JORDANVALVE

Combating Droop

In Self Contained Pressure Regulators

Combating Droop in Self-Contained Pressure Regulators

When selecting valves for pressure reducing applications, there are several factors to consider.

First you must decide whether the application requires a control valve in order to be effective, or if a self-operated or pilot-operated regulator will be sufficient. In order to make this decision, you should consider:

- What is the inlet pressure and pressure drop
- What is the set point
- Temperature
- Speed of response
- Process fluid
- Line size
- Will there be large flow variations or is the flow steady
- How critical is the regulation/control
- Is feedback to a Distributed Control System required (DCS)

If a regulator meets the design criteria, it will prove a more cost-effective means of pressure reduction in almost all cases. In addition to lower overall costs, a regulator offers two major advantages:

1. fast response, and
2. being self-contained (i.e. not requiring control loops, compressed air, or electrical power).

Fast response is a great advantage when applied to non-compressible media or in applications where delayed shut-off might lift a safety relief valve. Additionally, regulators are sensitive to load variations commonly seen when controlling fluid pressures on heating or cooling applications.

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When engineering the application, the Droop Effect of self-operated and pilot-operated regulators is the primary factor to consider.

So, What Is The Droop Effect?

Droop is an inherent characteristic of all self-operated and pilot-operated regulators. It is expressed as the deviation of controlled pressure from the set value or set point that occurs when a regulator travels from the minimum flow position toward the full flow position.

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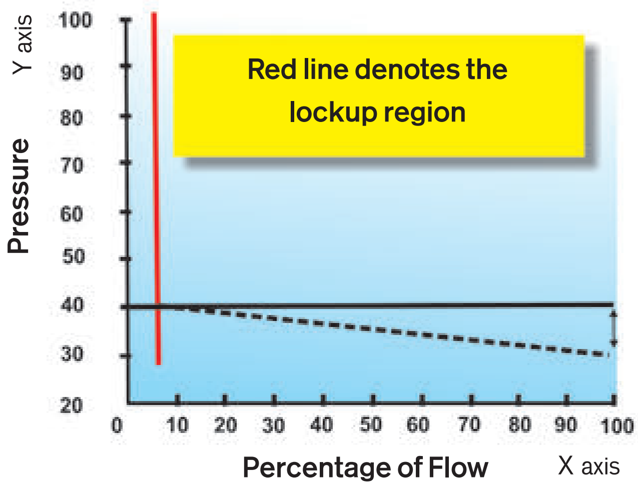

Figure 1

Figure 1 shows the droop effect for a regulator set at 40 psi as the valve travels from minimum flow position to the maximum flow position. The droop is expressed by the difference between the dotted line and solid line. The dotted line represents the actual controlled pressure obtained, and the solid line represents the line of perfect regulation. The red vertical line shows the Lockup Region. When operating to the left of the line, small changes in flow will result in large changes in controlled pressure.

Typical Application

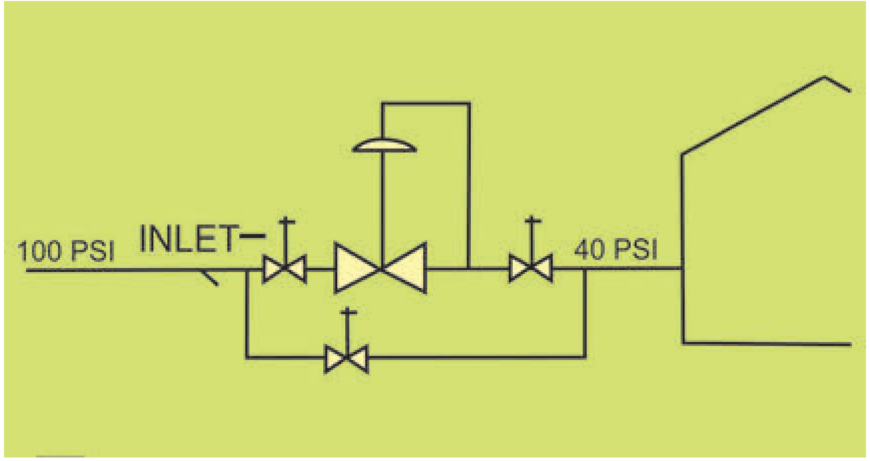

Figure 2

Increasing or decreasing the amount of force applied to the spring establishes the set point for a self-contained regulator.

Consider the application in Figure 2. We have 100 psi water pressure available to this building. To best operate the equipment and taps, it is necessary to reduce the pressure to 40 psi. We can install a pressure-reducing valve on the service line to handle this reduction for us.

When there is no demand for water, no flow is required and thus the regulator is in lockup. As demand for water increases to the full capacity of the valve, the regulator moves to the full open position. However, since the regulator will droop with increasing flows, the set pressure of 40 psi to the building will not be maintained. **Why?**

Increasing or decreasing the amount of force applied to the spring establishes the set point for a self-contained regulator. In most cases, this is done with an adjusting screw. Turning the adjusting screw clockwise threads the screw further into the spring housing, which compresses the spring and increases the set point. Turning the adjusting screw counter-clockwise allows the spring to expand and decreases the set point.

Downstream pressure is transmitted to the diaphragm, either internally or via a downstream control line tapped into the pipeline. When downstream pressure beneath the diaphragm exceeds 40 psi, the spring compresses and the valve closes. When the pressure beneath the diaphragm decreases, the valve opens once again. In other words, the spring will not expand or be compressed unless there has been a decrease or an increase in the pressure (force) opposing it. Therefore, the valve plug will not travel unless there is a change in downstream pressure.

When downstream demand increases, the valve travels toward the full open position. This causes the spring to push the valve toward open, increasing the flow to meet the higher demand and expanding the spring. The spring having just expanded to further open the valve is now exerting less force on the diaphragm than it was before, so therefore, to maintain a balance of forces the controlled pressure has to be less. (Note: The set point never changes. It is only the controlled pressure that changes and the deviation from set point is either droop or lock-up pressure).

It is possible to minimize droop which is determined by three factors.

How Do You Reduce Droop?

As stated earlier, droop is an inherent characteristic in any self-operated or pilot-operated regulator. However, it is possible to minimize droop, which is **determined by three factors**:

1. Diaphragm Area
2. Spring Rate (or stiffness)
3. Length of Stroke

Increasing the diaphragm area, decreasing the spring rate, and/or decreasing the length of the valve stroke can reduce droop. It is important to remember that these factors are interrelated.

Diaphragm Area - The diaphragm area is restricted by economic and practical reasons. Larger diaphragms tend to increase the overall cost of the regulator since they require larger spring housings, heavier bolting, etc.

Spring Rate - Manufacturers will typically utilize the lowest rate spring that will allow for an adequate range of pressure adjustments (set points) and still retain the sensitivity to small changes in pressure. It is possible to reduce droop with low rate springs, but there also exists the chance of making the regulator too sensitive, which will create instability. Additionally, the range of set points with a very light spring may prove too narrow for general industrial use. If a heavier spring is used, lengthening the spring can increase the sensitivity, but this is restricted by economics and valve size.

Length of Stroke - The distance a spring is required to expand to go from minimum to maximum flow can be reduced to decrease droop. The set point for any self-contained regulator is established by increasing or decreasing the initial compression required to balance the controlled pressure force on the diaphragm. In most cases, this is done with the adjusting screw. When flow conditions downstream cause the valve to move toward the full open position, this also "adjusts" the spring from the bottom. Thus, when the valve opens to compensate for additional flow demand, the spring is allowed to expand and the controlled pressure decreases (set point never changes, only the deviation from set point). To minimize the droop, Design Engineers can utilize regulators offering a shorter overall stroke length.

Pilot-Operated Valves

Pilot-operated valves have less droop than simple self-operated regulators. The additional sensitivity is obtained by a combination of the pilot diaphragm, pilot spring, and pilot valve stroke. The required stroke in most pilot valves is minimal because only a small amount of flow is required to load the diaphragm of the main valve. Minute pressure changes are all that is necessary to stroke the pilot valve to load the main diaphragm which will fully open the main valve. There will be droop, but it will not be as dramatic as a self-operated regulator.

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How to Choose the Right Valve

Most self-operated regulators will droop about 10-20% of the initial set point. For higher set points, heavier springs are often used and droop may be considerably higher. Most pilot-operated regulators have a droop around 1-5%.

The majority of applications do not require a valve to throttle from 5% open to 100% open, and so the droop will be minimized. In fact, if the lowest flow required is 20-30% of the maximum flow, the droop may be negligible. If the flow demands are relatively constant, or 10-20% deviation from set point is tolerable, a self-operated regulator should be used. If the fluctuations are great, or accuracy is essential, it may be necessary to go to a pilot-operated regulator or a control valve.

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General Rules

- A piloted operated regulator has less droop than a self-operated regulators
- Air loaded regulators are much more accurate because the spring is eliminated, however they can be prone to instability in fast changing applications
- High-flow regulators with longer strokes are less accurate than standard regulators
- Typically, the shorter the overall stroke, the lower the droop
- Larger diaphragms will increase overall accuracy
- Regulators supplying multiple users/vessels may be more accurate than regulators supplying a single unit/vessel since it is unlikely they will all go on or off at the same time
- The set point should be toward the high end of the selected spring range to give increased accuracy of regulation (always use the lowest practical spring range for best accuracy)
- Avoid the temptation to oversize the regulator (i.e. using a higher Cv value) to reduce the amount that the valve has to open to meet a given increase in demand with the thought that droop will be reduced. This can often cause instability resulting in major fluctuations in the controlled pressure.

Oversizing can also result in operation within the “Lockup Region” where small changes in flow can result in large changes in the controlled pressure.

About the Author

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