ADVANCED PRESSURE TECHNOLOGY

Product Note, PN 403
Supply Pressure Effect Related to use of the AP 1200 in High Pressure Cylinder Applications

The following is a report that outlines a few special considerations for high flow regulators used with varying supply pressure applications such as high pressure cylinders of gaseous phase specialty gases. The report defines terms and then presents issues with recommendations. The points raised herein are very important and require a clear understanding prior to utilizing the AP 1200 series in such applications. This report should not be considered as all encompassing but as merely an explanation of additional points to be accounted for.

Definition of terms

Supply pressure effect is the phenomena related to the change of outlet pressure corresponding to a change of inlet, also referred to as supply, pressure. This effect is usually described as a given outlet pressure rise per 100 psi decrease in supply pressure. If a regulator was so specified as to have a supply pressure effect of 1 psi per 100 psi decrease in supply pressure, it would mean that for every 100 psi drop in inlet pressure, the outlet pressure would rise by 1 psi. This increase can be significant during the consumption of a high pressure cylinder. If, for example, a full cylinder's pressure was 2,200 psi and it was considered empty at 200 psi, the outlet pressure of the regulator would rise by a total of 20 psi from a full to empty cylinder. The calculation would be 2,200 – 200 = 2,000; 2,000/100 = 20; 20 x 1 psi = 20 psi. Supply pressure effect is a linear function derived from a ratio of the effective working areas of the diaphragm and poppet to seat seal. Thus defined, it should be noted that supply pressure effect varies significantly based upon a regulator's design characteristics and intended application. The AP Tech product line has pressure regulators with a supply pressure effect that ranges from as little as 0.05 psi to as much as 3.5 psi per 100 psi change in supply pressure.

Supply pressure effect is caused by the change in forces due to the varying inlet pressure. A diaphragm type pressure regulator, typical of that employed in specialty gas delivery, is basically a balancing act of forces. The attached sketch graphically depicts the sum of forces that enable a pressure regulator to function. The adjustment spring applies force 'A' downward upon the diaphragm while force 'B' generated by the outlet pressure (pressure times area = force) pushes upward upon the diaphragm. In addition to force 'B', the poppet itself exerts an upward force because it has a surface area, albeit relatively small, exposed to the supply pressure. As shown in the diagram, force 'A' is equaled by the sum of 'B' and 'C'. If the supply pressure decreases, the amount of force contributed by 'C' also decreases. Force 'B' must correspondingly increase to maintain the equilibrium balance of forces which in turn translates to an outlet pressure rise.

Please refer to AP Tech Technical Bulletin #202 for further explanation of how a pressure regulator works and further definitions of terms.

AP 1200 and Cylinder Cabinet Applications

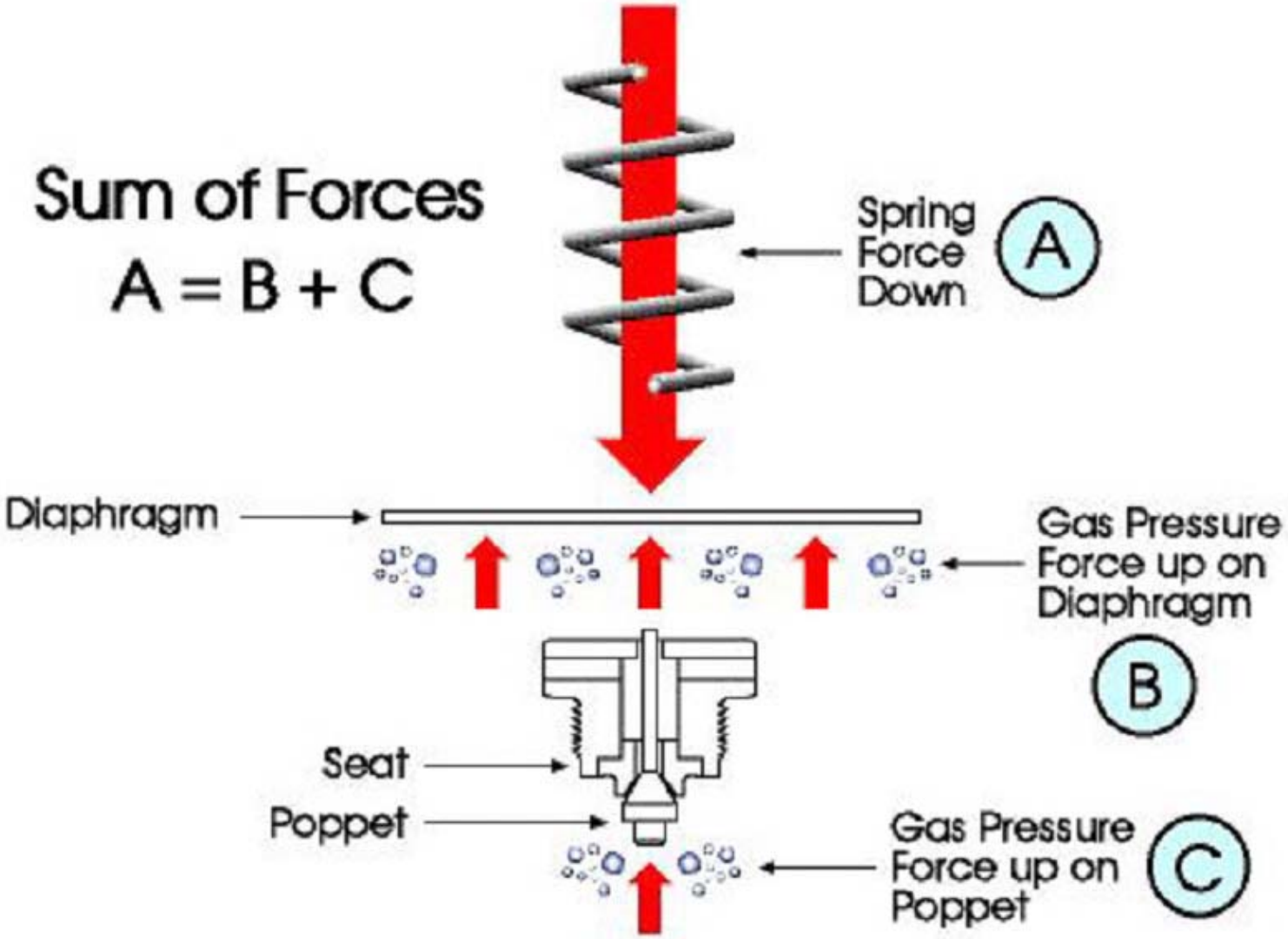
The AP 1200 has a significant supply pressure effect due to the relative size of the diaphragm to the poppet sealing area. Its specification is a 3.5 psi rise in outlet pressure per 100 psi decrease in supply pressure. This is not an issue in most high flow cylinder applications because the gases are liquid phase and therefore have a constant pressure. It is an issue in high flow cylinder applications where the gas isn't in liquid phase and the supply pressure decreases as the gas is consumed. If, for example, a gaseous phase cylinder has a full cylinder pressure of 1,200 psi and is considered empty at 200 psi, the outlet pressure of the regulator would rise by 35 psi from a full to an empty cylinder.

A significant supply pressure effect, such as 3.5 psi per 100 psi variance, is an important consideration for outlet gauge selection for gaseous phase high pressure cylinder applications. Supply pressure effect can cause the outlet pressure to rise above the specified range of the regulator depending how the knob adjustment stops are set at the factory. One should select a gauge with a range comfortably above that of the regulator outlet range. For example, an AP 1210 series with a 100 psig outlet range should have a 150 or 160 psig gauge to insure that the gauge is not over pressurized due to supply pressure effect.

An additional consideration is purging. Nitrogen pressure for purging is usually between 80 and 100 psi. If one adjust the AP 1200 to a given outlet pressure with purge Nitrogen, the outlet pressure will decrease, the opposite effect of diminishing supply pressure, when process gas of a higher pressure is applied. For example, if one adjusts the regulator to 50 psi with 100 psi of Nitrogen and then applies 1,100 psi of a given process gas, the outlet pressure would actually decrease by 35 psi to 15 psi. A further consideration is that if one charges the regulator with high pressure, shuts off the cylinder valve and proceeds to vent via the low pressure vent valve, the outlet pressure of the regulator will rise as the source pressure decreases. This means that if one pulses the vent valve slowly and intermittently releasing the pressure, the regulator's outlet pressure will rise with each successive venting due to the decreasing supply pressure.

Supply pressure effect is a normal phenomena that requires special consideration with the AP 1200. An AP 1500 series regulator, the workhorse of specialty gas delivery, has a minimal supply pressure effect at 0.25 psi per 100 psi decrease in supply pressure which has a negligible effect on outlet pressure. One must account for a much wider outlet pressure excursion with the AP 1200. Cylinder cabinet high and low pressure alarms require a broader band than one would typically expect. In addition, one must set the outlet pressure of the regulator considering the fact that it will vary with supply pressure. For example, if an outlet side low pressure alarm is set at 35 psi and the high pressure alarm set at 80 psi with a full cylinder pressure of 1,200 psi, one should either set the regulator to 75 psi with purge Nitrogen pressure or 40 psi with full process pressure of 1,200 psi. This action allows supply pressure effect to take its course without tripping an alarm or requiring readjustment of the regulator as the supply pressure varies. One must expect a larger excursion of outlet pressure with the AP 1200 and only be concerned if the pressure rises or falls beyond that caused by supply pressure.

Please consult the factory or your local distributor for further information or assistance.


Sum of Forces
A = B + C
Spring Force Down
A
Diaphragm
Gas Pressure Force up on Diaphragm
B
Seat
Poppet
Gas Pressure Force up on Poppet
C