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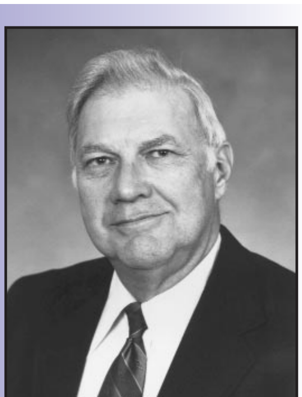

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Selecting Valves and Piping Coils

Selecting Valves: When the design of variable flow hydronic systems was initiated 30-40 years ago, very little emphasis was placed on the selection of the modulating two-way coil control valves. The existing valve specifications that were used for constant flow were often applied to variable flow systems. In many instances the valves that were used were not constructed to meet the high differential pressures encountered in variable flow systems. As a result many variable flow chilled water systems experience ΔT's that are below design and have chillers that operate inefficiently. This low ΔT is often caused by valves leaking due to either insufficient close off capabilities or erosion (often referred to as "wire drawing") of the seat or plug.

The globe type control valve commonly used in HVAC systems has three pressure ratings: the body static pressure rating, generally 250 psig; a close-off rating based on the power of the actuator; and a dynamic rating, which is defined as the maximum differential that the wetted parts will withstand. It is this last rating that is often inappropriately ignored when selecting valves for variable flow systems.

The present method of rating two-way valves may be confusing. The close-off rating is often many times the dynamic rating. The manufacturer's valve selection chart can show a high close-off rating when a large actuator is used. It is generally assumed that this is also the dynamic rating. For example the selection chart may list a valve with a large actuator as having a close-off rating of 120 psi, but a footnote may specify a "maximum flow differential of 25 psi for normal seat and disc life." The 25 psi is the dynamic rating of the valve body. This valve would have a short life if it were installed in a system where the dynamic requirements, that are found in many large chilled water systems, approached the close-off rating.

In Figure #1, the differential pressure sensor DP controlling the speed of the secondary pump P-5 is set at 30 feet. This is the differential pressure required to satisfy the branch with the highest pressure drop at design flow. It may be any one of the six branches serving the six coils. The setting on the differential pressure sensor DP must be determined when the system is commissioned by the test and balance agency. Just setting the differential pressure sensor at a "nominal" setting can waste pump energy for the

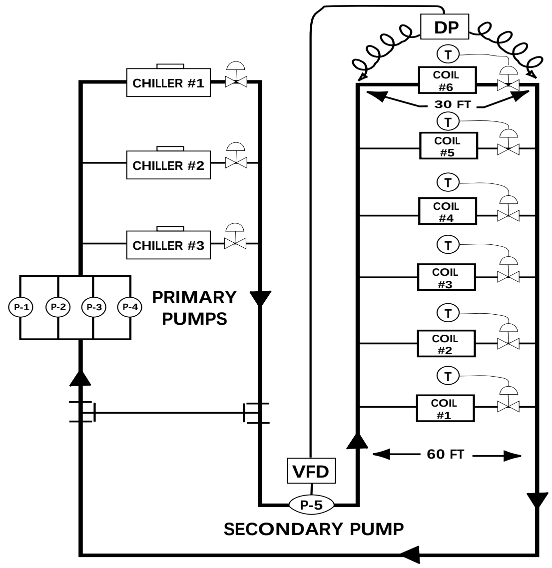


Figure 1

DIRECT RETURN PRIMARY-SECONDARY CHILLED WATER SYSTEM

life of a building.

The drop across the branches varies from 30 feet up to 60 feet at design flow, but the minimum differential pressure across any branch can be 30 feet at reduced flow. At system design flow, the drop across the branch serving coil #1 is 60 feet. If the load changes and all the other coil valves are closed, the drop across this branch will be only 30 feet. There is no flow in the mains between coil #1 and #6 and therefore no drop. The ΔP across the branch serving coil #1 is now the same as across differential pressure sensor DP. The control valves are selected so that the drop across the valve is as much as the total drop across the other components in the branch. In this example all valves should be selected for a drop of 15 feet.

The valve serving coil #1 will normally operate with a differential across the valve of 60 feet or less, depending on the load (flow) in the mains. If either the differential pressure sensor or the VFD malfunctioned and pump P-5 is operated on a full speed back-up across-the-line contactor, the differential pressure across any valve could be as high as the pump cut-off head. A good rule of thumb is to select valves with a close-off and dynamic rating of at least 1 1/2 times the pump design operating head; in this example, 90 feet. Pump cut-off head can occur across any valve during emergency operating conditions and therefore all coil valves in the system must be selected for this differential. Industrial type valves may be required on large complexes with high head pumps and long pipe runs. When pneumatic valve actuators are used and normally closed or normally open valves are an option then use normally open to take advantage of the higher close-off force that is available with this arrangement. The normally open valve uses the greater force of the actuator to seat the valve plug. The normally closed valve utilizes the lower force of the spring to seat the plug.

Piping Water Coils: Two-way valves for chilled and hot water variable flow systems may be installed on either the supply or return side of the coil. The valves will be subject to less extreme temperature operating conditions if they are installed on the return side as shown in Figure 2. In this location the valves handle the less severe chilled and hot return water temperatures. Many valves incorporate electronics in the valve actuator. Chilled water valves installed on the coil return side reduce the risk of moisture condensing in the actuator and hot water valves installed on the coil return side have a lower ambient operating temperature.

Three-way mixing valves in constant flow systems are installed as shown in Figure 3. Two balance valves are normally required; BV-1 to balance the branch for design flow through the coil when port 'B' is wide open, and BV-2 to balance the flow through the bypass when port 'A' is wide open so that the bypass flow is the same as the coil flow.

Piping coils as shown in Figure 4 and 5 will insure against freezing under almost any operating condition. The coil pump can be selected to maintain a constant and higher tube velocity and for a lower ΔT than a coil without a pump. For example, when the primary (main) hot water supply is 200°F, and the return temperature is 160°F (40°ΔT), the coils can be selected for a 10°F ΔT to insure high flow through the coil at all times.

A flow switch in the coil piping circuit may be used to stop the air handling unit and close the outdoor air damper if a low-flow condition occurs and the outdoor temperature is below freezing. This configuration can be used to protect chilled water as well as hot water coils.

The following equation can be used to determine the coil entering water temperature when dedicated coil pumps are used.

R_f = coil flow ÷ primary branch flow.
Tce = Temperature water entering coil.
Ts = Primary water supply temperature.
Tr = Return water temperature.
Tce = Tr + (Ts-Tr) ÷ Rf

Example: Ts = 200°F: Tr = 160°F: Rf = 4

Tce = 160 + (200-160) ÷ 4 = 170°F

In this example, the coil should be selected to handle the load with water entering at 170°F and leaving at 160°F. Sizing the main hot water system for a 40°F ΔT or higher will reduce the installed cost and water transport energy.

The dedicated coil pump not only minimizes the freezing problem but it provides a linear heat transfer with primary water flow as shown in Figure 6. Without the pump, the coil flow is varied with the load. This produces a very non-linear heat transfer with coil flow as shown in Figure 7. If the coil flow is one-half of design, the water in the coil stays in the coil twice as long and the heat transfer is reduced very little. With the dedicated coil pump, the water temperature to the coil is varied and the coil flow is constant. This pro-

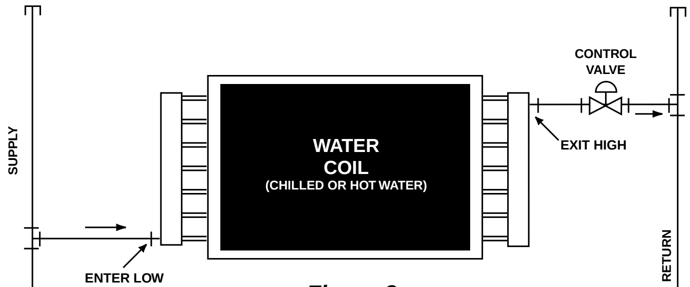


Figure 2

WATER COIL PIPING FOR VARIABLE FLOW SYSTEM

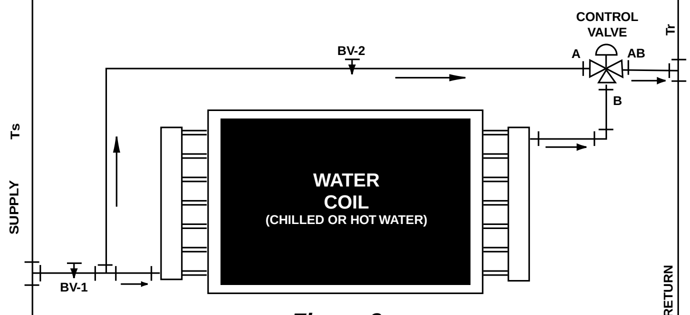


Figure 3

PIPING FOR CONSTANT FLOW SYSTEM

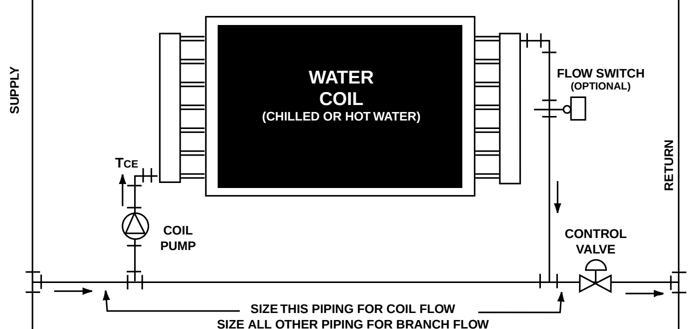


Figure 4

PIPING FOR VARIABLE BRANCH FLOW - CONSTANT COIL FLOW

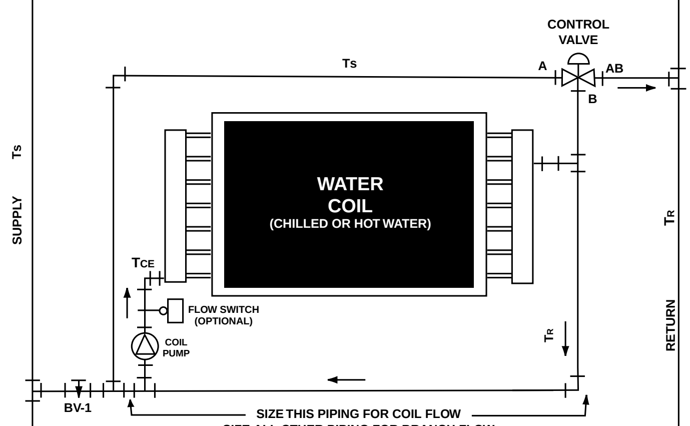
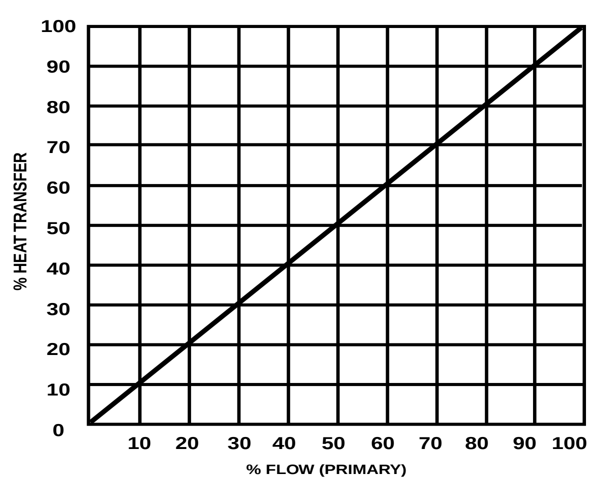


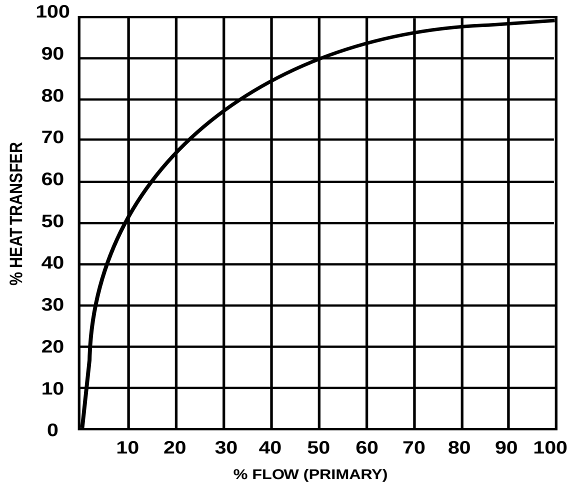
Figure 5

PIPING FOR CONSTANT BRANCH FLOW CONSTANT COIL FLOW



CONSTANT FLOW COIL

Figure 6



VARIABLE FLOW COIL

Figure 7

duces an almost linear heat transfer with primary flow from the main. This helps stabilize the control system.

All piping in the coil pump loop should be sized for the coil flow as shown in Figures 4 & 5. All control valves are sized for the primary flow.

The system pump head should not include the drop through the coil. This drop is handled by the coil pump. The only branch head, handled by the system pump, is for the control valve and branch piping to the coil pump loop.

Piping Steam Coils: To minimize the freezing of steam coils and to eliminate water hammer in low pressure steam systems, steam coils must be piped so that the flow of steam condensate out of the coil is not inhibited in any manner. When the heat output from the steam coil is controlled by a modulating steam valve, as shown in Figure 8, the only force available to move the condensate out of the coil is gravity. The coil tubes must slope toward the condensate header. The pipe connection from the return header to the dirt leg must be header outlet size so that the condensate will not collect in the bottom tubes of the coil. The dirt leg should be as long as possible, but not less than 12 inches. The height of the condensate in the dirt leg is the only pressure head available to force the condensate through the float and thermostatic trap. This trap must be liberally sized. The output from the F and T trap must slope unrestricted to the condensate pump, drain or boiler and steps must be taken to assure no pressure above atmospheric can exist in the return line.

A vacuum breaker connected to the steam supply header will ensure free flow of the condensate out of the coil. The pipe size of the breaker should be the same as the steam valve. Without the correct vacuum breaker, the condensing of steam will create a vacuum in the coil. This vacuum will prevent the condensate from freely draining from the coil. Tubes containing condensate can freeze and destructive water hammer is possible when the steam valve opens and the condensate is forced out.

The pressure drop in the steam supply between the valve and coil is generally less than 1 psi, and therefore the steam valve can be sized for a drop equal to the steam supply pressure less 1 psi.

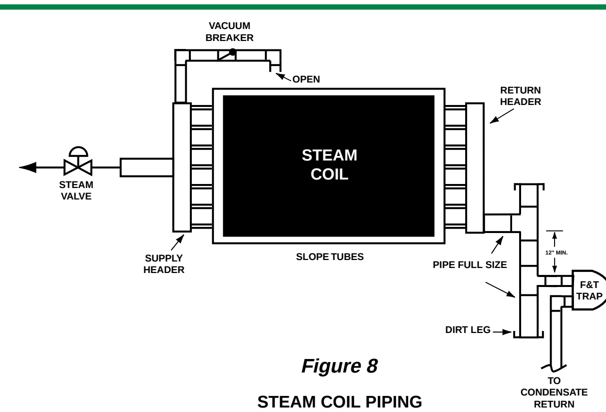


Figure 8

STEAM COIL PIPING

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