Accurate Flow Control with Enhanced System Performance

By Peter Biondo

Energy efficiency improvements within an HVAC system can be achieved not only by the selection of high efficiency equipment but also in the managed control of flow rates through each terminal unit. Terminal units include fan coils, air handlers, chilled beams, radiant heat emitters and convectors. Balancing valves and control valves typically manage flow through the terminal unit. Without good hydronic balancing, flow will vary and is difficult to control as valves open and close throughout the building.

Flow control across a terminal unit is a problem with some HVAC systems. Overflow will raise the average temperature of the terminal unit and resulting thermal output. Underflow lowers the average temperature, and the terminal unit may not meet load demand. Hydronic systems are subject to dynamic pressure changes when valves open and close. Because of these pressure changes, flows and temperatures in the building are often uneven. The situation worsens at low and medium loads and can cause unwanted system cycling. Boilers and chillers end up running more often. "Out of balance" means "out of pocket" for building owners.

The standard installation will experience differential pressure changes across the control valve, independent of the desired response. A controller signal may have to "hunt" for the flow, as differential pressures change and effectively delay the response time of the terminal unit. Operating efficiency is tightly linked to stable flow rates and a correlating response to a control signal. The ideal hydronic control would be represented by a balancing device and a control valve that achieve the desired flow regardless of any pressure fluctuations. The pressure independent control valve (PICV) combines the features of a differential pressure regulator, a control valve and a balancing valve.

PICVs have solved the vexing issue of regulating accurate flow over a wide range of pressure variations. The PICV is a two-way valve that combines control and balance in one valve. Actuators are available for common control signals, including on/off and proportional. Some models employ a dial for selecting the flow rate in the field. The big advantage that the PICV has over other balancing devices is the operation of the differential pressure regulator. All pressure changes across the PICV are absorbed by a differential pressure regulator, which maintains a constant differential pressure across the control valve. Because of this control, valve authority in the PICV is 100%.

Three design parameters to consider when selecting the appropriate PICV are maximum design flow rate, available minimum differential pressure and possible maximum differential pressure. To regulate the flow correctly, the valve needs to operate within a range of differential pressure, bound on the bottom by the minimum differential pressure available and on the top by the maximum differential pressure possible. When designing, be sure that the pump keeps the valve within these parameters. To keep costs in line, choose the smallest possible valve that achieves the maximum design flow rate. These design parameters will help you select the best PICV for your application.

Features of the PICV

Features vary with manufactured PICV models. A benefit of all models is that they are compact; one valve takes the place of two. Common to all PICVs is a pressure regulator, consisting of a spring and diaphragm cartridge assembly. Differences are in the flow control mechanism. Some models have a control disc to fine tune flow; others use the turn of a ball-style valve. Multiple flow rates may be available in one valve. Some of these models incorporate a field-adjustable dial for setting the top end flow rate. These dials are lockable. Getting to them may require removing the actuator or opening a side hatch; in others, the dials on the valve can be turned and are readable in any position.

Some dials are in percentage values, while others are marked in gpm. Pressure test points are available on most models. In addition to being easy to design with, PICVs offer a simplified balancing procedure. Some valves are not adjustable and are set at the factory; others are set in the field. Both types only require the differential pressure across the valve to be verified to ensure proper flow.

PICVs are designed to operate within the specifications that most HVAC systems will require. Flow control starts at

0.5 gpm with a ½-inch valve and covers the range of flow to over 700 gpm with a 6-inch valve. PICVs operate over a wide range of differential pressures. Minimum differential pressure, which can be as low as 3, is typically at 5 psi. Maximum differential pressure is up to 50 or 60 psi. Some models can operate with differential pressure as high as 90 psi. Flow accuracy per model varies from +/-3% to +/-10%. Depending on the model, working temperatures may range from 0 F to 250 F. Maximum working pressure for a PICV may be as high as 300 psi. Please consult manufactured models for product specification.

PICVs with variable flow systems

There is no doubt why PICVs have gained wide acceptance in today's energy efficient market. Using variable frequency drive (VFD) for pump control enables the pump to change speed based on a control differential pressure at a reference point in the system. A variable speed pumping system will provide just the right amount of flow to meet the changing requirements. PICVs lend themselves to the energy saving features that VSD provides by allowing the desired flow at each terminal unit.

Accurate flow capitalizes on the benefits of variable volume pumping systems. Overflow is eliminated, increasing available plant capacity and may minimize capital expense for additional capacity. The PICV's ability to maintain stable flow is useful as occupancy loads shift from one room to another. The use of PICVs assures that only the necessary amount of chilled or heated water is delivered to the cooling and/or heating load at all times.

This article describes how the use of PICVs results in improved efficiency and control. In writing it, I realized how important it is, in low energy buildings, to have design flow at the control of a fan coil, air handler, chilled beams, radiant heat appliance or convector. Ideally, every designer should plan for energy efficiency by accurately controlling flow. Installing PICVs at terminal units in order to correct flow issues is a simple solution.