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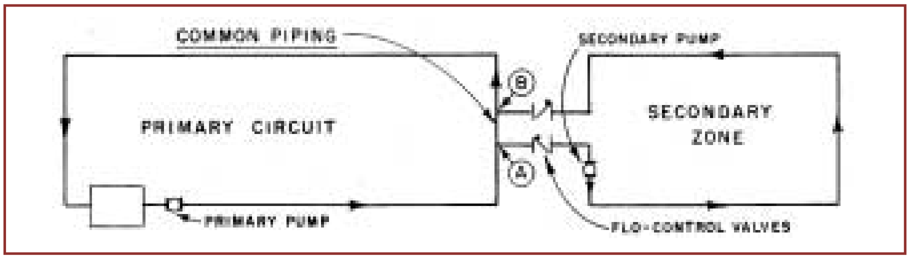
Modern Hydronics

Vol. 16 Issue 1

Primary-secondary pumping

The use of primary-secondary pumping ideas in new or retrofit projects will eliminate the zone control problems caused by the interaction of system components and multiple pumps. Pumps, pipes, and other fittings can be reduced in size and cost by using these ideas to design flow independent or "decoupled" piping loops. Primary-secondary pumping is especially applicable to new or retrofit radiant panel systems.



The common piping shown above must be designed for very low pressure drop. This is accomplished by putting the two tees, "A" and "B", close together, and sizing the pipe between them for very low pressure drop at the maximum flow it's supposed to carry. A Bell & Gossett System Syzer or Design Tables will help you choose the right pipe size for the flow.

Low pressure drop in the common pipe means that flow in the primary circuit cannot cause flow in the secondary zone, making flow in each loop independent.

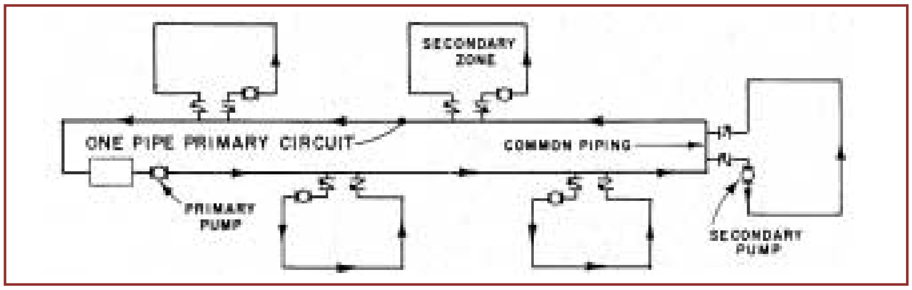
A pump in the secondary loop will cause flow in that loop, diverting water from the primary to the secondary at one tee and returning it at the other. If the secondary pump is off, low pressure drop in the common pipe will allow primary water to bypass the secondary, but when the control system turns on the secondary pump, water will automatically be diverted into the secondary loop to provide heat. This results in a very simple "on/off" method for controlling temperature in the secondary loop. The check valve symbol with the heavy dot represents a Bell & Gossett Flo-Control Valve used to prevent gravity circulation of lighter, warmer water from the primary loop into the secondary loop when the secondary pump is not on. Flo-Controls are used with secondary pumps that operate on or off.

They should not be used in secondary systems that use a constantly operating pump and valves that vary the flow. In order to prevent unwanted gravity circulation in these systems, use a "thermal trap" formed by keeping the hot loop at least one foot higher than the connection to the cold loop.

Note that the two loops are not independent in all respects. They share the same water, so it is impossible for additives such as glycol to be confined to one of the loops without eventual mixing. More importantly, the two loops share pressure. If a taller loop and a shorter loop are connected to the same primary distribution system, static pressure from the higher loop will be communicated throughout all loops. Some portion of pump pressure head from the primary pump will also exist at the secondary loop connection, and, if the secondary zone pump is properly installed as shown, will add to the secondary pump pressure. It's important to remember these facts so that the design pressure limit will not be exceeded in any circuit. Usually, these factors are of only minor importance in residential work.

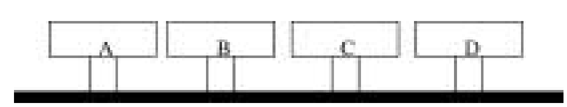
Primary-secondary pumping basics

One pipe systems



Note that in one-pipe primary-secondary systems, secondary zones farther away from the boiler get cooler water when the upstream secondary zones are calling for heat. Each secondary zone is easy to control because it is independent of flow in the primary, and in any of the other secondary loops.

Mixing strategies for combination heating systems using a one pipe primary:



Primary Supply at 180ºF

Where:

"A" is a baseboard zone requiring 180ºF

"B" is an air handler requiring 180ºF

"C" is a staple up radiant panel retrofit requiring 140ºF

"D" is a radiant slab requiring 100ºF

If the boiler is supplying several different heating zones in a one pipe primary loop, arrange the order so that the zone that requires the highest temperature is first in line, getting the highest temperature. Lower temperatures for the downstream zones can be obtained by mixing supply and return water as described below.

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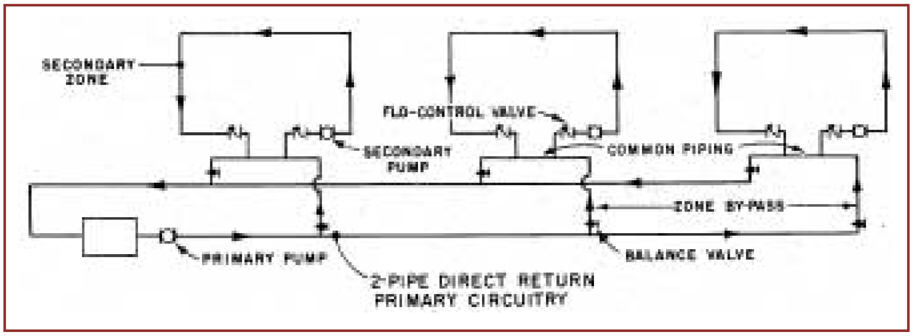
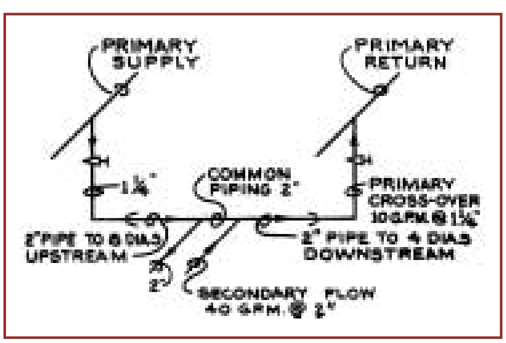
Two pipe systems



In a two pipe primary-secondary system, each secondary zone can get the same primary supply water temperature. The common pipe is part of a “zone bypass” or “cross-over bridge” between the primary supply and return. A balance valve in the zone bypass sets the primary flow in the bypass. The balance valve cannot be installed in the common pipe because that would increase pressure drop in the common. If that happens, flow in the primary loop will always generate flow in the secondary, and the two loops are no longer independent.

Sometimes flow in the secondary loop must be greater than the flow provided by the primary. That means the flow in the common pipe, between the tees, will be “backward”! Although this may sound a little strange, it’s actually very useful in a heating system. Suppose you have a typical baseboard system operating at a 20º temperature difference—that’s your secondary circuit. But you want to supply heat to that zone by using just a small amount of much hotter primary water. You’d need to mix the hot primary water with cooler secondary return water in order to get what the baseboard zone needs. At the other tee, the return water splits: some going to mix with the hot primary water, the rest going back to the boiler to pick up more heat. That means the primary loop is seeing a larger temperature drop than the secondary, and therefore the primary flow will be much smaller than the secondary so you can use smaller pipes and pumps in the primary. If you do this, just insure that the common pipe that’s carrying the “backward” flow is properly sized for low pressure drop. In order to avoid any possible “jet effects” carry the full sized common pipe at least 8 pipe diameters upstream and 4 pipe diameters downstream.



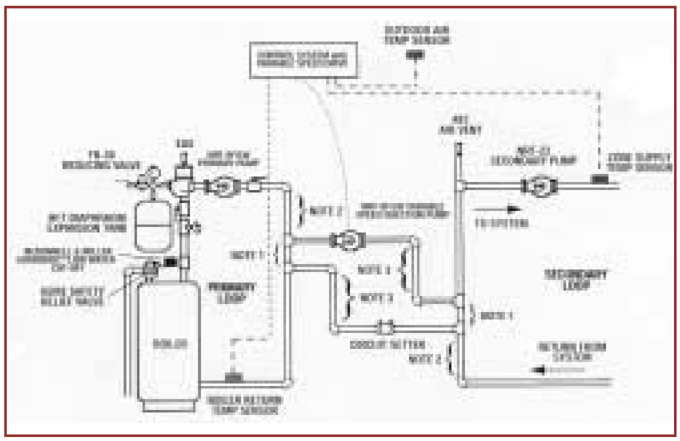
In the following example, 10 gpm of very hot primary water mixes with 30 gpm of return water to supply 40 gpm of intermediate temperature water to the zone. Notice that the common pipe has to be sized to carry 30 gpm at low pressure drop. This larger diameter pipe is continued at least eight pipe diameters upstream and four diameters downstream to avoid unwanted mixing.The rest of the cross over bridge is smaller, since it carries only the low primary flow.

Controlling Primary-Secondary System Temperature

Note 1: A length of three pipe diameters between the tees is recommended to prevent unwanted mixing of primary and secondary loop water.

Note 2: A minimum of eight pipe diameters upstream and four pipe diameters downstream is recommended to prevent unwanted mixing.

Note 3: A minimum elevation difference of one foot is recommended to create a thermal trap if flow in the secondary loop is valve controlled.



Typical Primary-secondary Variable Speed Injection Pumping System for Radiant Panel System
Figure 1

Figure 1 shows a very common way of providing hot water to a radiant panel system. Notice that the primary-secondary idea of using a low pressure drop common pipe has been applied twice; once at the boiler loop and again at the system loop to form an “injection loop”.

Adding the second common pipe in the secondary loop allows the system pump to remain on at all times, and creates other ways to control secondary loop temperature. The small injection pump shown above transfers water from the boiler loop to the panel loop when the system loop temperature goes down. These are especially useful in radiant panel systems. Several alternate piping details will work too. (see figures 1-5) In each of these, the following labels apply:

P1 Primary pump

P2 Injection pump

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P3 Secondary pump

C1 Controller with outdoor temperature, supply water temperature, and boiler return water temperature sensors, variable speed injection pump. May have additional output to pump and boiler.

C2 Mixing reset control with outdoor temperature, supply water temperature, and boiler return water temperature sensors, and output to mixing valve motor. May have additional output to pump and boiler.

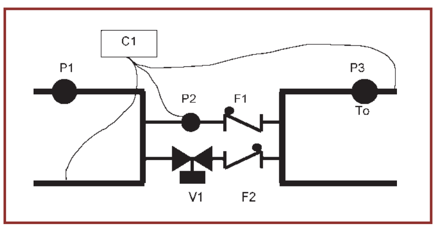
V1 RF Circuit Setter Balancing Valve set to design condition injection flow rate.

V2 Four-way motorized mixing valve.

V3 Non-electric three-way mixing valve with remote sensor. May also be a self-contained valve with built-in sensor or a motorized mixing valve.

V4 Non-electric two-way modulating valve with remote sensor. May be motorized. Controls flow into the secondary loop.

V5 Circuit Setter acting as a bypass valve set to throttle secondary loop flow, set for



Alternate Injection Piping Method
Figure 1a

design injection flow.

V6 Differential pressure regulator prevents deadheading secondary loop pump when all manifold valves close.

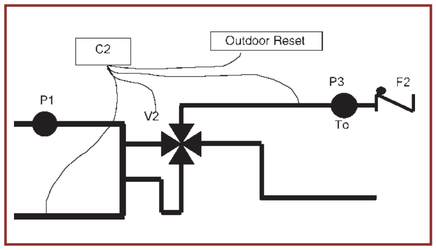
V7 Electrically actuated valves to provide individual loop control.

F1, F2 Flo-Control Valves to prevent unwanted gravity circulation into the secondary loop.

F3 Flo-Control valve if gravity circulation is a problem.

T1 Thermal trap alternative to Flo-Control Valve. Minimum distance of one foot drop required to prevent gravity circulation.

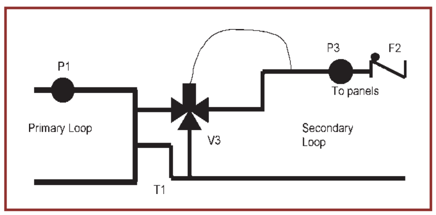
In Figures 1 and 1a, the control (C1) varies the speed of the injection pump (P2) to maintain or reset water temperature in the secondary loop. Since low return temperature in the primary loop can damage a boiler that's not designed to



Primary-secondary Piping with Four-way Mixing Valve
Figure 2

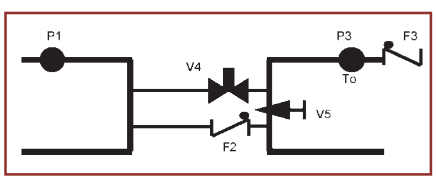
handle flue gas condensate, the controller will slow down the injection pump to prevent that problem.

The control (C2) positions the motorized four-way mixing valve (V2) to maintain or reset water temperature in the sec-



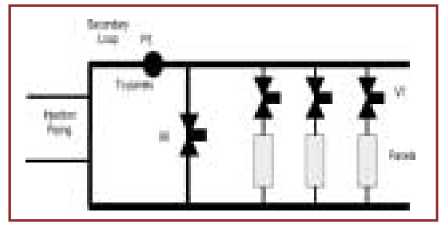
Primary-secondary Piping with Three-way Mixing Valve
Figure 3

ondary loop. Decreasing the primary water input in the case of low temperature in the primary loop return provides boiler protection.



Primary-secondary Piping with Two-way Modulating Valve
Figure 4

The non-electric three-way mixing valve (V3) modulates to maintain constant water temperature in the secondary loop



Secondary Loop Bypass with Sub-Zoning of Manifold Loops
Figure 5

based on an adjustable set-point on the valve actuator.

The non-electric two-way modulating valve (V4) maintains a constant temperature in the secondary loop based on an adjustable set point on the valve actuator and the throttling action of the balancing valve, (V5).

The normally closed differential pressure regulator (V6), opens to bypass flow as manifold valve actuators (V7) close.

Heating devices.

Radiant heating panels have become very popular in recent years, but there are a lot of other modern hydronic devices to consider too. In renovation projects small "kick-space heaters", and small hydronic air handlers may be a convenient way to supplement radiant heating in kitchens, bathrooms, or other rooms which lack adequate floor space for a full size radiant panel.

Dual temperature systems

Hydronic systems have been praised for providing even, comfortable winter-time heating for years. Summertime hydronic cooling has been restricted to very large systems until recently. Manufacturers of small packaged liquid chillers have begun to offer units that are well suited for air-conditioning small commercial buildings or even a single family house. If the hydronic coils are big enough to handle the cooling and dehumidification required during the summer, they will probably be more than capable of providing comfort heating all winter. This allows the hydronic system to be used all year long without a need for noisy, leaky ducts. Primary-secondary pumping is useful here too.

The system pump is sized to provide flow

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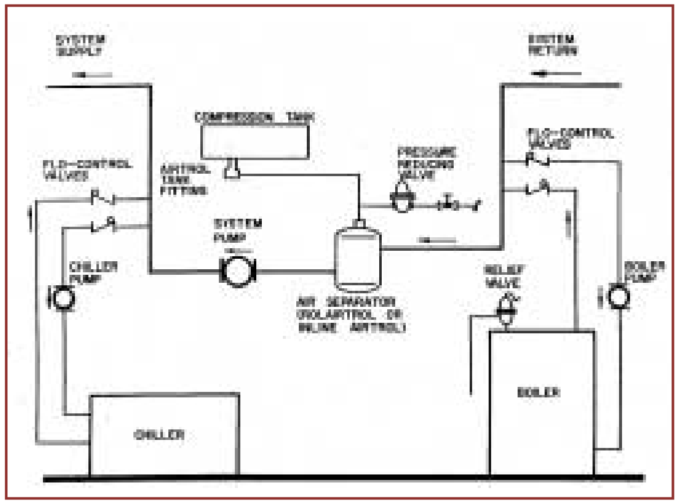
to all the coils year round. In the summer, the boiler and its small pump are turned off. The chiller and its small pump are on, providing the chilled water required for cooling and dehumidification. In the fall, the chiller and its pump are turned off, and the boiler with its pump is turned on. The low pressure drop common pipe at the boiler and the chiller insure flow independence at all times.

Compression tanks

Notice the compression tank with its special "Airtrol Tank Fitting" in figure 6. This represents the "Air Control" strategy that has been successfully used for decades in thousands of hydronic systems. Air that is separated from water in the air separator rises by buoyancy into the tank. The Airtrol Tank Fitting keeps it there, preventing water-logging of the tank. Contrast this with the "Air Elimination" strategy shown in figure 1. The EAS, or "Enhanced Air Separator" simply vents air out of the system. The tank shown in figure 1 is a pre-charged diaphragm tank. Either air management strategy can be used. They're both time tested and perfectly reliable. Generally, the pre-charged diaphragm or bladder tanks are smaller, but more expensive than the standard compression tank.



Dual Temperature System for Heating and Cooling
Figure 6