SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Water piping to connect HVAC equipment, including the following:

1. Chilled water, condenser water, heating hot water and drain piping.
2. Extension of domestic water make-up piping.
3. Glycol-water piping.
4. Factory prefabricated (preinsulated) chilled water piping for underground service. Steel or copper piping with field applied closed cell cellular glass insulation, Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION may be furnished for underground piping in lieu of factory prefabricated (preinsulated) piping.
5. Factory prefabricated (preinsulated) chilled water piping, with metal carrier pipe and metal jacket, may be provided in utility tunnels, pipe basements and crawl spaces, in lieu of field insulated piping.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Section 07 12 00, BUILT-UP BITMUMINOUS WATERPROOFING, and Section 07 13 52, MODIFIED BITUMINOUS SHEET WATERPROOFING.

E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION: General mechanical requirements and items, which are common to more than one section of Division 23.

F. Section 23 21 23, HYDRONIC PUMPS: Pumps.

G. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Piping insulation.

H. Section 23 25 00, HVAC WATER TREATMENT: Water treatment for open and closed systems.

I. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS: VAV and CV units, fan coil units, and radiant ceiling panels.

J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.

1.3 QUALITY ASSURANCE

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, which includes welding qualifications.

B. Design Working Pressure for Preinsulated Chilled Water Piping: 861 kPa (125 psig).

C. Submit prior to welding of steel piping a certificate of Welder’s certification. The certificate shall be current and not more than one year old.

D. Manufacturers Training Service: The Contractor shall obtain the services of an independent trained representative of the preinsulated chilled water pipe system manufacturer to instruct contractor's work force in installation procedures for all preinsulated, prefabricated systems.

E. On Site Supervision of Underground Preinsulated Chilled Water Piping Installation:

1. Provide services of a factory trained representative of the pipe manufacturer for a minimum of three days, to include pre installation, installation and testing periods.

2. Representative's daily written reports to the Resident Engineer: Present the original of each report on the day it is prepared and forward a copy to the manufacturer's main office. The report shall be signed by the manufacturer's representative. The report shall state whether or not the condition and quality of the materials used and the installation of the system is in accordance with the plans, specifications, and published standards of the manufacturer, and is satisfactory in all respects. If anything connected with the installation is unsatisfactory, the report shall state that corrective action has been taken or shall contain the manufacturer's recommendations for corrective action. The report shall cover any condition that could result in an unsatisfactory installation. The representative shall take prompt action to return to the factory all damaged and defective material, and shall order prompt replacement of such material.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's Literature and Data:

1. Pipe and equipment supports.

2. Pipe and tubing, with specification, class or type, and schedule.
3. Pipe fittings, including miscellaneous adapters and special fittings.
4. Flanges, gaskets and bolting.
5. Valves of all types.
6. Strainers.
7. Flexible connectors for water service.
8. Pipe alignment guides.
9. Expansion joints.
10. Expansion compensators.
11. All specified hydronic system components.
12. Water flow measuring devices.
13. Gages.
14. Thermometers and test wells.
15. Factory preinsulated piping components and installation instructions.
16. Pipe fittings, and mechanical couplings, if used, for preinsulated chilled water piping.
17. Anchors and thrust blocking for preinsulated chilled water piping.

C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
1. Convertors.
2. Air separators.
3. Expansion tanks.
4. Flash tanks.

D. Manufacturer's certificates for underground preinsulated chilled water piping:
1. That the field representative for the factory insulated pipe installation is technically qualified and experienced in installation of the manufacturer's system and is qualified to provide the required site reports.
2. Upon completion of the work and before final acceptance, the Contractor shall deliver a notarized statement, signed by a principal officer of both the manufacturing firm and the contracting firm, stating that the installation is satisfactory and in accordance with the plans, specifications, and manufacturer's standards.

E. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.

F. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

G. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser water, and heating hot water system and other piping systems and equipment. .

1. One wall-mounted stick file with complete set of prints. Mount stick file in the chiller plant or control room along with control diagram stick file.
2. One complete set of reproducible drawings.
3. One complete set of drawings in electronic format (Autocad, pdf, or other approved format).

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American Society of Mechanical Engineers (ASME):

B1.20.1-83.....Pipe Threads, General Purpose (Inch)
B16.1-98.....Cast Iron Pipe Flanges and Flanged Fittings
B16.3-98.....Malleable Iron Threaded Fittings
B16.4-98.....Gray Iron Threaded Fittings
B16.5-03.....Pipe Flanges and Flanged Fittings
B16.9-03.....Factory-Made Wrought Buttwelding Fittings
B16.11-05.....Forged Fittings, Socket-Welding and Threaded
B16.14-91.....Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads
B16.22-01.....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
B16.23-02.....Cast Copper Alloy Solder Joint Drainage Fittings
B16.24-01.....Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500
B16.39-98.....Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300

B16.42-98.....Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300

B31.1-01.....Power Piping

B31.9-04.....Building Services Piping

B40.100-05.....Pressure Gauges and Gauge Attachments

C. American National Standards Institute, Inc. (ANSI):

B16.1 00.....Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125 and 250

B16.3 00.....Malleable Iron Threaded Fittings Classes 150 and 300

B16.5 03.....Pipe Flanges and Flanged Fittings NPS ½ through NPS 24

B16.9 03.....Factory Made Wrought Butt Welding Fittings

B16.11 01.....Forged Fittings, Socket Welding and Threaded

B16.14 91.....Ferrous Pipe Plugs, Bushings and Locknuts with Pipe Threads

B16.18-01.....Cast Copper Alloy Solder joint Pressure fittings

B16.22 00.....Wrought Copper and Bronze Solder Joint Pressure Fittings

B16.24 01.....Cast Copper Alloy Pipe Fittings and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500 and 2500

B31.1 01.....Power Piping

D. American Society for Testing and Materials (ASTM):

A47/A47M-99 (2004).....Ferritic Malleable Iron Castings

A53/A53M-06.....Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M-06.....Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A126-04.....Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A181/A181M-01.....Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

A183-03 ..... Standard Specification for Carbon Steel Track Bolts and Nuts

A216/A216M-04 ..... Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service

A234/A234M 04 ..... Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A307-04 ..... Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

A536-84 (2004) ..... Standard Specification for Ductile Iron Castings

A 615/A 615M-04 ..... Deformed and Plain Carbon Steel Bars for Concrete Reinforcement

A653/A 653M-04 ..... Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) By the Hot-Dip Process

B32-04 ..... Standard Specification for Solder Metal

B61-02 ..... Standard Specification for Steam or Valve Bronze Castings

B62-02 ..... Standard Specification for Composition Bronze or Ounce Metal Castings

B88-03 ..... Standard Specification for Seamless Copper Water Tube

B209 04 ..... Aluminum and Aluminum Alloy Sheet and Plate

C177 97 ..... Standard Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus

C478-03 ..... Precast Reinforced Concrete Manhole Sections

C533 03 ..... Calcium Silicate Block and Pipe Thermal Insulation

C552 03 ..... Cellular Glass Thermal Insulation

D 3350-02 ..... Polyethylene Plastics Pipe and Fittings Materials

C591-01 ..... Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

D1784 03 ..... Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds

D1785 03 ..... Poly (Vinyl Chloride0 (PVC) Plastic Pipe, Schedules 40, 80 and 120

D2241 04 ..... Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)

D2464 99 ..... Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

D3139 98 ..... Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

F439-06 ..... Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

F441/F441M-02 ..... Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

F477-02 ..... Elastomeric Seals Gaskets) for Joining Plastic Pipe

E. American Water Works Association (AWWA):

C110/03.....Ductile Iron and Grey Iron Fittings for Water

C203 00.....Coal Tar Protective Coatings and Linings for Steel Water Pipe Lines Enamel and Tape Hot Applied

F. American Welding Society (AWS):

A5.8/A5.8M-04.....Specification for Filler Metals for Brazing and Braze Welding

B2.1-02.....Standard Welding Procedure Specification

G. Copper Development Association, Inc. (CDA):

CDA A4015-95.....Copper Tube Handbook

H. Expansion Joint Manufacturer's Association, Inc. (EJMA):

EMJA-2003.....Expansion Joint Manufacturer's Association Standards, Eighth Edition

I. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:

SP-67-02a.....Butterfly Valves

SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded Ends

SP-71-05.....Gray Iron Swing Check Valves, Flanged and Threaded Ends

SP-72-99.....Ball Valves with Flanged or Butt-Welding Ends for General Service

SP-78-05.....Cast Iron Plug Valves, Flanged and Threaded Ends

SP-80-03.....Bronze Gate, Globe, Angle and Check Valves

SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and Threaded Ends

J. National Sanitation Foundation (NSF):

14 03.....Plastic Piping System Components and Related Materials

K. Tubular Exchanger Manufacturers Association: TEMA 8th Edition, 2000

L. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

HVAC Duct Construction Standards, 2nd Edition 1997

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.2 PIPE AND TUBING

A. Chilled Water (above ground), Heating Hot Water, Glycol-Water, and Vent Piping:

1. Steel: ASTM A53 Grade B, seamless or ERW, Schedule 40.
2. Copper water tube option: ASTM B88, Type K or L, hard drawn.

B. Extension of Domestic Water Make-up Piping: ASTM B88, Type K or L, hard drawn copper tubing.

C. Cooling Coil Condensate Drain Piping:

1. From air handling units: Copper water tube, ASTM B88, Type M, or schedule 80 flame retardant polypropylene plastic.

D. Pipe supports, including insulation shields, for above ground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.3 FITTINGS FOR STEEL PIPE

A. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints. Mechanical couplings and fittings are optional for water piping only.

1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
2. Welding flanges and bolting: ASME B16.5:
   a. Water service: Weld neck or slip-on, plain face, with 6 mm (1/8 inch) thick full face neoprene gasket suitable for 104 degrees C (220 degrees F).
      1) Contractor's option: Convoluted, cold formed 150 pound steel flanges, with teflon gaskets, may be used for water service.
   b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.

B. 50 mm (2 inches) and Smaller: Screwed or welded. Mechanical couplings are optional for water piping only.
   1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
   2. Forged steel, socket welding or threaded: ASME B16.11.
   3. Screwed: 150 pound malleable iron, ASME B16.3. 125 pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
   4. Unions: ASME B16.39.
   5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.

C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

D. Mechanical Pipe Couplings and Fittings: May be used, with cut or roll grooved pipe, in water service up to 110 degrees C (230 degrees F) in lieu of welded, screwed or flanged connections.
   1. Grooved mechanical couplings: Malleable iron, ASTM A47 or ductile iron, ASTM A536, fabricated in two or more parts, securely held together by two or more track-head, square, or oval-neck bolts, ASTM A183.
   2. Gaskets: Rubber product recommended by the coupling manufacturer for the intended service.
   3. Grooved end fittings: Malleable iron, ASTM A47; ductile iron, ASTM A536; or steel, ASTM A53 or A106, designed to accept grooved mechanical couplings. Tap-in type branch connections are acceptable.

2.4 FITTINGS FOR COPPER TUBING

A. Solder Joint:
   1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
   2. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch

tube in a single process to provide free flow where the branch tube penetrates the fitting.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

2.5 FITTINGS FOR PLASTIC PIPING

A. Schedule 80, socket type for solvent welding.

B. Polypropylene drain piping: Flame retardant, drainage pattern.

C. Chemical feed piping for condenser water treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F439.

2.6 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 99 degrees C (210 degrees F).

2.7 SCREWED JOINTS

A. Pipe Thread: ANSI B1.20.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.8 VALVES

A. Asbestos packing is not acceptable.

B. All valves of the same type shall be products of a single manufacturer. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

C. Provide chain operators for valves 100 mm (4 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.

D. Gate Valves:

1. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.
2. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.
   a. MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.

E. Globe, Angle and Swing Check Valves:

1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe and angle valves shall be union bonnet with metal plug type disc.

2. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves and MSS-SP-71 for check valves.

F. Non-Slam or Silent Check Valve: Spring loaded double disc swing check or internally guided flat disc lift type check for bubble tight shut-off. Provide where check valves are shown in chilled water and hot water piping. Check valves incorporating a balancing feature may be used.
   1. Body: Cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
   2. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.

G. Butterfly Valves: May be used in lieu of gate valves in water service except for direct buried pipe. Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation.
   1. MSS-SP 67, flange lug type (for end of line service) or grooved end rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F).
      a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
      b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
      c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
         1) Valves 150 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
         2) Valves 200 mm (8 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.

H. Ball Valves: Brass or bronze body with chrome-plated ball with full port and Teflon seat at 4140 kPa (600 psig) working pressure rating.

Screwed or solder connections. Provide stem extension to allow operation without interfering with pipe insulation.

I. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size and be one of the following types.
   1. Butterfly valve as specified herein with memory stop.
   2. Eccentric plug valve: Iron body, bronze or nickel-plated iron plug, bronze bearings, adjustable memory stop, operating lever, rated 861 kPa (125 psig) and 121 degrees C (250 degrees F).

J. Circuit Setter Valve: A dual purpose flow balancing valve and adjustable flow meter, with bronze or cast iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.

K. Automatic Balancing Control Valves: Factory calibrated to maintain constant flow (plus or minus five percent) over system pressure fluctuations of at least 10 times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:
   1. Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
   2. Brass or ferrous body designed for 2067 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
   3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.

L. Manual Radiator/Convector Valves: Brass, packless, with position indicator.

2.9 WATER FLOW MEASURING DEVICES

A. Minimum overall accuracy plus or minus three percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.

B. Venturi Type: Bronze, steel, or cast iron with bronze throat, with valved pressure sensing taps upstream and at the throat.

C. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.

D. Self-Averaging Annular Sensor Type: Brass or stainless steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.

E. Flow Measurement/Balance Valves: A system comprised of two valves of bronze and stainless steel metallurgy designed for 1205 kPa (175 psig) pressure at 121 degrees C (250 degrees F), with thermal insulation sleeve.

   1. Measurement and shut-off valve: An on/off ball valve with integral high regain venturi and dual quick connect valves with integral check valves and color coded safety caps for pressure/temperature readout.
   2. A butterfly balancing valve as specified herein, with memory stop and quick connect valve for pressure/temperature readout.

F. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

G. Flow Measuring Device Identification:

   1. Metal tag attached by chain to the device.
   2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in l/m (gpm).

H. Portable Water Flow Indicating Meters:

   1. Minimum 150 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows, designed for 1205 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
   2. Bleed and equalizing valves.
   3. Vent and drain hose and two 3000 mm (10 feet) lengths of hose with quick disconnect connections.
   4. Factory fabricated carrying case with hose compartment and a bound set of capacity curves showing flow rate versus pressure differential.
   5. Provide one portable meter for each range of differential pressure required for the installed flow devices.

I. Permanently Mounted Water Flow Indicating Meters: Minimum 150 mm (6 inch) diameter, or 450 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in lps (gpm), with three valve manifold and two shut-off valves.

2.10 STRAINERS

A. Basket or Y Type. Tee type is acceptable for water service.

B. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows: 1.1 mm (0.045 inch) diameter perforations.

2. 100 mm (4 inches) and larger: 3.2 mm (0.125 inch) diameter perforations.

C. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

2.11 FLEXIBLE CONNECTORS FOR WATER SERVICE

A. Flanged Spool Connector:

1. Single arch or multiple arch type. Tube and cover shall be constructed of chlorobutyl elastomer with full faced integral flanges to provide a tight seal without gaskets. Connectors shall be internally reinforced with high strength synthetic fibers impregnated with rubber or synthetic compounds as recommended by connector manufacturer, and steel reinforcing rings.

2. Working pressures and temperatures shall be as follows:

a. Connector sizes 50 mm to 100 mm (2 inches to 4 inches), 1137 kPa (165psig) at 121 degrees C (250 degrees F).

b. Connector sizes 125 mm to 300 mm (5 inches to 12 inches), 965 kPa (140 psig) at 121 degrees C (250 degrees F).

3. Provide ductile iron retaining rings and control units.

B. Mechanical Pipe Couplings:

See other fittings specified under Part 2, PRODUCTS.

2.12 EXPANSION JOINTS

A. Factory built devices, inserted in the pipe lines, designed to absorb axial cyclical pipe movement which results from thermal expansion and contraction. This includes factory-built or field-fabricated guides located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.

B. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.

C. Bellows - Internally Pressurized Type:

1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.

2. Internal stainless steel sleeve entire length of bellows.
3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
4. Welded ends.
5. Design shall conform to standards of EJMA and ASME B31.1.
6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
7. Integral external cover.

D. Bellows - Externally Pressurized Type:
1. Multiple corrugations of Type 304 stainless steel.
2. Internal and external guide integral with joint.
3. Design for external pressurization of bellows to eliminate squirm.
4. Welded ends.
5. Conform to the standards of EJMA and ASME B31.1.
6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
7. Integral external cover and internal sleeve.

E. Expansion Compensators:
1. Corrugated bellows, externally pressurized, stainless steel or bronze.
2. Internal guides and anti-torque devices.
3. Threaded ends.
4. External shroud.
5. Conform to standards of EJMA.

F. Expansion Joint Identification: Provide stamped brass or stainless steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the contract drawings.

I. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides must be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors. Field-built guides may be used if detailed on the contract drawings.

2.13 HYDRONIC SYSTEM COMPONENTS

A. Convertor: Shell and tube type, U-bend removable tube bundle, steam in shell, water in tubes, equipped with support cradles.
   1. Maximum tube velocity: 2.3 m/s (7.5 feet per second).
   2. Tube fouling factor: TEMA Standards, but not less than 0.001.
   3. Materials:
      a. Shell: Steel.
      b. Tube sheet and tube supports: Steel or brass.
      c. Tubes: 20 mm (3/4 inch) OD copper.
      d. Head or bonnet: Cast iron or steel.
   4. Construction: In accordance with ASME Pressure Vessel Code for 861 kPa (125 psig) working pressure for shell and tubes. Provide manufacturer's certified data report, Form No. U-1.

B. Optional Heat Transfer Package: In lieu of field erected individual components, the Contractor may provide a factory or shop assembled package of converters, pumps, and other components supported on a welded steel frame.

C. Air Purger: Cast iron or fabricated steel, 861 kPa (125 psig) water working pressure, for in-line installation.

D. Tangential Air Separator: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, flanged tangential inlet and outlet connection, internal perforated stainless steel air collector tube designed to direct released air into expansion tank, bottom blowdown connection. Provide Form No. U-1. If scheduled on the drawings, provide a removable stainless steel strainer element having 5 mm (3/16 inch) perforations and free area of not less than five times the cross-sectional area of connecting piping.

E. Closed Expansion (Compression) Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, steel, rust-proof coated. Provide gage glass, with protection guard, and angle valves with tapped openings for drain (bottom) and plugged vent (top). Provide Form No. U-1.
   1. Horizontal tank: Provide cradle supports and following accessories:
      a. Air control tank fittings: Provide in each expansion tank to facilitate air transfer from air separator, or purger, into tank while restricting gravity circulation. Fitting shall include an integral or separate air vent tube, cut to length of about 2/3 of

tank diameter, to allow venting air from the tank when establishing the initial water level in the tank.

b. Tank drainer-air charger: Shall incorporate a vent tube, cut to above 2/3 of tank diameter, and drain valve with hose connection draining and recharging with air.

2. Vertical floor-mounted expansion tank: Provide gage glass, system or drain connection (bottom) and air charging (top) tappings. Provide gate valve and necessary adapters for charging system. Tank support shall consist of floor mounted base ring with drain access opening or four angle iron legs with base plates.

F. Diaphragm Type Pre-Pressurized Expansion Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, welded steel shell, rust-proof coated, with a flexible elastomeric diaphragm suitable for a maximum operating temperature of 116 degrees C (240 degrees F). Provide Form No. U-1. Tank shall be equipped with system connection, drain connection, standard air fill valve and be factory pre-charged to a minimum of 83 kPa (12 psig).

G. Pressure Reducing Valve (Water): Diaphragm or bellows operated, spring loaded type, with minimum adjustable range of 28 kPa (4 psig) above and below set point. Bronze, brass or iron body and bronze, brass or stainless steel trim, rated 861 kPa (125 psig) working pressure at 107 degrees C (225 degrees F).

H. Pressure Relief Valve: Bronze or iron body and bronze or stainless steel trim, with testing lever. Comply with ASME Code for Pressure Vessels, Section 8, and bear ASME stamp.

I. Automatic Air Vent Valves (where shown): Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 15 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Pipe air outlet to drain.

2.14 WATER FILTERS AND POT CHEMICAL FEEDERS

See section 23 25 00, HVAC WATER TREATMENT, Article 2.2, CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS.

2.15 GAGES, PRESSURE AND COMPOUND

A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window,

suitable for board mounting. Provide red "set hand" to indicate normal working pressure.

B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gages in water service.

C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.

1. For condenser water suction (compound): Minus 100 kPa (30 inches Hg) to plus 700 kPa (100 psig).

2.16 PRESSURE/TEMPERATURE TEST PROVISIONS

A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.

B. Provide one each of the following test items to the Resident Engineer:

1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.

2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, , --100 kPa (30 inches) Hg to 700 kPa (100 psig) range.

3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.17 THERMOMETERS

A. Mercury or organic liquid filled type, red or blue column, clear plastic window, with 150 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading.

B. Case: Chrome plated brass or aluminum with enamel finish.

C. Scale: Not less than 225 mm (9 inches), range as described below, two degree graduations.

D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.

E. Scale ranges may be slightly greater than shown to meet manufacturer's standard. Required ranges in degrees C (F):

Chilled Water and Glycol-Water 0 to 38 degrees C (32-100 degrees F)	Hot Water and Glycol-Water -1 to 116 degrees C (30 to 240 degrees F).

2.18 FIRESTOPPING MATERIAL

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

2.19 ELECTRICAL HEAT TRACING SYSTEMS

A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.

B. Provide tracing for outdoor winterized piping as follows:

1. Condenser water piping for cooling towers.
2. Make-up water.

C. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.

1. Provide end seals at ends of circuits. Wire at the ends of the circuits are not to be tied together.
2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
   a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
   b. 100 mm 300 mm (foot) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per 300 mm (foot) of pipe.

D. Electrical Heating Tracing Accessories:

1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 15 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

2.20 FACTORY PREFABRICATED (PREINSULATED) CHILLED WATER PIPING

A. Inner Carrier Pipe:

1. Steel pipe: ASTM A53 black steel. Pipe up through 300 mm (12 inch) diameter shall be standard weight. Wall thickness for pipe larger than 300 mm (12 inch) diameter shall be not less than 10 mm (0.375 inch). Pipe larger than 50 mm (2 inches) shall be joined by welding.
2. Copper tubing: Shall conform to ASTM B88, Type L, joined by solder fittings.
3. Polyvinylchloride (PVC) Pipe: PVC pipe shall conform to ASTM D 2241 with a Standard Thermoplastic Pipe Dimension Ratio (SDR) of 26 and PVC 1120 or 1220 as the material. Pipe shall be NSF approved based on NSF 14 and shall be joined by integral bell and spigot joints or fittings, using rubber ring gaskets.

B. Outer Casing: Outer casing shall be galvanized sheet metal, polyvinylchloride, Polyethylene or Reinforced Thermosetting Resin Pipe as specified below:

1. Metal jacket (Above ground only): Spiral wound galvanized (G90) steel sheet, 0.70 mm (24 gage) minimum thickness, conforming to SMACNA HVAC Duct Construction Standards. Provide sheet metal covers for joints and fittings permanently attached by bands and rivets. Seal all lap seams in metal covers and weatherproof with silicone sealant or flexible polyurethane sealant strips. Shape covers to allow for insulation of mechanical coupling joints if used.
2. Polyvinyl chloride (PVC): Made of clean, virgin, NSF approved (based on Standard No. 14) Class 12454-B PVC compound conforming to ASTM D1785 and ASTM D1784, Type 1, Grade 1, with thickness as follows:

Casing Diameter	Minimum Thickness
150 mm (6 inches) and smaller	60 mils
200 mm (8 inches)	80 mils
250 mm (10 inches)	100 mils
300 mm (12 inches)	120 mils
350 mm (14 inches)	140 mils
450 mm (18 inches)	180 mils
600 mm (24 inches)	240 mils

For sizes not shown above, the minimum casing thickness in mils shall be equal to the numerical value of the casing diameter expressed in inches times a factor of 10.

3. Polyethylene (PE): Shall conform to ASTM D 3350, Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

Casing Diameter mm (inches)	Minimum Thickness (in mils)
200 (8) and smaller	75
225 to 500 (9 to 20)	150
525 to 550 (21 to 22)	165
575 to 600 (23 to 24)	200

Sizes larger than those shown above shall be approved in accordance with the Article, SUBMITTALS.

C. Factory Applied Insulation:

1. Foam insulation for prefabricated insulated pipe and fittings shall be polyurethane foam having a density not less than 32 kcm (2 pcf).
   a. Polyurethane foam shall conform to ASTM 591, Type II, formed for conduit, density not less than 32 kg/cubic meter (2 pcf).
   b. The insulation "k" factor shall not exceed the numerical value of 0.025 W/(m.k) (0.17 Btu-inch/h. square feet degree F) at 24 degrees C (75 degrees F) mean temperature in accordance with ASTM C177.
2. Insulation thickness for carrier pipe 75 mm (3 inches) nominal diameter and smaller: Not less than 18 mm (0.70 inch) or the standard manufactured thickness exceeding 18 mm (0.70 inch).
3. Insulation thickness for carrier pipe larger than 75 mm (3 inches) nominal diameter: 50 mm (2 inches) nominal, but not less than 38 mm (1-1/2 inches).
4. The polyurethane foam shall completely fill the annular space between the carrier pipe and the casing. Manufacturer shall certify that the insulated pipe is free of insulation voids and describe quality control procedure followed to meet this requirement.

D. Field Applied Insulation:

1. Insulation for valves, fittings, field casing closures, if required, and other piping system accessories shall be cellular glass conforming to ASTM C552, calcium silicate conforming to ASTM C533 or polyurethane matching the pipe insulation. Insulation shall be

premolded, precut or job fabricated to fit and shall be removable and reusable. Thickness shall match adjacent piping.

E. End Seals:

1. General: Each preinsulated section of piping shall have a complete sealing of the insulation to provide permanent water and vapor seal at each end of the preinsulated section of piping. Preinsulated sections of piping modified in the field shall be provided with an end seal which is equivalent to the end seals furnished with the preinsulated section of piping. Provide complete sealing of the insulation at each end of each preinsulated conduit section by one of the following methods:
   a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe to ensure a permanent water and vapor-resistant seal.
   b. Using specially designed prefabricated caps made of the same material and not less than the same thickness as the casing. Provide sufficient surface bonding area between the cap, and both the casing and carrier pipe, to ensure permanent water and vapor-resistant seal.
   c. Using rubber ring gaskets designed and dimensioned to fit in the annular space between the casing and carrier pipe in such a manner as to ensure a permanent water and vapor-resistant seal.
   d. Using shrink sleeves that shall be either heat shrinkable high temperature rubber or polyethylene material that can be bound to the carrier pipes and casing to ensure a permanent water and vapor-resistant seal.
2. Factory casing and end seal testing and certification:
   a. Testing and certification procedures by an independent testing laboratory shall demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation at 60 kPa (20 feet) of head pressure, measured above the highest point of the test sample, subjected over the entire surface of an 2.5 m (8-feet) test sample of prefabricated pipe for not less than 48 hours. Test shall use 24 degrees C (75 degree F) water for chilled water service, while the sample is either buried or encased in dry bedding sand with a minimum of 305 mm (12 inches) of sand all around sample. The carrier pipe

size in the test section shall be 75 mm (3 inches) in diameter and shall be restrained during the test period. The insulation thickness shall not exceed the maximum thickness provided for the piping in the project.

b. Test results for Federal Agency Committee on Underground Heat Distribution System, or similar results may be substituted.

F. Couplings:

1. Insulated pipe couplings for copper tubing: Insulated pipe couplings for copper tubing shall be cast bronze containing an 0-ring seal on each end and shall be jacketed and sealed to act as an expansion joint.
2. Bell and spigot joints: Rubber ring joining system. Bell and spigot joints may also be of the bonded type where the joint is made up utilizing a suitable adhesive for the service specified. Adhesive shall be furnished by the pipe manufacturer.
3. Mechanical couplings for steel pipe: Mechanical couplings for steel pipe shall be the sleeve type or the type for grooved end pipe and shall provide a tight, flexible joint under all conditions including movements caused by expansion, contraction, slight settling or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Coupling strength shall not be less than the connecting pipe sections. Sleeve-type couplings shall be used for joining plain end pipe sections. The sleeve couplings shall consist of one steel middle ring, two steel followers, two gaskets, and the necessary steel bolts and nuts to compress the gaskets. Grooved end pipe couplings shall consist of identical coupling sections fastened in place, using track head bolts, ASTM A183, to confine a molded gasket over the pipe and gap. Couplings shall be malleable iron or ductile iron.

G. Joints:

1. Welded joints: Welded joints between sections of pipe and between pipe and fittings shall be provided where specified or indicated. Branch connections shall be made with either welding tees or forged branch outlet fittings attached to the main and reinforced against external strains.
2. Flanged joints: Flanged joints shall be provided with gaskets and made perfectly square and tight. Full-faced gaskets shall be used with cast-iron flanges and all gaskets shall be as thin as the

finish of the flange face permits. Gaskets shall be 5 mm (3/16-inch) thick for 25 through 300 mm (1 through 12 inch) flanges and 6 mm (1/4-inch) thick for flanges 350 mm (14 inches) and larger.

3. Threaded joints: Joints shall be made tight with polytetrafluoroethylene tape applied to the male threads only. Not more than three threads shall show after the joint is made up.
4. Brazed and soldered joints: Brazed and soldered joints for copper pipe and fittings shall conform to CDA A 4015. Silver solder or brazing alloys, ASTM B32, melting above 593 degrees C (1100 degrees F) shall be utilized.
5. Mechanical joints: Sleeve and grooved pipe couplings shall be installed and protected against corrosion as recommended by the coupling manufacturer. Joints between nonmetallic and metallic carrier pipe shall be designed and furnished by the piping system manufacturer. The transition pieces shall be factory fabricated and shall be designed so that no field chemical welding of the carrier pipe will be required. Transitional joint connections to manhole steel piping shall be made inside the manhole except for prefabricated, pre-piped manholes where joints shall be outside the manhole wall.
6. Insulating joints and dielectric fittings: Shall be installed where shown.
7. Nonmetallic pipe joints: Nonmetallic pipe joints shall be installed in accordance with the written instructions of the manufacturer.

2.21 EXPANSION LOOPS FOR PREINSULATED CHILLED WATER PIPING

A. Factory fabricated of casing, insulation, and carrier piping identical to that furnished for straight runs. Loops shall be properly designed in accordance with the allowable stress limits indicated in ANSI B31.1 for the type of pipe used. Ship loops to the job site in the maximum size sections feasible in order to minimize the number of field joints. The loop casing shall be suitably sized and all special guides and supports designed so that pipe movement will be contained without crushing the insulation or causing other damage.

B. Field joints shall be made in straight runs of the loops and the number shall be kept to a minimum. Piping shall be cold sprung one-half the calculated maximum operational expansion during field assembly. L- and Z-bends shall conform to the requirements for expansion loops specified above.

2.22 ANCHORS FOR PREINSULATED CHILLED WATER PIPING

Anchor design shall be in accordance with the published data of the manufacturer and for prefabricated systems shall be factory fabricated by the system manufacturer. In all cases, the design shall be such that water penetration, condensation, or vapor transmission will not wet the insulation.

2.23 VACUUM AND AIR RELIEF VALVES

Vacuum and air relief valves shall be iron body with bronze trim, and stainless steel floats.

2.24 REINFORCING STEEL

Reinforcing steel shall be deformed bars, ASTM 615, Grade 40, unless otherwise noted.

PART 3 - EXECUTION

3.1 GENERAL

A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.

C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.

D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.

F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.

G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

H. Provide manual air vent at all piping system high points and drain valves at all low points.

I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
   1. Water treatment pot feeders and condenser water treatment systems.
   2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.

K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.

L. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. See Welder’s qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

B. Screwed: Threads shall conform to ASME B1.20; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.

C. Mechanical Joint: Pipe grooving shall be in accordance with joint manufacturer's specifications. Lubricate gasket exterior including lips, pipe ends and housing interiors to prevent pinching the gasket during installation. Lubricant shall be as recommended by coupling manufacturer.

D. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

E. Solvent Welded Joints: As recommended by the manufacturer.

3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.

B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.

C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.

D. Access: Expansion joints must be located in readily accessible space. Locate joints to permit access without removing piping or other devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding packing.

3.4 INSTALLATION OF PREINSULATED CHILLED WATER PIPING

A. Handling and Storage: Handle and store conduits, pipes, and all accessories to ensure complete installation in a sound undamaged condition. Unloading, tacking, moving, and storing of materials shall be in strict accordance with the manufacturer's requirements. Take special care to ensure that materials which have exceeded their specified shelf life are not used in the installation of the system. Before installation all materials shall be inspected for defects. Materials found to be defective before or after installation shall be repaired or replaced with sound material, with no additional expense to the Government.

B. Installation of Piping Systems:

1. Piping system furnished shall be installed in accordance with the piping system manufacturer's instructions. Piping shall be installed without springing or forcing other than what has been calculated for thermal expansion and contraction. Pipe ends shall have burrs removed by reaming and shall be installed to permit free expansion and contraction without damage to joints or hangers. Nonmetallic pipe cut in the field shall be machined to fit couplings or joints and shall be coated or treated to match standard factory coated ends. Copper tubing shall not be installed in the same trench with ferrous piping materials. When nonferrous metallic pipe (e.g., copper tubing) crosses any ferrous piping material, a minimum vertical separation of 300 mm (12 inches) shall be maintained between pipes. Connections between different types of pipe and accessories shall be made with transition fittings approved by the manufacturer of the piping system.
2. Pitching of horizontal piping: Horizontal piping shall be pitched at a grade not less than 25 mm (1 inch) in 12 m (40 feet) toward the drain points unless otherwise indicated.
3. Install vacuum and air relief valves, as required, for filling and draining of the system.

C. Pipe Sleeves:

1. Pipe shall be continuous through sleeves. Set in place before concrete is poured.
2. Seal between sleeve and core opening with modular mechanical type link seal.
3. Provide where water lines pass through retaining walls and foundation walls.

D. Cutting of Prefabricated Conduit Sections: Prefabricated conduit sections shall be cut in strict accordance with the manufacturer's recommendations and standards. The cut section shall be treated as required to result in the cut section being identical in every respect to a standard conduit section produced at the factory.

E. Field Casing Closures: Field insulation and encasement of joints shall be accomplished after the visual and pressure tests specified are completed. Field insulation and encasement shall be in accordance with the manufacturer's written instructions. Thickness dimensions of the insulation and casing materials shall not be less than those of the

adjoining prefabricated section. Insulating material may be foamed in place polyurethane or premolded polyurethane foam sections. Care should be taken to ensure that field closures are made under conditions of temperature and cleanliness required to produce a sound continuous vapor barrier. A standard polyethylene heat shrink sleeve shall be installed over the casing and shall have a 150 mm (6-inch minimum) overlap at each end.

F. Insulation and Encasement of Pipe Accessories: Flanges, couplings, unions, valves, fittings, and other pipe accessories, unless otherwise shown or approved, shall be insulated with removable factory premolded, prefabricated or field fabricated insulation. Where accessories are designated not to be insulated, the adjoining insulation and jacket shall terminate neatly and in a manner to provide a complete vapor seal.

G. Open Ends: Open ends of pipe lines and equipment shall be properly capped or plugged during installation to keep dirt and other foreign matter out of the system.

I. Vapor Barrier: Install materials to provide and preserve the integrity of the vapor barrier.

3.5 LEAK TESTING ABOVEGROUND PIPING

A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the Resident Engineer. Tests may be either of those below, or a combination, as approved by the Resident Engineer.

B. An operating test at design pressure, and for hot systems, design maximum temperature.

C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

3.6 FLUSHING AND CLEANING PIPING SYSTEMS

A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.

1. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils,

control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/S (6 feet per second), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the Resident Engineer.

2. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 1.8 m/S (6 feet per second). Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.
3. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.7 WATER TREATMENT

A. Install water treatment equipment and provide water treatment system piping.

B. Close and fill system as soon as possible after final flushing to minimize corrosion.

C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.

D. Utilize this activity, by arrangement with the Resident Engineer, for instructing VA operating personnel.

3.8 ELECTRIC HEAT TRACING

A. Install tracing as recommended by the manufacturer.

B. Coordinate electrical connections.

3.9 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

B. Adjust red set hand on pressure gages to normal working pressure.

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