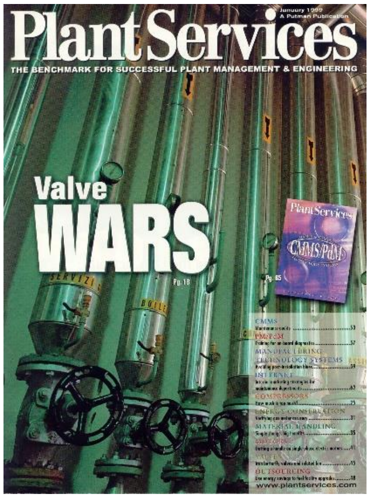

Can any valve be called "the best"?

Rising stem vs. rotary.

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The growing interest in rotary-action control valves resulted in a perceived battle between globe valves and the various styles of rotary valves. In a few industries and applications there is a clear winner. For example, globe valves are really not suitable for handling pulp stock in pulp and paper mills. As a general rule though, it cannot be said that one style of control vale is the best. If there were one "best" control valve type, it would be the only one that the valve manufacturers would make, and that has not happened.

The globe valve is the most mature of the control valve types and offers a wide choice of options. High pressure and temperature ratings are available from most manufacturers as is a broad range of trim materials. A variety of cavitation and noise reduction options are available, ranging from moderately severe duty to extremely severe service. The capacity or C_v rating of a globe valve, as well as the inherent flow characteristic, can be changed simply by changing the trim. Most modern globe valves are of the top entry design. This means that the internals can be replaced while the valve is in-line (although many plant standards do not permit the repair of valves in-line). The globe valve is an extremely versatile design. It is also a very expensive valve, especially for larger line sizes.

The ball valve, both full ball and segment ball, has approximately twice the flow capacity of the globe valves and has the added advantages of long-life rotary stem seals and of being less expensive, size-for-size, than globe valves. Ball valves, with the exception of one-inch segment valves, do not have the option of changing trim size. It is impossible to change the inherent flow characteristic of ball valves. Although there are some options for noise and cavitation reduction, the choices are not as extensive as with the globe valves. Because of their relatively unobstructed straight-through flow path, ball control valves are well suited to media such as slurries and pulp stock.

High-performance butterfly valves have gained widespread acceptance as control valves. They offer high flow capacities comparable to that of ball valves. Of the common control valve styles, these have the lowest price and weigh the least. They are also the least versatile, being more prone to cavitation problems than other control valve styles. They have no options for reduced trim and practically no options for noise or cavitation reduction.

Rotary eccentric plug valves combine several of the features of globe valves and rotary control valves into a single design. They offer much of the ruggedness and the lower pressure recovery factor of globe valves along with the compactness, lower cost and longer stem seal life of rotary valves. Some years ago, one manufacturer began referring to its rotary eccentric plug valves as rotary globe valves and successfully displaced globe valves in a variety of applications. Although less versatile than globe valves, rotary eccentric plug valves accommodate interchangeable reduced trim and provide some cavitation and noise control options. Unlike the other rotary valve styles that have approximately twice the flow capacity of globe valves, rotary eccentric plug valves have flow capacities that are comparable to those of globe valves.

Selecting a Valve Style

In the past, selecting a control valve style was relatively simple. The philosophy was simple: "Whatever valve style we traditionally use in this plant is what we will use this time, too."

Those who specify control valves today are expected to minimize expenses while simultaneously improving product quality and process efficiency. Doing so requires a discussion of some of the factors that need to be considered when selecting the best control valve style for a particular application.

First Cost

The first cost or purchase price of a control valve is, of course, only part of the story. The selection process must consider the total life cycle costs, including installation, maintenance and eventual replacement cost. Nevertheless, the first question that is always asked in a discussion of control valve types is how they compare on the basis of price.

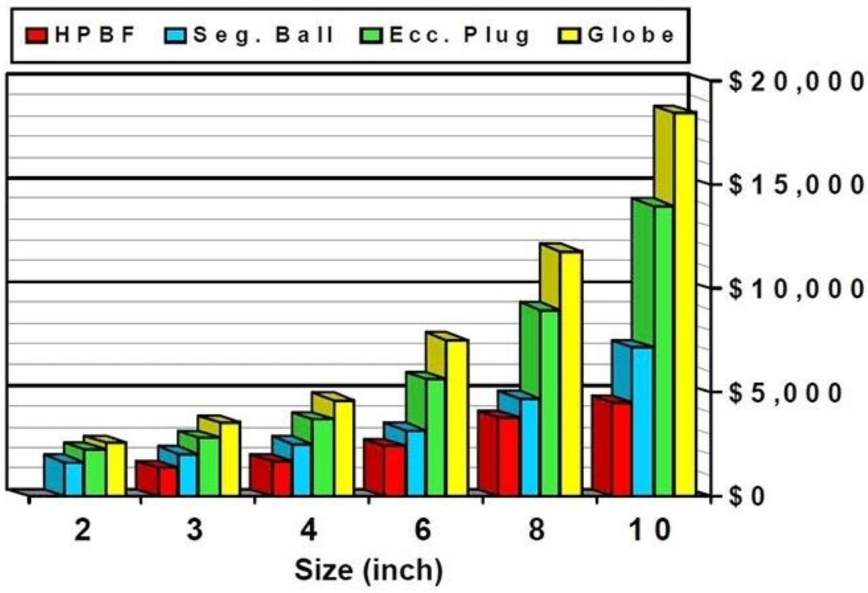

Figure 1: Control valve cost comparison

Figure 1 compares the approximate first costs of typical high-performance butterfly, segment ball, eccentric rotary plug and globe valves. Note that because two-inch high-performance butterfly valves are not very common, no price is shown for that size. The rotary valves are clearly less expensive than the globe valves, with the difference becoming greater as the size increases. If a 10-inch globe valve has the right flow capacity for your application, you should at least check to see if one of the rotary valves would also be suitable for the application.

Keep in mind that, size-for-size, a segment ball valve or high-performance butterfly valve has approximately twice the flow capacity of the globe valves. Most likely, the comparison would be between a 10-inch globe valve costing nearly $19,000 (1998 prices) and an eight-inch high-performance butterfly valve or segment ball valve, either of which would cost under $5,000.

Weight

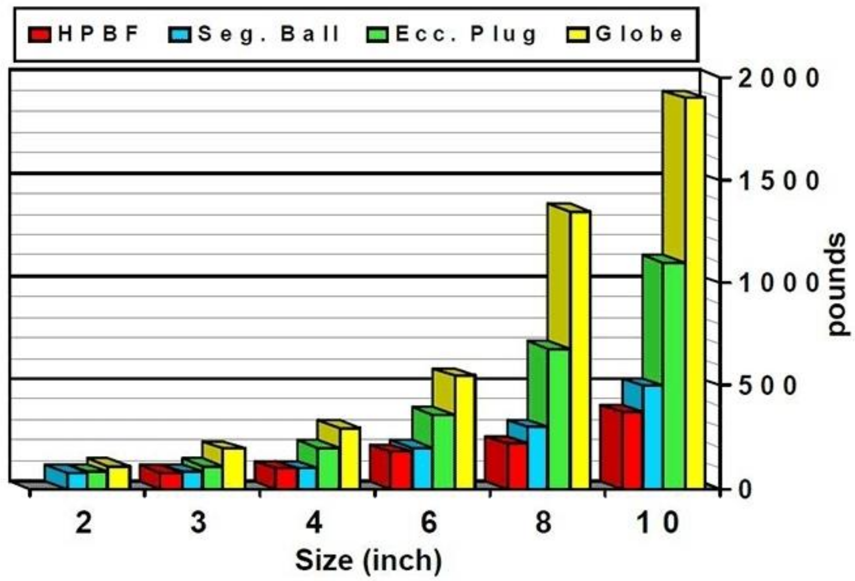

Figure 2: Control valve weight comparison

Figure 2 demonstrates the correlation between the size and the weight of a valve. A significant portion of the cost of a control valve is in the materials. The 10-inch globe valve weighing close to 2,000 pounds would certainly be more costly to install than the alternative high-performance butterfly valve that weighs closer to 300 pounds. Because control valves are among the hardest working components in a piping system, it is almost assured they will need to go to the instrument shop or valve shop for maintenance. Given the choice, most maintenance people would prefer to remove and transport a 300-pound valve than a 2,000-pound valve.

Potential for Cavitation

It is extremely important to avoid cavitation in liquid service. Cavitation very often results in unacceptably high noise and vibration levels and is almost assured to result in rapid valve damage. A detailed discussion of cavitation is beyond the scope of this article. However, recall that as liquid flow streams reach the point in the valve at which the cross-sectional flow area is at its minimum--the vena contracta--the fluid velocity reaches a maximum and the fluid pressure reaches a minimum (see Figure 3). If the reduced fluid pressure approaches the vapor pressure of the liquid, vapor bubbles form in the liquid. Once the flow stream passes the vena contracta, the velocity decreases and the local pressure increases. The bubbles collapse rapidly, generating noise and damaging nearby metal surfaces.

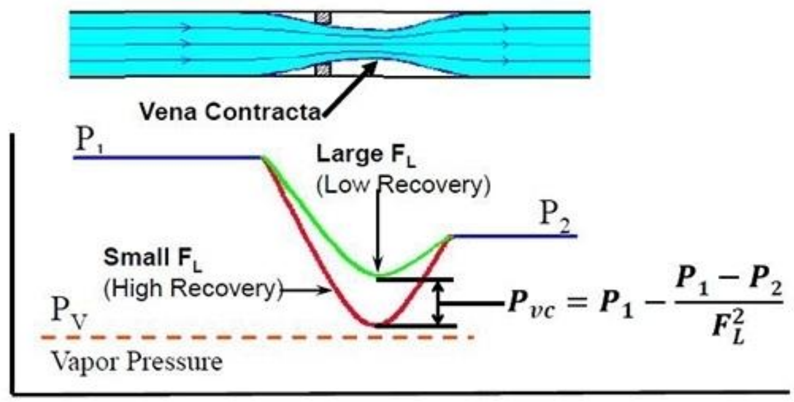

Figure 3: Behavior of liquid pressure inside a control valve

For a given flow rate and pressure drop imposed across a control valve by the system it is installed in, the extent to which the pressure decreases at the vena contracta--and thus the potential for cavitation--is dependent on the internal geometry of the valve. The Liquid Pressure Recovery Factor (F_L), published by valve manufacturers for each style of control valve, quantifies how much the pressure decreases at the vena contracta. The maximum possible value of F_L is 1.0 which makes P_{vc} equal to P_2.

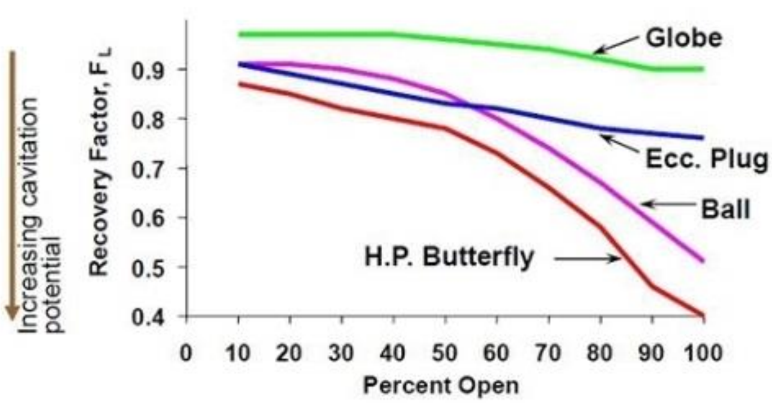

Figure 4: Liquid pressure recovery factor

Figure 4 shows some typical values of FL for different control valve styles. The larger the value of FL, the smaller the dip in pressure as the fluid flow passes through the vena contracta. Globe valves have the highest FL values and, therefore, are the least prone to cavitation. The high-performance butterfly valves have the lowest FL values and, thus, are the most prone to cavitation. This does not mean that high-performance butterfly valves cannot be used in liquid service, but it is important to carefully analyze the application for potential cavitation problems.

Inherent Flow Characteristic

The inherent flow characteristic of a control valve is the relationship between the amount of valve opening and the flow capacity when the pressure drop across the valve is held constant (that is, system characteristics are ignored). In a discussion of control valve characteristics, the actual published inherent characteristic of a control valve is usually compared to the ideal linear and equal percent characteristics shown in Figure 5.

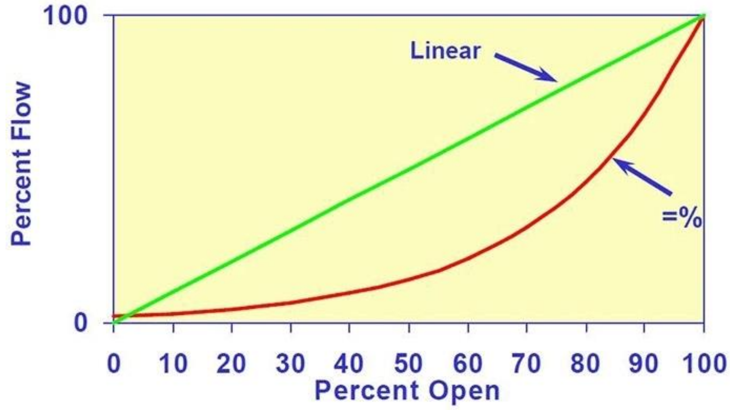

Figure 5. Ideal inherent flow characteristics

It should be obvious from the figure how the linear characteristic gets its name. The equal percent characteristic gets its name from the fact that equal changes in valve stem position produce equal percent changes in flow. Figure 6 shows some typical inherent characteristics taken from data that valve manufacturers publish. Only globe valves offer a choice between linear and equal percent. Experience shows that in 80 to 90 percent of systems, the equal percent inherent characteristic is the best match. The ball valves--both full ball and segment ball--tend to have an inherent characteristic that follows the ideal equal percent curve more closely than the typical equal percent globe valve.

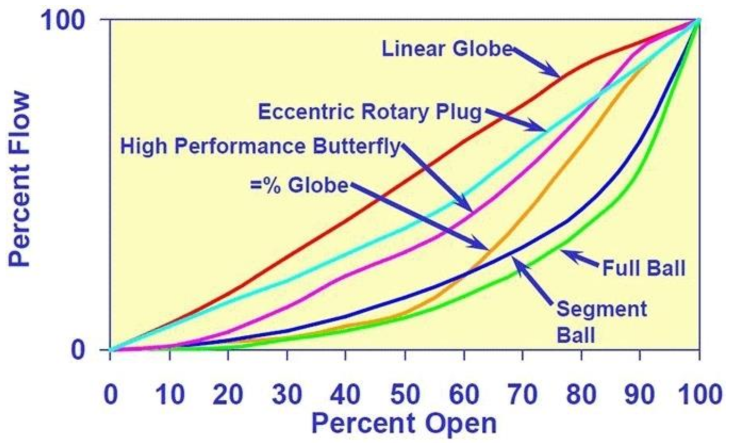

Figure 6. Typical inherent flow characteristics

The high-performance butterfly valves usually have an inherent characteristic that is between linear and equal percent. In fact, one well-known manufacturer refers to the inherent characteristic of its high-performance butterfly valve as "modified linear" while another well-known manufacturer refers to "modified equal percent" for its valves of a similar design. The truth is that it is difficult to argue with either description.

It is difficult to make a general statement about the inherent characteristic of the rotary eccentric plug valve. It tends to be closer to linear than to anything else, but the characteristic of some manufacturer's valves tend to graph above the ideal linear graph. That implies that they are slightly on the quick opening side of linear, while the valves of another manufacturer tend to graph on the equal percent side of linear, as illustrated in Figure 6.

Installed Characteristics and Gain

The reason one is interested in selecting the correct inherent characteristic is because it interacts with the rest of the system to produce the installed characteristic. The installed characteristic is the relationship between the degree of valve opening and resultant flow in the particular system.

Most control valves are installed in systems having centrifugal pumps and/or a significant amount of pipe and fittings. As the control valve opens to increase the flow, the pressure at the inlet of the valve decreases. If there is significant piping losses downstream of the valve, the pressure at the outlet of the valve increases at the same time. The combined effect of the decreasing upstream pressure and the increasing downstream pressure is to decrease the pressure drop available to the valve. It is the decreasing pressure drop across the valve that makes the installed characteristic different from the inherent characteristic.

The interaction between a valve with an inherent equal percent flow characteristic and a system exhibiting decreasing available pressure drop as flow increases results in an installed characteristic that is close to linear. As a general rule, systems that behave in a linear manner are easier to control than systems that behave in a non-linear manner. This is why a majority of control valves are specified with equal percent inherent characteristics.

Any non-linearity in the installed flow characteristic of the control valve means that the process gain changes with the operating point. This moving target makes optimum controller tuning difficult and can often result in loop instability. Analyzing the installed gain of the control valve (the instantaneous slope or derivative of the installed characteristic) gives a better idea of how well a particular valve can be expected to control a specific application. Calculating the installed flow characteristic and gain by hand can be quite tedious, but with the appropriate computer software, the process is quite easy.

Figure 7 shows the installed gain of a segment ball valve and a globe valve in the same system. Note that the "best fit" globe valve is larger than the "best fit" segment ball valve. This is not unusual since ball valves have a much higher flow capacity, size-for-size, than do globe valves. In this example, the gain for the segment ball valve is more constant within the relevant flow range--the two vertical lines on the graph. This means that more aggressive controller tuning will be possible without risking loop instability. It is not the intent of this example to state that one particular valve style always has a better installed gain graph, but rather that installed gain is one of the factors to be considered when selecting the best control valve for an application.

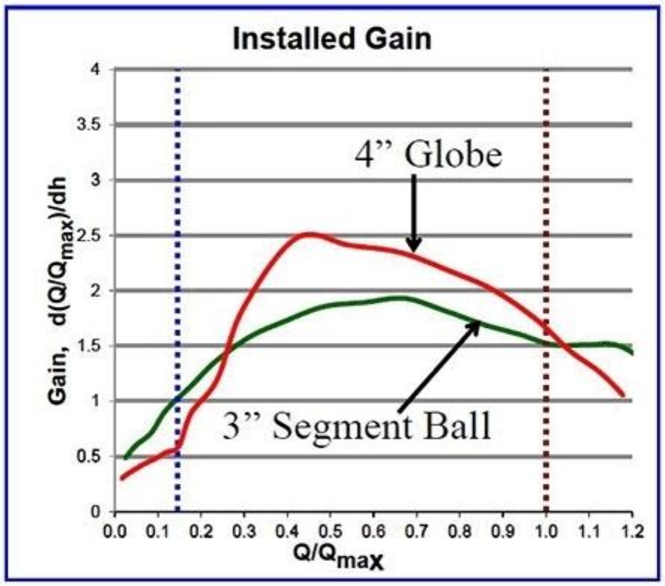

Figure 7: Comparison of the installed gain of two different valves in the same system.

The selection of a control valve for an application should not be left to chance. Tradition should be kept in mind, especially if a particular style performed well in the same service in the past. However, as a minimum, consider the areas mentioned above to ensure the lowest overall life cycle cost and the best possible degree of process control.