimum rate of one test for the first 25 cubic yards [CY] placed each day, and one test for each additional 50 CY placed. Concrete may be tested more often at the discretion of the Owner’s Representative.
      1) One additional set of test cylinders will be taken during cold weather, and as directed by Engineer, cured at Project Site under same conditions as concrete it represents.
   c. Slump, ASTM C143: 1 per each set of compressive cylinders.
   d. Air content, ASTM C173: 1 per every 50 cubic yards, or portion thereof.
   e. Unit weight, ASTM C138: 1 per every 50 cubic yards, or portion thereof.
   f. Concrete temperature, ASTM C1064: 1 measurement for every slump test.
   g. Casting of compressive cylinders, ASTM C39: 1 set of 4 cylinders for every 50 cubic yards, or portion thereof.
   h. Concrete delivery: Check batch ticket from every truck.

C. Batch plant inspection: Random basis as determined by Engineer.

END OF SECTION 321313
SECTION 321373 - CONCRETE PAVING JOINT SEALANT

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. Section Includes:
   1. Cold-applied joint sealants.

B. Related Sections:
   1. Division 32 Section "Concrete Paving" for constructing joints in concrete pavement.

1.3 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- wide joints formed between two 6-inch- long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Pavement-Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of joint sealant and accessory, from manufacturer.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.

C. Preconstruction Compatibility and Adhesion Test Reports: From joint-sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility with and adhesion to joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.
C. Product Testing: Test joint sealants using a qualified testing agency.
   1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.

D. Preinstallation Conference: Conduct conference at Project site.

1.6 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C)
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: As selected by Design Professional from manufacturer’s full range color.

2.2 COLD-APPLIED JOINT SEALANTS

A. Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C 920, Type M, Grade P, Class 25, for Use T.
   1. Products: Subject to compliance with requirements provide the following:
      b. Sika Corporation: Sikaflex-2C SL and Sikaflex-2C NS TG
      c. BASF: Sonolastic SL2.

2.3 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

2.4 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of joint-sealant backings.
   2. Do not stretch, twist, puncture, or tear joint-sealant backings.
   3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place joint sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
   1. Remove excess joint sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.
3.4 CLEANING

   A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

   A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

END OF SECTION
SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pavement markings for parking areas and roadways.
   2. Accessible parking symbols.
   3. Traffic direction arrows.

1.2 SUBMITTALS

A. Submit in accordance with Division 1 unless otherwise indicated.

B. Product Data: Manufacturer's specifications and technical data including the following.
   1. Product data sheet on each product.
   2. Material safety data sheet on each product.
   3. Manufacturer's installation instructions.

C. Quality Control Submittals:
   1. Manufacturer's certificate and test reports indicating that traffic marking material complies with requirements of this Section.
   2. Manufacturer's certificate indicating that glass beads comply with requirements of this Section, including test reports indicating roundness, refractive index, flow characteristics, and gradation.

D. Color Samples: Two sets of samples of the following.
   1. 2 inch by 3 inch sample of pavement marking material illustrating manufacturer's full range of standard colors.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer's Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following.
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

1.4 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer's identification.

B. Labeling: Include manufacturer's name, type of material, brand name, brand code, date of manufacturer, surface preparation, color designation, analysis of contents, instructions for application, and instructions for cleanup.

C. Storage and Protection: Comply with manufacturer's recommendations.
1.5 PROJECT CONDITIONS

A. Environmental Requirements:
   1. Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 degrees F for oil-based materials, 50 degrees F for water-based materials, and not exceeding 95 degrees F.
   2. Do not apply materials during rain or snow, or when relative humidity is above 50 percent, unless required otherwise by manufacturer's instructions.

1.6 SEQUENCING

A. Sequence Work of this Section to occur immediately prior to Substantial Completion, except as otherwise approved by Design Professional.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pavement-Marking Paint: latex, water-base emulsion; ready mixed; complying with FS TT-P-1952.
   1. Color: As determined by Owner from manufacturer’s full range.

B. Glass Beads: AASHTO M247, Type 1, including packaging and marking requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Verify surfaces to receive traffic markings is dry and pavements are free of moisture.
   2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection: Protect surfaces not being marked and finished Work of other Sections.

B. Surface Preparation:
   1. Prepare surfaces in accordance with manufacturer's instructions.
   2. Clean surfaces to receive pavement markings free of dust, dirt, concrete curing compounds, and other surface contaminants which may adversely affect adhesion or appearance.

3.3 APPLICATION

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Design Professional.

B. Allow paving to age for 30 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.
D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer’s recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).
   1. Broadcast glass spheres uniformly into wet pavement markings at a rate of 6lb/gal. (0.72 kg/L).

3.4 PROTECTION

A. Protect installed markings from damage until Substantial Completion.

3.5 DEFECTIVE TRAFFIC MARKINGS

A. Traffic markings which, in the opinion of the Design Professional, do not provide initial nighttime reflectivity or do not have the specified thickness shall be repaired and replaced at no increase in Contract Sum or extension in Contract Time.

B. Traffic markings which, in the opinion of the Design Professional, do not conform to required dimensions or specified requirements shall be completely removed and replaced at no increase in Contract Sum or extension in Contract Time.
SECTION 331100 – WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Site potable water lines
   2. Site fire protection water lines
   3. Related accessories.

B. Related Sections:
   1. Section 312000 – Earth Moving.

1.2 SYSTEM DESCRIPTION

A. Buildings located on the MU campus will typically have potable water service from MU's distribution system. Internal fire protection will also be served by the MU distribution system. Usually one service line into a building will provide both needs. If a separate service line is required for fire protection, installation of a post indicator valve will be required.

B. Flow tests, when required, can be obtained from the system owner.

C. A permanent line shall be installed to facilitate flushing of the water service line. The line shall be a minimum of 2" diameter and shall flow the water to a location outside of the building. The line shall be connected after the 1st valve inside of the building.

D. All water connections (fire and potable) shall include the installation of testable backflow prevention assemblies as required and approved by the Missouri Department of Natural Resources and MU Construction Standards.

E. All potable water service shall have a water meter.

F. All sizing and locations for mains, services and other auxiliary equipment shall be coordinated with system owner.

G. All service line entrances to buildings shall be designed to be maintainable. If a building is being built on a slab, a pit allowing access to the water line must be installed. Water service lines under buildings are not acceptable.

H. Water service-line connections to water mains shall include a three-valve (main-tap-main) cluster which will allow for maximum valving flexibility.

I. Nutating disc meters are to be installed on applications requiring water flows equal to, or less than one-hundred (100) gallons per minute. Turbine meters are to be installed on applications requiring water flows more than one-hundred (100) gallons per minute. Compound meter are to be installed on applications that will see large peak flows over typical normal flows.

1.3 SCHEDULING

A. Site utility tie-ins shall be coordinated with the Owner’s Representative. Contactor shall notify Owner’s Representative two (2) weeks in advance of desired tie-in time. Owner’s Representative will give Contractor 72 hours advance notice of actual time for tie-ins.
B. Tie-ins to utility systems shall be made on weekends or nights, and work shall be done around-the-clock until the tie-in is completed. Line outages are to be kept to a minimum.

1.4 SUBMITTALS

A. Product Data: Manufacturer’s specification and technical data on the following.
   1. Piping and Restraints.
   2. Water Meters.
   3. Valves.
   4. Fire Hydrants.

B. Quality Control Submittals:
   1. Field Quality Control submittals are specified under PART 3.

C. Contract Closeout Submittals.
   1. Project Record Documents.
      a. Contractor to provide X, Y and Z as-built coordinates, prepared by Registered Land Surveyor, at 25-foot intervals of installed water line, as well as all valves, fittings, and appurtenances prior to backfill of the water line.

1.5 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Not less than 5 years experience in the actual production of specified products.

B. Installer’s Qualifications: Firm experienced in installation of systems similar in complexity to those required for this Project, plus the following.
   1. Not less than 3 years experience with systems.
   2. Successfully completed not less than 5 comparable scale projects using this system.

C. Regulatory Requirements:
   1. Comply with the Missouri Department of Natural Resources requirements for fire and potable water.
   2. Comply with requirements of the University of Missouri construction standards.

1.6 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping: Deliver products in original unopened packaging with legible manufacturer’s identification.

B. Storage and Protection: Comply with manufacturer’s recommendations.
   1. Store valves indoors.
   2. Protect pipes from moisture and dirt.

PART 2 - PRODUCTS

2.1 MATERIALS, PIPE AND PIPE FITTINGS

A. All underground water piping shall be PVC.
   1. EXCEPTION 1: Domestic water service lines 2” or less shall be Type K copper or high density polyethylene (HDPE) piping.
   2. EXCEPTION 2: Lines passing directly over or under steam tunnels or direct buried steam/condensate lines must be ductile iron or Type K copper (2” or less) with 4” R-5 extruded polystyrene insulation board between the pipe and steam lines.
B. PVC Pipe (Open Trench Construction)
   1. 4 Inches to 12 Inches: AWWA C900; Pressure Class 235 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.
   2. 14 Inches to 48 Inches: AWWA C905; Pressure Rating 165 (DR 25); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

C. Ductile-Iron Pipe
   1. 4 Inches to 12 Inches: AWWA C151; Mechanical Joint Pipe; Minimum Thickness Class 52 or Pressure Class 350; with integrally cast flanged bell, cast iron gland, and rubber gasket.
   2. Lining: Standard cement lining with asphalt coating.

D. High-Density Polyethylene (HDPE) Pipe and Fittings
   1. 2 Inches and Less: SDR9 CTS Premium Grade Pipe, AWWA C901, ASTM D3035, NSF 14 and 61, 200 psi pressure rating. Pipe to be CenCore HDPE as manufactured by Centennial Plastics or approved equal.
   2. Fittings and Joints: All molded fittings and fabricated fittings shall be fully pressure rated to match the pipe pressure rating. All fittings shall be molded or fabricated by the pipe manufacturer. Connections must be made by either the use of brass/stainless steel compression couplings with insert rings or by creating a fusion butt weld all in strict accordance with manufacturer’s recommendations. All brass fittings shall be lead free.

E. Pipe Fittings
   1. 4 Inches to 24 Inches: AWWA C153; 350-psi pressure rating.
   2. Lining: Standard cement lining with asphalt coating.
   3. All pipe fittings shall be cast-iron construction, installed wrapped with AWWA C105 polyethylene film.

F. Restraints
   1. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92. Pipe sizes 4” to 12” must also be FM approved. Mechanical joint restraints shall be Megalug 2000 PV, as manufactured by EBAA Iron Inc., Eastland TX, or approved equal.
   2. Joint Retainers: Provide ductile iron split serrated ring harnesses and rod type joint retainers for PVC bell and spigot joints. Clamps shall be designed for use with PVC pipe and shall meet Uni-B-13-92 Standards and be FM approved on sizes 4” to 12”. Restraint harnesses shall be Series 1500 for pipe 4 inches to 12 inches, and Series 2800 for pipe 14 inches and larger, all as manufactured by EBAA Iron Inc., Eastland TX or approved equal.
   3. Rods, nuts and washers: ¾” SS304 all thread rods, nuts and washers.
   4. All pipe restraints and ductile iron fittings shall be installed wrapped with AWWA C105 polyethylene film.
   5. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal® as manufactured by PSI-Thunderline Corporation, Houston TX, or approved equal.

G. Trace Wire
   1. Tracer wire shall be #14 AWG Solid, steel core soft drawn high strength tracer wire, 250# average tensile break load, 30 mil high molecular weight-high density blue polyethylene jacket complying with ASTM-D-1248, 30 volt rating. No THHN insulated wire shall be allowed. Tracer wire shall be Copperhead Industries HS-CCS or approved equal.
   2. Tracer wire shall have moisture resistant splices for direct bury applications. Splices shall be Copperhead Industries Snakebite or 3M DBR or approved equal.
   3. Tracer wire test stations shall be designed to be easily detected by magnetic and electronic locators. A magnet shall be securely attached at the top of the upper tube of the box for locating purposes. Lid shall be blue and have a brass terminal for attaching locating equipment and a brass 5 sided nut for removing cap. Tracer wire test station shall be Copperhead Industries Snake Pit or approved equal.
2.2 WATER UTILITIES METERING

A. The University of Missouri Columbia campus has standardized on bronze disc and turbine utility meters as manufactured by BadgerMeter, Milwaukee, WI. Substitutes will not be accepted.

B. Compound Meter
   1. Construction shall comply with ANSI and AWWA C702 standards as required for domestic water compound metering applications.
   2. Meter housing shall be lead free cast bronze construction. Nose cone, straightening vanes, rotor, rotor and valve casing, measuring chamber and disc and high flow valve shall be thermoplastic construction. Register lid and shroud shall be thermoplastic and bronze and trim shall be stainless steel.
   3. Register shall be a straight-reading odometer-type totalization display (gallons), 360 degree test circle with dual center sweep hands. Register shall be installed using TORX tamper resistant seal screws. A tamper resistant calibration plug seal shall also be provided to protect from unauthorized personnel.
   4. Meters shall be Recordall Compound Series.

C. Plate Strainers
   1. Plate strainers shall exceed AWWA standards. Double-flanged housing and cover shall be constructed of cast bronze. Strainer screen and housing bolts shall be stainless steel. Housing cover seal and flange gaskets shall be neoprene rubber. Screen shall have 3/16" perforations with a minimum straining area that is double the meter inlet size. Flange connections shall be elliptical (2" meters) or round. Plate strainers shall be as manufactured by BadgerMeter or approved equal. Strainer not required for Electromagnetic meter

2.3 VALVES AND VALVES BOXES MATERIALS

A. Non-rising Stem Gate Valves: ANSI/AWWA C509, resilient seated, bronze stem, cast-iron or ductile-iron body and bonnet, epoxy coated disc, stem nut, 250 psig working pressure, mechanical joint ends. Valves shall be Model A-2360 as manufactured by Mueller Company, Decatur IL, or approved equal. Valves shall turn clockwise to close.

B. Ball Valves: Threaded lead free bronze, 125 lb., 2-piece design, full port. Valves shall be Model T-FP-600A-LF-LL as manufactured by NIBCO, Elkhart IL, or approved equal.

C. Valve Boxes: Valve box shall be 6" PVC C900 pipe with cast iron cover No. 2195 as manufactured by Clay and Bailey Manufacturing Company, Kansas City MO, or approved equal. Lid shall be marked "WATER". Provide below grade concrete collar in planted and asphalt areas.

2.4 FIRE HYDRANT MATERIALS

A. University fire hydrants shall be Super Centurion Fire Hydrants, Model 250, Number A-423, as manufactured by Mueller Water Products, Decatur IL. No substitutions will be allowed.

B. Fire hydrants shall be painted in the following manner using Sign Painters’ 1 Shot Lettering Enamel or approved equal:

C. University water:
   1. Barrel - Metallic Gold
   2. Caps – Black

D. City water, University maintained system:
   1. Barrel - Metallic Gold
   2. Caps - Blue.
E. Final hydrant bonnet color based on measured flow will be painted by MU.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which Work is to be performed and identify conditions detrimental to proper and timely completion.
   1. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE INSTALLATION

A. Preparation of Trench
   1. Final bury depth shall have a minimum of 42" cover to the top of the pipe.
   2. Trench bottom shall be graded to provide a smooth, firm, stable, and rock-free foundation throughout the length of the piping.
   3. All rock greater than one inch in diameter found in the trench shall be removed for a depth of six inches below the bottom of the pipe and replaced by suitable bedding material.
   4. Unstable, soft, and unsuitable materials shall be removed at the surface upon which pipes are to be laid and backfill with crushed stone as indicated on the drawings.
   5. Layers of crushed stone shall be installed in the bottom of trench as indicated on the drawings.

B. Pipe Separation
   1. Finished pipe installation shall have minimum 12" separation to all other utilities.
   2. Maintain at least a ten foot (10') horizontal separation of water mains from any existing or proposed sanitary sewer. The distance must be measured edge to edge. Installation of the water main closer to a sanitary sewer is acceptable where the water main is laid in a separate trench or on an undisturbed earth shelf located on one (1) side of the sanitary sewer at an elevation so the bottom of the water main is at least eighteen inches (18") above the top of the sanitary sewer.
   3. Provide a minimum vertical distance of eighteen inches (18") between the outside of the water main and the outside of the sanitary sewer where water mains cross the sanitary sewer mains. This shall be the case where the water main is either above or below the sanitary sewer. At crossings, one (1) full length of water pipe must be located so both joints will be as far from the sanitary sewer line as possible. Special structural support for the water and sanitary sewer pipes may be required.
   4. Provide at least a ten-foot (10') horizontal separation between water mains and sanitary sewer force mains. There shall be an eighteen-inch (18") vertical separation at crossings.
   5. Locate water mains so that they do not pass through or come in contact with any sanitary sewer manhole.
   6. Consult the system owner where above conditions cannot be met.

C. Installation of Pipe and Pipe Fittings
   1. Piping 2" and less:
      a. All domestic water service piping from the water main to the building with a nominal diameter of two inches and less shall be Type K copper or HDPE piping.
      b. In all installations, Type K copper shall be used where the water line enters the building. If the water meter is located in a meter pit, the piping within the meter pit, and stubbed out on either side shall also be Type K copper.
      c. All buried copper piping shall be wrapped.
      d. For pulled pipe installations, tracer wire shall be pulled with pipe, without splices. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.
      e. For trenched pipe installation, tracer wire shall be taped to the pipe at the three o’clock position every 5 feet. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.
   2. PVC (Polyvinyl Chloride) Pipe: Install in accordance with AWWA C605.
3. All joints shall be restrained with joint retainers. All fittings shall be restrained with retainer type packing glands.

1. Install stainless steel rods between fittings on all offsets and between fittings, valves, and blind flanges, in addition to the Megalugs. On isolated fittings, valves, etc., attach restraint rings to PVC pipe and install stainless steel rods between fitting and restraint rings. Rods shall be positioned through the bolt holes in fitting and Megalug. Each rod will require four nuts and washers. Duct lugs are acceptable. The number of stainless steel rods required per fitting flange shall be as follows:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>No. of Rods</th>
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</thead>
<tbody>
<tr>
<td>10” and Less</td>
<td>2</td>
</tr>
<tr>
<td>12”</td>
<td>3</td>
</tr>
<tr>
<td>14”</td>
<td>4</td>
</tr>
<tr>
<td>16”</td>
<td>5</td>
</tr>
<tr>
<td>18”</td>
<td>6</td>
</tr>
</tbody>
</table>

4. All ductile iron pipe, fittings, valves, bell end restraints, etc. shall be wrapped with a polyethylene cover conforming to AWWA C105, and installed per AWWA C600.

5. All dead end mains shall have a dry barrel fire hydrant at the end to facilitate flushing of the main.

6. Pipe shall be installed in clean condition, and shall never be laid in trenches with standing water. The trench shall be dewatered during installation of the water line. Open pipe ends shall be protected with a hard cap or inflatable plug at the end of the work day. NO PLYWOOD OR DUCTTAPE COVERINGS WILL BE ALLOWED.

D. Backfill

1. Under Pipe: All backfill under the barrel of the pipe shall be free from debris, organic matter, and stones larger than one inch, and shall be tamped into place. Sand or crushed stone aggregate (95% passing a ½” screen but not more than 10% passing a #200 sieve) are acceptable substitutes for soil.

2. Adjacent To and Top of Pipe: The first one foot of backfill over the top of pipe shall be “3/4 inch minus waste rock with fines” uncleaned crushed stone aggregate or suitable soil. Backfill shall be free of debris, brush, roots and stones or rubble more than one inch.

3. Rough final grading of subgrade and the placement of final topsoil shall be detailed on the drawings.

4. All sidewalks, paving, etc. which are removed or damaged during construction shall be replaced and shall match existing.

E. Identification

1. Install continuous plastic underground warning tape during back-filling of trench for underground water piping. Tape shall be located twenty-four (24) inches above pipe, directly over each water line.

2. Tape trace wire to the top of each water line with duct tape every five (5) feet. Wire splices shall be minimized. Terminate trace wires inside building and inside valve boxes. Drill ¼” hole in PVC valve box one inch below cast iron cover. Route wire up outside of valve box, through ¼” hole and knot. A tracer wire test station shall be installed at all fire hydrants and at all runs of piping without valves every 400 feet. Upon completion of installation and final grading, a continuity test on the wire shall be performed and all breaks shall be repaired.

3.3 WATER UTILITIES METERING INSTALLATION

A. Installation of water meter, valving, bypass loop and water sampler/test outlet shall be in strict accordance with manufacturer’s printed instructions and recommendations, applicable ANSI and AWWA requirements, and as detailed on “Bronze Disc Water Meter Installation Detail” and “Bronze Turbo Water Meter Installation Detail.”

B. The preferred location for water revenue meter installation is within a building mechanical room. In some cases, water meter may need to be installed in an exterior below-grade meter pit. These pit installations shall be installed in strict accordance with manufacturer’s printed instructions and University of Missouri-Columbia “Meter Box Pit Detail” drawing.
C. Water meters shall be installed with a three-valve bypass design using ball valves (2" or less) or OS&Y rising stem gate valves (larger than 2"). The bypass valve shall be full-flow and capable of being locked. All other valves associated with the meter installation shall be ball valves. Water meters shall be installed in a straight run with no obstructions a minimum of ten diameters upstream and five diameters downstream.

D. Water meter shall be installed after the backflow prevention device but prior to any booster pumps or pressure reducing valves.

E. Water meter shall be installed no greater than 4' from the floor. Variations from this requirement need prior approval from system owner. If this requirement is impossible or the meter is located in an inaccessible location, the meter shall be equipped with a remote read, and the register shall be mounted no greater than 4' from the floor.

3.4 WATER UTILITIES COMMISSIONING

A. Water service will not be turned on until the water meter is fully installed and operating satisfactorily, the downstream water piping is successfully leak tested and secure (including freeze protection), and the necessary backflow preventer device is installed and successfully tested with the delivery of the test report to Campus Facilities - Energy Management Steam and Water Distribution Engineering.

B. Only Energy Management Steam and Water Distribution personnel will be authorized to turn water service on or off.

3.5 VALVES AND VALVES BOXES INSTALLATION

A. Valve Storage: Use the following precautions for valves during storage:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect valves from weather - valves shall be stored indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

B. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Valves shall be rigged to avoid damage to exposed valve parts. Do not use hand wheels or stems as lifting or rigging points.

C. Domestic Water Service: AWWA-Type Gate Valves: Comply with AWWA C600. Install buried valves with stem pointing up and with valve box.

D. Valve boxes shall be installed vertically with top of box even with final grade.

3.6 VALVES AND VALVES BOXES TESTING

A. All valves shall be pressure tested in accordance with standards set forth in the Water Piping Construction Standard.

B. All valves shall be disinfected in accordance with standards set forth in the Water Piping Construction Standard.

3.7 VALVES AND VALVES BOXES COMMISSIONING

A. All valves under pressure in the MU water distribution mains will be operated only by Campus Facilities - Steam & Water Distribution personnel, except in cases of extreme emergency. All valves installed as part of new construction shall remain fully closed during construction.
3.8  FIRE HYDRANT INSTALLATION

A. The location of new fire hydrants shall be determined by a collaboration of system owner, City of Columbia Fire Department and the design engineers.

B. Installation of fire hydrants maintained by the University shall be installed per “Fire Hydrant Detail” and in strict accordance with manufacturer’s written instructions.

C. Installation of fire hydrants maintained by the City of Columbia shall be in strict accordance with Columbia Water and Light Specifications as last revised.

D. The pumper nozzle shall be installed pointing to the street and/or away from the building.

3.9  FIRE HYDRANT TESTING

A. Newly installed fire hydrants shall be cleaned and pressure tested in accordance with standards set forth in this section, and will be flow tested by system owner.

3.10  FIRE HYDRANT COMMISSIONING

A. Water will be turned on to the hydrant by Campus Facilities - Energy Management Utility Distribution personnel.

B. Hydrant will be flow tested by owner.

3.11  DISINFECTION AND TESTING OF WATER UTILITY DISTRIBUTION

A. MU will perform pressure testing and disinfection of new water lines. Contractor shall prepare water line for successful pressure testing and disinfection.

B. All domestic potable water systems will be pressure tested in accordance with AWWA M23.

C. All domestic potable water systems will be disinfected and tested for bacteriological contamination before the system is put into operation, as required by the Department of Natural Resources and in accordance with AWWA C651.

D. Contractor shall ensure internal surfaces of water line shall be clean and free of foreign matter.

E. Water line shall be completely separated from MU water system for pressure tests and disinfection purposes.

B. Contractor shall install number and size of taps based off of water line size in table below:

<table>
<thead>
<tr>
<th>Pipe Diameter (in)</th>
<th>2&quot; Taps Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>1</td>
</tr>
<tr>
<td>6&quot;</td>
<td>1</td>
</tr>
<tr>
<td>8&quot;</td>
<td>1</td>
</tr>
<tr>
<td>10&quot;</td>
<td>2</td>
</tr>
<tr>
<td>12&quot;</td>
<td>2</td>
</tr>
</tbody>
</table>

F. Contractor shall install water line entrance and exit piping which enters and exits above ground as shown in “Taps for Flushing and Disinfection of Water Line” per University of Missouri Construction Standards. The purpose of this piping is to provide a means for flushing, pressure testing, and disinfecting the new water line.
G. Contractor shall contact Energy Management 72 hours prior to requesting flushing and disinfection of new water line.

H. Campus Facilities - Energy Management Steam and Water personnel will draw water samples for bacteriological testing and send sample off for testing.

I. Allow twenty-four (24) hours for disinfection of water line and an additional forty-eight (48) hours for return of testing before making tie-ins to existing system.

J. Commissioning
   1. System shall be placed in operation only after testing shows the absence of bacteriological contamination and approved by system owner.

K. Only Campus Facilities - Energy Management Steam and Water personnel will be allowed to operate valves on new water systems.

END OF SECTION
PART 1 - GENERAL

1.1 SCOPE

A. The scope of this document is to provide instruction for the installation and testing of chilled water piping installed for the University of Missouri - Columbia.

B. The Contractor shall furnish and install all chilled water service piping as shown on the Drawings and specified herein.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions, apply to this Section.

B. Section 312000 Earth Moving.

1.3 SUBMITTALS

A. General: Submit the following in accordance with General & Special Conditions of Contract.

B. Product data:
   1. Pipe, valves and fittings
   2. Restraining devices
   3. Valve boxes

C. Maintenance data: valves

1.4 QUALITY ASSURANCE

A. Piping, valves and their installation shall conform to the standards referenced herein.

1.5 STORAGE AND HANDLING

A. Storage: Use the following precautions for valves during storage:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.
   3. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS - GENERAL

A. PVC (Polyvinyl Chloride) Pipe (for open trench construction):
1. 4 Inches to 12 Inches: AWWA C900; Pressure Class 235 (DR 18); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.
2. 14 Inches to 36 Inches: AWWA C905; Pressure Rating 165 (DR 25); Cast Iron O.D. equivalent; with bell end and elastomeric gasket.

B. Ductile-Iron Pipe:
1. 4 Inches to 36 Inches: AWWA C151; Mechanical Joint Pipe; 150 psi working pressure; Minimum Thickness Class 50; with integrally cast flanged bell, cast iron gland, and rubber gasket.
2. Lining: Standard cement lining with asphalt coating.

C. Ductile-Iron Pipe Fittings:
1. 4 Inches to 24 Inches: AWWA C153; 350-psi pressure rating.
2. Lining: Standard cement lining with asphalt coating.
4. Fitting Restraint:
   a. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92. Pipe sizes 4” to 12” must also be FM approved. EBAA Megalug 2000 PV or approved equal.
   b. Rods, nuts and washers: ¾” SS304 all thread rods, nuts and washers.
   c. Joint Retainers: Provide ductile iron clamp and rod type joint retainers for PVC bell and spigot joints. Clamps shall be designed for use with PVC pipe and shall meet Uni-B-13-92 Standards and be FM approved on sizes 4” to 12”.
   d. EBAA Series 1600 for pipe 4 inches to 12 inches, or approved equal.
   e. EBAA Series 2800 for pipe 14 inches and larger, or approved equal.
   f. Link Assembly: Seal annular space for piping passing through walls with interlocking synthetic rubber link assembly, Link-Seal by Thunderline Corporation or equal.

2.2 VALVES - GENERAL

A. Valves
1. Butterfly Valves: AWWA C504, Class 150B service, with cast iron body, cast iron disc with stainless steel seating edge, BUNA-N seal, 304 stainless steel valve shaft, self-lubricating valve bearings, fully grease packed actuator with stops in the open/close position. The actuator shall have a traveling nut which shall engage alignment grooves in the housing and shall have a built-in packing leak bypass to eliminate possible packing leakage into the actuator. Valve interior and exterior surfaces except for seating shall be coated with two coats of asphalt varnish. Valves shall have mechanical joint ends. Valves shall be Pratt Groundhog or approved equal.
2. Ball Valves: Threaded bronze, 125 lb., 2-piece design, full port. Valves shall be Nibco T-580 or approved equal.
3. Valve Boxes: Valve box shall be 6" PVC pipe, ASTM D3034, SDR 35, with cast iron water well cover. Clay and Bailey No. 2194 or approved equal. Lid shall be marked "WATER". Provide below grade concrete collar in planted areas.

B. Chilled Water Vent Boxes
1. Roadway, Parking Lots and Service Drives: Heavy duty, street rated cast iron with hot-dip galvanized finish. Removable cover shall be checkered steel with stainless steel cover screws. Removable cover shall be checkered steel with stainless steel cover screws. Junction box shall have an H-20 load rating and be suitable for installation in roadway. Minimum dimensions shall be 12” x 12” x 24” (L x W x D). Junction box shall be ER Series, as manufactured by Spring City Electrical Manufacturing Co., or approved equal.
2. Grass and Sidewalks: Vent box shall be 18" PVC pipe, ASTM F679, SDR 35, with cast iron water well cover. Clay and Bailey No. 2361 or approved equal. Lid shall be marked "WATER."
2.3 TRACE WIRE

A. Tracer wire shall be #14 AWG Solid, steel core soft drawn high strength tracer wire, 250# average tensile break load, 30 mil high molecular weight-high density blue polyethylene jacket complying with ASTM-D-1248, 30 volt rating. No THHN insulated wire shall be allowed. Tracer wire shall be Copperhead Industries HS- CCS or approved equal.

B. Tracer wire shall have moisture resistant splices for direct bury applications. Splices shall be Copperhead Industries Snakebite or 3M DBR or approved equal.

C. Tracer wire test stations shall be designed to be easily detected by magnetic and electronic locators. A magnet shall be securely attached at the top of the upper tube of the box for locating purposes. Lid shall be blue and have a brass terminal for attaching locating equipment and a brass 5 sided nut for removing cap. Tracer wire test station shall be Copperhead Industries Snake Pit or approved equal.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. Preparation of Trench

1. Grade trench bottom to provide a smooth, firm, stable, and rock-free foundation throughout the length of the piping. All rock greater than one inch in diameter found in the trench shall be removed for a depth of six inches below the bottom of the pipe and replaced by suitable bedding material.

2. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with crushed stone as indicated on the drawings.

3. Provide layers of crushed stone in the bottom of trench as indicated on the drawings. Shape stone layer to fit bottom of piping. Dig bell holes at each pipe joint to relieve the bells of all loads and to ensure continuous bearing of the pipe barrel on the foundation.

4. Finished pipe installation shall have minimum 12” separation to all other utilities.

B. Installation of Pipe and Pipe Fittings

1. PVC (Polyvinyl Chloride) Pipe: Install in accordance with AWWA C605.

2. All underground water / chilled water piping shall be PVC.

a. EXCEPTION: Lines passing directly over steam tunnels or direct buried steam/condensate lines must be ductile iron with 2” R-5 extruded polystyrene insulation board between the pipe and steam lines.

3. All joints shall be restrained with joint retainers. All fittings shall be restrained with retainer type packing glands.

4. Install stainless steel rods between fittings on all offsets and between fittings, valves, and blind flanges, in addition to the Megalugs. On isolated fittings, valves, etc., attach restraint rings to PVC pipe and install stainless steel rods between fitting and restraint rings. Position rods through the bolt holes in fitting and Megalug. Requires four nuts and washers on each rod. Duct lugs are acceptable. The number of stainless steel rods required per fitting flange are as follows:

<table>
<thead>
<tr>
<th>PIPE DIAMETER</th>
<th>NO. OF RODS</th>
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<tbody>
<tr>
<td>to 10”</td>
<td>2</td>
</tr>
<tr>
<td>12”</td>
<td>3</td>
</tr>
<tr>
<td>14”</td>
<td>4</td>
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<tr>
<td>16”</td>
<td>5</td>
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<tr>
<td>18”</td>
<td>8</td>
</tr>
<tr>
<td>20”</td>
<td>8</td>
</tr>
<tr>
<td>24”</td>
<td>12</td>
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<td>30”</td>
<td>14</td>
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<tr>
<td>36”</td>
<td>14</td>
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5. Ductile iron pipe, fittings and valves shall be wrapped with a polyethylene cover conforming to AWWA C105. Install per AWWA C600.
6. Pipe shall be installed in clean condition, and shall never be laid in trenches with standing water. Contractor shall make provisions to keep the trench dewatered during installation of the water line. Protect open pipe ends with a hard cap or inflatable plug at the end of the work day. NO PLYWOOD OR DUCT TAPE COVERINGS WILL BE ALLOWED.

7. Trace wire shall be pulled with pipe, without splices.

8. Tape trace wire to the top of each water / chilled water line with duct tape every 5 feet. Contractor shall minimize wire splices. Terminate trace wires inside building and inside valve boxes. Drill ¼” hole in PVC valve box 1” below cast iron cover. Route wire up outside of valve box, through ¼” hole and knot. Trace wire shall be tested for continuity in presence of Owner's Representative, after pulling is completed.

9. Install continuous plastic underground warning tape during back-filling of trench for underground water / chilled water and compressed air piping. Locate 24 inches above pipe, directly over each water line.

C. Trenchless Piping Installation

1. It is the desire of system owners to assure that trenchless piping installation be completed in a timely, quality and accurate manner utilizing good, well-maintained equipment and trained competent personnel. Trenchless piping must be installed on a route as close to the drawings as possible to prevent interference with buried utilities and other obstructions, and to prevent future accidental excavation damage.

2. Trenchless piping installation shall only be allowed if previously approved by system owner.

3. Directional drilling and pipe installation shall be done only by an experienced operator specializing in directional drilling and whose key personnel have at least five (5) year experience in this work.

4. Pipe installed by the directional drilled method must be located in plan as shown on the Drawings, and must be no shallower than shown on the Drawings unless otherwise approved. The actual horizontal and vertical alignment of the pilot bore shall be plotted at intervals not exceeding twenty (20) feet. This "as built" plan and profile shall be updated as the pilot bore is advanced. Instrumentation shall be utilized at all times that will accurately locate the pilot hole and measure drilling fluid flow and pressure.

5. Pilot hole shall be drilled on bore path with no deviations greater than 5 feet left/right/depth over a length of 100 feet. In the event that pilot does deviate from bore path more than this amount, the Engineer shall be notified and Engineer may require the pilot drill to be pulled back and redrilled from the location along bore path before the deviation. The final exit point of pilot hole shall be within five (5) feet of the location shown on the drawings.

6. Trenchless piping installed using directional drilling equipment shall be installed in full compliance with restrained joint piping system manufacturer's instructions.

7. Field grooving tools, pulling heads, spline insertion tools, etc. shall be piping system manufacturer's standard.

8. Comply with piping system manufacturer's requirements on maximum pulling force, minimum bend radius, maximum deflection, etc. During pull-back operations, no more than the maximum safe pipe pull pressure shall be applied at any time. Maximum allowable tensile force imposed on the pull section shall be equal to, or less than 80% of the pipe manufacturer's safe pull (tensile) strength.

9. Provide pressure relief holes at close enough intervals to prevent buckling of pavement/sidewalks. If damage does occur, the pavement shall be repaired in accordance with pavement details provided.

10. Trace wire shall be pulled with pipe, without splices. Upon completion of installation, a continuity test on the wire shall be performed and all breaks shall be repaired.

3.2 VALVE INSTALLATION

A. Valve Storage: Use the following precautions for valves during storage:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather. Store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement in watertight enclosures.

3. Handling: Use a sling to handle valves whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use hand wheels or stems as lifting or rigging points.

B. Valve Installation
1. Chilled Water Service 6" and Larger: AWWA-Type Butterfly Valves: Comply with AWWA C600. Install buried valves with stem pointing up and with valve box.
2. Chilled Water Vents: Bronze Ball Valves.
3. Valve boxes shall be installed vertically with top of box even with final grade.

3.3 PIPE TESTING

A. Field Quality Control
1. Piping Tests: Leak and pressure tests shall follow procedures outlined in AWWA M23. Conduct piping tests before joints are covered. Use only potable water.
2. Simultaneous Tests: Conduct leak and pressure testing at the same time. All tests shall be conducted in the presence of the Owner’s Representative –or their designee. Test at not less than 100 psig for 1 hour.
3. Test Report: Submit Test Reports to the system owner representative.

B. Cleaning
1. Cleaning of all piping shall be performed as detailed in section 331300 Disinfecting of Water Utility Distribution. Chilled water distribution piping does not require disinfection.

3.4 VALVE TESTING

A. All valves shall be pressure tested in accordance with standards set forth in the Chilled Water Piping.

3.5 COMMISSIONING

A. System shall be placed in operation only after piping has been leak tested, flushed clean and approved by system owner representative.

END OF SECTION