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SECTION 232113 - HYDRONIC PIPING

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on MasterWorks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on MasterWorks/Supporting Information.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Plastic pipe and fittings.
4. Fiberglass pipe and fittings.
5. Joining materials.
6. Transition fittings.
7. Dielectric fittings.
8. Bypass chemical feeder.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.
3. Joining materials.
4. Bypass chemical feeder.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

- C. Welding certificates.
- D. Field quality-control reports.
- E. Preconstruction Test Reports:
 - 1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 - 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.6 WARRANTY

- A. Manufacturer's Special Warranty on Domestic Products: Conbraco Industries, Inc. warrants products to be free of defects in workmanship or material for a period of five years. This warranty applies to Apollo brand products with "Made in the USA" markings only. Conbraco will correct such defects by suitable repair or replacement at Conbraco's discretion.
- B. Manufacturer's Special Warranty on International Products: APOLLO INTERNATIONAL products will be free of defects in workmanship or material for a period of two years. Conbraco will correct such defects by suitable repair or replacement at Conbraco's discretion.
- C. Manufacturer's Warranty on LASCO Fittings, Inc. products will be free of defects in workmanship for a period of three (3) years from date of installation. The manufacturers liability under expressed or implied warranty or for any reason is limited to furnishing replacement units or granting a credit for defective units. No labor expense or consequential damages will be paid by LASCO Fittings, Inc. For complete details please refer to: http://www.lascofittings.com/assets/1824/lasco_letter_of_warranty.pdf.

- D. Manufacturer's Special Warranty on Apollo-Shurjoint Products warrants products to free of defects in workmanship or material for a period of ten years. This Limited Warranty applies to manufacturing defects only and does not cover severe service/temperature applications or wear parts.
- E. Elkhart Products Corporation warranties our fittings to be free from defects in materials and workmanship for a period of fifty (50) years. The Elkhart Product Corporation Water Heater hoses carry a two (2) year warranty against defects in materials and workmanship. Any fitting which proves to be defective will be replaced or a credit issued, but no incidental labor charges, expenses or damages will be allowed.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: **[Owner will engage]** **[Engage]** a qualified testing agency to perform preconstruction testing on water quality.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 1. Hot-Water Heating Piping: **[100 psig (689 kPa)]** **<Insert psig (kPa)>** at **[200 deg F (93 deg C)]** **[180 deg F (82 deg C)]** **<Insert temperature>**.
 2. Chilled-Water Piping: **[150 psig (1034 kPa)]** **<Insert psig (kPa)>** at **[73 deg F (22 deg C)]** **<Insert temperature>**.
 3. Dual-Temperature Heating and Cooling Water Piping: **[100 psig (1034 kPa)]** **<Insert psig (kPa)>** at **[180 deg F (82 deg C)]** **<Insert temperature>**.
 4. Condenser-Water Piping: **[150 psig (1034 kPa)]** **<Insert psig (kPa)>** at **[73 deg F (66 deg C)]** **<Insert temperature>**.
 5. Glycol Cooling-Water Piping: **[150 psig (1034 kPa)]** **<Insert psig (kPa)>** at **[150 deg F (66 deg C)]** **<Insert temperature>**.
 6. Makeup-Water Piping: **[80 psig (552 kPa)]** **[150 psig (1034 kPa)]** **<Insert value>** at **[73 deg F (22 deg C)]** **[150 deg F (66 deg C)]** **<Insert temperature>**.
 7. Condensate-Drain Piping: **[150 deg F (66 deg C)]** **[180 deg F (82 deg C)]** **<Insert temperature>**.
 8. Blowdown-Drain Piping: **[180 deg F (82 deg C)]** **[200 deg F (93 deg C)]** **<Insert temperature>**.
 9. Air-Vent Piping: **[180 deg F (82 deg C)]** **[200 deg F (93 deg C)]** **<Insert temperature>**.
 10. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: **[ASTM B 88, Type L (ASTM B 88M, Type B)]** **[ASTM B 88, Type M (ASTM B 88M, Type C)]**.

- B. Annealed-Temper Copper Tubing: **ASTM B 88, Type K** (ASTM B 88M, Type A).
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; C10W, C11W, C20W, C21W, C26W, C50W, C52W, or comparable products by one of the following:
 - a. Anvil International.
 - b. Star Pipe Products.
 - c. Victaulic Company.
 - d. **<Insert manufacturer's name>**.
 2. Grooved-End Copper Fittings: **ASTM B 75** (ASTM B 75M), copper tube or ASTM B 584, bronze casting.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; C10, C11, C20, C21, C26, C50, C52, C55, C55T, C60, or comparable products by one of the following:
 - 1) Anvil International.
 - 2) Star Pipe Products.
 - 3) Victaulic Company.
 - 4) **<Insert manufacturer's name>**.
 3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, [prelubricated] EPDM gasket rated for minimum **230 deg F** (110 deg C) for use with housing, and steel bolts and nuts.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; C305, C306, C307, C341, or comparable products by one of the following:
 - 1) Anvil International.
 - 2) Star Pipe Products.
 - 3) Victaulic Company.
 - 4) **<Insert manufacturer's name>**.
- E. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
1. Basis-of-Design Product: Subject to compliance with requirements, provide products by Elkhart Products Corporation or comparable product by one of the following:
 - a. NIBCO INC.
 - b. Lee Brass.
 - c. **<Insert manufacturer's name>**.
- F. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

1. Basis-of-Design Product: Subject to compliance with requirements, provide products by Elkhart Products Corporation, made in USA, or comparable product by one of the following:
 - a. NIBCO INC.
 - b. <Insert manufacturer's name>.
- G. Copper Pressure-Seal-Joint Fittings: IAPMO PS-117.
1. Basis-of-Design Product: Subject to compliance with requirements, provide products by ApolloXpress, made in USA, or comparable products by one of the following:
 - a. NIBCO INC.
 - b. <Insert manufacturer's name>.
 2. For Types K, L, and M hard copper tubing **NPS 1/2 (DN 15)** to **NPS 4 (DN 100)** and soft copper tubing in **NPS 1/2 (DN 15)** to **NPS 1-1/4 (DN 32)**.
 3. Housing: Copper or bronze.
 4. Sealing Element: EPDM.
 5. Multiple leak path detection system.
 6. IAPMO PS-117.
 7. Tools: Manufacturer's special tools.
 8. Maximum **200 psig (1379 kPa)** working-pressure.
 9. Maximum temperature rating at **250 deg F (121 deg C)**.
 10. Maximum test pressures at **600 psig (4136 kPa)**.
 11. Fittings for **NPS 2 (DN 50)** and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
 12. Fittings for **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Cast-bronze or wrought-copper with stainless-steel grip ring and EPDM-rubber, O-ring seal in each end.
- H. Copper Push-on-Joint Fittings: ASSE 1061.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkhart Products Corporation; Copper Loc non-removable pressure fittings, made in USA, or comparable products by one of the following:
 - a. Victaulic Company.
 - b. <Insert manufacturer's name>.
 2. Description:
 - a. Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22.
 - b. Maximum **200 psig (1379 kPa)** working-pressure rating at **250 deg F (121 deg C)**.
 - c. Stainless-steel grip ring and EPDM-rubber O-ring seal.
- I. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; C723, or a comparable product by one of the following:

- a. T-DRILL Industries Inc.
- b. <Insert manufacturer's name>.

J. Wrought-Copper Unions: ASME B16.22.

1. Basis-of-Design Product: Subject to compliance with requirements, provide products by Elkhart Products Corporation, made in USA, or comparable products by one of the following:
 - a. NIBCO INC.
 - b. <Insert manufacturer's name>.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "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 "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. Grooved Mechanical-Joint Fittings and Couplings:
 1. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc., indicated in subparagraphs below, or comparable products by one of the following:
 - a. Anvil International.
 - b. Central Sprinkler Company.
 - c. Grinnell Mechanical Products.
 - d. National Fittings, Inc.
 - e. Nexus Valve, Inc.
 - f. S. P. Fittings.

- g. Smith-Cooper International.
 - h. Star Pipe Products.
 - i. Victaulic Company.
 - j. **<Insert manufacturer's name>**.
2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- a. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; 7110, 7111, 7112, 7113, 7120, 7121, 7130, 7135, 7137, 7150, 7151, 7160, 7160H, 7110LR, 7111LR, 7110B, 901SR, 903SR, 7110DR, 7125, 7127, 7150F, 7150M, 899, 55, 56, 57, 58, 59, W110LR, W111LR, L90-3D, L45-3D, L22-3D, 7170, 7180, 7181.
3. Couplings: Ductile- or malleable-iron housing and **[EPDM]** **[or]** **[nitrile]** gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- a. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; Z05, Z07, XH-1000, 7705, 7707, 7706, G28, C-7, 7041, 7043.
4. Mechanically Formed Tee Option: For forming T-branch on carbon steel water pipe.
- a. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; 7721, M21, 7722, M22.
- I. Steel Pressure-Seal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- a. Victaulic Company.
 - b. Viega LLC.
 - c. **<Insert manufacturer's name>**.
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum **300-psig (2070-kPa)** working-pressure rating at **230 deg F (110 deg C)**.
- J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.
 - 1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide products by LASCO Fittings, Inc., or comparable products by one of the following:
 - 1) NIBCO INC.
 - 2) Charlotte Pipe and Foundry Company.
 - 3) **<Insert manufacturer's name>**.
- B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide products by LASCO Fittings, Inc., or comparable products by one of the following:
 - 1) NIBCO INC.
 - 2) Charlotte Pipe and Foundry Company.
 - 3) **<Insert manufacturer's name>**.
 - 2. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 FIBERGLASS PIPE AND FITTINGS

- A. RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.
- B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
- C. Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum **1/8-inch (3.2-mm)** thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.

2.6 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 (3.2-mm)** maximum thickness unless otherwise 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/A5.8M, 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 D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for CPVC Piping: ASTM F 493.
 - 1. Solvent cement shall have a VOC content of 490 g/L or less.
 - 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- H. Solvent Cements for PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 1. Solvent cement shall have a VOC content of 510 g/L or less.
 - 2. Adhesive primer shall have a VOC content of 550 g/L or less.
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 4. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
 - 1. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.7 TRANSITION FITTINGS

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

- a. Charlotte Pipe and Foundry Company.
 - b. IPEX USA LLC.
 - c. KBI (King Bros. Industries).
 - d. Viega LLC.
 - e. **<Insert manufacturer's name>**.
2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- B. Plastic-to-Metal Transition Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Charlotte Pipe and Foundry Company.
 - b. IPEX USA LLC.
 - c. KBI (King Bros. Industries).
 - d. NIBCO INC.
 - e. **<Insert manufacturer's name>**.
 2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.8 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Central Plastics Company.
 - d. HART Industrial Unions, LLC.
 - e. Jomar Valve.
 - f. Matco-Norca.
 - g. WATTS.
 - h. Wilkins.
 - i. Zurn Industries, LLC.
 - j. **<Insert manufacturer's name>**.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: **[125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [250 psig (1725 kPa)] <Insert value>**.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Matco-Norca.
 - d. WATTS.
 - e. Wilkins.
 - f. Zurn Industries, LLC.
 - g. <Insert manufacturer's name>.
2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: [125 psig (860 kPa) minimum at 180 deg F (82 deg C)] [150 psig (1035 kPa)] [175 psig (1200 kPa)] [300 psig (2070 kPa)] <Insert value>.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - e. <Insert manufacturer's name>.
2. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: [150 psig (1035 kPa)] <Insert value>.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Apollo-Shurjoint Piping Products USA Inc.; DE-30GG, or a comparable product by one of the following:
 - a. Elster Perfection Corporation.
 - b. Grinnell Mechanical Products.
 - c. Matco-Norca.
 - d. Precision Plumbing Products.

- e. Victaulic Company.
 - f. <Insert manufacturer's name>.
2. Description:
- a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F 1545.
 - c. Pressure Rating: [300 psig (2070 kPa) at 225 deg F (107 deg C)] <Insert value and temperature>.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

2.9 BYPASS CHEMICAL FEEDER

- A. Description: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.
1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, [NPS 2 (DN 50) and smaller] <Insert pipe size range>, shall be[any of] the following:
- 1. [Type L (Type B)] [Type M (Type C)] NPS 1 (DN 25) and smaller, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push] joints.
 - 2. [Type L (Type B)] [Type M (Type C)], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint].
 - 3. [Schedule 40] [Schedule 30] [Schedule 20], Grade B steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 - 4. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 - 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- B. Hot-water heating piping, aboveground, [NPS 2-1/2 (DN 65) and larger] <Insert pipe size range>, shall be[any of] the following:
- 1. [Type L (Type B)] [Type M (Type C)], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 - 2. [Type L (Type B)] [Type M (Type C)] NPS 2-1/2 to NPS 4 (DN 65) to (DN 100), drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings] joints.
 - 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

4. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- C. Hot-water heating piping installed belowground and within slabs shall be[**any of**] the following:
1. **Type K (Type A), NPS 1 (DN 25)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push] joints. Use the fewest possible joints.
 2. **Type K (Type A), NPS 1-1/4 (DN 32)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings] joints. Use the fewest possible joints.
 3. **Type K (Type A)**, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 4. RTRP and RTRF with adhesive or flanged joints.
- D. Chilled-water piping, aboveground, [**NPS 2 (DN 50) and smaller**] <Insert pipe size range>, shall be[**any of**] the following:
1. [**Type L (Type B)**] [**Type M (Type C)**] **NPS 1 (DN 25)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push] joints.
 2. [**Type L (Type B)**] [**Type M (Type C)**] **NPS 1-1/4 (DN 32)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] joints.
 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 4. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- E. Chilled-water piping, aboveground, [**NPS 2-1/2 (DN 65) and larger**] <Insert pipe size range>, shall be[**any of**] the following:
1. [**Type L (Type B)**] [**Type M (Type C)**] **NPS 2-1/2 to NPS 4 (DN 65) to (DN 100)**, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings] joints.
 2. [**Type L (Type B)**] [**Type M (Type C)**], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 4. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- F. Chilled-water piping installed belowground and within slabs shall be[**any of**] the following:
1. **Type K (Type A) NPS 1 (DN 25)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push] joints. Use the fewest possible joints.

2. **Type K (Type A) NPS 1-1/4 (DN 32)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal]** joints. Use the fewest possible joints.
 3. **Type K (Type A)**, annealed-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed]** joints. Use the fewest possible joints.
 4. RTRP and RTRF with adhesive or flanged joints.
- G. Dual-temperature heating and cooling water piping, aboveground, **[NPS 2 (DN 50) and smaller]** <Insert pipe size range>, shall be **[any of]** the following:
1. **[Type L (Type B)] [Type M (Type C)] NPS 1 (DN 25)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push]** joints.
 2. **[Type L (Type B)] [Type M (Type C)]**, drawn-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal]** joints.
 3. **[Schedule 40] [Schedule 30] [Schedule 20]** steel pipe; **[Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron]** fittings; cast-iron flanges and flange fittings; and threaded joints.
 4. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 5. **[Schedule 40] [Schedule 80]** CPVC plastic pipe and fittings and solvent-welded joints.
- H. Dual-temperature heating and cooling water piping, aboveground, **[NPS 2-1/2 (DN 65) and larger]** <Insert pipe size range>, shall be **[any of]** the following:
1. **[Type L (Type B)] [Type M (Type C)] NPS 2-1/2 to NPS 4 (DN 65) to (DN 100)**, drawn-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed] [copper pressure-seal-joint fittings]** joints.
 2. **[Type L (Type B)] [Type M (Type C)]**, drawn-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed]** joints.
 3. **[Schedule 40] [Schedule 30] [Schedule 20]** steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 4. **[Schedule 40] [Schedule 30] [Schedule 20]** steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 5. **[Schedule 40] [Schedule 80]** CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- I. Dual-temperature heating and cooling water piping installed belowground and within slabs shall be **[any of]** the following:
1. **Type K (Type A) NPS 1 (DN 25)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push]** joints. Use the fewest possible joints.
 2. **Type K (Type A) NPS 1-1/4 (DN 32)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal]** joints. Use the fewest possible joints.
 3. **Type K (Type A)**, annealed-temper copper tubing, wrought-copper fittings, and **[soldered] [brazed]** joints. Use the fewest possible joints.
 4. RTRP and RTRF with adhesive or flanged joints.

- J. Condenser-water piping, aboveground, [**NPS 2 (DN 50) and smaller**] <Insert pipe size range>, shall be[**any of**] the following:
1. [**Type L (Type B)**] [**Type M (Type C)**] **NPS 1 (DN 25)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] [**copper-push**] joints.
 2. [**Type L (Type B)**] [**Type M (Type C)**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings**] [**pressure-seal**] joints.
 3. [**Schedule 80**] [**Schedule 40**] [**Schedule 30**] [**Schedule 20**] steel pipe; [**Class 125, cast-iron**] [**Class 150, malleable-iron**] [**Class 250, cast-iron**] [**Class 300, malleable-iron**] fittings; cast-iron flanges and flange fittings; and threaded joints.
 4. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 5. [**Schedule 40**] [**Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.
- K. Condenser-water piping, aboveground, [**NPS 2-1/2 (DN 65) and larger**] <Insert pipe size range>, shall be[**any of**] the following:
1. [**Type L (Type B)**] [**Type M (Type C)**] **NPS 2-1/2 to NPS 4 (DN 65) to (DN 100)**, drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings**] joints.
 2. [**Type L (Type B)**] [**Type M (Type C)**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] joints.
 3. [**Schedule 80**] [**Schedule 40**] [**Schedule 30**] [**Schedule 20**] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 4. [**Schedule 80**] [**Schedule 40**] [**Schedule 30**] [**Schedule 20**] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 5. [**Schedule 40**] [**Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- L. Condenser-water piping installed belowground and within slabs shall be[**any of**] the following:
1. **Type K (Type A) NPS 1 (DN 25)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] [**copper-push**] joints. Use the fewest possible joints.
 2. **Type K (Type A) NPS 1-1/4 (DN 32)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] joints. Use the fewest possible joints.
 3. **Type K (Type A)**, annealed-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] joints. Use the fewest possible joints.
 4. RTRP and RTRF with adhesive or flanged joints.
- M. Glycol cooling-water piping, aboveground, [**NPS 2 (DN 50) and smaller**] <Insert pipe size range>, shall be[**any of**] the following:
1. [**Type L (Type B)**] [**Type M (Type C)**] **NPS 1 (DN 25)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] [**copper-push**] joints.
 2. [**Type L (Type B)**] [**Type M (Type C)**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**pressure-seal**] joints.

3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; [Class 125, cast-iron] [Class 150, malleable-iron] [Class 250, cast-iron] [Class 300, malleable-iron] fittings; cast-iron flanges and flange fittings; and threaded joints.
 4. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
- N. Glycol cooling-water piping, aboveground, [NPS 2-1/2 (DN 65) and larger] <Insert pipe size range>, shall be[any of] the following:
1. [Type L (Type B)] [Type M (Type C)] NPS 2-1/2 to NPS 4 (DN 65) to (DN 100), drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings] joints.
 2. [Type L (Type B)] [Type M (Type C)], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 3. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 4. [Schedule 40] [Schedule 30] [Schedule 20] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 5. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings and solvent-welded joints.
 6. RTRP and RTRF with adhesive or flanged joints.
- O. Glycol cooling-water piping installed belowground and within slabs shall be[any of] the following:
1. Type K (Type A) NPS 1 (DN 25) and smaller, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push] joints. Use the fewest possible joints
 2. Type K (Type A) NPS 1-1/4 (DN 32) and smaller, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] joints. Use the fewest possible joints.
 3. Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints. Use the fewest possible joints.
 4. RTRP and RTRF with adhesive or flanged joints.
- P. Makeup-water piping installed aboveground shall be[any of] the following:
1. [Type L (Type B)] [Type M (Type C)] NPS 1 (DN 25) and smaller, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings] [copper-push] joints.
 2. [Type L (Type B)] [Type M (Type C)] NPS 4 (DN 100) and smaller, drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings] joints.
 3. [Type L (Type B)] [Type M (Type C)], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.
 4. [Schedule 40] [Schedule 80] CPVC plastic pipe and fittings, and solvent-welded joints.
- Q. Makeup-water piping installed belowground and within slabs shall be[any of] the following:
1. Type K (Type A) NPS 1 (DN 25) and smaller, annealed-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] [copper pressure-seal-joint fittings; pressure-seal] [copper-push] joints. Use the fewest possible joints.

2. **Type K (Type A) NPS 1-1/4 (DN 32)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] joints. Use the fewest possible joints.
3. **Type K (Type A)**, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

R. Condensate-drain piping shall be[**any of**] the following:

1. [**Type M (Type C)**] **NPS 1 (DN 25)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings**] [**copper-push**] joints.
2. [**Type M (Type C)**] **NPS 4 (DN 100)** and smaller, drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings**] joints.
3. [**Type M (Type C)**] [**Type DWV**], drawn-temper copper tubing, wrought-copper fittings, and soldered joints[or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints].

S. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

T. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

U. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet piping shall be[**any of**] the following:
 - a. **Type K (Type A) NPS 1 (DN 25)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] [**copper-push**] joints.
 - b. **Type K (Type A) NPS 1-1/4 (DN 32)** and smaller, annealed-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] [**copper pressure-seal-joint fittings; pressure-seal**] joints.

V. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. 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 (DN 20)** ball valve, and short **NPS 3/4 (DN 20)** threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- 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 branch connections to mains using [**mechanically formed**] tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to the following:
 - 1. Section 230523.11 "Globe Valves for HVAC Piping."
 - 2. Section 230523.12 "Ball Valves for HVAC Piping."
 - 3. Section 230523.13 "Butterfly Valves for HVAC Piping."
 - 4. Section 230523.14 "Check Valves for HVAC Piping."
 - 5. Section 230523.15 "Gate Valves for HVAC Piping."
- Q. Install unions in piping, [**NPS 2 (DN 50)**] <Insert pipe size> and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, [**NPS 2-1/2 (DN 65)**] <Insert pipe size> and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.
- T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

- U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for [NPS 2 (DN 50)] <Insert pipe size> and Smaller: Use dielectric [nipples] [unions].
- C. Dielectric Fittings for [NPS 2-1/2 to NPS 4 (DN 65 to DN 100)] <Insert pipe size range>: Use dielectric [flanges] [flange kits] [nipples].
- D. Dielectric Fittings for [NPS 5 (DN 125)] <Insert pipe size> and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
- B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
 2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
 3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
 4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
 5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
 6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).
- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
- F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- G. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- H. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. 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.
- D. 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/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 - G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
 - H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
 - J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
 - K. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
 - L. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
1. pH: [9.0 to 10.5] <Insert values>.
 2. "P" Alkalinity: [100 to 500] <Insert values> ppm.
 3. Boron: [100 to 200] <Insert values> ppm.
 4. Chemical Oxygen Demand: Maximum of [100] <Insert value> ppm. Revise this value if closed system contains glycol.
 5. Corrosion Inhibitor:
 - a. Sodium Nitrate: [1000 to 1500] <Insert values> ppm.
 - b. Molybdate: [200 to 300] <Insert values> ppm.
 - c. Chromate: [200 to 300] <Insert values> ppm.
 - d. Sodium Nitrate Plus Molybdate: [100 to 200] <Insert values> ppm each.
 - e. Chromate Plus Molybdate: [50 to 100] <Insert values> ppm each.
 6. Soluble Copper: Maximum of [0.20] <Insert value> ppm.
 7. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of [10] <Insert value> ppm.
 8. Total Suspended Solids: Maximum of [10] <Insert value> ppm.
 9. Ammonia: Maximum of [20] <Insert value> ppm.
 10. Free Caustic Alkalinity: Maximum of [20] <Insert value> ppm.
 11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maximum of [1000] <Insert number> organisms/mL.
 - b. Total Anaerobic Plate Count: Maximum of [100] <Insert number> organisms/mL.
 - c. Nitrate Reducers: [100] <Insert number> organisms/mL.
 - d. Sulfate Reducers: Maximum of [zero] <Insert number> organisms/mL.
 - e. Iron Bacteria: Maximum of [zero] <Insert number> organisms/mL.
 12. <Insert other requirements if necessary>.
- B. Install bypass chemical feeders in each hydronic system where indicated.
1. Install in upright position with top of funnel not more than 48 inches (1200 mm) above the floor.
 2. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
 3. Install NPS 3/4 (DN 20) pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

- E. Fill systems that have antifreeze or glycol solutions with the following concentrations:
1. Hot-Water Heating Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.
 2. Chilled-Water Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.
 3. Dual-Temperature Heating and Cooling Water Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.
 4. Glycol Cooling-Water Piping: Minimum of <Insert number> percent [ethylene] [propylene] glycol.

3.8 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. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 4. 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.
 5. 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.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.

4. 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).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113