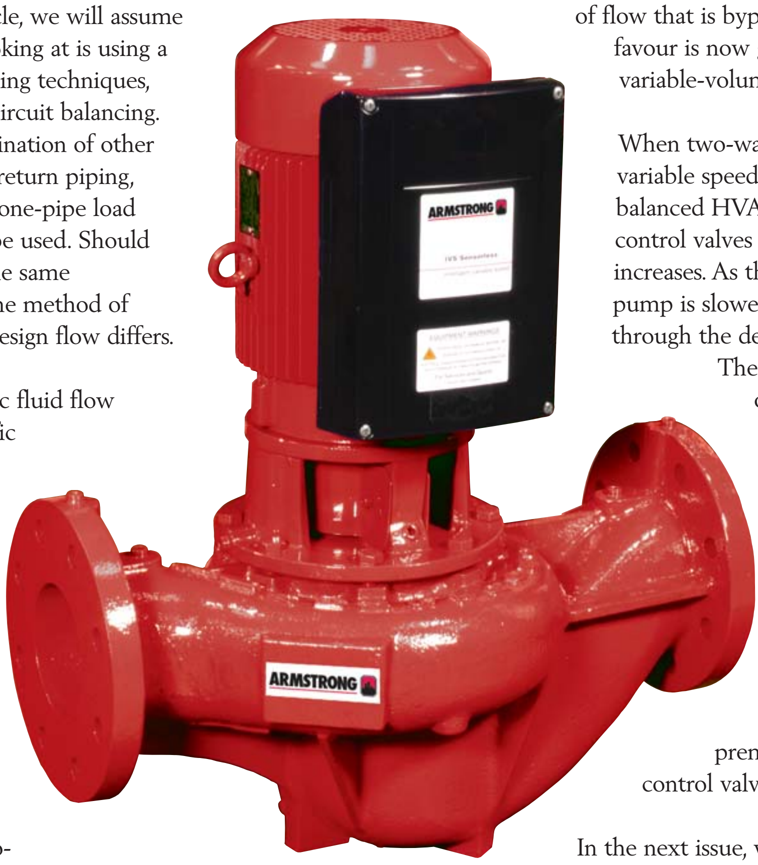
COMPLETE SYSTEM BALANCING
Proportional Balancing Method

As discussed in "Choosing a Balancing Design Strategy" (*Mechanical Business*, January/February 2008), there are many methods that can be used to balance the fluid flow in an HVAC system to ensure every terminal unit has at least design flow available.

For the purpose of this article, we will assume that the building we are looking at is using a combination of pipe stretching techniques, with provision for manual circuit balancing. It is possible that any combination of other techniques, such as reverse return piping, automatic flow limiting, or one-pipe load pump balancing, may also be used. Should that be the case, many of the same principles apply, and only the method of actual flow adjustment to design flow differs.



As variable volume hydronic fluid flow designs become more prolific for overall energy savings opportunities, the most common terminal unit control and regulation circuits used in new construction are based on two-way control valves. However, circuits based on three-way control valves are still very common in constant volume systems, or at the end of parallel two-way circuits to avoid completely shutting the system down, should all or a significant portion of control valves happen to close at the same time, which could happen during night setback activation.

For a constant volume scheme, the system will now run at optimum efficiency, with design flow delivered to each terminal unit. The control valve will dictate whether this flow runs through the terminal unit, or through the bypass back to the pump. While these systems can operate quite efficiently, ASHRAE 90.1 recommends limits on the amount of flow that is bypassed in a system, hence favour is now generally given to variable-volume systems.

When two-way control valves are used with a variable speed pump in a proportionally balanced HVAC system, as demand is met and control valves close, the system resistance increases. As this resistance increases, the pump is slowed to maintain design flow through the demand loads that remain open. The pump speed is controlled based on inputs from discrete pressure sensors, or via sensorless variable speed pump technology. This scheme assures consistent control valve authority despite dynamic diversity, and helps reduce control overshoot and hunting conditions, ultimately avoiding excess wear and premature failure of the control valves.

In the next issue, we'll look at various balancing valve technologies and how they perform in the HVAC system.

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COMMISSIONING

Regardless of which method or combination of methods are employed, responsible project management dictates that, upon completion, the HVAC system be thoroughly tested by a third party – to ensure the system engineer's design intent is met – and a formal report be produced that details the actual performance realized and any non-conformance issues found. Most commissioning authorities recommend that design flows throughout the system be tested and verified accurate to within five per cent (plus or minus) of design flow.

A 10-STEP PROGRAM

Let's take a closer look at the steps involved to proportionally balance a multi-storey building. A typical school may have two floors with 100 terminal units each, whereas a typical metropolitan building may have 25 floors with 20 terminal units per floor.

For illustration purposes, we'll look at only two floors with three terminals each. All of these principles will apply, regardless of the number of floors and number of terminal units per floor.

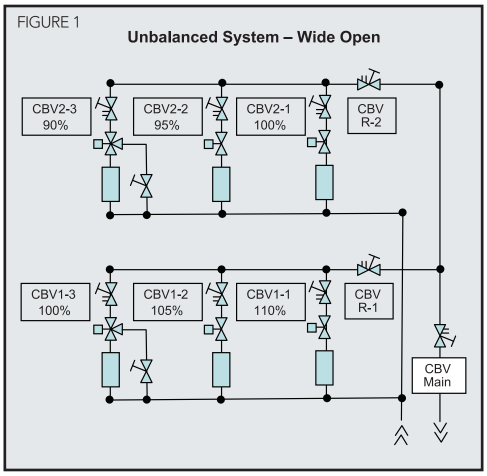

FIGURE 1 Unbalanced System – Wide Open

1 Ensure the system is running wide open. Set all control valves completely open, turn all balancing valves completely open, and ensure the pump is running at design speed.

2 Locate the most disadvantaged terminal unit. This is usually the one on the highest floor and furthest from the supply risers. (Figure 2, CBV2-3) This is the starting reference flow. This valve is always left wide open. Note that at this point, the flow through this terminal is likely well below design flow. If not, there is a good chance the pump is severely over-sized.

3 Adjust the balancing valves for all other terminal units on the floor (CBV2-2 & CBV2-1) to match the flow that will prevail through the most disadvantaged unit. Note that there is interaction between valves, and as any one is throttled, the flow through the others increases. Experienced balancers can often predict the amount of compensation required for this interaction and can adjust all valves to achieve a common flow through all in just one pass.

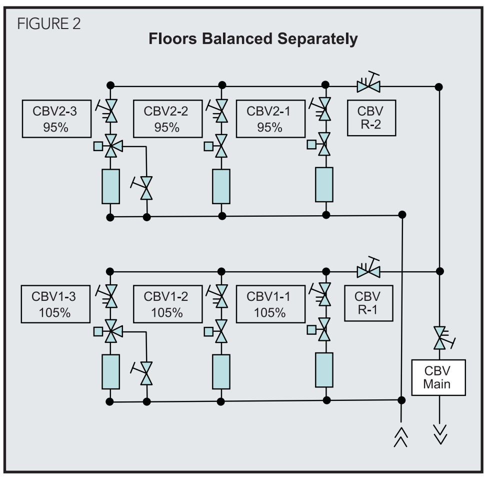

FIGURE 2 Floors Balanced Separately

4 Repeat step 1 to 3 for the next most disadvantaged floor. When complete, each floor will be balanced individually and separate from each other.

5 To balance the floors together, leave the riser balancing valve of the most disadvantaged floor wide open (Figure 3, CBVR-2). Adjust the riser valves of other floors, until all floors are at an equal flowrate.

6 Throttle the main system balancing valve (CBV Main) to achieve 100% design flow. The entire system is now proportionally balanced, with design flow available to all circuits. However, having the main CBV throttled is like driving a car with one foot to the floor on the gas pedal and the other on the brakes. Though the system is balanced, optimum efficiency is not realized.

7 With the system running wide open, measure the pressure drop across CBV main both as throttled and completely open. This pressure difference is the amount of excess pump head generated.

8 Shut down the system and have the pump impeller trimmed to eliminate the excess head and bring the pump into the most efficient zone of the performance curve.

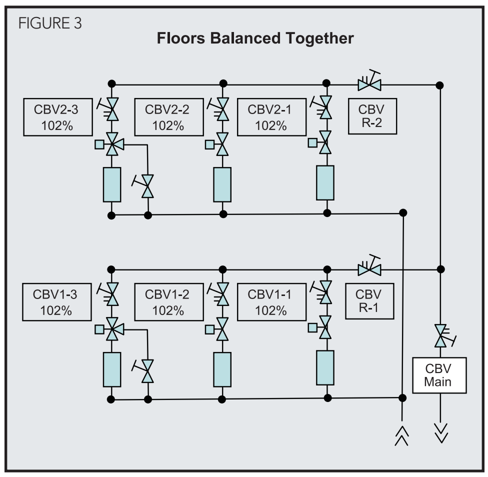

FIGURE 3 Floors Balanced Together

9 Reinstall the impeller, open CBV main, and verify that design flow is realized. The system is now proportionally balanced with design flow available to all terminal units, and operating at optimum efficiency.

10 Release all control valves for normal operation.

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