

FDO4-Rev6 Sanitary Precision Back Pressure Regulator

REGULATOR USE AND STARTUP

Installation Guide for FDO4 Revision 6 models with double diaphragms

WARNING:

Make sure that you have read and understand these directions before using, installing, or maintaining the Equilibr pressure regulator. Take steps to ensure this instruction manual reaches the operator of this regulator and stays with the regulator throughout its lifetime. Use, installation, operation, and maintenance of all pressurized products including this regulator must be performed by personnel who are properly trained and qualified through experience or specific training.

Failure to properly observe the instructions contained in this document may result in, but is not limited to:

- Serious personal injury or death
- Unconstrained release of the pressurized media
- Permanent damage to the pressure regulator and/or permanent damage to connected equipment



BACKGROUND

The Equilibr® FDO Series precision back pressure regulators (BPRs) control the fluid pressure at the inlet “I” port by allowing excess flow to vent from the system through the regulator’s outlet “O” port. The flow direction is from inlet to outlet. The Equilibr BPR is pilot operated, where the pressure setpoint is determined by the pressure applied to the “Pilot” or “Reference” port on the BPR (see Fig. 1). The BPR will control the pressure at its inlet port in a precise 1 to 1 relationship with the setpoint pressure applied to the pilot port. The pilot pressure may be applied using a manual pressure regulator or an electronic pressure regulator (electro-pneumatic regulator).

Refer to Fig. 1. The Equilibr BPR uses a flexible membrane diaphragm to both sense the pressure and to provide a direct seal against the orifices in the regulator body. The pilot pressure is applied to one side of the diaphragm. The Inlet “I” port pressure is sensed on the other side of the diaphragm. When the pilot pressure is higher than the Inlet pressure the diaphragm is pushed firmly against the orifices to form a seal and the regulator is effectively closed. When the inlet pressure builds and just equals the pilot pressure, the closing forces are removed from the diaphragm and media can begin to pass from the Inlet to the Outlet port. When sufficient media has passed through the regulator, the Inlet pressure will be reduced slightly, and the diaphragm is allowed to seal against the orifices again. In normal practice equilibrium is achieved and the diaphragm modulates into a position where just enough flow is allowed out of the regulator in order to maintain a steady pressure on the Inlet port. (see Fig. 2)

Typical Circuits:

A back pressure regulator is used to control the pressure in a system by venting any excess flow that would otherwise cause the system pressure to increase above the pilot setpoint pressure. In the circuit shown in Fig. 3, an Equilibr BPR is used to control the outlet pressure of a pump. Excess fluid is vented through the BPR back to the fluid storage tank.

A back pressure valve is sometimes used to prevent bubbles in flow instruments. Accurate flow measurements are not possible with Coriolis flow meters when bubbles are present. When bubbles pass through the sense tube of the mass flow meter, the resulting flow signal can be disturbed significantly. One common method to minimize or prevent bubble evolution is to increase the pressure at the outlet of the Coriolis meter (see Fig. 4). By installing a back pressure regulator downstream of the instrument, gases are more likely to remain in solution and the volume of small bubbles is minimized, thereby improving flow meter accuracy.

Equilibr has trained engineers who can work with you to suggest an Equilibr regulator design and wetted materials for your specific application. These suggestions are recommendations only and are dependent on complete and accurate information from the end user about the application. It is the ultimate responsibility of the user to determine the compatibility of the media both with the materials of construction of the back pressure regulator and with the pilot gas in use.

The diaphragm installed in the back pressure regulator is a careful balance between the requirements for pressure, temperature, media compatibility, and flow rate. Often performance in one area may be sacrificed in order to obtain acceptable performance in another. For instance, many diaphragm types cannot achieve tight shutoff and must have some minimum system flow always present. If the system flow rate into the back pressure regulator is less than the minimum flow rate required by the installed diaphragm, then the system pressure will fall below the target set point pressure.

2 SET-POINT OPTIONS

Fig. 1

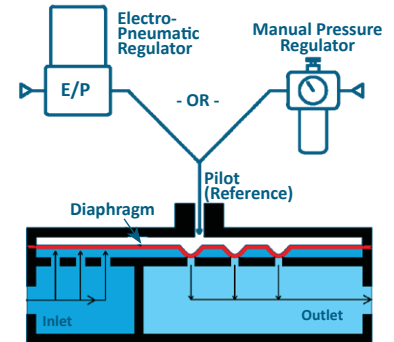


Fig. 2

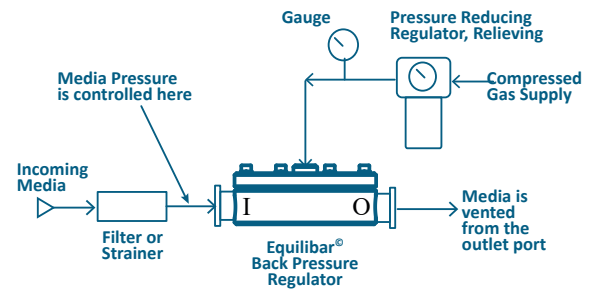


Fig. 3

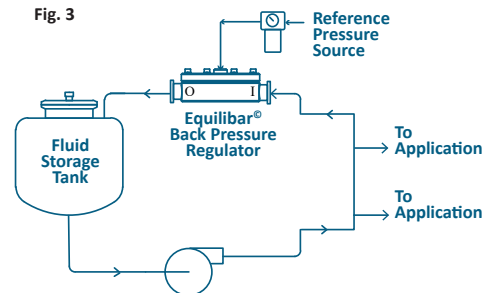
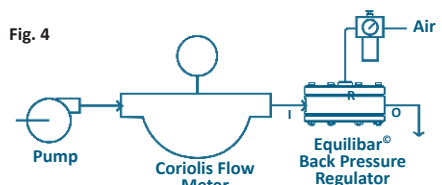


Fig. 4



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PREPARING FOR INSTALLATION

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- Inspect the Equilibar BPR for any damage. Consult Equilibar before proceeding if you find any damage.
- Verify that the part number on the Equilibar BPR product label matches what you had requested. Revision 6 model part numbers start with “FDO4xxx6-”.
- Verify that the rating on the Equilibar BPR label for maximum allowable working pressure (MAWP) and maximum allowable working temperature (MAWT) will not be exceeded when the BPR is used.
- Call or e-mail Equilibar if you have any questions, concerns, or need a new copy of these instructions. Be sure to include the full part number and serial number of the BPR you are inquiring about. (01-828.650.6590, info@equilibar.com)
- Take precautions to prevent injury to personnel in the event of a diaphragm failure or external leak. Sensitive fluid controls such as an Equilibar BPR can experience internal or external leaks. See standard terms and conditions for important limitations of liability notes.
- Diaphragms may fail in the open or closed position. Proper [safety precautions](#) should be taken for either failure mode
- Some diaphragms are manufactured with a small tab of protruding material. This is nonfunctional and is included only to allow easy inspection of the diaphragm material and thickness without the need to disassemble the regulator.
- Every Equilibar regulator is individually hand tested at the factory for operation and external leakage. Leak testing is typically performed at 1.5X the MAWP.
- The Equilibar BPR is not a “Safety Accessory” as defined by the Pressure Equipment Directive 2014/68/EU. Be sure to install appropriate over pressure protection devices such as safety relief valves or rupture discs to protect the system and the BPR from exceeding the maximum allowable working pressures. These safety devices must meet applicable law, codes, regulations, and standards for your jurisdiction.
- Equilibar regulators are cleaned internally and externally at the factory using aqueous based cleaners in an ultrasonic cleaner and manual wipe down with denatured alcohol.
- Install a strainer or filter (100 micron/100mesh or better upstream of the Equilibar BPR to prevent plugging of the orifices. Consider the effect the pressure drop in the filter will have on the system pressure control.
- Inlet ports are stamped with an “I”; Outlet ports are stamped with an “O”.
- The inlet “I” port is connected to the point in the system where it is desirable to maintain or control the pressure. The best pressure control will be seen if the plumbing to the BPR inlet port is as short and as large as practical to minimize the amount of pressure drop in the plumbing.
- System media will be vented out the BPR outlet “O” vent port, also called an exhaust port. Be sure that the media is vented to a safe environment, away from employees, and in accordance with applicable laws in your jurisdiction. Take care that the outlet port cannot become blocked during operation by a valve closure, snow, ice, condensate, insects, birds nesting, etc.
- Even inert gases can cause suffocation through oxygen displacement. Ensure adequate ventilation and oxygen levels will be maintained when media is vented from the BPR outlet.
- Provide adequate exhaust line capacity to prevent pressure build-up on the BPR outlet port. Short or oversized exhaust lines are recommended.
- Any bolt, screw, or connector threaded into a stainless steel body should have some small amount of lubricant to prevent thread galling. Thread galling is usually permanent and causes

the regulator to be scrapped. The Equilibar factory applies Krytox™ FDA, NSF H1 Food Grade Lubricant to bolt thread connections that are not wetted by the process fluid.

PREPARING THE PILOT REGULATOR

- The pilot pressure supply should be an inert compressible gas. Incompressible media such as liquids do not make effective pilot pressures because they do not allow the BPR diaphragm to adjust quickly. Make sure the pilot media is compatible with the media flowing through the BPR.
- The controlled pressure is a near exact 1:1 relationship to the pilot pressure. Installing a pressure gauge in the pilot port may offer advantages over installing a gauge in the Inlet “I” port. The inert pilot media can be read with a less expensive gauge and the pilot pressure may be set even when there is no system media actively flowing.

INSTALLING

1. The Equilibar BPR and pilot regulator arrive ready to use.
2. Install the pilot regulator following instructions included with the order. Check the performance of the pilot regulator before attaching to the reference port of the Equilibar BPR.
3. The Equilibar BPR will control pressure or flow in any orientation and may be mounted in any plane. However, for maximum drainability performance, install the FDO vertically with the inlet down, such that fluid flows upward through the valve during normal operation. See figure C on page 4.
4. Install the BPR ensuring the inlet “I” and outlet “O” are installed in the proper direction of flow. Pressure is controlled at the inlet “I” port.
5. Connect the pilot regulator outlet port to the reference port of the BPR and adjust the pressure to the desired setpoint.
6. Equilibar recommends an initial ‘*setting*’ of diaphragms at application operating pressure. This is achieved by applying that pressure to the reference port of the Equilibar. This ‘*setting of the diaphragm*’ can help the diaphragm perform at lower flow rates.
7. The BPR is designed to have maximum reference pressure applied even when there is no pressurized media at the inlet “I” port. No damage will result.
8. Start the flow of process fluid *after* the reference pressure has been applied and the diaphragm has been set. Equilibar recommends that reference pressure always be applied when running the process fluid through the Equilibar, such as in the case of pressure testing a system that has an Equilibar BPR installed. This helps prevent the diaphragm from lifting and deforming into the cap which can have a negative impact on performance.
9. Cleanability has been evaluated using riboflavin at 5 ft/sec. Reference pressure must be disengaged during the cleaning process to allow full flow through the valve. Cleaning results will vary by media and process design. Customer is responsible for verifying the efficacy of their process cleaning cycle.
10. Exercise caution when reducing the reference pressure. The BPR will attempt to reduce the inlet pressure at the same rate that the reference pressure is being reduced. This can result in extremely rapid release of media through the outlet (O) port of the regulator. Reduce the reference pressure as slowly as practical.
11. After CIP/SIP step, ensure process line remains pressurized for optimal drainability.
12. When preparing for maintenance or shutting the system down, turn the process fluid off before removing pilot pressure supply to the reference port.

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MAINTENANCE NOTES

- Maintain strainer or filter upstream of device
- Annual inspection of diaphragm integrity is recommended, especially for applications where there is strong or regular pulsing (i.e. reciprocating pump, etc.).
- It is expected that diaphragms will need to be replaced on a regular basis, the timing of which is dependent on the application.
- It is recommended to order spare diaphragms prior to performing maintenance. [Contact Equilibar](#) to order a “DI Kit” or Diaphragm Kit for this model. Please have the part number available to ensure proper spare parts are ordered.
- Visit our [maintenance website](#) or contact us for more information at www.equilibar.com/contact/

PREPARING FOR MAINTENANCE OR TROUBLESHOOTING

- When preparing for maintenance or shutting the system down, turn the process fluid off before removing pilot pressure supply to the pilot port. This step will prevent a sudden release of system media pressure through the BPR.
- Release the pilot pressure and remove the pilot/reference port piping to clear the BPR for maintenance.
- Loosen the bolts in the cap of the BPR and disassemble wearing proper protective equipment. See exploded view on page 4 for more details.
- Inspect diaphragms for integrity to determine if they need to be replaced or cleaned
- Clean all stainless steel surfaces to remove any residual process fluid or debris
- Reassemble the clean parts with new or cleaned diaphragms following the instructions on page 4.

TROUBLESHOOTING

PROBLEM	POSSIBLE SOLUTIONS
Maximum flow is reduced	Clean out internal orifices
Will not maintain back pressure at low flow rates	<ol style="list-style-type: none">1. Inspect the regulator for debris or diaphragm damage which prevents the diaphragm from sealing against the orifice in the regulator body2. Contact Equilibar Applications Engineer to review low flow specifications
External leak around diaphragm	<ol style="list-style-type: none">1. Check for loose screws. If they have loosened, tighten to torque values listed on p.42. Check for misaligned flanges or diaphragm3. Check for scratched sealing surfaces4. Check diaphragms for damage. Replace as necessary
Chatter on the downstream tubing	<ol style="list-style-type: none">1. Increase exhaust piping size2. Contact factory for additional assistance
Air in process exhaust	Check for ruptured diaphragm
Fluid out of the reference port	Check for ruptured diaphragm

RATED PRESSURE NOTE

Equilibar regulator bodies have a *shell pressure rating* based on the body and bolt strength using principles of the ASME B31.3 and confirmed using hydrostatic testing. These shell pressure ratings are the maximum rating for each design as listed in the technical brochures. For example, FDO6 is listed as having a maximum pressure rating of 150 psig (10bar) standard.

Equilibar configures individual regulators to the specific customer application which may involve fitting the valve with a thinner diaphragm to meet precision or low-flow requirements. The diaphragm selection, operating temperature, chemical composition or other factors may cause pressure derating. Therefore, the MAWP printed on an Equilibar BPR label reflects that of the selected diaphragm and application conditions but will not exceed the shell pressure rating of the body design.

The maximum pressure rating for the shell is always based on the body and bolt strength and is not printed on the product label. Customers may contact Equilibar engineers if they desire to increase unit MAWP by upgrading diaphragm thickness.

Equilibar’s quality system is
ISO 9001:2015 certified.

PATENT INFORMATION: Equilibar patent details found here: www.equilibar.com/support/patents/

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INSTALLING NEW DIAPHRAGMS

1. Prior to beginning, review [this YouTube video](#) for a demonstration of and important considerations for disassembly and assembly. Link to video using the QR code.
2. Be sure process fluid and pilot fluid are turned off and isolated.
3. Disconnect pilot fluid piping from Reference/top cap.
4. Disassemble the FDO4 by removing machine screws and taking Top Cap off.
5. Remove and inspect diaphragms for wear.
6. Clean Body, Top Cap and Bottom Cap surfaces with isopropyl alcohol using a clean lint-free cloth.
7. Remove new diaphragms (*and passive dampener, if you have one*) from your "Diaphragm Kit", checking the label to ensure that the diaphragms are the material and thickness you ordered.
8. If your rebuild kit includes two diaphragms of varying thickness, use the thicker one on the bottom.
9. Some diaphragms are manufactured with a small tab of protruding material. This is nonfunctional and is included to allow easy inspection of the diaphragm material and thickness without the need to disassemble the regulator. Tabs are not orientation sensitive. The diaphragms do not have a top or bottom side and can be installed with either surface contacting the media.
10. Install new passive dampening insert onto clean Bottom Cap if you have one.
11. Install one new diaphragm on top of clean Bottom Cap as shown in Figure A (if the diaphragms are of varying thickness, use the thicker one here).
12. Note: *Installation can be in any orientation where the bolt holes align -- as described in YouTube video in step 1.*
13. Align Body on top of Bottom Cap in any orientation where the bolt holes align, and install the second new diaphragm on top of clean Body.
14. Align Top Cap on top of Body and diaphragm so bolt holes align.
15. Install Screws through Top Cap, Top Diaphragm, Body and Bottom Diaphragm as shown.
16. Tighten all screws finger-tight into the Bottom Cap following pattern shown in Figure B so that all pieces in the assembly contact each other.
17. Using a calibrated torque wrench, tighten all screws to **15 in-lbf / 1.69 N-m** following the pattern shown in Figure B.
18. Note: *If using for low pressure flow control below 50 psi/2.5 bar MAWP, the sensitivity and performance can be improved by keeping the final torque at 15 in-lbf / 1.69 N-m.*
19. *For all other applications*, using the torque wrench once again, tighten all screws to **30 in-lbf / 3.39 N-m** following the pattern shown in Figure B. Use this step-wise procedure to ensure even pressure distribution. [Contact us with questions.](#)
20. Make one final pass with the torque wrench to verify all bolts are tightened to 30 in-lbf / 3.39 N-m.



YouTube demonstration

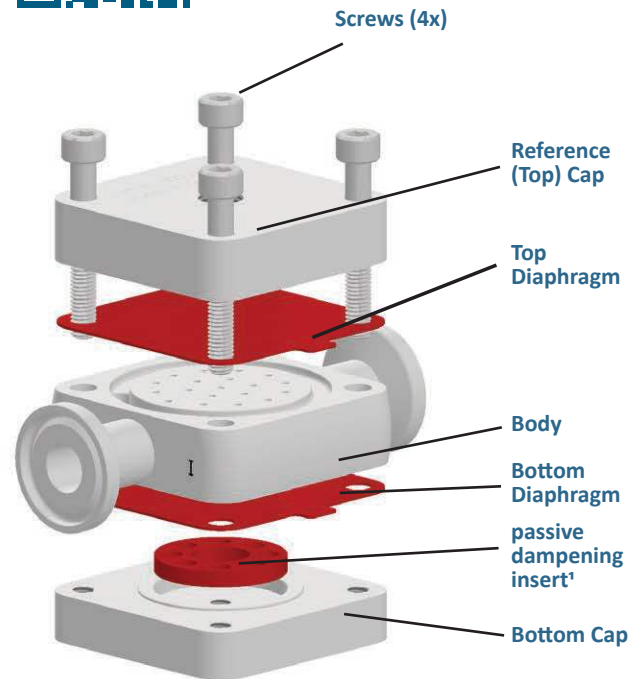


Figure A: FDO4 Exploded View

*shown with optional passive dampening insert

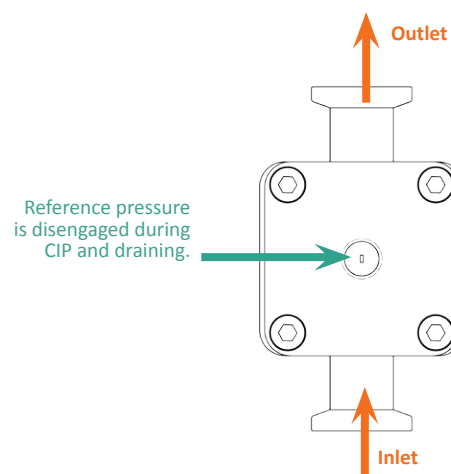
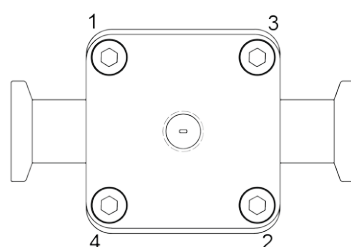


Figure C: FDO4 orientation with inlet down for optimal drainability results



Apply torque to screw #1 and then to the opposing screw #2. Continue by applying torque to screw #3 and then #4.

Figure B: Sample Torque Pattern

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SYSTEM HAZARD ANALYSIS

Both normal operation as well as possible failure modes and foreseeable misuse must be accounted for in the design of the system which interacts with and connects to the Equilibar back pressure regulator (BPR). It is the responsibility of the end user to account for these hazards. **Please read all of the following safety and hazard precautions before installing or operating any equipment.**

- a. The BPR is not certified as or marketed as a pressure vessel safety relief valve. The BPR is a precision control valve. Guarding against overpressure must be achieved with devices designed and marketed as such.
- b. Sensitive diaphragms and external seals can leak. It is the responsibility of the end user to use this product in a way that prevents injury to personnel should leakage occur. See Standard Terms and Conditions for important Limitation of Liability notes.
- c. If the internal diaphragm ruptures or leaks, the gas or fluid on the pilot port can be introduced into the process fluid. Make sure that the fluids are compatible and not hazardous when mixed.
- d. If the internal diaphragm ruptures or leaks, process fluid can enter the pilot port plumbing. Follow precautions below and on our website: www.equilibar.com/equilibar-safety-information/
 - i. Make sure that the process fluids and the pilot are compatible and not hazardous when mixed. Most auxiliary pressure regulators used to provide pilot pressure to the BPR are of the self-relieving design. Guard against the process fluid relieving out the pilot regulator if the BPR diaphragm fails. One method to accomplish this is to set the pilot pressure into a static volume chamber that is sealed with an ON/OFF valve after the pressure is set to the desired value. Another method is to feed the pilot pressure from the pilot regulator through a check valve to the BPR. In order to reduce the pilot pressure a bleed from the pilot port to a safe location must be employed. In many cases this bleed can be made to the output of the BPR.
 - ii. If an electronic pressure regulator is used then special consideration must be made. In addition to reviewing the prospect of having the process media coming in contact with and venting out of the electronic pressure regulator, the possibility of ignition of the media by the electronic pressure regulator must be examined. It is the user's responsibility to determine if a hazardous area classification exists and to make sure that the electronic pressure regulator employed meets or exceeds the requirements of intrinsic safety for that area.
- e. If the internal diaphragm ruptures or leaks the result is often that the BPR will fail into a closed position. This results in a blocked pipe with no path for the fluid to escape through the BPR. Over pressurization of the upstream can occur. Ensure that the upstream piping is made sufficiently strong to withstand this and that it is guarded by an overpressure relief device.
- f. Make sure the process pressure to be controlled is connected to the BPR "I" Inlet port. Process fluid flow is from "I" Inlet to the "O" Outlet. If the BPR is connected in reverse it will still operate but it will give poor control and can result in excess pressures.
- g. Observe the maximum temperature and pressure ratings on the BPR label. Take steps to ensure these values cannot be exceeded. Where necessary to protect equipment, a suitable type of safety overpressure relief valve must be connected in parallel to the BPR. The overpressure relief valve must be rated to prevent the pressure or temperature from exceeding the BPR maximums as listed on the BPR label. In some installations a rupture disc may be substituted for the safety relief valve.
- h. If the discharge piping on the BPR "O" Outlet port becomes blocked, the BPR will open and fill the discharge piping to the same pressure as the maximum pressure in the system. The discharge piping must be rated to contain this pressure and must have a safety relief valve to limit this pressure at or below the safe pressure of the discharge piping.
- i. Do not use the BPR as a structural member. All piping and plumbing connections to the BPR should be adequately supported. The BPR series is available with a mounting bracket to facilitate the installation.
- j. Enriched oxygen media (>21%) should not be used in the BPR unless Equilibar has specifically worked with you to provide a product rated and labeled for enriched oxygen. Standard products are not oxygen cleaned. Particle impact, adiabatic compression, and diaphragm motion can all cause ignition in an enriched oxygen media. This kindling chain can cause the entire BPR to oxidize extremely rapidly resulting in high temperatures, discharge of flames and molten metal, and unrestrained escape of process fluid.
- k. The metal cap and body of the BPR are excellent conductors of heat.
 - i. Assume the external temperature of the BPR will rise or fall to match the temperature of the process media flowing through it. In addition to thermal hazards posed to humans by directly touching the BPR exterior, it is the duty of the end user to verify that the temperatures of the process media do not exceed the ignition temperatures of any combustible gases or dust (or mixture) that may be present local to the BPR.
 - ii. Assume the internal temperature of the BPR will rise or fall to match the temperature of the ambient environment. Ensure that the process media flowing through the BPR cannot be damaged or ignited by the maximum and minimum ambient environment temperatures. Low ambient temperatures can cause the media within the regulator to freeze. Expansion cooling in certain gases can also cause freezing. Freezing can block the BPR and cause excess pressures to build on the "I", Inlet, port. Expansion of water due to freezing can damage the regulator. Ice formation from freezing can perforate metallic foil diaphragms.
- m. The BPR has been carefully designed by skilled engineers to provide proper safety ratios and adequate pressure regulation. Do not attempt to modify the BPR in any way, including adding or enlarging orifices or ports or replacing machine screws (bolts). Replace the internal diaphragms **only** with Equilibar factory provided repair parts.
- n. Never perform maintenance or inspections on a system when pressurized fluids are present. De-pressurize the system before performing this work. De-pressurize inlet pressure before reference otherwise a quick drop in reference pressure can lead to a violent exhaust of the upstream pressure through the regulator.