Product Note, PN 455
Understanding a Pressure Regulator Cv Value

May 23, 2023

Overview

The flow coefficient, Cv, is a value that is utilized to define the flow capacity of a device. The usefulness of a Cv is different for pressure regulators compared to other flow devices, such as a valve or a fitting. The purpose of this product note is to explain the difference.

Cv Defined

A Cv is defined as the flow of water in one minute through a wide open device with no more than a 1 psi (0.07 bar) differential inlet to outlet. The Cv value is the amount of water in gallons per minute (gpm). The definition uses a non-compressible fluid, water. There are formulas to calculate Cv using gases, compressible fluids. In both cases, non-compressible and compressible fluids, the testing is specified by trade organizations to enable uniform and comparable test results between manufacturers.

The device being fully open works well for a valve, metering device, check valve, etc. because this state is within the intended operating range. A pressure regulator is tested wide open with an inlet pressure less than the maximum outlet range of the device. A pressure regulator tested in this manner means that it is not regulating pressure because the inlet pressure is less than the adjusted set point, the maximum. Pressure regulation means that the outlet pressure is lower than the inlet pressure, not equal. Measuring the flow capacity of a pressure regulator wide open does not translate to the usable flow capacity of the device when regulating pressure.

Cv as it Applies to a Pressure Regulator

The Cv of a pressure regulator is used to define the point of choked flow for the device. Choked flow is the region where increasing the pressure drop through the regulator no longer yields an increase in flow. The point of choked flow is often referred to as the ‘knee’ on a flow curve which is the inflection point where the curve starts to drop off.

The usable flow range of a gas regulator is less than when choked flow occurs. The usable flow range varies based upon inlet pressure, outlet pressure, gas density among other factors. In

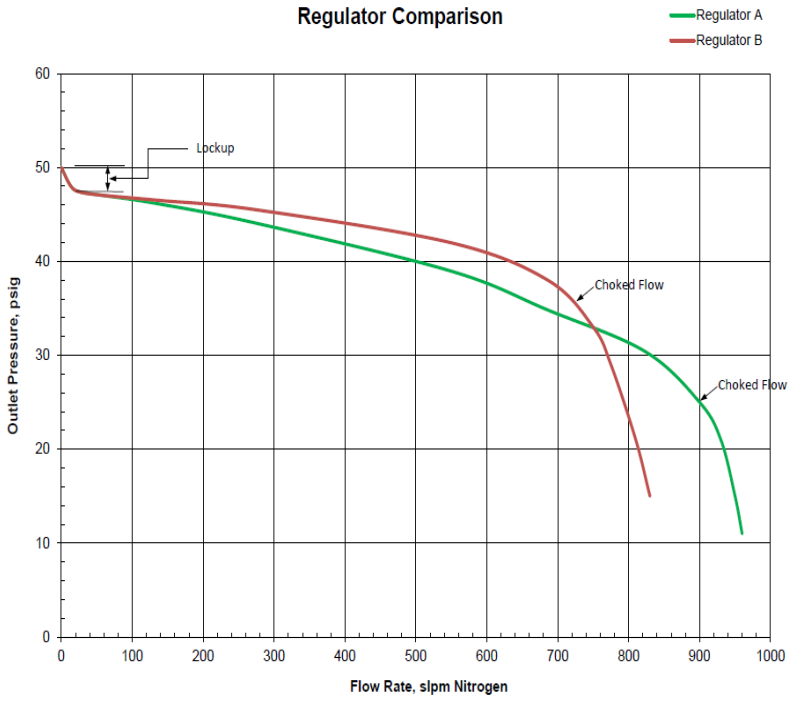
general, manufacturers provide guidance as to the maximum pressure drop from static, no flow, to dynamic, flowing condition. If one exceeds the recommended pressure drop, the pressure regulation degrades and the life of the product may be reduced. A range of 7 psi to 20 psi (0.5 to 1.3 bar) is common with the specific number, such as 10 psi (0.7 bar), depending upon actual regulator model and size. Regardless, the flow where the recommended, maximum usable pressure drop occurs is less than the flow where choked flow occurs. There is no correlation between usable flow and choked flow, meaning a Cv value does not indicate the usable flow of a regulator.

Cv's are specified in data sheets for pressure regulators because the rating is useful for some calculations. For example, a Cv can be employed to calculate the maximum flow through a regulator with a catastrophic across the seat failure. This is a safety consideration due to the containment requirements for excessive flow and exhaust scrubber sizing in the event of an outboard leak.

Examples

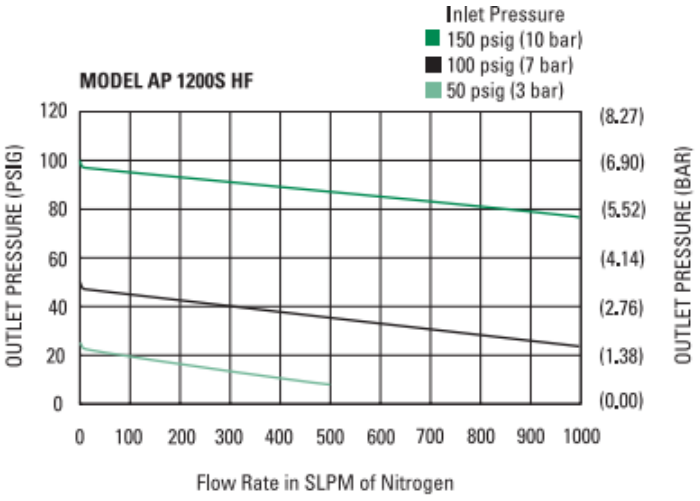
1) Flow curve #1 has red and green flow curves with different pressure drops and choked flows. Let's assume the recommended pressure drop is 10 psi and the same test parameters of gas and pressure. The green flow curve is flowing 500 slpm at the 10 psi pressure drop whereas the red is flowing 600 slpm. However, choked flow occurs on the red curve before the green curve. As Cv defines the point of choked flow, the red regulator would have a lower Cv than the green regulator. This is an example where a regulator with a lower Cv has more usable flow than a regulator with a higher Cv.

Flow Curve #1

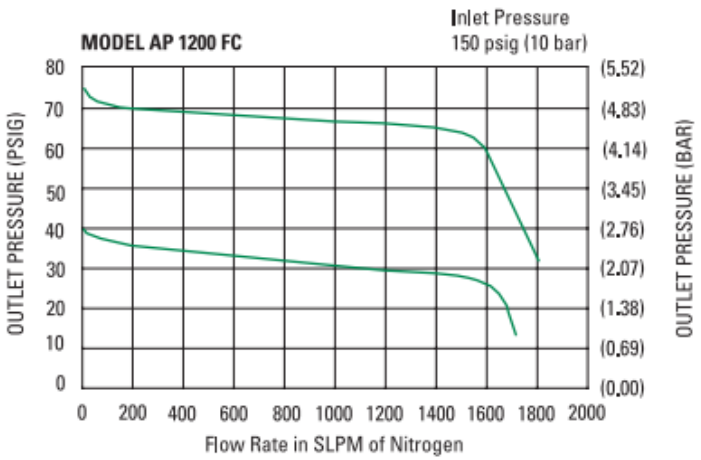


2) Flow curves #2 and #3 are from the AP 1200 data sheet. #2 flow curve is for an AP 1200 HF with a 1.1 Cv and #3 is for an AP 1200 FC with a 0.65 Cv. The AP 1200 HF with 150 psig (10 bar) inlet flows to 800 slpm of N2 with a 20 psi (1.3 bar) pressure drop whereas the AP 1200 FC flows to 1,400 slpm with the same conditions. The FC option is added to an AP 1200 HF and is a mechanism that offsets the negative impact of a range spring upon droop. This is an example where a smaller Cv has much higher flow than a regulator with a larger Cv.

Flow Curve #2



Flow Curve #3



3) A Cv value can be calculated with a regulator regulating pressure. It would not be the Cv rating for the device per definition and industry guidelines, but a value determined with a given set of parameters.

   The AP 1400T is generically rated to 400 slpm of N2. The calculated Cv of an AP 1400T at 400 slpm of N2 with an inlet pressure of 100 psig (0.7 bar) and 80 psig outlet (0.6 bar) is 0.32. The same regulator with an inlet of 50 psig (0.3 bar) and 30 psig (0.2 bar) and a flow of N2 of 20 slpm has a calculated Cv of 0.02 with these parameters. The rated Cv of the AP 1400T is 0.5 which is higher than the usable, recommended range of the device.

Conclusion

Cv does not define the usable flow range of a pressure regulator. A flow curve is the best way to determine a regulator's performance for specific applications, not Cv. The regulator Cv is useful for some calculations, such as safety concerns. The Cv does provide some indication of the flow capacity of a regulator but it should not be used to compare different regulators for an application. General piping specifications stating a regulator Cv should note Cv as a nominal value rather than a minimum value. The better approach is to qualify models utilizing flow curves or to state a pressure drop maximum with given inlet and outlet pressures.