



Badger Meter

Specifying Control Valves to Optimize Continuous Processes



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White Paper

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INTRODUCTION

Process plants such as those in the chemical industry rely on a number of demanding operations requiring the highest level of measurement and control performance. Control valve technology, in particular, plays a vital role in production processes. Valves are the most important single element in any fluid handling system, because they regulate the flow of fluid to the process.

When choosing a valve to meet a specific application requirement, and taking into account key factors such as sizing and trim materials, it is wise to consult with a qualified valve engineer capable of analyzing the application to ensure the right device is chosen and deployed appropriately.

TODAY'S CHALLENGES

Chemical and petrochemical manufacturers are trying to stay on top of more industry changes than ever — maintaining utmost product quality, and meeting and exceeding increasingly stringent safety regulations are just two of the challenges they're facing. They must implement effective manufacturing techniques, which are cost-efficient, time saving and reliable.

Process plants consist of hundreds, or even thousands, of control loops all networked together to produce a product to be offered for sale. They are designed to keep some important process variable such as pressure, flow, level, temperature, etc. within a required operating range to ensure the quality of the end product. Each control loop receives and internally creates disturbances that detrimentally affect the process variable, and interaction from other loops in the network provides disturbances that influence the process variable.

To reduce the effect of load disturbances, sensors and transmitters collect information about the process variable and its relationship to some desired set point. A controller then processes this information and decides what must be done to get the process variable back to where it should be after a load disturbance occurs. When all the measuring, comparing, and calculating are done, some type of final control element, such as a control valve, must implement the strategy selected by the controller.

Control valves are employed in many different ways in a typical plant. They typically manipulate a flowing fluid, such as gas, steam, water, or chemical compounds, to compensate for load disturbance and keep the regulated process variable as close as possible to the desired set point. The varying resistance that the valve introduces into the system as it is stroked accomplishes this regulation. As the valve modulates to the closed position the system pressure drop shifts to the valve and reduces the flow in the system (See Fig. 1).



Figure 1. Control valves play a crucial part in complex process plant operations.

Modern control valve designs allow them to be used simply as an on and off device, or for any combination of controlling to include regulation, modulation, mixing or even isolation. They are a highly engineered instrument and should not be treated simply as a commodity. Addressing control valve performance has a dramatic impact on plant efficiency, overall profitability, and asset lifecycle costs.

IMPORTANCE OF VALVE SIZING

It is claimed that the majority of control valves throughout the world have not been correctly sized and that large numbers operate on manual mode. Whether this is true or not is difficult to establish, but it is clear that the method of sizing and selecting a control valve for a specific application is generally not well understood.

When engineers talk about control valve sizing, they refer to the entire process of selecting equipment that will provide an optimal solution for a specified measurement and control function. Indeed, choosing a properly sized valve is essential to achieving the highest degree of control for the liquid, gas or multi-phase fluid (See Fig. 2).

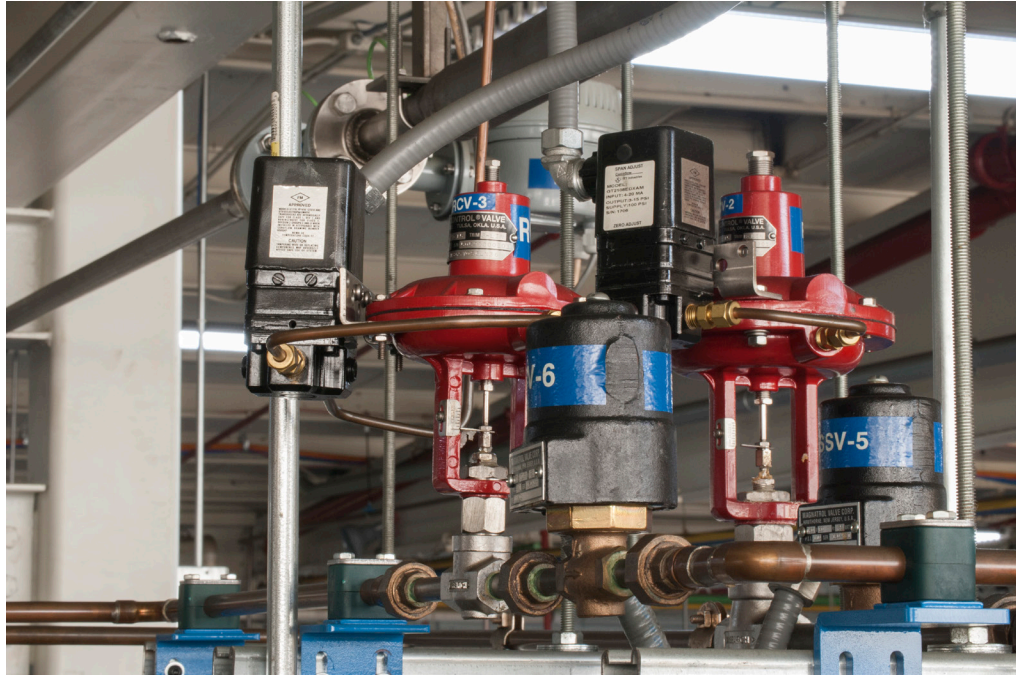


Figure 2. Proper control valve sizing helps optimize measurement and control functions.

The style of control valve is usually determined by the user's requirements, past experiences, or plant preference. Valve selection can be a tricky process, but sizing the valve can be even more difficult. All too often, valves are incorrectly specified at the time of installation.

The most important variables to consider when sizing a valve include:

- What medium will the valve control?
- What effects will specific gravity and viscosity have on the valve size?
- What will the inlet pressure be under maximum load demand?
- What is the inlet temperature?
- What pressure drop (differential) will exist across the valve under maximum load demand?
- What maximum capacity should the valve handle?
- What is the maximum pressure differential for closing the valve?

The required flow rate the valve must pass and the pressure drop that can be allowed across the instrument typically govern its sizing for a particular duty.

If the right size valve is not selected, there are two possibilities: (1) The valve may be too small. If it is, it won't be able to pass the required flow. In actual practice, undersized valves are fairly uncommon; (2) The valve may be too large, which turns out to be all too common. An oversized control valve will cost more than is necessary, although that is only a minor point compared to the real problem. The real problem with an oversized valve is that it will be very sensitive, meaning small changes in valve position will cause large changes in flow. This will make it difficult, or even impossible, for it to adjust exactly to the required flow.

Frequently, control valves are sized based on a future maximum process design plus a "safety factor." This leads to specifying, buying, and maintaining a larger device than is needed for the flow rate, and results in imprecise control and poor production outcomes.

When sizing a control valve, the general rule is to size it so that it operates somewhere between 20-80 percent open at maximum required flow rate and whenever possible, not much less than 20 percent open at the minimum required flow rate. This approach is intended to use as much of the valve's control range as possible while maintaining a reasonable (but not excessive) safety factor. Properly sized globe valves, for instance, are usually one size smaller than the line.

Experience shows there is no substitute for working with a knowledgeable expert to ensure the correct valves are specified for a given installation. The problem with just filling out the specification sheet is that optimal valve or process performance is not guaranteed, even if the spec sheet is filled out exactly right. When valves misbehave and the result is poor process control, the root cause of the problem is likely an inadequate selection process.

ROLE OF TRIM MATERIALS

After a high level of performance is achieved through proper valve sizing, how can it be maintained? A control valve behaves much like other mechanical devices. Over time, wear gradually decays control performance. If left unchecked, this decay can eventually lead to failure, downtime on production lines, and unanticipated costs for spare parts and repair.

The internal elements of a control valve (collectively referred to as its "trim") are a crucial consideration in the valve selection process. Valve trim typically includes a disk, seat and stem, as well as the sleeves needed to guide the stem. The disk and seat interface, along with the relation of the disk position to the seat, normally determines a valve's performance (Fig. 3).

A control valve's trim can be selected to create a variety of passage shapes that control the flow in deliberate ways. The valve opens the gap by moving the plug, disc or valve away from the seat. The length of the stroke determines the opening size and how much liquid, gas or vapor passes the seat. By altering the size of the internal gap, the control valve increases, decreases or holds steady the flow through itself. The valve alters the opening whenever the process parameter, or variable, being controlled does not equal the value it is meant to be (i.e., the set point).

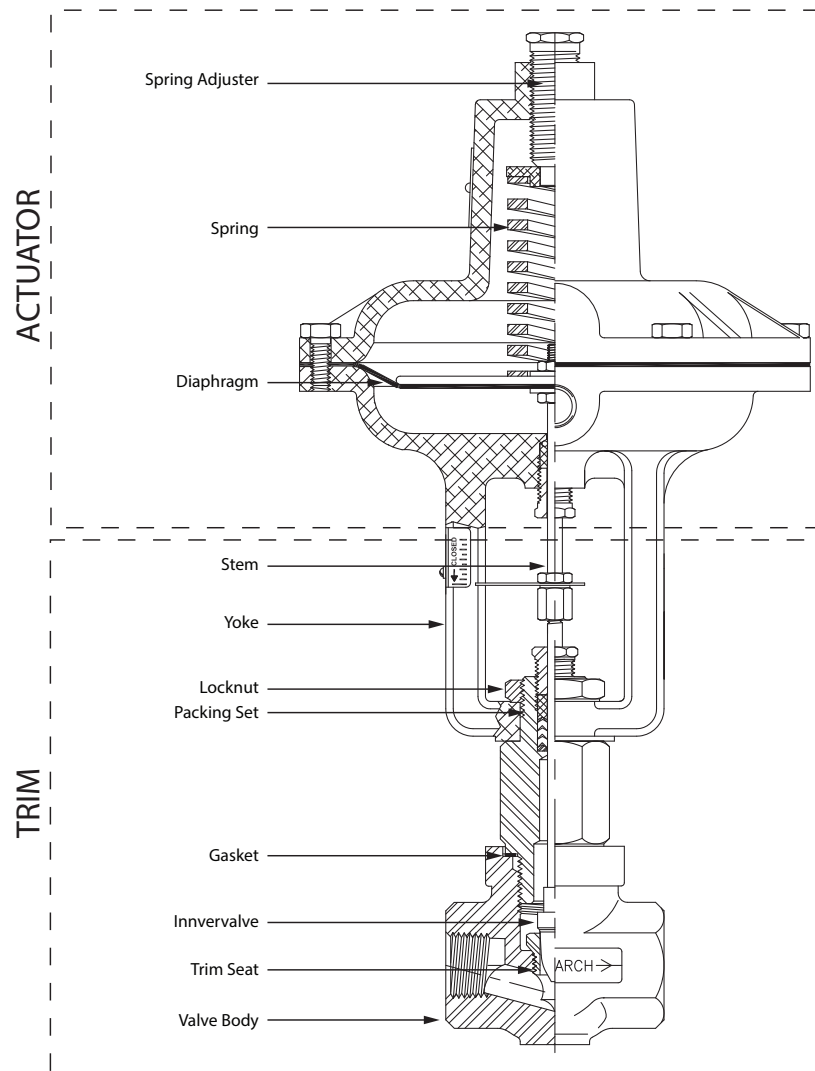


Figure 3. The internal elements of a control valve (i.e., its “trim”) are key factors in the valve selection process.

Erosion, or the gradual reduction and weakening of valve bodies or trim components due to severe process conditions, is a significant problem in modern manufacturing plants. Typical damage includes seal ring and gasket loss; stem, body and trim retainer wear on the seat ledge; plug, seat ring and cage wear; and packing leakage.

There are several common reasons for premature trim wear in control valves. For example, flashing occurs when the pressure of a fluid falls below its vapor pressure, changing from a liquid to a vapor. During this process, small vapor cavities form that grind away at the outlet of the valve and its trim components. Cavitation is similar to flashing, except the fluid pressure recovers to a pressure that is above its vapor pressure. This causes the previously formed vapor cavities to implode, producing impinging jets with the potential to cause severe erosive damage. Outgassing occurs when the pressure of a fluid drops below the saturation pressure of a dissolved gas. Once this point is reached, the gas separates from the solution and produces high-velocity, erosive vapor droplets.

FACTORS IN EQUIPMENT SELECTION

For manufacturers with continuous process operations, the proper sizing of control valves and the choice of valve body and trim materials are essential steps in optimizing performance and combating erosion-related damage. They could mean the difference between an unplanned shutdown and continued operation.

There are other important decisions involved in identifying the right valve solution. Many leading industrial companies choose globe-style valves on the basis of their proven performance and lifecycle advantages. Compared to alternative valve designs, this type of device offers:

- High differential pressure across valve
- Better control performance
- Better low flow (partial load) performance
- Use for steam, water or water/glycol media
- Smaller physical profile than a comparable ball valve

Depending on the type of supply, the globe valve's disc is moved by a hydraulic, pneumatic, electrical or mechanical actuator. The valve modulates flow through movement of a valve plug in relation to the port(s) located within the valve body. The valve plug is attached to a valve stem, which, in turn, is connected to the actuator.

Some globe valve designs feature a bolted bonnet and post-guided inner-valve. They are well suited for modulating control of liquids and vapors in environments where compact size, coupled with the ability to withstand high temperature and pressure, are essential (See Fig. 4).



Figure 4. The Badger Meter RCV Model 9000 globe-style control valve.

Globe valves meet demanding process application requirements due to the quality and precision tuning of their trim components. For example, valves are available with pre-formed diaphragm and multi-springs to ensure extremely linear travel versus input signal performance. Plus, valves utilizing a single “O” ring and Nylatron guide bushing provide minimum hysteresis. Technicians can adjust the spring preload to suit specific closing force requirements and make use of adjustable travel stops.

A significant improvement in control valve technology is the implementation of 316 Stainless Steel for trim material such as the valve body, bonnet and inner valve. This ensures longer trim life, and as such, less downtime and lower device repair and replacement costs. The most common stainless steel on the market, 316 is an austenitic grade with the addition of 2-3% molybdenum, which further improves corrosion resistance. It is often referred to as a marine-grade stainless steel because of its effective resistance to chloride corrosion in comparison to other stainless steel grades. The material also has superior welding and forming qualities.

Many chemical industry users choose to mate globe valves to high-accuracy, electro-pneumatic I/P positioners to position the device based on a 4–20 mA control signal. The latest generation of I/P positioners delivers fully automatic determination of the control parameters and adaptation to the final control element.

USE OF ADVANCED SIZING TOOLS

Leading automation technology suppliers have developed sizing tools able to adapt to the unique process requirements of a plant and guide specifiers through selection of the right control valve for any project. Some of these software solutions have the ability to create customized media, plus automatic phase identification, to provide accurate and meaningful valve sizing information to better reflect the system parameters of individual applications.

With an advanced valve-sizing tool, end-users can graphically visualize their operational set points and review various trims and characteristics, which are dynamically filtered based on their selections. The software can provide real-time scenarios to review trims and control points while considering the rangeability of each inner valve. For low flow calculations, it may feature advanced formulas to serve transitional and laminar flow situations. Leveraging the REFPROP package from the National Institute of Standards and Technology (NIST), valve-sizing software applications can also provide direct access to predetermined thermodynamic equations of various fluid states — ensuring higher accuracy for high pressure and/or low temperature applications (See Fig. 5).



Figure 5. With an advanced valve-sizing tool, end-users can graphically visualize their operational set points and review various trims and characteristics.

BENEFITS TO CHEMICAL PRODUCERS

A demanding business environment calls for the most reliable and accurate control of production processes possible. Failure to meet specific operating standards can have serious consequences for quality and safety, while running an inefficient operation can significantly affect the financial margins for the product. In both cases, optimal control valve performance is vital.

Chemical producers will benefit from working closely with their manufacturers representative or instrumentation supplier to specify an appropriate measurement and control solution. This collaboration can meet important performance criteria such as:

- Precise flow and pressure control resulting in stable and consistent production results
- Lower repair and maintenance costs resulting from longer valve trim life
- Fewer unplanned shutdowns and increased plant availability
- Efficient energy usage and reduced costs

Control valves must withstand the erosive effects of the flowing fluid while holding an accurate position to maintain the process variable. A valve will perform these tasks satisfactorily if it is sized correctly for the application, and designed and built in a way that's appropriate for the process service conditions.

SUMMARY

There is no doubt that enhanced control valve technology helps all kinds of manufacturers continually improve process efficiency and product quality, while safeguarding people, plant assets and the environment. The right solution can support a comprehensive system to track every step of the manufacturing process.

Key to the outcome of any control valve project is the assistance of qualified engineers, who analyze the application to ensure the right instruments are selected and sized correctly. Valve manufacturers that understand control performance can share those capabilities and show they can conform to a user's performance specifications.

ABOUT BADGER METER

Badger Meter is an innovator in flow measurement, control and communications solutions, serving water utilities, municipalities, and commercial and industrial customers worldwide. The Company's products measure water, oil, chemicals, and other fluids, and are known for accuracy, long-lasting durability and for providing valuable and timely measurement data. For more information, visit www.badgermeter.com.



Control. Manage. Optimize.

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