APTech
ADVANCED PRESSURE TECHNOLOGY

Product Note, PN 402

Regarding Use of 'Positive Shut-off' Pressure Regulators

'Positive Shut-off' pressure regulators, commonly termed 'Diaphragm-Linked Poppet' or 'Tied Diaphragm', require special care by their very nature. This type regulator can be damaged by improper use or operation. The purpose of this application note is to alert and educate users to such.

The typical diaphragm type pressure regulator (see Figure #1) is used to reduce some inlet pressure to a lower outlet pressure. The heart of the regulator is the poppet and seat. The poppet seals against the seat to isolate the inlet, high pressure side from the outlet low pressure side. Applying pressure to a regulator with the adjustment knob turned off, fully counterclockwise, will pressurize the inlet side of the regulator. Turning the knob clockwise compresses the adjustment spring which exerts a downward force on the diaphragm. This causes a downward movement of the diaphragm which pushes the poppet away from the seat. As the regulator opens, the gas flows from the inlet to the outlet side. As the pressure increases on the outlet side, the diaphragm will react and move up as the pressure counteracts the downward force from the spring. The poppet will seal against the seat at the point the force from gas pressure pushing upward on the diaphragm equals the downward force of the spring. Simply speaking, it is a balancing act with spring force verses gas pressure.

A 'Free Poppet' type pressure regulator is shown in Figure #1. The poppet is not attached to the diaphragm. It merely contacts the diaphragm whenever the outlet pressure is at set point or below. Should the outlet pressure rise above the set point, the diaphragm will move away from the poppet. This can occur due to various reasons such as foreign contamination lodging on the seat causing an across the seat leak. The outlet pressure can, and often does with an across the seat leak, eventually equal the inlet pressure which can be a serious safety hazard.

The 'Positive Shut-off' type pressure regulator (shown in Figure #2) has the poppet physically attached to the diaphragm as the other common names 'Tied Diaphragm' and 'Diaphragm-Linked Poppet' imply. As differentiated from the 'Free Poppet' design, the diaphragm of a 'Positive Shut-off' regulator pulls the poppet closed as the outlet pressure rises above set point. This occurs because the poppet is attached to the diaphragm. These are the regulators of choice for source cylinder cabinet applications where the inlet, supply pressure is above 50 psig. This is especially true with high inlet pressures because of the potential for damage to downstream components if the outlet pressure rises significantly above set point. It should be noted that in rare cases, severe contamination can even prevent this style regulator from sealing across the seat. Additional over pressure protection from relief devices and/or high outlet pressure detection coupled with a valve for shut down are necessary for a truly 'fail-safe' system

'Positive Shut-off' pressure regulators should not be used as valves or shut off devices even though their name implies such. Trapping pressure on the outlet side of the regulator by turning the knob to the fully closed position is not a recommended practice. This action allows force to be applied upward to the diaphragm without a counteracting force downward from the spring. In turn, this exerts a significant force to the seat as the poppet is pulled upward by the diaphragm. The higher the difference between the locked up pressure and the adjusted set point, the higher the force will be. The seat material is typically a polymer, such as PCTFE, which can be permanently deformed if a force is applied which exceeds its elastic limits. This is a long way of saying that the seat can and will change shape with enough force applied. The length of time, amount of pressure and frequency of pressure lock up each affects when permanent deformation occurs. Pressure regulators can usually accommodate a limited amount of pressure lock ups without damage. **The main message here, though, is that using a regulator as a valve is not a recommended practice. Valves should be used as shut-off devices, not regulators. There is no reason or advantage to do so.**

Typical Applications: Problems & Recommendations

Line Pressure Test

Line pressure tests are performed upon commissioning a line and periodically throughout its life. A common test in Japan, for instance, is to pressurize a line with high pressure Nitrogen to the source cylinder cabinet regulator which is adjusted to deliver 80 - 150 psig downstream pressure. The line is isolated with valves at the cylinder and tool, the regulator turned fully off trapping pressure under the diaphragm and then the system is left static for a long period of time such as during a holiday shut down. This tests the line for leak integrity and the regulator across the seat by monitoring pressure variance. A pressure decay indicates an outboard leak while a pressure rise on the outlet side of the regulator indicates an across the seat leak.

This causes significant and undue stress upon the seat as previously described. A better test would be to only turn the knob counterclockwise one half turn which is 180°. This lowers the adjusted set point of the regulator. A leak in the line could then be noted by a decrease in downstream pressure as the pressure falls to the lower set point. An across the seat leak would cause a downstream pressure rise. This test effectively accomplishes the same as the first but does not cause high stress on the seat. This is because the difference between the spring force down and the upward force from the gas pressure is minimized. The force up on the diaphragm is the same, but there is a force down on the diaphragm from the spring which almost equals the upward force. In essence, this is also a more stringent test across the seat because less closure force is exerted by the diaphragm to assist pulling the poppet closed.

Systems in Transit

It is a common practice to ship systems, manifolds or tools, pressurized with Nitrogen to maintain the purity level. This isn't a problem unless the regulator is turned fully off after the system is pressurized. If this occurs, the regulator may have pressure locked up on the downstream side for days, weeks or even months while the system is shipped and awaiting installation. This lock up can cause damage to a regulator as noted in this report. If the regulator is simply left in the adjusted state as during pressurization, no damage will occur.

Reverse Pressure

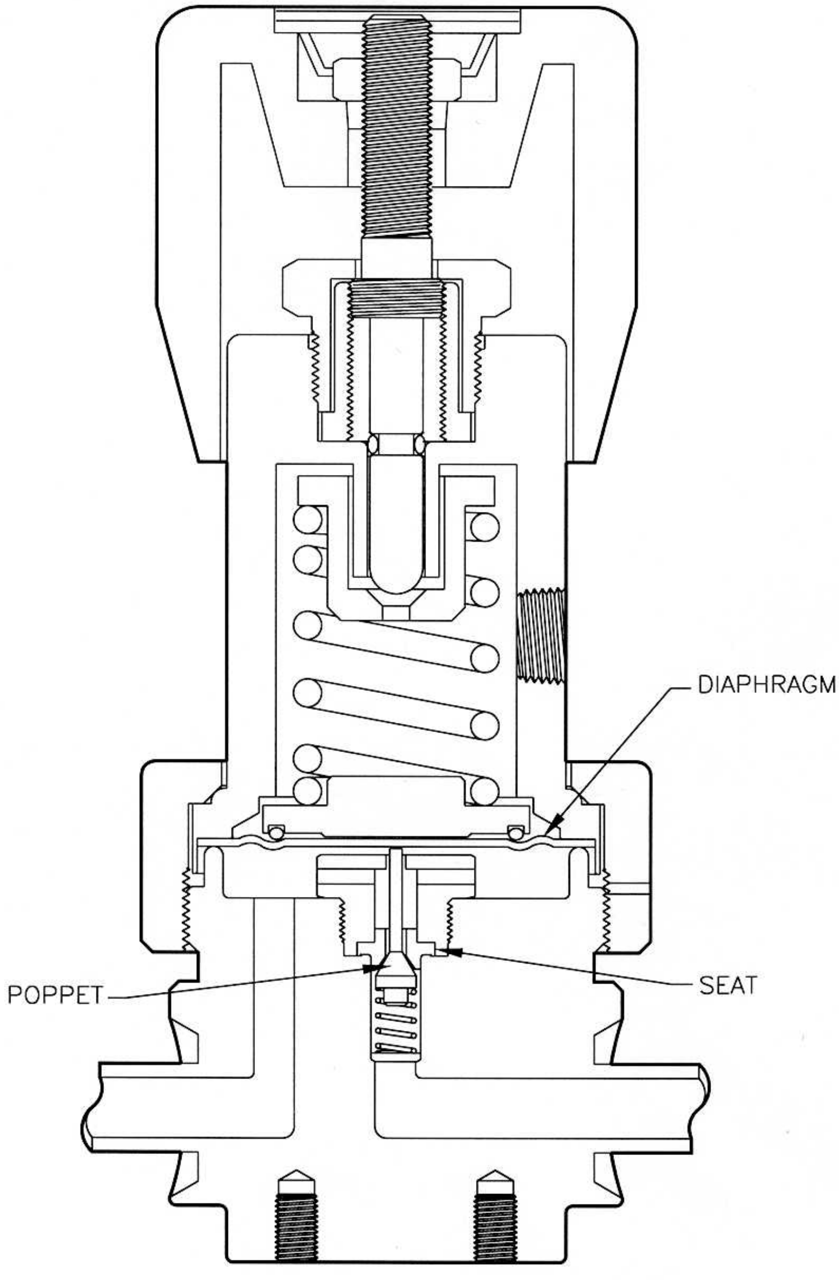
There are occasions when a regulator may be pressurized from the downstream side rather than the upstream during line maintenance or qualification. This is not problematic so long as the reverse - or back - pressure does not exceed the adjusted set point of the regulator. If the pressure from the downstream side exceeds the set point, problems may occur. The higher the difference between adjusted set point and the reverse pressure, the higher the probability of damage from seat deformation as described above.

It is recommended for downstream testing, that the regulator be fully opened and pressure applied that is less than the outlet pressure rating of the regulator. This assures that the seat will not be subjected to undue stress during testing. A pressure lower than the regulator set point is required to have reverse flow through the regulator.

Summary

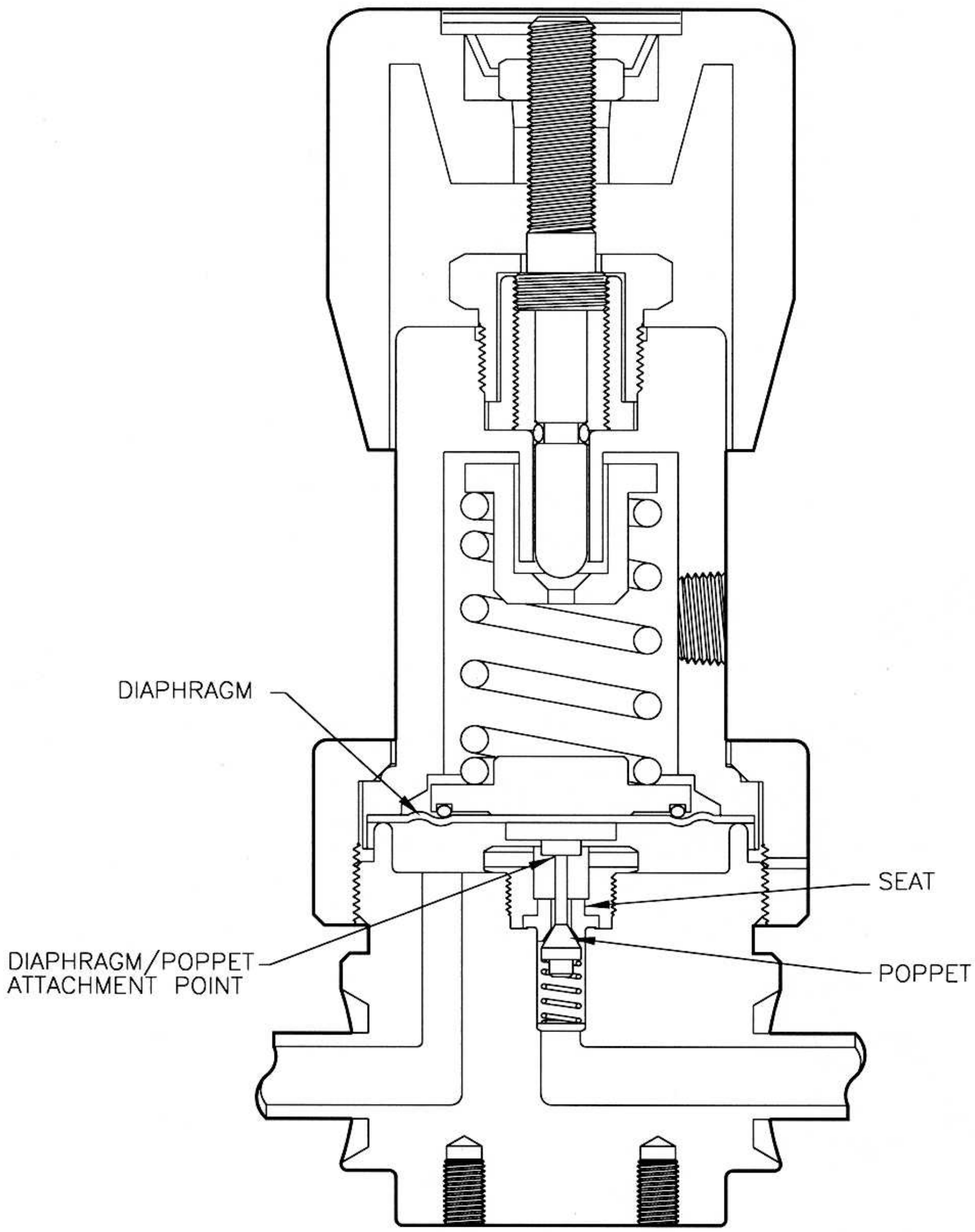
'Positive Shut-off' regulators should not be used as valves. Trapping pressure on the downstream side of the regulator with the knob turned to the off position can cause permanent damage to the seat. Though most regulators can withstand a certain amount of trapped pressure as described, why subject it to any? Proper testing can be accomplished without doing such. Fundamentally, it is not worth the risk of potential damage - there is no need to do so.

Please feel free to contact the factory, or your local representative, should you wish any further information.



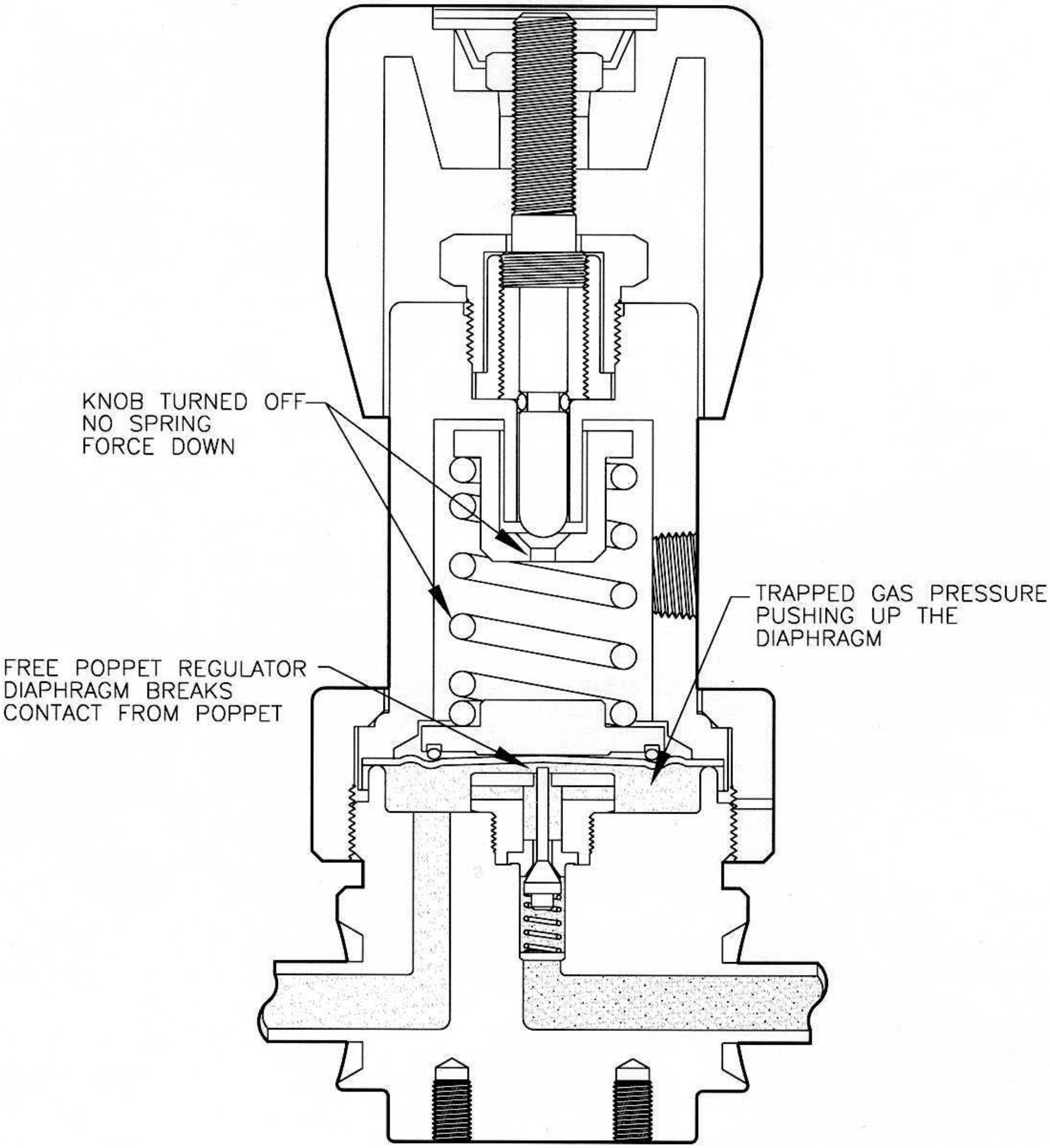
AP1000 PRESSURE REGULATOR
FIGURE 1

CAT\1000-J01



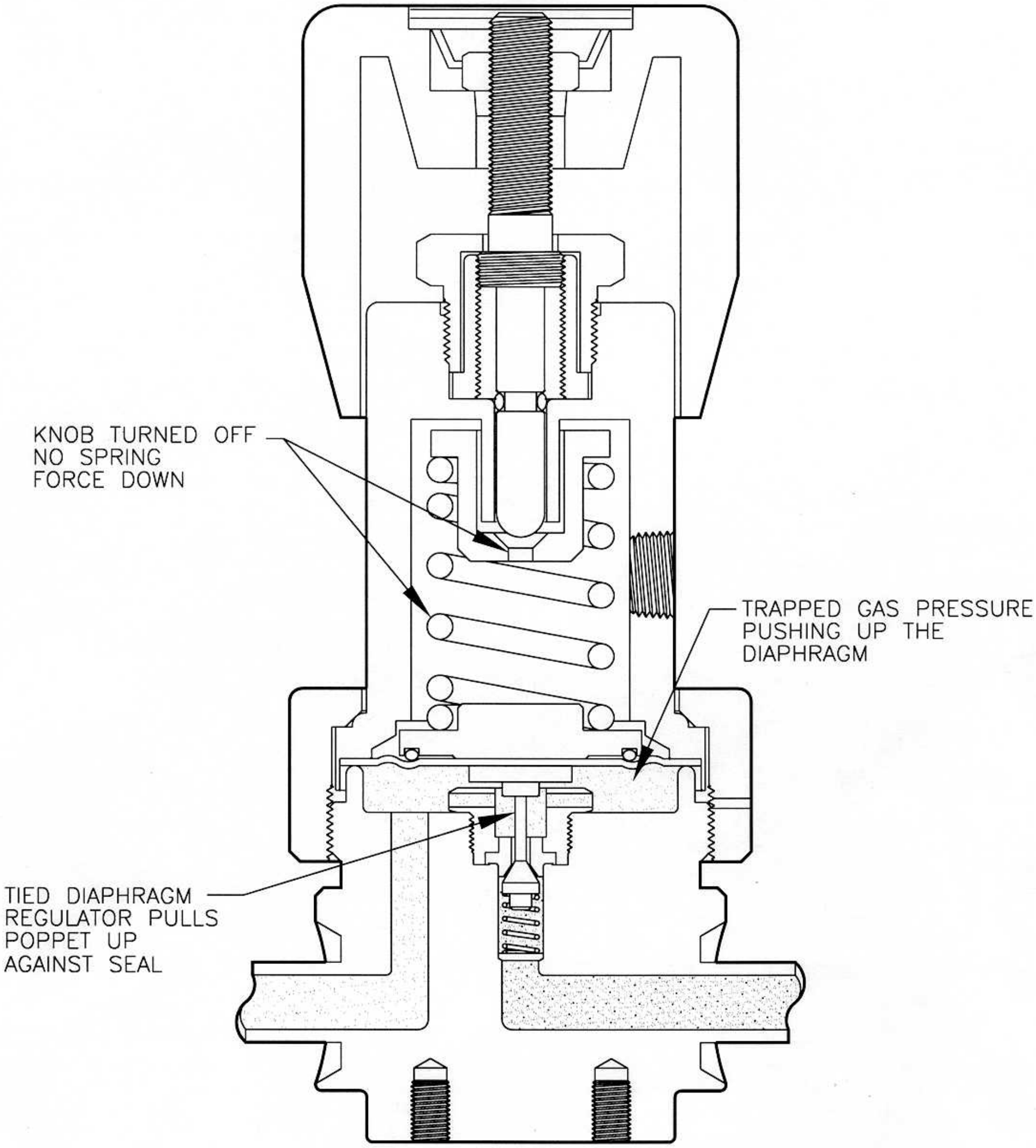
AP1500 PRESSURE REGULATOR
FIGURE 2

CAT\1500-J02



TRAPPED PRESSURE
AP1000 REGULATOR

CAT\1000-JON



TRAPPED PRESSURE
AP1500 REGULATOR

CAT\1500-JON