

Combating Droop in Self-Contained Pressure Regulators

by Tim Gainer

When qualifying valves for any pressure reduction application, there are several factors to consider. Initially, you must decide whether the application requires a control valve in order to be effective, or would a self-contained or piloted regulator be sufficient? In order to make this decision, you should consider:

- What is the pressure drop, or the difference between P1 and P2?
- What is the set point?
- Will there be large flow variations?
- How critical is the regulation/control?

If it meets the design criteria, a regulator will prove a more cost effective means of pressure reduction in almost all cases. In addition to lower overall costs, a regulator offers other advantages, primary of which is fast response.

This responsiveness is of great value when applied to non-compressible media, or in applications where delayed shut-off might blow a safety relief valve. Additionally, regulators are sensitive to load variations commonly seen when controlling heating or cooling pressures.

When further engineering the application, the Droop Effect in a self-operated and pilot-operated regulator 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 pressure from the set value that occurs when a regulator travels from the minimum flow position to the full flow position.

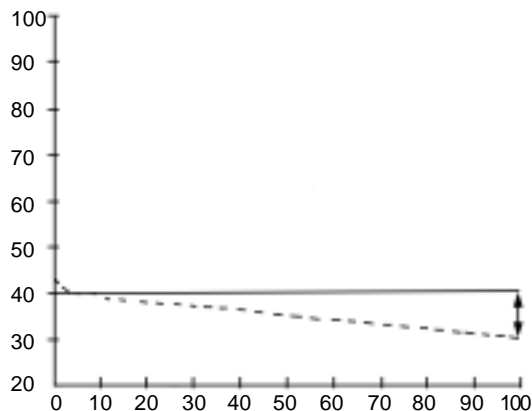


Figure 1

Figure 1 shows the effect of droop in 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.

1. **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.
2. **Spring Rate** - Design Engineers 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 the Droop with low rate springs, but there also exists the chance of making the regulator too sensitive, which will create instability. Plus, 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.
3. **Length of Stroke** - The distance a spring is allowed to relax in proceeding from minimum to maximum flow can be reduced to decrease the droop. The set point for any self-contained regulator is established by increasing or decreasing the amount of force applied to the spring (spring compression). In most cases, this is done with the adjusting screw. When flow conditions downstream causes the valve to move toward full open, this also “adjusts” the spring from the bottom. Thus, when the valve opens to compensate for additional flow demand, the spring is allowed to relax and the set point decreases. To minimize the Droop, Design Engineers can utilize regulators offering a shorter than normal overall stroke length.

Pilot-Operated Valves

Pilot-operated valves have less Droop than self-contained valves. The additional sensitivity is obtained by a combination of the pilot diaphragm, pilot spring, and pilot valve stroke. The required stroke in most piloted valves is minimal, as little flow is required to load the diaphragm of the main valve. Minute pressure changes are all that is necessary to fully move the pilot spring. There will be droop, but it will not be dramatic.

How to choose the right valve

Most self-contained regulators have a droop of about 10-20% of rated capacity. For higher set points, heavier springs are utilized and droop may be considerably higher. Most piloted-operated regulators have a droop around 2-5%.

Most 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 minimum 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-contained regulator should be used. If the fluctuations are great, or accuracy is essential, it may be necessary to go to pilot-operated valves or instruments.

General Rules

- A piloted regulator has less droop than a non-piloted regulator
- Air loaded regulators are much more accurate because the spring is eliminated
- High-flow regulators are less accurate than standard regulators
- Typically, the shorter the overall stroke, the less the amount of Droop
- Larger diaphragms will increase overall accuracy
- Regulators supplying a medium to multiple users/vessels will be less accurate than regulators supplying a medium to a single unit/vessel
- The set point should be toward the high end of the selected spring range to give increased accuracy of regulation