The UPS & DOWNS of PRESSURE

By Ric Brindamour

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The modern residential or light commercial hydronic heating system that doesn't include the use of at least a few zone valves is rare. Installed downstream of the system circulator, zone valves eliminate the need for a separate circulator on each circuit (see Figure 1).

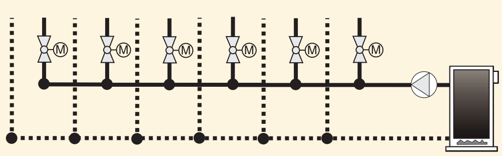

Figure 1

If the system is operating at design load conditions, all zones will call for flow at the same time. This means that all zone valves will be open, and the distribution system will exhibit its lowest flow resistance. Zone valves will close when thermostats reach their respective setpoints. As each valve closes, the flow resistance increases. The overall system flow rate decreases, while the flow rate through each open zone increases.

Hydronic systems constantly seek a balance between the mechanical energy (head) input from the circulator and the head-loss from fluid friction in the piping. Plotted on a graph, the system always operates at the point where the system head loss curve crosses the pump curve (see Figure 2).

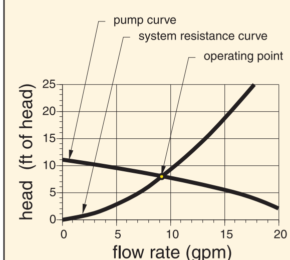

Figure 2

When a zone valve opens or closes, it causes the head-loss curve to change. If resistance increases, the curve will steepen. If resistance decreases, the curve will flatten out. As the system curve shifts, so does the point where it intersects the pump curve. Figure 3 shows this effect for a system having several identical floor heating circuits, each controlled by its own zone valve.

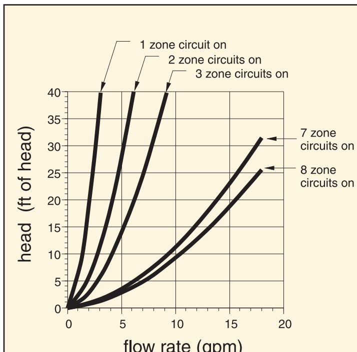

Figure 3

When a zone valve closes, it increases the pressure differential imposed on the zones that remain open. The increased pressure differential increases the flow rate through these zones. At some point, the increased velocity will probably cause noise in either the zone valve or the piping.

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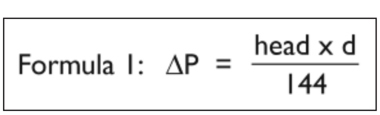
the BYPASS

In lieu of a variable speed circulator, differential pressure across the circulator can be controlled by installing a differential pressure bypass valve. As zone valves close, this device opens up, increasing amounts of flow through detour piping, rather than forcing the pump to operate at higher pressure differentials trying to push flow through a restricted system.

You can estimate the differential pressure across the system when all zones are operating by finding the head at the operating point and converting it to a differential pressure using Formula 1.



$$\text{Formula 1:} \quad \Delta P = \frac{\text{head} \times d}{144}$$

For silent operation, a differential pressure bypass valve should be installed in zone valve systems that don't use a variable speed circulator. A bypass should also be installed to prevent dead heading the circulator in systems where several parallel-piped heat emitters are controlled by thermostatic radiator valves.

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To find the flow rate through the circulator, draw a line straight down from the intersection of the system and pump curves (operating point) to the lower axis of the graph. To determine the differential pressure across the circulator, draw a horizontal line from the operating point to the vertical axis and read the head added to the fluid as it passes through the circulator. Convert that head number to a corresponding differential pressure using Formula 1.

$$\text{Formula 1: } \Delta P = \frac{\text{head} \times d}{144}$$

Where:

ΔP = pressure differential across pump
head = head added by circulator (in ft. of head)
d = density of fluid being pumped (in lb/cubic ft.)
(for water at 140 °F d= 61.3 lb / ft3)

Noise isn't the only problem associated with a high pressure differential inside a hydronic system. In some systems, the increased differential pressure generated by several inactive zones can force zone valves to open that are meant to be closed, even if only slightly. This causes heat input to zones that are supposed to be off.

One way to eliminate the possibility is to use zone valves with a ball valve design.

LESS IS MORE *(curve, that is)*

To minimize change in differential pressure as zone valves open and close, select a circulator with a relatively flat pump curve, such as the one shown in Figure 4. For comparison, the pump curve of a high-head circulator is also shown.

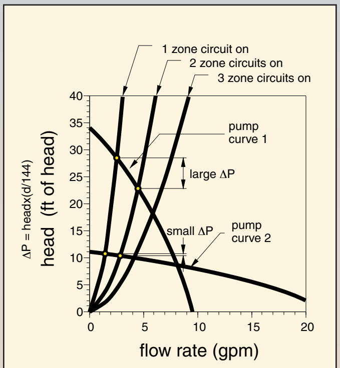


Figure 4

Compare the changes in differential pressure as the operating point shifts upward along the flat pump curve, to those of the high-head circulator. In both cases, zones that remain open will experience increased differential pressure as the others close, but much less in the system using a circulator with a relatively flat pump curve.

Using a circulator with a flat pump curve is not a new concept. Still, some installers have the impression that using a high-head circulator is a better choice when they think about pushing flow through several zone circuits. Unfortunately, it can actually create problems, like pipe erosion, unwanted heat in closed zones and velocity noise.

A straight horizontal line at some fixed value of differential pressure is the ideal pump curve for a circulator in a system using zone valves. Such a pump curve would mean constant differential pressure regardless of the flow rate. As a given zone valve opened or closed, the other operating circuits wouldn't undergo a change in differential pressure or a change in flow rate.

Unfortunately, no fixed-speed centrifugal pump can provide this ideal curve. But a variable-speed circulator can.

VARIABLE SPEED & DELTA T

A variable-speed circulator can be used to control differential pressure as zone valves operate. As the system speed decreases, the pump curve shifts to the left and downward on the graph as shown in Figure 5.

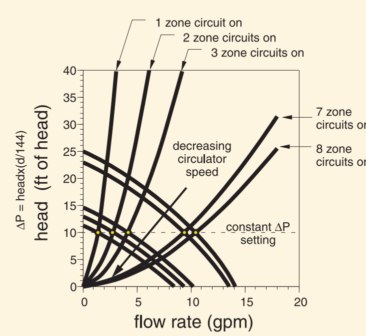
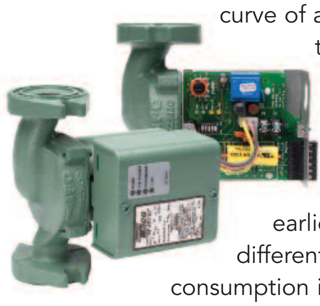


Figure 5

As different zone valves open and close, and the system curve changes pitch, the pump curve of a variable speed circulator can shift as necessary to maintain the same differential pressure across the operating zones. The open circuits don't sense that others have opened or closed.



Properly controlled, a variable speed circulator can operate as a constant differential pressure device regardless of its flow rate. It adopts the optimum pump curve discussed earlier. A variable speed circulator not only prevents changes in differential pressure, but can also reduce electrical energy consumption in the process.