REPRINTED FROM Chemical Processing DECEMBER, 1990

# Sixteen Considerations for Valve Selection You Can't Afford to Ignore

VINOD C. BHASIN, PE

*Vinod Bhasin, PE, is a Fellow Engineer at Westinghouse Electric Corp., Machinery Technology Div., Pittsburgh, Pa. He has more than 15 years experience in the supervision, design, application and testing of valves and actuators, and has taught courses in solids mechanics for ten years at Illinois Institute of Technology, Chicago, Ill. Mr. Bhasin has written several articles in the valve industry, where he has been active in standards societies. He holds BSME, MSME and MSIE degrees. Mr. Bhasin is a member of American Society of Mechanical Engineers (ASME) and American Society of Naval Engineers (ASNE).*

How often have you specified a control valve only to find that it didn't perform as you had expected it to? Although the selection of a proper control valve and its companion actuator is a complex process, it can be mastered. By taking into consideration the criteria discussed in this article, you can avoid problems associated with improperly specified valves.

The 16 factors listed below are often overlooked in the valve selection process. Identifying the influence of each in the context of the process requirements will enable you to select a control valve that will provide years of satisfactory service at optimum cost.

### Flow medium

Identifying the fluid that will flow through the valve is the first and most important consideration. Highly erosive fluids, such as those carrying suspended solids or slurries, may require full port valves which do not provide any obstruction to flow in the full open position. Never specify butterfly valves for such services.

If the flow stream contains fibrous particles, the valve will plug when throttled to some limiting opening. This limit would depend on the size and shape of the particulates in the stream, as well as the shape of the valve port as it is throttled. Diamond port plug valves, V-plug and V-ball valves have port shapes that minimize plugging.

Highly viscous or gummy fluids create a high pressure drop through valves and piping. Valves with a large, smooth and simple flow path—such as ball, plug, diaphragm and butterfly valves—will conserve pumping energy and should be used for these services.

### Flow regulation

Ask yourself these questions: Should the valve merely start and stop the flow? Should it regulate (throttle) flow within a preset flow range limit? Or should it provide a combination of these two functions? How much through valve leakage can the system tolerate? These questions are extremely important in selecting the right valve type.

Many inexpensive control valves will provide excellent throttling, but may not shut tight, e.g., butterfly valves can provide excellent flow control, but may not be bubbletight. Gate valves will provide tight shutoff but should not be used to regulate flow.

Service requirements which necessitate both precise flow control and tight shutoff place tough demands on control valves. Many times it is not possible to achieve such goals with a single, standard, off-the-shelf valve. A special, custom-built valve—or two standard valves in series—may be required to obtain the desired results.

### Valve size

Valves are sized according to their ability to pass the required rate of flow based upon the valve's flow coefficient ($C_v$). $C_v$ is the rated flow described as gallon per minute of water flowing through the valve at 60°F, when a pressure drop of 1 psi is applied across the valve. Under most situations, sizing of a control valve can be based on valve $C_v$ using a simple flow equation. However, in many situations, other factors—such as compressi-

**It is important to choose the size of a control valve based on its $C_v$ for the desired flow rate . . .**

ble flows, viscous flows, pipe size, elbows, pipe reducers/expanders, choked flow—must be determined. Flow formulae for these situations can be extremely complex, and the valve manufacturer should be consulted to determine the proper valve size.

It is important to choose the size of a control valve based on its $C_v$ for the desired flow rate, otherwise the valve will not pass the desired flow. However, it should be noted that one should not become obsessed with $C_v$. In an increasingly competitive market, many valve manufacturers promote their products by overemphasizing higher $C_v$s for their valves. However, it should be noted that most valves available in the market, in a given valve type and size, would differ in $C_v$ by only 15% or so. Choosing a valve with a smaller $C_v$ will produce an additional system pressure loss of only a few psi, and would probably not be detrimental to the system.

The control valve need not be of the same size as the pipe. Contrary to conventional wisdom, it is better to make an error in undersizing a control valve than to oversize it. If a selected control valve is too large, it will not provide the desired control, because it would be operated at low valve openings (below 20% open). When a valve is operated at below 10% of its $C_v$, its flow characteristics are unreliable. Furthermore, operation at these narrow openings damages the valve seat and the closure member.

### Line-pressure vs valve-pressure-drop ($\Delta P$)

Often this is a misunderstood subject. The valve pressure envelope (valve body) is subjected to the full line pressure (valve upstream pressure), whereas the pressure drop ($\Delta P$) is the difference between the valve upstream pressure and the pressure that exists just downstream of the valve. Both pressures are equally important when selecting a control valve. The line pressure determines the valve body (and pipe flange) rating, whereas the pressure drop determines the valve trim or seat rating.

The valve body and its closure members may easily handle high line pressures, yet the valve stem may be too weak to handle large pressure drops. If a control valve must open or close under high pressure drops, the user must investigate the possible transient noise or cavitation during valve operation. Cavitation would damage valve internals and could also cause damage to downstream piping. A case in point is "high pressure recovery" quarter-turn valves which can handle very large line pressures, but not large pressure drops.

### Pressure-temperature rating (P-T rating)

P-T is the maximum pressure which the valve can handle at a particular temperature, and varies with the valve's materials of construction. Pressure handling capability declines with an increase in temperature. Usually, the valve *body* can handle large pressures, but the material and design of the valve seating element cannot, thus dictating the "overall" P-T rating of the valve. Valve standards (such as ANSI B16.34 for steel valves) specify the highest valve *body* pressure rating at 100°F, with declining pressure ratings at elevated temperatures.

Usually, most valves available in the market today permit "overall" valve pressure ratings equal to ANSI valve body pressure ratings at 100°F. However, these valves permit much lower overall pressure ratings at elevated temperatures. P-T ratings for plastic-seated (soft-seated) valves are significantly lower at temperatures beyond 300°F.

Another poorly understood concept relates to the valve pressure rating itself. Valves are rated as ANSI classes 150, 300, 600, etc. ANSI class 150 (also loosely termed as 150#) does not mean that the maximum pressure rating of this valve is only 150 psi. A steel valve that is rated as ANSI class 150 can handle pressures up to 285 psi at 100°F. Yet an ANSI class 150 bronze valve is rated at a much lower pressure.

### Normal vs design pressure/temperatures

Is the valve operating consistently near the system's maximum design pressure and temperature? Do the system's peak pressure and temperature occur simultaneously? Do these conditions peak out only when the valve is open? These questions would decide the type of valve and its seating material. Many inexpensive soft-seated valves can easily handle high pressures at elevated temperatures for short periods of time, even more so when the valve is open. Metal-seated valves, on the other hand, can handle much higher temperatures for extended periods of time—in both open and closed positions—but may not provide tight shutoff.

### Materials of construction

Selection of a valve's materials of construction is generally based upon their corrosion resistance to the line medium. Both metallic and non-metallic components must be considered. But ask this question: Does the valve stay closed (or open) most of the time? Many materials exhibit different corrosion characteristics in stagnant versus flowing conditions. A case in point is Monel®, a nickel-copper alloy. Monel is extremely well-suited to handling brine in flowing conditions, but is a poor choice in stagnant conditions (Inconel® would be a better choice). The materials must have good corrosion resistance to the line medium, and particular attention should be paid to the possibility of crevice and galvanic corrosion, which may occur when dissimilar parts come in contact with each other.

Concentration of the material in the fluid is very important. Most chemicals are easier to handle in dilute concentrations. However, acids—such as sulfuric acid—become more aggressive as they are diluted with water. Some organic materials that are not corrosive by themselves become so in the presence of water.

Temperature is an important factor in choice of materials because high temperature increases corrosion. In addition, at very elevated temperatures, the pressure rating of the valve can be severely lowered due to deterioration of either metallic or non-metallic material properties.

Materials used in valves in petroleum production, drilling and field processing facilities in $H_2S$ bearing hydrocarbon service experience sulfide stress cracking. NACE standard MR-01-75 provides specific guidelines for their selection

**Determine how much rangeability is required from the control valve. This is sometimes the single most important factor . . .**

criteria.

### Valve rangeability

The ratio of maximum to minimum flow rate can be controlled by a given valve type. A control valve with higher rangeability will control flow over wider flow rates. Determine how much rangeability is required from the control valve. This is sometimes the single most important factor involved in selecting the right type of valve. Typically, globe valves with a quick-opening, flat disc plug provide high rangeability (100 or more). However, quarter-turn valves—such as ball, plug and butterfly valves—are best suited for applications requiring a rangeability of 50 or so. The point to remember is not to be obsessed with having a very high rangeability, because no process approaches this large flow variation, and plug (or ball, disc) positioning accuracy to obtain it is beyond the precision limits of most valve actuators.

### Fire-safe construction

Fire-safe valves allow a small leakage (both internal through seat leak, as well as external stem packing leak) when exposed to a fire. These valves employ a dual seating arrangement made up of plastic and metal seats. Decide if fire-safe construction is a necessary requirement. Stay away from fire-safe valves if you possibly can. Among other problems, fire-safe valves typically require a large size actuator and exhibit a small leak during and after a fire.

### Precise system control

Some system control loops require highly accurate control in the face of severe disturbances. Only narrow deviations from the set point are permitted. The control valve must have good dynamic performance, exhibiting responsiveness, sensitivity, stability and reproducibility. To achieve this, the valve should have low friction, no backlash, and no unstable flow pattern. Rotary valves, such as high-performance butterfly and plug valves employing low-friction bearings and packings, are good candidates. Ball valves have large backlash and are not recommended. Similarly, linear motion valves, such as globe valves, cannot match the low friction of rotary valves.

### Valve actuators

Valve actuators must be stiff enough to resist disturbing fluid forces when the control valve is modulating. They should have no backlash, little friction and good response characteristics. Pneumatic-spring-return actuators have low friction and backlash compared to pneumatic-piston-type actuators. Electro-hydraulic actuators have better dynamic characteristics compared to electro-mechanical actuators. The method of attachment of the valve stem to the actuator is also important, since it is likely to be the principal source of backlash. A tapered spline coupling is a good example of zero backlash. Furthermore, valve positioners may also be mounted on control valves to maintain precise control.

### Aerodynamic noise considerations

Aerodynamic noise generated by the medium flowing through the valve can be estimated by following the manufacturer's published literature. Valves are available with low noise level requirements. However, it should be determined if low noise level valves are justified, since these valves are considerably more expensive. They also have lower flow capacities. Their size increases significantly when discharging to atmosphere or to very low pressures. Furthermore, the small flow passages in some "low-noise" valves are prone to clogging by line debris, thus further reducing their flow capacity.

If noise level is less than 100 dBA, the most economical way to reduce noise would be to use some form of path treatment such as insulation, heavier walled pipe or a silencer. Noise level greater than 100 dBA may create dangerous pipe vibration; path treatment alone is not likely to be effective, so some form of source treatment (such as using some flow restrictor in series with the valve) is needed. Consider installing valves prone to high noise levels away from plant personnel.

### Bi-directional sealing

Decide if this is an important desired valve feature. In most situations, a valve is expected to seal only in one direction, and a unidirectional sealing valve would do. Understand the implications of a wrongly installed unidirectional valve. The valve installation crew often installs a unidirectional valve backwards. Also understand that the valve flow characteristics of certain valve types may vary with the direction of flow.

### Ease of maintenance

Certain valves, especially the "top-entry" ball and plug valves, are very easy to maintain and do not require removal of the valve from the pipeline to replace the seat or the closure member. Similarly, valves with soft seats do not require highly polished seating surfaces to maintain tight sealing, as opposed to metal-seated valves, where the valve closure member and its seat must be lapped together. Lapping is highly labor-intensive and, in many cases, will require special tooling.

### Special services

Specialty and custom-built control valves are often required for difficult applications such as solids, high-pressure/temperature steam, high-temperature fluids subjected to solidification upon cooling to ambient temperatures, cryogenic fluids at temperatures below −100°F, vacuum service, flammable service, dry chlorine, hazardous toxics and fluids with very large pressure drops. Materials required at high temperatures must not only be strong and corrosion resistant, but must also have low galling potential. Extremely low temperatures cause elastomers—or even many metals—to become brittle and crack. Lubricants become stiff and ineffectual, and the stem packing loses the required resiliency for sealing.

When two troublesome conditions exist in the same application, the solution to one problem may be diametrically opposed to the recommendation for the other problem. For example, to minimize plugging for valves handling solid or fibrous particles, the valve should have a large free-flowing orifice, but to minimize noise—or to avoid cavitation—the passages should be small, long and tortuous. If both conditions are present, possible solutions may be extremely limited. The solids must be strained out of the stream before the valve, or else the pressure must be reduced in stages through two or more valves in series. Sometimes a variable speed pump would be required to control the flow rate.

**Piping considerations**

Valves in general can easily withstand the usual loads imposed by piping of the same size. However, if a valve is two or more sizes smaller than the line size, the valve may experience dangerously high bending loads. High bending loads will distort the valve and may cause internal as well as external leakage through the valve.

One solution may be to use several diameters of valve size pipe in series with the valve so that the pipe and not the valve may yield slightly, acting as a fuse to protect the valve. Flange gasket quality and bolt material, as well as the length of the bolts, are equally important to provide a good flange joint.

Sudden opening or closing of the valve can impose excessive forces on the valve. The pressure rise caused by rapid closure of the valve (known as waterhammer) can be predicted. Sudden opening of a valve discharging fluids to the atmosphere can cause excessive reaction thrust, like the recoil of a gun. However, these difficulties rarely arise except with exceptionally long lines and valves with extraordinarily fast actuators. ■