How to Read a Regulator Flow Curve, Part 1

BILL MENZ, Field Engineering Manager, Swagelok Co.

The best way to select a regulator for your application is to examine its flow curve, which is often provided by the manufacturer. “Flow curve” is a misleading name. You could easily call it a “pressure curve” instead, since a regulator controls pressure, not flow. The curve represents the range of pressures that a regulator will maintain given certain flow rates in a system.

When selecting a regulator, you are not just looking for the right size. You’re looking for a set of capabilities, which is a function of the regulator’s design. A flow curve illustrates the regulator’s range of capabilities at one glance. Once you understand a flow curve – and we’ll explain how – it is easy and very quick to read.

Unfortunately, a more common way to select a regulator is to consult its flow coefficient (Cv). If the system flow is within range of the Cv, some people may believe that the regulator is the right “size.” But that is not necessarily true. The Cv represents the regulator’s maximum flow capacity. At maximum flow, a regulator can no longer control pressure. If you’re expecting flow rates to reach the regulator’s Cv, it is probably not the right regulator for your system.

Let’s discuss how to read a flow curve. We’ll cover the basics first and then some of the complexities, including droop, choked flow, seat load drop or lock-up, hysteresis, and accumulation.

The Basics

A regulator’s main purpose is to maintain a constant pressure on one side of the regulator even though there is a different pressure or fluctuating pressure on the other side. In the case of a pressure-reducing regulator, you control the downstream pressure. In the case of a back-pressure regulator, you control the upstream pressure.

For now, let’s talk in terms of pressure-reducing regulators since they are more common. Later, we will provide some direction for selecting back-pressure regulators.

A flow curve illustrates a regulator’s performance in terms of outlet pressure (Y axis) and flow rate (X axis). Flow is not controlled by the regulator. It is controlled downstream by a valve or flow meter. The curve shows you how a regulator will respond as flow in the system changes.

Let’s look at the top curve in Figure 1. The curve starts at 400 pounds per square inch gauge (psig) (27.5 bar). This is the original set pressure for the regulator. No adjustments are made to the regulator, yet the curve shows a change in pressure.

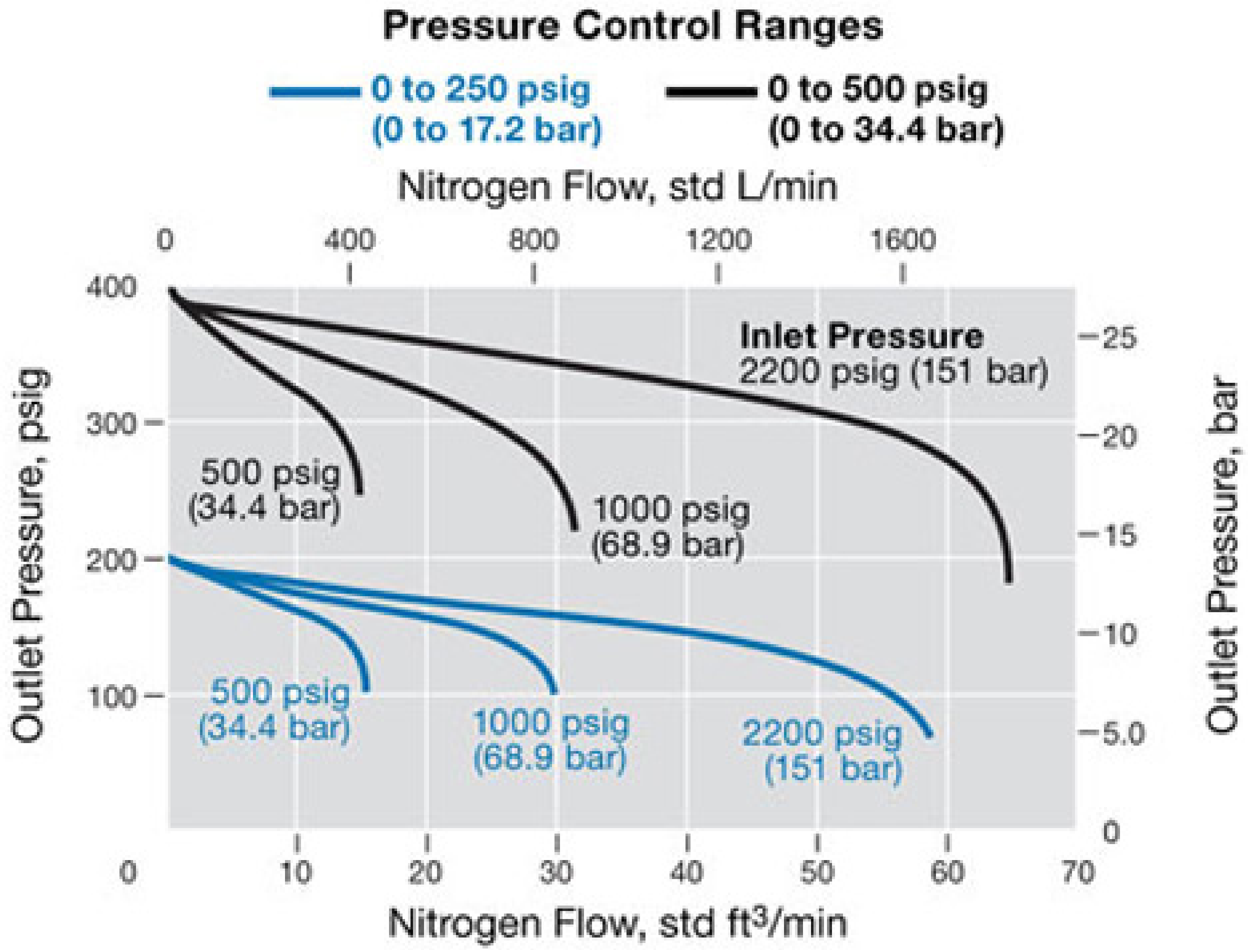

Figure 1. Manufacturers often provide multiple flow curves for the same regulator at different inlet pressures to provide a range of the regulator's operating capabilities.

The regulator is making adjustments, trying to maintain the original set pressure as flow changes. But, it is not perfect. No regulator is. As system flow increases, pressure downstream of the regulator drops. The important question is: How much does it drop?

When reading a flow curve, first identify the range of flows that you can expect to see in your system. Mark these on the graph. Then, look to see what the corresponding changes in outlet pressure will be. Is that range of pressures acceptable to you? If not, you need to look for a different regulator.

Ideally, you want to operate the regulator on the flattest part of the curve. There, the regulator will maintain relatively constant pressures even with significant changes in flow. At the far ends of the curve, there are steep drops, where pressure will change dramatically with even the slightest change in flow. You do not want to operate the regulator at these locations.

Any given regulator can produce a nearly infinite number of curves, so you need to make sure you are looking at the right one. For every set pressure, there will be a different curve. In Figure 1, there are two main sets of curves: one based on a set pressure of 400 psig (27.54 bar) and one for a set pressure of 200 psig (13.7 bar). It is helpful when a manufacturer provides more than one set of curves representing the range of set pressures possible with a particular regulator. If your set pressure lies between the curves, you can interpolate. Note that the two curves are close to the same shape but in different locations on the graph.

Flow curves for spring-loaded pressure regulators feature broad horizontal sections.

There is one additional variable that affects the shape of a curve – inlet pressure (i.e., pressure going into a pressure-reducing regulator on the upstream side). Note that for each of the two sets of curves in Figure 1, there are three curves representing a range of inlet pressures.

In sum, to locate the right curve for your system, look for (1) the right set pressure; (2) the right inlet pressure; and (3) the right range of flows.

Finally, make sure you are looking at the right units. Pressure readings are provided most commonly as psig or bar. Flow rate units vary depending on the system media, so be sure to note whether the regulator is rated for liquid or gas service. Liquid flow is typically expressed as gallons per minute (gal/min) or liters per minute (L/min), while gas flow is conveyed as standard cubic feet per minute (std ft3/min) or standard liters per minute (std L/min).

Curves are usually created using air or nitrogen (for gas service) or water (for liquid service). If your system media is a gas, you may need to make an adjustment in the manufacturer’s curve. Gases compress at different rates, so you may need to multiply the flow curve’s volume units by a gas correction factor. For example, hydrogen’s correction factor is 3.8; meaning 3.8 molecules of hydrogen have the same volume as one molecule of air. Therefore, the point on a flow curve showing an air flow volume of 100 std ft3/min (2831 std L/min) indicates a comparable hydrogen flow of 380 std ft3/min (10 760 std L/min). The curve stays the same, but the flow scale will change.

For liquids, the difference in flow between water and a different medium is not as dramatic due to the incompressibility of liquids.

Tune into the Chemical Equipment Daily *for part two of this two-part series. For more information, please email Menz via* bill.menz@swagelok.com *[1] or visit* www.swagelok.com *[2].*

Links:
[1] mailto:bill.menz@swagelok.com
[2] http://www.swagelok.com/