

WHY MOST CONTROL VALVES TODAY ARE THROTTLING AROUND 60% OPENING

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VALVES ARE ALWAYS OVERSIZED

The required flow capacity, C_v , of a control valve for an intended application is determined by the use of recognized valve sizing equations.

The minimum rated capacity of a control valve is deliberately chosen to be greater to provide for the ability to control the designated variable in the process. This is often accomplished by a specification requirement that stipulates that the rated capacity must be at least 20 percent greater than that calculated to be required by process conditions corresponding to maximum flow.

There is a second influence upon the degree of oversizing of a control valve, and that is the normal progression of valve flow capacity by valve size. This normal progression of capacity is equal to 80% per size in a typical line of valves. In this way the average percentage of oversizing is 40 %.

The combined effect of these two influences is the average control valve in a large population will be oversized by a factor of $1.20 \times 1.40 = 1.68$, or 68% oversized in capacity. The inverse number of 1.68 is approximately 0.60. This means that the average control valve will throttle at 60% of signal span at maximum flow conditions.

More important is the fact that the valve will spend its life responding to 0% to 60% of the signal span (e.g, 4 to 13.6 mA, or 20 to 10.4 mA) taking into account the fact that the normal flow condition is somewhat lower than the maximum flow.

INSTALLED FLOW CHARACTERISTIC

The inherent flow characteristic of a valve is normally shown as the relationship of C_v versus travel. The same characteristic would apply to flow versus travel at constant pressure drop. It is often useful to show the characteristic of flow versus signal.

Once a valve is installed in a system, the flow characteristic is altered.

The degree to which the characteristic is altered depends upon the relative system resistances and the characteristics of the pressure source.

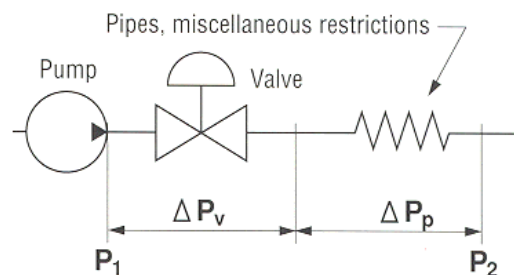


Figure 1

These influences are most easily treated as a lumped parameter of the ratio of pressure drop across the valve in the open position to the closed position. Figure 1 represents the context of the process. Figure 2 illustrates the installed flow characteristic of a valve having an ideal linear characteristic with various pressure drop ratios across the valve.

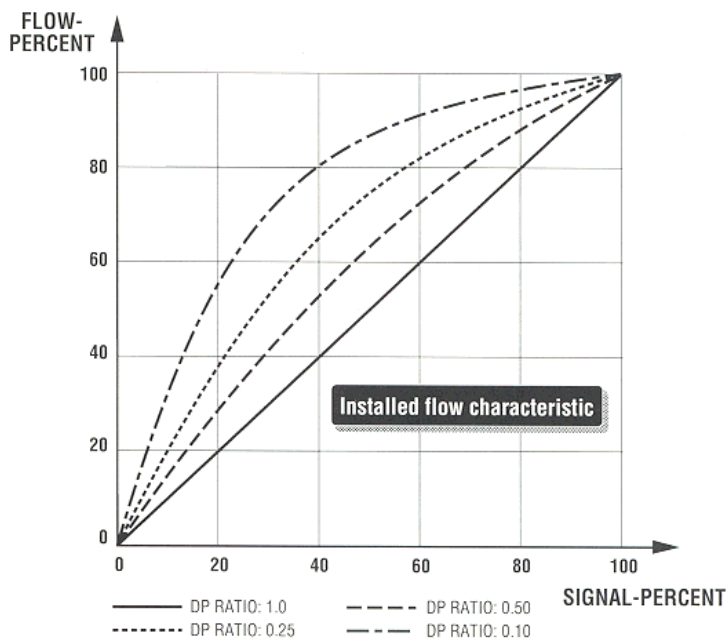


Figure 2

For the case of the average 68% oversized valve, the installed characteristic at various pressure drop ratios for the same valve is shown in Figure 3. The entire curves are now compressed into the first 60% of signal span.

The effect of oversizing is twofold:

1. *A reduced portion of the signal span is used, increasing the effect of deadband.*
2. *Valve gain is increased having an effect on optimum controller settings-wider proportional band and faster reset.*

IMPROVED PERFORMANCE

The installed performance of a control valve would be improved if the valve could respond to the full instrument signal range, or a greater portion of the signal range. This will change the installed flow characteristic from the Figure 3 condition to the more favourable Figure 2 condition.

This can easily be accomplished through the use of a valve with externally adjustable flow capacity. In order to accomplish this goal, however the valve must possess high inherent Cv ratio, i.e., a Cv ratio of greater than 100 to 1.

The advantages of a control valve having externally adjustable capacity combined with high inherent Cv ratio are:

1. *A greater portion of the signal range can be used resulting in improved sensitivity through reduced deadband.*
2. *Improved control through reduced valve gain allowing narrower proportional band and slower reset.*

Furthermore, through the selection of the proper cam characteristic depending upon pressure drop ratio, a more linear installed characteristic of flow versus signal can be achieved. Figure 4 illustrates, for example, the difference between a 6" oversized globe valve (full area trim, rated Cv = 400, curve A) and a 6" valve with adjustable Cv (trim Cv 550 adjusted at rated Cv = 240, curve B or C). As the pressure drop ratio chosen in the example is 0.25, the equal percentage Cv characteristic C is obtained by the proper cam of the positioner to get a flow characteristic C' almost linear. This is, of course, a better solution than the linear Cv characteristic B. The Cv characteristic A is the worst solution using only 60% of the input signal.

"C" solution results in more constant valve gain over the signal range. Because loop gain is the multiple of all individual gains of the elements of the loop including the valve, the net result is a more constant loop gain, allowing optimum controller tuning.

MASONEILAN OFFERS A NEW CONCEPT IN CONTROL VALVE

In addition to the reasons given above, the uncertainties inherent in the process conditions used to calculate the required valve flow coefficient Cv, the control valve is almost always not at the initially desired control position.

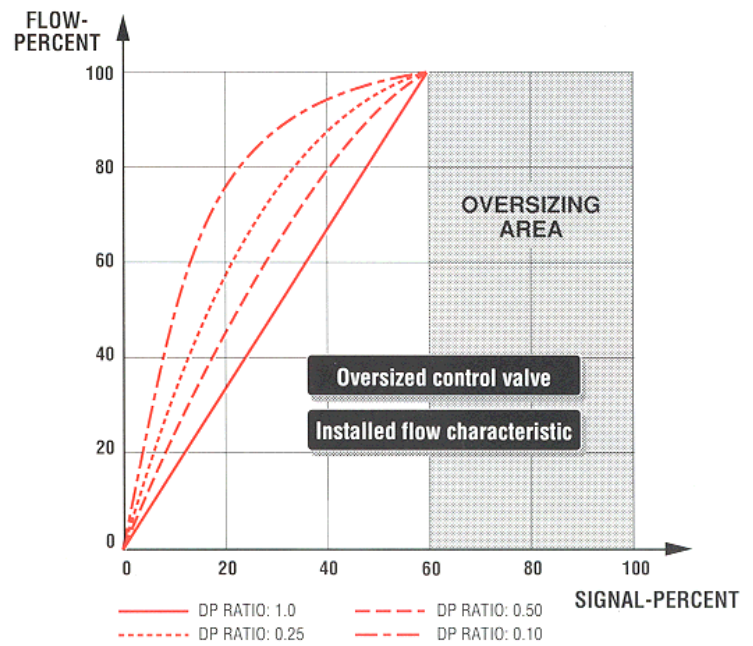


Figure 3

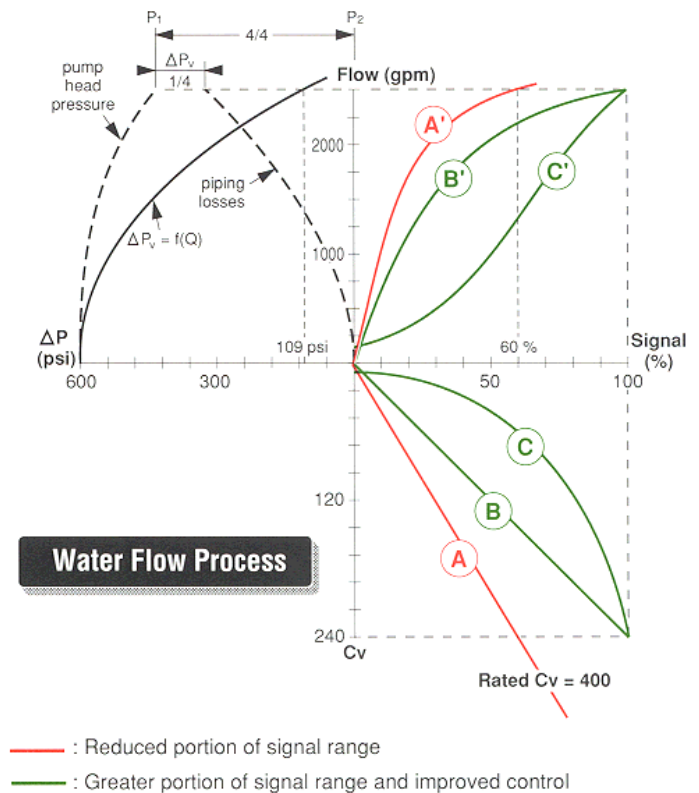
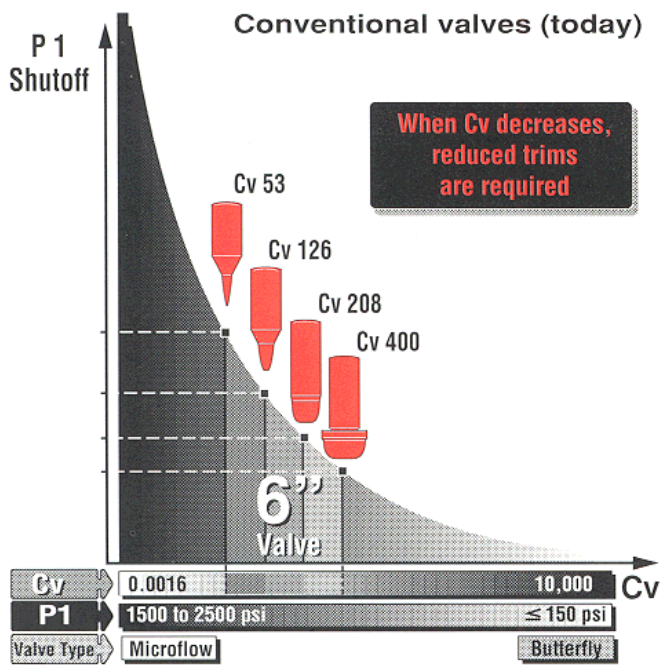


Figure 4

Two of the uncertainties in this field is the knowledge of real value of pump head pressure and piping losses during system design. One recent paper from Stone & Webster Engineering Corporation shows that the problem exists. For instance a pump with a flow capacity greater than required will develop higher discharge head. Conservative data concerning friction in pipes improperly increase pipes losses. The common consequence is the underestimation of the actual pressure drop through the control valve and so the oversizing of the flow coefficient Cv.



Note: Schematic curve with typical example (without scale) for a 6" valve size.

Figure 5

To overcome this problem, one of the solutions offered today is to provide a large number of different trim sizes with incremental Cv value to meet the required flow rate. See Figure 5.

This obviously calls for both a large number of different plugs and different seat rings for each valve size. It is not always sufficient to avoid the oversizing of Cv. The example of the figure 4 imposes to use the trim with the rated Cv 400 giving an oversizing of 67 %.

VARIMAX ELIMINATES THE OVERSIZING PHENOMENON

VARIMAX ELIMINATES THE NEED FOR REDUCED TRIM

Thanks to the Adjustable Torque Actuator[®] ATA, the flow coefficient of Varimax can be adjusted without change in control signal. See Figure 6.

With Varimax you can select the valve size as soon as you have determined the pipe size, knowing that you will be able to ultimately adjust the Cv of the Varimax as required.

The Cv of Varimax for instance could be adjusted by plus or minus 45% if initially set at mid band setting; however, depending upon the needed final Cv, other specific adjustments are possible.

Our previous example, figure 4, with a rated Cv of 240 can be achieved by the 6" Varimax eliminating all oversizing.

WHEN P1 INCREASES THE Cv DECREASES

A worldwide Product Marketing Survey conducted recently by Masonellan has shown the practical and physical relationship between pressure and flow coefficient. It is not surprising that the general rule is that large valves (butterfly) work under low pressure and low flow valves (microflow) are subject to high shutoff pressure.

This phenomenon illustrated in Figure 7 explains why the actuator thrust required to overcome the unbalanced force created by the fluid acting on the valve trim is proportionally higher on small valves than on large valves.

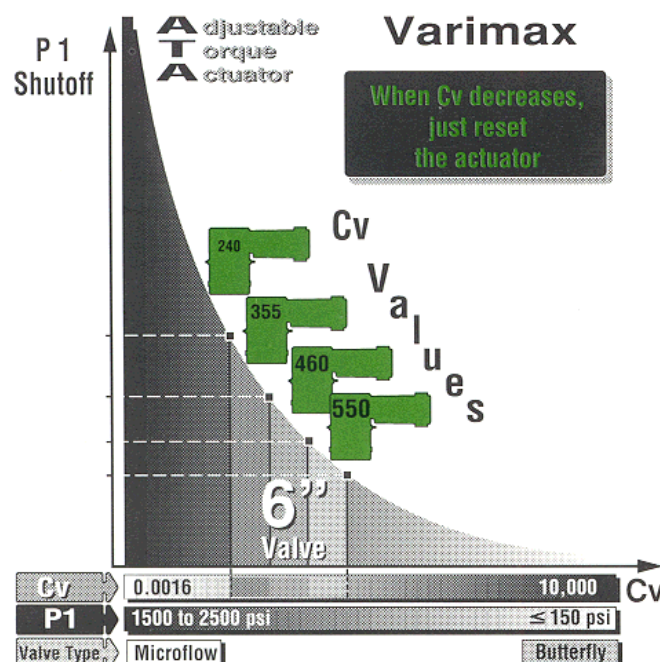


Figure 6

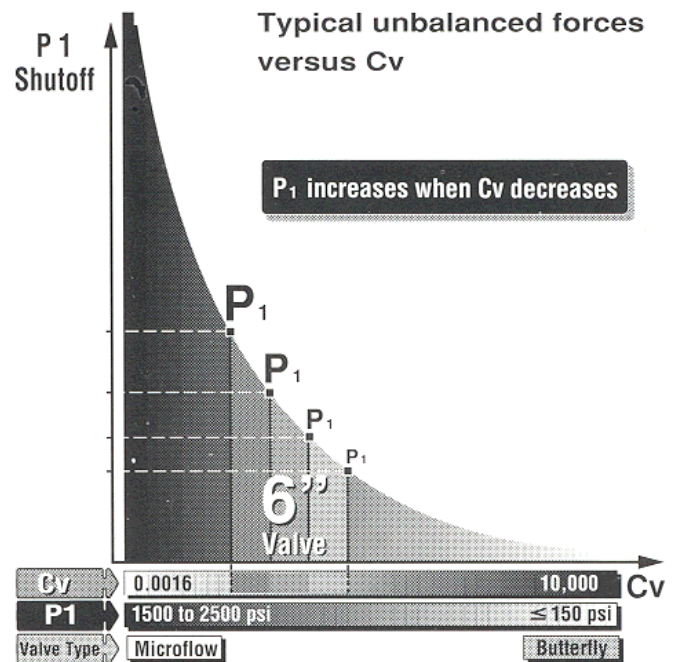


Figure 7

This means that for example in the range of Cv covered by a 6" valve, the shutoff pressure P1 is on average higher on the lowest Cv values than on maximum Cv values; this explains why valves with reduced trim are often simultaneously equipped with an oversized actuator. See figure 8.

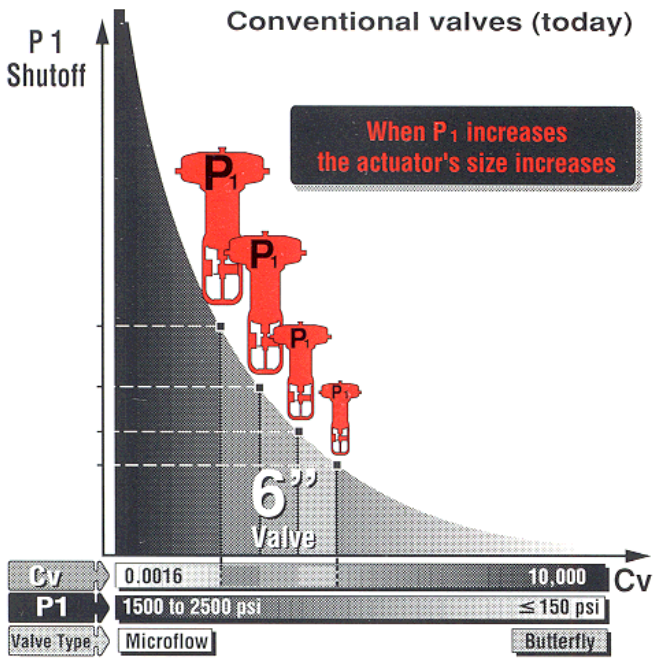


Figure 8

VARIMAX ELIMINATES THE NEED FOR OVERSIZED ACTUATORS

Varimax is equipped with an Adjustable Torque Actuator[®] ATA eliminating the need for oversized actuators as needed by today's technology. The output torque of the ATA is adjustable to the ratio of 1 to 2.5 depending on the initial setting required; as shown on Figure 9 the standard ATA mounted on a 6" Varimax could be adjusted to an output torque of 54 inch/pound if set at maximum Cv or to an output torque of 135 inch/pound if set at minimum Cv.

The example of the figure 4 page 2 leads to a pressure drop of 109 PSI and a flow rate of 2500 gpm through the valve in open position (shut off pressure drop equals 600 PSI). This situation corresponds to 118 kW of hydraulic power dissipated in the valve when fully opened.

References:

- ① J. Harkins and E. Hoyle, (Stone & Webster Engineering Corp, Boston, Mass) Control-valve sizing: The first step, EPRI Valve Symposium, August 1990
- ② ISA Standard S75.01
- ③ Handbook for Control Valve Sizing - Masoneilan
- ④ Instrumentation Industrielle. Volume 2 - Partie 2 Edition Technique et Documentation

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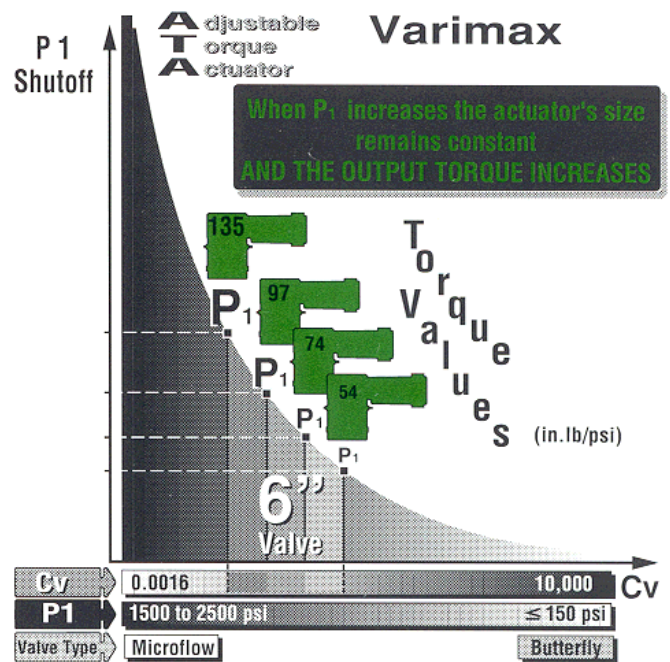


Figure 9

Due to the growth in output torque on the ATA when the Cv decreases, the standard actuator of the figure 8 is quite sufficient: the maximum allowable pressure drop in open position (Cv 240) is 395 PSI and 1170 PSI in closed position. This upper limit corresponds to 820 kW of hydraulic power dissipated in the valve when fully opened...what will be of course never reached!

THE NEW GENERATION IN CONTROL VALVE

Varimax represents a major advance in the evolution of automatic throttling control valves. Its application envelope extends beyond the already successful Rotary Valves. It assimilates all the globe valve performances with the technical advantages specific to the rotary design.

The new Adjustable Torque Actuator includes a new concept to compensate for control valve oversizing that leads to improved dynamic control characteristics. The Varimax is the only control valve in today's market with these unique design features ■