GENERAL:

Hydronic systems included in this document are chilled water, heating hot water, heating hot water via GSHP (MS&T), dual temperature and glycol based systems.

DESIGN GUIDELINES:

Design General

1. Where campus steam is available, heating hot water systems will operate at a maximum of 180°F with a 40°F ΔT temperature difference. Otherwise, heating hot water systems will operate at a maximum of 140°F with a 40°F ΔT or as specified by the campus PM. For Missouri S&T campus heating hot water systems shall be designed for 120°F with a 40°F ΔT in all facilities connected to the ground source heat pump system.

2. Chilled water systems will operate at 45° F with a 15°ΔT temperature difference. See **23 0000 Heating Ventilating and Air-Conditioning (HVAC)** for exceptions.

3. Dual temperature systems will operate between 45° F and 150° F. New systems shall NOT be installed with dual temperature systems.

4. Heat recovery systems operate from 0° F to 95° F depending on applications. Use propylene glycol, ethylene glycol is forbidden.

5. Piping friction, velocity, and sizing shall be in accordance with recommendations found in ASHRAE Fundamentals, Chapter 22, Pipe sizing. Alternatively, a commercial computerized piping design program may be used if approved by the Project Manager.

6. Piping system pressure loss calculations shall include the following considerations:
   - 6.1. Pipe friction based on 10-year-old pipe;
   - 6.2. Fluid properties for Chilled water, Heating hot water or Glycol systems.
   - 6.3. Pressure loss of valves, fittings, and other associated equipment;
   - 6.4. Equipment pressure loss;
   - 6.5. System model should accurately reflect the piping as drawn and intended to be installed. Safety factors should be kept to a minimum of 5% to avoid oversizing pumps which results in poor operating characteristics. Do not use the balance valve to provide excessive throttling as this wastes energy.
   - 6.6. DO NOT use triple duty valves.

7. Ensure construction drawings include details for all the proposed firestopping systems that could be encountered on the project based on the construction type and rating of the assemblies being penetrated. A specific Division 23 firestopping spec can be inserted, or reference related section 078400 for details.

Piping Layouts

1. Piping shall be routed in designated pipe chases and/or above corridor ceilings. Piping above corridor ceilings shall be drawn to scale with pipe insulation shown to assure all services will fit. Piping shall be coordinated with plumbing, electrical and ductwork systems.

2. Provide shutoff valves on chilled water loop supply and return piping inside the building.

3. Provide shutoff valves on supply and return at all pieces of equipment, including pumps, coils, heat exchangers, reheat coils, etc. Provide pressure/temperature ports to be added at the inlet and outlet of each coil. Refer to typical AHU chilled and heating hot water coil piping drawings within Division 23 design guidelines. **Please note:** There are specific requirements for **Missouri S&T's** low temperature heating coils served by the geothermal campus system. Refer to **230000 Heating Ventilating and Air-Condition (HVAC)**, **AHU Preheat Coil Circulating Pump (in Parallel) Detail & Control Valve Sequence of Operation (MS&T)**

4. Provide shutoff valves at each floor and major branches in heating water systems, to minimize the effect of any outages.

5. Locate piping unions on the equipment or branch side of any shutoff valves. Unions on the system side defeat the purpose of the shutoff valve. Grooved couplings act as unions. All control valves shall have unions. (Refer to details referenced in this section).

6. Return Arrangements. The use of automatic balance valves has alleviated many problems in balancing water flow. Therefore, parallel return piping systems are acceptable on all systems.

7. On hot water reheat systems, branch piping shall be taken off the top of each main. This helps prevent accumulation of dirt in terminal devices but, it does require special attention to air venting requirements outlined below.

8. **Pipe Expansion**. Thermal expansion in piping systems shall be evaluated. In general, piping layout, offsets, risers, and changes in direction shall be used to accommodate this expansion. If necessary, expansion loops shall be provided. Expansion joints are not permitted. Design for multi-story HW risers shall accommodate pipe expansion in a vertical direction and shall include provisions to support piping at each floor.

9. **Pipe Anchors**. Pipe anchor locations shall be indicated on contract drawings and located to direct pipe expansion in a known direction.
   9.1. Pipe Supports and hangers. Provide pipe supports per IMC. Additionally, supports shall be located next to all changes in direction, horizontal and vertical. Pipe supports shall be selected for loads and shall consider the amount of thermal expansion at each location.

9.2. When hanging piping to be connected to a base mount pump, spring type hangers shall be used within 10 ft of the pump.

10. **Pipe Penetrations**. All penetrations of foundation walls will be leak proofed.
    10.1. All penetrations will be individual pipes or conduits. Groups of pipes or conduits in a common penetration will not be allowed.
    10.2. Minimum strength of pipe penetrating foundation walls will be equal to Schedule 40.
    10.3. All penetrations will be waterproofed in the following manner:
        10.3.1. For new construction, the foundation wall will have a steel sleeve installed that is 2" larger in diameter than the conduit to be installed. For existing construction, the hole will be core drilled. In multiple duct situations, sufficient space will remain between the penetrations to maintain the structural integrity of the foundation wall.
        10.3.2. Rubber seals, equal to Link-Seal, will be installed in the space between the conduit and the sleeve or drilled hole near the interior surface of the foundation wall and within 2" of the exterior. This dual application shall have the bolts accessible from the interior surface of the foundation wall. (Refer to 336113-CW Pipe Wall Penetration Detail)

11. **Air Vents**. Air vents shall be provided at all system high points. This includes **ALL high points** in both the supply and return piping wherever the piping changes elevations. All air vents in a system shall be manual vents except for an automatic air vent at the air separator. All automatic air vents shall be preceded by a manual ball valve and piped to nearest floor drain.
    11.1. Provide a hose bib connection on all manual air vents.
    11.2. Hot Water Piping to Reheat Coils. Water coils will not perform if there is air in the piping. Ensure that the piping from the main, to the coil, and to the return main is appropriately sloped up and vented to eliminate entrained air that can air lock the flow.

Equipment Selection and Design

1. Pumps
    1.1. Pumps 2 HP and smaller should be inline circulator with flexible couplings. Do not specify direct coupled pumps. Bell and Gossett Series 60 or approved equal.
        1.1.1. Support in-line pumps from adjacent piping. Do not support the pump motor
        1.1.2. Install with pump shaft in horizontal plane.
        1.1.3. Refer to Pump In-Line Detail.
    1.2. All other pumps shall be a base mount, flexible coupled pumps. Pumps may be end suction, horizontal or vertical split case design. Bell and Gossett Series 1510, VSC or HSC. Paco, Armstrong and Peerless are also acceptable.
        1.2.1. All pumps on variable speed drives shall be provided with a TB Woods "Dura-flex" HP rated coupling. Standard rubber couplings are not acceptable. No substitutions are allowed.

1.2.2. Provide a compatible suction diffuser for all end suction pumps. Suction diffusers with grooved end cap shall be Victaulic Series 731-D or equal.
1.2.3. All bearings shall be re-greaseable with L10 = 200,000 hours.
1.2.4. Concrete bases shall be 5X pump weight.
1.2.5. Include the following in the equipment schedule:
1.2.5.1. Tag #
1.2.5.2. Manufacturer and Model #
1.2.5.3. Service
1.2.5.4. Flowrate, GPM
1.2.5.5. Total Head, Ft
1.2.5.6. Impeller size
1.2.5.7. Suction size
1.2.5.8. Disharge Size
1.2.5.9. Suction diffuser
1.2.5.10. Motor data
1.2.6. Provide one pressure gage, piping, and valving to connect between pump suction and discharge to measure ΔP.
1.2.7. Provide an additional tap before the strainer for a pressure gage.
1.2.8. Provide valves and unions or flanges on inlet and outlet piping to equipment to expedite future removal and repairs. Grooved couplings act as unions.
1.2.9. Do not use a Triple Duty Valve. Provide a balance valve on building hot water pumps. No balance valve needed on building chilled water pumps.
1.2.10. Provide strainers on the suction side of the pump.
1.2.11. Do not overestimate the pumping head on the pump. A conservative overestimation of the head can result in the pump delivering more than the required gpm and thereby requiring more horsepower than estimated. Pump shall be selected within 5% of the optimum efficiency point.
1.2.11.1. Specify a pump that is non-overloading.
1.2.11.2. Remove the impeller and machine it to reduce capacity.
1.2.12. Arrange pumps in parallel, i.e., one pump for each boiler, chiller, cooling tower, etc.

2. Heat Exchanger

2.1. Steam-to-water heat exchangers shall be a shell and tube design with removable U-bend tube bundle, steam in shell, water in tubes, equipped with mounting legs. Materials shall be as follows:
2.1.1.Shell: Steel
2.1.2. Tubes: 3/4" O.D. copper
2.1.3. Heads: Cast iron or steel
2.1.4. Tube Sheets: Steel
2.1.5. Tube Supports: Steel
2.2. Heat exchanger construction shall be per ASME for 150 psi design pressure at 375 degrees F (190 degrees C). Vessel shall bear the ASME stamp and have a National Board Number.

2.3. Heat exchanger shall be mounted high enough so that the condensate can be gravity fed to the receiver, but no higher than 7'-0" AFF.
2.4. Include the following in the equipment schedule:
  2.4.1. Water flow
  2.4.2. Inlet water temperature
  2.4.3. Leaving water temperature
  2.4.4. Water pressure head loss
  2.4.5. Inlet steam pressure
  2.4.6. Steam flow
  2.4.7. Trap size and rating
  2.4.8. Shell pressure rating
  2.4.9. Tube bundle pressure rating
  2.4.10. Control Valve (Cv)
  2.4.11. Temperature control scheme (e.g., resetting the water temperature from the outdoor temperature)
2.5. Converters shall be ASME rated and stamped.
2.6. Detail the supports for the converter and the expansion tank. See Figures16 and 17.

3. Expansion Tanks
3.1. Diaphragm (or bladder) type closed expansion tanks shall be installed on all hydronic systems. Design temperature delta T shall be based on 60° entering temperature for heating and heat recovery systems. Chilled water system expansion tanks shall be sized for a 35°ΔT (45°-80°).
3.2. Open expansion tanks located at the system high point are not permitted.
3.3. Required expansion tank pressure shall be included in the schedule.

4. Air and Dirt Separators
4.1. All hydronic hot water and chilled water systems will be equipped with a combination air and dirt separator by Spirotherm or approved equal.
4.2. On chilled water systems, a separator shall be located on the chilled water supply between the building entrance and the building pump. On hot water systems, locate the separator as recommended on the pump suction line.

5. Pressure Relief Valve
5.1. Provide a Relief Valve on Heat exchangers, chilled water and dual temp systems.

6. Automatic Fill
6.1. Do not install automatic fill valves on the chilled water system in a building if it is connected to the chilled water loop unless specifically requested by Campus Facilities.
6.2. Automatic fill valve/regulator shall be installed with backflow preventer suited for the application. A pressure switch or meter should be considered for installation to monitor flow and connected to BAS.
6.3. The fill pressure for the system should be indicated on the drawings.

SPECIFICATION REQUIREMENTS:

The following items should be included in the final specifications:

1. Provide and submit for approval to the owner's representative a Hydrostatic Test Report on hydronic Water Systems.

2. All work shall conform with ANSI B31.9 and International Mechanical Code.

3. Automatic air vents shall be Spirotherm Spirotop Air Release Valve. Size, ½", designed not to leak. Route air vent discharge in ¼" copper tubing to floor drain.

4. Do not use dielectric unions when joining dissimilar metals. Use a dielectric waterway equal to Victaulic or Clearflow. (Refer to 232100 Hydronic Piping di-electric waterway detail).

5. At AHU coil connections, use a dielectric waterway at a copper or red brass connection.

6. Flexible Connectors: Stainless steel, woven braided design. Rubber type connectors are not permitted.

7. Manual Air Vent. See detail providing a ball valve and auto air vent at all locations outlined in piping layouts section above. Reheat coils may be vented by a multi-purpose type valve.

8. Contractor is responsible for the installation of all specialty items specified herein, pressure gauges, thermometers and other items as shown on the contract drawings.

9. Acceptance Testing: Perform hydrostatic tests on the hydronic piping in accordance with ANSI B 31.9 and as follows:
   - 9.1. Notify Owners Representative 24 hours before required testing. All tests shall be conducted in the presence of the Owners Representative.
   - 9.2. 8.2 Flush system with clean water. Clean strainers.
   - 9.3. 8.3 Minimum test pressure shall be 100 PSIG.
   - 9.4. 8.4 Pressure gauge shall be min 4" diameter face, 0-160 PSIG, and shall be calibrated within 1 year of test date.
   - 9.5. Test pressure shall be held for 1 hour.
   - 9.6. Prepare reports for all tests and required corrective action.
   - 9.7. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
   - 9.8. System shall be operated for a minimum of 24 hours to demonstrate to the Owner's Representative that system is complete and operational.

10. The following tables:

PIPING for HYDRONIC SYSTEMS

ITEM	SIZE	DESCRIPTION
Pipe	All Sizes	Carbon steel, SCH 40, ASTM A53, Gr B.
	2" and Smaller	Copper, type K or type L, ASTM B88.
Fittings	2" and Smaller	Malleable iron, 150 pound Threaded, per ANSI B16.3
	2" and Smaller	Copper, solder joint per ANSI B16.22.
	2” and Smaller	Copper and copper alloy **press sealed fittings** of the double pressed type complying with ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements shall be EPDM and factory installed. Viega, Mueller or approved equal.
Fittings	2 1/2" and Larger	Carbon steel, buttweld type, long radius, SCH 40. Per ANSI B16.9.
Grooved	2” and Larger	Couplings and Fittings, ductile iron ASTM A-536 Grade 65-45-12. Victaulic or equal and per notes 4.1- 4.3.
Unions	2" and Smaller	Malleable iron, Class 150 hexagonal stock with ball-and socket joints, bronze seating, ANSI B16.39
	2" and Smaller	Bronze for copper pipe.
Flanges	2 1/2" and Larger	Forged steel, Class 150, Slip-on or grooved flange adapter, per ANSI 16.5

Notes:

1. Branch connections shall be made with approved fittings (straight tees, reducing tees, threadolets, or weldolets). Fish mouths and pulled tees are not acceptable and shall be excluded in the specifications.

2. Tap side of weldolet or threadolet to be no more than 1/3 of the size of the tapped pipe.

3. Flanges shall be flat face when mating with 125# class cast iron valves.

4. GROOVED MECHANICAL JOINTS for HYDRONIC SYSTEMS as an option to welded or threaded pipe.
   4.1. Grooved couplings are allowed in mechanical rooms. Grooved mechanical couplings and valves shall **not** be used on Residential Housing facilities.
   4.2. Grooved mechanical couplings 2”-12” shall achieve rigidity by way of an offsetting angled bolt-pad in accordance with ASME B31.1, B31.3, B31.9 and require visual verification *only* of correct installation in accordance with these standards. Couplings with a minimum bolt torque setting will not be accepted. Couplings shall be installation-ready, with no loose parts or requirement to be disassembled for installation. Standard of acceptance: Victaulic Style 107N Rigid Coupling.
   4.3. Grooved mechanical couplings 14” and greater shall be rigid in accordance with ASME B31.1, B31.3, B31.9 and specifically designed as an advance groove

system for large diameter services based on the following features: an extended "A" dimension (pipe end to groove) for wider gasket seating area, a wedge shaped groove for ease of coupling installation and alignment. Couplings 14" and greater shall be comprised of two housing segments. Multi-segmented couplings (3+ housing segments) will not be accepted. Standard of acceptance: Victaulic Style W07 Rigid Coupling.

4.4. For large projects, the engineering consultant and/or the campus PM may want to specify enhanced tooling requirements as follows:

4.4.1. Grooved pipe shall be produced using a Victaulic fully automated (RG5200i) grooving tool with touch screen controls and integral laser sensors. Tools provide traceable measurements that can be recorded locally or exported as required. Measurements include groove traceability documents, corresponding identification marks on the pipe, and confirm all critical dimensions fall into the required tolerance range as listed by the tool manufacturer for each groove. Validation records provided for the gasket sealing surface, groove width, groove diameter, pipe flare, and pipe OD.

5. MECHANICAL PRESS SEALED FITTINGS for HYDRONIC SYSTEMS as an option to soldered copper joints.
   5.1. Specify installers to be qualified and familiar in the installation of copper press sealed fittings of the double press type.
   5.2. Installer shall use the proper tool, actuator, jaws and rings as instructed by the press fitting manufacturer's requirements.
   5.3. The installation shall be appropriate for use with copper tubing in hydronic systems conforming to the International Mechanical Code and ASME B31.9 for building services piping valves.

VALVES for HYDRONIC SYSTEM

ITEM	SIZE	DESCRIPTION
Ball	2" and Smaller	Threaded or soldered, brass / bronze, 150 lb. 2 piece design, full port. Victaulic 722, Nibco, or equal.
Ball	2" and Smaller	Press connection with EPDM sealing element, brass / bronze, full port, non-potable application. Viega 2973, or equal.
Butterfly	2 1/2" to 12"	Cast iron, Threaded Lug type, EPDM seats, Aluminum bronze disc, 200 PSIG WOG, 316SS stem and TFE bushings. Gear operators for 6" and larger. Grinnel or equal.
Butterfly	2" and Larger	Cast ductile iron, grooved ends, EPDM seat, off-set electroless-nickle fusion bonded DI disc,

		300 PSI bubble tight dead-end service, 316SS stem, Victaulic Series 761 / W761 or equal.
Check	2" and Smaller	Threaded, bronze, 150 lb., horizontal swing. Nibco or equal.
Check	2 1/2" to 8"	Flanged, cast iron, 125 lb., bolted bonnet, horizontal swing, bronze trim. Nibco or equal.
Check	2" and Larger	Grooved, cast ductile iron, 300 PSI, horizontal or vertical swing, brass / SS trim. Victaulic Series 716 / W716 / 779 or equal.
Check	All sizes	Wafer Check, Lug style, split disc. 125 lb.
Strainer	2" and Smaller	Threaded, cast iron, 250 lb., 20 mesh stainless steel screen. Hoffman or equal.
Strainer	2 1/2" to 12"	Flanged, cast iron 125 lb., .045" perforated S.S. screen. Hoffman or equal.
Strainer	2" and Larger	Grooved, cast ductile iron, 300 PSI, SS 304 screen, Victaulic Series 732 / W732 or equal.
Balance Valves:		Bell and Gossett CBV, Tour & Andersson or Armstrong – Flow Setter ΔP type.
Auto Balance Valves:		Bell & Gossett, Flow Design, Tour & Andersson or Griswold with removable/adjustable cartridge
Pressure Independent Control Valves:		PICV's at all coils (except pumped coils). Delta P, Belimo P Series, Danfoss AB-QM Series.

Notes:

1. Be clear whether PICV's or Auto Balance Valves are specified and detailed. Do NOT include both in the specifications or details. Refer to coil piping details referenced at the end of this section and the requirements of these UM Design Guidelines.

REFERENCES

230000 Heating Ventilating and Air-Condition (HVAC)

Details on UM FPD website for design guidelines:

- 237000 AHU Chilled Water Coil Piping Detail
- AHU Hot Water Preheat Coil Piping
- AHU Preheat Coil Circulating Pump (in Parallel) Detail & Control Valve Sequence of Operation (MS&T) (*New*)
- AHU Hot Water Heating Coil Piping
- Pump in-line Detail
- 232100 Di-electric Waterway Construction Detail