Modify *subsection .01 in Section 23 21 00* per the following (deletions are shown struck through and additions are double underlined).
Remove existing Subsection .01 and replace with new in its entirety.
Retain text from Subsection .02.
Add new text in subsections .03, .04, and .05.
Add Subsection .06 and relocate text from existing Section 23 21 13, Subsection .08.

23 21 00 HYDRONIC SYSTEMS

.01 Hydronic Systems (General)

A. Follow Bell and Gossett guidelines for air separation. Use an air separator, with an automatic air vent, on the suction side of the pump. Pump away from converter. Manual vents are standard but automatic vents will be considered in special situations and locations. Where vent location is high or otherwise inaccessible, install valve at vent chamber, then extend 3/8" tubing to nearest janitor sink or mechanical room floor drain and terminate with ball valve. Use automatic water feed set to maintain proper system pressure. Add cold water make-up at air vent line above air separator.

B. Ethylene Glycol systems shall be considered when outside air at a temperature below 20 degrees exceeds 50% of the total air stream. However, the professional shall not specify Ethylene Glycol systems until specifically approved by the University. See 23 25 00 for more information.

C. All hot and chilled water systems shall be chemically cleaned after all items of equipment have been connected to the system and all piping has been completed. Cleaning shall be done prior to installing chemical treatment or glycol, and prior to acceptance by the University. See 23 25 00 for more information:

    1. Notify the University at least one week in advance of the date and time that system cleaning is to take place. The University shall observe the system cleaning process.

D. All air handling and terminal unit coils shall be provided with flow measuring devices.

E. Reduced pressure principal back flow preventers shall be installed on all make-up water lines.

.01 General Requirements and Design Intent

A. Summary: Section includes basic design requirements for hydronic heating and cooling systems in HVAC applications.

B. General: Professional shall design each hydronic system for optimal operating efficiency throughout capacity range, reliability, flexibility, and ease of maintenance with the lowest life cycle cost.

1. Comply with 23 00 01 Owner General Requirements and Design Intent.

2. ASHRAE/IESNA Compliance: Comply with applicable high-performance building requirements in ASHRAE/IESNA 90.1 or ASHRAE 189.1 per 01 81 13 Sustainable Design Requirements.

3. Follow the Hydronic Heating and Cooling System Design guidelines in current edition in current edition of ASHRAE Systems and Equipment Handbook.

4. Strive to keep systems simple to understand and operate.

C. Systems Design Criteria:

1. Design for low flow, high temperature differences and variable flow distribution systems to minimize pump energy.

2. Selection of cooling coils in typical HVAC applications is recommended with a minimum 14-16°F rise at peak conditions.

3. Terminals shall be “right-sized” for both part load and partial load performance.

4. Minimum full load design flow at any terminal device shall not be less than 0.5 gpm for effective flow measurement and heat transfer.

D. Shut-Off Valves: Design and indicate positive shut-off valves throughout the distribution piping system to facilitate shutdown and draining of smallest segment as practical for repairs while keeping the rest of the system operational.

1. Clearly show locations of all shut-off valves on construction drawings to be able to properly isolate the systems for service.

2. Locations: Shutoff valves shall be installed at:

   a. All locations required by the current building Mechanical Code.

   b. Each piece of central or terminal equipment. All valves shall be installed such that valve remains in service without shutting down system when downstream piping or equipment is removed for service, alterations or repairs. Provide arrangement of unions or flanges and removable sections of pipe at final equipment connections to allow easy dismantling and pulling of associated equipment past remaining pipe assemblies without cutting pipe or breaking sweat or press-joint fitting connections.

c. Secondary / tertiary loops off of primary/secondary piping systems.

d. Pipe mains at points exiting mechanical rooms, located accessibly within the mechanical room.

e. Any pipes at points exiting the building or running under slab or underground, located accessibly within the building interior.

f. Base of each riser

g. Each horizontal branch takeoff of each riser

h. Each branch takeoff serving groups of multiple terminals arranged to create hydronic modules to achieve strategically divided sections that can be isolated for service, modifications, and troubleshooting while the rest of system can remain in service.

i. Main or branch strainers or filters (on entering and leaving sides to allow for pulling screen).

j. Any thermal control zone, (i.e. perimeter finned tube zones controlled by exterior orientation0).

k. Any 3 valve bypass around devices as required maintaining continuous flow for critical applications while servicing device.

l. Tees for future connections. Review with OPP – in some cases valves might be unnecessary and/or undesirable.

m. Pipe expansion compensating devices that would otherwise require extraordinary effort for system shutdown and drainage to be able to service or replace. Review with OPP.

3. Refer to section on Shut-Off Valves for types.

E. Bypasses:

1. Three valve bypasses shall be installed around control valves and pressure-reducing stations serving critical areas. Areas deemed to be critical shall be reviewed with the Project Manager. No other equipment is to be provided with a bypass unless approved by the Project Manager.

2. In all applications, use ball valves for shut-off purposes and globe valves for throttling purposes in the bypass line.

a. Gate valves may be used for shut-off purposes in large line sizes.

b. Ball valves equipped with “characterizing discs” may be used for throttling purposes in lieu of globe valves.

F. Freeze Protection:

1. Hydronic systems subject to freezing conditions shall be protected with separate piping loops with antifreeze solution, heat exchangers, pumps, expansion tanks, as required to prevent freezing in the event of extended electrical power outage and to minimize and isolate portions of systems requiring antifreeze from the main hot and chilled water loops.

2. Glycol anti-freeze systems shall be considered when outside air at a temperature below 20 degrees exceeds 50% of the total air stream. However, the professional shall not specify Glycol systems until specifically approved by the University.

3. See 23 25 00 for more information.

.02 Flow Balance and Differential Pressure Control

(Editor Note: Retain existing text from Subsection .02 in its entirety)

.03 Air and Dirt Elimination

A. All closed loop hydronic systems shall have effective means for elimination of air and dirt that are safe and convenient to access and service.

B. Primary air eliminator shall be located at the point of lowest solubility in the system main, that being where the pressure is the lowest (on suction side of main pumps) and the temperature is the highest.

C. Primary dirt separation on discharge side of main pumps is best. That will allow constant blowdown through a side-stream bag filter using pump pressure.

D. For primary air eliminator and dirt separator, refer to **23 21 16 Hydronic Piping Specialties**.

E. Manual vents shall be installed at high points to remove all air trapped during initial operation. Manual vents are standard but automatic vents will be considered in special situations and locations. Shutoff valves should be installed on any automatic air removal device to allow servicing without draining the system. Where vent location is high or otherwise inaccessible, install valve at vent chamber, then extend 3/8" tubing to nearest janitor sink or mechanical room floor drain and terminate with ball valve.

F. If pumps and primary air/dirt eliminators are not at the bottom of the system, provide additional dirt separator(s) as required to collect and remove sediment at the bottom of the system.

G. System Cleaning and Flushing Bypass assemblies:

1. Provide bypass valve and piping assemblies at all central plant heating and cooling sources and at all distribution terminal units. The purpose is to be able to isolate all equipment and bypass around it to prevent circulating dirt through equipment strainers, control valves or heat transfer surfaces while performing main piping system cleaning and flushing.

2. Bypasses shall be of adequate size to achieve the minimum velocities required to effectively clean and flush system mains and branches out to each piece of equipment.

3. Provide bypasses at ends of main risers and branches as required on new or existing systems to achieve the minimum velocities required to effectively clean and flush system main risers and branches without having to rely on flows through small runout branches.

.04 Hydronic Plant Design

A. Makeup Water Systems:

1. Use automatic makeup assembly to maintain positive pressure at the highest point of at least 4 psig for system operating temperatures up to 210°F.

   a. Exception: Cold water make-up piping is not to be directly connected to any system that utilizes glycol. Refer to 23 25 00 HVAC WATER TREATMENT for mix and fill tank assembly for automatic makeup in lieu of direct makeup water connections on glycol systems.

2. Reduced pressure principal back flow preventers shall be installed on all make-up water lines.

3. Make-up water connection shall be located along with the expansion tank at the point of no pressure change and pumps shall pump away from that point. Keep pressure drop low between pump suction and make-up water/expansion tank connection location.

4. Install water meter on makeup water lines. Tracking makeup water use is needed to correctly maintain chemical levels and to detect leaks. If project budget permits, the meter should include transmitter and be connected to the building BAS / campus CCS system to monitor readings and alarm abnormal conditions.

B. Primary Heating and Cooling Production Equipment:

1. Ensure primary production equipment is circuited and piping system is arranged to achieve maximum efficiency.

2. Ensure the manufacturer's recommended range of water flow through equipment is maintained.

3. Connect piping so that all return water and any water from a bypass are thoroughly mixed before any of the water enters production equipment. After the tee, there should be at least 10 pipe diameters to the nearest unit. This is to help avoid the possibility of having stratification in the primary return line, which can lead to unmixed water to the nearest unit. This can lead to control cycling.

4. Arrange piping such that all production equipment obtains equal return water temperature.

   a. Exception: in systems where "backloading" or "preferential" loading of chillers is advantageous by design to maximize the operating performance of different types of chillers.

C. Pumping Arrangement and Configuration:

1. General: Refer to 23 21 23 HVAC Pumps.

2. Chilled and Condenser Water Systems:

   a. In general, arrange pump assemblies to pump into chilled water heat exchangers, chiller evaporators, and condenser bundles.

   b. Locating the chilled water pump and associated air separator on the building chilled water return provides the warmest temperature along with the lowest pressure for most effective air removal. This location also helps to minimize potential pump cavitation problems resulting from pressure buildups in fouled strainers or heat exchangers.

3. Hot Water Systems:

   a. In general, arrange pump assemblies to pump away from low pressure, low temperature heating sources (low pressure boilers or gasketed-plate water to water heat exchangers).

   b. Locating the hot water pump and associated air separator on the leaving side of the heat source provides the warmest temperature along with the lowest pressure for most effective air removal.

c. However, specify pump construction and seals to be rated for a minimum of 250°F to improve the longevity of the useful life at higher operating temperatures.

d. Provide strainer on return of each heat sources to prevent system dirt from collecting in low velocity inner heat transfer surfaces of heating equipment. Also, a sediment dirt leg with blow down valve is recommended as near to inlet as possible (local low point).

e. Steam to hot water heat exchanger systems:

1) Controls on steam heat exchangers have a higher risk of routinely overshooting supply water setpoint. By placing the pumps on the return side, the advantage is that lower operating temperatures on the pumps will better ensure and enable longer useful life on pump internals such as seals.

2) The difference in solubility of air in water due to the entering hot water return temperature vs. leaving supply temperature is relatively minor with respect to the difference due to pump pressure differential. With the air removed by the air separator on the suction side of the pump (lowest pressure point), the solubility after the pump will be much higher so air will not come out of solution as it is heated going through the heat exchanger.

3) Pumping into heat exchangers also allows the pump strainer and system dirt eliminator to be before the heat source to better protect it without having to add an additional strainer.

D. Primary-secondary systems:

1. The system must be piped and controlled so that water never flows in the reverse direction in the decoupler bypass during normal operation.

2. The supply tee connecting the building supply distribution loop to the primary loop shall be arranged such that the secondary loop is the side branch and the bypass is the straight through direction. This directs the primary loop water's energy into the decoupler bypass and requires the secondary loop to pull the water out of the tee.

3. The return tee connecting the secondary return loop to the primary return shall be arranged such that the bypass is the side branch and the secondary return to the primary return loop is the straight through direction.

4. The secondary loop return must not be connected too closely to the supply pipe with a bullhead tee in which the velocity head rams into the decoupler bypass which can encourage migration.

5. Although in theory there should be no pressure drop in the decoupler, in order to avoid thermal contamination in actual systems the decoupler should be at least 10 pipe diameters in length (per ASHRAE Systems Handbook). Longer decouplers tend to increase the pressure drop.

6. Size decouplers for the flow rate of the largest primary pump. This may be more than the design flow rate of the largest individual piece of production equipment if overpumping is being considered. The pressure drop should not exceed 1.5 ft. As the pressure drop through the decoupler increases, it tends to make the primary and secondary pumps behave like they are in series.

.05 Building Automation System Performance Monitoring

A. Return Water Temperature – Heat Transfer: Provide return water temperature transmitters at individual terminals and in main building return to continuously monitor heat transfer performance and alarm abnormal conditions when adequate temperature differential is not maintained.

B. Energy Consumption of Water Distribution: Provide flow, temperature difference and watt transmitters to measure operating parameters, programming and trending/reporting to continuously monitor pumping system effectiveness through the BAS and alarm abnormal conditions. Include pump system efficiency ratios based on system type (such as kW/100 tons for chilled water and kW/1000 MBH for hot water).

.06 Ground-Coupled Heat Pump Well Field Systems

A. The University encourages the use and application of equipment that reduce the energy consumption of building systems. However, the installation of ground-coupled or geothermal wells have groundwater contamination risks that must be addressed prior to design of any geothermal or ground-coupled systems.

B. Prior to the start of design, the Design Professional shall review any proposed geothermal or ground-coupled systems at any University location with the Office of Physical Plant, Engineering Services and obtain written consent to proceed prior to any further design development or installation. No geothermal or ground-coupled systems shall be installed at any University location without written approval of the Office of Physical Plant, Engineering Services.

C. Where approved, well systems shall be designed and constructed in accordance with 23 81 00.03 and 33 20 00.

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) *To remove reference to Bell and Gossett guidelines with respect to air separators. Air eliminators are now covered in greater detail in Hydronic Specialties.*
2) *To add guidelines and requirements for the basic design of hydronic systems.*
3) *To remove reference to “ethylene” glycol since other types might be used.*
4) *To remove reference to flow measuring devices, which are covered more in depth in subsection .02 of section 23 2100.*
5) *To consolidate and relocate various references from Section 23 21 13 Hydronic Piping into this more general design guideline for Hydronic Systems.*