



**MERCER VALVE CO., INC.®**  
"AUTO SEAT TECHNOLOGY"®

## **ENG-420000**

**9500 SERIES MODULATING PILOT  
OPERATED PRESSURE RELIEF VALVE**

**INSTALLATION, OPERATION, &  
MAINTENANCE MANUAL**



**MERCER VALVE**

Before installation of a Mercer Valve Co., Inc. Pressure Relief Valve, all sections of this document and all regulatory authority codes must be read and understood. Failure to do so voids all warranties.

REV	ECN	DATE
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## **I. Scope**

This document is used for the installation, operation, and maintenance of a Mercer Valve 9500 Series modulating pilot operated pressure relief valve. This document should be read and understood before the valve is installed, put into service, or maintained. Failure to do so can result in improper operation that could result in damage to equipment or affect the safety of individuals around the equipment. The recommendations in this document should be used in conjunction with all regulatory bodies and all end-user company policies.

All safety precautions should be adhered to and all appropriate personal protective equipment should be utilized during all procedures indicated in this document. Pressure relief valves contain and relieve impressive amounts of energy and forces, so safety measures should be used to prevent injury to personnel. This document does not cover safety precautions or safety equipment to be used in the procedures.

Some additional information on installation, operation, and maintenance can be found in the following specifications. These specifications should be used in addition to this document but are not limited to this list:

**American Petroleum Institute:**

API 510 – Pressure Vessel Inspection Code

API RP 520 Parts I & II – Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries

API RP 521 – Guide for Pressure-Relieving and Depressuring Systems

API STD 526 – Flanged Steel Pressure Relief Valves

API STD 527 – Seat Tightness of Pressure Relief Valves

API RP 576 – Inspection of Pressure-Relieving Devices

API STD 598 – Valve Inspection and Testing

**American Society of Mechanical Engineers:**

ASME PTC 25 – Pressure Relief Devices

ASME Boiler and Pressure Vessel Code Section VIII, Division I – Unfired Pressure Vessels

ASME Boiler and Pressure Vessel Code Section XIII – Rules for Overpressure Protection

ASME B16.5 – Pipe Flanges and Flanged Fittings

**National Board of Boiler Inspectors:**

NB-18 – Pressure Relief Valve Certifications

NB-23 – National Board Inspection Code

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## **II. Definitions**

**Accumulation** is the amount of pressure increase above the MAWP of the system that is allowed. Accumulation is set from the applicable codes.

**Backpressure** is the amount of pressure on the outlet side of the pressure relief valve. This is pressure downstream of the nozzle of the pressure relief valve. It is a combination of superimposed and built-up backpressures.

**Blowdown** is the reclosing point of the pressure relief valve. It can be expressed as a pressure but is most commonly expressed as a percentage of the set pressure.

**Built-up Backpressure** is pressure on the outlet of the pressure relief valve that is caused by the flow of the pressure relief valve. Piping size, length of outlet pipe, fittings, or other flow friction producing items all affect the built-up backpressure.

**Capacity** is the flow rate as required by the applicable code.

**Cold Differential Test Pressure (CDTP)** is the pressure at which the pressure relief valve is adjusted to open on the test stand. The CDTP includes corrections for the service conditions of backpressure and/ or temperature.

**Conventional Pressure Relief Valve** is a direct spring operated valve where the spring tension is used to hold the disk closed. The operational characteristics of the valve are directly affected by changes in the backpressure. These characteristics include opening pressure, closing pressure, relieving capacity, and valve function. This is also referred to as a spring operated pressure relief valve (SOPRV).

**Inlet Size** is the nominal pipe size (NPS) of the inlet of the pressure relief valve.

**Leak Test Pressure** is the pressure below the set pressure that the leak test is to be performed. This pressure is often calculated as a percentage of the set pressure.

**Lift** is the amount of travel of the disk from the fully closed to the fully open position when the valve is relieving.

**Maximum Allowable Working Pressure (MAWP)** is the pressure rating the system can withstand at a specific temperature. The MAWP is often used as the setting of the pressure relief valve.

**Modulating Pilot** is a gradual open pilot operated valve. The valve opens in response to the overpressure. The pilot will slowly drain the dome pressure to allow the main valve to open. On reclose, the dome pressure is slowly refilled to close the main valve piston.

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**Outlet Size** is the nominal pipe size (NPS) of the outlet of the pressure relief valve.

**Overpressure** is the amount of pressure increase above the set pressure allowed for the pressure relief valve to achieve full lift and full flow. Set pressure plus overpressure should never exceed MAWP plus accumulation, but they will often be equal.

**Pilot Operated Pressure Relief Valve (POPRV)** is a pressure relief valve with two parts, a main valve and a pilot valve. The pilot valve controls the operation of the main valve. This is achieved by the pilot controlling the pressure in the dome area above the main valve piston. Backpressure does not affect the set pressure of a pilot operated valve.

**Pressure Relief Valve (PRV)** is a pressure relief device designed to open and relieve excess pressure and to reclose and prevent the further flow of fluid after normal conditions have been restored.

**Set Pressure** is the pressure on the inlet of the pressure relief valve that the valve is set to open. Each pressure relief valve manufacturer will define this setting based on how their valve is to act. Set pressure definitions for each manufacturer's series can be found in NB-18.

**Simmer or Warn** is the audible or visual release of test fluid from between the disk and seat prior to the opening of the valve. This is caused by the force holding the disk closed and the inlet pressure force equalizing just before the valve begins to open at the set pressure.

**Snap Pilot** is a fast action pilot operated valve. The valve is either fully open or fully closed; it "snaps" open at set pressure and "snaps" closed on reseal. The snap pilot achieves this by fully venting the dome pressure at set point and fully refilling the dome pressure at reclose.

**Superimposed Backpressure** is the pressure on the outlet of the pressure relief valve that is caused by a closed discharge system. This type of backpressure is present before the valve begins to open. It can be constant or variable. Superimposed backpressure can affect the set pressure of a conventional spring operated PRV.

**VR** is an accreditation the National Board offers to organizations/ facilities that have been shown to independently operate and repair pressure relief valves sufficiently within codes and regulations.

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### **III. Handling and Shipping**

Mercer Valve produces a very durable pressure relief valve. Even though these valves are able to take some abuse, it is recommended that they are handled and shipped with care. This will help prevent damage prior to their installation. These PRVs are safety devices and are the last line of defense when a system overpressures. An impaired PRV could leave the system unprotected.

A PRV should be carried by a structural part, such as the body, flange, or eye bolts. If the valve is dropped, it should be checked to assure it is still functioning properly. Any damage to the connections (flanges, threads, etc.), such as denting and scratching, may cause a leak or inhibit proper installation. All precautions should be taken to ensure no valve damage occurs.

During shipping, all open ports of the PRV should be sealed to prevent the ingress of dirt and moisture. Proper precautions to prevent rust should be taken. All flanges and threads should be covered with protectors to prevent damage. The valve should be sealed in a plastic bag.

The valve may be placed in a shipping container upright or on its side, however, it should be packed so that it cannot move within. Upright shipment is preferred, especially for larger valves. Movement can cause the valve to become damaged during the shipping process. The proper shipping container should be chosen for the size and weight of the valve. After being packaged, the shipping container should be handled with care.

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## **IV. Unpacking and Storing**

A PRV should be installed immediately after being removed from the storage/ shipping box when possible. When the valve cannot immediately be installed, certain storage precautions should be taken to keep it functioning properly until it is installed. Following these recommendations will encourage proper function of the valve prior to installation. These recommendations only apply to Mercer Valve manufactured pressure relief valves. Other valve brands can have different requirements and their manufacturer should be contacted for information.

The PRV should be stored in a dry, indoor environment at temperatures between 50°F (10°C) and 90°F (32°C). The inlet and outlet of the valves should be protected from any possible damage. Threaded valves should have thread protectors installed. Flanged connections should be covered to protect their raised faces from scratches and dents. The protectors should also seal the openings so that foreign materials cannot ingress.

PRVs are usually stored vertically to keep parts aligned, however, this isn't required for Mercer's PRVs. Although vertical storage can help with initial startup in certain circumstances, these valves may be stored horizontally. If stored horizontally, it should be verified that the disk is down and sealed before installation.

Before installing a valve that has been stored, it should be visually inspected for any damage. It is recommended to test the valve before installation if it has been stored for more than one (1) year.

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## **V. Installation**

Proper installation of a PRV is mandatory to ensure safe and accurate operation. Incorrect installation can cause failures that result in damage or destruction to the equipment and also possible injuries or even death to anyone around the equipment.

Before installation, the valve should be visually inspected for any damage that occurred during shipping and storage. If any damage is found, do not install and immediately contact Mercer Valve.

Always remove all thread and flange protectors from the inlet and outlet before installing. These protectors can stop pressure from entering or exiting the PRV and this may result in malfunction. Make sure that a test gag is not engaged when the valve is in operation. Test gags are only used in controlled overpressures situations, such as hydrostatic testing of the system.

The set pressure should be tested before installation if the valve has been shipped great distances or has been in long term storage. This verification helps to confirm proper valve function and correct settings.

It is also important to check that the backpressure and temperature of the application are within the valve's ratings and limitations. There are two types of backpressure: superimposed and built-up. Each type of backpressure affects the valve differently. Superimposed backpressure can come in two forms, constant and variable. The correct form of backpressure must be considered during the sizing and selection of the valve. If the wrong type of backpressure is assumed, the valve may not operate properly.

The PRV's seat and o-rings have pressure-temperature limitations. Using these materials outside their limitations will cause issues. Contact Mercer Valve to find the limitations of the valve. Compatibility, in terms of reactivity and corrosion, between the system media and the materials used within the valve must be considered. Appropriate material selection is the responsibility of the end user/ purchaser of the valve.

The nameplate information should be verified for the service conditions of the application before the valve is installed. The fluid state, capacity, service temperature, set pressure, and backpressure can all be found on the PRV's nameplate, which is also called the tag. If the information indicates improper settings or the wrong service conditions, the valve should not be installed. The service temperature listed is not the temperature limit. It is important that the set pressure is examined against the system's MAWP. It should also be noted that the capacity on the tag is not specific to the application. A gas valve will have a tag capacity in SCFM (Nm<sup>3</sup>/hr) of air at 60°F (16°C) and standard atmospheric conditions. A liquid valve will have a tag capacity in GPM (LPM) of water at 60°F (16°C) and standard atmospheric conditions.

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The PRV should be oriented in a vertical position with its inlet pointing downwards and its outlet pointing in a horizontal direction. Mercer Valve must be contacted to ensure proper operation if the valve cannot be installed in this orientation.

Use a suitable sealing mechanism (PTFE pipe tape, gasket, etc.) when installing a PRV on a system. Do not put a wrench on the PRV's body or bonnet during installation. Flanged valves require the correct amount, type, and size of bolts and the correct type of gasket to be used. Flange information can be found in ASME B16.5.

One common cause of early PRV failure is debris trapped on the valve's seat, resulting in a leak. Weld slag and pipe tape are among the more common items that cause this. It is recommended that all piping and tank systems are cleaned prior to the initial installation of the PRV.

A pressure relief valve should be attached to the system with the shortest amount of piping possible. All piping leading to the PRV must be equal to or larger than the PRV's inlet pipe size; it must **never be smaller**. Any restriction within the inlet lines can cause valve chatter, which can result in serious damage to the valve. It is recommended that any pressure drop created from inlet piping is less than 3% of the set pressure. Piping restrictions can also reduce the relief capacity of the valve, which can leave the system under protected.

Outlet piping from the pressure relief valve should be a minimum length to keep built-up backpressure low. It is recommended that the built-up backpressure be kept below 30% for POPRVs for robust functionality. It is recommended that the outlet piping be less than 4 ft (1.2 m) in length. All outlet piping after the PRV must be equal to or larger than the PRV's outlet pipe size; it must **never be smaller**. Increasing the outlet piping size can help reduce the backpressure on the valve.

PRVs must be braced and supported for reaction forces, vibrations, weight, and other external forces applied during operation. These and all other loads must be considered when installing the valve and adding bracing.

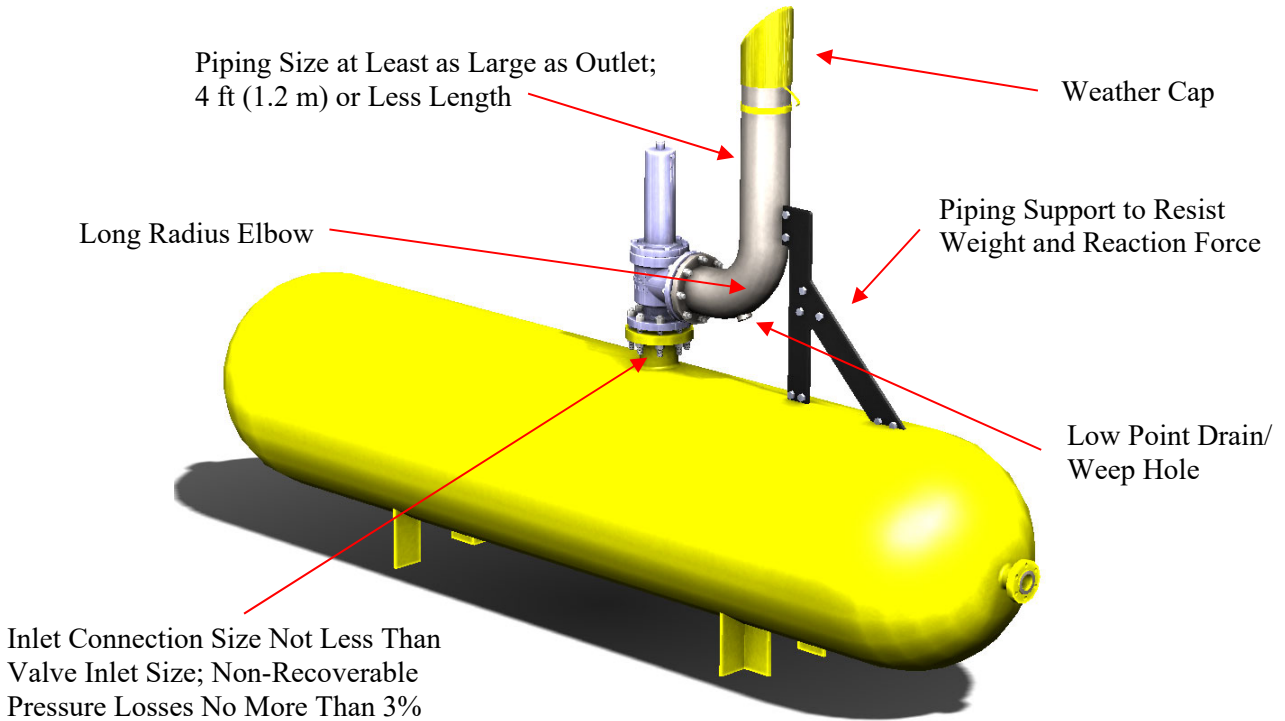
See Figure 1 for an example installation of a pressure relief valve.

Excessive vibrations can cause a PRV to open below its intended set pressure. Vibrations apply acceleration to the internal movable parts and create an upward force. When this force is added to the force balance within the valve, the required pressure to open the valve is lowered. When the operating pressure is close to the set pressure and vibrations exist, premature relieving can occur.

In pilot operated pressure relief valves, the pilot valve may be removed from the main valve and remote mounted to prevent the pilot from being subjected to the vibrations. Since the pilot controls when the main valve operates, the main valve will not prematurely open due to these vibrations.

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**Figure 1: Typical Recommended Installation of a PRV**

Additionally, vibrations may produce stresses on sensing lines and brackets, which can cause cracking within components and could lead to failure of the PRV.

Extreme caution is required in the outlet piping if liquid can be present. The presence of liquid can increase the required force the valve needs to open and this alters the actual relief pressure. At low temperatures, the liquid can freeze and form an ice block in the discharge piping or valve body that restricts the relief flow. Discharge lines should be weather capped and provided with a drain hole to prevent liquid from collecting. If these precautions are not taken, the valve may not be able to adequately protect the system.

POPRVs are especially susceptible to freezing temperatures and special consideration should be taken during the installation. A pilot valve has several tubing runs along the exterior of the main valve. Since these lines are directly exposed to the cold outside conditions, there is a possibility that the media passing inside of them will freeze and block the pressure. Insulation or other means need to be carried out to prevent freezing of the lines in order to maintain proper operation of the valve.

Additionally, it is not recommended that a modulating pilot operated relief valve be used for reciprocating compressor applications. The vibrations and pressure pulses can cause the pilot to inadvertently open during normal operation.

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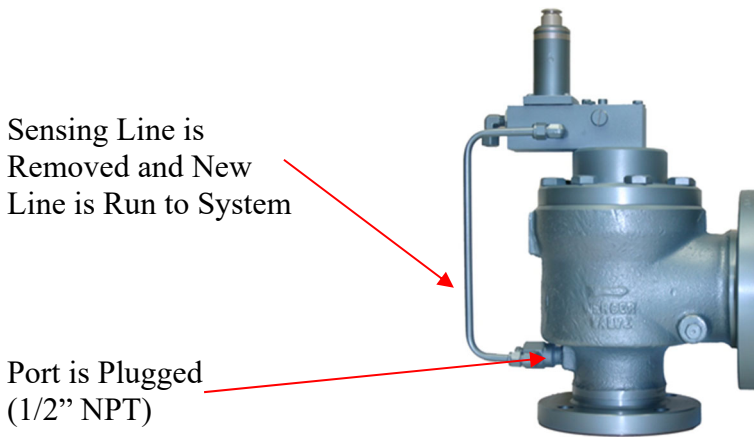
**DO NOT BREAK THE SEAL WIRE.** Breaking the seal wire invalidates the manufacturer's warranty to repair or replace the valve. If resetting is required in a field emergency situation, qualified personnel with calibrated instrumentation should perform it. A PRV with a broken seal wire is not considered to be an ASME coded valve until it has been repaired by a VR Certified repair shop.

Important installation information is contained in the ASME Boiler and Pressure Vessel Code and API RP 520 Part II. Other standards and codes may be applicable depending on the jurisdiction and area of use.

**a) Remote Sensing Pilot Valve**

At times, the pressure at the main valve inlet of a pilot operated valve may be a false pressure reading caused from pressure spikes or large pressure losses in the inlet piping. These variations from actual system pressure can affect the operation of the valve. They may cause premature valve pressure releases, rapid cycling, or chatter.

Remote sensing a pilot operated valve is when the sensing line for the pilot is removed from the main valve's inlet and is instead plumbed to somewhere else on the system. This allows the pilot to see a stable system pressure, which may not be present at the main valve's inlet. This will enable a consistent pressure reading and improve the operation of the valve.



**Figure 2: Direct Sensed POPRV**

To remote sense a pilot valve, the sensing line and pressure probe assembly are removed from the inlet of the main valve and the port on the main valve is plugged. A location on the system is chosen for the pilot pressure to be sensed. This location will be somewhere the pressure is going to be more consistent and not affected by flow conditions. This location should never be able to be isolated from the pressure source that the main valve is connected to. This ensures that the pilot can also sense any pressure increase under the main valve. Often, the remote sense location is a

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larger volume piping where the pressure does not fluctuate as significantly. It could also be run to a section of piping where the inlet pressure losses are not as significant.

After the location is selected, a new inlet pressure line is run from the pilot valve back to the new sensing location. This line should never have a smaller ID than originally used on the valve. Mercer Valve uses 3/8” stainless steel seamless tubing for the sensing lines on the pilot operated valves. For straight runs, the remote sensing line can be 3/8” tubing up to 10 ft (3 m) distances. For distances further than 10 ft (3 m) but less than 25 ft (7 m), the tubing size should be increased to 1/2” stainless steel seamless tubing. Use Table 1 to pick tubing thickness for the appropriate inlet flange rating. Using the proper tubing size and wall thickness will reduce the probability of a delayed signal to the pilot valve.

*Table 1: Sensing Line Tube Size*

<i>Inlet Flange Rating</i>	<i>Tube Size</i>	
	<i>3/8” Tubing</i>	<i>1/2” Tubing</i>
<i>150#, 300#, 600#, &amp; 900#</i>	0.035in Wall Thickness	0.049in Wall Thickness
<i>1500#</i>	0.049in Wall Thickness	0.065in Wall Thickness
<i>2500#</i>	0.049in Wall Thickness	0.083in Wall Thickness

With a proper setup, remote sensing will help with valve operation by allowing the pilot valve to see a more accurate system pressure. When remote sensing a pilot operated valve, all precautions need to be taken to ensure the proper operation of the pilot operated valve. Mercer Valve accepts no responsibility for the modifications made to the original valve.

***b) Remote Mounting Pilot Valve***

Excessive vibrations can cause a pressure relief valve to open below the set pressure of the valve. The vibration applies acceleration to the moving parts in the valve that create an upward force. When this force is added to the force balance in the valve, the required pressure to open the valve is lowered. The vibration is offsetting part of the spring force.

This especially becomes a problem the closer the operating pressure is to the set pressure. When the operating pressure is close to the set pressure, any reduction in the closing force brings the valve that much closer to reaching the pressure it needs to open.

In pilot operated pressure relief valves, the pilot can be removed from the main valve and remote mounted to stop the pilot from being subjected to the vibrations. Since the pilot controls when the main valve operates, when the pilot is not affected by the vibrations, the main valve does not prematurely open due to these vibrations.

There are several precautions that must be taken when remote mounting a pilot. If these precautions are not taken, improper operation of the valve can occur and the system may not be properly protected in an overpressure situation. Review the following:

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1. All work should be performed when the valve/ system is not pressurized.
2. The pilot should be moved to a location that does not experience the vibrations that would exist if installed directly on the main valve. This can be accomplished by installing the pilot on a pole in the ground or attaching it to a rigid structural member of a building or piece of equipment. It is recommended that any accessories equipped be included with the remote mounting of the pilot valve.
  - a) If there is an auxiliary filter attached to the main valve, the sensing line will go to the option prior to it going to the pilot valve. In order, it would be plumbed as follows: the sensing line to the auxiliary filter, then to the pilot valve, and then to the backflow preventer.
3. The pilot must be installed using the same type of mounting as is used to attach the pilot to the main valve. This includes the original orientation and mounting holes of the pilot valve. No modifications to the pilot shall occur.
4. New sensing tubing lines have to be run from the main valve inlet to the pilot and also from the pilot to the main valve dome. The proper size and pressure rating for the tubing must be used. When selecting the tubing size, the distance from the pilot to the main valve must be considered. Ideally, the tubing line should be sized so that there is no pressure loss across each tubing line during valve operations. The tubing lines should also not cause any change in the operation of the pressure relieve valve. This may mean using larger tubing than what was originally installed. Review the following recommendations:
  - a) 3/8" tubing may be used when the pilot is mounted 10 ft (3 m) or less away from the main valve. Larger tubing should be considered otherwise. See Table 1 for proper tubing thickness.
  - b) Flexible lines may be used to help reduce vibration induced stresses.
  - c) Routing should be done in a safe manner to prevent accidental damage/ kinking to the sensing lines.
  - d) Direct and simple routing should be done to prevent losses/ restrictions in the sensing lines. The shortest length possible is recommended.
  - e) Lines should be free draining (no pockets) whenever possible.
  - f) Temperature considerations should be made in order to prevent freezing of the lines.
5. Sensing tubing lines should be routed to ensure that the vibration does not cause breaks in the line due to fatigue or other stresses. With the pilot not vibrating at the same frequency and amplitude as the main valve body, the motion in the tubing lines will be inherent. It is important to make sure that the sensing lines are flexible enough to reduce these stresses.
6. The sensing lines need to be routed to the proper ports on the pilot and main valve. The valve will not be able to properly function otherwise, which will leave the system unprotected.
7. This work should only be done by competent individuals that have been trained and have experience with pressure relief valves.
8. After all installation and work has been performed, the valve should be tested for functionality, set pressure checked, and observed for any potential leaks.

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## **VI. Operation**

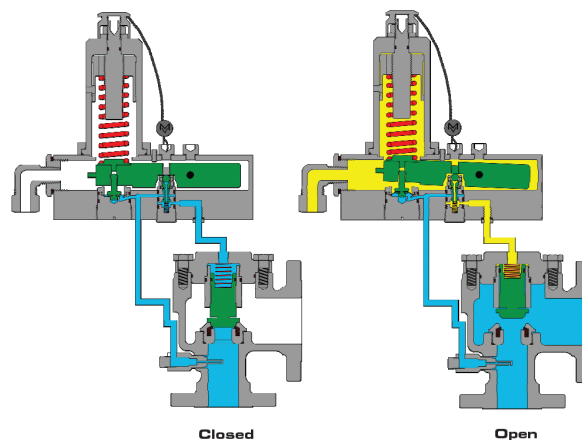
The Mercer Valve 9500 Series modulating pilot operated pressure relief valve is designed and tested in accordance with ASME Boiler and Pressure Vessel Code for UV stamped pressure relief valves in gas/ vapor and liquid applications. This valve series has a set pressure definition for gas/ vapor valves of the first audible discharge/ sound from the main valve, while liquid valves have a set pressure definition of the first steady stream from the main valve.

The 9500 Series modulating pilot is a pilot operated PRV. The pilot controls the pressure above the main valve piston. This area, which is referred to as the dome area, is larger than the seating area in the main valve. This larger area allows for a tight seal of the main valve seat. The pilot pressurizes the dome area to hold the main valve closed and relieves the dome pressure to allow the main valve to open.

In a modulating pilot, the pilot gradually opens the main valve in response to the system overpressure. It achieves this by controlling the dome pressure at a rate related to the system pressure. The pilot is constantly comparing the system pressure to the valve's dome pressure to allow the main valve piston to open due to the system pressure.

When the system pressure exceeds the set pressure, the resulting error signal activates a control within the modulating pilot. The pilot valve then reduces the main valve dome pressure in proportion to the amount of system overpressure. If the system pressure continues to increase, the dome pressure will be relieved more, lifting the main valve piston until the system overpressure has stopped increasing.

After the overpressure is relieved and the system pressure is reduced, the main valve dome pressure is gradually increased and the main valve piston is pushed closed. If the system pressure is relieved before the main valve piston goes to full lift, the modulating pilot will close the main valve without the piston fully opening. See Figure 3.



**Figure 3: Operation of Modulating Pilot Diagram**

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The PRV's orifice should be sized so its capacity rating at the allowable overpressure exceeds the maximum flow capacity the system will produce. Sizing information can be found in the ASME Boiler and Pressure Vessel Code and API RP 520 Part I. Additional requirements by local authorities also need to be considered.

Since the PRV's flow capacity will exceed the required capacity of the system, the system pressure will drop. The valve will reclose when the inlet pressure has dropped enough to allow the spring force to reclose the pilot valve. The disk of the main valve will then reseal against the seat and the relief valve will be ready for the next overpressure scenario.

Best performance is usually obtained on a system where the operating pressure is at least 5% less than the valve's set pressure. Performance improves with a greater margin between operating and set pressure. A target margin of 7% below set pressure is more desirable. A larger margin helps with the reclosing of the PRV and reduces the chance of inadvertent opening from system characteristics such as pressure pulses, vibration, temperature, etc.

It should be noted that operating at extremely low pressures may make it more difficult for the main valve to get a good seal. This is because the system pressure is directed into the dome area above the seating area. The system pressure is used to get a good seal. So, if there is minimal operating pressure, the seal will not be as tight and leakage can occur. ASME's Boiler and Pressure Vessel Code and API's standards require that the set pressure does not exceed the MAWP of the system.

In addition to checking the set pressure versus the maximum allowable working pressure of the system, also check to ensure that backpressure and temperature limitations of the process are consistent with valve ratings. The fluid state, capacity, temperature, set pressure, and backpressure can all be found on the tag of the valve. Pressures and temperatures outside the normal ranges require special materials. Media considerations relative to corrosion or chemical reactions also need to be examined to ensure suitability of the valve in its service.

**a) Auxiliary Valve**

The ideal service condition for a modulating pilot operated relief valve is one where the pressure is steady and not pulsating. If the pressure is pulsating, then the modulating pilot will constantly react to the system. When there are quick, large pressure pulses, the modulating pilot has to react quickly to vent the dome pressure and allow the main valve to open in order to relieve the overpressure scenario. This can be an issue with large main valves because of their large dome volumes and because modulating pilots are designed to be slow acting.

To ensure that the entire dome pressure of the main valve is able to be relieved properly, Mercer Valve adds an **auxiliary (AX) valve** to the dome area on gas modulating pilots with full bore orifice sizes 4" and larger and with API orifice sizes N and larger. See Figure 4. The AX valve is designed as a fail-safe valve and will not start to open unless the modulating pilot has not relieved

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the overpressure condition. At this time, the auxiliary valve will vent some of the dome pressure to allow the main valve to open and relieve the overpressure situation.

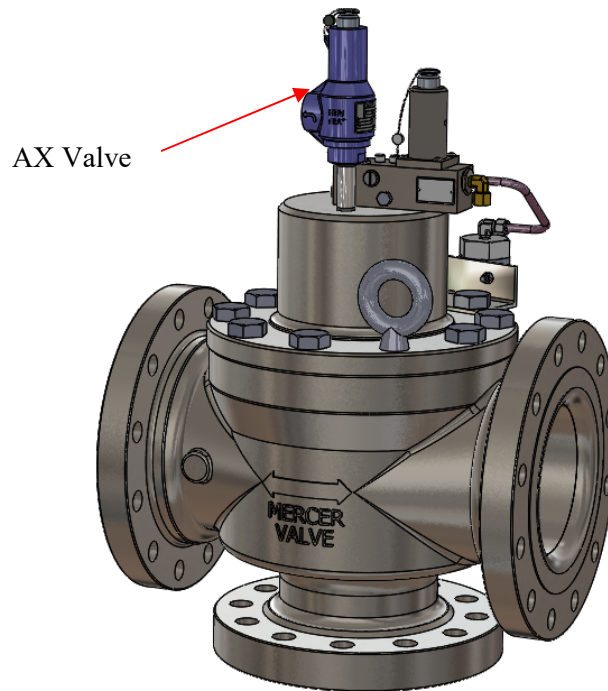


Figure 4: Modulating POPRV with AX valve

In regards to maintaining a POPRV, the AX valve shall be treated as an integral component of the entire assembly. The AX valve is a modified Mercer 9100 Series D orifice SOPRV. Its part number will follow the same format as the 9100 threaded valves with an AX special code on the end of its part number. It should be noted that the AX valves have their own spring chart.

The 9100 Series AX valve receives the same serial number as the 9500 Series valve but the AX valve will not have an NB or UV stamp on its tag and it will not have a certificate of compliance. This valve is a non-code valve, as it is an auxiliary valve to the main valve. The AX valve should never be removed while the pilot is in service or it could leave the system under protected.

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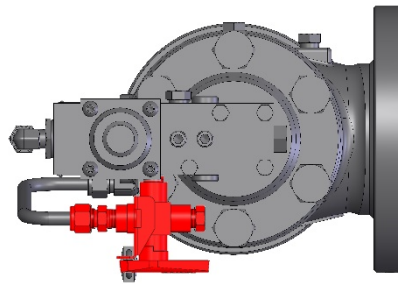
## **VII. Pilot Operated Valve Options**

Pilot operated safety relief valves may be equipped with several options to enable serviceability or to ensure satisfactory operation. Listed are some of the common components which a pilot operated valve may be equipped with. Some equipment combinations of these components may not be available for some valves due to dimensional and suitability limitations.

### **a) Field Test Connection**

A field test connection (FTC) makes in situ testing easier since the technician does not have to disassemble the pressure sense line to test the pilot. The technician can simply attach a controlled pressure supply to the field test connection to test the set pressure of the valve. This can make regular service on the pilot valve more expedient.

The field test connection operates the pilot and vents the dome. If there is any pressure in the system, the main valve will also open unless the inlet is blocked in. Highlighted in red in Figure 5 is a typical field test connection on a gas modulating pilot. Mercer recommends using a block valve under the main valve when using a field test connection on a modulating pilot.



**Figure 5: Field Test Connection on a Gas Modulating Pilot Operated Valve**

### **b) Backflow Preventer**

A backflow preventer (BFP) can be installed on a pilot valve in situations where the superimposed backpressure exceeds the system operating pressure. With this component equipped, the relief valve uses either the backpressure or the system pressure to hold the valve shut. It acts like a comparative switch, utilizing whichever pressure is greater to fill the dome and hold the valve shut.

Highlighted in red in Figure 6 is a typical backflow preventer on a gas modulating pilot. On a gas service modulating pilot, the backflow preventer is located inside the pilot valve. Highlighted in red in Figure 7 is a typical backflow preventer on a liquid modulating pilot.

A backflow preventer is intended to combat superimposed backpressure only; it will not do anything for built-up backpressure. It should also be noted that total backpressure should not exceed 30% of the set pressure when a backflow preventer is installed. Too much backpressure could affect the operation of the BFP and valve.

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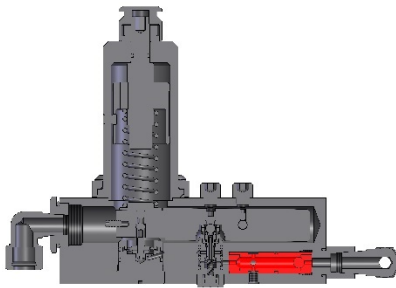


Figure 6: Backflow Preventer on a Gas Modulating Pilot Operated Valve

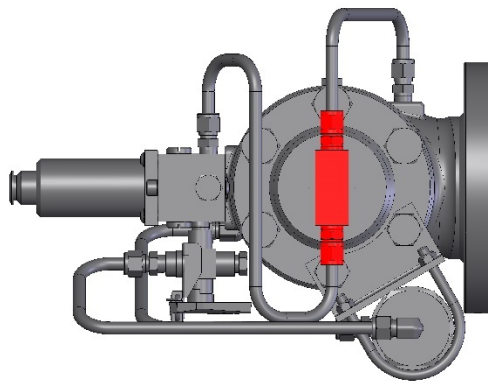


Figure 7: Backflow Preventer on a Liquid Modulating Pilot Operated Valve

### ***c) Auxiliary Inlet Supply Filter***

An auxiliary inlet supply filter may be installed on a pilot operated valve to prevent debris from entering the pilot valve. This may be necessary for dirtier services and is required on liquid service valves or when liquids may be present. Since there are small ports and tight passageways between the internal components of the pilot valve, dirt and debris may clog ports and galleries within the pilot valve.

Though Mercer Valve's pilot operated valves have smaller filters that come standard on all pilot assemblies, an auxiliary inlet supply filter, which is much larger, can provide additional filtering to improve functionality and prolong the life of the pilot valve. An auxiliary filter requires regular maintenance based on service conditions. Highlighted in red in Figure 8 is a typical auxiliary inlet supply filter on a liquid modulating pilot.

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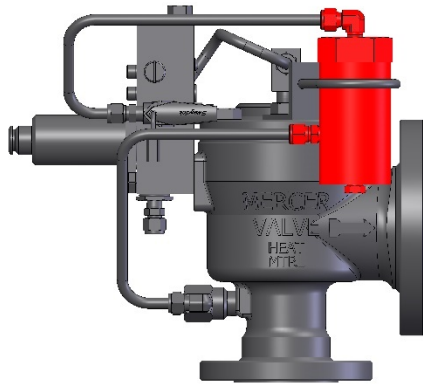


Figure 8: Auxiliary Inlet Supply Filter on a Liquid Modulating Pilot Operated Valve

**d) Remote and Manual Blowdown**

Remote and manual blowdown is a component that can be equipped on a pilot operated valve to empty the dome pressure and open the main valve without reaching set pressure. This is used to easily and quickly empty or reduce the pressure of a system. The dome pressure is vented to the outlet of the valve.

The manual blowdown uses a ball valve to vent the dome pressure, whereas the remote blowdown uses a pneumatic or electric actuator that can be remotely activated to vent the dome pressure. Highlighted in red in Figure 9 is a pneumatic blowdown option on a gas modulating pilot.

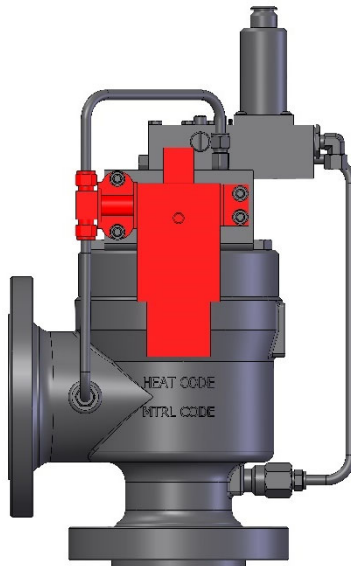


Figure 9: Remote Blowdown (Pneumatic) on a Gas Modulating Pilot Operated Valve

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## **VIII. Maintenance**

For dependable performance, PRVs must be maintained regularly. **Mercer Valve recommends its PRVs are inspected and tested annually.** After the valve has been installed and a service history has been established, the testing and inspection frequency may be adjusted. Some guidelines for testing frequencies can be found in NB-23, API 576, and API 598. Additionally, government jurisdiction should be reviewed.

When maintenance is performed, only qualified repair personnel should complete it. Qualified repair personnel conducting the annual inspection and testing may alter the maintenance schedule based on the service conditions.

Before performing maintenance, it should be ensured there is no pressure within the main valve or pilot valve. All 6x8 and larger gas modulating pilots will have a check valve on the pilot inlet line to help with dome loading. With the inline check valve installed, the pilot and main valve bonnet will remain pressurized. Be sure to remove any and all pressure before servicing.

During the inspection, a visual inspection, set pressure verification, and leak check should be completed. These tests can be performed while the PRV is installed on its system or when it is on a testing bench. The PRV can only be tested while on its application if there is a method and procedure to apply a controlled pressure to the PRV's inlet without exceeding any limits of the system.

A visual inspection is used to identify if the PRV is installed properly, is correct for the application, and doesn't have any apparent problems. Check the nameplate information to verify that the valve is installed on the proper service. A missing nameplate requires immediate addressing. If the valve is installed on gas/ vapor service, the nameplate's capacity will indicate an air capacity in SCFM (Nm<sup>3</sup>/hr) at 60°F (16°C) and standard atmospheric conditions. If the valve is installed on liquid service, the nameplate's capacity will indicate a water capacity in GPM (LPM) at 60°F (16°C) and standard atmospheric conditions.

Check the seal wire. A broken seal wire indicates that an unqualified person may have adjusted the set pressure; this also voids any warranty the valve may have had. The valve should be inspected for damages. If there is damage to the valve, it may not operate properly.

Look for potential issues that would keep the valve from opening or would inhibit flow. Rust or dirt accumulation, insect or animal nests, and pooled water are just some of the things that can restrict the flow or stop the valve from opening. If any problems are found during the visual inspection, the valve must be repaired by a qualified person or replaced with an equal.

When verifying the set pressure, the appropriate fluid should be used. Gas/ vapor PRVs should only be tested with a gas, usually air or nitrogen. Liquid PRVs should only be tested with a liquid,

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usually water. Testing a pressure relief valve with the incorrect fluid will likely cause inaccurate readings.

The set pressure of UV stamped pressure relief valves, in accordance with the ASME Boiler and Pressure Vessel Code, has a tolerance of  $\pm 3\%$  of the specified set pressure or  $\pm 2$  psi ( $\pm 15$  kPa), whichever is greater. If the examined set pressure is not within this tolerance, the PRV should be reset or possibly repaired by qualified repair personnel. A PRV's set pressure definition will depend upon its manufacturer and will be listed in NB-18 if it is ASME certified. NB-18 can be found at <http://www.nationalboard.org/>.

After the set pressure has been verified, the valve is leak checked for any leaks coming from its seat. Leak checks are usually performed at 90% of the set pressure or 5 psi (34.5 kPa) below set pressure, whichever is greater. The valve must be actuated and resealed to perform this test. The pressure is then brought up to and held at the leak check pressure. If the valve does not pass a leak check, it will need to be repaired by a qualified person or replaced with an equal.

For POPRVs, a common maintenance routine includes inspecting all the filters within the pilot and draining the auxiliary filter accessory, if equipped. This action will help reduce the tendency for the pilot valve to become fouled and improve the overall reliability of the valve.

**Start of Service Period**

In many codes and standards, there is ambiguity about when the PRV's inspection interval begins for newly constructed equipment. When a governing code or standard has defined this start date specifically, then it should be followed. When the start date is not specified, the following is what Mercer Valve recommends for its products, which will clarify this ambiguity should the user/owner of the PRV adopt it to their standards. This recommendation is irrespective of the warranty Mercer Valve has for its goods.

Contingent that proper storage and transportation of the PRV was utilized, the start time for the inspection interval (otherwise known as the service life) is the PRV's commissioning date not exceeding one year after it was manufactured; the manufactured date is listed on the PRV's nameplate. Commissioning is defined as the first time the equipment is operated with the PRV installed.

This recommendation is based on Mercer Valve's storage policy. Mercer Valve recommends testing a valve only if it has been in storage for more than a year. Testing of the valve should be in accordance with NB-23 standards and with a clean, inert media. The testing must not excessively exercise the valve. The valve should not have any wear or damage prior to the commissioning date.

Additional maintenance instructions can be found in API RP 576, the ASME Boiler and Pressure Vessel Code, and the National Board Inspection Code.

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## **IX. Inspections**

Pressure relief valves are used to help with safe operation of the system that they are installed on. They are designed to stop excessive overpressure scenarios. More information on causes of overpressure can be found in API 521. If a PRV fails during an overpressure scenario, the system can increase to an unsafe pressure.

These overpressure situations can exceed the MAWP and result in failures. These failures can be catastrophic in nature and result in damages to the system or even destruction of the equipment. The safety of people around the system will be affected as well. Because of the gravity of these types of failures, keeping pressure relief valves in proper working order is essential. Regular inspections must be conducted to assure a properly functioning PRV.

These inspections are used to verify if the PRV is suitable for the service conditions it is installed in. If the PRV is not correct for the conditions, it may not be able to protect the system properly and this could result in a failure.

The inspection of the PRV can be done while in place, in the field, or offsite within a repair shop. During the inspection, three tests should be performed: a visual inspection, set pressure test, and leak test. Using these three inspections can help determine the functionality of the valve or if repair or replacement is necessary.

Relief valves can generate an enormous amount of noise and pose other hazards to personnel during its operation. Appropriate personal protective equipment must be worn and other safety standards must be followed when working with pressure relief valves.

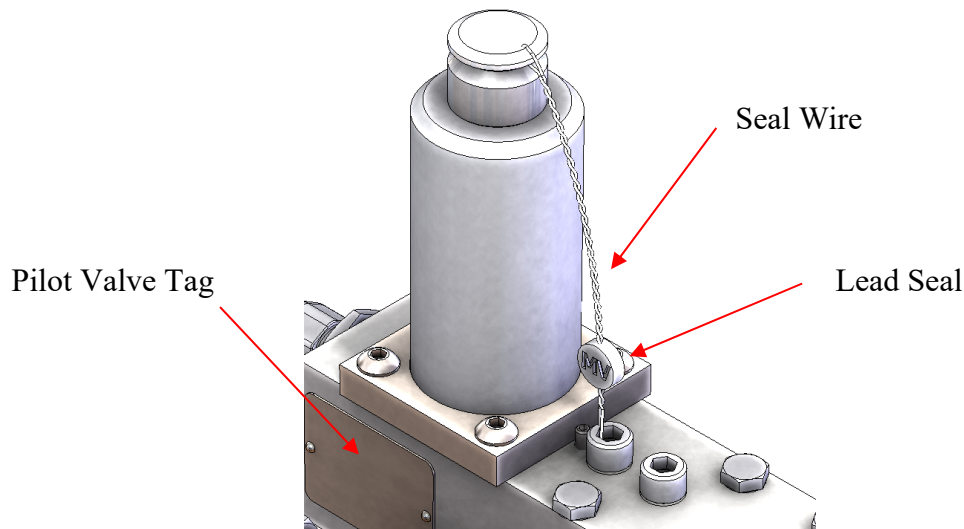
### ***a) Visual Inspection***

During the visual inspection, the pressure relief valve is checked for any potential issues that may restrict the operation of the valve. This inspection will be performed with the valve still assembled but the valve should not be pressurized for the safety of the person performing the inspection. Corrosion and damage to the valve are some of the common problems found in the visual inspection. Some of the items that should be checked in the visual inspection are as follows:

- Cap and Seal Wire – The valve cap and seal wire should be checked first on all inspections. These parts prevent adjustment tampering. On the seal wire, there is a pressed security seal that has an impression on it to indicate the certified company that last adjusted the set point of the valve. When this seal wire is cut or removed, it indicates that someone may have adjusted the set point or altered the valve. This voids any warranty the valve may have had. See Figure 10.
- Flanged Connections – The flanges should be checked for wear, such as pitting or reduction in width, which could cause the flange to not seal properly or could reduce the pressure rating of the flange. Flanged connections should also be checked for proper fasteners.

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**Figure 10: Typical Cap and Seal Wire on a Modulating Pilot Valve**

- **Outlet** – The valve’s outlet should be inspected to make sure there is not any corrosion or other debris accumulation within that could inhibit the operation of the valve.
- **External Surface** – The valve should be checked for any damage that has occurred that could restrict or impair the operation of the valve. Tubing lines, bent piping, and other external attachments are commonly damaged and can cause malfunction.
- **Valve Tag** – The tag information should be inspected and verified to the service conditions. Some of the items on the tag that are to be verified are the set pressure, CDTP, and capacity in appropriate unit of measure for the service fluid. If any of the tag information is found to not correspond to the conditions of the system, the valve should be removed and replaced with an appropriate valve. A missing tag also warrants further inspections. There are two tags on 9500 Series valves: one is located on the main valve while the other is on the pilot valve.

If, for any reason, the valve has failed the visual inspection and the valve is deemed to be dangerous to test, the set pressure inspection and the leak inspection should not be carried out. Valves that fail visual inspection should be replaced or repaired immediately.

### ***b) Set Pressure Inspection***

During the set pressure inspection, the set pressure is verified in accordance with the ASME Boiler and Pressure Vessel Code. For all valves set 70 psi (500 kPa) and above, the set pressure has a tolerance of  $\pm 3\%$  of the nameplate set pressure. For all set pressure below 70 psi (500 kPa), the tolerance is  $\pm 2$  psi ( $\pm 15$  kPa) of the nameplate set pressure. If the valve has a CDTP associated with it due to temperature and/ or backpressure, the test pressure is checked to the CDTP. Even with a CDTP, the set pressure tolerance is calculated based on the actual nameplate set pressure. The set pressure test should be performed before (if it passes the visual inspection) and after any repairs.

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The set pressure is inspected to the definition listed in NB-18, a publication by the National Board of Pressure Vessel Inspectors, which is found at <http://www.nationalboard.org/>. This publication lists all ASME Boiler and Pressure Vessel Code certified pressure relief valves. It indicates the correct set pressure definition and other characteristics of a valve. The set pressure has been defined to achieve particular operational characteristics. If the wrong set pressure definition is used in the inspection test, the valve's set pressure will not be accurate and it may not operate appropriately.

The correct fluid for testing has to be used to achieve accurate results. For gas/ vapor service, nitrogen or compressed air is used as the test fluid. For liquid service, water is used as the test fluid. If the incorrect fluid is used during the testing, the test's results will be inaccurate. Depending on the size of the valve and its set pressure, the set pressure discrepancy can vary outside of ASME tolerances.

Setting procedures should be in accordance with ASME PTC 25. The rate of the system pressure increase should be slow when the pressure is within 15% of the set pressure. Within this range, the rate should never be more than 2 psi/ sec (15 kPa/ sec). Ideally, each pressure increment on the pressure gauge should be clearly read as the pressure is increased. Slow pressure increase helps to accurately read the pressure gauge.

The procedures for testing set pressure are as follows:

1. Check the set pressure definition from NB-18. For Mercer 9500 Series modulating pilot operated pressure relief valves, the set pressure definition for a gas/ vapor valve is the first audible discharge or sound from the main valve, while the set pressure definition for a liquid valve is the first steady stream from the main valve.
  - a. When the configurations have an AX PRV attached, it will require inspection.
2. Rigidly connect the valve to a test fixture.
3. Slowly increase the pressure on the inlet side until the main valve opens. This will be the set pressure of the valve. **If the pressure reaches more than 1.5 times the expected set pressure and hasn't opened, do not proceed with the test. The valve is to be considered stuck closed and has failed.**
4. Verify the set pressure 2-3 more times. Verification relief should be no more than  $\pm 1\%$  or  $\pm 0.5$  psi (3.5 kPa), whichever is greater, from the average of all verifying set pressures.

If the test equipment is not adequate, the results can produce a false reading. Refer to Section X on proper test equipment.

**Common Set Pressure Definitions**

-POP – A crisp “pop” sound from the valve. The “pop” sound is made from the rapid increase in the lift of the disk, allowing more flow out of the valve.

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-1<sup>st</sup> Audible Sound – The 1<sup>st</sup> sound heard from the outlet of the valve. This definition is usually for gas service.

-1<sup>st</sup> Steady Stream – A continuous stream from the outlet of the valve. This stream should flow out from the outlet and not dribble down the outlet. This definition is usually for liquid service.

### ***c) Leak Inspection***

After the set pressure is verified, the valve undergoes a leak inspection. This is performed to verify the disk and seat are sealed to a degree appropriate for the type of pressure relief valve being tested. Leak tests are always performed below the set pressure of the valve, usually at a certain percentage of the set pressure. The leak check is usually performed at 90% of the set pressure or 5 psi (34.5 kPa) below the set pressure, whichever is greater.

If the valve has a CDTP, the leak test pressure will be below the CDTP in lieu of the set pressure. Mercer Valve should be contacted for proper leak pressure and specification for the valve. In the tests, the pressure is held steady for a length of time and the valve is observed for any leakage. Before this test is performed, the valve must have had its set pressure examined.

There are several methods used in testing for leakage. All of the tests can indicate a leak at the seat but some of the tests are more sensitive to leakage than others.

One common test for gas valves is listed in API STD 527. In this test, the outlet is blocked with a tube coming out of it into a cup of water. The tube and water are observed for any bubbles developing in the water from the tube's end. This test has specific requirements for its apparatus, pressure, and duration of observation. This specification should be reviewed before testing the valve. For soft seated valves, such as the 9500 Series, zero bubbles must be observed for one minute to pass leak inspection per API 527.

Flow gauges can also be used to check for leakage. These tests are similar to the API 527 test except a flow gauge is attached to the outlet instead of a cup of water.

Soap film test is another common method for leak testing. In this test, the valve's seat and disk are sprayed with a soap and water mixture. The mixture is then observed for any growth of bubbles.

Another simple test is to apply a membrane, a wet paper towel for example, onto the outlet. This membrane seals the outlet. If there is any leakage, the pressure will push the membrane out, causing it to bulge.

Sometimes, there is not a way to access the outlet due to outlet piping when a valve is left on the unit. In these cases, the valve cannot be leak checked by normal means. One method of checking for a seat leak is by maintaining a blocked-in pressure in the valve's inlet. In this test, a block valve must be installed below the pressure relief valve and it must be closed during the test. It is

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important to make sure that the gas used to pressurize the valve does not react with the system fluid in these tests.

If the pressure remains stable during the test, there are no leaks present. If the pressure is not stable, there is a potential leak and the valve should be removed for further testing. Even though the test indicates a leak, it doesn't guarantee that it's from the valve. It could be in the connections on the inlet or the block valve. This is why the valve should be removed and rechecked on a test stand using normal leak check methods if it fails using this method.

**Backpressure Testing**

The purpose of backpressure testing is to check for leaks in the secondary pressure zone (the outlet side of the pressure relief valve). This includes the body, bonnet, outlet flange, and all parts included in the upper valve assembly. Backpressure testing is not required by ASME for field repair. If this is conducted, it should be performed before the valve's seal wire has been attached.

The backpressure test is performed after the valve has been assembled and set to the correct set pressure. The test is performed by attaching a sealed and controlled pressure to the outlet and then entirely submerging the valve in a solution of water treated with rust inhibitor. The pressure in the secondary pressure zone is brought to 30 psig (200 kPa) at a minimum.

For PRVs installed on systems with backpressure, this test should be performed at the backpressure of the system. This is the pressure required by the ASME Boiler and Pressure Vessel Code. The valve is then visually inspected for any leaks by checking for bubbles coming from any part of the valve.

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## **X. Test Equipment**

Testing and inspections can be performed in multiple locations. They can be performed onsite in place (in situ testing), onsite on a mobile test unit, or offsite in a shop or test facility. Each environment offers its own advantages and disadvantages.

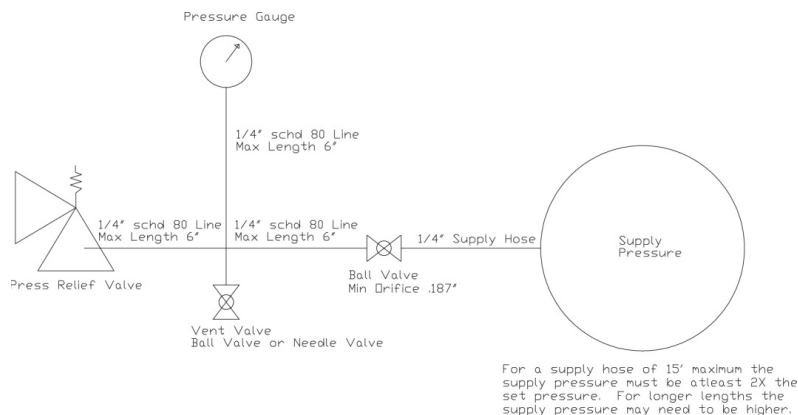
### **a) In Situ Testing**

Testing and inspecting in place eliminates the laborious task of removing and handling the valve. This is especially desirable with large PRVs. Additionally, not disturbing the existing connections reduces the chance of compromising the existing seals. This type of testing is very useful when a system cannot be shut down for long lengths of time.

There are disadvantages to this type of testing. The inspection process is more difficult because the accessibility of the valve is reduced. The outlet pipe is often still attached and the internal parts are not observable for the visual inspection. This can also make it difficult to leak check. Different methods for leak checking are required. In addition, the set pressure testing process is difficult. Block valves are mandatory to be able to properly test the set pressure. Even with a block valve under the valve, the volume under the valve may not be sufficient to accurately test the set pressure. A heavy warm or simmer can cause false readings as a result of insufficient test volume.

Gauge placement is critical to get an accurate pressure reading. If the gauge is placed too far away from the valve or the line has too many restrictions, there will be pressure losses. When this happens, the pressure gauge will indicate a pressure that includes the pressure losses. This is an inaccurate reading compared to the actual pressure at the valve's inlet.

The supply pressure can also be a factor. Usually, the pressure source in these types of tests is far away from the actual valve. Compressed air or nitrogen bottles are heavy and usually a line is run from the bottles to the valve. The length of this line can create a pressure drop. This will usually mean that additional pressure in the bottles will be required to properly test the set pressure of the valves. Typical testing apparatus can be seen in Figures 11 and 12.



**Figure 11: Diagram of Proper In Situ Testing Apparatus**

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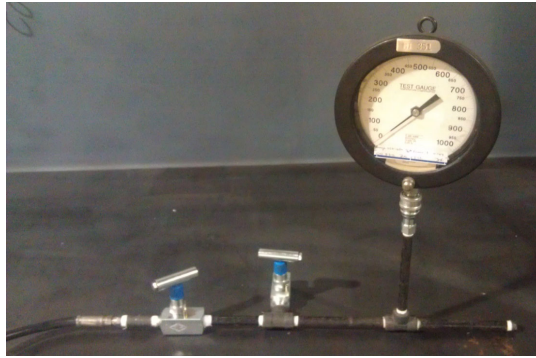


Figure 12: Picture of Typical In Situ Testing Apparatus

***b) Using a Field Test Connection***

A field test connection enables a set pressure verification and leak test to be performed while the valve remains installed in its application. A field test connection is an option for pilot operated valves. The main valve will open if there is pressure within its inlet, so there should be a block valve at the main valve's inlet connection when using the field test connection.

To use a field test connection, an external pressure source is attached. This pressure source is typically a nitrogen bottle. It is important that the pressure source's media is chemically compatible with the application. Some fluids can react when mixed and could cause corrosion, an explosion, or other undesirable effects.

The pressure source will need to have a metering valve leading to a pressure gauge and a vent valve. See Figure 12. The pressure source must be greater than the set pressure of the valve but it should not exceed the pressure rating of the valve; it must be regulated to be below the rating of the valve.

With the pressure source attached and the field test valve closed, increase the pressure equal to the current pressure within the PRV. This ensures that when the field test is opened so the pressure in the dome does not drop and cause the main valve to open. Once the pressures are equal, the field test connection can be opened. The gauge after the metering valve will show the pressure in the valve.

The metering valve may now be opened slowly to increase the pressure up to the set point. This test will operate the pilot valve only. During this test, the main valve dome will be pressurized and vented.

***c) Offsite Testing***

Offsite testing allows for the most thorough and accurate testing and inspection. The valves are removed from their units and brought to a shop. In the shop, a valve can be completely tested and

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inspected. The shop environment gives the technician the most advantages because more tools are available, there is adequate space to work, and test benches enable accurate results.

All of the same concerns in testing are still present in offsite testing as in situ testing. The volume of pressure, valve simmer, pressure losses to the gauges, and supply line pressure are all factors in getting an accurate result. Proper assembly of a test bench is crucial in limiting these effects.

The main disadvantage in offsite testing is time. A valve must be removed from the unit and then transported to the shop. After testing, it is transported back to the field to be reinstalled. This time frame can be long and cause delays.

For gas/ vapor valves, there should be approximately 1/4 ft<sup>3</sup> (7 liters) or more capacity below the valve when setting. This volume is sufficient to accurately test the set pressure for most 4 x 6 M orifices and smaller valves. To see other valve characteristics (e.g. blowdown), a larger vessel is required. If excessive warn is observed during the test, a larger volume is required. See Figure 13 for an example.

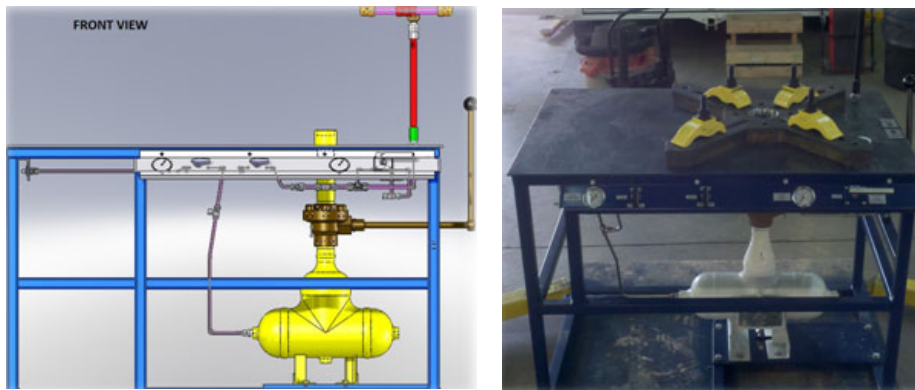


Figure 13: Typical Gas/ Vapor Test Stand Setups

For liquid testing, the test bench, at a minimum, should have enough volume to perform 5 to 10 consecutive set pressure tests before the test stand has to be refilled with liquid. Approximately 2 ft<sup>3</sup> (60 liters) of volume is required for most valves. The larger the volume, the more accurate the settings will be. To see other valve characteristics (e.g. blowdown), a larger vessel is required.

The test bench must be set up so that liquid is present at the nozzle each time the PRV is opened. This can be accomplished with a J-tube design or a down tube that is completely submerged into the liquid. In both styles, gas pressure is used to push the liquid through the valve's inlet, generating continuous liquid flow absent of any gas. See Figure 14 for an example.

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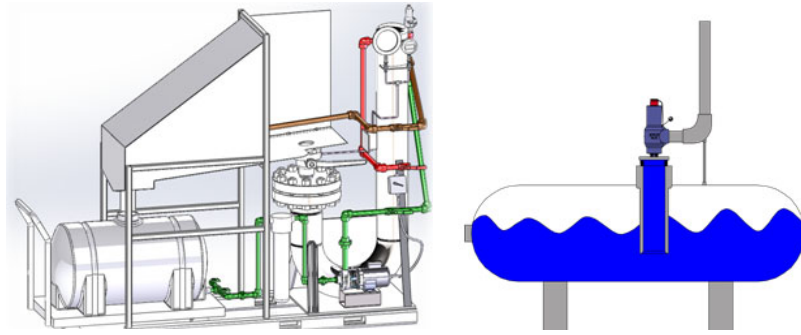


Figure 14: Typical Liquid Test Stand Setups

**d) Mobile Test Units**

Mobile testing units are similar to offsite testing. The valve is removed from the application, which enables a more thorough inspection. Mobile testing units can save time because transporting the valve offsite isn't necessary. Mobile test units do have their disadvantages though.

Mobile test units are often not setup to test all valve types and sizes. The testing equipment on a mobile test unit can vary. Some mobile test units have test stands similar to an offsite test stand, allowing for larger valves to be tested accurately. Other mobile test units are setup only for smaller valves. In each case, the limitations of the test stand should be documented and the test stand should only be used for the sizes and pressure that it is designed for. See Figure 15 for an example.



Figure 15: Typical Mobile Test Stand Setups

**e) Test Stand for Modulating Pilot**

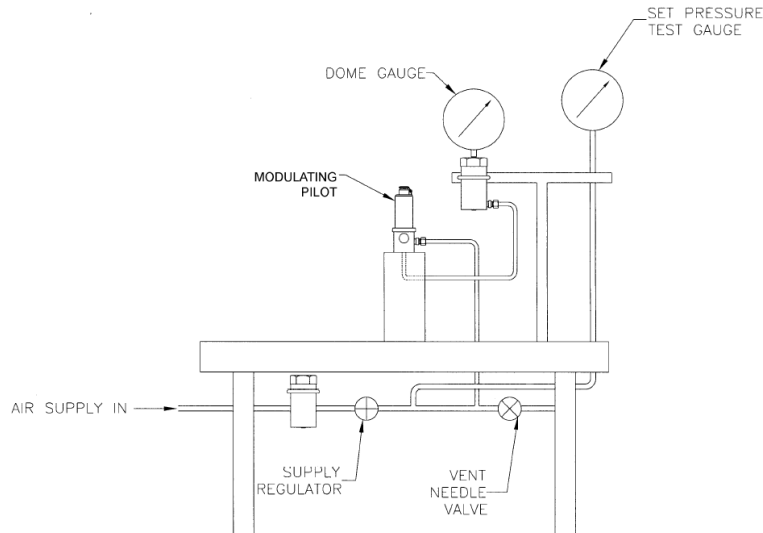
For the modulating pilot valve, a special test stand is needed to properly calibrate it. Shown in Figure 16 is a typical test stand used for a modulating pilot valve. This type of test stand is only necessary when the modulating pilot valve has been disassembled and the settings need adjusting.

It is important that an accurate and high-quality regulator is used so that a constant input pressure can be attained. This will help in the adjustment process tremendously. Two gauges should be used: one to measure the dome pressure and one to measure the system pressure. The dome area should have a volume similar to the size of the actual dome of the main valve of the pilot.

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Lines should all be 3/8" tubing or larger and kept to minimal distances to reduce the chance of creating flow losses. All components used must be rated for the pressures being tested. This test stand can be used for adjusting the set pressure of the modulating pilot valve, but ultimately the pilot valve should be installed with the main valve and then tested on a full-sized test stand for accurate setting.



**Figure 16: Recommended Test Stand for a Modulating Pilot**

### **f) Test Gauges**

When testing the set pressure or leak checking, it is recommended that two pressure gauges are used. This enables quick identification if they are reading incorrectly. If the gauges are not reading identical values within their respective tolerances, it is an indication that at least one gauge is inaccurate and both should be checked to make sure they are calibrated correctly.

The test gauges should have at least 0.25% accuracy over their full scale. The portion of the gauge used should be selected so that the tolerance of it is more stringent than the set pressure's tolerance. For analog gauges, only the middle 1/3 or less of the gauge should be used; it is the most accurate portion of the gauge. Each gauge should be calibrated using a dead weight tester. Monthly calibrations of the gauges are recommended.

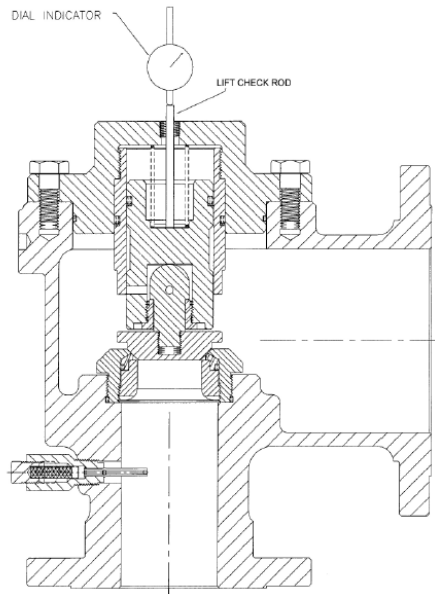
### **g) Lift Checking**

The lift of the valve is checked by seeing how much the disk subassembly moves. See Figure 17 for a typical lift checking apparatus. The lift is the measurement of the movement of the disk from the closed position to the mechanical stops at the fully open position. The minimum lift for certified PRVs can be found in the NB-18 publication, which is located on the National Board website [www.nationalboard.org](http://www.nationalboard.org).

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**Figure 17: Typical Lift Check Setup**

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## **XI. Tester Qualifications**

Only qualified individuals should perform PRV tests and repairs. They should be trained to test and calibrate pressure relief valves. They should understand how to properly operate the equipment and know the hazards involved. They should be familiar with the specific PRV being tested and know how it functions and operates. It is recommended that the individual attend factory approved training class for each type of valve worked on.

The end user's company may have additional requirements for the individual conducting the PRV inspection. These requirements should be checked before any PRV work is carried out. Government authorities can also have requirements for the individual. For every PRV installment, regional specifications that apply should be reviewed.

It is recommended that the individual be qualified in a program similar to US DOT OPS Operator Qualification. This is a qualification program for pipeline operators. Operator Qualification (OQ) Rules can be found in 49 CFR Part 192, Subpart N and 49 CFR Part 195, Subpart G.

It is also recommended that any company that repairs PRVs is VR certified through ASME and The National Board of Boiler and Pressure Vessel Inspectors. VR is an accreditation program administered by the National Board for the repair of pressure relief valves. A PRV repair is any process or operation that affects the valve's flow passage, capacity, function, or pressure-retaining integrity; this includes cleaning. VR companies are certified to work on all types of pressure relief valves.

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**XII. Tool List**

The following tool list shows the recommended tools used with a respective valve component. This list is not exhaustive and more tools, such as typical shop tools, may be required.

**a) Main Valve**

**Table 2: Tools Used on Main Valve**

<b>Tool</b>	<b>Where it is Used</b>
1-1/2" Hex Socket	D, E, & F Nozzles
2-1/2" Hex Socket*	G, H, & J Nozzles in 2x3 Bodies and 1-1/2" FB Nozzles
3" Hex Socket*	2" FB Nozzles
3-1/2" Hex Socket*	J, K, & L Nozzles in 3x4 Bodies
4" Hex Socket*	L & M Nozzles
4-1/8" Oct Socket*	3" FB Nozzles
4-13/16" Oct Socket*	N & P Nozzles
3/4" Hex Socket	Q & R Nozzles (Valves After 2004)
Q & R Nozzle Tool (Available Through Mercer)	Q & R Nozzles (Valves Prior to 2005)
5/16" Allen Key	4" FB Nozzles
3/8" Allen Key	6" FB Nozzles
5/16" Allen Key	T Nozzles

*\*Large sized hex sockets, which can be used for nozzle removal/ installation, are similar to "Truck Wheel Bearing Lock Nut Sockets".*

**b) Modulating Pilot Valve**

**Table 3: Tools Used on Pilot Valve**

<b>Tool</b>	<b>Where it is Used</b>
Cutter Dikes	Seal Wire
Flat Head Screwdriver	Bearing Screws
7/16" Open End Wrench	Mounting Bolts (Gas Only)
9/16" Open End Wrench	Mounting Bolts (Liquid Only)
5/8" Open End Wrench	Pipe Plug and Fittings
11/16" Open End Wrench	Tube Fittings and Lock Nut
5/64" Allen Key	Beam Limiting Set Screw and Pivot Rod Set Screw
1/8" Allen Key	Control Module Set Screw
5/32" Allen Key	Bonnet Bolts
7/32" Allen Key	Adjustment Screw
1/4" Allen Key	Cap Head Screws
3/4" Open End Wrench	Backflow Preventer Plug
1-1/8" Open End Wrench	Pilot Vent Plug
Beam Extension Tool (Comes in Repair Kit)	Beam Setting
Control Module Tool (Comes in Repair Kit)	Input Module and Control Module
Pick	O-Ring Removal

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**c) Miscellaneous**

**Table 4: Miscellaneous Items Used**

Nickel Based Anti-Seize (similar to Loctite® LB 771™)
Low Strength Thread Retainer (similar to Purple Loctite® 222)
Medium Strength Thread Retainer (similar to Blue Loctite® 242)
High Strength Thread Retainer (similar to Red Loctite® 271)
Fine Grade Abrasive Hand Pad (similar to Scotch-Brite™ 7447®)
Multi-Purpose Lubricating Oil (similar to 3-In-One® Oil)
Phenyl-Methyl Silicone Grease (similar to Molykote® 33)
Water Resistant NLGI #2 Grease (similar to Aqua Lube Marine Grease)
PTFE Thread Sealant Tape (or similar)

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### **XIII. Disassembly**

The following general procedure is recommended for disassembling a modulating POPRV. The disassembly is separated into sections and only some of them will apply, depending on what is being done. For example, if only the set pressure needs to be changed, the modulating pilot bonnet may be the only item that needs to be addressed. Consult Figures 70 and 71 for component identifications and locations. Modulating POPRVs have two types of service applications: gas and liquid. The mounting of the pilot valve varies between the services. Look at Figures 18 and 19 to see the differences in mounting.

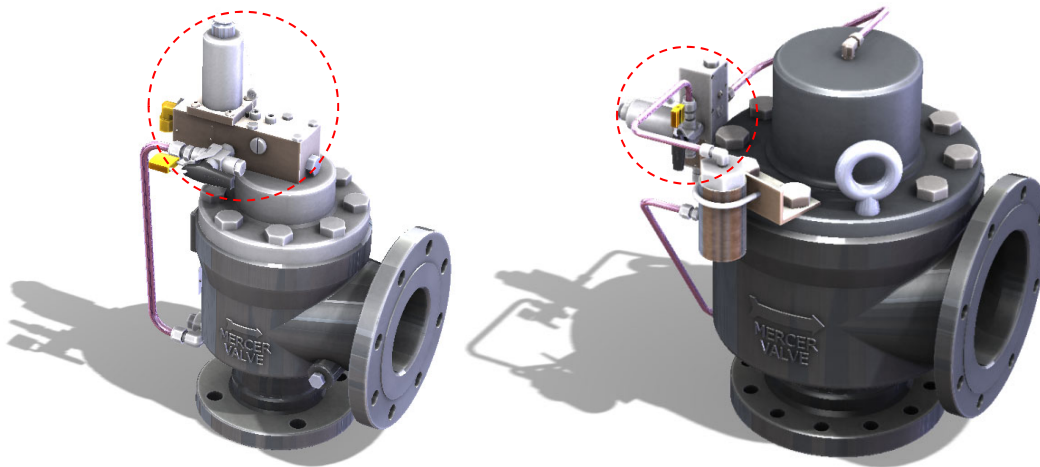


Figure 18: Differences Between Gas Modulating Pilot (Left) and Liquid Modulating Pilot (Right)

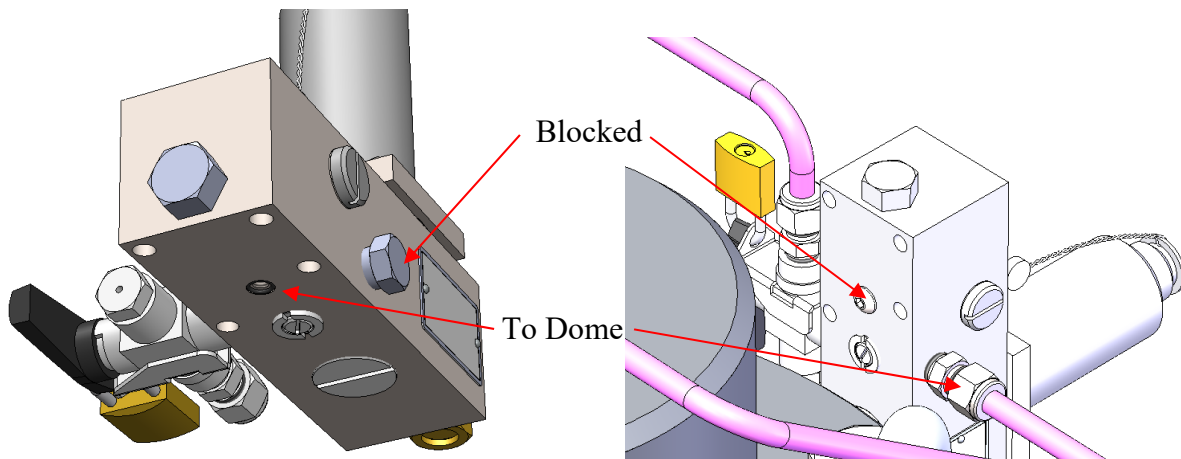


Figure 19: Differences Between Gas Modulating Pilot (Left) and Liquid Modulating Pilot (Right)

#### **a) Filter Inspection**

A common maintenance routine for POPRVs is inspection of the filters. The filters can be replaced regularly to prevent dirt and debris from entering or clogging the pilot valve, which helps ensure proper function. If any of the filters appears congested with debris, the entire pilot should be

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disassembled and inspected for other debris accumulations. The following describes the filter disassembly process:

1. Make sure there is not pressure within the main and pilot valves.
2. Remove the probe filter from the pressure probe subassembly. See Figure 20.
  - a) The pressure probe should remain with the main valve body.

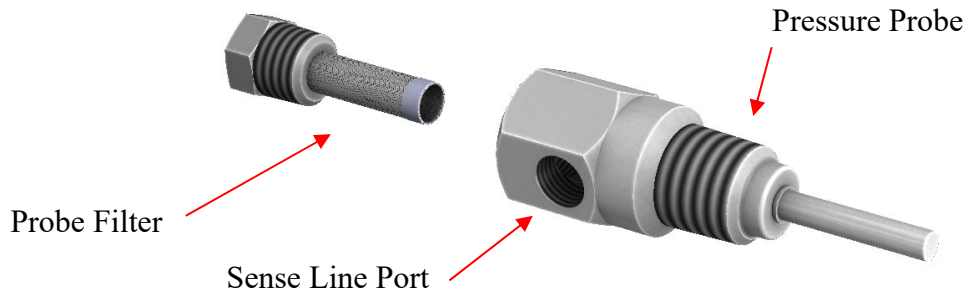
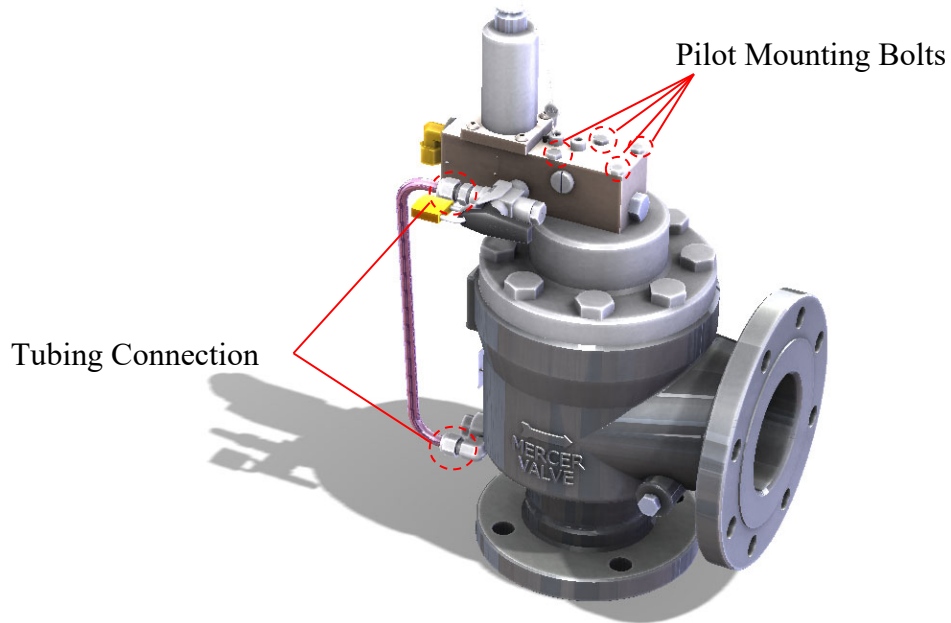


Figure 20: Typical Filter and Pressure Probe from a Pilot Operated Relief Valve

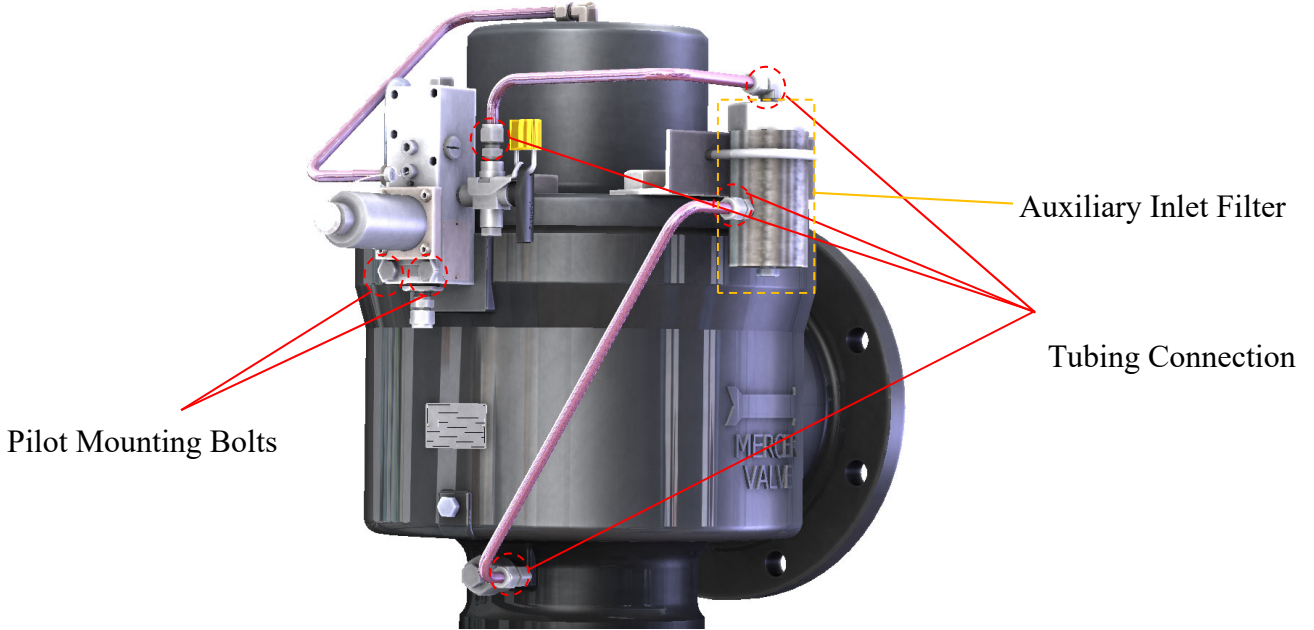
3. Inspect the filter for debris, which may have accumulated in the bore of the filter.
  - i) A replacement filter is included in the repair kit.
4. Inspect the inside of the pressure probe for any debris and make sure that it is clean.
  - a) Only remove the pressure probe if debris has clogged the inside and the debris is difficult to remove.
  - b) Note the orientation of the sense line port (in reference to the sensing tubing) and then remove the pressure probe, if required. This notation will be needed for reassembly. The pressure probe tube hole must always face towards the main valve's inlet and down into the flow path.
5. Remove the pilot valve from the main valve by removing the mounting bolts and disconnecting the attached tubing. See Figure 21 or 22. Carefully remove the pilot valve from the main valve bonnet.
  - a) On gas service modulating POPRVs, there is an o-ring on the bottom of the pilot that seals the pilot to the main valve bonnet. See Figure 51.

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**Figure 21: Typical Gas Modulating Pilot Operated Relief Valve (Actual Valve May Vary in Appearance)**



**Figure 22: Typical Liquid Modulating Pilot Operated Relief Valve (Actual Valve May Vary in Appearance)**

6. If there is a field test connection, there will be filters in all three ports of it. Remove the two tube-to-pipe fittings on both sides of the 3-way valve.
7. Remove the connection into the pilot (this will either be a tube-to-pipe fitting or the field test 3-way valve). See Figure 23.
  - a) There will be one filter screen in the pilot body behind this connection.

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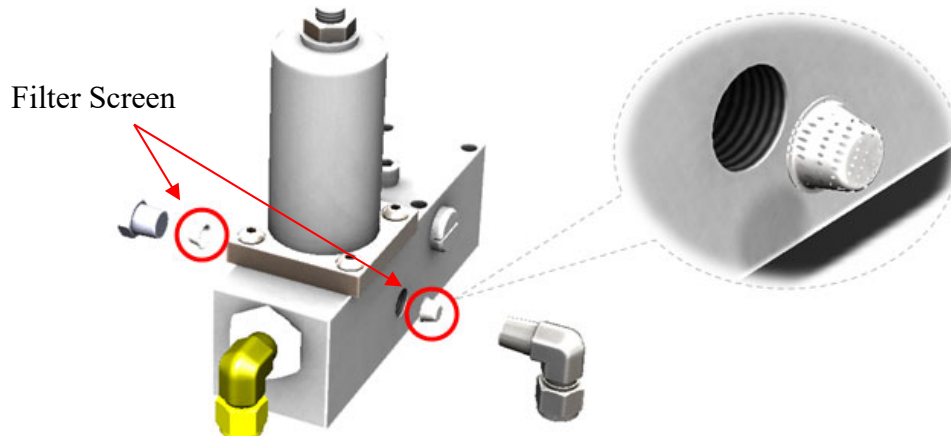


Figure 23: Exploded View of Typical Filter Screen Locations on a Modulating Pilot Valve

8. All filter screens and ports should be inspected for debris.
  - i) Replacement filter screens are included in the repair kit.

***b) Main Valve Disassembly***

1. Make sure there is not pressure within the main and pilot valves.
2. Remove the tubing connecting the main valve to the pilot valve.
3. Remove the pilot mounting bolts and carefully remove the pilot valve from the main valve. See Figure 21 or 22.
  - a) On gas service, there is an o-ring on the bottom of the pilot that seals the pilot to the main valve dome. See Figure 51.
4. Remove the main valve bonnet.
  - a) Main valve bodies which are 1" x 2" or 1-1/2" x 2" will have threaded bonnets, while larger sizes will have bolted bonnets.
    - i) The bonnet will have an o-ring that can be replaced, which is included in the repair kit. See Figure 24.
5. Remove the piston subassembly, along with the return spring, from the bonnet.
6. Remove the piston o-rings. See Figure 24.
  - i) Replacement o-rings are included in the repair kit.

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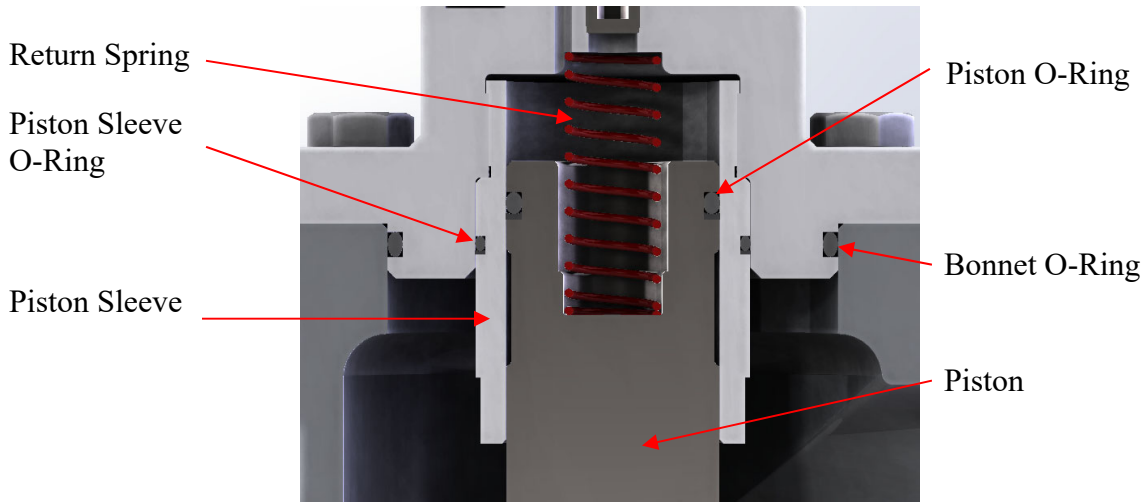


Figure 24: Typical Piston/ Dome Section

**Piston Subassembly**

The disk can be disassembled from the piston subassembly, if deemed necessary. If the disk is damaged beyond repair, it should be replaced.

- i) The disk is not included in the repair kit and needs to be specially ordered.
- ii) The whole piston subassembly is not included in the repair kit and needs to be specially ordered.

- 7. Radially fix the inner stem by inserting a rigid steel pin into the outer hole of the piston sleeve. See Figure 25.

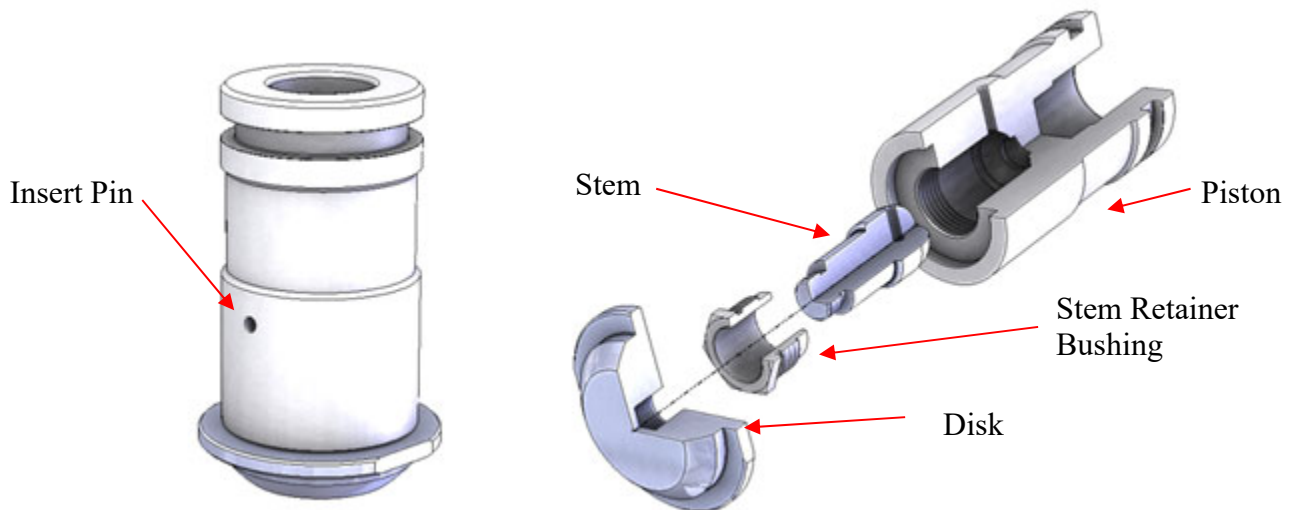


Figure 25: Piston Subassembly

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8. Gently fix the outer portion of the piston and use a square wrench to unscrew the disk in a counter clockwise direction.
  - a) Be careful not to scratch or ruin the piston.
  - b) The stem's threads will have thread retainer applied.
9. If the stem needs removal, keep the piston and inserted pin gently fixed and use a hex socket to unscrew the stem retainer bushing. See Figure 25.
  - a) The stem retainer bushing will have thread retainer applied.
10. The stem can now be removed.

**Piston Sleeve**

The piston sleeve should be checked for wear or damage and needs to be removed in order to replace the o-ring behind it. The piston sleeve should be handled with extreme care, as it can be deformed and damaged. Any deformation, damage, or wear will require a replacement, which must be specially ordered.

11. Rigidly support the main valve bonnet to prevent rotation.
12. Using the flats on the piston sleeve, unscrew it carefully. Figure 26.
  - a) The piston sleeve is securely installed into the main valve bonnet and can be difficult to remove due to the limited area on the wrenching flats and the use of thread retainer on the threads. Special care and consideration should be taken upon removal because if the piston sleeve gets misshapen during removal, it will need to be replaced.

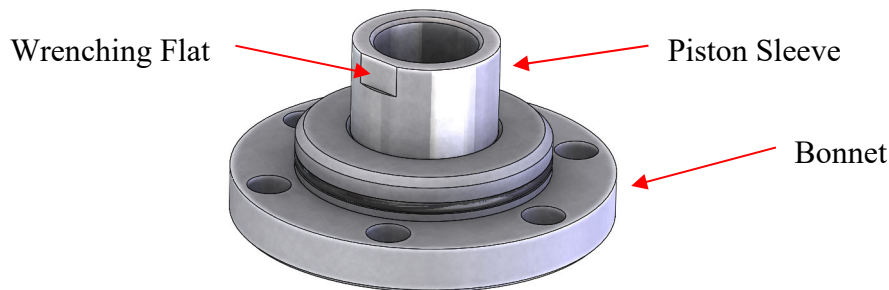


Figure 26: Piston Sleeve and Bonnet (Shown Upside-Down)

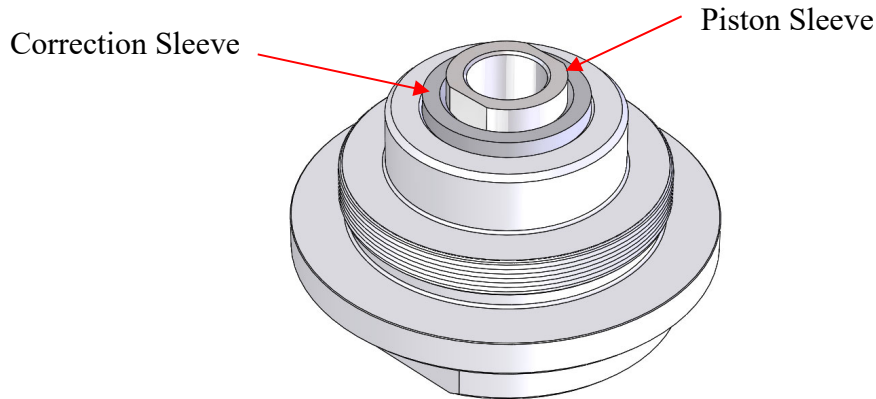
13. Remove the piston sleeve o-rings.
  - i) Replacement o-rings are included in the repair kit.

**Correction Sleeve**

Some D, E, and F configurations have a correction sleeve installed. See Figure 27. The correction sleeve should only be removed if the correction sleeve o-ring is leaking.

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**Figure 27: Correction Sleeve**

**Nozzle Subassembly**

14. Unscrew and remove the nozzle subassembly.
  - a) It is removed by going through the top of the main valve.
  - b) Some of the nozzles require large sockets for removal, while others are bolted in. Review the tool list to determine the appropriate tool.
    - i) A replacement nozzle is included in the repair kit.
15. Pull the o-ring out of the nozzle pocket.
  - i) A replacement o-ring is included in the repair kit.

***c) Modulating Pilot Valve Disassembly***

1. Make sure there is not pressure within the main and pilot valves.
2. Remove the tubing connecting the modulator pilot valve to the main valve and any accessories.
3. Remove the pilot mounting bolts and carefully remove the pilot valve from the main valve. See Figure 21 or 22.
  - a) On gas service, there is an o-ring on the bottom of the pilot that seals the pilot to the main valve dome. See Figure 51.
4. Remove the pilot vent and body plug from the back of the modulating pilot valve. See Figure 29.
  - a) The o-ring on the body plug can be removed.
    - i) A replacement o-ring is included in the repair kit.

**Pilot Bonnet**

5. Cut and remove the pilot valve seal wire and remove the cap from the pilot bonnet. See Figures 28 and 29.
  - a) The seal wire is located on the cap and runs to the seal screw closest to the bonnet of the pilot valve.
  - b) Go to Section XIII e) if the valve is a lift lever configuration.
6. Loosen the lock nut from the adjustment screw. See Figure 28.

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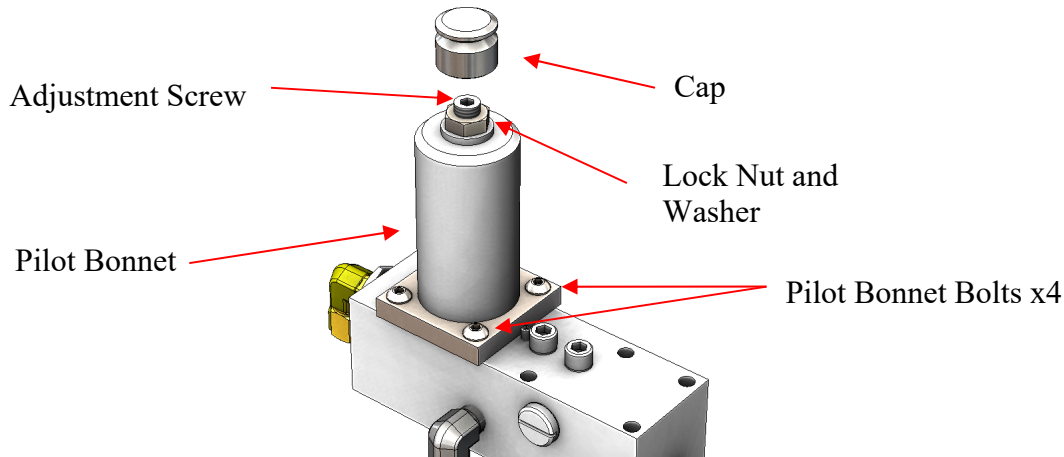


Figure 28: Pilot Bonnet

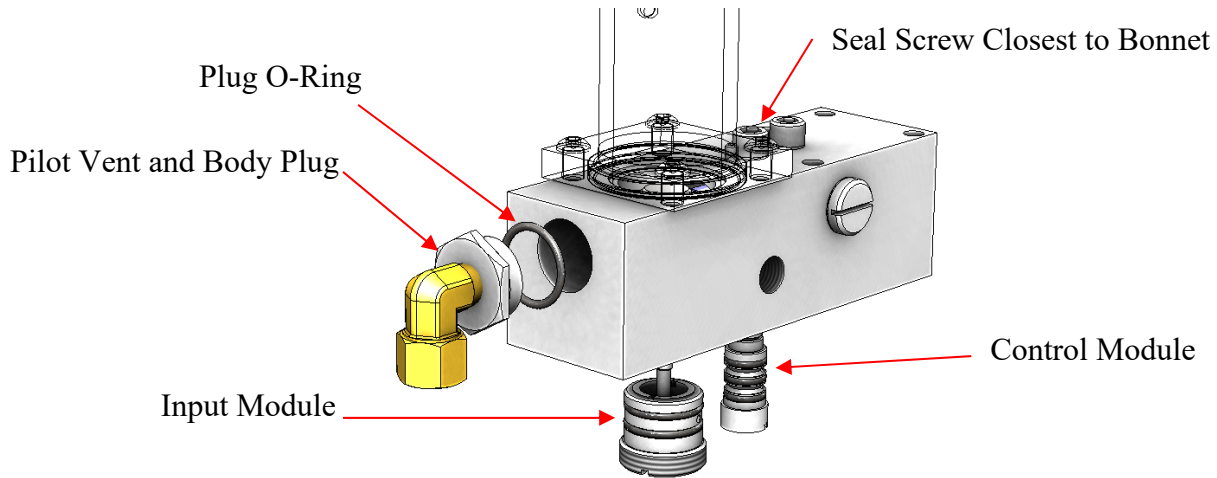
7. Relieve the spring tension by turning the adjustment screw counter clockwise.
  - a) This is important so that components will not spring out and pose a hazard.
  - b) If the adjustment screw begins to recede back into the bonnet during the relieving of the preload, then the spring compression has been completely removed.
8. Remove the four pilot bonnet bolts. See Figure 28.
  - a) This will allow the pilot bonnet to be removed.
9. Remove the bonnet o-ring, spring, and set spring disk.
  - i) A replacement o-ring is included in the repair kit.
10. The bonnet can be disassembled. See Figure 54. Remove the lock nut and washer from the top of the pilot bonnet.
11. Push down on the adjustment screw from the modulator bonnet.
  - a) This will remove the adjustment screw and adjustment bushing.
12. Unscrew the adjustment bushing from the adjustment screw.
  - a) These have left handed threads.
13. Remove the o-ring from the adjustment screw.
  - i) A replacement o-ring is included in the repair kit.

**Removing the Control and Input Modules**

14. Remove the seal screw and seal washer closest to the pilot bonnet. See Figure 29.
  - i) A replacement seal washer is included in the repair kit.

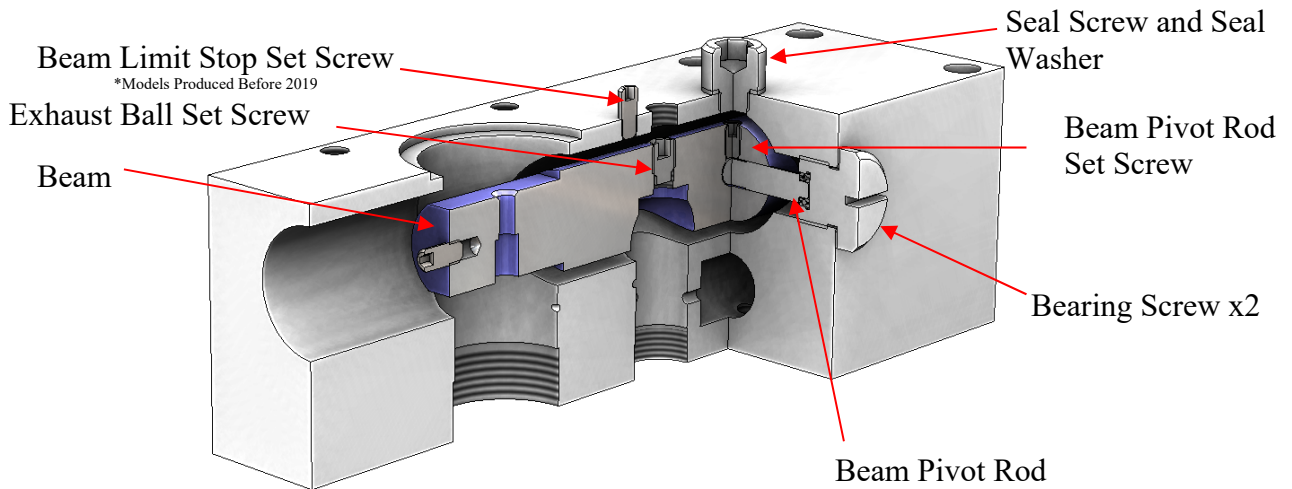
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**Figure 29: Input and Control Module Removal**

15. Loosen the exhaust ball set screw under the cap head seal screw referenced in step 14.
  - a) This should be loosened 2-3 turns.
16. If it exists, loosen the beam limit stop set screw 2-3 turns. See Figure 30.
  - a) Modulating pilots produced after December 2018 will not have this set screw.



**Figure 30: Section View of Beam**

17. Using the control module key tool that is provided in the kit, remove the control module from the bottom of the pilot body. **DO NOT** use a screw driver on this part. See Figures 29 and 31.
  - i) A replacement control module is included in the repair kit and will come with preinstalled o-rings.
18. Remove the input module from the bottom of the modulating pilot body using either the flush end of the module key tool or a wide flat head screw driver. See Figure 31.

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- i) A replacement input module is included in the repair kit and will come with preinstalled o-rings.

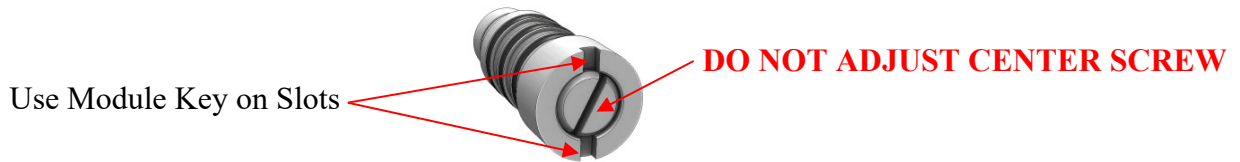


Figure 31: Control Module

**Removing the Beam**

Make sure the bonnet, set spring disk, control module, input module, and body plug have been removed before continuing.

- 19. Remove the seal screw and seal washer furthest from the pilot bonnet. See Figure 30.
  - i) A replacement seal washer is included in the repair kit.
- 20. Loosen the bearing set screw under the cap head seal screw referenced in step 19.
  - a) This should be loosened 3-4 turns.
- 21. Remove the two bearing screws from the sides of the pilot body. See Figure 30.
  - a) Do not remove the bearings within the screws and make sure to keep each gasket(s) with its respective screw.
- 22. Once the bearing screws are removed, the pivot rod usually slides out when the pilot body is turned to the side.
  - a) You should be prepared to catch the pivot rod. It can also be pushed out from the beam.
  - b) If the pivot rod does not slide or push out easily, the set screw referenced in step 20 needs to be loosened further or possibly removed.
- 23. Remove the beam from the modulating pilot body.
- 24. The pilot valve is completely disassembled.

***d) Pilot Options Disassembly***

The following instructions should be used in the disassembly of any POPRV accessories.

**Backflow Preventer (BFP)**

If equipped, the backflow preventer can be removed. Note that the locations of the BFP between gas and liquid service are different. Refer to Section VII b) or see Figures 32 and 33.

***For Gas Service BFP:***

- a) Make sure there is not pressure within the main and pilot valves.
- b) Remove the tubing and fittings from the front of the pilot body.
- c) Pull out one of the rubber seats through the front of the pilot body port.
- d) Remove the backflow preventer ball; it will roll out of the pilot body.
  - i) A replacement ball is included in the repair kit.

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- e) Carefully, pull the backflow preventer tube out of the pilot body. A soft metal hook or pick can be used to help grasp the tube. Be careful not to scratch the bore surface.
- f) Remove the other rubber seat and outer o-ring from the backflow preventer tube.
  - i) Replacement seats are included in the repair kit.
  - ii) A replacement o-ring is included in the repair kit.

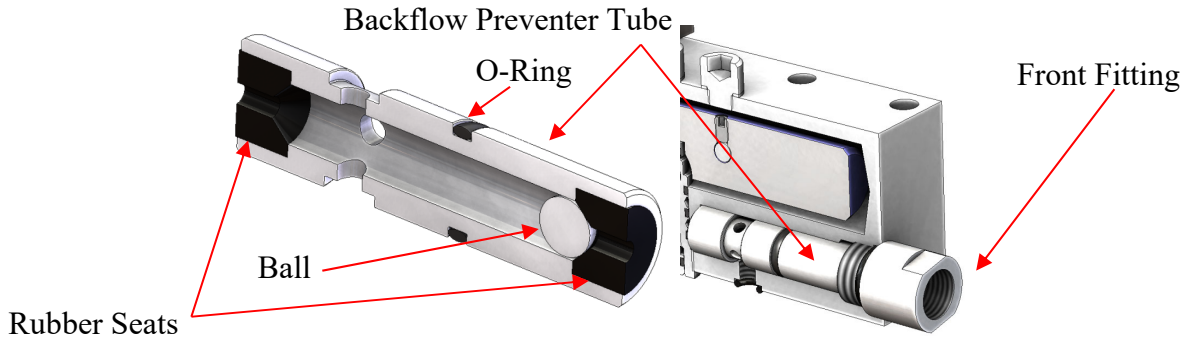


Figure 32: Backflow Preventer (Gas Service)

***For Liquid Service BFP:***

- a) Make sure there is not pressure within the main and pilot valves.
- b) Remove the tubing to and from the BFP.
- c) Take the BFP off the bonnet of the main valve.
- d) Remove the fittings from the BFP body. See Figure 33.
- e) Push the shuttle out from the bore of the BFP body.
  - i) A replacement shuttle with preinstalled o-rings is included in the repair kit.
- f) Inspect the BFP body's internal bore for damage or wear. Replace, if needed.
  - i) Replacement fittings are included in the repair kit.

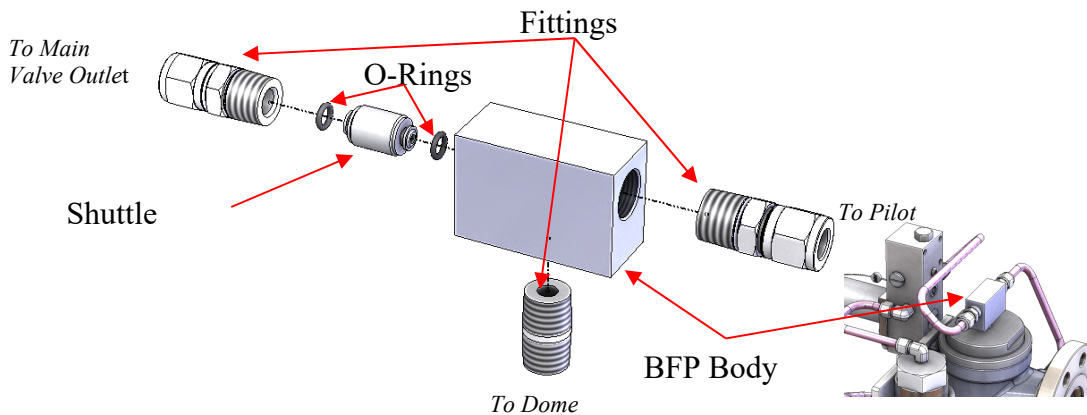


Figure 33: Backflow Preventer (Liquid Service)

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**Auxiliary Filter (AF)**

A common maintenance routine that will help prolong the reliability of the valve is regular draining of the auxiliary filter.

- a) Make sure there is not pressure within the main and pilot valves.
- b) Remove all the tubing leading to the AF.
- c) Remove the U-bolt mounting the AF to the main valve.
- d) Rigidly affix the body and unscrew the cap. See Figure 34.

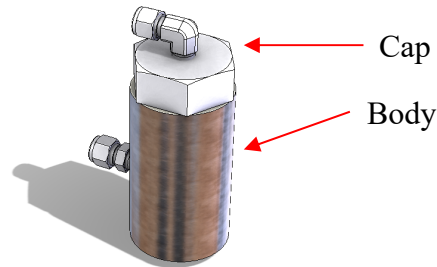


Figure 34: Auxiliary Filter

- e) Remove the o-ring on the cap that is located just above the threads. The filter element should be connected to the cap. See Figure 35.
  - i) A replacement o-ring is included in the repair kit.
- f) The filter element can be cleaned.
  - i) A replacement filter element subassembly is not included in the repair kit but can be specially ordered.

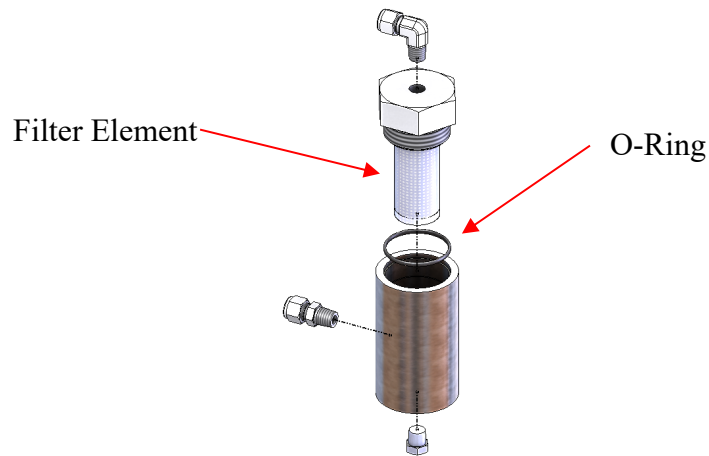


Figure 35: Auxiliary Filter Exploded Assembly

**e) Lift Lever Disassembly**

1. Cut and remove the seal wire. See Figure 36.

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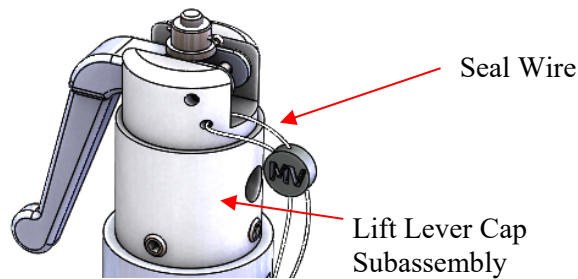


Figure 36: Lift Lever Cap

2. Bend straight and pull out the cotter pin. See Figure 37.
  - i) A replacement cotter pin is not provided in the repair kit.
3. Unscrew and remove the stem lift nut. See Figure 37.

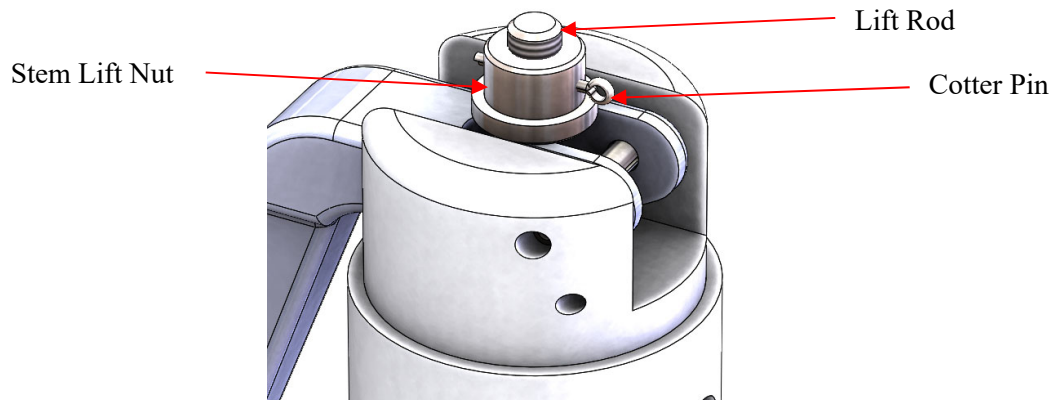


Figure 37: Upper Portion of Lift Lever Cap

4. Loosen the three lift lever cap set screws. See Figure 38.
  - a) These must be unscrewed enough so that they no longer engage the lift lever lock nut.

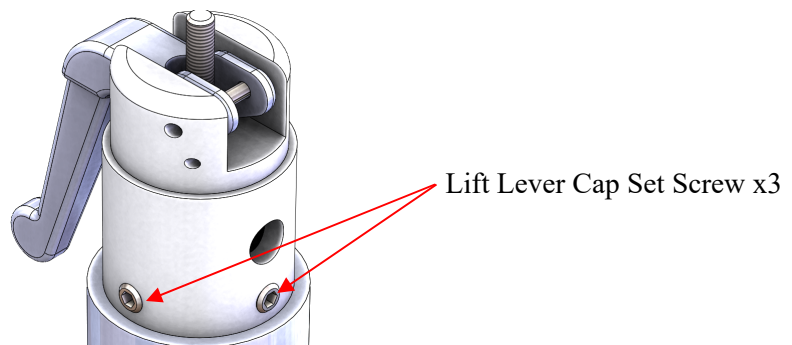
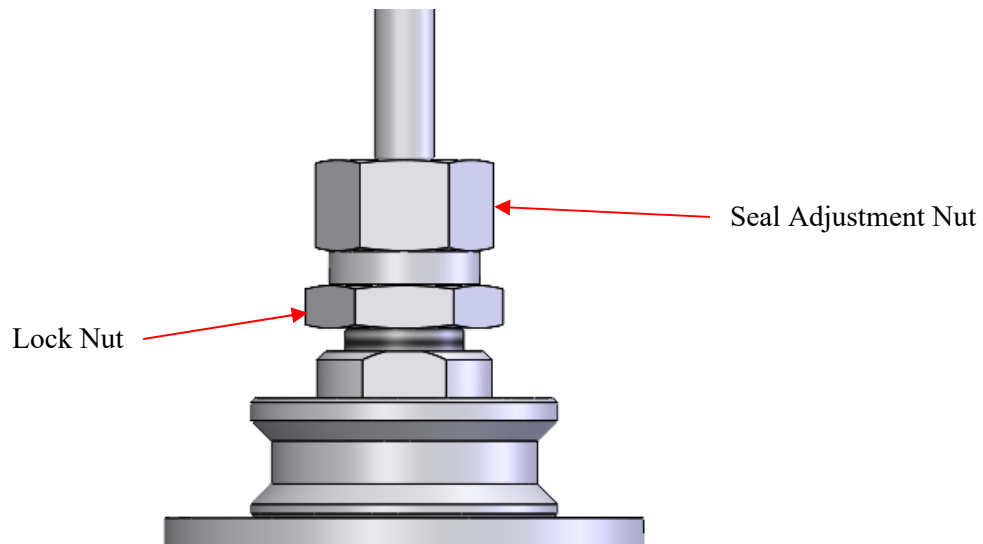


Figure 38: Lift Lever Cap Set Screws

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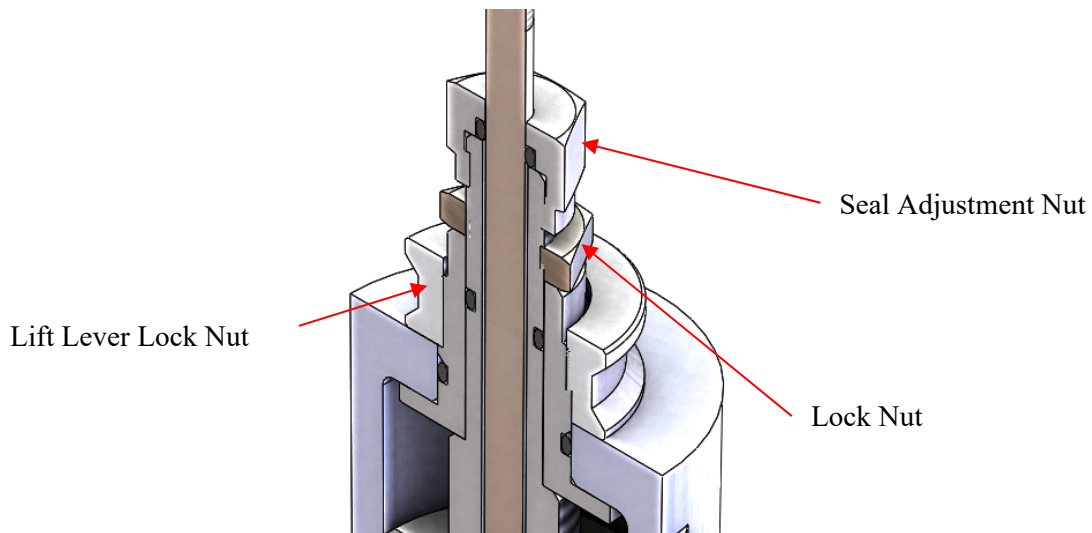
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5. Raise the entire lift lever cap to remove it from the bonnet.
6. Loosen the lock nut and jam it against the seal adjustment nut. See Figure 39.



**Figure 39: Lock Nut Jammed Against Seal Adjustment Nut**

7. With the locknut and seal adjustment nut tightened against each other, turn the adjustment screw counter clockwise to remove the spring load.
8. Unscrew and remove the seal adjustment nut. See Figure 40.



**Figure 40: Removed Lift Lever Cap**

9. Remove locknut.

*If removing the center bushing, continue to step 10. Otherwise, skip to step 11.*

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10. If necessary\*, the lift lever lock nut may be removed by using a wrench on the flats of the center bushing and a pipe wrench on the lift lever lock nut. See Figure 41.
  - a) One wrench should remain stationary while the other is applied on the other component to break the two parts loose.
  - b) \*These components do not have to be disassembled unless the center bushing o-ring is suspected of leaking. Removing these parts is not recommended.
  - c) This lock nut has high strength thread retainer applied and can be difficult to remove.
  - d) The center bushing o-ring is not included in the repair kit and needs to be specially ordered.

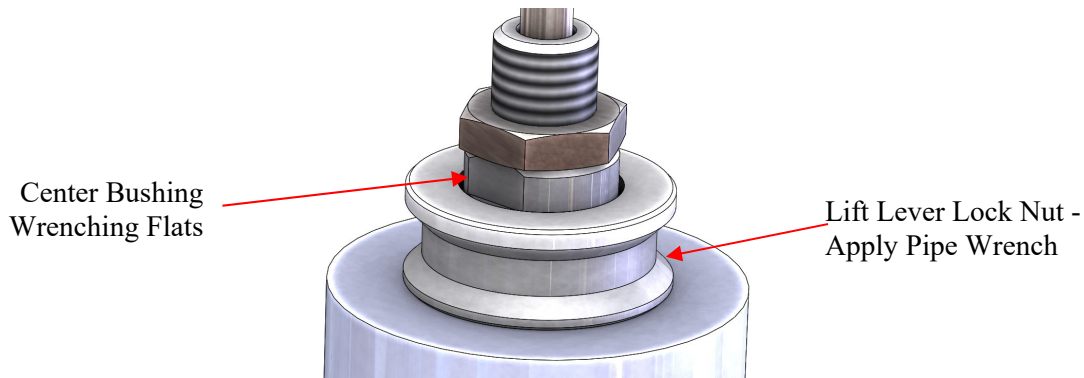


Figure 41: Lift Lever Lock Nut Removal

11. The disassembly is now typical of the process described for a non-lift lever configuration. Return to step 8 in XIII c).

**f) Auxiliary Valve Disassembly**

When repairing a modulating POPRV that has an AX valve attached, the AX valve requires repair service as well. Consult Section VI for more information regarding the maintenance of an AX valve.

1. Cut and remove the AX valve seal wire and remove the cap from the bonnet.
2. Loosen the lock nut from the adjustment screw. See Figure 42.

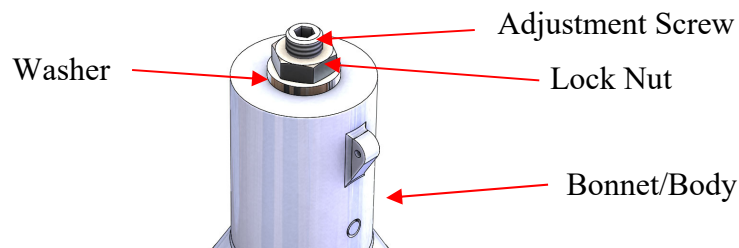


Figure 42: Upper Bonnet Components

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3. Relieve the spring tension by turning the adjustment screw counter clockwise.
  - a) This is important so that components will not spring out and pose a hazard.
  - b) If the adjustment screw begins to recede back into the bonnet during the relieving of the preload, then the spring compression has been completely removed.
4. Rigidly support the body of the AX valve to prevent rotation.
5. Remove the inlet base by unscrewing it using the wrenching flats.
6. Remove the set spring and disk subassembly. See Figure 43.
  - i) A replacement disk is included in the repair kit.
7. Remove the inlet base seal. See Figure 43.
  - i) A replacement base seal is included in the repair kit.

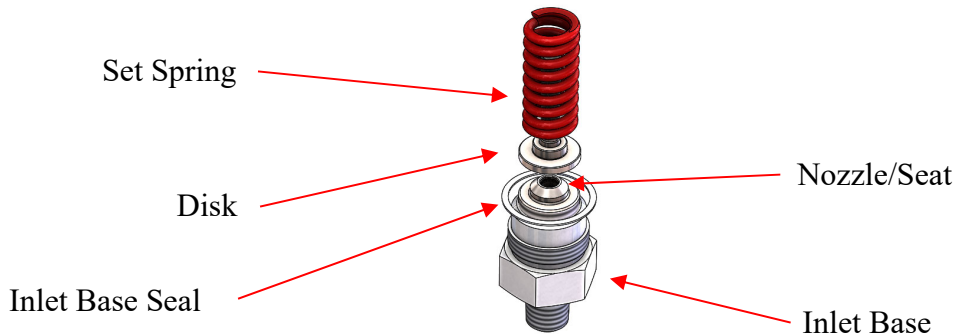


Figure 43: Inlet Base Components

8. Rigidly support the inlet base.
9. Unscrew the nozzle subassembly using the wrenching flats.
  - a) The nozzle will have thread retainer on its thread.
    - i) A replacement nozzle is included in the repair kit.
10. Remove the nozzle base o-ring. See Figure 44.
  - i) A replacement o-ring is included in the repair kit.

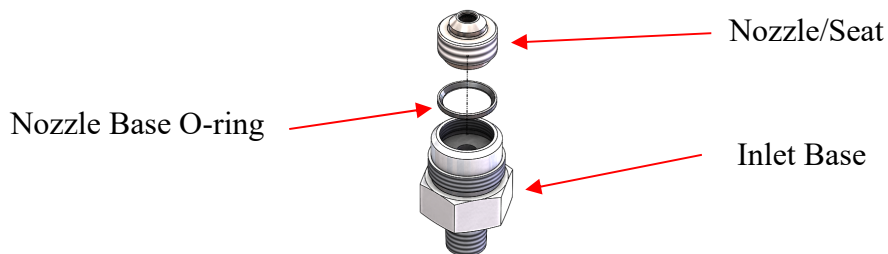
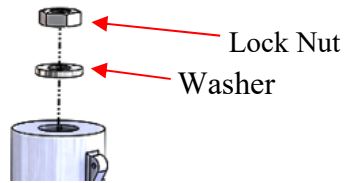


Figure 44: Nozzle/ Seat Subassembly

11. Remove the lock nut and washer from the top of the bonnet. See Figure 45.

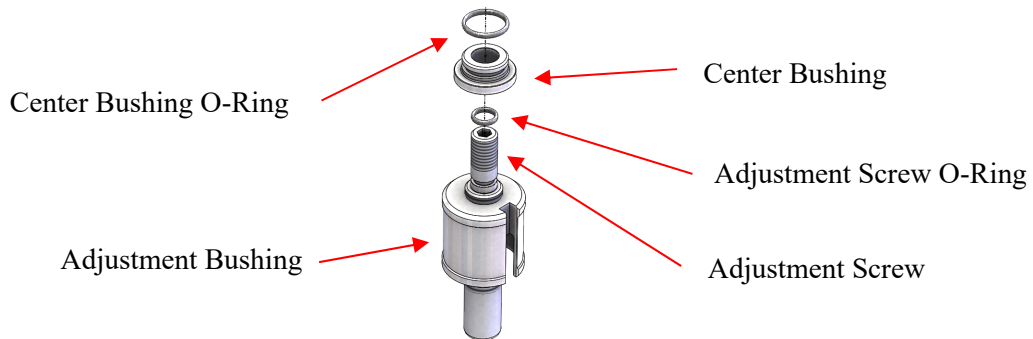
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**Figure 45: Upper Bonnet Components**

12. Push down on the adjustment screw from the AX valve bonnet.
  - a) This will remove the adjustment screw and adjustment bushing.
13. Unscrew the adjustment bushing from the adjustment screw. See Figure 46.
  - a) These have left handed threads.
14. Disassemble the center bushing from the adjustment screw if they are still attached.
15. Remove the o-ring from the center bushing. See Figure 46.
  - i) A replacement o-ring is included in the repair kit.
16. Remove the o-ring from the adjustment screw. See Figure 46.
  - i) A replacement o-ring is included in the repair kit.



**Figure 46: 1" Body Inner Bonnet Components**

17. The AX valve is disassembled.

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## **XIV. Reassembly**

The following general procedure is recommended for the reassembling of a 9500 Series modulating POPRV. Parts should not be difficult to put back together and excessive force should **never** be used.

Always remove and clean any form of preexisting thread sealant from components prior to reapplication of thread sealant and reassembly. This will help prevent the accumulation of thread sealant over time and reduce the chances of clogging any ports and passages.

### **a) Cleaning, Lubricating, & Sealing**

#### ***Cleaning:***

- All of the modulating pilot parts **except** the input module and control module can be cleaned with a solvent bath. This will help rid debris from within the pilot valve. **Remove all soft goods before applying solvent.**
- An abrasive pad may be used to clean dirty surfaces. Always rinse off parts after using Scotch-Brite™.
- All parts shall be drained and dried before reassembly.
- **Parts should never be media blasted.** This process leaves beads/ sand in the valve, which can cause improper function. It may also ruin a required surface finish condition.
- After parts have been cleaned, they can be re-lubricated.

#### ***Lubricating:***

- All o-rings should be lubricated with silicone grease similar to Molykote® 33 grease. It is especially important to grease the o-rings on the control module and input module since they are slid into tight fits. This will make assembly easier and help prevent cutting the o-rings.
- The threads (where indicated) should be lubricated with a small amount of anti-seize, preferably a nickel base type. For example, a good method for doing this is to apply a small line of anti-seize on the upper half of the adjustment screw threads. When the adjustment bushing is threaded on, the anti-seize will be spread. This prevents using too much.
- The adjustment bushing should be greased on the outer cylindrical area with a water resistant lubricant similar to Aqualube.
- The bearing screw bearings should be lubricated with “3-In-One Oil®”.
- **Never apply grease, oil, or other lubricants on seats, seal faces, or sliding components.**

#### ***Thread Sealant on Pipe Fittings:***

- Wrap the threaded portion of pipe fittings with PTFE pipe tape.
- Do not use too much tape and make sure that the tape is only exposed on the thread.
- The recommended number of wraps of tape is three wrap levels; this should be done in a manner that does not cause the tape to unravel during tightening.

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- If the tape isn't located exclusively on the threads, a portion could break free and get lodged in the flow path and cause the pilot valve to get blocked.
- Tighten pipe plugs/ fittings approximately 2-3 turns past hand tight.

**b) Filter Reassembly**

1. If the pressure probe was removed, reinstall it in its original orientation.
  - a) The sense line port must be oriented horizontally so the pitot tube inlet is facing downwards, parallel to the flow. See Figure 47.

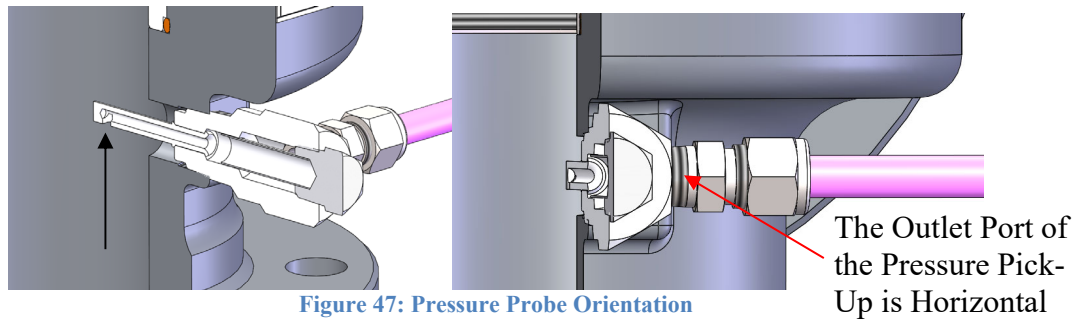


Figure 47: Pressure Probe Orientation

2. Utilizing pipe thread sealant, thread the probe filter into the pressure probe until tight.
3. To install the filter screens located in the pilot valve, make sure that the outside of the filter screen is towards the process flow (convex) and replace each filter screen. See Figure 23 for an illustration of the proper orientation of the filter screens.
4. The appropriate fittings should then be rethreaded into the pilot valve.

**c) Modulating Pilot Reassembly**

Once all of the components have been cleaned and lubricated, the pilot valve is ready to be reassembled.

1. Screw **one** bearing screw into the modulating pilot body.
  - a) Make sure to put the same number of bearing screw gaskets with its associated bearing screw.
  - b) There is a minimum of 1 bearing screw gasket with each bearing screw. However, there can be a second gasket on one side to prevent binding. It is crucial all gaskets are put back on during reassembly.
2. Tighten the bearing screw to the value shown in Table 5.

Table 5: Bearing Screw Torque Value

Component	Torque, lb-ft (N-m)
Bearing Screw	10 (14) max.

3. Attach the beam extension rod tool to the beam. See Figure 48.

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- i) The extension rod tool is included in the repair kit.
4. Insert the beam into the pilot body using the extension rod to maneuver it.
  - a) Make sure that the beam is facing the correct directions, as seen in Figure 48; notice the set screw ports are on top.
  - b) Insert the beam at a depth where the two set screw locations are visible and lined up with the two upper ports of the modulator body.

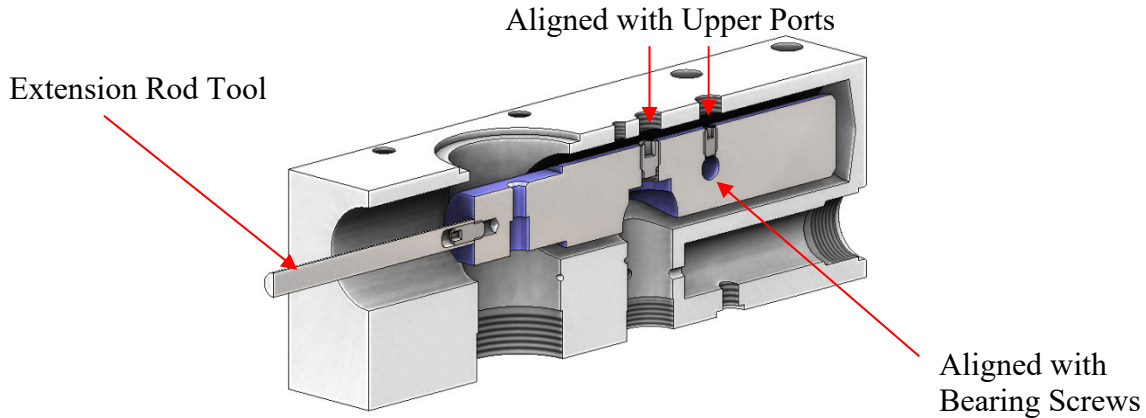


Figure 48: Beam Alignment

5. Slide the beam pivot rod through the side of the pilot body, into the beam, and into the bearing screw bearing on the opposite side. See Figure 30.
  - a) Use the extension rod to move the beam for alignment, as necessary.
6. Again, using the extension rod to help with alignment, screw the other bearing screw with its respective gasket(s) into the pilot body.
  - a) Make sure that the pivot rod gets inserted and aligned into the bearings of the bearing screws. If the beam pivot rod is not aligned and inserted into both bearings, the bearing screws will not easily thread in and can crush the bearings if forced.
  - b) When this is finished, the bearing screws and washer(s) will be flush against the pilot body.
7. Tighten the bearing screw to the value shown in Table 5.
8. The beam should appear approximately centered, as shown in Figure 49.

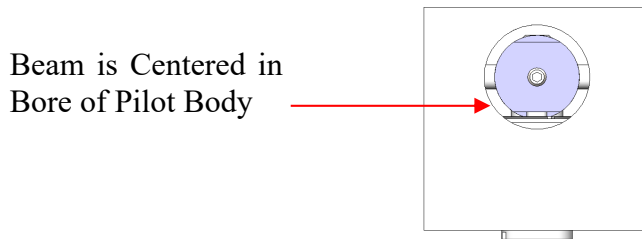


Figure 49: Beam is Centered

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9. Place a small drop of medium strength thread retainer on the threads of the beam pivot rod set screw.
  - a) Make sure that the beam is approximately centered from left to right.
10. Install the beam pivot rod set screw into the beam, locking it against the beam pivot rod.
11. Tighten the beam pivot rod set screw to the value shown in Table 6.

**Table 6: Beam Pivot Rod Set Screw Torque Value**

Component	Torque, lb-ft (N-m) ± 5%
Beam Pivot Rod Set Screw	8 (11)

12. **Check and make sure that the beam still has the ability to pivot up and down freely.**
  - a) **If the beam does not move freely, the bearing screws are binding. A gasket is most likely missing from the bearing screw and needs to be added.**
13. Screw in the cap head seal screw above the hole for the beam pivot rod set screw. See Figure 30.
  - a) Do not forget the seal washer.
14. Tighten the cap head seal screw to the value shown in Table 7.

**Table 7: Cap Head Seal Screw Torque Value**

Component	Torque, lb-ft (N-m) ± 5%
Cap Head Seal Screws	10 (14)

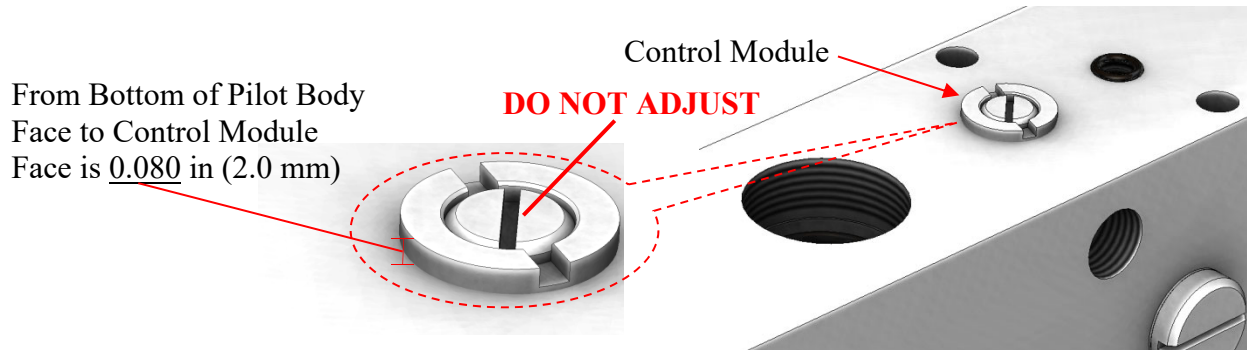
15. Again, check to make sure that the beam is free to pivot up and down and doesn't have any binding or sticking present during its movement.

**Control Module**

16. Lightly lubricate the o-rings on the control module with a silicone grease.
17. Gently push the control module into the appropriate location of the pilot valve body.
  - a) Be careful that the control module o-rings do not get cut.
18. Use the control module key tool to tighten the control module into the body.
  - a) Do not use a flat head screw driver.
  - b) The control module does not thread in flush with the pilot body. See next step.
19. The control module will protrude from the body by 0.080 in. (2.0 mm). See Figure 50.
  - a) Use an accurate dial caliper or similar device to ensure this.
  - b) The notched part of the control module tool is 0.080 in. (2.0 mm). The tool can be held next to the control module to check the distance.

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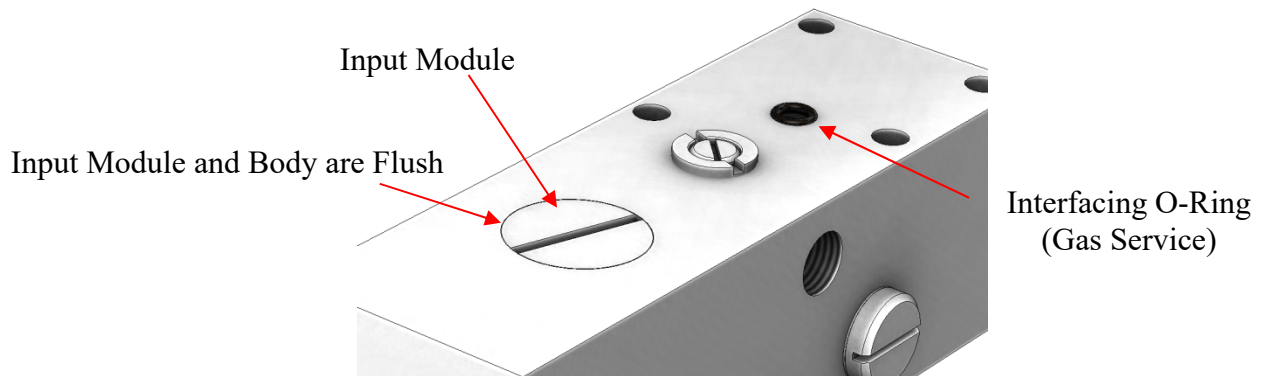
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**Figure 50: Control Module Installation (Pilot Shown Upside Down)**

**Input Module**

20. Lightly lubricate the o-rings on the input module with a silicone grease.
21. Gently push the input module into the appropriate location of the pilot valve body.
  - a) Be careful that the input module o-rings do not get cut.
22. Screw the input module into the bottom of the pilot body. See Figure 51.
  - a) Either a large flat head screw driver or the back end of the control module tool can be used.
  - b) The input module is threaded in so that the bottom face of the input module is flush with the bottom face of the pilot body.
  - c) Do not insert the input module any further than flush.
  - d) The beam should still appear centered in bore.



**Figure 51: Input Module Installation (Pilot Shown Upside Down)**

23. Insert one filter screen into the input port on the side of the pilot body and one filter screen into the dome port on the other side of the pilot body. See Figure 23.
  - a) The filters should be installed so that the concave section is towards the inside of the hole.
24. Screw the test port plug into the side of the pilot body.
25. Screw in the field test port or input port fitting into the input port on the side of the pilot body.
  - a) The test port or input port fitting should be oriented so that they are facing towards the back of the pilot body.

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**Backflow Preventer**

26. If the valve is equipped with a backflow preventer, continue with the following steps. Otherwise, thread in the backflow preventer plug and o-ring, tighten to the value shown in Table 8, and skip the following steps.

**Table 8: Backflow Preventer Fitting/ Plug Torque Value**

Component	Torque, lb-ft (N-m) ± 5%
Backflow Preventer Fitting/ Plug	35 (47)

**Gas Service** (Reference Figure 32)

- a) Install one of the backflow preventer seats into one side of the backflow preventer tube. The seat should be oriented so that the flat face is on the outside of the tube.
- b) Drop the backflow preventer ball into the tube. It should roll freely.
- c) Insert the other seat into the tube so that the flat face is on the outside of the tube.
- d) Insert the outer o-ring onto the tube. The o-ring should be well lubricated.
- e) Insert the tube assembly into the front of the pilot body. Note the orientation of the tube. This is shown in Figure 32.
- f) Screw the backflow preventer fitting into the pilot body. The fitting should be oriented so that it faces towards the side of the pilot body that has the dome port.
- g) Tighten the backflow preventer to the value shown in Table 8.

**Liquid Service** (Reference Figure 33)

- a) Reinstall the shuttle.
- b) Insert the shuttle into the bore of the BFP body.
- c) Reinstall all the fittings onto the BFP body.
- d) Reinstall the BFP onto the dome port on the main valve bonnet.

**d) Modulating Pilot Calibration**

***Conduct the following if either the input or control modules were removed. The calibration process can be done using gas for both a gas and liquid service modulating POPRV.***

1. Setup the pilot on a test stand similar to Figure 16 or use the top of the main valve bonnet.
  - a) If the pilot is on the main valve, take out the test port plug. Insert a pressure gauge in this test port. This will measure the dome pressure.
  - b) There are two gauges in this setup. The other gauge is the input pressure.
  - c) Use of a high-quality regulator will aid in the calibration. It is important that the test setup has the ability to maintain a constant input pressure.
2. Put a small drop of low strength thread retainer on the threads of the exhaust ball set screw. See Figure 30.
3. Screw the exhaust ball set screw into the beam 2 to 3 turns.
4. Bring the input pressure up to 30 psi (200 kPa).
  - a) Gas will most likely be heard venting from the pilot.

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- b) Keep the input pressure constantly at 30 psi (200 kPa).
- c) The recommended pressure of 30 psi (200 kPa) can be used regardless of set pressure. This pressure is high enough to easily see a pressure change, which makes setting the valve easier. This pressure is also low enough that the beam can be held down without exerting great force.
5. Use the beam extension tool attached to the beam to hold the beam down. See Figure 48.
6. While holding the beam down, screw in the exhaust ball set screw until the pressure on the dome gauge rises up to 30 psi (200 kPa) (or equal to the input pressure).
  - a) The input pressure should still be at 30 psi (200 kPa).
7. Turn the exhaust ball set screw an additional 1/4 turn.
  - a) The purpose of this adjustment is to properly engage the control module.
8. Check the settings by letting go of the beam.
  - a) The dome pressure should quickly drop to zero. Again, hold the beam down and the dome pressure should quickly rise back up to 30 psi (200 kPa) (or equal to the input pressure). This process should be repeatable.
  - b) If the pressure does not rise quickly, turn the exhaust ball set screw clockwise and repeat the test.
  - c) If the pressure drop has a delay in dropping to zero, the exhaust ball set screw is turned in too far and should be turned counter clockwise.
  - d) The test should be repeated until the rate at which pressure rises is equal (or as close as reasonably possible) to the rate at which pressure drops. Since it can be difficult to get the rates perfectly equal, it is preferable that the rate at which pressure drops is greater than the rate at which pressure rises if it has to lean one way. This ensures pressure vents quickly enough in an overpressure event.
9. Screw the other cap head seal screw into the hole located above the exhaust ball set screw.
  - a) Make sure to include the seal washer.
10. Tighten the cap head seal screw to the value shown in Table 7.
11. If a beam limiting set screw is present, put a small drop of low strength thread retainer on its threads.
  - a) Skip to step 15 if a beam limiting set screw does not exist.
  - b) Modulating pilots produced after December 2018 will not have this set screw.
12. Begin to insert the beam limiting set screw into the modulating body.
13. Let the 30 psi (200 kPa) of input pressure hold the beam up.
  - a) The dome gauge should be at 0 psi (0 kPa).
  - b) Screw in the beam limiting set screw until the dome gauge pressure begins to rise above 0 psi (0 kPa).
14. Unscrew the set screw 1/2 a turn.
  - a) This adjustment limits the travel of the beam so that the input module diaphragm cannot be overstressed.
15. Recheck the settings prescribed in step 8 to make sure the pilot valve is calibrated properly.
16. Remove the beam extension tool from the beam.
17. Thread the body plug and dome vent subassembly into the pilot body. See Figure 29.

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- i) A replacement o-ring is included in the repair kit.  
 18. Tighten the body plug to the value shown in Table 9.

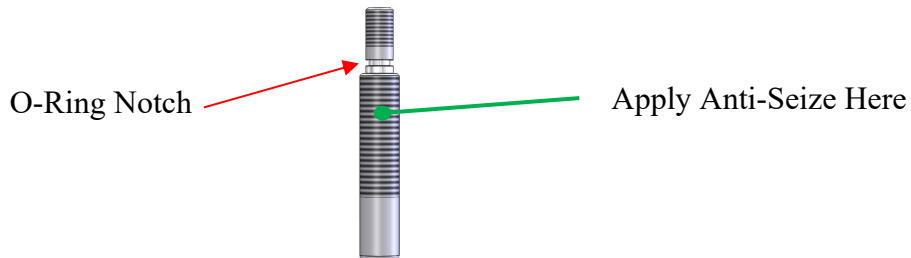
**Table 9: Body Plug Torque Value**

Component	Torque, lb-ft (N-m) ± 5%
Body Plug	20 (27)

19. Vent the pressure from the pilot valve.

**Pilot Bonnet**

20. Insert the spring disk onto the beam through the top of the pilot body. See Figure 54.  
 21. Check the spring dimensions to make sure that the correct spring is being used for the intended set pressure of the overall safety pressure relief valve.  
 a) Mercer’s spring chart, a separate document, contains this information.  
 b) Make sure the spring appears square and is not bent.  
 22. Insert the spring onto the spring disk.  
 23. Lightly apply a small amount of silicone grease to the adjustment screw o-ring.  
 24. Carefully place the adjustment screw o-ring onto the adjustment screw, making sure not to cut the o-ring. See Figure 52.  
 a) The o-ring should reside in a notch groove below the upper threads of the adjustment screw.  
 25. Lightly apply a small amount of anti-seize to the threads of the adjustment screw. See Figure 52.



**Figure 52: Adjustment Screw**

26. Thread the adjustment bushing onto the adjustment screw until approximately 2 threads of the adjustment screw are visible from the top. See Figure 53.  
 a) These have left handed threads.

*If the pilot valve has a lift lever, go to Section XIV f). Otherwise, continue with the following steps.*

27. Lightly coat the outer surface of the adjustment bushing with a water-resistant grease similar to Aqualube. See Figure 53.

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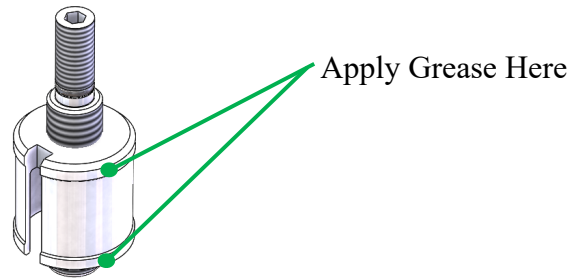


Figure 53: Adjustment Bushing

28. Carefully slip fit the adjustment screw and bushing into the pilot bonnet by aligning the bonnet side pin with the slot of the adjustment bushing. See Figure 54.
- a) The subassembly should get stopped by the adjustment screw upper shoulder hitting the top of the pilot bonnet.
  - b) The adjustment bushing must slip into the valve bore freely but with little radial play.
  - c) Remove and inspect/ re-clean parts if the fit is not correct.
  - d) **DO NOT FORCE THE ADJUSTMENT BUSHING INTO THE VALVE BODY. Forcing the parts may restrict valve lift and cause serious malfunction.**

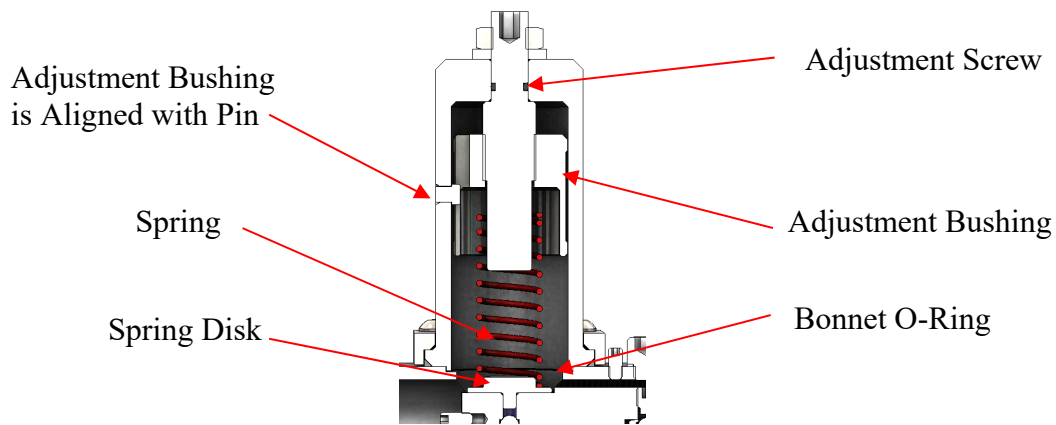


Figure 54: Detail of Pilot Bonnet

29. Place the washer over the top of the bonnet and onto the adjustment screw with the rounded edge side of the washer away from the body (towards the top of the valve).
30. Thread on the lock nut over the top of the bonnet and onto the adjustment screw.
- a) **DO NOT** fully tighten. The lock nut just needs to be hand tight at this point, only to retain the inner bonnet components.
  - b) The lock nut will be tightened once the setting process is completed.
31. Place the bonnet o-ring on the recess groove of the bonnet. See Figure 54.
- a) The o-ring should be lubricated with silicone grease.
32. Install the pilot bonnet subassembly onto the modulating pilot body.

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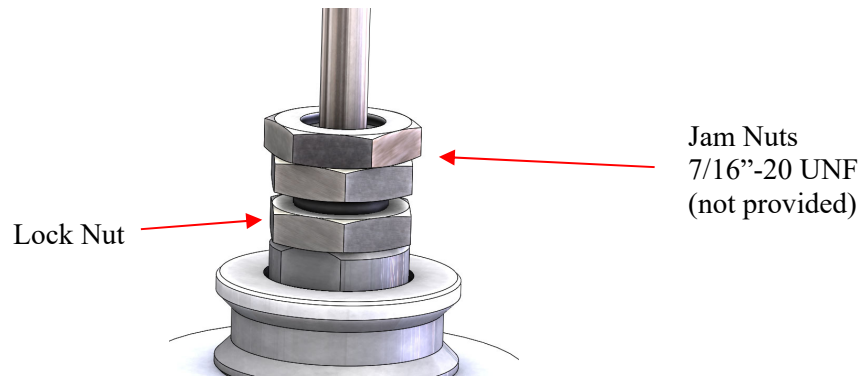
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- a) The bonnet will fit over the spring with the adjustment screw running through the center of the spring.
  - b) Make sure that the o-ring is properly placed and won't get pinched.
33. Screw in the four modulating pilot bonnet retainer bolts. See Figure 28.
34. Tighten the four pilot bonnet bolts to the value shown in Table 10.

**Table 10: Pilot Bonnet Bolt Torque Value**

Component	Torque, lb-ft (N-m) ± 5%
Pilot Bonnet Bolts	6.3 (8.5)

35. Turn the adjustment screw clockwise until resistance is felt; the spring is engaged.
- a) Turn the adjustment screw an additional 4-5 more times. This is increasing the compression on the spring.
  - b) If the PRV has a lift lever option, utilize two jam nuts to turn the adjustment screw. See Figure 55. The jam nuts are tightened against each other to 100 lbf-ft (136 N-m).



**Figure 55: Jam Nuts Used on Adjustment Screw**

36. Assembly is complete and the modulating pilot valve is now ready to have its set pressure adjusted. See Section XV.
37. Once the modulator pilot valve has been set, leak check the pilot valve.
- a) This can be done by submerging the pilot's exhaust vent under water in a cup and observing if bubbles are formed when pressure exists. Bubbles would indicate a leak in the pilot.

*If the pilot valve has a lift lever, return to step 9 in Section XIV f) to install the lift lever cap before proceeding to step 38. If there is no lift lever, continue with the following steps.*

- 38. Install the pilot valve onto the main valve by using the mounting bolts. See Figure 21 or 22.
- 39. Tighten the pilot mounting bolts to the value shown in Table 17.
- 40. Install any accessories that were equipped on the valve and tighten all fittings.

Recheck the set pressure of the POPRV with the pilot and all accessories attached to the main valve.

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**e) Main Valve Reassembly**

1. Lightly apply a small amount of silicone grease to the nozzle base o-ring.
2. Insert the new nozzle base o-ring into the nozzle pocket.
3. Apply a small coat of anti-seize to the new nozzle subassembly threads. See Figure 56.



Figure 56: Nozzle/ Seat Subassembly

4. Install the nozzle subassembly into the main valve body's nozzle pocket.
5. Tighten the nozzle to the appropriate value shown in Table 11.

Table 11: Nozzle Torque Values

<b>Nozzle Orifice</b>	<b>Inlet &amp; Outlet Size</b>	<b>Torque, lb-ft (N-m) ± 5%</b>
D, E, F	1x2; 1-1/2x2	200 (270)
G, H, J	1-1/2x3; 2x3	350 (475)
J, K, L	3x4	500 (680)
L, M	4x6	600 (810)
N, P	4x6; 4x6x6	600 (810)
Q, R	6x8; 6x8x8	*SS - 25 (34)/ bolt; CS - 65 (88)/ bolt
T	8x10; 8x10x10	*SS - 50 (68)/ bolt; CS - 130 (176)/ bolt
1-1/2" FB	1-1/2x2; 1-1/2x3; 2x3	200 (270)
2" FB	2x3	350 (475)
3" FB	3x4	500 (680)
4" FB	4x6; 4x6x6	*SS - 7 (10)/ bolt; CS - 19 (26)/ bolt
6" FB	6x8; 6x8x8	*SS - 25 (34)/ bolt; CS - 65 (88)/ bolt
8" FB	8x10; 8x10x10	*SS - 50 (68)/ bolt; CS - 130 (176)/ bolt

\*SS = Stainless Steel Body; CS = Carbon Steel Body

**Piston Sleeve**

Inspect the piston sleeve bore. If there are scratches or damage present, then the piston sleeve will need to be specially ordered and replaced. If the piston sleeve was removed, continue to step 6. Otherwise, skip to the next section (Reassembly of Piston Subassembly).

6. Lubricate the piston sleeve o-ring and back-up ring (if it exists) with a silicone grease.
7. Install the piston sleeve o-ring and back-up ring (if it exists).
  - a) When a backup ring is being installed, it gets positioned as shown in Figure 57 with the top being towards the dome volume.

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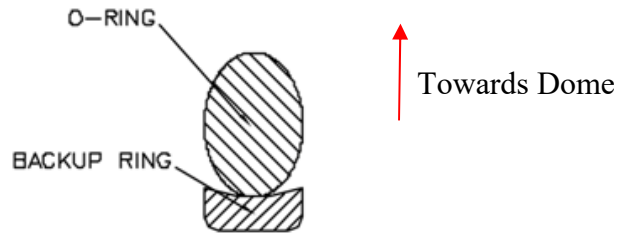


Figure 57: Proper O-Ring and Back-Up Installation Orientation

8. Apply a small amount of medium strength thread retainer on the piston sleeve's threads. See Figure 58.

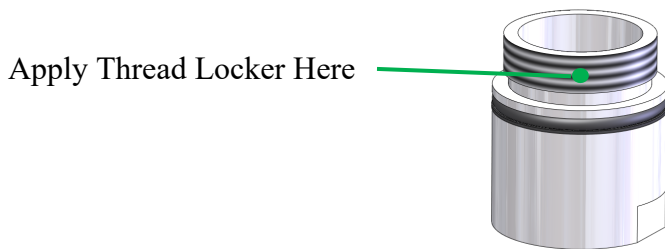


Figure 58: Piston Sleeve

9. Screw the piston sleeve into the bonnet by hand. See Figure 24.  
 a) Make sure the o-rings do not get cut when installing the sleeve.  
 10. Tighten the piston sleeve to the appropriate value shown in Table 12.

Table 12: Piston Sleeve Torque Values

<u>Nozzle Orifice</u>	<u>Inlet &amp; Outlet Size</u>	<u>Torque, lb-ft (N-m)</u>
D, E, F	1x2; 1-1/2x2	10 (14) max.
G, H, J	1-1/2x3; 2x3	35 (47) max.
J, K, L	3x4	50 (68) max.
L, M	4x6	35 (47) max.
N, P	4x6; 4x6x6	50 (68) max.
Q, R	6x8; 6x8x8	40 (54) max.
T	8x10; 8x10x10	*SS - 25 (34)/ bolt; CS - 65 (88)/ bolt
1-1/2" FB	1-1/2x2; 1-1/2x3; 2x3	40 (54) max.
2" FB	2x3	35 (47) max.
3" FB	3x4	50 (68) max.
4" FB	4x6; 4x6x6	80 (110) max.
6" FB	6x8; 6x8x8	*SS - 25 (34)/ bolt; CS - 65 (88)/ bolt
8" FB	8x10; 8x10x10	*SS - 25 (34)/ bolt; CS - 65 (88)/ bolt

\*SS = Stainless Steel Body; CS = Carbon Steel Body

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**Table 13: Retaining Bushing Torque Values**

<b><u>Nozzle Orifice</u></b>	<b><u>Inlet &amp; Outlet Size</u></b>	<b><u>Torque, lb-ft (N-m) ± 5%</u></b>
D, E, F	1x2; 1-1/2x2	15 (20)
G, H, J	1-1/2x3; 2x3	100 (135)
J, K, L	3x4	100 (135)
L, M	4x6	150 (200)
N, P	4x6; 4x6x6	200 (270)
Q, R	6x8; 6x8x8	250 (340)
T	8x10; 8x10x10	10 (14)/ bolt
1-1/2" FB	1-1/2x2; 1-1/2x3; 2x3	100 (135)
2" FB	2x3	100 (135)
3" FB	3x4	200 (270)
4" FB	4x6; 4x6x6	200 (270)
6" FB	6x8; 6x8x8	10 (14)/ bolt
8" FB	8x10; 8x10x10	25 (34)/ bolt

16. Apply a small amount of high strength thread retainer on the male threads of the stem. See Figure 59.
17. Thread the disk onto the stem by hand.
18. Tighten the disk to the appropriate value shown in Table 14. Use the wrenching flats.

**Table 14: Disk Torque Values**

<b><u>Nozzle Orifice</u></b>	<b><u>Inlet &amp; Outlet Size</u></b>	<b><u>Torque, lb-ft (N-m) ± 5%</u></b>
D, E, F	1x2; 1-1/2x2	5 (7)
G, H, J	1-1/2x3; 2x3	25 (34)
J, K, L	3x4	30 (41)
L, M	4x6	35 (47)
N, P	4x6; 4x6x6	50 (68)
Q, R	6x8; 6x8x8	50 (68)
T	8x10; 8x10x10	75 (100)
1-1/2" FB	1-1/2x2; 1-1/2x3; 2x3	30 (41)
2" FB	2x3	30 (41)
3" FB	3x4	50 (68)
4" FB	4x6; 4x6x6	50 (68)
6" FB	6x8; 6x8x8	75 (100)
8" FB	8x10; 8x10x10	100 (135)

19. Remove the pin that was inserted through the stem and the piston and let the thread retainer dry.

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**Reassembly of the Bonnet/ Piston**

20. Lightly apply a small amount of silicone grease on the bonnet o-ring.
21. Install the bonnet o-ring.
22. Place the return spring in the top of the piston subassembly.
23. Insert the piston subassembly into the piston sleeve. See Figure 24.
  - a) The piston sleeve should be attached to the main valve bonnet at this point.
  - b) Make sure to keep the return spring centered in the piston.
24. Install the bonnet subassembly onto the main valve body.
  - a) Make sure the piston stays in the piston sleeve when installing.
25. Either bolt or thread the bonnet onto the main valve.
26. Install the bonnet bolts, if applicable.
27. Tighten the bonnet (or bonnet bolts) to the appropriate value shown in either Table 15 or 16.

**Table 15: Bonnet Bolt Torque Values**

<b>Bolt Size</b>	<b>Torque, lb-ft (N-m) ± 5%</b>
5/8"-11	35 (47)
1"-8	115 (155)

**Table 16: Threaded Bonnet Torque Value**

<b>Orifice Sizes</b>	<b>Torque, lb-ft (N-m) ± 5%</b>
D, E, F & 1-1/2" FB	500 (680)

28. Though it isn't required by code, the main valve's lift can be checked.
  - a) The lift is measured with a starting position of nozzle to disk contact.
  - b) To accurately measure the lift, the soft seat may need to be compressed by cold pressing or other means. Refer to Section X g).
29. Reinstall the pilot valve onto the main valve by threading the mounting bolts by hand.
30. Tighten the pilot mounting bolts to the appropriate value shown in Table 17.

**Table 17: Pilot Mounting Bolt Torque Values**

<b>Component</b>	<b>Torque, lb-ft (N-m) ± 5%</b>
Mounting Bolts – Gas Service	6.3 (8.5)
Mounting Bolts – Liquid Service	20 (27)

31. Reinstall any accessories that were equipped.
32. If any U-bolts are used, the U-bolt nuts should be tightened to the value shown in Table 18.

**Table 18: U- Bolt Nut Torque Value**

<b>Component</b>	<b>Torque, lb-ft (N-m) ± 5%</b>
U-Bolt Nut	11 (15)

33. Reinstall the tubing connections.
34. The entire assembly should now be tested for set pressure and checked for leaks.

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**f) Lift Lever Reassembly**

*If the center bushing was removed, begin with step 1. Otherwise, skip to step 4.*

1. Lightly apply a small amount of silicone grease to the center bushing o-ring.
2. Carefully place the center bushing o-ring onto the center bushing.
  - a) The o-ring should reside in a notch groove on the center bushing.
3. Install the center bushing over the top of the adjustment screw.
4. Lightly coat the outer surface of the adjustment bushing with a water-resistant grease similar to Aqualube.
5. Carefully slip fit the adjustment screw and other parts into the bore of the body.
  - a) The adjustment bushing must slip into the valve bore freely.
  - b) Remove and inspect/ re-clean parts if the fit is not correct.
  - c) **DO NOT FORCE THE ADJUSTMENT BUSHING INTO THE VALVE BODY.** Forcing the parts may restrict valve lift and **cause serious malfunction.**

*If the center bushing was removed, continue with step 6. Otherwise, skip to step 8.*

6. Apply a small amount of high strength thread retainer on the threads of the center bushing only.
7. Install and tighten the lift lever lock nut against the center bushing. Tighten to the appropriate value shown in Table 23.
  - a) When tightening, use the flats on the center bushing to stop the center bushing from turning.
8. Thread the lock nut onto the adjustment screw finger tight against the center bushing.
  - a) Do not tighten fully.

*Return to step 31 in Section XIV d).*

***To install a lift lever cap, the PRV must have its set pressure adjusted first.***

9. Slip the seal adjustment nut over the lift rod and thread it onto the adjustment screw.
  - a) The seal adjustment nut should be finger tightened so that the adjustment screw does not get turned.
10. Place the lift lever cap subassembly over the adjustment screw and lift lever lock nut.
11. Insert and tighten the three lift lever cap set screws to the value listed in Table 19. See Figure 38.

**Table 19: Lift Lever Cap Set Screw Torque Value**

Component	Torque, lbf-ft (N-m) ± 5%
1/4"-20 Lift Lever Cap Set Screw	6.3 (8.5)

12. Thread the stem lift nut onto the lift rod until its pin hole is aligned with the lift rod's pin hole.
  - a) It will be in light contact with the lift lever.

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- b) Once installed, the lift lever should have some play in its action.
- 13. Insert the cotter pin through the two pin holes.
- 14. Slightly bend the end of the cotter pin so that it is captured within the lift rod and stem lift nut assembly.

*Return to step 38 in Section XIV d).*

**g) Auxiliary Valve Reassembly**

- 1. Lightly apply a small amount of silicone grease to the adjustment screw o-ring.
- 2. Carefully place the adjustment screw o-ring onto the adjustment screw, making sure not to cut the o-ring. See Figure 52.
  - a) The o-ring should reside in a notch groove below the upper threads of the adjustment screw.
- 3. Lightly apply a small amount of anti-seize to the threads of the adjustment screw. See Figure 52.
- 4. Thread the adjustment bushing onto the adjustment screw until approximately 2 threads of the adjustment screw are visible from the top. See Figure 53.
  - a) These have left handed threads.
- 5. Lightly apply a small amount of silicone grease to the center bushing o-ring.
- 6. Carefully place the center bushing o-ring onto the center bushing. See Figure 60.
  - a) The o-ring should reside in a notch groove on the center bushing.



**Figure 60: Center Bushing O-Ring Notch**

- 7. Install the center bushing over the top of the adjustment screw.
- 8. Lightly coat the outer surface of the adjustment bushing with a water-resistant grease similar to Aqualube. See Figure 53.
- 9. Carefully slip fit the adjustment screw and bushing into the bore of the bonnet by aligning the index pin of the body with the notch of the adjustment bushing.
  - a) The center bushing should end against the top of the inner bonnet.
  - b) The adjustment bushing must slip into the valve bore freely but with little radial play.
  - c) Remove and inspect/ re-clean parts if the fit is not correct.
  - d) **DO NOT FORCE THE ADJUSTMENT BUSHING INTO THE VALVE BODY.** Forcing the parts may restrict valve lift and **cause serious malfunction.**
- 10. Place the washer over the top of the bonnet and onto the adjustment screw with the rounded edge side of the washer away from the body (towards the top of the valve).
- 11. Thread the lock nut on over the top of the bonnet and onto the adjustment screw.
  - a) **DO NOT** fully tighten. The lock nut just needs to be hand tight at this point, only to retain the inner bonnet components.
  - b) The lock nut will be tightened once the setting process is completed.

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12. Lightly apply a small amount of silicone grease to the nozzle base o-ring.
13. Install the nozzle base o-ring into the lower corner of the nozzle pocket. See Figure 61.

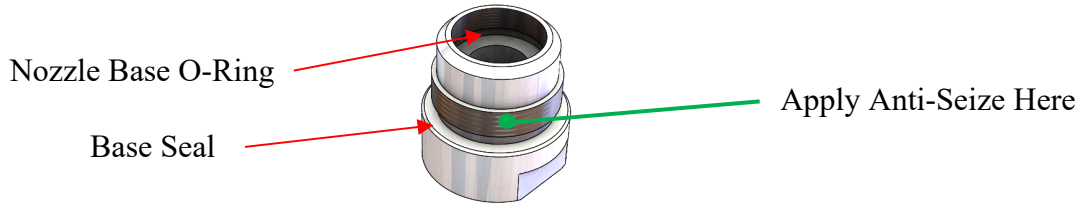


Figure 61: Inlet Base

14. Put a dot of medium strength thread locker onto the threads of the nozzle.
15. Thread the nozzle/ seat subassembly into the nozzle base.
16. Rigidly hold the inlet base.
17. Tighten the nozzle to the value shown in Table 20.

Table 20: AX Nozzle Torque Value

Nozzle Orifice	Torque, lbs-ft (N-m) $\pm$ 5%
D	100 (135)

18. Check the spring dimensions to make sure that the correct spring is being used for the intended set pressure of the overall safety pressure relief valve.
  - a) This is done by utilizing Table 21 and cross referencing it with Mercer’s spring chart. Mercer’s spring chart is a separate document.
  - b) The AX valve springs do not have the same set pressure ranges as a 9100 D orifice.
  - c) Make sure the spring appears square and is not bent.

Table 21: Set Pressure and Spring Chart for AX Valve

Set Pressure Range (psig)	Spring Code
15-22	03
23-30	04
31-40	05
41-75	06
76-120	07
121-230	09
231-400	11
401-750	60
751-1300	63
1301-1900	15

19. Hold the valve body/ bonnet upside down.

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20. Before reinstalling the spring, insert the disk subassembly's stem into the bore of the adjustment screw and simulate the valve opening operation.
  - a) The disk stem must slide freely within the bore of the adjustment screw.
21. Remove the disk subassembly.
22. Check and make sure the set spring slides over the disk freely without sticking.
23. Install the spring over the adjustment screw so it is resting on the lower portion of the adjustment bushing.
24. Install the disk subassembly into the adjustment screw and spring.
  - a) Do not put any grease on the disk or disk stem.
25. Place the base seal onto the inlet base. See Figure 61.
26. Put a small amount of anti-seize on the threads of the inlet base that get screwed into body. See Figure 61.
27. While still holding the body/ bonnet of the valve upside down, hand tighten the inlet base subassembly threads into the body while making sure all internal parts remain aligned.
  - a) Make sure that the inlet base seal is centered on the inlet base and body and is not getting bent or caught.
28. Tighten the inlet base to the body to the value shown in Table 22.

**Table 22: Inlet Base Torque Value**

<b>Component</b>	<b>Torque, lb-ft (N-m)</b>
Inlet Base	min. 350 (475)

29. Turn the valve upright.
30. Turn the adjustment screw clockwise until resistance is felt; the spring is engaged.
  - a) Turn the adjustment screw an additional 4-5 more times.
  - b) This is increasing the compression on the spring.
31. Assembly is complete and the AX valve is now ready to have its set pressure adjusted. See Section XV c).

***h) Retroactively Installing an Accessory***

Mercer Valve's 9500 Series pilot operated pressure relief valves (POPRVs) can be equipped with several options, including an auxiliary inlet supply filter (AF). Options are normally equipped on a POPRV at Mercer's factory upon initial manufacturing. However, they can be added at a later time.

The order of routing the components, beginning at the inlet of the PRV, is shown below. If one of the options is not equipped, it can be eliminated from this order.

- (1) Inlet Pressure Probe
- (2) Auxiliary Inlet Supply Filter (option)
- (3) Pilot Valve
- (4) Backflow Preventer (option)
- (5) Bonnet Port/ Dome Area

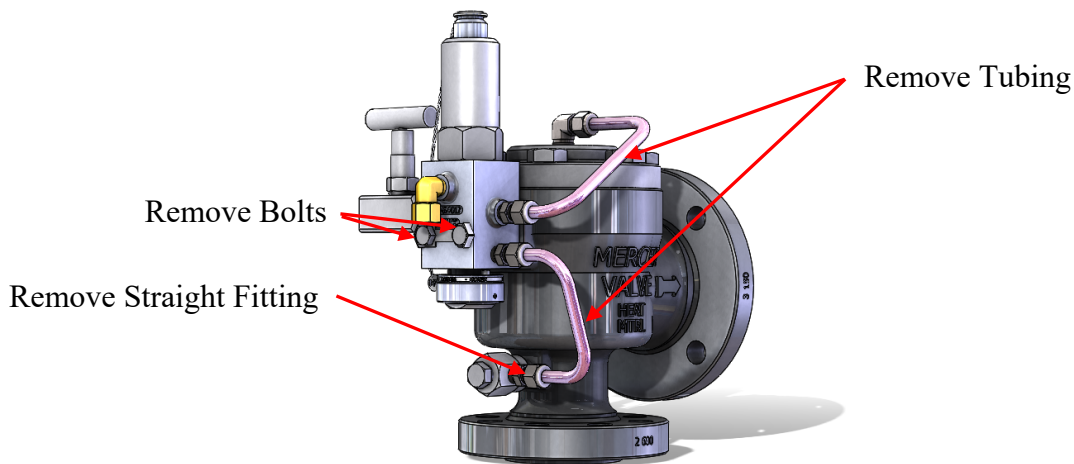
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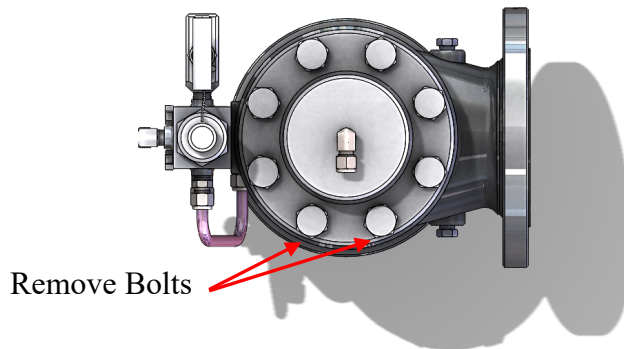
Mercer's 9500 Series POPRVs come in multiple sizes as far as orifice designation and overall body size. The actual configuration of the possible options largely depends on the size of the PRV. These instructions will display the most common configurations (as far as component locations), however, it is not reflective of all possible arrangements.

1. Remove the existing tubing connecting the pilot valve to the main valve. See Figure 62.
  - a) *For threaded bonnets, continue to step 2. Otherwise, skip to step 3.*
2. Remove the bolts that hold the pilot to the main valve. See Figure 62.



**Figure 62: No Options Equipped**

3. Remove the two bonnet bolts where the accessory mounting bracket is going to be located. See Figure 63.



**Figure 63: Bolted Bonnet - Remove Bonnet Bolts**

4. Remove the 3/8" tube to 1/4" NPT straight fitting from the pressure probe. See Figure 62.
  - a) The pressure probe should remain with the main valve.
5. Install the AF onto the mounting bracket with the U-bolt included in the kit. See Figure 64.

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- a) The U-bolt should be positioned around the body, not the hex cap.
- b) The fittings on the body are always oriented backwards (towards the pilot valve).
- c) The AF may already be installed on the bracket from the factory.

**Threaded Bonnet  
Type of Mounting**

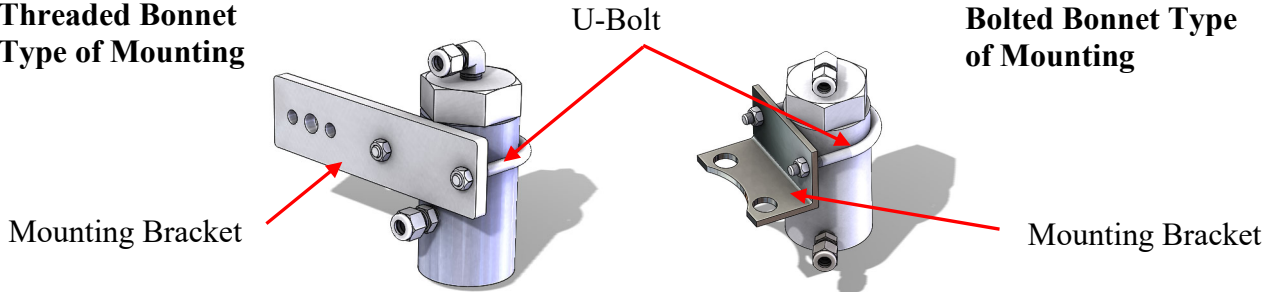


Figure 64: Accessory and Mounting Bracket

6. Install the 3/8” tube to 1/4” NPT elbow fitting included in the kit into the pressure probe. See Figure 65.
7. Install the mounting bracket with option(s) attached to the main valve:
  - a) **Threaded Bonnets:** Install the bracket in between the pilot and the main valve with the new bolts supplied in the kit. See Figure 65.
  - b) **Bolted Bonnets:** Install the bracket on top of the bonnet of the main valve with the new bolts supplied in the kit. See Figure 65.

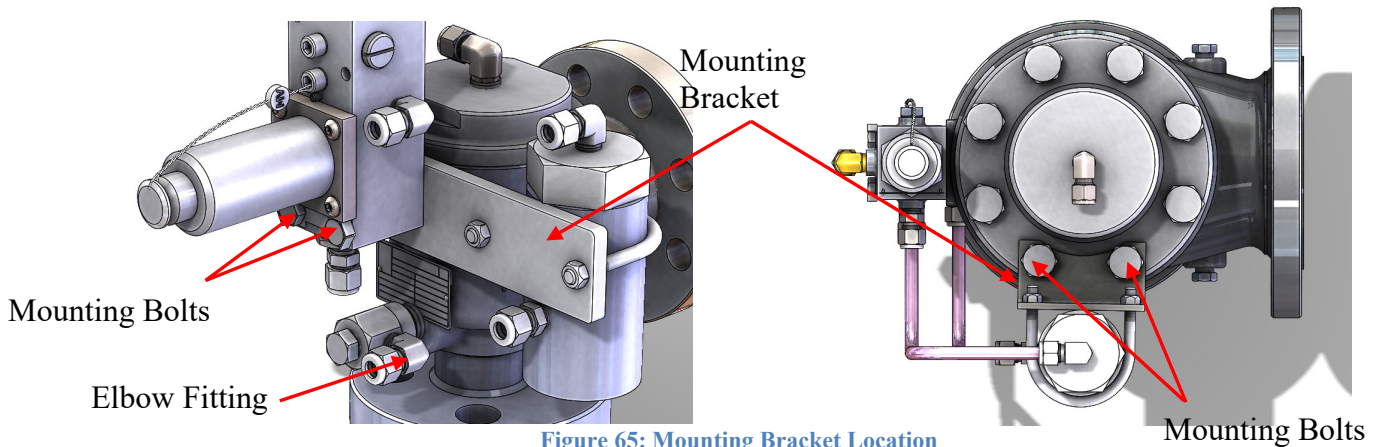


Figure 65: Mounting Bracket Location

8. Bend and install the tubing supplied in the kit to complete the flow circuit.
  - a) Route components in the order listed previously.
  - b) Routing path will vary with each configuration. Use simple and direct paths with “U” shaped runs.
  - c) Consult Swagelok™ for more information regarding bending and fitting procedures.
9. The entire PRV should be tested for functionality and leakage before installing it onto a pressurized system.

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## **XV. Modulating Pilot Valve Setting Procedure**

The idea of a modulating pilot is that the main valve gradually opens and closes. Because pilot operated valves have a greater dome area than the main valve seat area, the dome pressure has to be reduced at the set pressure so that the forces on the piston are equaled out before the piston will slowly move. To achieve this at set pressure, the dome pressure must be 30% less than the input pressure. This will mean that the pilot will begin to vent slightly before set pressure.

The set pressure definition for a Mercer modulating pilot operated valve is the 1<sup>st</sup> audible sound from the main valve for gas service and the 1<sup>st</sup> steady stream from the main valve for liquid service. Again, the pilot valve must begin venting before set pressure for the main valve to open. That is why the set pressure definition is based on the main valve, not the pilot valve.

Setting procedures are to be in accordance with ASME PTC 25. The ramp rate of the system pressure increase should be a slow increase when close to set pressure (within 15-20% of the set pressure). Within this range, the ramp rate should never be more than 2 psi/ sec (15 kPa/ sec). Ideally, each pressure increment on the pressure gauge should be able to be clearly read as the pressure is increased. Slow pressure increases help to accurately read the proper pressure readings.

### **Cold Differential Test Pressure (CDTP)**

Some variables can affect the set pressure of the valve. For example, high temperatures cause materials to relax, causing a set pressure change. The cold differential test pressure is a compensation made to the set pressure for backpressure and temperature present on the valve when it is in service.

The CDTP is the pressure that the valve will go off at without the backpressure and temperature of the service conditions, i.e., when the valve is being set on a test stand. For pilot operated valves, the set pressure is not affected by backpressure. The temperature is all that is compensated for by a CDTP in pilot operated valves.

#### **a) Setting Modulating Pilot Valve without Main Valve Attached**

The valve can be set using the same set up as when the pilot calibration settings were completed. See Figure 16. Make sure the pressure ratings of the stand are sufficient. The input and dome pressure will need to be closely monitored. One possible dome pressure pickup port can be seen in Figure 66.

1. Mount the pilot valve rigidly to the test stand.
2. Turn the adjustment screw clockwise so that there is spring tension.
3. Increase the input pressure up to the set pressure of the valve.
  - a) The dome pressure gauge should follow along with the input pressure.
  - b) If the dome pressure starts to drop before the intended set pressure, increase the spring tension on the adjustment screw by turning it clockwise.

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4. When the input pressure is at the set pressure, the adjustment screw will be adjusted to lower the dome pressure. Turn the adjustment screw counter clockwise until the dome pressure is 30% below the set pressure.

*EXAMPLE:*

*INTENDED SET PRESSURE = 100 psi (kPa)*

*30% of 100 psi (kPa) = 30 psi (kPa)*

*100 psi (kPa) – 30 psi (kPa) = 70 psi (kPa)*

*Input Gauge would read 100 psi (kPa) at set pressure*

*Dome Gauge would read 70 psi (kPa) at set pressure*

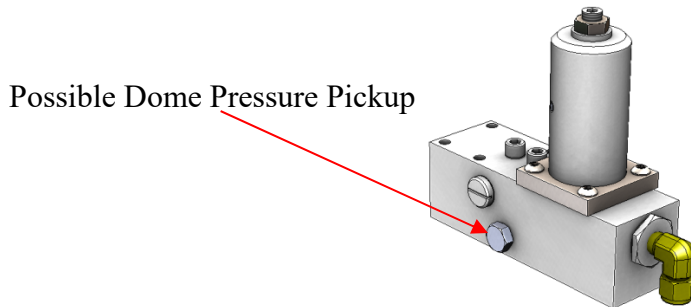
*Remember to keep the input pressure at the set pressure. When the input pressure is at the set pressure and the dome pressure is 30% below the set pressure, the pilot is set.*

5. Tighten the lock nut to the appropriate value shown in Table 23.
  - a) When tightening, use an Allen wrench or the two jam nuts to prevent the adjustment screw from rotating so that the pilot set pressure will not be changed.

**Table 23: Lock Nut Torque Values**

Component	Torque, lb-ft (N-m) ± 5%
Lock Nut	25 (34)
Lift Lever Lock Nut	80 (110)

6. After tightening the lock nut, recheck the set pressure.
  - a) If the set pressure is off, the lock nut will have to be loosened and the valve set pressure will need to be readjusted.
7. After the pilot is set, thread the pilot cap onto the adjustment screw.
  - a) If the pilot is a lift lever configuration, go to step 9 in Section XIV f).
8. Leak check the pilot valve.
  - a) This can be done by submerging the pilot's exhaust vent under water in a cup and observing if bubbles are formed when pressure exists. Bubbles would indicate a leak in the pilot.
9. Wire a seal wire from the pilot cap to the 1<sup>st</sup> cap head seal screw.
10. If there is a dome gauge in the side test port, the gauge should be removed and the port re-plugged.



**Figure 66: Dome Pressure Port**

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The pilot valve is now ready to be installed on the main valve. It is a recommended practice to re-verify the entire valve's set pressure once the modulating pilot valve has been installed on the main valve. It is also recommended to leak check the POPRV with the pilot and all accessories attached to the main valve.

***b) Setting Modulating Pilot Valve with Main Valve Attached***

The valve can be set when the pilot valve is installed on the main valve using a test stand similar to that shown in Figure 13 or 14.

1. Mount the inlet of the main valve rigidly to the test stand.
2. Turn the adjustment screw clockwise so that there is spring tension.
3. Increase the input pressure up to the set pressure of the valve.
  - a) If the main valve begins to open before the intended set pressure, increase the tension on the adjustment screw by turning it clockwise.
4. When the input pressure is at the set pressure, turn the adjustment screw clockwise until the main valve remains shut, then slowly back it off by turning the adjustment screw counter clockwise until the main valve has an audible hiss sound.
5. Tighten the lock nut to the appropriate value shown in Table 23.
  - a) When tightening, use an Allen wrench or the two jam nuts to prevent the adjustment screw from rotating so that the pilot set pressure will not be changed.
6. After tightening the lock nut, recheck the set pressure.
  - a) If the set pressure is off, the lock nut will have to be loosened and the valve set pressure will need to be readjusted.
7. After the pilot is set, thread the pilot cap onto the adjustment screw.
  - a) If the pilot is a lift lever configuration, go to step 9 in Section XIV f).
8. Leak check the valve.
9. Wire a seal wire from the pilot cap to the 1<sup>st</sup> cap head seal screw.
10. If there is a dome gauge in the side test port, the gauge should be removed and the port re-plugged.

***c) Setting Auxiliary Valve***

The AX valve has a modulating type of performance. It will not have a "pop" action as other 9100 Series valves do. Its set point is defined as the first audible sound from its outlet. It is imperative that the rate of supply pressure to this valve be relatively slow (2 psi/ sec) during setting to accurately adjust the set pressure.

As pressure is increased past the set point, the disk will continue to gradually rise. As the pressure is decreased, the disk will gradually close until no audible sound is detected. This point is the blowdown. The performance criteria of the AX valve are listed below:

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**SET PRESSURE:**

**30 psi and above:** AX valve will be set 15% above the 9500 valve set pressure

**15 psi to 29 psi:** AX valve will be set 5 psi above the 9500 valve set pressure

**Below 15 psi:** AX valve is not required

**SET POINT DEFINITION:** 1st Audible Sound

**LEAK SPECIFICATION:** API 527

1. Mount the AX valve rigidly to the test stand.
2. Turn the adjustment screw clockwise so that there is spring tension.
3. Slowly increase the pressure on the inlet side until it reaches the bench test pressure.
  - a) If the valve begins to open before the bench test pressure is reached, increase the spring tension and again increase the input pressure to the bench test pressure.
4. Slowly reduce the spring tension by turning the adjustment screw counter clockwise while keeping the system pressure at the bench test pressure. Turn the adjustment screw counter clockwise until there is a slight audible sound coming from the outlet.
5. Verify the bench test pressure 3-4 more times, making any adjustments as needed.
  - a) Each verification of the bench set pressure should be no more than  $\pm 1\%$  or  $\pm 0.5$  psi (3.5 kPa), whichever is greater, of the average of all set points observed.
6. Tighten the lock nut to the appropriate value shown in Table 23.
  - a) When tightening, use an Allen wrench to prevent the adjustment screw from rotating so that the pilot set pressure will not be changed.
7. After tightening the lock nut, recheck the set pressure.
  - a) If the set pressure is off, the lock nut will have to be loosened and the valve set pressure will need to be readjusted.
8. Leak check the pilot valve by conducting an API 527 leak check.
  - a) Leak check is performed at 90% of the set point or 5 psi below the set point, whichever is greater.
  - b) Zero bubbles are allowed to pass for one minute to pass the leak check.
9. After the AX valve is set and leak and backpressure checks have been performed, thread the cap onto the adjustment screw.
10. Wire a seal wire from the cap to the tab on the AX valve body.

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**XVI. Tag Information**

Information and identification about the valve can be found on the tag, also called the nameplate. This information can be used to verify if the valve is installed in the proper service. It also can be used to get an appropriate replacement. A POPRV will have two tags, one is located on the main valve and the other is located on the pilot valve.

A PRV’s original nameplate must always remain attached. If changes are made that would alter its information, such as the part number, the original information should be crossed out but left legible. The updated information should either be stamped on the original or on an attached repair nameplate. The information on the tag is as follows:

- Product Number (PN) – This indicates the series and identifies the configuration of the valve.
- Serial Number (Serial No.) – This will be a unique identifier to the valve and provides a means of traceability through Mercer Valve Co., Inc.
- Set Pressure (Set P.) – Identifies the set pressure of the valve while in its service conditions.
- Cold Differential Test Pressure (CDTP) – This indicates the bench test pressure that was used to compensate for temperature and/ or backpressure of the service conditions.
- Backpressure (Back Press) – This indicates possible pressure in the valve’s outlet.
- Valve Capacity (CAP. Air/ Water) – This indicates the capacity of the valve at standard atmospheric conditions of air for gas service valves or water for liquid service valves.
- Service Temperature (Service Temp) – This indicates the valve’s normal operating condition. It is not a temperature limit.
- Size – This indicates the nominal inlet size of the valve.
- Repair Kit (Repair Kit No.) – This designates the associated repair kit for the product number.
- Date – This indicates the month and year the valve was made.
- CRN – This is the Canadian Registration Number.



	<b>MERCER VALVE CO., INC.</b>		
	PATENT # 4,799,506		
	PN 91-55H11V78U1		
	SIZE	1-1/2 IN	SET P.
DATE	5/16	CDTP	PSI
CAP. AIR	1617 SCFM	BACK PRESS	PSI
CAP. WATER	GPM	SERVICE TEMP	70 F
REPAIR KIT NO.	3H1V1U1	SERIAL NO.	XXXXXX
			CRN 0G8841.5C

Figure 67: Example Tag

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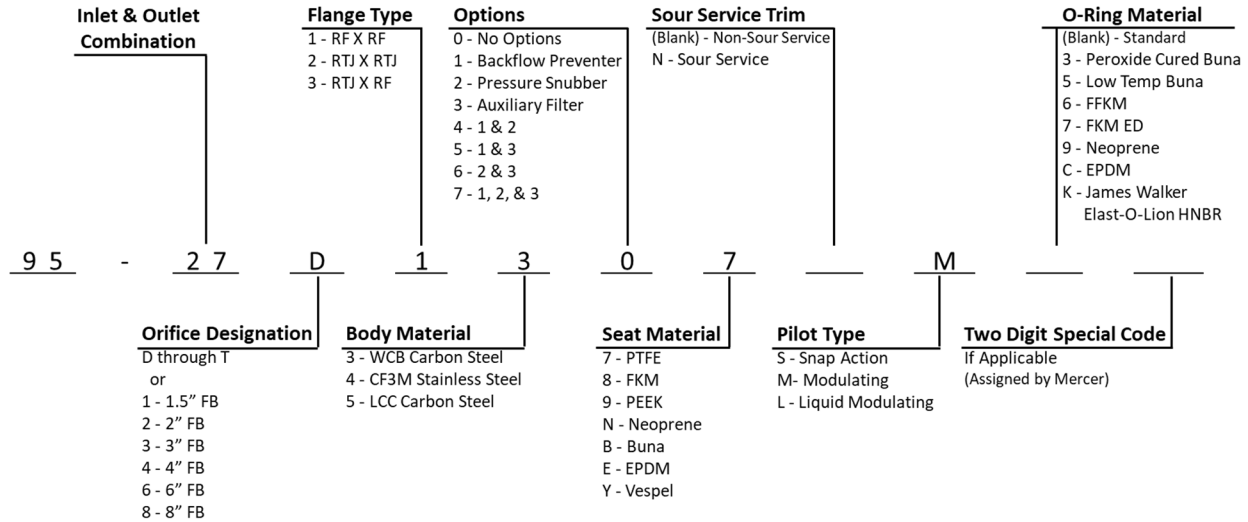
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## XVII. Basic Product Number System

*Not all code combinations are valid product numbers. Not all possible configurations are shown. Consult Mercer Valve Co., Inc. for any questions on valid product number configurations.*

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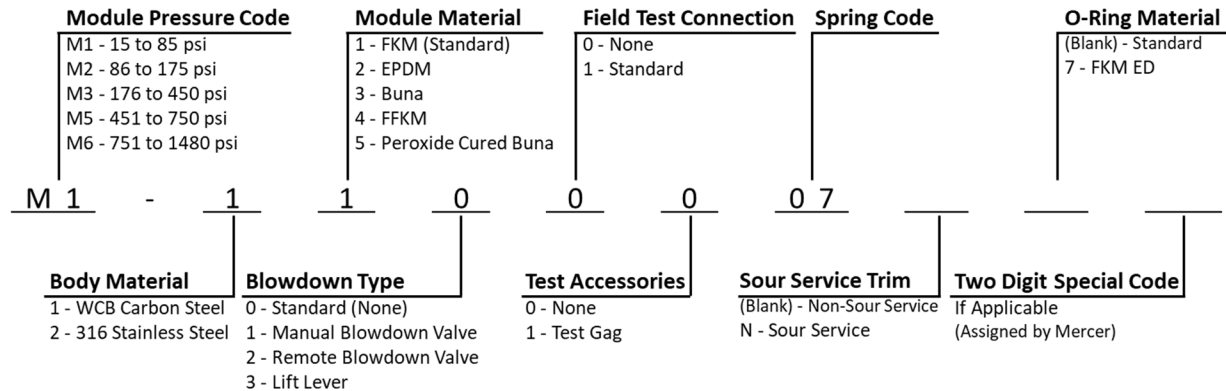
### a) Main Valve Product Numbering



**Note:**

- 1) Fluorocarbon (FKM) o-rings supplied with seat codes 7, 8, 9, and Y.
- 2) Seat codes N, B, and E receive like material o-rings. No o-ring code required.

### b) Gas Modulating Pilot Valve Product Numbering



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**c) Liquid Modulating Pilot Valve Product Numbering**

Module Pressure Code		Module Material		Field Test Connection		Spring Code		O-Ring Material	
L1 - 15 to 85 psi L2 - 86 to 175 psi L3 - 176 to 450 psi L5 - 451 to 750 psi L6 - 751 to 1480 psi		1 - FKM (Standard) 2 - EPDM 3 - Buna 4 - FFKM 5 - Peroxide Cured Buna		0 - None 1 - Standard				(Blank) - Standard 7 - FKM ED	
L	1	-	2	1	0	0	0	0	7
Body Material		Blowdown Type		Test Accessories		Sour Service Trim		Two Digit Special Code	
2 - 316 Stainless Steel		0 - Standard (None) 1 - Manual Blowdown Valve 2 - Remote Blowdown Valve 3 - Lift Lever		0 - None 1 - Test Gag		(Blank) - Non-Sour Service N - Sour Service		If Applicable (Assigned by Mercer)	

**d) Main Valve Repair Kit Product Numbering**

Outlet Size		Seat Material		Trim Code		O-Ring Material	
2 - 2" 3 - 3" 4 - 4" 6 - 6" 8 - 8" 10 - 10"		7 - PTFE 8 - FKM 9 - PEEK N - Neoprene B - Buna E - EPDM Y - Vespel		(Blank) - Standard M - Monel D - Duplex SS A - Alloy 20 H - Hastelloy		(Blank) - Standard 3 - Peroxide Cured Buna 5 - Low Temp Buna 6 - FFKM 7 - FKM ED 9 - Neoprene C - EPDM K - James Walker Elast-O-Lion HNBR	
9	5	-	2	D	7	0	7
Orifice Designation		Options				Two Digit Special Code	
D through T or 1 - 1.5" FB 2 - 2" FB 3 - 3" FB 4 - 4" FB 6 - 6" FB 8 - 8" FB		0 - No Options 1A - Backflow Preventer, Snap & Liquid Modulator 1B - Backflow Preventer, Gas Modulator 2 - Pressure Snubber 3 - Auxiliary Filter 4A - 1A & 2 4B - 1B & 2 5A - 1A & 3		5B - 1B & 3 6 - 2 & 3 7A - 1A, 2, & 3 7B - 1B, 2, & 3		If Applicable (Assigned by Mercer)	

**Note:**  
1) Fluorocarbon (FKM) o-rings supplied with seat codes 7, 8, 9, and Y.  
2) Seat codes N, B, and E receive like material o-rings. No o-ring code required.

**Parts Included in the Repair Kit:**

- (1) Nozzle Subassembly
- (2) Complete Set of O-Rings
- (3) Filter Subassembly

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**NOTE:**

FOR Q AND R ORIFICE ONLY, ADD “B” FOR BOLTED NOZZLE (9/2005 & AFTER) AND “T” FOR THREADED NOZZLE (8/2005 AND BEFORE) TO THE END OF KIT NUMBER. ADD SPECIAL CODE “B” OR “T”, IF APPLICABLE.

***Parts for Accessories Repair:***

1. Backflow Preventer (BFP)

***For Liquid Modulating Pilot***

- 2-009 O-Ring (2)
- Shuttle (1)
- Fitting (2)

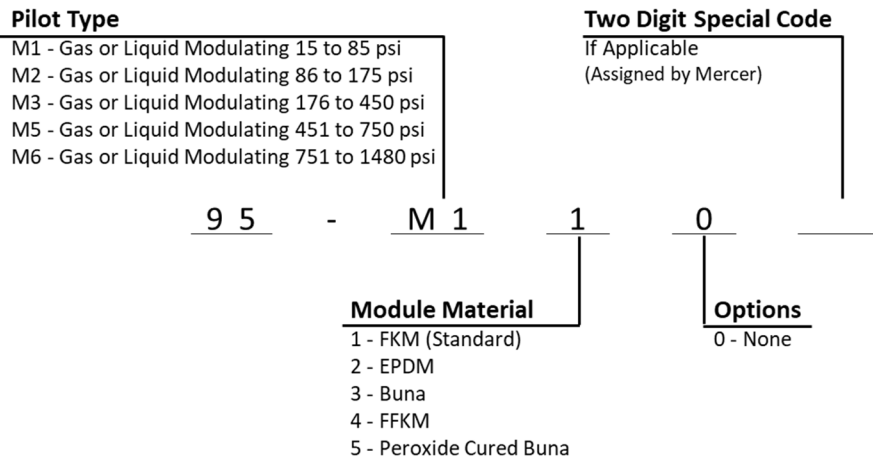
***For Gas Modulating Pilot***

- 2-012 O-Ring (1)
- Seats, FKM (2)
- Ball (1)

2. Auxiliary Pilot Filter

- a. 2-133 O-Ring (1)
- b. 95-629001 Filter (1)

**e) Modulating Pilot Valve Repair Kit Product Numbering**



***Parts Included in Repair Kit:***

1. Input Module
2. Control Module
3. Complete Set of O-Rings and Gaskets
4. Filters
5. Control Module Tool
6. Beam Extension Tool

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**XVIII. Exploded Views**

**a) Main Valve**

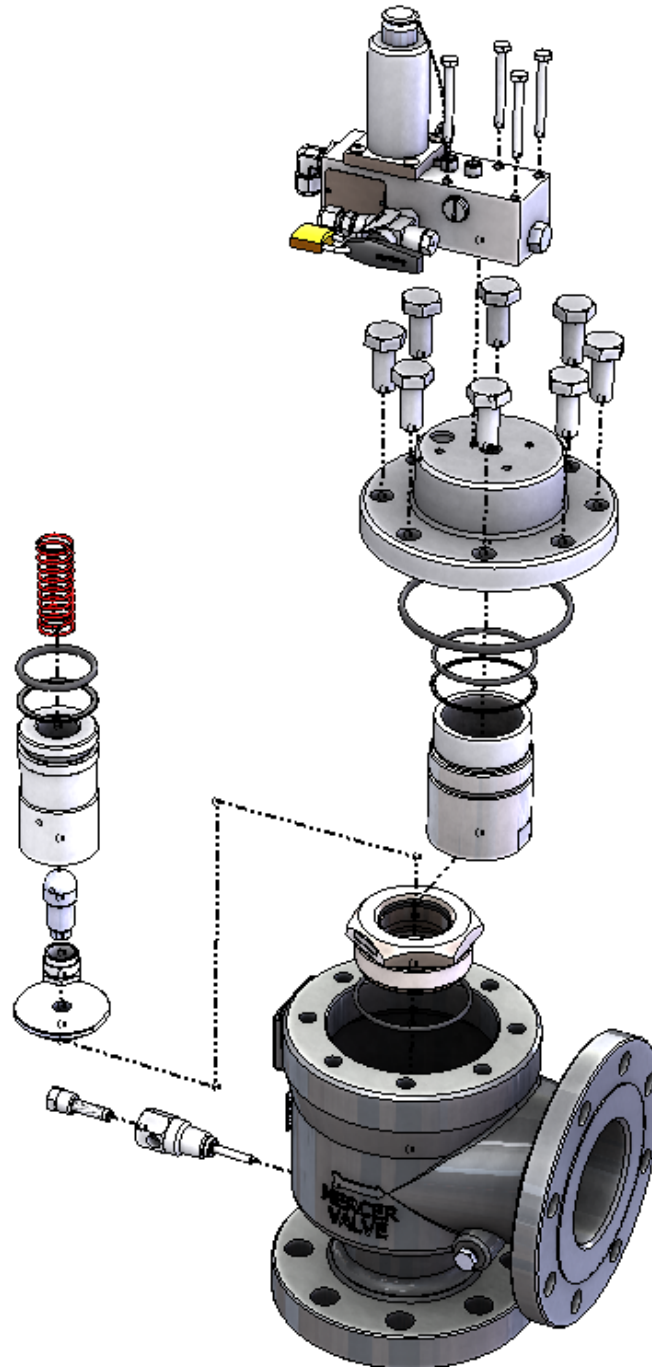


Figure 68: Exploded View of Main Valve

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***b) Modulating Pilot Valve***

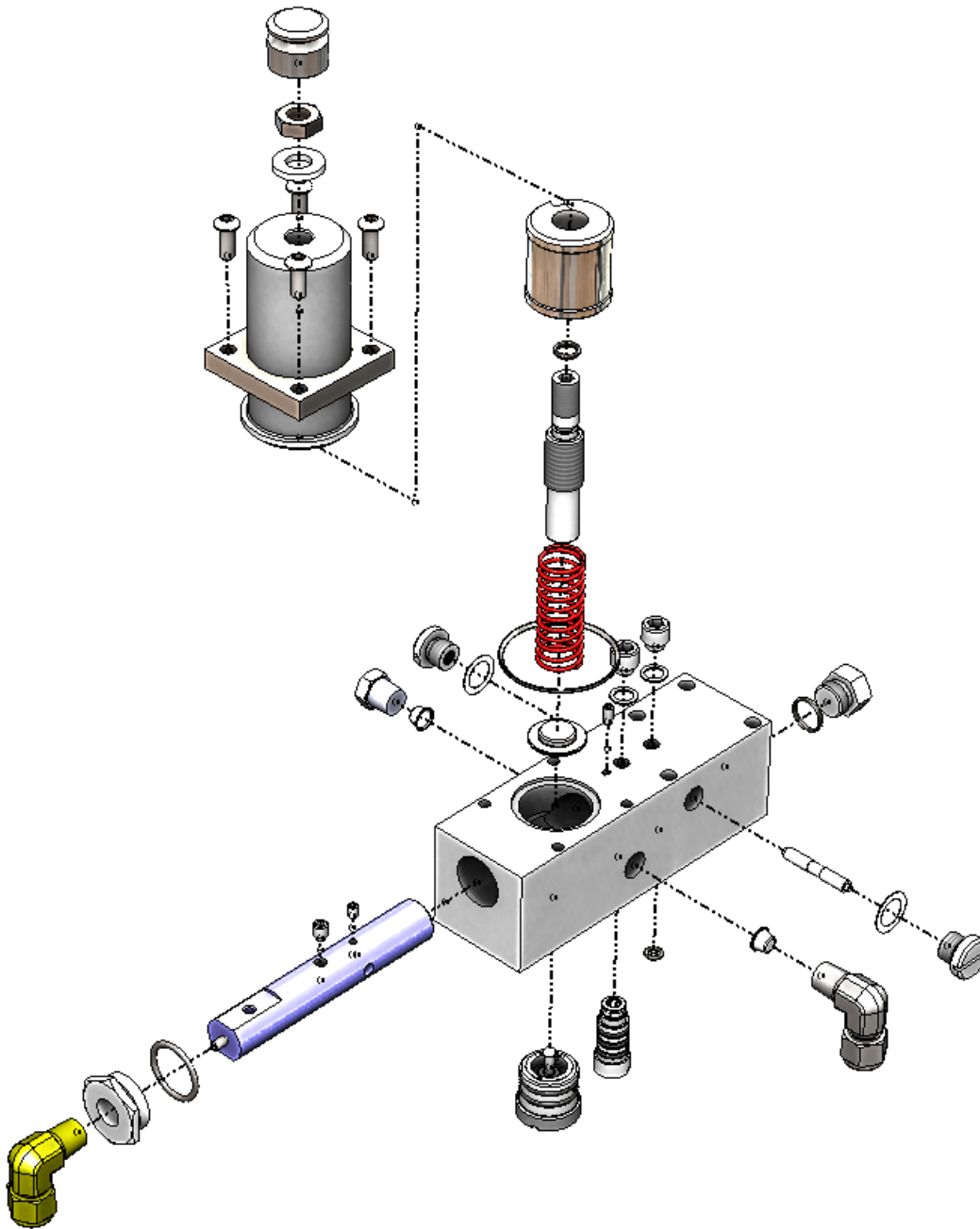


Figure 69: Exploded View of Modulating Pilot Valve

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## XIX. Cutaway Views

### a) Main Valve

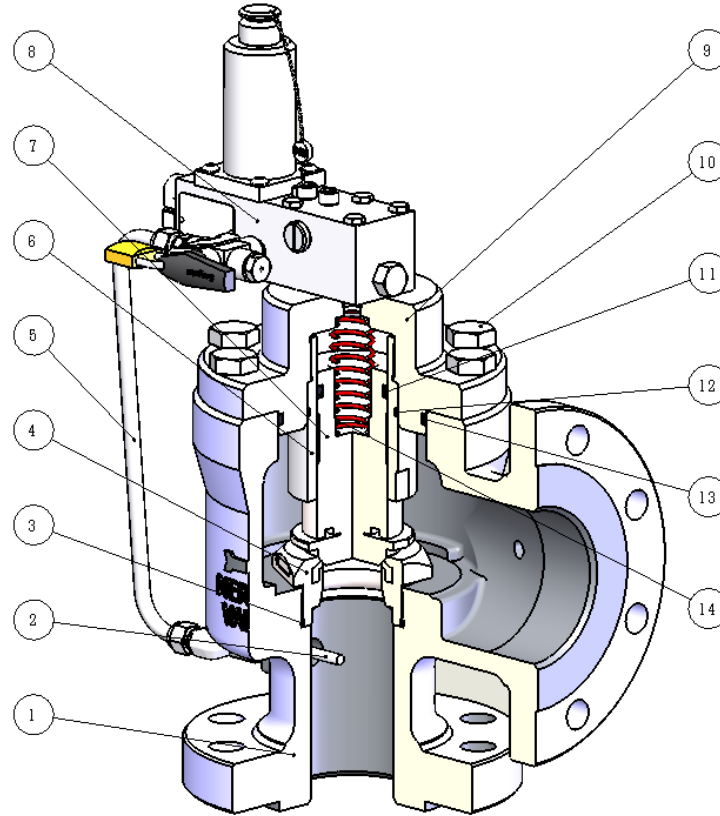


Figure 70: Cutaway View of Main Valve

Item No.	Part Name	Standard Materials
1	Main Valve Body	Carbon Steel
2	Pressure Probe Subassembly	Carbon Steel w/ Stainless Steel Trim
3	Nozzle Pocket O-Ring	Fluorocarbon
4	Nozzle Subassembly	Stainless Steel w/ Soft Seat
5	Pressure Sensing Line	Stainless Steel
6	Piston Sleeve	Stainless Steel w/ Nedox® Coating
7	Piston Subassembly	Stainless Steel
8	Modulating Pilot Valve	-
9	Main Valve Bonnet	Carbon Steel
10	Bonnet Bolts	Carbon Steel
11	Piston O-Ring	Fluorocarbon
12	Piston Sleeve O-Ring	Fluorocarbon
13	Bonnet O-Ring	Fluorocarbon
14	Return Spring	Stainless Steel

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**b) Modulating Pilot Valve**

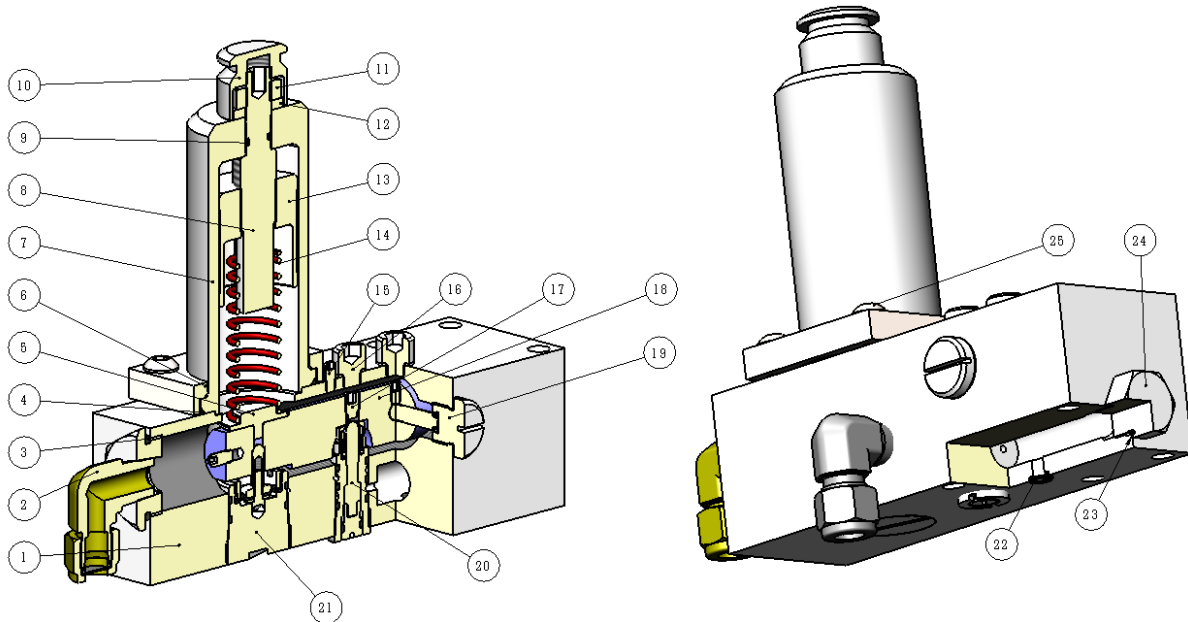


Figure 71: Cutaway View of Modulating Pilot Valve

Item No	Part Name	Standard Materials
1	Modulator Body	Carbon Steel
2	Dome Vent	Brass w/ Stainless Steel Filter
3	Dome Vent O-Ring	Fluorocarbon
4	Modulator Bonnet O-Ring	Fluorocarbon
5	Set Spring Disk	Stainless Steel
6	Bonnet Retainer Ring	Carbon Steel
7	Pinned Bonnet	Carbon Steel
8	Adjustment Screw	Stainless Steel
9	Adjustment Screw O-Ring	Fluorocarbon
10	Closed Cap	Aluminum Alloy
11	Lock Nut	Carbon Steel
12	Washer	Carbon Steel
13	Adjustment Bushing	Stainless Steel
14	Set Spring	Stainless Steel
15	Beam Stop Set Screw	Stainless Steel
16	Seal Screw	Carbon Steel
17	Exhaust Ball Set Screw	Stainless Steel
18	Modulator Beam	Aluminum Alloy
19	Bearing Mounting Screw	Stainless Steel
20	Control Module Subassembly	Stainless Steel w/ Soft Seat
21	Input Module Subassembly	Stainless Steel w/ Soft Seat
22	Interfacing O-Ring (Gas Service)	Fluorocarbon
23	Backflow Plug O-Ring	Fluorocarbon
24	Backflow Plug	Stainless Steel
25	Pilot Bonnet Retaining Bolt	Stainless Steel

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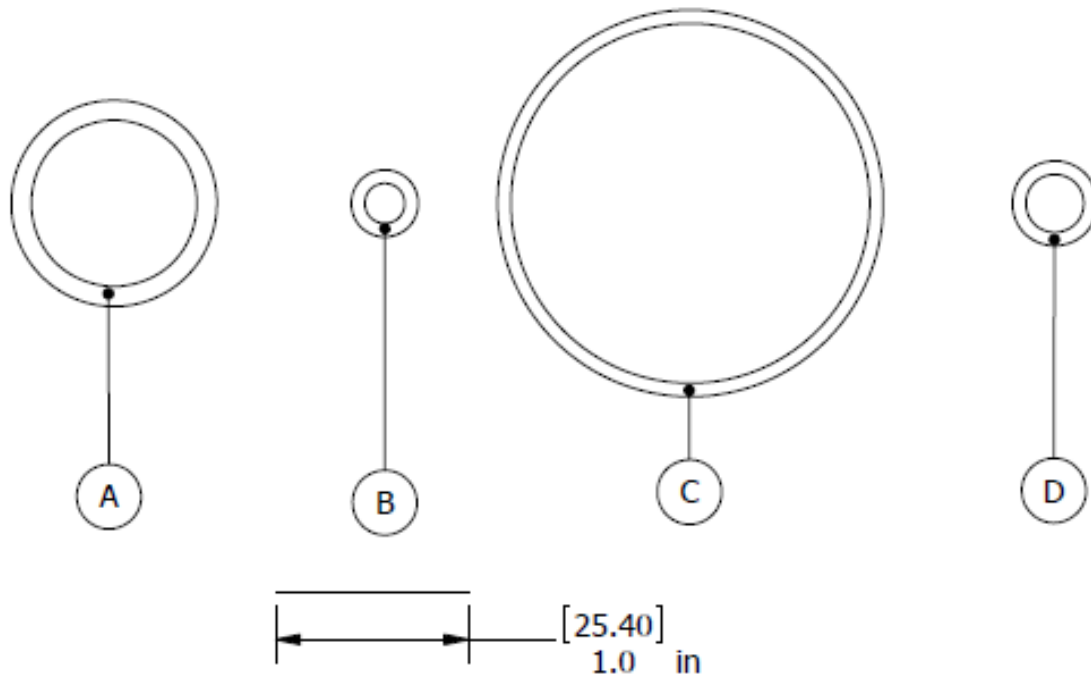
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**XX. O-Ring Reference Guide**

The following can be used as a quick guide in determining the o-ring usage within the pilot valve. These are all included in a repair kit. Figure 72 outlines the o-rings and is approximately a 1:1 scale, which can be used to identify each of the o-rings.

**Table 24: Repair Kit O-rings in Modulating Pilot**

<b>Inner Diameter, in. (mm)</b>	<b>Width, in. (mm)</b>	<b>Location/Description</b>	<b>Reference ID</b>
7/8 (21.89)	3/32 (2.62)	Pilot Vent Plug	A
7/32 (5.28)	1/16 (1.78)	Dome Interface	B
1-7/8 (47.35)	1/16 (1.78)	Bonnet Base	C
5/16 (7.65)	1/16 (1.78)	Adjustment Screw	D



**Figure 72: Modulating Pilot O-Rings**

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## **XXI. Trouble Shooting Guide**

The following describes some, but not all, problems that could occur in PRVs. This list is not exhaustive. Complicated problems and causes may exist, which require more involved solutions.

- Always take the proper safety precautions when working with PRVs.
- Always work on the valve within a controlled environment, not on an active pressurized system.

*1) Symptom*

*a) Possible Cause (ordered by priority)*

*i) Solution (ordered by priority)*

**1) There is a leak coming from the main valve on initial startup.**

- a) The disk is not initially fully seated against the nozzle.
  - i) Push the piston down against the nozzle seat by pressurizing the dome or manually pushing the disk and piston down when no pressure is present.
  - ii) Check main valve seat and replace if needed. It is possible during startup for debris in the system to be blown through and cut the main valve seat.
- b) The backflow preventer (BFP) is allowing blow-by.
  - i) Make sure the BFP shuttle is seated against either side of its seals; when shuttle is centered, blow-by can occur.
  - ii) Check and replace backflow preventer seals.
- c) A pilot accessory is delaying signal to the pilot.
  - i) Give reasonable time for pressure to work its way through all accessories.

**2) There is a leak coming from the main valve.**

- a) The main valve seat is leaking.
  - i) Inspect disk and nozzle seat for damages; replace if needed.
- b) The dome area is leaking.
  - i) Check and/ or replace piston seal o-rings.
  - ii) Check and/ or replace piston sleeve seal o-rings.

**3) There is a leak coming from the dome vent of the pilot valve.**

- a) The input module is leaking.
  - i) Inspect the seals for cuts or other possible causes of leakage; replace if needed.
- b) The control module is leaking.
  - i) Inspect the seals for cuts or other possible causes of leakage; replace if needed.

**4) The valve is relieving at a pressure lower than the set pressure tolerance allows (-2 psi or -3% of set pressure, whichever is greater).**

- a) A fitting is leaking.
  - i) Make sure that all fittings are tight and have the appropriate sealing element.
- b) The pilot valve's settings are not correct.

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- i) Recheck the set pressure.
  - ii) Recheck the pilot valve's settings (input and control modules).
  - c) There are blockages in a port(s), filter(s), or sensing line(s).
    - i) Remove filters and lines and ensure that they are clean. Check ports and passages for blockages and make sure they are clean.
    - ii) Make sure the environment is not causing freezing within the tubing lines.
  - d) Pressure pulses/ spikes are causing valve to relieve.
    - i) Check and make sure the operating conditions are suitable for the valve. Modulating pilots are not intended for use in services with pressure pulses/ spikes due to their construction and because they modulate and need time to open.
  - e) Vibrations are causing the valve to relieve.
    - i) Check and make sure the operating conditions are suitable for the valve. Modulating pilots are not intended for use in vibratory services, such as compressor service. This type of service can cause abnormal wear and tear on the modulator.
    - ii) Remote mount pilot valve and accessories to isolate it away from vibrations.
  - f) Vibrations are causing stresses in either the sensing lines or accessory mounting brackets. This is causing either cracking or breaking of the sensing line, which leads to leaking of the dome pressure.
    - i) Remote mount pilot valve and accessories to isolate it away from vibrations.
    - ii) Utilize flexible lines to absorb some of the vibrations.
- 5) The valve is relieving at a pressure higher than the set pressure tolerance allows (+2 psi or +3% of set pressure, whichever is greater).**
- a) A fitting is leaking.
    - i) Make sure that all fittings are tight and have the appropriate sealing element.
  - b) The pilot valve's settings are not correct.
    - i) Recheck the set pressure.
    - ii) Recheck the pilot valve's settings (input and control modules).
  - c) There are blockages in a port(s), filter(s), or sensing line(s).
    - i) Remove filters and lines and ensure that they are clean. Check ports and passages for blockages and make sure they are clean.
    - ii) Make sure the environment is not causing freezing within the tubing lines.
  - d) The beam's movement is being hindered.
    - i) Remove beam and make sure bore of pilot valve's body is clean.
    - ii) Remove bearing screws and check to make sure bearings are clean and allow rotation.
- 6) The valve is opening below set pressure and is back flowing into the system.**
- a) Superimposed backpressure is higher than the operating pressure.
    - i) Add a backflow preventer. (Total backpressure must not exceed 30% of the set pressure when a backflow preventer is installed).

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