

Commissioning Control Valves

Begin the process at the design phase

By **DAVID SELLERS, PE**
Senior Engineer
Portland Energy Conservation Inc.

Several months ago, I wrote an article regarding damper commissioning in which I stated that many damper commissioning issues were best addressed during the design phase¹. A similar statement can be made about control valves. By carefully considering the application requirements and installation details during design, the startup and commissioning of the valves and systems they serve will flow much more smoothly, and field problems will be avoided.

VALVE BODIES

Proper sizing is critical for modulating control applications if good controllability is to be achieved. Some designers prefer to size the control valves as a part of their design process. Others prefer to assign this responsibility to the control contractor. If this approach is taken, it is important for the designer to clearly communicate the sizing criteria that need to be met for his or her design to function properly. One aspect of this relates to the wide open pressure drop of the valve. For the valve to provide good modulating control, there must be a pressure drop across it that is significant in the context of the system that it is controlling. A good rule of thumb is that the valve should have at least as much pressure drop as the element it serves.

The valve-flow characteristic is also an important selection criteria. Common characteristics are illustrated in Figure 1. It often is possible to improve the overall performance of a system by carefully matching the valve flow characteristic to the heat-transfer characteristic of the load it serves.²

Valve body-style selection represents an opportunity to control valve performance and cost. Globe configurations are quite common for control valves, but can become expensive for the larger valve sizes. Selecting a butterfly-valve body style can reduce costs for several reasons. One is that the cost of the valve body itself is simply lower in the larger sizes. Another is that the required pressure drop often can be achieved with a smaller butterfly valve as compared to a globe valve for a given flow rate.

A butterfly or ball valve represents an ideal solution for a two-position application in

which a valve must simply allow or stop flow in a line. Most line-size butterfly and ball valves will have a much lower pressure drop than the same size globe valve, thereby providing the potential to reduce both first cost and operating cost.

The valve cavitation coefficient is a less known but important criteria in some applications. The dynamics of the fluid flow in and around the control-valve disc can cause localized low-pressure areas. If the water flowing through the valve is warm enough, these low-pressure areas may be below the water's vapor pressure, and the water "boils" in their vicinity, causing noise, unpredictable performance and damage to the valve seat.

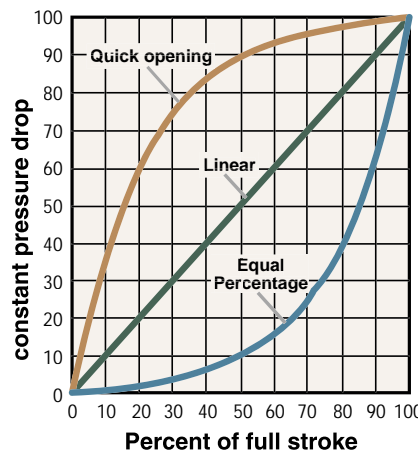


FIGURE 1. Typical flow characteristics.

It is important to match the valve temperature and pressure ratings to the application, including the entire range of operating conditions that the valve will see. The material used for the valve seats and packing should be selected based on the application and the fluid handled. Stainless steel often is specified for seats in valves serving steam systems to provide more resistance to the erosion that is associated with high velocities in the neighborhood of the valve plug. Resilient materials should be checked for compatibility with both the temperature and type of fluid.

Three-way valves come in both diverting and mixing arrangements. The mixing arrangement, which combines two flow streams, is the most common. Many manufacturers also offer a diverting arrangement, which splits one flow stream into two. A valve that is configured for one application often cannot perform the other.

ACTUATORS

Actuators also need to be properly sized if the valve they serve is to perform well under all operating conditions. Consideration needs to be given to the forces associated with the design flows and pressure drops as well as the forces required to completely close the valve against the full available differential pressure. The shutoff differential pressure for a two-way valve is often significantly higher than is the operating differential pressure because the pressure drop due to flow in the lines to and from the valve is no longer present. A good rule of thumb is to size actuators to close the valve at the peak pressure on the pump curve for the system they serve, at the very least. A little allowance should be added for seating the disc into a resilient seat (if the valve is so equipped).

The position that a valve fails in under loss of control power is an important consideration. Diaphragm-type pneumatic actuators and many electric actuators usually use a spring to move the valve stem in one direction and power (air or electricity) to move the stem in the other. Piston and vane-type pneumatic actuators use air power to drive the valve in both directions, so if a specific failure mode is required, then this needs to be provided via additional springs that may not be part of the standard actuator assembly. Coordination with the positioner on modulating valves and the switching solenoids on two-position valves may also be required to achieve the proper failure mode.

The spring selected to provide the "normal" position for pneumatic actuators also controls the input signal span over which the valve will modulate. By selecting different spring ranges for valves controlled by the same signal, it is possible to sequence control functions. However, the forces generated on the valve disc or plugged by the flow dynamics through the valve often can shift this spring range under operating conditions. If this is not considered when the actuator is selected and applied, the result can be loss of the sequencing function and energy waste. Positioning relays are accessories that can be installed on an actuator to prevent this problem. The relay senses both valve position as well as the signal from the control system and then uses an independent air source to move the actuator as required to match the valve position with the signal requirements. Some positioners will allow actuators to be downsized by using a pressure significantly above the 15-to-20 psi maximum that is typically

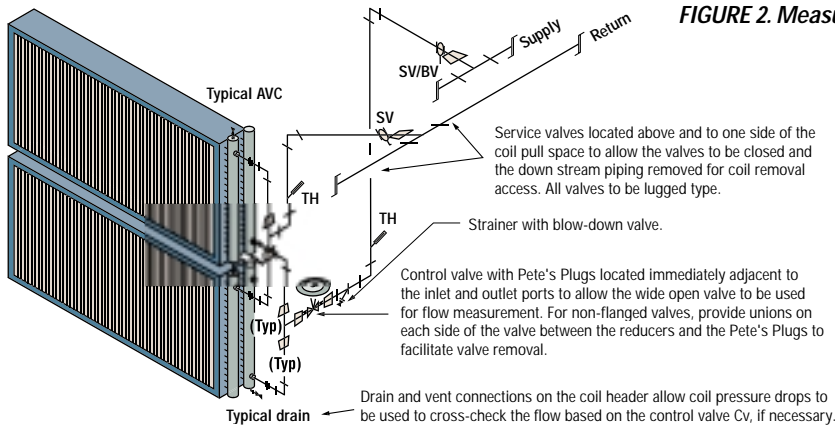


FIGURE 2. Measuring coil flow rate using a control valve.

used for control signals for the independent pressure source. Higher quality positioners can also allow the valve characteristic to be changed or even customized by a simple replacement of the feedback cam rather than a changing of the valve plug or body.

New electric actuators, when combined with DDC systems, often eliminate the need to consider pneumatic actuation. However, pneumatic actuation may still be desirable if the project has large control valves requiring significant actuating force or applications that require very rapid valve movements. Electric actuators on large valves can have travel times in excess of 60 sec due to the gearing required to allow the actuator motor to handle the valve torque requirements. This travel time shows up in the control loop as part of the loop time constant and can make the loop difficult if not impossible to tune. Pneumatic actuators can often be selected so that the full range travel time is a matter of seconds.

Some manufacturers have expanded their product lines in the larger sizes to include valves that use piston-type pneumatic damper actuators to provide the large operating forces required at lower first costs as compared to a double acting cylinder or a large diaphragm type actuator. This approach can provide a good value for two-position and non-precision modulating applications. However, the linkage system associated with this arrangement can have significant hysteresis and poor repeatability characteristics, making the more costly actuators a better selection if precise and repeatable control is a mandatory requirement for the application.

INSTALLATION CONSIDERATIONS

One common commissioning problem encountered with control valves is that the valve is installed with the wrong direction of flow through it. If the flow is in the same direction in which the valve plug is moving, there comes a point, usually near shut off, where the combination of differential pressure across the plug and the velocity pressure

effects acting on the plug overcome the valve spring and actuator and force the plug closed. When this happens, the flow is stopped, along with the velocity effects that forced the plug closed. Since the actuator by itself had not reached the point where the valve closed, the plug pops back open, and the cycle repeats, often at a very high frequency (several times per second). At a minimum, this makes the valve "chatter". It also can cause severe waterhammer. The waterhammer problem can be particularly dangerous; I have seen it make large pipes move several inches with a frequency that made the motion blurry. Flow direction is a consideration for both two-way and three-way valves. Most manufacturers cast an arrow into the valve body indicating the direction of flow, but lacking that information, a good rule of thumb is to arrange the valve so that the flow will tend to hold the valve open. For three-way valves, it is also a good idea to verify that mixing valves have not accidentally been installed as diverting valves and vice-versa.

Most control valves are accurately machined devices with very predictable wide-open pressure drops, as seen in Figure 2. By taking advantage of this feature, it is possible to reduce both the first cost and the operating cost of a project. By providing gauge cocks across the control valve, the pressure drop across the wide-open valve can be used to determine flow to the load for balancing purposes. The air vent and drain connections can be used to measure coil pressure drop, and this information can be compared to the coil shop drawing data as a cross check on the flow information from the control valve pressure drop. This feature, when combined with the use of a butterfly valve or ball valve with a memory stop for one of the service valves, will allow the balance valve to be eliminated from the piping connection to many loads, thereby saving both first cost and operating cost associated with the pressure drop through an independent balancing device.

The installed position of an actuator should be considered, especially for actua-

tors on valves serving steam or high-temperature hot-water systems. Offsetting the actuator from the vertical will partially remove it from the pipe's convective heat path. A radiation shield still may be required to protect the actuator from radiated heat, regardless of the position relative to the line that it serves. Some gear-train actuators may also be sensitive to mounting positions due to lubrication issues.

In most cases, actuators with quick response times are considered more desirable than slow actuators because the control loops are more responsive. However, there are instances where having an actuator respond to a control signal too quickly can lead to problems, especially in two-position applications. In water and steam systems, the sudden opening or closing of a control valve can lead to waterhammer. Many times, the inactive section of a steam line leading to a closed valve becomes filled with condensate. If the valve opens suddenly, the accumulated condensate becomes a high-velocity slug propelled through the system at a high velocity (thousands of feet per min). There have been instances where such a high velocity slug has torn piping loose from its anchors and deformed and ruptured pipe, fittings, and specialties. To avoid this type of problem, it is important that the piping ahead of a control valve in a steam system be trapped to drain the accumulated condensate, and two-position steam valves be controlled in a manner that causes them to open gradually.

CONCLUSION

By carefully specifying valve and actuator requirements both in the project specifications as well as a valve schedule, a designer is taking an important first step in assuring the successful commissioning of the valve and its associated system. The commissioning agent can follow up by reviewing the project submittals for conformance with design requirements, inspecting the valves as they are installed and carefully starting up the systems.

REFERENCES

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Dave Sellers, PE, is a senior engineer with PECI in Portland, Ore. He can be reached at dsellers@peci.org. For more information on commissioning, visit www.peci.org.