SECTION 232113 - HYDRONIC PIPING

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
   * + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
      1. SUMMARY
         1. Section Includes:

Copper tube and fittings.

Steel pipe and fittings.

Plastic pipe and fittings.

Fiberglass pipe and fittings.

Joining materials.

Transition fittings.

Dielectric fittings.

Bypass chemical feeder.

* + - 1. SUBMITTALS
         1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions
         2. Manufacturer’s installation instructions shall be provided along with product data.
         3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
         4. Product Data: For each type of the following:

Pipe and tube.

Fittings.

Joining materials.

Transition fittings.

Bypass chemical feeder.

USE PARAGRAPH BELOW WITH EPD REQUIREMENT WHEN PROJECT ESTIMATE IS $1M OR MORE.

* + - * 1. Submit an Environmental Product Declaration (EPD) from the manufacturer for steel pipe within this specification section, if available. A statement of the contractor’s good faith effort to obtain the EPD shall be provided if not available.

Manufacturer-provided EPDs must be Product Specific Type III (Third-Party Reviewed), in adherence with ISO 14025 *Environmental labels and declarations*, ISO 14044 *Environmental management – Life cycle assessment*, and ISO 21930 *Core rules for environmental product declarations of construction products and services*.

* + - * 1. Qualification Data: For Installer.

Retain "Welding certificates" paragraph below if retaining "Steel Support Welding" or "Pipe Welding" paragraph in "Quality Assurance" Article.

* + - * 1. Welding certificates.
        2. Field quality-control reports.
      1. QUALITY ASSURANCE
         1. Installer Qualifications:

Retain "Installers of Pressure-Sealed Joints" subparagraph below for pressure-sealed joints in copper or steel piping.

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.

Retain "Fiberglass Pipe and Fitting Installers" subparagraph below for fiberglass pipe assembly.

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.

Retain "Steel Support Welding" and "Pipe Welding" paragraphs below for welded supports or piping. Retain "Welding certificates" paragraph in "Informational Submittals" Article if retaining below. AWS states that welding qualifications remain in effect indefinitely unless welding personnel have not welded for more than six months or there is a specific reason to question their ability.

* + - * 1. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
        2. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

Delete this article if polypropylene piping (PP-R) product type is not retained.

When warranties are required, verify with Director’s Representative that warranties stated in this article are not less than remedies available to Owner under prevailing local laws. Most manufacturers offer 10-year extended warranties on their equipment. Verify available warranties and warranty periods.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. PERFORMANCE REQUIREMENTS

Performance requirements in this article are for the piping system. Individual components may have higher pressure or temperature ratings.

* + - * 1. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

Pressures and temperatures below are provided for information only, and should be inserted for each Project as the working pressures and temperatures are unique.

Working pressure is equal to the relief pressure plus the static height of the system and pumping head. The only working pressure mandated by authorities having jurisdiction is for makeup water.

Hot-Water Heating Piping: [**100 psig] <Insert psig> at [200 deg F] [180 deg F] <Insert temperature**>.

High Temperature Hot Water Heating Piping: [**100 psig] <Insert psig> at [250 deg F] <Insert temperature**>.

Chilled-Water Piping: [**150 psig] <Insert psig> at [73 deg F] <Insert temperature**>.

Dual-Temperature Heating and Cooling Water Piping: [**100 psig] <Insert psig> at [180 deg F] <Insert temperature**>.

Condenser-Water Piping: [**150 psig] <Insert psig> at [73 deg F] <Insert temperature**>.

Glycol Cooling-Water Piping: [**150 psig] <Insert psig> at [150 deg F] <Insert temperature**>.

Makeup-Water Piping: **[80 psig] [150 psig] <Insert value> at [73 deg F] [150 deg F] <Insert temperature**>.

Condensate-Drain Piping: [**150 deg F] [180 deg F] <Insert temperature**>.

Blowdown-Drain Piping: [**180 deg F] [200 deg F] <Insert temperature**>.

Air-Vent Piping: [**180 deg F] [200 deg F] <Insert temperature**>.Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

* + - 1. COPPER TUBE AND FITTINGS

Tube in "Drawn-Temper Copper Tube" paragraph below is generally available in NPS 1/8 to NPS 12 (DN 6 to DN 300). Drawn-temper copper tube is commonly referred to as "hard" copper tube.

* + - * 1. Drawn-Temper Copper Tube: [**ASTM B88, Type K] [ASTM B88, Type L] [and] [ASTM B88, Type M**].

Tube in "Annealed-Temper Copper Tube" paragraph below is generally available in NPS 1/8 to NPS 12 (DN 6 to DN 300). Annealed-temper copper tubing is commonly referred to as "soft" copper tube.

* + - * 1. Annealed-Temper Copper Tube: [**ASTM B88, Type K] [ASTM B88, Type L] [and] [ASTM B88, Type M**].
        2. DWV Copper Tube: ASTM B306, Type DWV.

Fittings in "Cast-Copper, Solder-Joint Fittings" paragraph below are generally available in NPS 1/4 to NPS 12 (DN 8 to DN 300).

* + - * 1. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

Fittings in "Wrought-Copper, Solder-Joint Fittings" paragraph below are generally available in NPS 1/4 to NPS 8 (DN 8 to DN 200).

* + - * 1. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

Flanges in "Bronze Flanges" paragraph below are generally available in NPS 1/2 to NPS 12 (DN 15 to DN 300).

* + - * 1. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

Unions in "Cast Copper Unions" paragraph below are generally available in NPS 1/4 to NPS 4 (DN 8 to DN 100).

* + - * 1. Cast Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

Manufacturers cite wrought copper unions complying with ASME B16.22, although that standard applies to wrought copper and copper alloy solder-joint pressure fittings. No alternative standards specific to wrought copper unions was found.

* + - * 1. Wrought Copper Unions: ASME B16.22.

Retain "Copper-Tube, Mechanically Formed Tee Fitting" paragraph below if formed tees can be used instead of tee fittings in copper tubing; delete if prohibited by authority having jurisdiction.

* + - * 1. Grooved, Mechanical-Joint, Copper Tube Appurtenances:

Grooved-End Copper Fittings: ASTM B75, copper tube or ASTM B584, bronze castings.

Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM-rubber gasket rated for minimum [**230 deg F**] <**Insert temperature**> for use with ferrous housing, and steel bolts and nuts; 300 psig minimum CWP pressure rating.

Fittings in "Copper-Tube, Pressure-Seal-Joint Fittings" paragraph below are generally available in NPS 1/2 to NPS 4 (DN 15 to DN 100).

* + - * 1. Copper-Tube, Pressure-Seal-Joint Fittings:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Mueller Industries, Inc.

NIBCO INC.

Viega LLC.

Approved equivalent.

Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.

Minimum 200-psig working-pressure rating at 250 deg F.

Retain stainless steel pipe and fittings paragraph below where required for specific project requirements, examples include exposed piping areas such as food production facilities. Coordinate with and make corresponding edits in Part 3 Applications

* + - 1. STAINLESS STEEL PIPE AND FITTINGS
         1. Stainless Steel Pipe: ASTM A312, with wall thickness as indicated in “Piping Applications” Article.
         2. Stainless Steel Pipe Fittings: ASTM A815.

Fittings and couplings in “Appurtenances for Grooved-End, Stainless Steel Pipe” Paragraph below is available in NPS 1 to NPS 24.

* + - * 1. Appurtenances for Grooved-End, Stainless Steel Pipe:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Victaulic Company.

Anvil International.

GroovJoint

Approved equivalent.

Fittings for Grooved-End, Stainless Pipe: Stainless steel casting with dimensions matching stainless steel pipe.

Mechanical Couplings for Grooved-End, Stainless Steel Pipe:

Stainless steel housing sections.

Stainless steel bolts and nuts.

EPDM-rubber gaskets suitable for hot and cold water.

Minimum Pressure Rating:

NPS 8 and Smaller: [600 psig] <Insert value>.

NPS 10 and NPS 12: [400 psig] <Insert value>.

NPS 14 to NPS 24: [250 psig] <Insert value>.

Fittings in “Stainless Steel piping, Pressure-Seal-Joint Fittings” paragraph Below are currently available form Viega in NPS ½ to NPS 4. Victaulic and Grinnell currently offer pressure-seal joints for NPS ½ to NPS 2 but use their grooved fittings lines to cover NPS 2-1/2 and larger.

* + - * 1. Stainless Steel Piping, Pressure-Seal-Joint Fittings:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Viega LLC.

Victaulic Company.

Grinnell.

Approved equivalent.

Material: Type 316 stainless steel, ASTM A312, Schedule 10.

Fittings: Type 316 stainless steel with EPDM O-ring in each end, and approved for potable water applications.

Listing: ICC-ES LC1002 or UL Classified in accordance with NSF 61 and NSF 372.

Minimum 200 psig working-pressure rating at 250 deg F.

* + - 1. STEEL PIPE AND FITTINGS
         1. Steel Pipe: ASTM A53, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
         2. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
         3. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
         4. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

Coordinate flange class in "Cast-Iron Pipe Flanges and Flanged Fittings" paragraph below with products in other parts of this Section and in related Sections to match face size and bolt patterns.

* + - * 1. 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.
        2. Wrought-Steel Fittings: ASTM A234, wall thickness to match adjoining pipe.
        3. 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:

Material Group: 1.1.

End Connections: Butt welding.

Facings: Raised face.

* + - * 1. Grooved Mechanical-Joint Fittings and Couplings:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Grinnell G-Fire by Johnson Controls Company.

Nexus Valve, Inc.

Victaulic Company.

Approved equivalent.

Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47, Grade 32510 malleable iron; ASTM A53, Type F, E, or S, Grade B fabricated steel; or ASTM A106, 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.

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.

* + - * 1. Plain-End Mechanical-Joint Couplings:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Anvil International.

Shurjoint-Apollo Piping Products USA Inc.

Victaulic Company.

Approved equivalent.

Housing: ASTM A536 Grade 65-45-12 segmented ductile iron or type 304 stainless steel.

Housing coating: [**None] <Insert coating type**>.

Gasket: [**EPDM] [NBR**].

Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.

Bolts, hex nuts, washers, or lock bars based on manufacturer's design.

Minimum Pressure Rating: Equal to that of the joined pipes.

* + - * 1. Steel Pressure-Seal Fittings:

Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

Victaulic Company.

Viega LLC.

Approved equivalent.

Housing: Steel.

O-Rings and Pipe Stop: EPDM.

Tools: Manufacturer's special tool.

Minimum 300-psig working-pressure rating at 230 deg F.

Non-reinforced, welded, in-branch connections weaken a main pipeline; reinforcement is necessary unless wall thickness of both mains and branches is sufficient to sustain pressure required in "Performance Requirements" Article.

* + - * 1. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.
      1. PLASTIC PIPE AND FITTINGS

See the Evaluations for discussion of product characteristics and maximum temperatures.

* + - * 1. CPVC Plastic Pipe: ASTM F441, with wall thickness as indicated in "Piping Applications" Article.

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Charlotte Pipe and Foundry Company.

IPEX USA LLC.

Spears Manufacturing Company.

Approved equivalent.

CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F438 for Schedule 40 pipe; ASTM F439 for Schedule 80 pipe.

* + - * 1. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Charlotte Pipe and Foundry Company.

IPEX USA LLC.

Spears Manufacturing Company.

Approved equivalent.

PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.

* + - * 1. Polypropylene (PP-R) Pipe:

Pipe in this article is generally available in nominal 1/2-inch to nominal 24-inch diameter.

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Aquatherm.

IPEX USA LLC.

Nupi Americas.

Approved equivalent.

* + - * 1. Polypropylene Pipe: ASTM F2389, pipe pressure rating to comply with temperature and pressure ratings of code requirements for the applicable service.

Polypropylene Fittings: ASTM F2389, socket fusion, butt fusion, electrofusion, or fusion outlet fittings to be used for fusion-welded joints between pipe and fittings.

Mechanical fittings and transition fittings to be used where transitions are made to other piping materials or to valves and appurtenances.

Polypropylene pipe is to be unthreaded. Threaded transition fittings per ASTM F2389 to be used where a threaded connection is required.

Retain "Smoke and Fire Ratings" paragraph below when plenum-rated PP-R piping systems are required.

* + - * 1. Smoke and Fire Ratings:

Where indicated on the Drawings that a plenum-rated piping system is required, the pipe is to be wrapped and/or insulated with fiberglass or mineral wool pipe insulation, field installed.

The system is to have a flame spread classification of less than 25 and smoke development rating of less than 50.

Pipe, wrap, or insulation as a system to meet the requirements of CAN/ULC-S102.2-03, ASTM E84 or UL 2846.

For insulation required for thermal and condensation reasons, see Section 230719 "HVAC Piping Insulation."

* + - 1. FIBERGLASS PIPE AND FITTINGS

"Fiberglass Pipe and Fittings" is not listed in Ch. 46, "Pipes, Tubes, and Fittings" of the 2012 ASHRAE Handbook.

Piping is available with ends for other types of joints. See the Evaluations for discussion of product characteristics and maximum temperatures and pressures.

* + - * 1. RTRP: ASTM D2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.
        2. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
        3. Flanges: ASTM D4024. Full-face gaskets suitable for the service, minimum 1/8-inch thick, 60-70 durometer. ASTM A307, Grade B, hex head bolts with washers.
      1. JOINING MATERIALS
         1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

* + - * 1. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
        2. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

See the Evaluations for discussions of solder and brazing materials described in "Solder Filler Metals" and "Brazing Filler Metals" paragraphs below.

* + - * 1. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
        2. 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.
        3. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
        4. Solvent Cements for CPVC Piping: ASTM F493.
        5. Solvent Cements for PVC Piping: ASTM D2564. Include primer according to ASTM F656.
        6. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
      1. TRANSITION FITTINGS
         1. Plastic-to-Metal Transition Fittings:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Charlotte Pipe and Foundry Company.

Uponor.

Viega LLC.

Approved equivalent.

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.

* + - * 1. Plastic-to-Metal Transition Unions:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Charlotte Pipe and Foundry Company.

IPEX USA LLC.

NIBCO INC.

Approved equivalent.

Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

* + - 1. DIELECTRIC FITTINGS
         1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

Fittings in "Dielectric Unions" paragraph below are available in NPS 1/2 to NPS 2 (DN 15 to DN 50).

* + - * 1. Dielectric Unions:

Description:

Standard: ASSE 1079.

Revise pressure rating in "Pressure Rating" subparagraph below to suit Project, or insert other options for specific applications.

Pressure Rating: [**125 psig minimum at 180 deg F] [150 psig] [250 psig] <Insert value**>.

End Connections: Solder-joint copper alloy and threaded ferrous.

Fittings in "Dielectric Flanges" paragraph below are available in NPS 1-1/2 to NPS 4 (DN 40 to DN 100).

* + - * 1. Dielectric Flanges:

Description:

Standard: ASSE 1079.

Factory-fabricated, bolted, companion-flange assembly.

Revise pressure rating in "Pressure Rating" subparagraph below to suit Project, or insert other options for specific applications.

Pressure Rating: [**125 psig minimum at 180 deg F] [150 psig] [175 psig] [300 psig] <Insert value**>.

End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

Flanges in "Dielectric-Flange Insulating Kits" paragraph below are available in NPS 1/2 to NPS 48 (DN 15 to DN 1200).

* + - * 1. Dielectric-Flange Insulating Kits:

Description:

Nonconducting materials for field assembly of companion flanges.

Revise pressure rating in "Pressure Rating" subparagraph below to suit Project, or insert other options for specific applications.

Pressure Rating: [**150 psig] <Insert value**>.

Gasket: Neoprene or phenolic.

Bolt Sleeves: Phenolic or polyethylene.

Washers: Phenolic with steel backing washers.

Nipples in "Dielectric Nipples" paragraph below are available in NPS 1/2 to NPS 4 (DN 15 to DN 100).

* + - * 1. Dielectric Nipples:

Description:

Standard: IAPMO PS 66.

Electroplated steel nipple, complying with ASTM F1545.

Revise pressure rating and temperature in "Pressure Rating" subparagraph below to suit Project, or insert other options for specific applications.

Pressure Rating: [**300 psig at 225 deg F] <Insert value and temperature**>.

End Connections: Male threaded or grooved.

Lining: Inert and noncorrosive, propylene.

* + - 1. BYPASS CHEMICAL FEEDER

Retain this article if chemical-treatment systems are not specified in Section 232500 "HVAC Water Treatment."

* + - * 1. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

1. EXECUTION
   * + 1. PIPING APPLICATIONS

Retain at least one pipe material in paragraphs below for each service required for Project. Services are specified separately to allow different pipe materials and joining methods for each. If materials and methods are the same for multiple services, combine the requirements by revising paragraph titles. To allow Contractor to choose among various pipe materials, retain multiple materials for each required service and pipe size. Pipe materials and joining methods in this article, in general, are as listed in the 2012 ASHRAE Handbook - "HVAC Systems and Equipment," Ch. 46, "Pipes, Tubes, and Fittings." The change point for pipe materials and joining methods is specified, in this master, where the pipe size changes from NPS 2 to NPS 2-1/2 (DN 50 to DN 65). Revise this change point to suit office policy. See "Writing Guide" Article in the Evaluations.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Hot-water heating piping, aboveground, [**NPS 2 and smaller] <Insert pipe size range>,** shallbe**[ any of**] the following:

Retain one or more of four subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed] [pressure-seal**] joints.

[**Schedule 40**], 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.

CPVC pipe in subparagraph below has temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Hot-water heating piping, aboveground, [**NPS 2-1/2 and larger] <Insert pipe size range**>, shall be[ any of] the following:

Retain one or more of five subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints.

[**Schedule 40**] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

[**Schedule 40**] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

[**Schedule 40] <Insert schedule number**> steel pipe, plain-end mechanical-coupled joints.

CPVC and RTRP in two subparagraphs below have temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

RTRP and RTRF with adhesive or flanged joints.

Retain "either of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Hot-water heating piping installed belowground and within slabs shall be[ either of] the following:

Retain one or both subparagraphs below. If retaining both and it is not the intent to give Contractor the choice to select materials, delete "either of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

Type K, [**drawn-] [annealed-**]temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints. Use the fewest possible joints.

RTRP in subparagraph below has temperature and pressure limitations. See the Evaluations.

RTRP and RTRF with adhesive or flanged joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Chilled-water piping, aboveground, [**NPS 2 and smaller] <Insert pipe size range**>, shall be[ any of] the following:

Retain one or more of four subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [**brazed] [pressure-seal**] joints.

[**Schedule 40**] 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.

Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.

CPVC pipe in subparagraph below has temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Chilled-water piping, aboveground, **[NPS 2-1/2 and larger] <Insert pipe size range**>, shall be[ **any of**] the following:

Retain one or more of five subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [soldered] [brazed] joints.

[**Schedule 40**] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

[**Schedule 40**] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

[**Schedule 40] <Insert schedule number**> steel pipe, plain-end mechanical-coupled joints.

CPVC and RTRP in two subparagraphs below have temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

RTRP and RTRF with adhesive or flanged joints.

Retain " either of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Chilled-water piping installed belowground and within slabs shall be[ either of] the following:

Retain one or both subparagraphs below. If retaining both and it is not the intent to give Contractor the choice to select materials, delete "either of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

Type K, [**drawn] [annealed**]-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints. Use the fewest possible joints.

RTRP in subparagraph below has temperature and pressure limitations. See the Evaluations.

RTRP and RTRF with adhesive or flanged joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Dual-temperature heating and cooling water piping, aboveground, [NPS 2 and smaller] <Insert pipe size range>, shall be[ any of] the following:

Retain one or more of four subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed] [pressure-seal**] joints.

[**Schedule 40**] 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.

Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.

CPVC pipe in subparagraph below has temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Dual-temperature heating and cooling water piping, aboveground, [**NPS 2-1/2 and larger] <Insert pipe size range**>, shall be[ **abny of**] the following:

Retain one or more of five subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints.

[**Schedule 40**] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

[**Schedule 40**] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

[**Schedule 40] <Insert schedule number**> steel pipe, plain-end mechanical-coupled joints.

CPVC and RTRP in two subparagraphs below have temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

RTRP and RTRF with adhesive or flanged joints.

Retain " either of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Dual-temperature heating and cooling water piping installed belowground and within slabs shall be[ **either of**] the following:

Retain one or both subparagraphs below. If retaining both and it is not the intent to give Contractor the choice to select materials, delete "either of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

Type K, annealed-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints. Use the fewest possible joints.

RTRP in subparagraph below has temperature and pressure limitations. See the Evaluations.

RTRP and RTRF with adhesive or flanged joints.

Retain " any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Condenser-water piping, aboveground, [**NPS 2 and smaller] <Insert pipe size range**>, shall be[ **any of**] the following:

Retain one or more of four subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed] [pressure-seal**] joints.

[**Schedule 80] [Schedule 40**] steel pipe; [Cla**ss 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.

Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.

CPVC pipe in subparagraph below has temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

PP-R plastic piping and fittings with heat fusion joints.

Retain " any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Condenser-water piping, aboveground, [**NPS 2-1/2 and larger] <Insert pipe size range**>, shall be[ **any of**] the following:

Retain one or more of five subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints.

[**Schedule 80] [Schedule 40**] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

[**Schedule 80] [Schedule 40**] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

[**Schedule 40] <Insert schedule number**> steel pipe, plain-end mechanical-coupled joints.

CPVC and RTRP in two subparagraphs below have temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

RTRP and RTRF with adhesive or flanged joints.

PP piping and fittings with heat fusion joints.

Retain "either of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Condenser-water piping installed belowground and within slabs shall be[ **either of**] the following:

Retain one or both subparagraphs below. If retaining both and it is not the intent to give Contractor the choice to select materials, delete "either of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

Type K, annealed-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints. Use the fewest possible joints.

RTRP in subparagraph below has temperature and pressure limitations. See the Evaluations.

RTRP and RTRF with adhesive or flanged joints.

PP piping and fittings with heat fusion joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Glycol cooling-water piping, aboveground, [**NPS 2 and smaller] <Insert pipe size range**>, shall be[ **any of**] the following:

Retain one or more of four subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed] [pressure-seal**] joints.

[**Schedule 40**] 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.

Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.

CPVC pipe in subparagraph below has temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

Retain "any of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Glycol cooling-water piping, aboveground, [**NPS 2-1/2 and larger] <Insert pipe size range**>, shall be[ **any of**] the following:

Retain one or more of five subparagraphs below. If more than one type of material and joining method is retained and it is not the intent to give Contractor the choice to select materials, delete "any of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints.

[**Schedule 40**] steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

[**Schedule 40**] steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

[**Schedule 40] <Insert schedule number**> steel pipe, plain-end mechanical-coupled joints.

CPVC and RTRP in two subparagraphs below have temperature and pressure limitations. See the Evaluations.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings and solvent-welded joints.

RTRP and RTRF with adhesive or flanged joints.

Retain "either of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Glycol cooling-water piping installed belowground and within slabs shall be[ **either of**] the following:

Retain one or both subparagraphs below. If retaining both and it is not the intent to give Contractor the choice to select materials, delete "either of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

Type K, annealed-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints. Use the fewest possible joints.

RTRP in subparagraph below has temperature and pressure limitations. See the Evaluations.

RTRP and RTRF with adhesive or flanged joints.

Retain "either of" option in first paragraph below to allow Contractor to select piping materials from those retained.

* + - * 1. Makeup-water piping installed aboveground shall be[ **either of**] the following:

Retain one or both subparagraphs below. If retaining both and it is not the intent to give Contractor the choice to select materials, delete "either of" option in last paragraph above and identify each material on Drawings. Show points of transition from one material to another.

[**Type L] [Type M**], drawn-temper copper tubing, wrought-copper fittings, and [**soldered] [brazed**] joints.

[**Schedule 40] [Schedule 80**] CPVC plastic pipe and fittings, and solvent-welded joints.

* + - * 1. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

Retain "Condensate-Drain Piping, Copper" or "Condensate-Drain Piping, PVC" paragraph below.

* + - * 1. Condensate-Drain Piping, Copper: [**Type M] [Type DWV**], drawn-temper copper tubing, wrought-copper fittings, and soldered joints[ **or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints**].
        2. Condensate-Drain Piping, PVC: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
        3. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
        4. Air-Vent Piping:

Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

* + - * 1. 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.
      1. INSTALLATION OF PIPING

Coordinate piping installations and specialty arrangements with schematics on Drawings. If Drawings are explicit enough, these requirements may be reduced or omitted.

* + - * 1. 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.
        2. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
        3. 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.
        4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
        5. Install piping to permit valve servicing.
        6. Install piping at indicated slopes.
        7. Install piping free of sags and bends.
        8. Install fittings for changes in direction and branch connections.
        9. Install piping to allow application of insulation.
        10. Select system components with pressure rating equal to or greater than system operating pressure.
        11. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
        12. 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.
        13. Install piping at a uniform grade of 0.2 percent or 1/4 inch per 10 feet upward in direction of flow.
        14. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
        15. 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.
        16. Install unions in piping, [**NPS 2] <Insert pipe size**> and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
        17. Install flanges in piping, [**NPS 2-1/2] <Insert pipe size**> and larger, at final connections of equipment and elsewhere as indicated.
        18. Install shutoff valve immediately upstream of each dielectric fitting.
        19. 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.
        20. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
        21. 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."

Retain first paragraph below for piping that penetrates an exterior concrete wall or concrete slab.

* + - * 1. 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."
        2. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
      1. JOINT CONSTRUCTION
         1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
         2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
         3. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
         4. 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.
         5. 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:

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

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.

* + - * 1. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
        2. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
        3. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.

CPVC Piping: Join according to ASTM D2846 Appendix.

PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D2855.

PVC Nonpressure Piping: Join according to ASTM D2855.

* + - * 1. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

Retain "Grooved Joints" paragraph below for grooved-end pipe couplings for copper or steel pipe.

* + - * 1. 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.

Retain "Plain-End Mechanical-Coupled Joints" paragraph below for plain-end mechanical-coupled steel pipes.

* + - * 1. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

Retain "Mechanically Formed, Copper-Tube-Outlet Joints" paragraph below for mechanically formed outlets in place of tee fittings in copper pipe.

* + - * 1. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tools and procedure, and brazed joints.

Retain "Pressure-Sealed Joints" paragraph below for pressure-sealed joints in copper or steel piping.

* + - * 1. Pressure-Sealed Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.
      1. INSTALLATION OF DIELECTRIC FITTINGS
         1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
         2. Dielectric Fittings for [**NPS 2] <Insert pipe size**> and Smaller: Use dielectric [**nipples] [unions**].
         3. Dielectric Fittings for [**NPS 2-1/2 to NPS 4**] <**Insert pipe size range**>: Use dielectric [**flanges] [flange kits] [nipples**].
         4. Dielectric Fittings for [**NPS 5] <Insert pipe size**> and Larger: Use dielectric flange kits.
      2. INSTALLATION OF HANGERS AND SUPPORTS

Retain first paragraph below for projects in areas that require seismic restraints.

* + - * 1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
        2. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices
        3. Install hangers for [**copper tubing] [and] [steel piping**], with maximum horizontal spacing and minimum rod diameters, shall be in accordance with Section 230529 “Hangers and Supports for HVAC Piping and Equipment, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
        4. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
        5. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
        6. Support horizontal piping within [**12 inches] <Insert dimension**> of each fitting and coupling.
        7. Support vertical runs of [**copper tubing] [and] [steel piping**] to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
        8. Support vertical runs of [**CPVC] [PVC] [and] [PP-R**] piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
        9. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
      1. TERMINAL EQUIPMENT CONNECTIONS
         1. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
         2. Install control valves in accessible locations close to connected equipment.
         3. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
         4. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."
      2. CHEMICAL TREATMENT

Delete this article if using Section 232500 "HVAC Water Treatment."

Delete first paragraph below if water analysis has been or will be conducted by Owner.

* + - * 1. 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:

Consult water-treatment specialist and insert, in subparagraphs below, specific values required for Project.

pH: [**9.0 to 10.5] <Insert values**>.

"P" Alkalinity: [**100 to 500] <Insert values**> ppm.

Boron: [**100 to 200] <Insert values**> ppm.

Chemical Oxygen Demand: Maximum of [**100] <Insert value**> ppm. Revise this value if closed system contains glycol.

Corrosion Inhibitor:

Retain one of first five subparagraphs below.

Sodium Nitrate: [**1000 to 1500] <Insert values**> ppm.

Molybdate: [**200 to 300] <Insert values**> ppm.

Chromate: [**200 to 300] <Insert values**> ppm.

Sodium Nitrate Plus Molybdate: [**100 to 200] <Insert values**> ppm each.

Chromate Plus Molybdate: [**50 to 100] <Insert values**> ppm each.

Soluble Copper: Maximum of [**0.20] <Insert value**> ppm.

Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of [**10] <Insert value**> ppm.

Total Suspended Solids: Maximum of [**10] <Insert value**> ppm.

Ammonia: Maximum of [**20] <Insert value**> ppm.

Free Caustic Alkalinity: Maximum of [**20] <Insert value**> ppm.

Microbiological Limits:

Total Aerobic Plate Count: Maximum of [**1000] <Insert number**> organisms/mL.

Total Anaerobic Plate Count: Maximum of [**100] <Insert number**> organisms/mL.

Nitrate Reducers: [**100] <Insert number**> organisms/mL.

Sulfate Reducers: Maximum of [**zero] <Insert number**> organisms/mL.

Iron Bacteria: Maximum of [**zero] <Insert number**> organisms/mL.

<**Insert other requirements if necessary**>.

Retain first paragraph below if chemical water treatment is not specified in Section 232500 "HVAC Water Treatment." Coordinate floor drain location for equipment drain near feeder.

* + - * 1. Install bypass chemical feeders in each hydronic system where indicated.

Install in upright position with top of funnel not more than 48 inches above the floor.

Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.

Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

* + - * 1. 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.
        2. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.
        3. Fill systems that have antifreeze or glycol solutions with the following concentrations:

Hot-Water Heating Piping: Minimum of <**Insert number> percent [ethylene] [propylene**] glycol.

Chilled-Water Piping: Minimum of <**Insert number> percent [ethylene] [propylene**] glycol.

Dual-Temperature Heating and Cooling Water Piping: Minimum of <**Insert number> percent [ethylene] [propylene**] glycol.

Glycol Cooling-Water Piping: Minimum of <In**sert number> percent [ethylene] [propylene**] glycol.

* + - 1. FIELD QUALITY CONTROL
         1. Prepare hydronic piping according to ASME B31.9 and as follows:

Leave joints, including welds, uninsulated and exposed for examination during test.

Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

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.

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.

* + - * 1. Perform the following tests on hydronic piping:

Procedures in subparagraphs below are paraphrased from ASME B31.9.

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.

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.

Isolate expansion tanks and determine that hydronic system is full of water.

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."

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.

Prepare written report of testing.

* + - * 1. Perform the following before operating the system:

Open manual valves fully.

Inspect pumps for proper rotation.

Set makeup pressure-reducing valves for required system pressure.

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).

Set temperature controls so all coils are calling for full flow.

Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.

Verify lubrication of motors and bearings.

END OF SECTION 232113