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Compressed Air Audit Services

PNEUMATIC POINT OF USE AIR SUPPLY ISSUES

The fundamental question this paper poses is;

"Are you happy with vendors of manufacturing equipment dictating your energy footprint requirements?"

How is that working for you?

To fully understand the ramifications of the imbedded misconceptions with respect to compressed air supply, one must take into consideration the actual point of use need for compressed air.

By far the largest category of uses that typically invoke cries of *"We don't have enough pressure. Buy/Start up another air compressor"* appears to be the actuation of pneumatic cylinders. These cylinders are found throughout the plant in the form of rotary valve actuators, slide gate actuators, and in the internal operating components for production and packaging machinery, material handling services, and a myriad of other devices.

It has long been the habit of industry to perceive cylinder actuation timing adjustment to be a function of pressure, thereby requiring the installation of the ubiquitous pressure regulator in the supply line.

The reality is that it simply is not the case in terms of the Laws of Physics that apply to compressed air.

It should be recognized that with the exception of those cylinder applications and services where small and incremental changes in down/up-force for nip rolls, press rolls, lift applications where down/up thrust or tensioning must be carefully controlled, and on some valve operators for positioning I/P devices, for the most part pressure regulators are misused and misapplied as de facto flow controls.

The vast majority of the balance of the cylinder applications are not, in fact, pressure dependent.

The thrust of this portion of the report is to focus staff on the reality that cylinder actuation is a function of the time rate of change initiated by adding the specific volume of air needed to properly actuate the device as the air is gated into the internal volume of the cylinder. Stated in

another and more simplistic fashion, cylinder actuation time is a function of mass flow and time of the rate of recharge, not pressure.

It is the restriction created by the pressure regulator, along with the other parallel restrictions in tubing, fittings, filters, oilers, solenoid valves and other components which are controlling the flow of the volume of air into the cylinder over a chosen period of time.

Unfortunately, at the same time, this type of assembly creates the perception of the need to artificially raise pressure (add energy) in the plant to overcome the restriction these devices create.

Plant staff should seriously consider an incremental project to first educate all concerned personnel on this issue. Subsequent to the education effort, steps should be taken to identify point of use applications involving cylinders which are amenable to change and begin removing filters, lubricators, and regulators, along with concurrent undersized tubing and fittings, upsizing of feed tubing, and installing common bar stock needle flow control valves. The net result will be more accurate control of stroke times and a commensurate reduction in the pressure needed to do the job.

This in turn will result in allowing staff to lower the pressure in the overhead transmission piping of the compressed air system.

Remember, the force applied on a cylinder is directly proportional to the cross sectional area of the cylinder ram times the net article pressure of air in PSIG applied to that ram.

The hidden factor that is generally overlooked is the time domain of the stroke. If one is desirous of sizing the approach pipe/tubing to adequately feed a sufficient volume (NOT PRESSURE) of air to do the task in the time allotted, one must realize that the time frame of one minute is the common denominator in calculating flow in cubic feet per MINUTE.

If a cylinder is designed to stroke in a 2 second time domain, one must take into account that there are 30 two second increments in every minute. If you know the cylinder diameter and stroke length, you have a volume. In this example, in order to delineate the exact flow, you must multiply the volume times 30. That number is the actual cubic feet per minute equivalent but taken in 2 seconds.

This characteristic is described as a “Sudden Event Demand” and must be properly dealt with accordingly.

Please understand that this dissertation is not a full essay on all the specific factors surrounding compressed air supply to cylinders. The intent is to alert the reader to the underlying and rarely realized issues involved and create a different perspective on which to base new and rational efforts to correct problems.

The specific issue of the improper use of pressure regulators as a faux flow control device is the preeminent issue that must be understood fully in order to create an open pathway for beneficial change.

Please carefully note that this regulator is sized for ¼ NPT pipe size.

The photograph depicted above shows a disassembled standard ¼" NPT industrial air pressure regulator. The left portion is the main body. The next item to the right is the diaphragm and the follower plate with an integral flow port. The next item to the right is the compression spring and follower cup. The final item to the right is the bonnet with an integral threaded compression rod.

The entire assembly is held together by the six screws.

This photograph is a close view of the body. The small raised rod in the center is the spring-loaded pilot poppet assembly. The hole above the poppet contains a .060” drilled hole to allow air from the input from the adjacent very small orifice around the poppet rod to flow up into the visible cavity area from the cavity below to exit the regulator through the nipple to the right.

This photograph depicts the diaphragm and follower plate with a center orifice port. The hole in the orifice centers directly on the spring-loaded pilot rod in the main body.

When a worker tightens down the thread compression rod into the follower cup, it compresses the spring against the diaphragm. This in turn presses the pilot hole in the diaphragm more tightly against the spring-loaded poppet

below.

For the sake of comparison, this photograph superimposes the point of a .7 mm lead pencil immediately adjacent to the pilot hole. In this way the viewer can easily see the very small diameter of the pilot hole in relation to the pencil point .

Taken in a common sense view, the tighter one compresses the spring against the diaphragm follower plate, the tighter the compressive pressure pushes the flat brass seat on the bottom of the diaphragm against the pilot rod seat. This in turn creates an inordinately high restriction which prevents mass flow of air from passing rapidly through the circular orifice around the poppet.

Naturally the adjacent pressure gauge reflects a higher pressure. The physical laws of air (P1V1=P2V2) dictate that with reduced flow, pressure must rise until it mirrors the highest supply pressure.

Given the non-linear characteristics of this standard compression spring, the more the rod is turned down into the bonnet, that tighter the diaphragm seat plate is pushed against the pilot rod seat.

Here’s the top with the pin (actually a poppet) removed from the .060” hole. Note the poppet has a tapered shoulder which seats in the cavity below the hole as shown in next view.

This is a bottom view showing the seat where the tapered poppet sits in the center hole, pin up through the hole in the center. The cavity to the right is the air entrance into the regulator through the elbow. The post protruding from the bottom is the stop for the poppet bottom which has a small spring for purported flow control and to keep the poppet from being blown out of its hole. This view shows the poppet on its spring and follower cup to keep things centered and prevent the pin from falling out of the hole due to gravity.

Air enters through the pipe on the right and the annular space in the body of the regulator shown to the right of center.

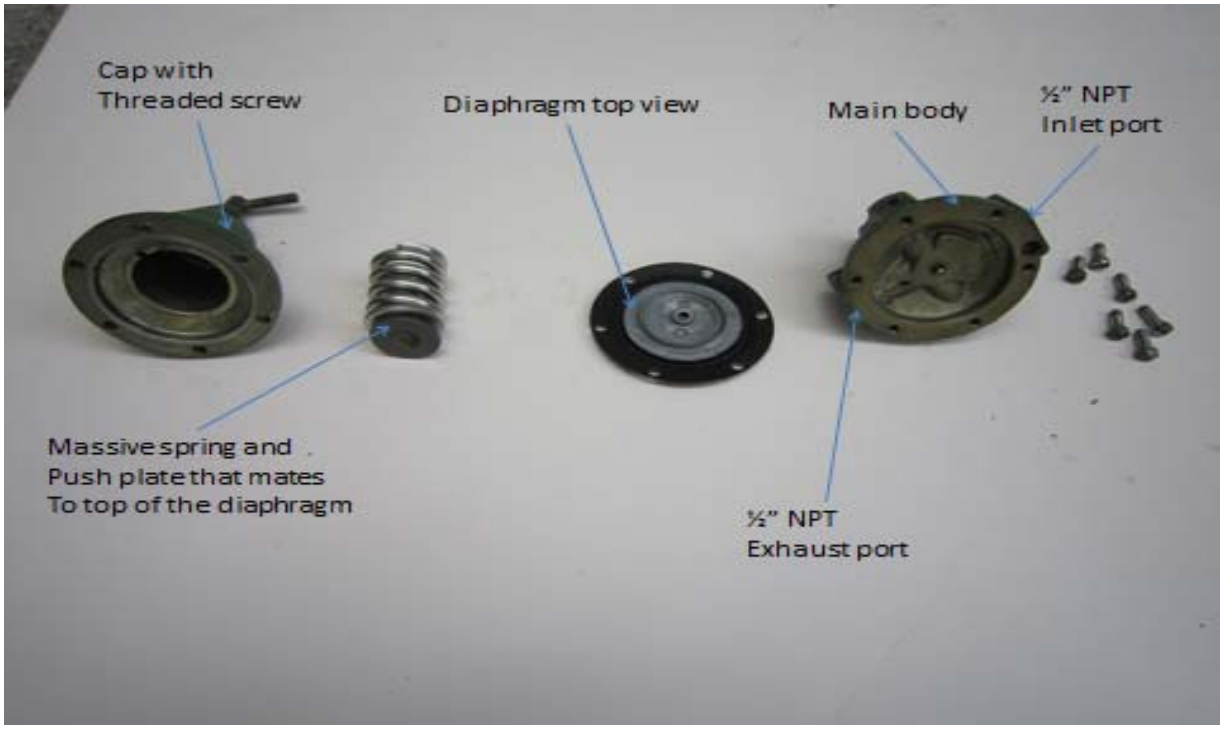
All being said, the air in must flow through the cavity area, and around the shaft of the poppet, a passage considerable smaller than one realizes, and up into the upper cavity below the diaphragm.

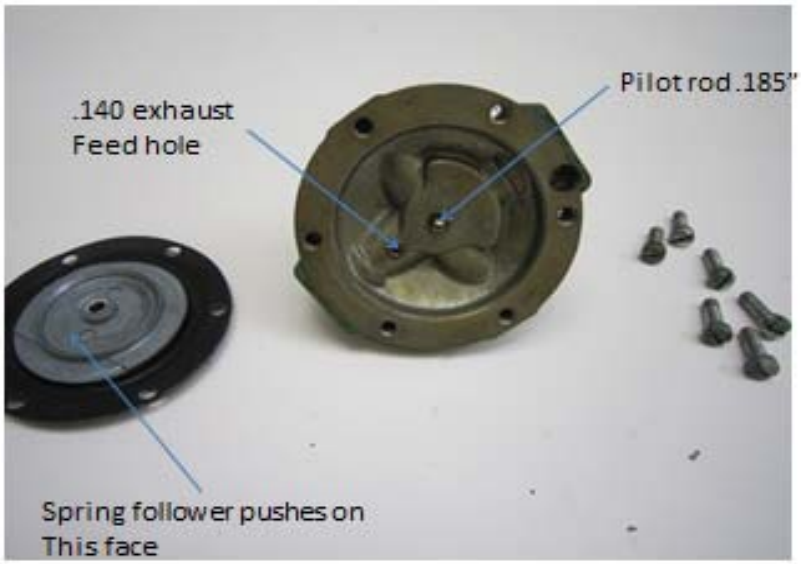
It is easily understood that this mechanism creates extremely high levels of restriction against the flow of air while at the same time establishing a barrier that allows the adjacent pressure gauge to read a higher pressure.

It would be nice if someone could logically explain how an orifice this small can pass a sufficient volume of air through it to successfully actuate a large cylinder in an acceptable short time frame while using a minimum of energy to do so. Unfortunately, the laws of Physics militate against the possibility.

The other and not so often understood mechanism is that no matter what anyone does to push the spring down or release it, the limiting factor is the size of the passage around the pilot rod, .008” and the .060 hole in the upper body**. That size never changes**.

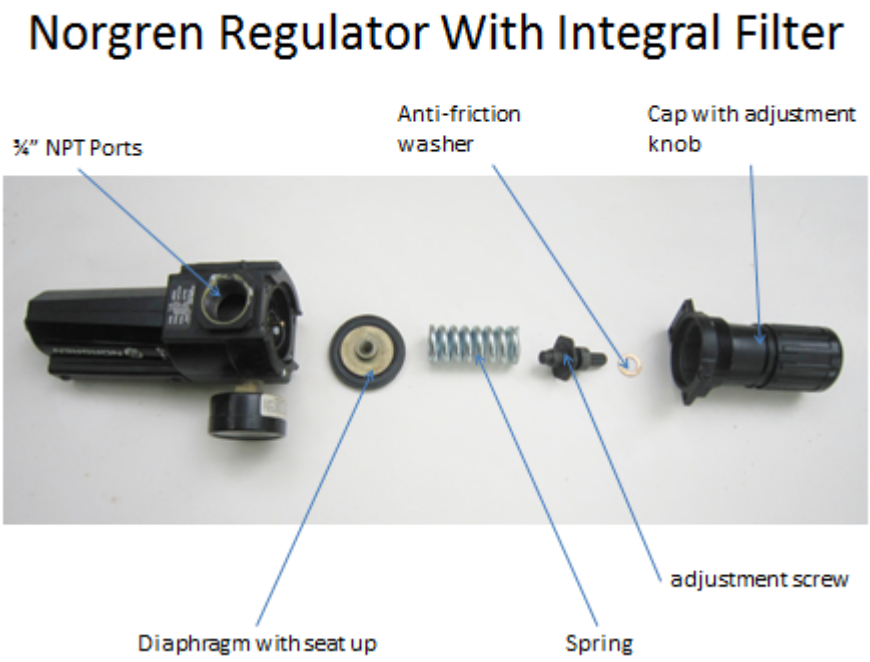
The next item to study is the ½” NPT pressure regulator shown below.




.140 exhaust
Feed hole
Pilot rod .185"
Spring follower pushes on
This face

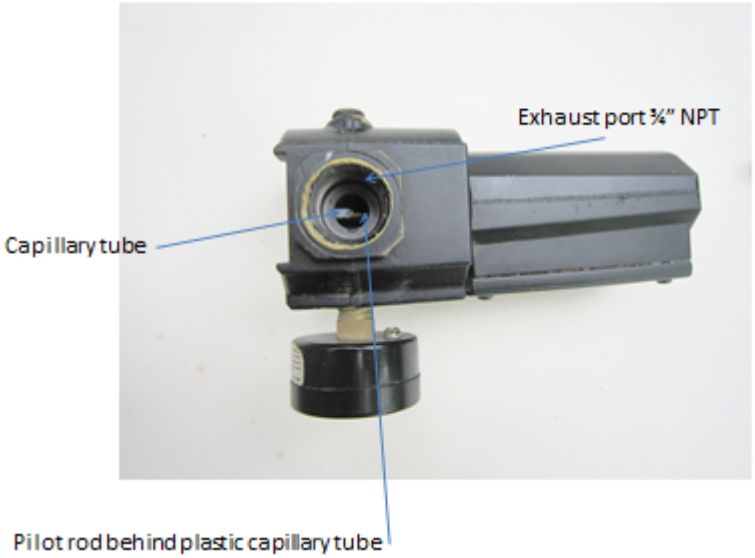
Pilot rod hole
.203"
Pilot rod .185"
Orifice around Pilot
Rod is .009"
Bottom cap with strainer

For sake of comparison, let us examine a larger sized regulator, one designed for ¾” NPT.

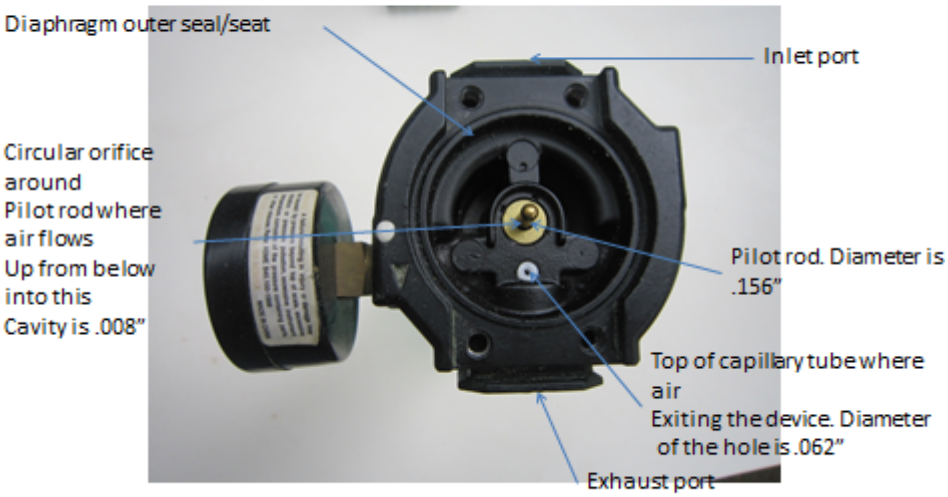


Inlet Port View

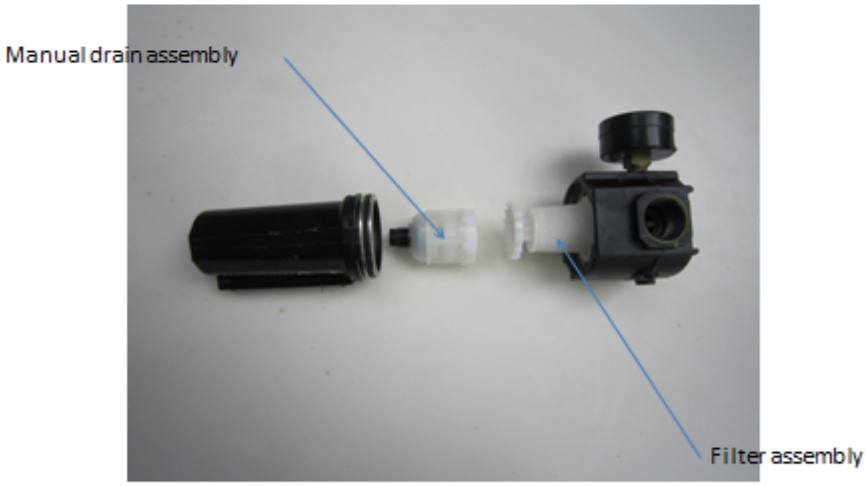
Exhaust Port View



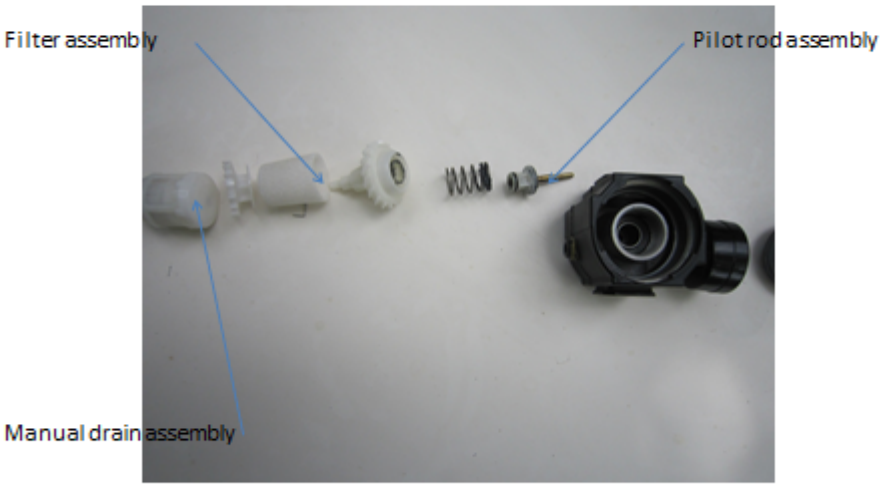
Top View With Pilot Rod In



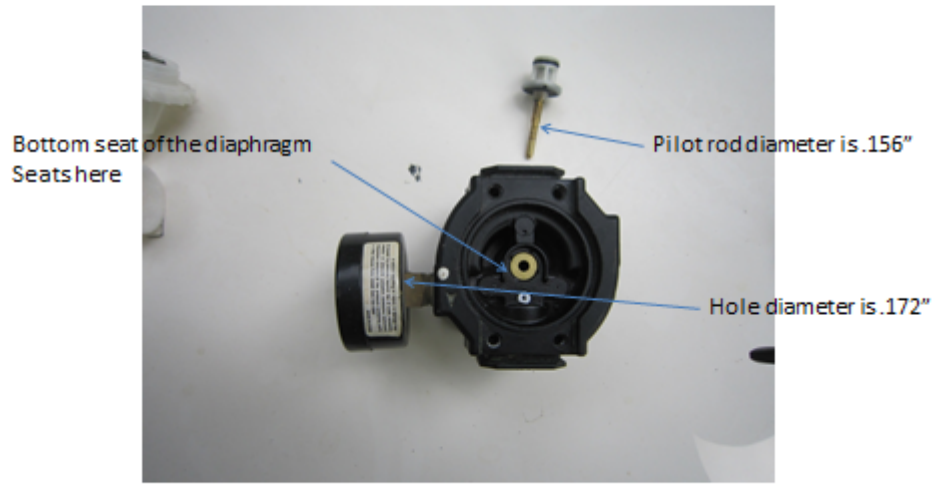
Body Disassembly 1st View



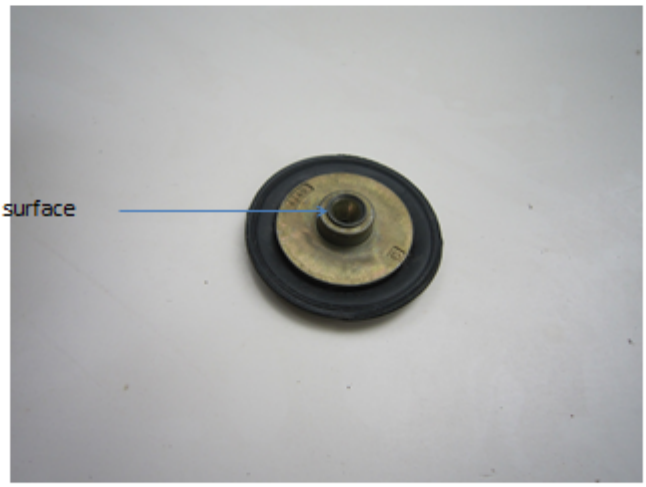
Body Disassembly 2nd View



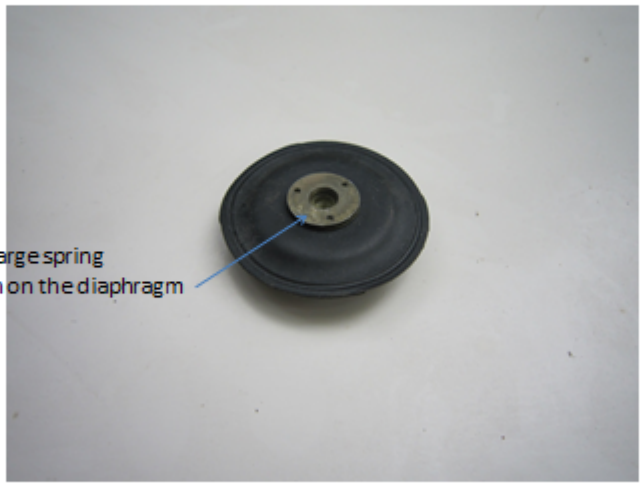
Top View With Pilot Rod Out



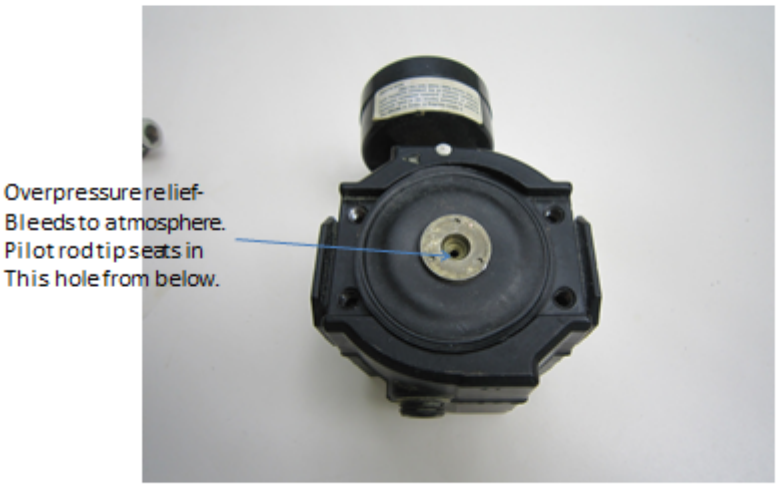
Diaphragm With Seat Facing Up



Diaphragm With Seat Facing Down (Towards The Body)



Upper Body With Diaphragm Installed



What is abundantly clear is that even with a regulator significantly larger than the ¼” NPT first example, the same astounding restrictions exist with one difference. In this particular regulator, when the diaphragm pushes down on the pilot rod and the seat backs off of the underside of the body, a port in the body allows a flow or air into the exhaust port, though that flow is not by any means the amount that a full ¾” port would allow.

If we examine the mini-regulator below, an item that is seen throughout industry, the same problems are self-evident.

The above photo depicts the so-called mini ¼” NPT regulator found in great abundance throughout industry.

The assembly is very similar to the larger body unit.

For the sake of comparison, however, a common sewing needle has been inserted through the pilot hole in the diaphragm, the same size as the internal flow port under the white seat area in the lower body, to substantiate the .035 inch hole through which the air must pass.

Even when looking at larger pipe size regulators such as the 1” NPT unit shown below, this problem is obvious!

The configuration is essentially the same as the others shown above. The hole in the center of the body is 1/8”. The poppet is .220 inches in diameter. The air cross over port seen in the poppet stem leads to a hole in the bottom of the poppet seat that is slightly less than .080” in diameter. However, please take notice of the poppet.

The passage in the poppet stem is the path through which the exit air flows out of the regulator, to the left past the 0 ring seal which separates the top chamber from the bottom one, through the center of the stem.

This view reveals the determinant port through which the air finally passes to exit the regulator. It measures .060 “ which actually limits flow to 11.5 cfm at 90 psig.

Which exits through the small tube seen in the other side of the body, NOT a 1” port, but the reduced passage from which the flow through the poppet exits the regulator..

The folly of installing this type of regulator is immediately obvious.

The perception that higher pressure settings in a regulator allow for more air flow are totally erroneous and flies in the face of common sense and reason, not to mention the laws of physics.

With this firmly in mind, it now becomes abundantly clear that any facility wishing to improve the actuation of pneumatic cylinders and the equipment on which they work, should seek an alternative to the standard practice of using regulators.

It is far more reasonable to utilize a common bar stock precision linear needle flow control valve to control the rate of recharge of the cylinder volume.

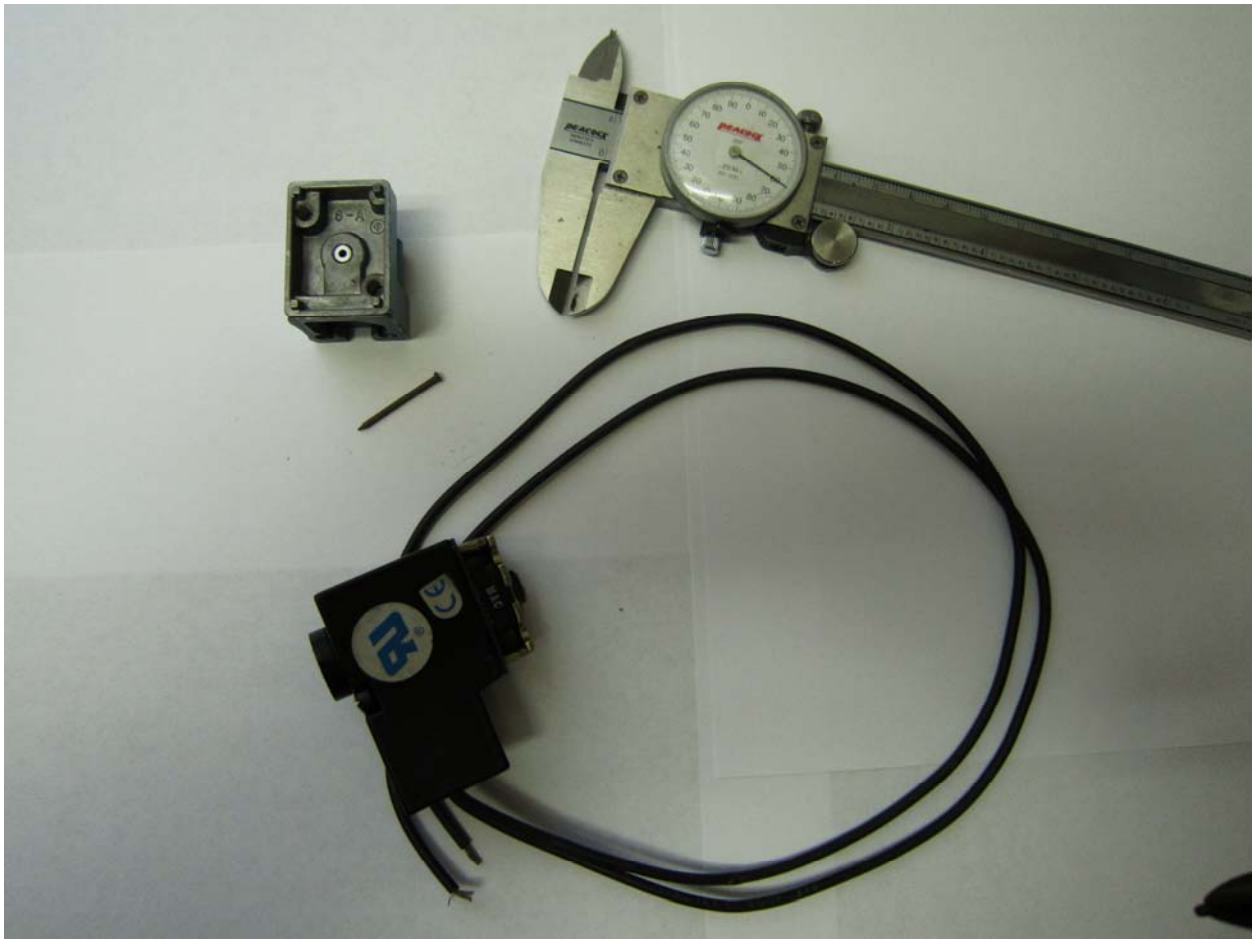
Along with this technique, due diligence must be followed in increasing the diameter of the approach tubing, solenoid valves and their internal porting, and other component issues which will reduce restriction to flow in the most expedient and cost-effective manner.

If pressure must by nature of a service requirement be regulated, the use of a low differential, high flow, piloted regulator should be a point of focus.

Along with the pressure versus flow issue we must simultaneously consider the supply control issue. The usual means of supply control is a solenoid valve which opens when demand is calling for supply.

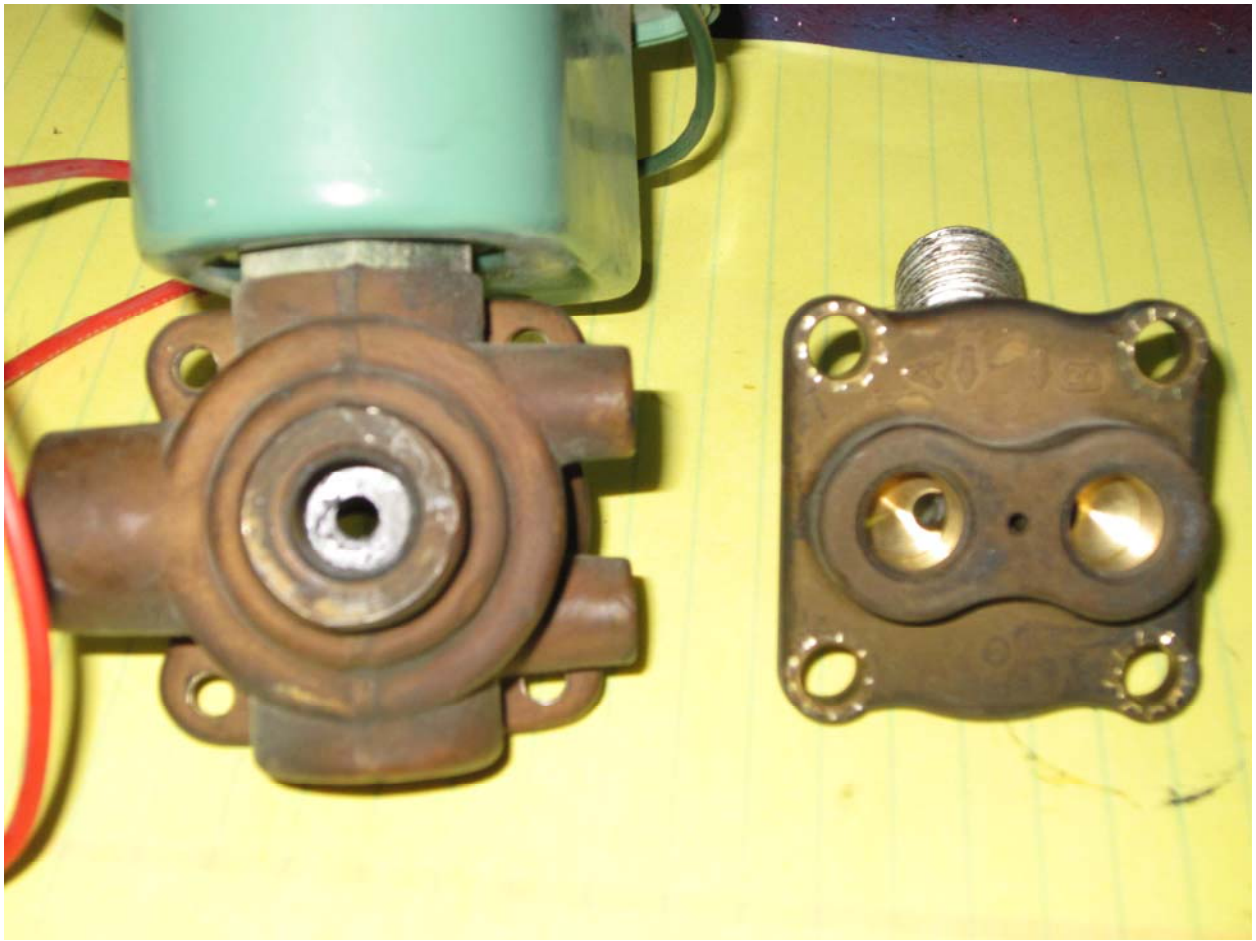
Research on this subject demonstrates that the same restriction issue is found to be prevalent in most solenoid valve applications.

The photo below depicts a common manifold mounted solenoid found on a myriad of production and packaging machinery.



The orifice was gauged with the help of the small nail which was then measured at .060 inches with the calipers.

Banks of these types of valves are found throughout American industry where overhead transmission pipe compressed air pressures are typically 85 PSIG or greater.



We can further follow this logic and common sense train of thought by observing this common ASCO ¼” NPT solenoid valve found on all too many point of se applications throughout industry. Please take careful note of the fact that while the pipe connections are 1/4 “ NPT, internal to that connection the actual flow ports are let than one half that size. This demonstrates the forcing factor which requires application of larger amounts of energy at the compressor to attempt, albeit all too often unsuccessfully, to overcome restriction through higher pressure at unnecessarily higher costs.

The next in our rogue’s gallery is the ubiquitous quick disconnect hose fittings found everywhere in industry.

If an interested person were to look carefully inside these devices you would quickly see the very small air passage which is the reason these devices typically have a minimum of 7 PSIG differentials across them. Some are even higher going to as much as 12 PSIG differential.

If these are in line with the prior devices, it is easy to see why differentials in the range of 40 PSIG are not uncommon.

The higher pressures are obviously governed by the inability of the small diameter openings in these types of valves, taken in combination with restrictions in FLR sets, to pass sufficient volumes of air at lower pressures to accomplish the task assigned the mechanism at a faster rate and lower energy applied in the compressor room.

The consequence is an overall higher cost of operation, quality excursions, and reduced rates of product throughputs.

It is long past time for American industry to wake up and take a look at how they specify and purchase pneumatic equipment.

I invite any comments or challenges to the material set forth herein.

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