Pressure Controls EXPRESS

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Droop and accumulation, they go with the flow!

By Louis J. Arcuri, Territory Sales Manager

We've all heard the term droop used when referring to regulator performance, but most of us never fully understand the meaning of this term. Yet, its presence can send your customer running to the phone, complaining that the regulator he just bought doesn't work very well. If you include a droop evaluation as part of your application sizing effort, you'll prevent this problem from making your day feel like a train wreck in the making.

Simply put, droop is the change in outlet pressure (P2) of a regulator as the flow (Qg) changes. In a pressure reducing regulator, the outlet pressure drops (or droops) as the flow increases. As the flow decreases, the P2 pressure goes up, or recovers to just above the original setpoint. Droop is the result of loading force changes in the regulator, and is caused primarily by the load spring. We'll address ways of dealing with droop later in this document.

How does it work?
To better understand droop, let's evaluate the performance of a regulator for a typical application. Our customer needs a regulator for nitrogen service, set at 100 PSIG. The gas source is a cylinder, pressurized to 2600 PSIG (P1 pressure.) Most nitrogen cylinders are packaged at 2200 – 2600 PSIG when full. If the cylinder

sits outside on a gas pad in the heat of the sun, you can assume that the initial cylinder pressure will be on the high side of this range. Small lecture bottles are packaged at lower pressures, but will still exhibit pressure decay as the process consumes the gas. The subject regulator needs to deliver 2 SCFM. Let's refer to a flow (or droop) curve for our subject pressure-reducing regulator (*Figure 1 - page 3*). Note that at zero flow, the regulator setpoint (P2) is established as 100 PSIG. We will use the flow curve labeled

Continued on page 3.

INSIDE

QUOTE OF THE MONTH

"October, here's to you. Here's to the heady aroma of the frost-kissed apples, the winey smell of ripened grapes, the wild-as-the-wind smell of hickory nuts and the nostalgic whiff of that first wood smoke."

– Ken Weber
in Providence, RI, *Journal-Bulletin*

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EMERSON. Process Management

Congratulations Distributors!

Industrial Controls held their **Level I Distributor Training** on September 26 - 27, 2005 at the IC facility in Elk River, Minnesota.

Congratulations to the following participants who completed this 2 day training course:

Left to right

Mike Schreiner, Accutech
Reed Christensen, Dowland-Bach
Doug Robbins, Dowland-Bach
Bob Johansen, Army Dive School
Robert Prause, Hatfield/Houston
Chad Calvert, Enpro
Andy Gorrell, Enpro
Bill Wright, Fiero
Andy Schaeffel, Enpro
Brian Huza, Enpro

Product/System Spotlight

No interruptions please... get continuous high pressure supply

This panel is used to automatically switch supply gas, without service interruption, to a back up supply when the primary side falls below a pre-set pressure. The system can use multiple 6 Kg PSIG bottles with outlet ranges up to the supply pressure. Indicators on the panel tell the user if the back up supply is in use or getting low. Once the primary supply is replenished the system will automatically switch back and continue to run off of the primary supply. The system runs off of 24 volts and may be mounted to a wall.

NA-46

For questions about this product or to inquire what Systems can do for you, please contact Jeff Wakefield, Systems Sales Engineer at 763-241-3316 or jwakefield@tescom.com.

Literature

High Purity Controls

22-5400 Series - Form No. 1988
NEW PRODUCT - catalog page

64-5400 Series - Form No. 1987
NEW PRODUCT - catalog page

12 Series - Form No. 1890
Revised - catalog page
Please use up old stock.

35 Series - Form No. 1889
Revised - catalog page
Scrap *old stock.*

Please order through our 'Distributor's Only' section of our web site or contact Robyn Seitzer at rseitzer@tescom.com.

"Ideas are like rabbits. You get a couple and learn how to handle them, and pretty soon you have a dozen."

– John Steinbeck

Droop and accumulation, continued

for P1=3500 PSIG to evaluate our subject regulator's performance, since our inlet pressure is 2600 PSIG. To determine the droop at 2 SCFM, follow the 3500 PSIG flow curve until it intersects the vertical line marked 2 SCFM. At this point, draw a horizontal line to the left until it intersects the vertical line marked with P2 pressures, and read the pressure value on the vertical (P2) scale. In our example, we find that the outlet pressure has drooped to approximately 68 PSIG. We just learned that at a flow rate of 2 SCFM, the outlet pressure of our regulator would drop from 100 PSIG to 68 PSIG; the droop is 32 PSIG.

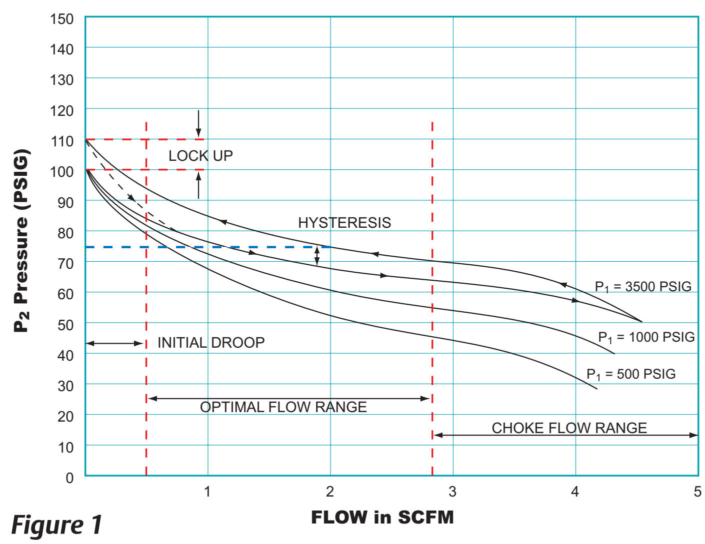

Figure 1

Moving further along the droop curve to 3 SCFM, we see that the P2 pressure is now 65 PSIG. At approximately 2.8 SCFM, the droop curve starts to drop off significantly. This is the point at which the main valve of the regulator is wide-open, and no longer regulating pressure. We call this area of the flow curve the choke flow range. The regulator is no longer working; it's really nothing more than a fixed orifice in a piece of pipe. We generally don't consider the choke flow range as part of the regulator's working flow range, so try to avoid specifying a regulator with a flow requirement that falls into the choke flow range of the regulator you're evaluating for an application.

If we start to reduce the flow from 3 SCFM towards zero flow, we note that the P2 pressure climbs toward the original 100 PSIG set point. Something interesting occurs, however. The P2 pressure at 2 SCFM is approximately 75 PSIG, not the 68 PSIG we observed when the flow was increasing. This phenomenon is known as the hysteresis of the regulator, and is usually consistent in flow excursions. Other than recognizing it for what it is, hysteresis is usually not an issue in evaluating the performance of a regulator.

To get a full picture of how the regulator will perform in our application, we should take into account the fact that the inlet pressure will decrease as we consume gas from the cylinder. In fact, most people try to get as much gas from the cylinder as possible, usually allowing cylinder pressure to drop to 200 PSIG before they change out the cylinder. Therefore, we should perform a droop evaluation at P1 = 500 PSIG to see if the regulator will still meet our customer's expectations. Using the flow curve labeled P1 = 500 PSIG, we see that the droop at 2 SCFM is now approximately 52 PSIG, or nearly half of the original 100 PSIG setpoint. Clearly, the droop gets worse as the inlet pressure falls. If our customer had specified an outlet pressure of 100 PSIG, +/- 40 PSIG, we might have considered the subject regulator as suitable for the application if we

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Trade Shows

TechnoPharm
October 11-13, 2005
Exhibition Centre Nuremberg
Nuremberg, GERMANY
Booth 12-250

ISPE Scotsdale, AZ
November 6-8, 2005
JW Marriott Desert Ridge
Scotsdale, AZ USA

Fuel Cell Seminar
November 14-18, 2005
Palm Springs Convention Center
Palm Springs, CA USA
Booth 242

Droop and accumulation, continued

only considered its performance when the cylinder is full. But, by conducting an evaluation with a low inlet pressure, we see that the regulator would not meet the customer's expectations under this condition. Therefore, we would not have specified this regulator for our customer's application, thereby eliminating that dreaded phone call from an unhappy customer!

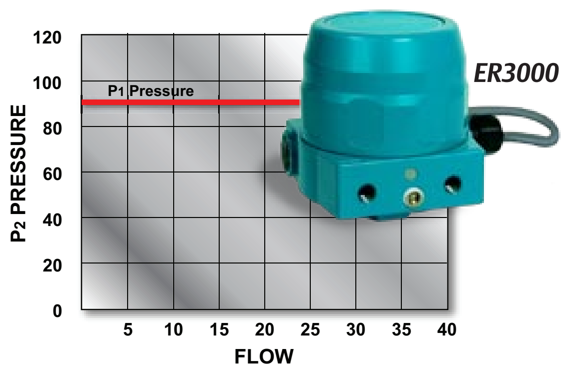
Evaluating droop for gases other than air or nitrogen

You can use the flow curves to evaluate applications for gases other than air or nitrogen. Using compensation factors found in Tescom's document, 'Flow Formulas For Computing Gas and Liquid Flow Through Regulators and Valves', you multiply the flow values by the appropriate multiplier to get a new flow scale for the gas involved. For example, to convert nitrogen flow to hydrogen flow, the multiplier is 3.79; 1 SCFM of nitrogen equals 3.79 SCFM of hydrogen, 2 SCFM of nitrogen equals 7.58 SCFM of hydrogen, and so on. The shape of the flow curves remains the same, only the flow scale changes.

Dealing with Droop

There are several ways to deal with droop. To minimize droop, choose a regulator with a better droop curve, such as one that has a low-droop bonnet construction. Since droop is caused mostly by the load spring, then a better spring should provide better droop performance.

The taller low-droop bonnet houses a longer load spring *(see photo page 1)*, which provides better droop performance. Low droop bonnets are available for most of the high purity regulators we offer. Another approach is to eliminate the load spring altogether, by using a dome



or air-loaded construction. Dome and air-loaded regulators generally have much flatter flow curves, often cutting the droop of a given regulator by half. For the ultimate in droop control, a closed-loop control scheme that uses Tescom's ER3000 in conjunction with a properly sized dome or air-loaded regulator will eliminate droop all together.

Accumulation Pressure

So far we've only discussed droop, which applies only to pressure reducing regulators. Back pressure regulators exhibit a similar trait, though it's not called droop. Since back pressure regulators control the upstream pressure (P_1), rather than the downstream pressure, we notice that as the flow increases, the set-point goes up. The increase in set-point as flow increases is called accumulation, and is also caused primarily by the load spring.

To minimize accumulation, choose a back pressure regulator with a low-droop bonnet, or a dome or air-loaded regulator.

Tescom maintains a substantial library of flow curves for our regulators. If you have an application for which the catalog flow curves don't provide you with enough information to properly evaluate the regulator, please contact our Applications Engineer for assistance in your evaluation.

If we don't have a flow curve with appropriate process conditions, we can request a flow curve from our Engineering Flow Lab. Please contact your Regional Manager or our Applications Engineers for application assistance. ▮

Holiday Schedule

Facilities/Offices Closed:

USA
November 24-25
Thanksgiving

EUROPE
October 3
National Holiday
October 31
Reformations Day

SOUTH KOREA
October 3
National Foundation Day

FEEDBACK? COMMENTS? Click Here!

"Curiosity is the wick in the candle of learning."

– William A. Ward