

# RSV Precision Vacuum Regulator

## REGULATOR USE AND STARTUP

**Warning:** Make sure that you have read and understand these directions before using, installing, or maintaining the Equilibar® vacuum 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 pressure control 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 Equilibar® RSV Precision Vacuum Regulator is most often used as a pilot regulator for the EVR Series family of precision vacuum pressure regulators. The EVR vacuum regulators control the vacuum pressure that is on the inlet “I” port. The Equilibar® controls this vacuum by allowing flow from the system to vent through the regulators outlet “O” port. A vacuum supply source is connected to the outlet “O” port. The flow direction is from inlet to outlet. The Equilibar® is pilot operated. The vacuum pressure set point is determined by the pilot vacuum pressure that is applied to the “R” reference (also known as pilot or dome) port. The EVR vacuum regulator will control the vacuum pressure on its inlet port in a precise 1 to 1 relationship with the vacuum pressure applied to the pilot port. See EVR

Series Installation and Maintenance Guide for more information on the EVR series.

The Equilibar® EVR uses a flexible membrane diaphragm to both sense the vacuum pressure and to provide a direct seal against the orifices in the regulator body. The pilot vacuum pressure is applied to one side of the diaphragm. The Inlet “I” port vacuum pressure is sensed on the other side of the diaphragm. When the pilot vacuum is closer to atmospheric pressure than the vacuum on the Inlet port then the diaphragm is pushed firmly against the orifices to form a seal and the regulator is effectively closed. When the inlet vacuum pressure 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 vacuum 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 controlled vacuum on the inlet port, see Fig 2.

The RSV works by monitoring the upstream pressure of the system via the remote sense “RS”. The regulator will respond by either applying more or less vacuum pressure to the pilot “P” port that is connected to the EVR “R” reference. This closed loop performance offers greater precision over a wider flow range. See Fig 1a and 1b. For open loop performance the RSV Remote Sense is connected back into the Pilot line and will operate as a simple pilot as shown in Fig 2. Equilibar® has trained engineers who can work with you to suggest a regulator design and wetted materials for your specific application.

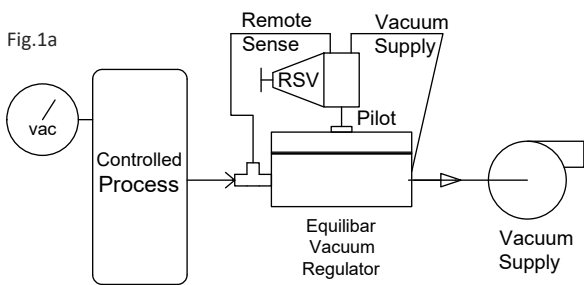
These suggestions are recommendations only and are dependent on complete and accurate information from the end user about the application.

It is the ultimate responsibility of the user to determine the compatibility of the media with the materials of construction of the vacuum pressure regulator.

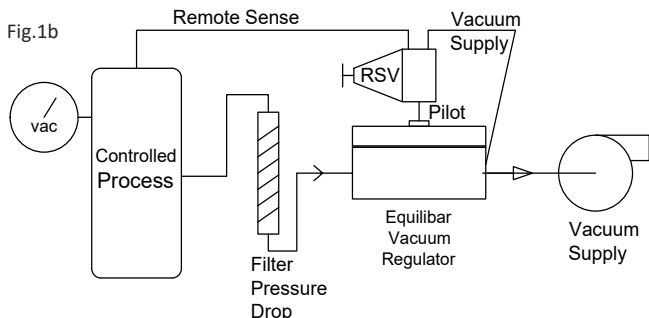
The diaphragm installed in the EVR vacuum pressure regulator is a careful balance between the pressure, temperature, media compatibility, and flow rate. Often performance in one area must be sacrificed to obtain acceptable performance in another. Many diaphragm types cannot achieve tight shutoff and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

Another example application is to use an Equilibar® EVR vacuum regulator to precisely control the vacuum pressure surrounding a plastic extrusion. Immediately after the extrusion exits the die it remains in a soft and formable state until it cools sufficiently. During this cooling phase the pressure on the inside of the tubing must remain higher than the pressure on the outside of the tubing to prevent the extrusion from collapsing. The Equilibar® allows the vacuum pressure to be fine-tuned so that the pressure differential is optimized to maintain the extrusion wall thickness and overall dimensions, see Fig 4.

### STANDARD RSV CLOSED LOOP SET UP LOCAL SENSING

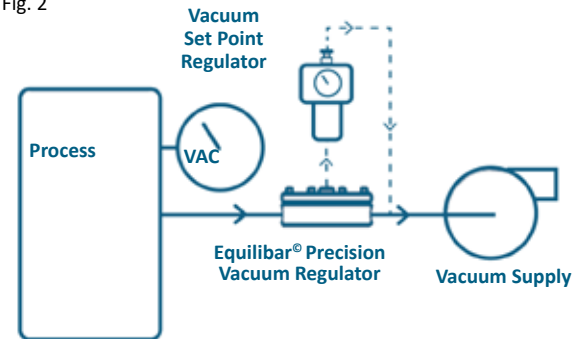


### STANDARD RSV CLOSED LOOP SET UP LOCAL SENSING



### OPEN LOOP GENERIC SET UP

Fig. 2



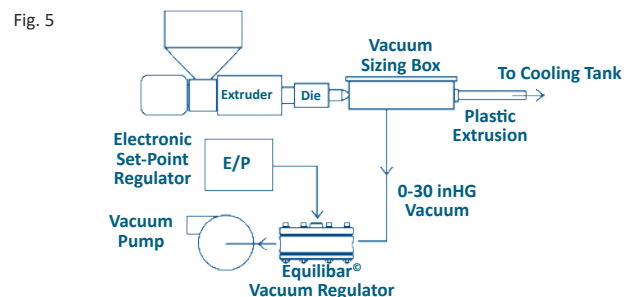
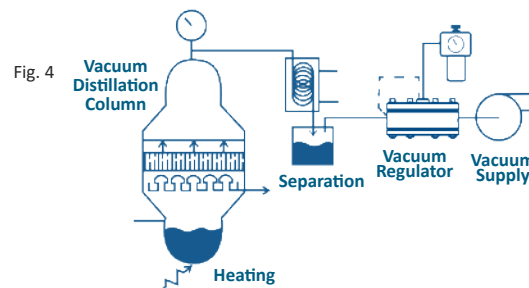
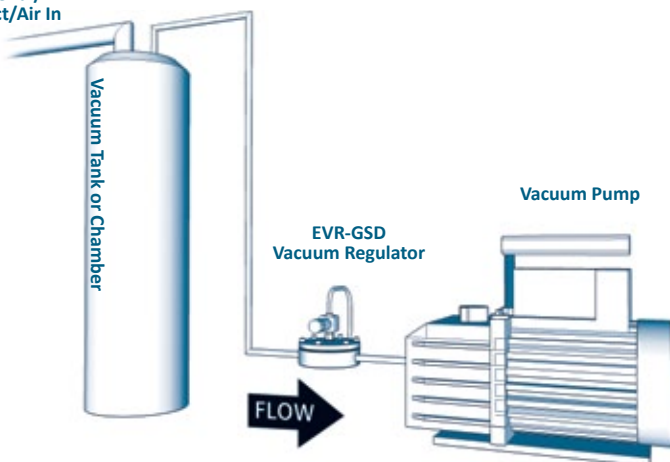
# RSV Precision Vacuum Regulator

## PREPARING FOR INSTALLATION WITH WITH EQUILIBAR EVR SERIES REGULATOR

The following preparation instructions relate to the combined assembly of the RSV and Equilibar EVR series.

- Inspect the Equilibar® EVR for any damage. Consult Equilibar® before proceeding if you find any damage.
- Verify that the part number on the Equilibar® EVR product label matches what you had requested
- Verify that the rating on the Equilibar® EVR label for maximum allowable working pressure (MAWP) and maximum allowable working temperature (MAWT) will not be exceeded when the EVR is used.
- Call, write, 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 EVR you are inquiring about. (Equilibar, 320 Rutledge Road, Fletcher, NC, 28791, USA, Phone 01-828-650-6590, www.equilibar.com, info@equilibar.com )
- Take precautions to prevent injury to personnel in the event of a diaphragm failure or external leak. Sensitive fluid controls can experience internal or external leaks. See standard terms and conditions for important limitations of liability notes.
- The Equilibar® EVR is not orientation sensitive and may be mounted in any plane and maintain good vacuum control. Media draining or other considerations may need to be taken in to account by your specific application requirements.
- The ports in the EVR series that are plugged with pipe plugs are for machining operations during the manufacturing process. They are common with the outlet “O” vent port. These ports may be used to conveniently connect the vacuum supply to the pilot regulator.
- Every Equilibar® regulator is individually hand tested at the factory for operation and external leakage. Leak testing is performed at 1.5X the MAWP. Typically this is 1.5 X standard atmospheric pressure, or 1.5 Bar gauge pressure.
- 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.
- A small amount of DuPont Krytox lubricant is occasionally used on the internal non-wetted o-ring.
- Inlet ports are stamped with an “I” as shown. Outlet ports are stamped with an “O”.
- Many 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.
- 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 EVR inlet port is as short and as large as practical to minimize the amount of pressure drop in the plumbing.
- Tapered pipe thread connections will require the addition of a sealant. PTFE tape may be used if it is compatible with your process and media. Take care not to let the PTFE tape extend past the first two male threads to prevent the PTFE tape from being ingested by the regulator. Tape or other debris can prevent the EVR from closing tightly and therefore not able to maintain the vacuum pressure at low flow rates. PTFE based pipe dope or an anaerobic “Loctite” product may also be used. Confirm the thread sealant used is compatible with your process, temperature, and media.
- Install a strainer or filter upstream of the Equilibar® vacuum pressure regulator where necessary to prevent plugging of the orifices. Recommended 100 micron/100 mesh or better.
- System media will be vented out the EVR 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.
- Even inert gasses can cause suffocation through oxygen displacement. Take care to ensure that adequate ventilation and oxygen levels will be maintained.
- Provide adequate exhaust line capacity. Short or oversized exhaust lines are recommended.
- The Equilibar EVR is not a “Safety Accessory” as defined by the Pressure Equipment Directive 2014/68/EU. Be sure to install appropriate over and/or under pressure protection devices such as safety relief valves, vacuum relief valves, or rupture discs to protect the system and the EVR from exceeding the maximum allowable working pressures and to protect the system from excessive vacuum that could collapse tanks, vessels, or plumbing. These safety devices must meet applicable law, codes, regulations, and standards for your jurisdiction. All EVR regulators are rated to withstand full vacuum without damage.
- Any bolt, screw, or connector that is threaded into a stainless steel body should have some small amount of lubricant to prevent thread galling. Threads galling together is usually permanent and causes the regulator to be scrapped. The Equilibar factory applies Swagelok® brand Silver Goop® to all bolt and screw thread connections that are not wetted by the process fluid.
- The pilot vacuum pressure is a nearly exact 1:1 relationship to the vacuum pressure being controlled. Many users find that installing a vacuum pressure gauge in the pilot port offers 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.
- The pilot pressure should be an inert compressible gas, usually atmospheric air. Incompressible media such as liquids do not make effective pilot pressures because they do not allow the EVR diaphragm to adjust. Make sure the pilot media is compatible with the media flowing through the EVR.
- Exercise caution when adjusting the pilot pressure. The EVR will attempt to adjust the inlet vacuum pressure at the same rate that the pilot vacuum pressure is being adjusted. This can result in extremely rapid release of media through the outlet (O) port of the regulator. Adjust the pilot pressure as slowly as practical.
- The EVR is designed to have maximum pilot pressure applied even when there is no pressurized media at the inlet (I) port. No damage will result.
- The EVR is designed, manufactured, and tested in accordance with sound engineering practices and the European Community Pressure Equipment Directive 2014/68/EU (the PED). Because the EVR series is used only at pressures less than 0.5 Bar gauge (above atmosphere) the PED does not apply and no specific PED Declaration of Conformity is issued for the EVR Series.

Fig. 3  
Material/  
Product/Air In



# RSV Precision Vacuum Regulator

## INSTALLATION OF RSV WITH AN EQUILIBAR VACUUM REGULATOR

The RSV is a highly sensitive mechanical vacuum pilot regulator that provides closed-loop control of the Equilibrar Vacuum Regulator (EVR).

Both regulators work together to control the vacuum at the location sensed by the remote sense port on the RSV.

The schematic shows how the RSV works together with the EVR.

- The control vacuum is shown in blue.
  - The vacuum supply is shown in red
  - The pilot pressure supplied to steer the EVR is shown in purple.
1. The Vacuum Supply Port of the RSV is labelled “VS”. Connect the “VS” port to the strongest vacuum in the system. Most Equilibrar Vacuum Regulators have a small fitting on the bottom (BD Series) or side (GS Series) that can be conveniently used to connect the Vacuum Supply for the pilot regulator. Or this can be connected to any strong vacuum source that you have available.
  2. The Pilot Port of the RSV is labelled “Pilot”. Connect the “Pilot” port to the reference or top port of the Equilibrar Vacuum Regulator.
  3. The Remote Sense Port of the RSV is labelled “RS”, but is located on the upper end of the unit, closest to the adjusting screw. Connect this upper Remote Sense port to the portion of your process that you would like to be controlled. Equilibrar vacuum regulator assemblies may come with a “Tee” or fitting on the inlet of the regulator for easy assembly. See sample schematics in Fig. 8, 9, 10, and 11.
  4. There is an unlabeled port next to the “Pilot” port on the lower part of the unit. This port senses the atmospheric pressure, and a small amount of air is ingested here (goes to Vacuum Supply). This port has a preinstalled filter.
  5. Keep all tubing lengths to a minimum practical length and use tubing with an outer diameter of at least 3/8” or 10mm.

The RSV is shown mounted directly to the Equilibrar Vacuum Regulator. Users can install the regulator away from the Equilibrar Vacuum Regulator.

The RSV is shown to sense directly at the inlet of the port in Fig. 8 and Fig. 10. Users can install the sensing line closer to the point of control for higher precision.

Fig. 6 Operating Schematic

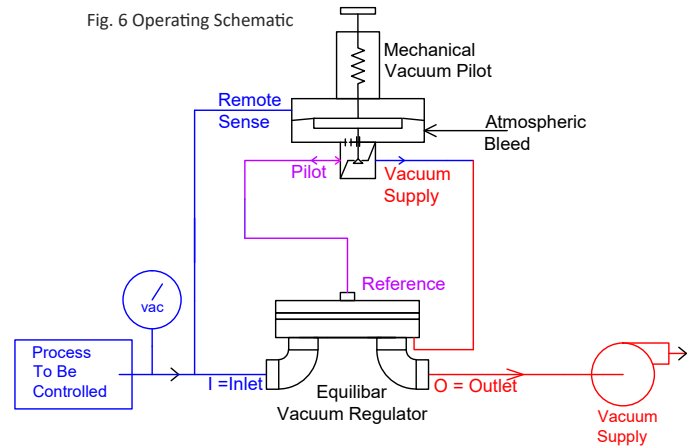


Fig. 7 Port Configuration

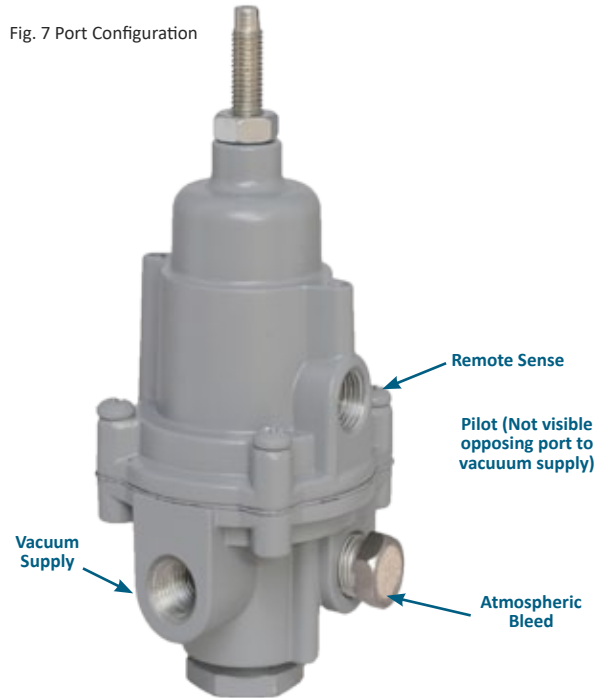


Fig. 8 Sample EVR-GS(D) Assembly with RSV

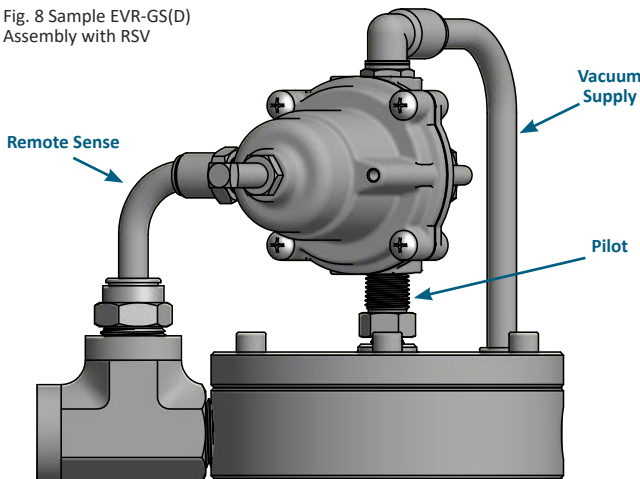
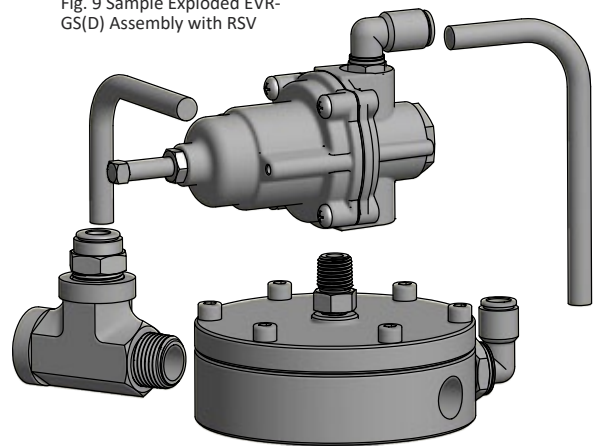


Fig. 9 Sample Exploded EVR-GS(D) Assembly with RSV



# RSV Precision Vacuum Regulator

Fig. 10 Sample EVR-B(D) Assembly with RSV

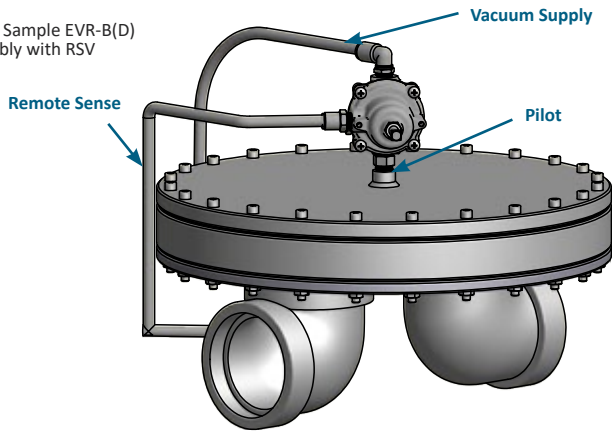
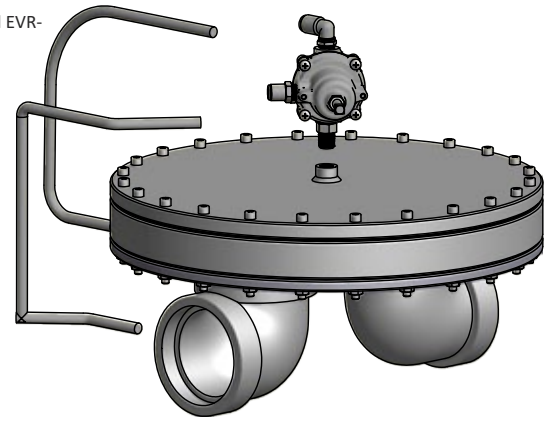


Fig.11 Sample Exploded EVR-B(D) Assembly with RSV



## HOW TO ADJUST THE RSV PILOT

Once installed per the instructions below, the RSV Pilot can be adjusted by simply turning the adjusting screw on the top of the unit. Turning clockwise will increase the vacuum set-point (lower the pressure). Turning counter-clockwise will lower the vacuum set-point (increase the pressure).

## DISASSEMBLY / CLEANING

To maintain or clean the RSV regulator,

1. Remove each of the 4 main screws
2. Remove the top cap and diaphragm assembly
3. Remove the hex nut on the bottom of the regulator
4. Clean out any dust or debris
5. Note that there is a small precision bleed orifice under the diaphragm. Check to make sure that it is not blocked.

## RE-ASSEMBLY

To maintain or clean the RSV regulator,

1. Remove each of the 4 main screws
2. Remove the top cap and diaphragm assembly
3. Remove the hex nut on the bottom of the regulator
4. Clean out any dust or debris
5. Note that there is a small precision bleed orifice under the diaphragm. Check to make sure that it is not blocked.

## TROUBLESHOOTING RSV

If the unit fails to perform, contact factory engineers to review system installation.

Fig.12 RSV Dimensions

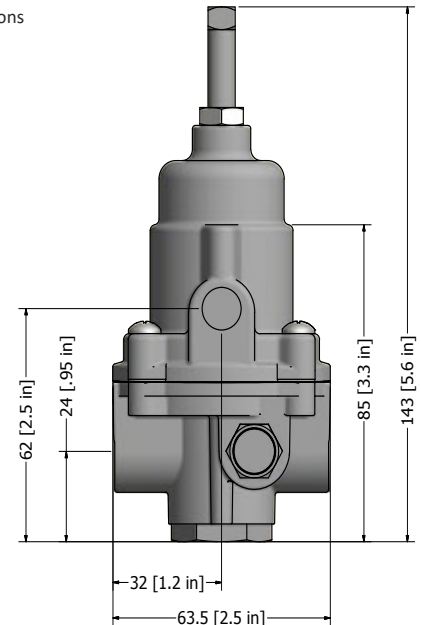


Fig.13 RSV Integrated with EVR-GSD4 and adjustment knob cap



# RSV Precision Vacuum Regulator

## SYSTEM HAZARD ANALYSIS

This System Hazard Analysis pertains to the assembly of the RSV with Equilibar EVR Series.

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.

- A. The EVR is not certified as or marketed as a pressure vessel safety relief valve. The EVR is a precision control valve. Guarding against overpressure or underpressure 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.
  - 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 EVR are of the self-relieving design. Guard against the process fluid relieving out the vacuum pilot regulator if the EVR 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 vacuum pressure is set to the desired value. In order that the pilot pressure to the EVR can be reduced, most pilot regulators incorporate an internal bleed to atmosphere. This bleed port does introduce atmospheric air into the output "O" port and the vacuum supply line. If atmospheric air cannot be tolerated in the vacuum supply line please contact Equilibar® for alternate methods.
  - 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 vacuum pilot 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 vacuum pilot 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 EVR will fail into a closed position. This results in a blocked pipe with no path for the fluid to escape through the EVR. Over pressurization of the upstream can occur. Steps must be taken to insure that the upstream piping is made sufficiently strong to withstand this or is guarded by an overpressure relief device.
- F. Make sure the process vacuum pressure to be controlled is connected to the EVR "I" Inlet port. Process fluid flow is from "I" Inlet to the "O" Outlet. If the EVR is connected in reverse it may still operate but it will give poor control and can result in excess pressures.
- G. Observe the maximum temperature and pressure ratings on the EVR label. Take steps to insure these values cannot be exceeded. Where necessary to protect equipment, a suitable type of safety overpressure and/or vacuum relief valve must be connected in parallel to the EVR. The overpressure relief valve must be rated to prevent the pressure or temperature from exceeding the EVR maximums as listed on the EVR label. In some installations a rupture disc may be substituted for the safety relief valve.
- H. If the discharge piping on the EVR "O" Outlet port becomes blocked, the EVR 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 or have a safety relief valve to limit this pressure at or below the safe pressure of the discharge piping.
- I. Do not use the EVR as a structural member. All piping and plumbing connections to the EVR should be adequately supported. The EVR series is available with a mounting bracket to facilitate the installation.
- J. Enriched oxygen media (>21%) should not be used in the EVR 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 EVR 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 EVR are excellent conductors of heat.
  - i. Assume the external temperature of the EVR 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 EVR 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 EVR.
  - ii. Assume the internal temperature of the EVR will rise or fall to match the temperature of the ambient environment. Ensure that the process media flowing through the EVR 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 gasses can also cause freezing. Freezing can block the EVR 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 EVR has been carefully designed by skilled engineers to provide proper safety ratios and adequate pressure regulation. Do not attempt to modify the EVR in any way, including adding or enlarging orifices or ports or replacing machine screws (bolts). Only replace the internal o-rings or diaphragms 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.

## PATENT

The Equilibar back pressure regulator is subject to one or more of these patents: US6,886,591, US7,080,660, US7,673,650, US8,215,336, DE60322443D1, GB1639282, FR1639282, CH1639282

## MAINTENANCE NOTES FOR COMBINED RSV & EVR UNIT ASSEMBLY

Contact factory for replacement diaphragms or for additional maintenance or assembly instructions.

Important notes: Sensitive diaphragms and seals can leak. It is the responsibility of the end user to use this product in a way that prevents injury to persons and property. See Standard Terms and Conditions for important Limitation of Liability 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.) Repair parts and kits are available for diaphragms and o-rings of the EVR.

## TROUBLESHOOTING FOR COMBINED RSV & EVR UNIT ASSEMBLY

PROBLEM	POSSIBLE SOLUTIONS
Maximum flow is reduced	The internal orifices may be blocked with debris. Inspect and remove as required. Maintain an upstream filter.
Excessive vacuum is on the controlled port	<p><b>Many EVR diaphragm types cannot seal tightly and require a constant flow rate.</b></p> <ul style="list-style-type: none"> <li>• Add a small bleed of suitable gas and continuously add gas to the EVR inlet port.</li> <li>• Ask an Equilibar engineer if a different diaphragm might be more suitable</li> </ul> <p><b>Debris may be preventing the diaphragm from making an effective seal.</b></p> <ul style="list-style-type: none"> <li>• Make sure all the outlet orifices under the diaphragm are clear and in good repair</li> </ul> <p><b>The vacuum on the pilot port may be different than expected</b></p> <ul style="list-style-type: none"> <li>• Install a vacuum pressure gauge in the line feeding the EVR pilot reference port. Make sure the pilot pressure regulator is functioning correctly.</li> </ul>
Too little vacuum is on the controlled port	<p><b>Inadequate supply vacuum</b></p> <ul style="list-style-type: none"> <li>• Install a vacuum pressure gauge in the vacuum supply line as near to the EVR as possible. The supply line for the pilot regulator is a good spot.</li> <li>• Verify that the supply vacuum is greater than the desired vacuum control pressure</li> </ul> <p><b>EVR may be undersized</b></p> <ul style="list-style-type: none"> <li>• Compare the pilot vacuum pressure (using a vacuum gauge) to the controlled vacuum pressure as near the EVR inlet port as possible</li> <li>• A large difference indicates an undersized EVR regulator</li> <li>• Confirm this by reducing the amount of system flow to the EVR. The EVR should resume normal operation with reduced flows.</li> </ul>
No control over vacuum level	<ul style="list-style-type: none"> <li>• Diaphragm may ruptured; check and replace if necessary. This can be done by applying a small amount of positive pressure to the pilot port (less than 1 Bar/15 psig), trapping it, and observing any leak down rate.</li> <li>• Pilot regulator inlet and outlet might be reversed. Verify using the pilot connection procedure in this manual</li> <li>• Using a vacuum gauge as near the EVR outlet port as possible, verify that adequate supply vacuum is present</li> <li>• Using a vacuum pressure gauge, verify that the pilot vacuum pressure applied to the EVR pilot port is at the correct level</li> </ul>