SECTION 23 20 00 - PIPING

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Snow Melt
1. The use of snow melt systems is discouraged because of high energy use.
2. Snow melting installations are divided into two classes.
   a. Class I: Main pedestrian entrances, walks or driveways on the north side of the buildings.
   b. Class II: Commercial sidewalks and driveways.
3. Design snow melt systems for areas critical to safety. It is unacceptable to have snow on the snow melt surface for any length of time. Consider snow melt systems for sidewalks, loading docks, service entrances, main entrances and steps.
4. Base typical system for 150 Btu-h per square foot with a 10-mph wind at 0 degrees F.
5. Provide systems with 60 percent water and 40 percent Dowfrost.
6. Provide dedicated steam to water heat exchanger(s).

B. Pipe Connections: Provide required straight sections for flow measurement stations.

C. Expansion Compensation:
1. Piping and joints shall be designed to eliminate damage by expansion and contraction.
2. Mechanical expansion devices are discouraged. Expansion loops are preferred. Where mechanical expansion devices are necessary, bellows type shall be specified. Other types with mechanical seals are not permitted.
3. Devices shall be readily accessible for maintenance and repair per the manufacture’s recommendations.

D. Natural Gas Piping Systems:
1. Provide shut-off cocks on all branch lines, and lab benches, and make cocks easily accessible for service and operation. Provide drip legs at all equipment connections. Use pipe dope on threaded pipe fittings, Teflon tape is prohibited.

E. Sanitary Sewer Piping Systems:
1. Provide manholes at major junctions of exterior sewer lines, and provide cleanouts on all other junctions.
2. Locate interior clean-out caps and plugs such that they can be removed without damaging the surfaces in which they are installed.
3. Do not discharge chemical waste, oils, antifreeze, and other wastes into the sanitary sewer without written approval of the University Project Manager. Coordinate the requirement of acid neutralizing systems and sand and oil interceptors with the University Project Manager.
4. Do not discharge domestic water used for cooling into the sanitary sewer except for emergency back up for critical systems and vacuum systems.

F. Storm Drain Piping Systems:
1. Do not discharge sanitary waste into the storm sewer system. Do not discharge storm drain water into the sanitary waste system.

G. Ejector Pumps
1. At system low points where gravity drain is not possible provide duplex sump pump systems with high water alarms connected to Building Automation System. Provide gravity drainage piping downstream of pumps sized to accommodate the discharge of both pumps running at the same time and any additional load produced from normal gravity drainage.

2. Provide sump pump controls with a manual selectable, alternating relay to switch lead-lag operation.
3. Provide all sump pumps with standby or emergency power.
4. Stainless Rails, chains, etc Removable System…
5. Provide flanged pump connections.

H. Chemical and Acid Waste Systems:
1. Discuss the treatment and handling of chemical and acid wastes with the University Project Manager. Typically, most wastes at the university are collected in containers and are disposed of through the university and the need for acid waste pipe is the exception. Acid wastes may be generated in deionized water systems and in these cases a neutralization system must be approved by the University Project Manager through EH&S and Operations.
2. Where chemical and acid waste is required by specific circumstance and it is virtually inaccessible (i.e., concrete slab) polypropylene pipe should be used in these locations.
3. Lab waste lines shall be constructed from polypropylene pipe with mechanical joints.
4. Building waste water effluent must meet state and federal regulations.
5. Pretreatment may be necessary based on specific program requirements.
6. Engineer to determine whether pretreatment is recommend based on discussions with program representatives regarding types and amounts of chemicals and other materials with which they will be working
7. Provide sampling ports building discharge for laboratory effluent systems.
8. Coordinate with regulatory agencies, including Metro Waste Water.
9. Coordinate requirements closely with the University Project Manager.

I. Potable Water Piping System:
1. Lead pipe or lead solder is prohibited for all potable water piping systems.
2. Make domestic water piping joints with lead free solder.
3. Size domestic water piping to maintain maximum velocities of 8 feet per second for cold water and 5 feet per second on hot water and hot water circulation piping.
4. Provide main shutoff valve for potable water inside the building.
5. As a minimum, provide shut-off valves at each branch, floor, equipment and bathroom group.

1.2 QUALITY ASSURANCE

A. Welders Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications

B. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as “B31.9 Building Services Piping”.

C. The types and extent of non-destructive examinations required for pipe welds are as shown in Table 136.4 of the ASME Code for Pressure Piping, ANSI/ASME B31.1 - Power Piping. If requirements for non-destructive examination are to be other than that stated above, the degree of examination, and basis for rejection shall be a matter of prior written agreement between the fabricator, of contractor and the purchaser.

D. Soldering and brazing procedures shall conform to ANSI B9.1 Standard Safety Code for Mechanical Refrigeration.

E. Welding: All welding work shall be performed by welders certified to ASME or AWS standards within the last year for the type of material and application suited for the job. Contractors shall submit copies of qualification tests of the welders to the Project Manager prior to construction.

F. ASME B31.9 “Building Services Piping” for materials, products and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

1.3 WARRANTY:

A. Manufacturer’s warranty of 25 years for snowmelt tube and 18months for snowmelt manifolds.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years
2. Grooved Piping:
a. ITT Grinnell Corp.
b. Victaulic Co. of America
3. Piping Connectors
a. Fernco, Inc.
4. Pipe Thread Sealant
a. The Rectorseal Corp.
5. Drainage Piping Specialties, including backwater valves, expansion joints, drains, cleanouts, flashing flange and vent flashing sleeve.
a. JR Smith
b. Zurn Industries
c. Wade
d. Josam
6. Gas Cocks
a. Crane
b. Hammond
c. Peter Healy

B. Acceptable Manufacturers - Snowmelt: Subject to compliance with requirements, provide products by the following:
1. Tube, Fittings, Pipe, and Manifolds:
a. Uponor
b. Watts Radiant
c. Quest Hydronics
2. Controls: Integrated into BAS (preferred)

2.2 MATERIALS, GENERAL - SNOWMELT

A. Provide components of the buried tubing system by one manufacturer, including tubing, fittings, manifolds, and ancillary items.

B. Small Systems, Less Than 5000 Square Feet:
1. Tube: ASTM F876, cross linked polyethylene, 5/8-inch inside diameter, rated at 180 degree F maximum working temperature and 100 psi working pressure, with oxygen diffusion barrier capable of limiting oxygen diffusion through the tube to no greater than 0.10 g/m3/day at 104 degree F. Minimum bend radius for cold bending shall no be less than six times the outside diameter.
2. Fittings: Dezincification resistant brass fittings consisting of a barbed insert, compression ring, and compression nut.

3. Manifolds: Cast brass construction, manufactured of alloys to prevent dezincification, with integral circuit balancing valves. Provide with support brackets and tube bend supports. Isolate manifolds from supply and return tubing with valves suitable for isolation and balancing. Manifolds shall be capable of venting air from the system.

C. Large Systems, Over 5000 Square Feet:
1. Tube: ASTM fd3350, cross linked, low density polyethylene without oxygen diffusion barrier. 7/8-inch inside diameter, rated at 140 degree F maximum working temperature and 55 psi working pressure.
2. Fittings: Dezincification resistant brass fittings or HDPE,SDR 11 polyethylene fittings.
3. Manifolds: Pre-manufactured of HDPE, fusion welded, designed for balanced flow. Include proper fittings or compression clamping sleeve and locking caps.

D. Supply and Return Main Pipe:
1. 2 Inch and below: ASTM F876, cross linked polyethylene, rated at 180 degree F maximum working temperature and 100 psi working pressure with oxygen diffusion barrier capable of limiting oxygen diffusion through the tube to no greater than 0.10 g/m3/day at 104 degree F.
a. Fittings: Brass or Bronze
2. Above 2 Inches: Industrial pressure pipe, HDPE polyethylene pipe, fusion welded.
a. Fittings: HDPE, SDR 11, fusion welded.

E. Access Covers:
1. Removable access covers constructed of reinforced concrete formed in place or precast concrete over pipe connections, fittings, and distribution manifolds. Provide tapered forms for covers. Covers subject to vehicular traffic shall be traffic rated.

F. Controls:
1. Control by Division 23 09 00..

2.3 MATERIALS, GENERAL

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class in not indicated, provide proper selections determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, and valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer’s recommendations where applicable.

C. Steel Pipes and Pipe Fittings:
1. Black Steel Pipe: ASTM A53, Grade B, Type E, electric resistance welded.
2. Galvanized Steel Pipe: ASTM A 53, Grade B.
3. Seamless Steel Pipe: ASTM A53, Grade B, type S or A106 high temperature.
4. Stainless Steel Pipe: ASTM A312; Grade TP 304 (high temperature and corrosive service, 1/8-inch through 30-inch.
5. Coal Tar Protective Coatings and Linings for Ductile Iron Water Pipe: AWWA C203 for enamel and tape, hot applied.
6. Cement-Mortar Protective Lining and Coating for Steel Pipe: AWWA.
7. Steel Water Pipe: AWWA for pipe 6-inch and larger.
8. Cast-Iron Flanged Fittings: ANSI B16.1, including bolting (class 125 and 250)
9. Cast-Iron Threaded Fittings: ANSI B16.4; plain or galvanized as indicated (Class 125 and 250)
10. Malleable-Iron Threaded Fittings: ANSI B16.3; plain or galvanized as indicated (Class 125 and 300)

11. Malleable-Iron Threaded Unions: ANSI B16.30, Class 150, 250 or 300; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated (Class 150, 250 and 300).
12. Threaded Pipe Plugs: ANSI B16.14.
13. Steel Flanges/Fittings: ANSI B16.5, ASTM A234 (Fire Protection) including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.
14. Corrosion-Resistant Cast Flanges/Fittings: MSS SP-51, including bolting and gasketing (threaded where pressure is not critical).
15. Forged-steel Socket-Welding and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe up to 4 inch pipe size).
16. Wrought-Steel Butt-welded Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.
17. Cast-Iron Threaded Drainage Fittings: ANSI B16.12.
18. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.
19. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less that Schedule 80 pipe where length remaining unthreaded is less that 1-1/2 inch and where pipe size is less than 1-1/2 inch, and do not thread nipples full length (no close nipples).

D. Copper Tube and Fittings:
1. Copper Tube: ASTM B 88; Type K or L as indicated for each service; hard-drawn, except as otherwise indicated.
2. DWV Copper Tube: ASTM B306
3. ACR Copper Tube: ASTM B280.
4. Cast-Copper Solder-Joint Fittings: ANSI B16.18.
5. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.
6. Cast-Copper Solder-Join Drainage Fittings: ANSI B16.23 (drainage and vent with DWV or tube).
7. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.
8. Cast-Copper Flared Tube Fittings: ANSI B16.26
9. Bronze Pipe Flanges/Fittings: ANSI B16.24 (Class 150 and 300)
10. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

E. Brass Pipe and Fittings:
1. Red Brass Pipe: ASTM B43 (boiler feed pipe, 1/8 inch through 12 inch, regular or extra strong weight)
2. Cast-Bronze Threaded Fittings: ANSI B16.15, Class 125 or 250.
3. Cast-Bronze Threadless Fittings: ASTM B61 or B62 brazed joints.

F. Cast-Iron Soil Pipes and Pipe Fittings:
1. Hubless Cast-Iron Soil Pipe: FS WW-P-401 and CISPI Standards 301 and 310.
2. Cast-Iron Hub-and-Spigot Soil Pipe Fittings: Match soil pipe units; complying with ASTM A74.
3. Hubless Cast-iron Soil Pipe Fittings: Neoprene gasket complying with ASTM C564, CISPI Standard 310 and stainless steel clamp holding band.
4. Cast-Iron Hub-and-Spigot Soil Pipe Fittings: Match soil pipe units; complying with ASTM A74.
5. Neoprene Compression Gaskets: ASTM C564

G. Grooved Piping:
1. Coupling Housings: Malleable iron conforming to ASTM A47.
2. Coupling Housings: Ductile iron conforming to ASTM A536.
3. Coupling Housings Description: Grooved mechanical type, which engages grooved or shouldered pipe ends, encasing an elastomeric gasket which bridges pipe ends to create seal. Cast in two or more parts, secure together during assembly with nuts and bolts. Permit degree or contraction and expansions specified in manufacturer’s latest published literature.

4. Gaskets: Mechanical grooved coupling design, pressure responsive so that internal pressure serves to increase the seal's tightness, constructed of elastomers having properties as designated by ASTM D2000.
   a. Water Services: EDPM Grade E, with green color-code identification.
   b. Other Services: As recommended by Manufacturer.
5. Bolts and Nuts: Heat-treated carbon steel, ASTM A183, minimum tensile 110,000 psi. (Exposed locations require tamper resistant nuts).
6. Branch Stub-ins: Upper housing with fill locating collar for rigid positioning engaging machine-cut hole in pipe, encasing elastomeric gasket conforming to pipe outside diameter around hole, and lower housing with positioning lugs, secured together during assembly with nuts and bolts.
7. Fittings: Grooved or shouldered end design to accept grooved mechanical couplings.
   a. Malleable Iron: ASTM A47
   b. Ductile Iron: ASTM A536
   c. Fabricated Steel: ASTM A53, carbon steel, Schedule 40, Type F, for 3/4 inch to 4 inch; Type E or S, Grade B for 5 inch to 20 inch.
   d. Steel: ASTM A234
   e. Wrought Copper and Bronze: ASTM B75 tube and ASTM B584 bronze castings.
   f. Galvanized: ASTM A106, ASTM A46, or A536. Couplings for use with AWWA dimension piping shall conform to AWWA C606.
8. Flanges: Conform to Class 125 cast iron and Class 150 steel bolt holes alignment.
   a. Malleable Iron: ASTM A47.
   b. Ductile Iron: ASTM A536.
9. Grooves: Conform to the following:
   a. Standard Steel: Square cut.
   b. Lightweight Steel: Roll grooved.
   c. Cast Iron: Radius cut grooved, AWWA C606.

H. Miscellaneous Piping Materials/Products:
1. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.
2. Soldering Materials: Lead-free solder
3. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.
   a. Comply with AWS A5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
      1) Copper phosphorus – Bcup
      2) Silver - BAg minimum 4% Silver content
4. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.
5. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.

I. Piping Systems:
1. Domestic Hot and Cold Water:
   a. Above Grade, Inside Buildings: Type L, hard drawn copper tube with wrought copper or bronze fittings, lead free solder joints or Schedule 40, galvanized steel pipe A53 grade B, ERW w/galvanized Grooved end fittings.
   b. Below Grade, Inside and Outside Buildings: Underground outside fittings shall comply with City of Aurora standards.
      1) 2 inches and Smaller: Type K, soft copper or Type K annealed copper tube with wrought copper fittings, silver brazed solder joints.
      2) 2.5 inches and Larger: Class 250, tar coated outside, cement lined, cast iron or ductile iron with mechanical or push on joints.
2. Equipment drain and overflows: Type "M" or "DWV" copper.
3. Sanitary Sewer and Vents:

a. Above Grade: Service weight cast iron, no-hub type with neoprene gaskets; service weight cast iron, hub and spigot type with neoprene gaskets; or DWV copper with wrought copper or cast brass fittings.
   1) Use heavy duty no hub couplings4" wide 304 stainless steel shield, with six (6) stainless steel clamps mounted in series on the following:
      a) Sanitary vent piping 4" and larger.
      b) Sanitary piping 3" and larger.
      c) All storm piping.
   2) Torque to minimum 80 inch pounds or per manufacturer's recommendation.
   3) Acceptable manufacturers: Husky Series 4000 or Mission Heavy Weight.
b. Below Grade: Sizes 2 inches to 20 inches, service weight cast iron, hub and spigot type with neoprene compression gaskets; or sizes 12 inches and larger ductile cast iron with neoprene gasket joints.
c. Cleanout Openings: Two-way type, 1-1/4 inch nominal size minimum and located such that long lines can be entered from both ends. Lubricate plugs at installation.
d. All sump pumps receiving floor drains located in boiler rooms will be non-submersible type. Pumps will be designed to handle hot water because boilers are flushed or emptied at intervals into floor sumps.

4. Storm Drain
   a. Above Grade:
      1) Same as sanitary sewer.
      2) Utilize heavy duty, 8 psi, no-hub couplings for cast iron. No-hub may only be used on piping within 20' below the roof. This limitation is to prevent a failure of the 8 psi rated couplings in the event of a downstream system blockage. In lieu of this restriction adequate relief or a higher rated fittings, must be provided and approved by the engineer.
      3) Threaded or mechanical couplings with galvanized piping are acceptable for all locations.
   b. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type or sizes 12 inch and larger ductile cast iron with neoprene gasket joints.
   c. Roof drains or drains located in outside areaways, not subject to regular foot traffic, shall be of the dome type to minimize clogging with leaves or other debris.
5. Natural Gas:
   a. Within the Building: Schedule 40 black iron pipe, threaded for sizes 2 inches and smaller and welded for 2-1/2 inch and larger. All lines shall be accessible.
   b. Flex lines to equipment and fixtures shall be stainless steel with epoxy coating on both sides, UL stamped. Other types are prohibited.
   c. Pipe dope shall be Teflon based. Oil based is not permitted. Teflon tape prohibited.
6. Chemical and Acid Waste:
   a. Acid resistant, flame retardant, schedule 40 polypropylene pipe and fittings with electrically-induced or mechanical joints.

J. REFRIGERANT PIPING
1. Line sets are not allowed.
2. Tube Material:
   a. Size 3/4” and smaller: Soft annealed temper copper tube.
   b. Size 7/8” through 4-1/8”: Hard drawn temper copper tube.
   c. Type ACR.
3. Fittings: Wrought-copper, solder-joints, ANSI B16.22.
4. Joints: Brazed or soldered with material having shear strength of 10,000 PSI or greater.
5. End Caps:
   a. Provide factory applied plastic end caps on each length of pipe and tube.
   b. Maintain end caps through shipping, storage and handling as required to prevent pipe end damage and eliminate dirt and moisture from inside of pipe and tube.
6. Shut Off Valves:

K. Manufacturers:
1. Henry
2. Other Acceptable Manufacturers:
3. Parker Hannifin Corp.
4. Singer
5. Sporlan Valve Co.
6. Size 7/8 Inch and Smaller:
   a. Model: Series 600.
   b. Type: Pack-less diaphragm.
   c. Material: Forged bronze.
   d. Flow: Non-directional.
   e. Servicing: Diaphragm changeable under line pressure.
7. Size 1-1/8 Inch and Larger:
   a. Model: Series 200.
   b. Type: Wing cap, back seating.
   c. Material: Bronze.

L. Pipe Connectors:
1. Manufacturers
   a. Mason
   b. Metraflex
   c. Flexonics
2. Braided bronze with copper tube ends, compatible with refrigerant type for system
3. Flexible connector shall be line size or connection size, whichever is larger.

M. Piping Specialties:
1. Refrigeration Accessories (Strainers, Moisture-Liquid Indicators, Filter-Driers, Evaporator Pressure Regulators, Discharge Line Mufflers, Expansion Valves, Superheat Adjustment):
2. Manufacturers:
   a. Alco Controls Division, Emerson Electric Co.
   b. Henry Valve Co.
   c. Parker Hannifin Corp.
   d. Sporlan Valve Co.
3. Filter Drier:
   a. Conform to ARI Standard 710.
   b. Sizes ½" and larger - interchangeable core, full flow.
   c. Sizes smaller than ½" - sealed type.
   d. Minimum burst pressure - 1500 psig.
4. Expansion Valve:
5. Thermostatic type, diaphragm or bellows operated.
6. External superheat adjustment factory set for 10ºF superheat (adjustable).
7. Compatible with refrigerant type for the project.
8. Pressure rated per project requirements.
9. Power elements and valve size shall be as recommended by the manufacturer, for the service intended.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance.
1. Comply with ANSI B31 Code for Pressure Piping.

2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment shall be allowed.
3. Use fittings for all changes in direction and all branch connections.
4. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.
5. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
6. Install drainage piping with a minimum 1/8 inch per foot downward slope in the direction of the drain and a maximum slope of ¼ inch per foot.
7. Install drains at all low points in mains, risers, and branch lines consisting of a tee fitting, ¾-inch ball valve, and short ¾-inch threaded nipple, hose connection, and cap.

B. Piping System Joints:
1. General: Provide joints of type indicated in each piping system.
2. Thread pipe in accordance with ANSI B2.1Braze copper tube-and -fitting joints in accordance with ASME B31.
3. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31. Provide weld-o-let fittings for two pipe sizes less than main pipe size.
4. Weld pipe joints as follows:
   a. Weld pipe joints only when ambient temperature is above 0 degrees F. (-18 degrees C)
   b. Bevel pipe ends at a 37. 5-degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
   c. Use pipe clamps or tack-weld joints with 1-inch long welds; 4 welds for pipe sizes to 10 inch, 8 welds for pipe sizes 12 inch to 20 inch.
   d. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures, which will ensure elimination of unsound or un-fused metal, cracks, oxidation, blow-holes and non-metallic inclusions.
   e. Do not weld-out piping system imperfections by tack-welding procedures; re-fabricate to comply with requirements.
5. Weld pipe joints of steel water pipe in accordance with AWWA C206.
6. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

C. Pipe Fittings:
1. Place unions at all equipment, regulators, controls, etc., that require removal or replacement. Do not block removal with adjacent equipment or piping. Where necessary for removal of equipment, install unions on both sides of equipment. Unions are not required on flanged devices.
2. Use dielectric waterway fittings where dissimilar metals are connected. Isolate building distribution gas piping with dielectric unions from gas main for cathodic protection.
3. All unions shall be ground joints.
4. Make reductions in size with reducing fittings.
5. All screwed nipples from copper fittings shall be red brass.

D. Pipe Connections: Install pipe connections to pumps, compressors, etc., with adequate allowance for movement and vibration. Support connections so the equipment does not carry weight.

E. Expansion Compensation: Arrange pipes and equipment with due regard for the effects of thermal expansion.

F. Hangers and Supports:
1. Maintain uniform grading and pipe slope of piping system. Install supports between piping and building structure to prevent swaying and vibration. Install hangers to provide a minimum 1/2-

inch clear space between finished covering and adjacent work. Use threaded rods with two lock nuts.

2. Do not support weight of piping from mechanical equipment, ductwork, pump flanges, coil connections, and related items.
3. Support hanger rods by coach screw rods, angle iron clips, or beam clamps. No drilling of structural members will be permitted without approval. Hanger rods shall be attached to the top of joist beams.
4. Do not bend hanger rods to provide alignment of piping offset from overhead supports.
5. Provide sway bracing every 40 feet on cast iron.
6. Hanger Spacing: Per current code.
7. Vertical Supports
   a. Cast Iron Pipe: Support at each floor, not to exceed 15 feet between supports, and at pipe base.
   b. Screwed Pipe: Support at 8 foot on center for 1-1/2 inch and smaller pipe. Support at 10 foot on center for 2-inch and larger pipe.
   c. Copper Pipe: Support at 6 foot on center for 1-1/2 inch and smaller pipe. Support 8 foot on center for 2-inch and larger pipe.
8. Trapeze Hangers: Space for smallest pipe in-group. Provide additional hanger rod at mid span where trapeze length exceeds 4 feet. Secure pipe at each trapeze with standard pipe strap. Rest un-insulated copper pipe on neoprene sleeves.

G. Pipe Joint Construction:
1. Soldered Joints: Comply with the procedures contained in the AWS “Soldering Manual”.
2. Brazed Joints: Comply with the procedures contained in the AWS “Brazing Manual”.
   CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
3. Fill all medical gas and refrigerant pipe and fittings during brazing with an inert gas, i.e., nitrogen or carbon dioxide, to prevent formation of scale.
4. Heat joints using oxy-acetylene torch. Heat to proper and uniform temperature.
5. For all copper piping, ream and remove all burrs prior to making joints.
6. Threaded Joints: Conform to ANSI B1.20.1.
7. Damaged Threads: Do not use pipe with threads that are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.
8. Welded Joints: Comply with the requirement in ASME Code B31.9 “Building Services piping”.
9. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

3.2 INSTALLATION, GENERAL - SNOWMELT

A. Secure tubing to wire mesh or rebar every 4 feet along straight runs and on 180 degree turns secure at the top of the arc and on each side, 12 inches from the top of the arc,

B. Install fittings accessible for maintenance. Install tubing loops without splices, as a minimum, from the point at which the tubing enters the panel to the point at which it exists the panels.

C. Pressurize the tubing system with water or air to a pressure of 60 psig 24 hours prior to encasement in the radiant panel. Maintain pressurization during the panel installation and for a minimum of 24 hours after panel installation to ensure system integrity.

D. Label piping, vales, and equipment in accordance with 23 05 53.

E. Drain water or air from the system after leak testing the system and fill with 60 percent water and 40 percent propylene glycol water mix.

F. Do not extend pipe through expansion, construction, or working joints in concrete slab unless specifically addressed during design. Carefully coordinate expansion joints installed during or cut after concrete pour with the tubing layout and snow melt manufacturer.

G. Hydraulically balance mains. Coordinate balancing with Section 23 05 43 and include balancing information in balancing report.

3.3 INSTALLATION, GENERAL – RERIGERATION

A. Size lines for total pressure drop not to exceed 2º F saturation temperature.

B. Provide necessary flexibility for vibration and expansion with offsets and loops, not expansion joints.

C. Provide flexible connectors at all unit connections.

D. Replace air in pipe with dry nitrogen to prevent corrosion during soldering.

E. Install valves, sight glasses, filter-driers, and accessories, furnished by equipment supplier, but not factory installed.

F. Insulate all underground refrigerant lines with ½" flexible foam.
1. Use un-slit covering.
2. Cement all joints.

G. Hangers:
1. For insulated piping, provide hangers of size to fit outside insulation.
2. For non-insulated piping, provide hangers with elastomer insert to prevent damage to piping from vibration.

H. Testing:
1. Use the following procedure to test and hydrate the systems:
2. Isolate any elements which would be damaged by test pressures.
3. Test system with trace gas using an appropriate leak detector.
4. Pressure Test - System shall hold 150 psi nitrogen charge for a 24-hour period.
5. Repair or replace leaking elements of system and re-test.
6. After system has been proven to be free of leaks, evacuate it with a high efficiency vacuum pump to 2.5 mm of mercury absolute.
7. Evacuation - System shall be evacuated to 250 microns, and inspected by a University HVAC representative.
8. Break the final vacuum by charging with the correct refrigerant.

3.4 TESTING, CLEANING, AND CERTIFICATION

A. Test all piping systems in accordance with tests outlined in individual sections. Provide temporary equipment for testing, including pump and gages. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Test all new piping and parts of existing piping that have been altered extended or repaired. Submit report(s) on the results of each test.

B. Give a minimum of twenty-four hours notice to the Engineer for dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of the University Project Manager or representative of agency having jurisdiction. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.

C. Compressed air tests may be substituted for hydrostatic tests only when ambient conditions or existing building conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing.

D. Remove equipment not able to withstand test procedure during test.

E. For piping, which is to be concealed, piping shall remain uncovered until tests have been completed.

F. Drain test water from piping systems after testing and repair work has been completed.

G. Repair piping systems sections that fail testing, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics or other temporary repair methods.

H. Potable Water Piping System:
1. Cap domestic water piping and subject piping to static water pressure of 50 psig above operating pressures or 150 psig maximum without exceeding pressure rating of piping system materials. Allow the system to remain pressurized for 4 hours. Correct leaks and loss in pressure and retest system.
2. Disinfect all domestic hot and cold water systems upon completion of final piping installation. Following disinfection, flush water from system through its extremities. Continue flushing until samples show quality is comparable with public water supply and complies with requirements of public health authority.

I. Gas Pipe Testing:
1. Test with air, nitrogen, or carbon dioxide.
2. Test piping system with a pressure 1-1/2 times the proposed maximum working pressure, but not less than 3 psig. Test systems having a volume of 10 cubic feet or less for a period of not less than 10 minutes and larger systems for a period of not less than ½ hour for each 500 cubic foot of pipe volume or fraction thereof without showing any drop in pressure.
3. Fully purge gas piping after piping has been checked.

J. Sanitary Sewer Pipe Testing:
1. Test drain, waste, and vent piping on completion of rough in. Close openings in piping system and fill with water to point of overflow but not less than 10 feet of head. Water level must not drop from 15 minutes before inspection starts through completion of inspection. Correct leaks and retest system.

K. Adjusting and Cleaning:
1. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush piping systems with clean water. Inspect each run of each system for completion of joints, supports and accessory items.
2. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.
3. Flush each new extension of existing systems, via hose connections prior to filling. Fill each new extension of existing systems with water that has the proper water treatment chemicals and in the proper quantity prior to connection, or opening valves to the main or existing system. Use chemicals that are compatible with the chemicals in the existing system. Flush each new system with the university representative present. Fill each new system with the proper chemicals, and with the university representative present.

3.5 COMMISSIONING (DEMONSTRATION)
1. Fill system and perform initial chemical treatment.

2. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
3. Before operating the system, perform these steps:
4. Open valves to full open position. Close coil bypass valves.
5. Remove and clean strainers.
6. Check pump for proper rotation and proper wiring.
7. Set automatic fill valves for required system pressure.
8. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
9. Set temperature controls so all coils are calling for full flow.
10. Check operation of automatic bypass valve.
11. Check and set operating temperature of converters and chillers to design requirements.
12. Lubricate motors and bearings.

END OF SECTION 23 20 00