Modify *Section 23 21 00 by adding subsection .02* per the following. Remainder of section is unchanged.

23 21 00 HYDRONIC PIPING AND PUMPS

.02 Flow Balance and Differential Pressure Control

A. General: Professional shall design the layout and components of each hydronic distribution system to deliver the specified comfort level using minimal energy with optimal operating stability, serviceability, and future flexibility with the lowest life cycle cost.

1. To enable systematic balancing with absolute minimum pressure drop result, distribution piping must be subdivided into hydronic modules within a hierarchical tree.

2. At any node between multiple units, consider the direction of the larger flow and place a flow balancing / DP control device on the lower flow side.

3. Do not use multiple self-regulating DP controllers in series. For example, do not use a DP controller at a main, riser, or branch and then also use a pressure independent control valve at individual terminals.

B. Isolation and Flow Measurement: In all hydronic systems, provide isolation and flow measuring devices as required for service isolation and to ensure design flow at heat transfer equipment with the minimum amount of system pressure drop.

1. Combination Isolation/balance valve: Hydronic heating or cooling equipment connections shall have a combination ball or butterfly isolation valve for service with high signal, low-loss, fixed orifice venturi flow measuring device with P/T ports for diagnostics.

a. Acceptable Manufacturers:

1) FlowDesign "Flowset"

2) Hydronic Components Inc. (HCi) “Terminator B”

3) Nexus manual flow control valves

4) Taco "Accu-Flo"

b. Globe style manual balance valves with high pressure loss, variable orifice for flow measurement are prohibited.

2. Constant flow applications:

a. Generally use only for smallest systems (under 300,000 Btu/h output capacity) – verify and conform to most stringent of current Energy Conservation Code, ASHRAE 90.1 and ASHRAE 189.1 High Performance Building Standard.

1) Exceptions: Limited modifications to existing systems. Review with OPP.

b. The Isolation/balance valves shall be:

1) Throttled as little as possible.

2) Always fully open at terminals at ends of hydronic modules.

c. Consider potential for future conversion to variable flow systems if part of a larger facility. Include provisions for main, riser or branch Adjustable Self-acting Differential Pressure Controllers as discussed in variable flow systems below.

3. Variable flow applications:

a. Generally use on most systems to minimize energy usage.

b. The Isolation/balance valves are intended primarily for isolation and flow diagnostics. They shall be:

1) Fully open, except for very minor balancing of a group of terminals in a balancing "module" downstream of a shared dynamic pressure independent control device.

2) Always fully open at terminals at ends of hydronic modules.

3) Used on individual coil modules in stacked coil configurations for flow equalization to each coil. One in common to all the coils is not required for total flow measurement.

C. Differential Pressure Control: Maintain differential pressure within acceptable range to achieve stable operation of automatic control valves in most energy-efficient and lowest-life cycle cost effective manner.

1. Control valves of circuits subject to high pressure differentials and thus susceptible to overflow will tend to short cycle. This dramatically reduces their actuator life. Therefore differential pressure across control valves must not vary too much.

2. Avoid cavitation: Ensure control valves are selected to avoid cavitation due to combination of low static pressure in the system, large pressure drop across valve, high fluid temperature and/or poor valve design.

a. Cavitation causes vibrations in the valve, wears down cone and valve seat in a very short time.

b. Rule of thumb to prevent cavitation at control valves: Static pressure at valve inlet > 2 times pressure drop across control valve.

3. Maintain superior control valve authority range for stable operation, close temperature control, and actuator longevity.

   a. Control valve authority: a ratio that indicates the relationship of the pressure drop of the fully open control valve at design flow vs. the overall differential pressure in the system at that point with the control valve fully shut. Its value indicates how effectively the control valve can reduce the flow while it is closing. The lower the authority, the larger the pressure differential variations on the control valve and the larger the distortion of the valve control characteristics.

      1) In a variable flow distribution, the authority of the control valve is variable. Therefore dynamic differential pressure stabilization may be required depending on the system operating characteristics.

      2) Evaluate differential pressures throughout hydronic system between minimum and maximum operating ranges. To achieve good control performance, select control valve and DP control device to ensure design control valve authority of at greater than or equal to 0.5, and minimum authority of at no less than 0.25.

4. Strategically locate self-regulating differential pressure controllers throughout distribution system, only as needed, to stabilize wide variations in differential pressure. Determine the most cost effective combination that will ensure recommended control valve authority at all operating conditions. Depending on size and complexity of system, various pressure independent control components may be applied:

   a. On large mains or risers (greater than approximately 220 gpm):

      1) Adjustable Self-acting Differential Pressure Controller: Similar to:

         a) Tour Andersson DA 50 Series

      2) Combine with manual balance valves for terminals downstream.

   b. On Branches serving multiple similar terminals (up to total of approximately 220 gpm):

      1) Adjustable Self-acting Differential Pressure Controller: Similar to:

         a) Flow Design DA516

b) Tour Andersson DA516

2) Combine with manual balance valves for terminals downstream.

c. On smaller individual terminals (up to approximately 100 gpm, 2" and under):

1) Pressure Independent Characterized Control Valves (PICCV).

a) For specifications and acceptable manufacturers, see Div 25 - Building Automation Systems (BAS) Guidespec.

b) For selection criteria, see Div 25 - Pressure Independent Control Valve Selection

c) These combination valves are more costly than regular characterized control valves and are not needed at the more hydraulically remote parts of system. Use them strategically only as needed to maintain control authority criteria based on careful analysis of anticipated pressure differentials throughout the system.

d) Control valves must be characterized ball type. Globe style control valves are not permitted.

d. On larger individual terminals (greater than approximately 100 gpm):

1) Adjustable Self-acting Differential Pressure Controller same as above for DP stabilization, with separate regular characterized control valve. See Div 25 Building Automation Systems (BAS) Guidespec for control valve. Or,

2) No more than 2 paralleled PICCVs (for up to approximately 200 gpm). Or

3) Medium or Large Pressure Independent Control valves with internal mechanical pressure regulator in addition to the characterized disk control valve. Similar to:

a) Flow Control Industries, DeltaPValve.

b) These combination valves are more costly than regular characterized control valves and are not needed at the more hydraulically remote parts of system. Use them strategically only as needed to maintain control authority criteria based on careful analysis of anticipated pressure differentials throughout the system.

4) Valves using flow sensors controls to reposition the characterized ball or disk without a mechanical pressure regulator are not acceptable.

D. Maintain proper balance of flows in primary (production) loops vs. secondary (distribution) loops.

1. Correct Method: When using primary/secondary pumping, ALWAYS ensure secondary loops are designed, balanced and controlled to have less flow than primary to avoid mixing of secondary return with primary supply and thus secondary supply temperature degradation.

2. Ineffective methods:

a. Increasing secondary flow beyond primary only increases the flow imbalance and therefore mixing worsens making the condition worse.

b. Producing colder primary chilled water or warmer hot water can compensate only a little but at a higher energy cost. Mixing will still occur, only shifted slightly.

E. Miscellaneous Coordination:

1. Minimize pump energy with Optimized pump DP reset based on terminal heating/cooling requests. Coordinate with BAS sequence of operations.

a. Locate system remote DP sensor on the most probable index branch/circuit, prior to any self-regulating DP controller or PICCV.

b. Never place remote DP sensor for pump speed control downstream of any self-regulating DP controllers or PICCVs in the system.

2. Ensure each control valve/actuator combination has sufficient close-off pressure rating for application within distribution system.

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) *To provide guidelines for application of manual isolation/balance valves and differential pressure regulating valves and proper primary/secondary flow balance for improved hydronic system operation and control.*