

SECTION 23 07 00

HVAC INSULATION

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Insulation Materials:
 - a. Mineral fiber.
2. Insulating cements.
3. Adhesives.
4. Mastics.
5. Lagging adhesives.
6. Sealants.
7. Factory-applied jackets.
8. Field-applied fabric-reinforcing mesh.
9. Field-applied cloths.
10. Field-applied jackets.
11. Tapes.
12. Securements.
13. Corner angles.

B. Related Sections:

1. Division 22 Section "Plumbing Insulation."
2. Division 23 Section "Ductwork" for duct liners.

1.03 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 pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties, equipment connections, and access panels.
5. Detail application of field-applied jackets.
6. Detail application at linkages of control devices.

7. Detail field application for each equipment type.

C. Qualification Data: For qualified Installer.

1.04 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.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.05 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.

1.06 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.
- C. Coordinate installation and testing of heat tracing.

1.07 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

2.01 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. Mineral-Fiber Blanket Insulation (MF): Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I; thermal conductivity (avg) of 0.27 Btu/hr-ft²-°F or lower at mean temperature of 75°F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Refer to Part 3 below for insulation density.
- G. Rigid Fiberglass Ductwork Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type 1, 4.2 lb./cu. ft. density for up to 450°F. Service shall meet or exceed ASTM C 680 thermal conductivity test of .23 BTU-in/hr-ft² - °F at 75°F mean temperature. Provide with factory applied FSK jacket.
- H. Mineral-Fiber, Preformed Pipe Insulation (MF): 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; thermal conductivity (avg) of 0.25 Btu/hr-ft²-°F or lower at mean temperature of 75°F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral-Fiber, Pipe and Tank Insulation (MF): 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. Nominal density is 3.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.02 INSULATING CEMENTS

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

2.03 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.04 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. 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.
4. Color: White.

2.05 LAGGING ADHESIVES

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

2.06 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 4. Color: Aluminum.
- B. ASJ Flashing Sealants, and Vinyl, PVDC, 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.
 4. Color: White.

2.07 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. Vapor retarder shall be rated for 150°F service, ASTM E 96 vapor permeance rated at 0.02 perms.

2.08 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, as follows:
1. Shall comply with ASTM C921, Type I, for applications where the equipment or pipes operate below ambient temperature at least part of the time or where a vapor barrier is required.
 2. Shall comply with ASTM C921, Type II, for applications where equipment or pipes operate above ambient temperatures or where a vapor retarder is not required.
- B. 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. Adhesive: As recommended by jacket material manufacturer.
 2. Color: White.
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 4. Factory-fabricated tank heads and tank side panels.
- C. Metal Jacket:
1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Outdoor Applications: 2.5-mil- thick Polysurlyn.
 - d. 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.

2.09 TAPES

- A. 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.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.

6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM 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.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
1. Width: 2 inches.
 2. Thickness: 6 mils.
 3. Adhesion: 64 ounces force/inch in width.
 4. Elongation: 500 percent.
 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
 2. Thickness: 3.7 mils.
 3. Adhesion: 100 ounces force/inch in width.
 4. Elongation: 5 percent.
 5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

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

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-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, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
 5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 6. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

2.11 CORNER ANGLES

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

PART 3: EXECUTION

3.01 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.

3.02 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 PIPING INSULATION APPLICATION

- A. Indoor Piping System Insulation: Insulate with insulation types and thicknesses as listed in the table below. If more than one pipe material is listed for a piping system, selection from materials listed is the contractor's option.

TABLE NO. 23 07 00: MINIMUM PIPE INSULATION

Piping System Types	Fluid Temp Range, °F	Runouts 2" ¹ and less	Type of ⁽⁴⁾ Insulation	Insulation Thickness in Inches for Pipe Sizes				
				1" and smaller	1-1/4" to 2"	2½" to 4"	5" to 6"	8" and larger
<u>Heating Systems</u>								
Low temperature	105-200	½"	MF	1½"	1½"	1½"	1½"	1½"

¹ Runouts not exceeding 12 feet in length and 2" size to individual terminal units.

² Insulation material abbreviations:

a. Mineral fiber (MF)

- B. Refer to Division 23 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for insulation insert and insulation shield requirements.
- C. Outdoor Piping System Insulation: Increase insulation thicknesses indicated for indoor applications by ½". All outdoor insulation shall be flexible elastomeric or polyolefin. Provide with weather barrier aluminum jacket.
- D. Insulation Omitted: Omit insulation for the following:
 - 1. Hot low pressure piping within radiation enclosures or unit cabinets.
 - 2. Cold piping within unit cabinets provided piping is located over drain pan.

3.04 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply, outdoor, and combustion air.
 - 2. Indoor, exposed supply (unless otherwise noted), outdoor, and combustion air.
 - 3. Indoor, concealed return located in nonconditioned space. This includes ducted returns above a non-plenum ceiling. Return ducts in a return air plenum do not require insulation.
 - 4. Indoor, exposed return located in nonconditioned space.
 - 5. Indoor, concealed exhaust and relief between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust and relief between isolation damper and penetration of building exterior.
- B. Items Not Insulated:
 - 1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Factory-insulated access panels and doors.

3.05 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, supply-air duct and plenum insulation:
 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.0-lb/cu. ft nominal density.
- B. Concealed, return-air duct and plenum insulation; non-conditioned areas including ducted returns in a non-plenum ceiling (insulation not required in return air ceiling plenums or in chases or shafts within the conditioned building perimeter):
 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.0-lb/cu. ft nominal density.
- C. Concealed, outdoor and combustion air duct and plenum insulation:
 1. Mineral-Fiber Blanket: 2 inches thick and 1.0-lb/cu. ft nominal density.
- D. Concealed, exhaust-air and relief-air duct and plenum insulation (within 10 feet of exterior wall or roof):
 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.0-lb/cu. ft nominal density.
- E. Exposed, supply-air duct and plenum insulation.
 1. Mineral-Fiber Board: 2 inches thick and 4.2-lb/cu. ft nominal density.
- F. Exposed, return-air duct and plenum insulation, non-conditioned areas:
 1. Mineral-Fiber Board: 2 inches thick and 4.2-lb/cu. ft nominal density.
- G. Exposed, outdoor and combustion air duct and plenum insulation:
 1. Mineral-Fiberboard: 2 inches thick and 4.2-lb/cu.ft. nominal density.
 2. Mineral-Fiberblanket: 2 inches thick and 1.5 lb/cu.ft nominal density. For round ducts only.
- H. Exposed, exhaust-air and relief-air duct and plenum insulation:
 1. Mineral-Fiber Board: 2 inches thick and 4.2-lb/cu. ft nominal density.

3.06 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. 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 duct and 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.

4. Manholes.
5. Handholes.
6. Cleanouts.

3.07 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. 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 "Firestopping" for firestopping and fire-resistive joint sealers.
- F. 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 "Firestopping."

3.08 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.

3.09 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. 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.

- C. 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.

3.10 FIELD-APPLIED JACKET INSTALLATION

- A. 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.
- B. 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.
 - C. 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.

3.11 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 "Firestopping."

END OF SECTION 23 07 00

SECTION 23 09 00

BUILDING AUTOMATION SYSTEM

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. General Description: Furnish integrated Building Automation Systems utilizing intelligent distributed control modules for equipment monitoring and control. EMCS is hereby defined to include, but not limited to, input/output (I/O) devices, I/O interfaces, housings, interconnect cabling, valves, sensors, thermostats, dampers, controllers, actuators, and control modules and other panels associated with equipment and required to provide system control functions as indicated on drawings and schedules, and by requirements of this section.
- B. All new control system work shall integrate with and be an extension of the existing Tridium-based building control systems. LONworks communication is standard, the use of BACnet is not allowed. Coordinate all new work, graphical user interface, and accessibility to system with Owner's representative.
- C. Program systems to accomplish all control functions in accordance with the requirements of Specification Section 23 09 93 "BAS Sequence of Operations."

1.03 ELECTRICAL WORK

- A. Provide the following electrical work as work of this section, complying with all Division 26 specification requirements:
 - 1. Power supply wiring from power source to power connections on controls and/or control modules. Provide all 24 VAC transformers as required for all control operations. Coordinate with the electrical contractor for the locations and quantities of available spare breakers. Review the Electrical Drawings prior to bid to determine power source locations and voltage. The Building Automation System Contractor is required to provide all transformer installations as required for the available power voltage.
 - 2. Control wiring between field-installed controls, indicating devices, thermostats and sensors unit control panels.
 - 3. Raceways, and Electrical Boxes and Fittings: Provide raceways, and electrical boxes and fittings complying with Division 26 specifications.
 - 4. Conduit and junction boxes for all control devices (temperature sensor, thermostats, wall switches, etc.) shall be provided by the Building Automation System Contractor. Route conduit from control device junction boxes in wall up to ceiling/plenum spaces. All wiring in outdoors and in mechanical rooms, electrical rooms and similar spaces shall be completely in conduit.
 - 5. The Temperature Control Contractor shall provide relays as required for starters of all 120/1-volt equipment not furnished with factory starters, or if starters are not furnished by the Electrical Contractor. Control relays shall be provided in NEMA 1 enclosure.
 - 6. All conduit in spaces other than mechanical rooms, boiler rooms, and electrical rooms that is not routed above the ceiling shall be concealed in walls. It is the responsibility of the Building Automation System Contractor to coordinate conduit required to be installed in poured concrete walls prior to construction.

1.04 QUALITY ASSURANCE

- A. Contractors shall have a minimum ten years of experience installing and programming control systems. Contractors shall also be factory authorized representative for the control product installed. Submit proof of years of experience and factory authorization upon request.
- B. NEC Compliance: Comply with applicable requirements of NEC pertaining to installation of energy management and control systems, including, but not limited to, remote-control, signaling and power-limited circuits.
- C. UL Compliance: Provide energy management and control system components and ancillary equipment which are listed and labeled in accordance with UL 864 and UL 916.
- D. NEMA Compliance: Comply with NEMA'S Pub No. 250, and Stds ICS 1, 2, 3 and 6 pertaining to enclosures and controls for energy management and control systems.
- E. FCC Compliance: Comply with Subpart J of Part 15, Federal Communications Commission Rules, pertaining to Class A radiation and computing devices and low power communication equipment operating in commercial type environment. Comply with Part 68, Federal Communication Commission Rules, pertaining to labeling of telephone equipment, including data sets and modems, indicating FCC registration and numbering.
- F. EIA Compliance: Comply with Electronic Industries Association's Std RS-232 pertaining to interfacing requirements for connecting data terminals and communication equipment.
- G. IEEE Compliance: Comply with IEEE Std 488, "Standard Digital Interface for Programmable Instrumentation", for interfacing instrumentation into system.
- H. ANSI Compliance: Comply with ANSI X3.4, "Code for Information Interchange", requirements for interfacing computer data processing with communication terminal equipment.
- I. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to electronic controls and control sequences.

1.05 RELATED WORK

- A. Refer to other Division 23 sections for the installation of instrument wells, valve bodies, sensors, flow switches, and dampers. Coordinate equipment delivery schedules and installation requirements.

1.06 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each control device furnished, dampers, valves, sensors, thermostats, etc. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions. Indicate system power connections to electrical power feeders.
- B. Shop Drawings
 - 1. Provide system architecture lay out showing field panels, Application Specific Controllers (ASC), central computer terminal, required network hardware, horizontal and backbone network cabling, tie-in to existing systems, and power panels (see system layout for system requirements).
 - 2. Provide panel numbering sequence and ASC's submittal showing specific units controlled by each piece of DDC hardware.
 - 3. Provide point address, set points, alarm limits, wire types, conduit knock out diagrams and wiring diagrams for all points of interface.

4. Provide power panel layouts showing number and type of transformers and termination strips. Panels must meet UL listing requirements.
5. Provide technical cut sheets for DDC hardware and sensors.
6. Submit drawings for each system automatically controlled, containing the following information:
 - a. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, sensors and control devices. List all equipment associated with each system, no general references will be accepted. Include damper and valve failure positions.
 - b. Label each control device with setting or adjustable range of control.
 - c. Indicate factory and field wiring.
 - d. Indicate each control panel required, with internal and external piping and wiring clearly indicated. Provide detail of panel face, including controls, instruments, and labeling. Include verbal description of sequence of operation.
- C. User Interface Graphics: Submit for review all user interface graphics prior to substantial completion of the project. The Owner reserves the right to modify system graphics prior to final payment.
- D. Wiring Diagrams: Submit power, signal and control wiring diagrams, breaker location and identification, transformer locations, and communication link locations indicating panel-to-panel connections, for energy management and control systems. Clearly differentiate between portions of wiring that are manufacturer- installed and portions that are field-installed.
- E. Maintenance Data: Submit maintenance instructions and spare parts lists. Include product data and shop drawings in maintenance manual in accordance with requirements of Division 1. Include copy of shop drawings in each maintenance manual in accordance with requirements of Division 1.
- F. Samples: Submit samples of each type of thermostat/temperature sensor, in accordance with requirements of Division 1.
- G. Agreement to Maintain: Prior to time of final acceptance, installer shall submit 4 copies of agreement for continued service and maintenance of energy management and control systems, for Owner's possible acceptance. Offer terms and conditions for furnishing parts and providing continued testing and servicing, including replacement of materials and equipment, and software maintenance for one-year period commencing after the warranty period required by the terms of this contract. the Owner's representative shall retain the option for annual renewal of the offered service agreement.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.

1.08 WARRANTY

- A. Provide a warranty and maintain the stability of work and materials and keep same in perfect repair and condition for a minimum of one (1) year.

- B. Correct defects of any kind immediately and at Contractor's expense, due to faulty work or materials appearing during the above mentioned period and made to the entire satisfaction of the Owner and Architect/Engineer. Such reconstruction and repairs shall include damage to the finish or the building resulting from the original defect or repairs thereto.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering energy management and control systems which may be incorporated in the work include the following:
 - 1. Tridium-based hardware provided and installed by ControlNet.

2.02 BUILDING AUTOMATION SYSTEM – HARDWARE

- A. General: Provide energy management and control systems with adequate capacity and performance rating to process the number of system points indicated. Comply with manufacturer's standard design, materials, and components; construct in accordance with published product information, as required for complete installation, and as herein specified.
 - 1. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system.
 - 2. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system.
 - 3. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
 - 4. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's network system. Systems employing a "flat" single tiered architecture shall not be acceptable.
 - a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
 - b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.
 - 5. Control modules shall be capable of proper operation in an ambient environment of 32°F to 120°F and 10% to 90% relative humidity--non-condensing.
- B. The Central Computer Workstation is existing. Field verify existing conditions and notify Engineer of issues related to completing the scope of work required.
- C. Control Networks
 - 1. Building Automation System Network:
 - a. Provide a microprocessor-based communications data path which shall act as a "peer-to-peer" network allowing all control modules to communicate with equal authority. Provide all network switches, cabling, and devices to achieve the performance requirements herein.
 - b. The network switch devices shall be managed and provide full-duplex communication. The switch packet routing algorithm shall minimize bandwidth consumption. Network hubs or unmanaged switches will not be acceptable.

- c. The BAS network shall be responsible for routing global information from the various control module networks.
- d. The BAS Network shall be a 1 Gigabit/Sec Ethernet network supporting BACnet, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local host computer system.
- e. BAS network minimum physical and media access requirements:
 - 1) Ethernet; IEEE standard 802.3
 - 2) Cable; 10 Base-T, UTP-8 wire, CAT 6, Plenum Rated (Type CMP)
 - 3) Minimum throughput; 1 Gbps with backwards compatibility with 10/100 networks.

2. Application Specific Controller (ASC) Network

- a. ASC Controllers shall be used for direct digital control of selected single zone equipment. They shall be microprocessor based. In the event of loss of communication with the network, the controller shall function in a stand-alone mode, with all control sequences and schedules performed. Provide user-defined default algorithms (values) for global points affecting the operation of the ASC, such as outside lights levels, outside temperatures, status of heating system, etc.

D. Application Specific Control Modules (ASC)

- 1. Provide one of the following ASC's:
 - a. ASC Modules shall be microprocessor based Interoperable. ASC's shall be capable of providing the direct digital control of single zone Terminal HVAC Units, Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
- 2. The ASC's shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
- 3. The ASC Sensor shall connect directly to the ASC and shall not utilize any of the I/O points of the controller. The ASC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive.
- 4. All ASC's shall be fully application programmable. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the ASC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- 5. All control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units.
- 6. Each ASC shall communicate with equal authority on a "peer-to-peer" basis.
- 7. Each ASC shall execute application programs, calculations, and commands via a microcomputer resident in the ASC. The database and all application programs for each ASC shall be stored in read/writable non-volatile memory. All volatile memory shall have a battery backup.
- 8. Each ASC shall contain both software and hardware to perform full DDC/PID control loops. ASC shall be able to provide analog output, in addition to normal binary type output.

9. Control modules shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type. Analog outputs shall be industry standard signals (e.g. 24V floating control) allowing for interface to a variety of modulating actuators.
 10. The control modules shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC(-25% to +17%), allowing for power source fluctuations and voltage drops. Provide each module with a suitable cover or enclosure to protect the intelligence board assembly.
 11. Each ASC shall have LED indication for visual status of communication, power, and all outputs.
 12. Each controller shall include provisions for manual and automatic calibration of associated transducers in order to maintain stability and control drift over time.
 13. The module shall interface to a variety of matching electronic room temperature sensors of the RTD or thermistor type with the following characteristics:
 - a. Independent setpoint modes for heating, cooling, and Night Setback.
 - b. Tamperproof locking cover.
 - c. Allow installation up to 100 ft from controller.
 14. Controller points and set points shall be accessible from the central workstation and from a plug in jack at the base of each controller's sensor.
 15. Contractor shall field verify operation of all controllers to insure correct field wiring, test actuator stroke, and correlate with controller submittal.
 16. Contractor shall provide a POT and instructions to the balancer to read and adjust system perimeters for the balancing report.
- E. Fault-Tolerance: Select components to operate over a wide range of supply voltage and frequency, with static, transient and short-circuit protection on all inputs and outputs. Protect communication lines against incorrect wiring, static transients and induced magnetic interference. Provide AC coupled devices for connection to communication network to limit device time-outs.

2.03 GRAPHICAL USER INTERFACE SOFTWARE

- A. All new graphics as required herein shall be an extension of the existing system. All new graphics shall conform to District standard.

2.04 MATERIALS AND EQUIPMENT

- A. General Description: Furnish direct digital electronic control products in sizes and capacities indicated, including valves, dampers, thermostats, clocks, sensors, controllers, and other components required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer. Provide direct digital electronic control systems with the following functional and construction features, as indicated.
- B. System Accuracy:
1. The system shall maintain an end-to-end accuracy for one year from sensor to diagnostic display the following applications.
 - a. Space temperature in range of 50-85°F: within plus or minus 0.5°F.
 - b. Duct temperature in range of 40-140°F: within plus or minus 0.5°F.
 - c. Outside air (OA) temperature in range of minus 40-130°F: within plus or minus 1.0°F.

- d. Water temperature in range of 30-100°F: plus or minus 0.5°F; in range of 100-300°F: within plus or minus 1.0°F.
 - e. Pressure: Within plus or minus 2.0 percent of range.
- C. Environmental Conditions: Furnish equipment designed to operate under ambient environmental conditions of 35-120°F dry bulb and 10 to 95 percent relative humidity. Furnish sensors and control elements designed to operate under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.
- D. Power Line Surge Protection: Protect equipment power supplies from power line surges.
- E. Grounding Protection: Protect equipment from any ground fault by providing special grounding as required to prevent equipment failure under any kind of ground fault.
- F. Control Relays: Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices. Provide control relays for all 120/1-volt motors not provided with a motor starter with auxiliary contacts.
- G. Fault-Tolerance: Select components to operate over a wide range of supply voltage and frequency, with static, transient and short-circuit protection on all inputs and outputs. Protect communication lines against incorrect wiring, static transients and induced magnetic interference. Provide AC coupled devices for connection to communication network to limit time-outs.

PART 3: EXECUTION

3.01 INSPECTION

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.02 INSTALLATION OF ENERGY MANAGEMENT AND CONTROL SYSTEMS

- A. Install energy management and control systems as indicated, in accordance with system manufacturer's written instructions, and with recognized industry practices, to ensure that energy management and control equipment complies with requirements. Comply with requirements of NEC, and applicable portions of NECA's "Standard of Installation" pertaining to general electrical installation practices. Mount controllers at convenient locations and heights.
- B. Coordinate with other electrical work, including power distribution and equipment, as necessary to interface installation of energy management and control equipment work with other work.
- C. Control Wiring: The term "control wiring" is defined to include providing EMCS manufacturer-approved wiring, conduit and miscellaneous materials as required for mounting and connecting control devices. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. Provide plenum rated multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly. Control wiring shall be plenum rated. Tees or wye taps in the communication network are not permitted.
- D. Number-code and color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system. Label ends of all conductors in control cabinets with 3M tape indicating control device.

- E. Install electrical terminations in UL approved, vented panel enclosures. Locate panels in spaces designated for use as electrical or mechanical equipment rooms. Panels shall be located to provide adequate access and clearance for servicing.
- F. All control transformers shall be located in mechanical rooms, janitor closets, or electrical rooms exposed to view. All transformers shall be clearly labeled with the systems it serves.
- G. Reset Limit Controls: Install manual-reset limit controls to be independent of power controllers.
- H. Unit-Mounted Equipment: Where control devices are indicated to be unit-mounted, ship relays, switches, etc. to unit manufacturer for mounting and wiring at factory.
- I. Grounding: Provide tight equipment grounding connections, sufficiently tight to assure permanent and effective ground, for energy management and control systems as indicated.

3.03 LOCATION OF EQUIPMENT

- A. Every effort shall be made to conceal the installation of new valves and controllers. Refer to drawings for installation requirements.

3.04 PROJECT SCHEDULING

- A. Provide a detailed critical path schedule within 14 days of the Owner's acceptance of the General Contractor's or Construction Manager's master schedule. The critical path schedule shall incorporate the project phasing plans, and identify all equipment start-up dates. The equipment start-up dates shall be planned such that there is an adequate period of time to complete the quality control requirements and associate self-performed functional performance testing. Coordinate any specific requirements of other trades, such as power wiring, with the General Contractor or construction manager such that the master schedule incorporates these requirements of other subcontractors. The schedule shall prove a methodology to complete all work prior to Substantial Completion.
- B. The critical path schedule shall include at a minimum the following elements.
 - 1. Start and end dates for work in each phase established on the master schedule.
 - 2. Delivery of submittal documents.
 - 3. Delivery of control components to other trades such as valves and dampers.
 - 4. On-site installation of control wiring, controllers, and other control components.
 - 5. Start-up dates for each piece of equipment.
 - 6. Functional performance tests for each phase of construction and each piece of equipment.
 - 7. Delivery of all Quality Control documents.
 - 8. Start date for Owner's testing agent for each phase and each piece of equipment.
 - 9. Substantial Completion date.

3.05 QUALITY CONTROL

- A. Upon completion of installation of system hardware and software and after circuitry has been energized, demonstrate capability and compliance of system with requirements. All testing work shall be self performed and completed by the installer and appropriate subcontractors. Where possible, correct malfunctioning units at site, then re-test to demonstrate compliance; otherwise remove and replace with new units, and proceed with re-testing.
 - 1. Functional Performance Tests: Completion and documentation of all functional performance tests are required as a condition of substantial completion and shall be complete prior to demonstration with Owner's representative. The functional performance tests shall be in checklist form and include the initials of the assigned tester and the pass date of each item to be tested. The checklists shall include but not be limited to the following:
 - a. Visual inspection verifying the installation of all control components and wiring is complete.

- b. Calibration of all analog sensing devices.
- c. Conductance tests of all communication and network wiring.
- d. Visual crosscheck of each control point by making a comparison between the command and field-controlled device.
- e. Verification of loss of power and control failure modes for each control device.
- f. Verification of alarm notifications on the system front end as required in the control sequences.
- g. A checklist of deficiencies that require corrective work by other trades and an anticipated date for completion.

3.06 GRAPHICAL USER INTERFACE

- A. Provide a sample of each graphic intended for the front end user interface for review and approval by the Engineer and Owner's representative prior to final installation. The graphic must illustrate the following for review.
 - 1. Intended procedure for navigating between graphics.
 - 2. Sensor and control signal information available.
 - 3. Mode of operation status, and safety information available.
 - 4. Operator override procedures.
 - 5. Room number and equipment designations.
- B. Update final graphics with Owner requested revisions to room name and number identification and equipment identifications. Allocate time for technicians to update graphics and associated engineering drawing and as-built submittals after final installation of system software. The work shall be scheduled to occur prior to substantial completion.

3.07 DEMONSTRATION AND TRAINING

- A. Provide demonstration and training for Owner's representative in accordance with Division 1 specification section 01 79 00.
- B. Building Operating Personnel Training: Train Owner's building personnel in procedures for starting-up, testing and operating energy management and control system equipment. In addition, train building personnel to maintain software, that they are capable of initiating changes to computer programs including addition and deletion of points.
- C. Provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays as follows:
 - 1. Provide on-site training for owner's operating personnel. Training time allocated shall be 8 hours for an Elementary School and 16 hours for secondary schools. Training shall include:
 - a. Explanation of drawings, operations and maintenance manuals.
 - b. Walk-thru of the job to locate control components.
 - c. Operator workstation and peripherals and operation/functions.
 - d. Operator control functions, including graphic generation and field panel programming
 - e. Operation of portable operator's terminal.
 - f. Explanation of adjustment, calibration and replacement procedures.

2. Technical support staff must be made available to discuss problems as they arise, at no additional cost to the Owner.
3. If additional such training is required by the Owner, it will be contracted at a later date. Provide description of available local and factory customer training.

3.08 ADJUSTING AND CLEANING

- A. Start-Up: Start-up, test, and adjust direct digital electronic control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- C. Final Adjustment: After completion of installation, adjust controllers, sensors and similar equipment provided as work of this section.
 1. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.

3.09 SIGNAGE

- A. Provide an engraved plastic laminate sign at all push buttons in occupied spaces to identify the function of the button. Coordinate exact language of each sign with the Owner's representative. Refer to specification section 23 05 53 for sign requirements.

3.10 CLOSEOUT PROCEDURES CONTROL SEQUENCES AND POINTS SCHEDULES

- A. Every connected analog output (AO), analog input (AI), digital output (DO), and digital input (DI) represents a "point" where referred to in this specification. Refer to the attached data sheets for specific control sequences and for complete listing of these points. Each analog output shall have its own distinct control loop. All analog points shall be adjustable through the EMCS
- B. Each air handling unit, exhaust fan, unit heater, or other equipment indicated to be controlled by a time clock schedule through the EMCS shall be capable of being individually programmed for its own schedule of operation.

END OF SECTION 23 09 00

SECTION 23 09 93

BAS SEQUENCE OF OPERATIONS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Division 23 Section "Building Automation System" for control equipment and devices and for submittal requirements.

1.03 DEFINITIONS

- A. DDC: Direct digital control.

1.04 HEATING CONTROL SEQUENCES

- A. Refer to the attached control sequences and points schedule for required Building Automation Systems work.

PART 2: PRODUCTS (Not Applicable)

PART 3: EXECUTION (Not Applicable)

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: **Packaged Energy Recovery System**

1. GENERAL

A. Air Handling Systems: All equipment indicated shall be controlled by the same software defined occupied/unoccupied schedule through the Building Automation System.

1. AREA SERVED:

ERU-1 Science Lab

B. Energy recovery units are indirect gas fired and are complete with all factory installed controls including control dampers. Refer to specification section 23 74 14.

C. Provide all required programming, wiring, all devices to incorporate the factory controls and sequences indicated herein into the District's existing front-end control system.

D. Install and wire the factory provided unit controls in accordance with all manufacturer's instructions and guidelines.

E. Provide and wire all electrical interlocks to other equipment associated with this system, as indicated or otherwise necessary for proper system operation.

F. Scope of BAS work shall also include updating the District's front end to remove existing unit ventilators, fans, etc. currently indicated to demolished and update the existing graphics.

2. CONTROL SEQUENCE

A. Occupied

1. The system shall be indexed to the occupied mode by a timeclock schedule determined through the Building Automation System software (District's existing Tridium front-end).

2. ERU-1 shall be controlled as a single zone based on an enable/disable command from the District's front-end.

3. The unit shall operate on its own internal controls to maintain unit discharge air temperature setpoint. The front-end system shall send the factory controller a space temperature setpoint (operator adjustable) that will adjust the DA temperature setpoint through the factory controller.

B. Unoccupied Mode

1. The unit shall start to maintain a night set-back temperature initially set as 55°F (operator adjustable through the District's front-end) and operate in full re-circulating mode.

C. Safeties

1. High Discharge Air Temperature - De-energize fan and transmit alarm to EMCS when the discharge air temperature exceeds 100.0 degrees.

2. Low Discharge Air Temperature - De-energize fan and transmit alarm to EMCS when the discharge air temperature drops below 38.0 degrees.

3. ALARMS

- A. Generate an alarm if the make-up air unit is in fault alarm.

4. POINTS SCHEDULE

Provide at a minimum the following control points for each system and as required to accomplish the control sequences. All points shall be part of the front-end graphics.

(AO)Space Temperature Setpoint

(DO)ERU-1 Control

(DI) ERU -1 Fault

(AI) Space Temperature

(AI) Outside Air Temperature [Existing Control Point]

(AI) Discharge Air Temperature

END OF SECTION 23 09 93

SECTION 23 11 23

NATURAL-GAS PIPING

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.
 - 6. Mechanical sleeve seals.
 - 7. Grout.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, 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 Space: A space that does not have an opening through its boundary to allow the free passage of air to an occupied space. The opening size and location within the space boundary required for a space to be considered non-concealed is at the discretion of the Engineer and the plumbing inspector. The measure of a space that is defined as non-concealed is that odors from a potential gas leak will be readily detected by a building occupant.

1.04 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig, and is reduced to secondary pressure of 0.5 psig or less.

1.05 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Corrugated, stainless-steel tubing with associated components.

3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.
6. Mechanical sleeve seals.
7. Escutcheons.

B. Welding certificates.

C. Field quality-control reports.

D. Operation and Maintenance Data: For motorized gas valves and pressure regulators to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

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

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

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

D. Products and installation shall comply with the International Fuel Gas Code with State amendments.

1.07 DELIVERY, STORAGE, AND HANDLING

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

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

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

1.08 PROJECT CONDITIONS

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

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

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.

1.09 COORDINATION

A. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2: PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
- B. Galvanized Steel Pipe and Fittings: Conform to ASTM A53/A 53M, Type E or S, Grade A or B, Schedule 40.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - 3. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
- C. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - 2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
- D. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.

2.02 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

E. T-Pattern Strainers:

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

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.03 JOINING MATERIALS

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

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

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

2.04 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- B. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig.
 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- C. Bronze Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lee Brass Company.
 - b. McDonald, A. Y. Mfg. Co.
 2. Body: Bronze, complying with ASTM B 584.

3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.05 MOTORIZED GAS VALVES

- A. Electrically Operated Valves: Comply with UL 429.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASCO Power Technologies, LP; Division of Emerson.
 - b. Dungs, Karl, Inc.
 - c. Eclipse Combustion, Inc.
 - d. Goyen Valve Corp.; Tyco Environmental Systems.
 - e. Magnatrol Valve Corporation.
 - f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
 - g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 2. Pilot operated.
 3. Body: Brass or aluminum.
 4. Seats and Disc: Nitrile rubber.
 5. Springs and Valve Trim: Stainless steel.
 6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
 7. NEMA ICS 6, Type 4, coil enclosure.
 8. Normally closed.
 9. Visual position indicator.

2.06 PRESSURE REGULATORS

- A. General Requirements:
 1. Single stage and suitable for natural gas.
 2. Steel jacket and corrosion-resistant components.
 3. Elevation compensator.
 4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.
- B. Line Pressure Regulators: Comply with ANSI Z21.80.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Eclipse Combustion, Inc.
 - d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
 - e. Invensys.
 - f. Maxitrol Company.
 - g. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Optional Features:
 - a. Overpressure Protection Device: Factory mounted on pressure regulator.
 - b. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - c. Maximum Inlet Pressure: 2 psig.

2.07 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Minimum Operating-Pressure Rating: 150 psig.
2. Combination fitting of copper alloy and ferrous materials.
3. Insulating materials suitable for natural gas.
4. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

1. Minimum Operating-Pressure Rating: 150 psig.
2. Combination fitting of copper alloy and ferrous materials.
3. Insulating materials suitable for natural gas.
4. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

1. Minimum Operating-Pressure Rating: 150 psig.
2. Companion-flange assembly for field assembly.

3. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.08 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, 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.

2.09 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 2. Pressure Plates: Stainless steel.
 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.10 ESCUTCHEONS

- A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

2.11 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 1. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 2. Design Mix: 5000-psi, 28-day compressive strength.
 3. Packaging: Premixed and factory packaged.

2.12 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3: EXECUTION

3.01 PIPE APPLICATIONS

- A. Within Building: Install steel pipe with welded joints for all pipe sizes. Steel pipe with threaded joints or copper pipe with brazed joints, may be installed for 2" and smaller piping where routed in locations not defined as a concealed space.
- B. Outside Building: Install galvanized steel pipe with threaded joints and fittings painted to match existing roof mounted gas piping.

3.02 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 and smaller shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.

3.03 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
 - B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 - C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 - D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
 - E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
- ### **3.04 EXAMINATION**
- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
 - B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.05 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to State Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with State Code requirements for prevention of accidental ignition.

3.06 OUTDOOR/UNDERGROUND PIPING INSTALLATION

- A. Comply with State Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - 1. For natural-gas piping installed less than 36 inches below finished grade, install it in a rented containment conduit to comply with the International Fuel Gas Code.
- C. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to coating on pipe as recommended in writing by protective coating manufacturer.
- D. Install fittings for changes in direction and branch connections.
- E. 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.
- F. 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.
- G. Install pressure gage downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.07 INDOOR PIPING INSTALLATION

- A. Comply with State Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install escutcheons at penetrations of interior walls, ceilings, and floors. Escutcheons in areas exposed to view shall have a chrome plated finish.
- K. Seal space outside of sleeves in concrete slabs and walls with grout.
- L. Install sleeves that are large enough to provide ¼-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
- M. 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 Concrete Roof Slabs: Steel pipe.
 - 4. Sleeves for Piping Passing through Interior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6.
- N. 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."
- O. Verify final equipment locations for roughing-in.
- P. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- Q. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- R. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- S. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

- T. Concealed Space: In accordance with the definition in Part 1, the following conditions are considered to be concealed spaces. The following is not intended to be a complete list of all concealed conditions within the building. All piping in a concealed space shall have welded joints and fittings. Mechanical fittings, valves, and unions are not allowed.
 - 1. Above-Ceiling Locations: That are not return plenums or do not have a reasonably sized and located opening to allow free passage of air to the occupied space below.
 - 2. Piping In Partitions: Piping routed in partition walls shall be open to a non-concealed ceiling space and allow the free passage of air for the entire height of the partition.
- U. Prohibited Locations: Do not install gas piping in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumb waiter, elevator shafts within poured concrete floors, or below grade within the building perimeter.
- V. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- W. Connect branch piping from top or side of horizontal piping.
- X. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- Y. Do not use natural-gas piping as grounding electrode.
- Z. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- AA. Install pressure gage downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.08 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- C. Install a code approved shut-off valve in the gas main in an accessible location, just inside the building, before the first branch line.

3.09 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. – Inches
Up to ¾	8	7	3/8
1	8	7	3/8
1¼	9	7	3/8
1½	9	8	3/8
2	9	8	3/8
2½	10	9	½
3	10	10	½
3½	10	10	½
4	10	10	½

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

3.10 CONNECTIONS

- A. Install piping adjacent to appliances to allow service and maintenance of appliances.
- B. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.11 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.12 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

3.13 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to State Code and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 23 11 23

SECTION 23 21 13

HYDRONIC PIPING

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
- B. Related Sections include the following:
 - 1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.03 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Hot-Water Heating Piping: 150 psig at 200 deg F.

1.04 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
- B. Welding certificates.
- C. Qualification Data: For Installer.

1.05 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 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. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

PART 2: PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.

2.02 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.03 JOINING MATERIALS

- A. 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.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, 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 joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.04 VALVES

- A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

PART 3: EXECUTION

3.01 PIPING APPLICATIONS

- A. Hydronic Piping (unless otherwise specified here-in):
 1. Up to 2½": Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 2. 1½" and Larger: Schedule 40 steel pipe with welded joints and fittings.

3.02 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

3.03 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping.
- P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- R. Install all temperature sensors and flow switches at the direction of the Building Automation System Contractor.

3.04 HANGERS AND SUPPORTS

- A. Comply with requirements in Division 23 Section "Hangers and Supports for HVAC 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: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs: Field fabricated, heavy duty trapeze. Fabricate from steel shapes required for loads.
- 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 supports for vertical copper tubing every 10 feet.
- E. Install supports for vertical steel piping every 15 feet.
- F. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to 3/4	7	5	3/8
1	7	6	3/8
1-1/4	7	7	3/8
1-1/2	9	8	3/8
2	10	8	3/8
2-1/2	11	9	1/2
3	12	10	1/2
3-1/2	13	11	1/2
4	14	12	1/2
5	16	13	5/8
6	17	14	3/4
8	19	16	7/8
10	22	18	7/8
12	23	19	7/8

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

3.05 PIPE 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.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- 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/D10.12M, 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.

3.06 FIELD QUALITY CONTROL

- A. 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. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
 - 5. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens and install new filter in the bypass feeder. Notify the Owner and Engineer one week prior to performing flushing procedures such that procedures can be witnessed.
 - 6. Prepare a written report of flushing procedures indicating the date of flushing and signed by the person performing the procedures validating it has been completed.
- B. Perform the following before operating the system:
 - 1. Open manual valves fully.

2. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).

END OF SECTION 23 21 13