



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

ENG-502000

9100 SERIES

**DIRECT SPRING 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.

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1. Scope

This document is used for the installation, operation, and maintenance of a Mercer Valve Co., Inc. 9100 Series 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.

Proper safety precautions must be followed during all procedures indicated in this document. This document does not cover these precautions or the required safety equipment.

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 by it.

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 1 – Unfired Pressure Vessels

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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2. 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.

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

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Over Pressure 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 over pressure should never exceed MAWP plus accumulation, but they will often be equal.

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 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.

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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3. Handling and Shipping

Mercer Valve Co., Inc. 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 over pressures. 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. 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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4. 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 Co., Inc. 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.

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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5. 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 Co., Inc.

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 over pressures 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 back pressure is assumed, the valve may not operate properly. Built-up backpressure should not exceed the allowable overpressure for conventional PRVs. 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 of air at 60°F (16°C) and standard atmospheric conditions. A liquid valve will have a tag capacity in GPM 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 Co., Inc. 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. When screwing a threaded valve onto inlet piping, always use the wrench flats on the inlet connection. See Figure 1. Use a square jaw type of wrench. Do not put a wrench on the PRV's body or bonnet during installation. Tighten 1.5 to 3 turns past finger tight for national pipe threads. 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.

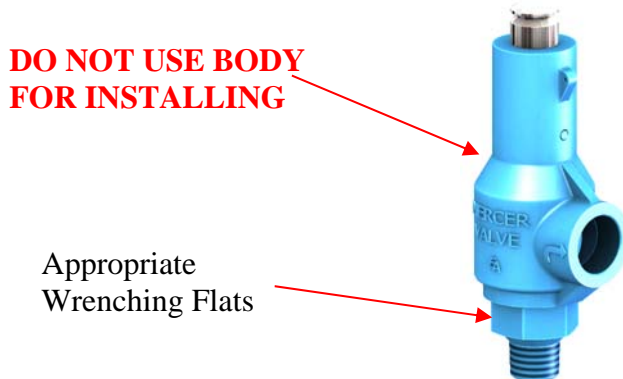


Figure 1: 9100 Series Threaded Valve Wrenching Flats

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 should be as short and direct as possible to keep built-up backpressure to a minimum. For spring operated PRVs, built-up backpressure should never exceed the allowable over pressure. For most but not all cases, the allowable over pressure is 10% of the set pressure. It is recommended that the outlet piping be less than 4 ft (1.2 m) in total length. Its nominal size should be equal to or greater than the outlet size of the PRV. Increasing the outlet piping size will reduce the built-up backpressure potential and enable longer lengths. Long runs, additional fittings and bends, and small diameter pipes will increase the propensity of valve chatter. Valve chatter can

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have damaging effects and can reduce the relieving capacity, which potentially leaves the system under protected.

Special consideration should be made when multiple relief valves are installed on a system with a common discharge header. The size of the header should be based on the sum of the discharge areas for each relief valve and any pressure loss. The built-up backpressure still cannot exceed the allowable overpressure. When greater built-up or variable superimposed backpressure exists, a 9100 Series valve may not be suitable and Mercer Valve Co. should be consulted prior to installation.

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 2 for an example installation of a pressure relief valve.

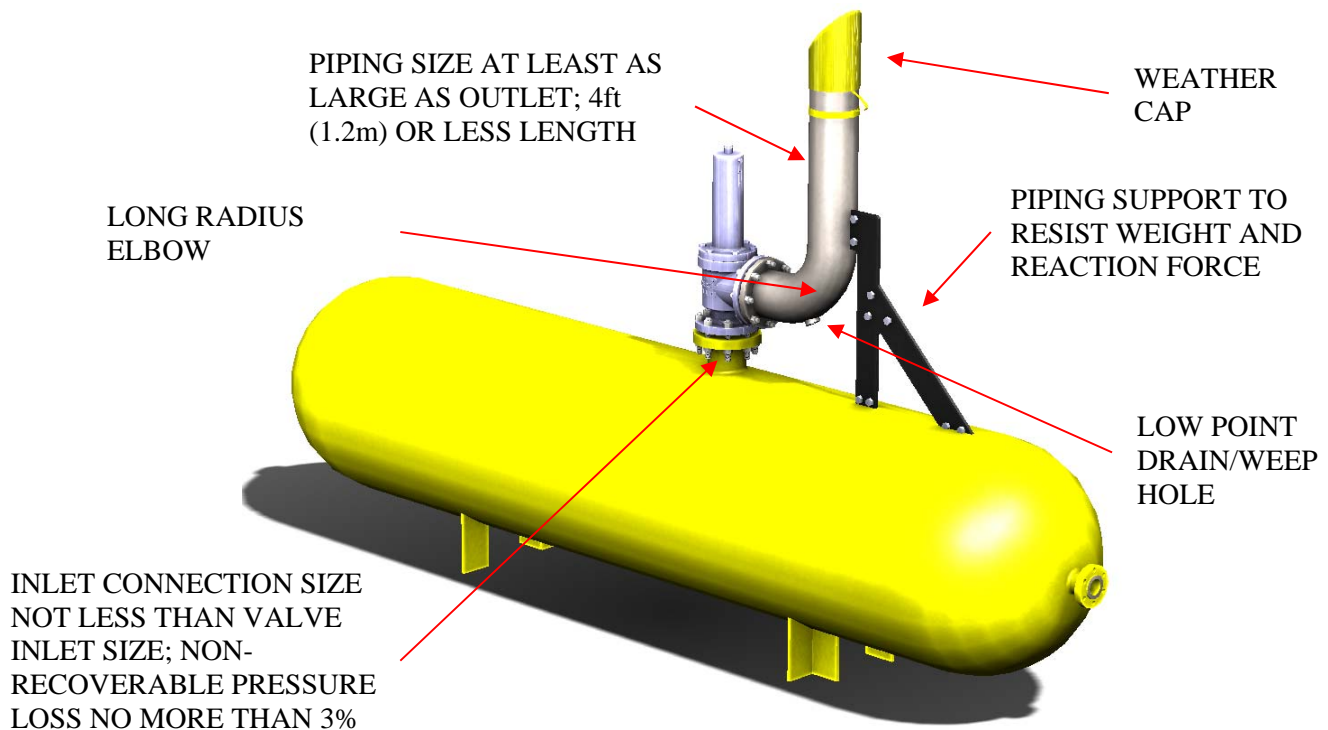


Figure 2: Typical Recommended Installation of a PRV

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.

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Extreme caution is required regarding 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.

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 Paragraph UG-135 and Appendix M of the ASME Boiler and Pressure Vessel Code and in API RP 520 Part II. Other standards and codes may be applicable depending on the jurisdiction and area of use.

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6. Operation

The Mercer Valve 9100 Series is an ASME Section VIII, Division 1 certified PRV for gas/ vapor and liquid applications. It has a set pressure definition for both gas/ vapor and liquid applications of a “POP.” When the valve reaches set pressure, the disk will open, creating a “POP” sound. The valve could exhibit simmer or warn before its set pressure but this is not considered the set point. The valve will open to full lift at set pressure.

The 9100 Series is a direct spring operated PRV. The valve uses spring compression to keep the valve closed. The inlet pressure opens the valve. In normal operation, the spring compression has been adjusted to achieve the set pressure setting of the valve. The spring tension pushes down on the disk, which presses against the nozzle subassembly. The disk seals against the seat within the nozzle subassembly. The pressure on the inlet pushes up on the disk through the nozzle. At set pressure, the force generated by the inlet pressure exceeds the spring’s force. This makes the disk rise up, letting the inlet pressure escape past the seat. The disk stem is guided by the adjustment screw’s bore, which keeps the disk aligned with the nozzle subassembly during this movement. The disk rises until it reaches a mechanical stop located on the adjustment screw. At this point, the valve is at full lift and will flow the media at its discharge coefficient rating. 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 ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1, Appendix 11 and in 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 push the disk back down against the seat. The disk will reset against the seat, stopping any further flow and the valve will be ready for the next overpressure event.

Best performance is usually obtained on a system where the operating pressure is at least 15% or 20% less than the valve’s set pressure for gas or liquid service applications, respectively. Performance improves with greater margin between the operating and set pressures. 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. ASME’s BPVC and API’s standards require that the set pressure does not exceed the MAWP of the system.

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7. Maintenance

For dependable performance, PRVs must be maintained regularly. **Mercer Valve Co., Inc. 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 done, qualified repair personnel should perform it. Qualified repair personnel conducting the annual inspection and testing may alter the maintenance schedule based on the service conditions.

During the inspection, a visual inspection, a set pressure verification, and a leak check should be completed. These tests can be performed while the PRV is installed on its system or when it's 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 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 at 60°F (16°C) and standard atmospheric conditions. Check the seal wire. A broken seal wire indicates that an unqualified person has 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, usually water. Testing a pressure relief valve with the incorrect fluid will cause inaccurate readings. The set pressure of the pressure relief valve, in accordance with the ASME Boiler and Pressure Vessel Code, has a tolerance of $\pm 3\%$ of the specified set pressure or ± 2 psi (± 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. The valve is 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 reseated to

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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.

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 Co. 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 Co. has for its goods.

Contingent that proper storage and transportation of the PRV was accomplished, the start time for the inspection interval, otherwise known as 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, ASME Boiler and Pressure Vessel Code Section VIII, Division 1, and the National Board Inspection Code.

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8. 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 over pressure scenarios. More information on causes of over pressure can be found in API 521. If a PRV fails during an over pressure scenario, the system can increase to an unsafe pressure. These over pressure 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 failures.

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, a set pressure test, and a leak test. Using these three inspections can help determine the functionality of the valve or if repair or replacement is required.

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 had. See Figure 3.

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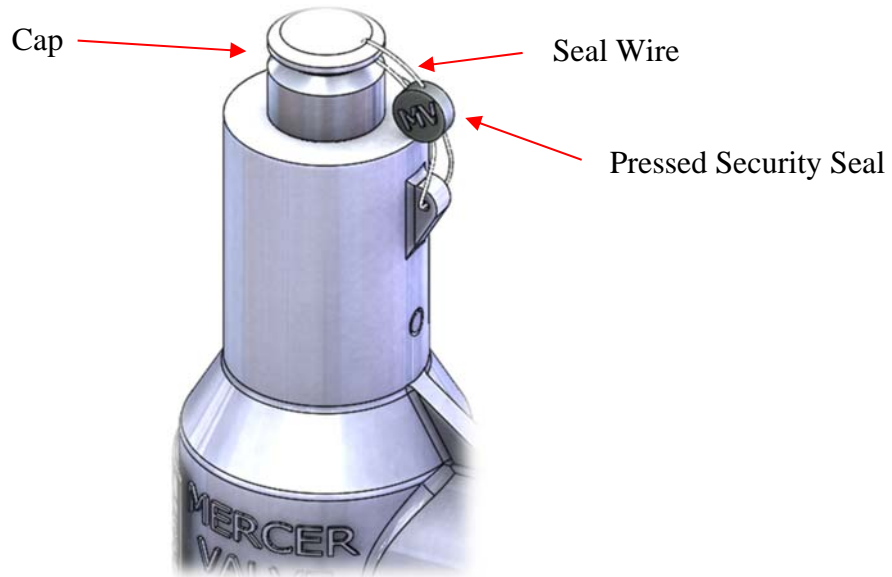


Figure 3: Typical Cap and Seal Wire

- Flanged Connections – The flanges should be checked for wear, such as pitting, and any reduction in width that would cause improper sealing and reduction in pressure rating. Proper fastening should also be checked.
- Threaded Connections – The threads on the threaded connections should be checked for any damage that could potentially compromise the sealing of the threads or the strength of the connection.
- 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 one. A missing tag also warrants further inspections.

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.

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b) Set Pressure Inspection

During the set pressure inspection, the set pressure is verified in accordance with the ASME BPVC. For all valves set 70 psi (500 kPa) and above, the set pressure has a tolerance of $\pm 3\%$ of the set pressure. For all set pressure below 70 psi (500 kPa), the tolerance is ± 2 psi (± 15 kPa). 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 and after any repairs.

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 BPVC 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 9100 Series valves, a crisp "pop" is the definition of set pressure for both gas/ vapor and liquid valves.
2. Rigidly connect the valve to a test fixture.
3. Slowly increase the pressure on the inlet side until the 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 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 ± 0.5 psi (3.5 kPa), whichever is greater, from the average of all verifying pops.

If the test equipment is not adequate, the results can produce a false reading. Refer to section 9 on proper test equipment.

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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.
- 1st Audible Sound – The 1st sound heard from the outlet of the valve. This definition is usually for gas service.
- 1st 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 Co., Inc. 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. See Figure 4. 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 9100 Series, zero bubbles must be observed for one minute to pass leak inspection per API 527.

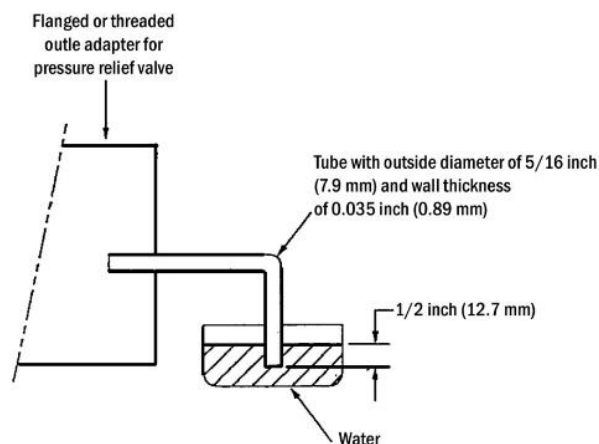


Figure 4: API 527 Leak Check Apparatus

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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 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 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 superimposed 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, SECTION VIII, PART UG-136(d) "Production Testing by Manufacturers and Assemblers". The valve is then visually inspected for any leaks by checking for bubbles coming from any part of the valve.

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9. 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. However, there are disadvantages. 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 loss. When this happens, the pressure gauge will indicate a pressure that includes the pressure loss. 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 Figure 5 and Figure 6.

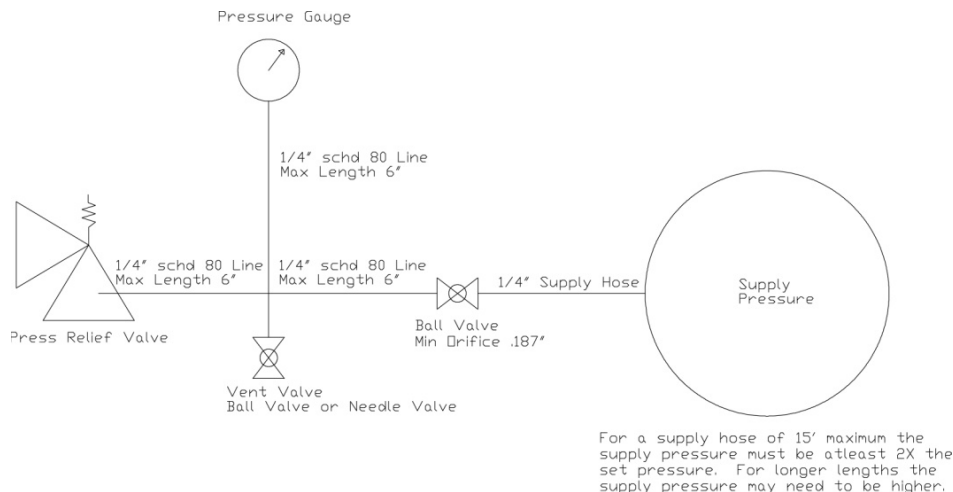


Figure 5: Diagram of Proper In Situ Testing Apparatus

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Figure 6: Picture of Typical In Situ Testing

b) Offsite Testing

Offsite testing allows for the most thorough and accurate testing and inspection. The valves are removed from the units and brought to a shop. In the shop, a valve can be completely tested and 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 installed. This time frame can be long and cause delays.

For gas/ vapor valves, there should be approximately $\frac{1}{4}$ ft³ (7 liters) or more capacity below the valve when setting. This volume is sufficient to test the set pressure for most 4 x 6 M orifices and smaller valves accurately. 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 7 for an example.

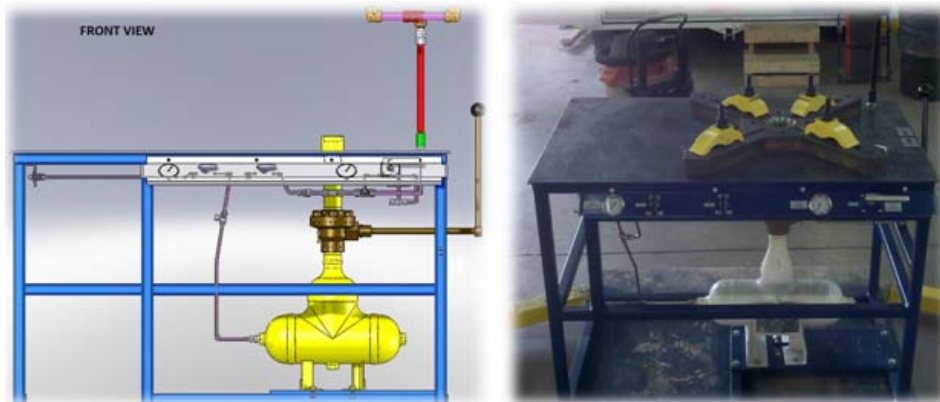


Figure 7: Typical Gas/Vapor Test Stand

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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 ft³ (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. See Figure 8 for an example. In both styles, gas pressure is used to push the liquid through the valve's inlet, generating continuous liquid flow absent of any gas.

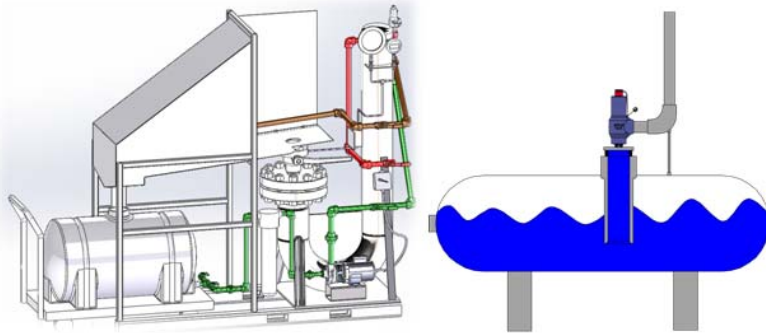


Figure 8: Typical Liquid Test Stand Setups

c) Mobile Test Units

Mobile testing units are similar to offsite testing. The valve is removed from the application. This enables a thorough inspection. Mobile testing units can save time because transporting the valve isn't necessary. Mobile test units are often not setup to test all 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 9 for an example.

Truck Bed Mounted Test Bench (Small PRVs)



Trailer Mounted Test Bench (Larger PRVs)



Figure 9: Typical Mobile Test Stand Setups

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d) 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. At least one of the gauges should be an analog (dial) gauge that is not liquid filled. This type of gauge responds to pressure quickly and gives accurate readings. Digital gauges can be used for the second gauge, if desired. Digital gauges have to be used carefully because quick pressure increases are not always seen on the gauge readings. 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.

e) Lift Checking

The lift of the PRV is checked by seeing how much the disk subassembly moves from the closed position to the opened position. Figure 10 depicts a typical apparatus for checking the lift of a PRV. To use the standard lift check setup, the PRV is placed in an arbor press upside down; the PRV's set spring must initially have tension. A rod is placed through the inlet and it touches the disk. The rod should be sized to fit in the inlet base without damaging the seat or touching the side walls of the nozzle insert. The lift is the measurement of the displacement of the disk from the closed position to the mechanical stops at the fully open position. The shaft of the arbor press will press against the rod sticking out of the valve inlet base. To find the lift, a slight force is applied by using the arbor press. A dial indicator is placed on the arbor press so that it can measure the displacement of the arbor press shaft. This measurement will be the PRV's lift. The minimum lift for certified PRVs can be found in NB-18 publication, which is located on the National Board website www.nationalboard.org. If the PRV doesn't meet the minimum lift, there is something wrong and the valve must be reexamined.

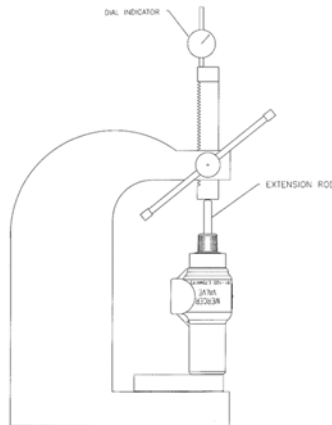


Figure 10: Lift Checking Apparatus

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10. 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 will 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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11. Tool List

The following Tool List shows the recommended tool to be used with an associated component. The list is not exhaustive and more tools that are not listed may be necessary.

a) Valve

Table 1: Tools Used on 9100 Series PRVs

<u>Tool</u>	<u>Where it is Used</u>
Cutter Dikes	Seal Wire
11/16" Open End Wrench	Lock Nut
7/8" Open Wrench	Lock Nut and Center Nut (2" Bodies)
15/16" Open Wrench	Lock Nut
7/32" Allen Wrench	Adjustment Screw (Bottom Entry Valves)
7/16" Open Wrench	Adjustment Screw
1/2" Open Wrench	Adjustment Screw
9/16" Open Wrench	Center Bushing (2" Bodies)
Adjustable 1-1/8" to 5-5/8" Hex/ Straight Jaw Wrench	Inlet Base (Bottom Entry Threaded Valves) and Bonnet (H Orifice)
Flange Wrench	Inlet Base (Bottom Entry Flanged Valves)
1-1/6" Open Wrench	Bonnet Bolts (J-K-L-M Orifice)
1/2" Wrench/ Socket	Inlet Keeper Screw (Bottom Entry Valves)
1" Open End Wrench	Nozzle/ Seat Subassembly (C-D-E Orifice)
Special 1" Flat Socket (optional)	Nozzle/ Seat Subassembly (C-D-E Orifice)
1-3/4" Open Wrench	Nozzle/ Seat Subassembly (F-G Orifice)
Special 1-3/4" Socket (optional)	Nozzle/ Seat Subassembly (F-G Orifice)
2" Hex Socket*	Nozzle/ Seat Subassembly (H Orifice)
2-1/2" Hex Socket*	Nozzle/ Seat Subassembly (J Orifice)
2-3/4" Hex Socket*	Nozzle/ Seat Subassembly (K Orifice)
3-1/2" Hex Socket*	Nozzle/ Seat Subassembly (L Orifice)
4" Hex Socket*	Nozzle/ Seat Subassembly (M Orifice)
5/16" Allen Wrench	Nozzle/ Seat Subassembly and Bonnet Sleeve Bolts (N-P Orifice)
Pick	O-Ring (Removal)
Torque Wrench <small>(refer to section 14 for the required torque range)</small>	Nozzle/ Seat Subassembly (Installation)

**Large sized hex sockets that can be used for nozzle removal/installation are similar to "Truck Wheel Bearing Locknut Sockets."*

b) Miscellaneous

Table 2: Miscellaneous Items Used

Nickel Based Anti-Seize (similar to Loctite® LB 771™)
Medium Strength Thread Retainer (similar to Blue Loctite® 242®)
High Strength Thread Retainer (similar to Red Loctite® 271®)

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Fine Grade Abrasive Hand Pad (similar to Scotch-Brite™ 7447®)
Phenyl-Methyl Silicon Grease (similar to Molykote® 33)
Water Resistant NLGI #2 Grease (similar to Aqua Lube Marine Grease)

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12. Disassembly

The following general procedure is recommended for the disassembling of a 9100 Series PRV. Non-standard or “special” configurations are possible and these instructions may not be reflective of them; a special configuration is indicated by a special code at the end of the PRV’s part number. See section 17. Always make sure there is no pressure in the system prior to removing a PRV.

The 9100 Series contains several different orifice sizes. For most C to G orifices, the valves are bottom entry type with the bonnet integral to the body cavity. These valves have a removable inlet base. Larger orifice sized valves are top entry types and have removable bonnets.

These instructions are divided into three sections: 1” Body-Bottom Entry, 2” Body-Bottom Entry, and Top Entry. See Figure 11 to identify the difference in appearance. Each type may have either flanged or threaded connections.

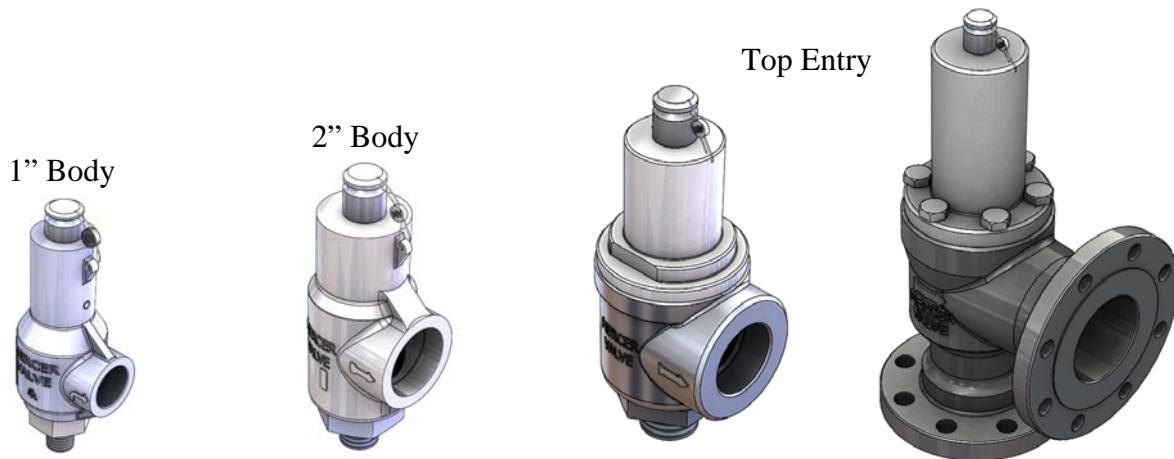


Figure 11: Different Sized Valve Bodies

a) 1” Body - Bottom Entry

1. Cut and remove the seal wire and unscrew the cap to expose the adjustment screw. See Figure 3.
 - i) Go to section 12 d) if the valve is a lift lever configuration.
2. Loosen the lock nut from the adjustment screw. See Figure 12.

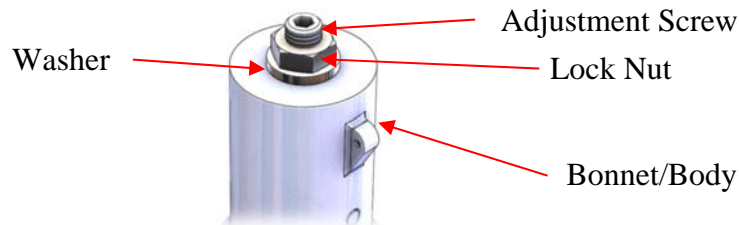


Figure 12: 1” Body Upper Bonnet Components

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3. Relieve the compression on the spring by turning the adjustment screw counter clockwise. This is important so that components will not spring out and pose a hazard. If the adjustment screw begins to appear as receding back into the bonnet during the relieving of the preload, then the spring compression has been completely removed and the adjustment bushing is beginning to re-compress the spring.
4. Remove the inlet base:
 - a) For threaded valves,
 - i) Rigidly support the body to prevent movement during disassembly.
 - ii) Unscrew the inlet using the appropriate wrenching flats. See Figure 1.
 - b) For flanged valves,
 - i) Make an identifiable reference mark on the valve body and inlet base. The two marks should be aligned on both parts prior to disassembly. This mark will be used as a reference during reassembly.
 - ii) Rigidly support the body to prevent movement during disassembly.
 - iii) Unscrew the inlet using a flange wrench.
5. Remove the set spring and discard the disk subassembly. See Figure 13.
 - i) A replacement disk is included in the repair kit.
6. Remove and discard the inlet base seal. See Figure 13.
 - i) A replacement base seal is included in the repair kit.

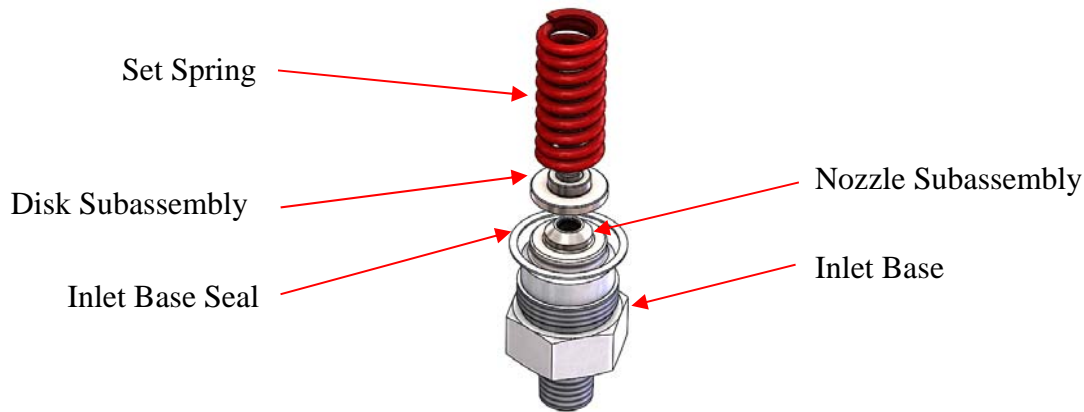


Figure 13: Bottom Entry Thread Inlet Base Components

7. Rigidly support the inlet base to prevent movement during disassembly.
8. Unscrew and discard the nozzle subassembly using the appropriate tool. See Table 1. The nozzle will have thread retainer on its thread.
 - i) A replacement nozzle subassembly is included in the repair kit.
9. Remove and discard the nozzle base o-ring. See Figure 14.
 - i) A replacement o-ring is included in the repair kit.

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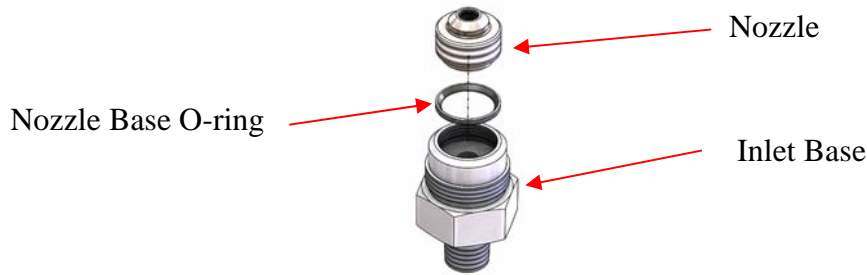


Figure 14: Nozzle/Seat Subassembly of Bottom Entry Valve

10. Remove the lock nut and washer. See Figure 15.
 - a) If the valve is a lift lever and the center bushing is being removed, the lift lever lock nut is unscrewed as well.

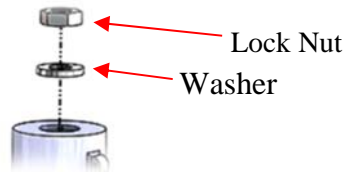


Figure 15: 1" Body Upper Bonnet Components

11. Push downwards on the adjustment screw and center bushing to remove them from the bonnet.
12. Disassemble the center bushing from the adjustment screw if they are still together. See Figure 16.
13. Remove and discard the o-ring located on the center bushing.
 - a) Older models have two o-rings located on the center bushing
 - i) Two replacement o-rings are included in the repair kit.
14. Remove and discard the o-ring located on the adjustment screw. See Figure 16.
 - i) A replacement o-ring is included in the repair kit.

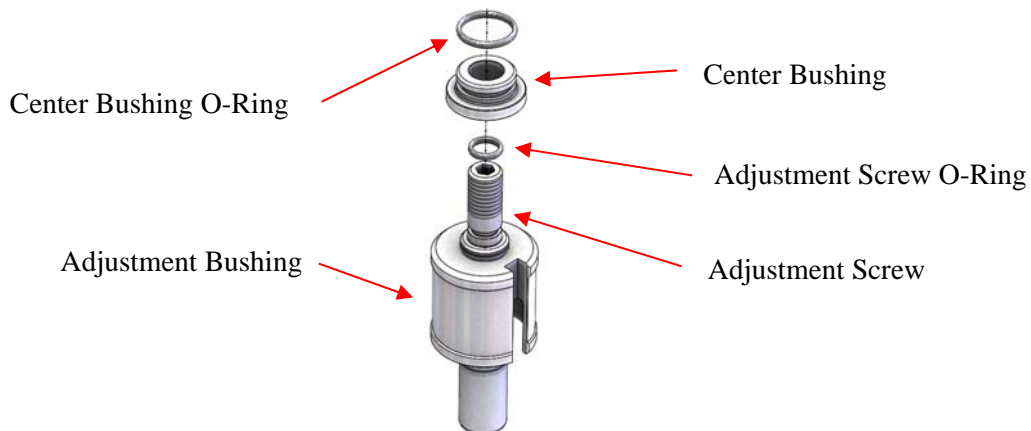


Figure 16: 1" Body Inner Bonnet Components

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15. Unscrew the adjustment bushing from the adjustment screw. The adjustment bushing has left handed threads. See Figure 16.
16. PRV is disassembled.

b) 2" Body - Bottom Entry

1. Cut and remove the seal wire and unscrew the cap to expose the adjustment screw. See Figure 3.
 - i) Go to section 12 d) if the valve is a lift lever configuration.
2. Loosen the lock nut from the adjustment screw. See Figure 17.

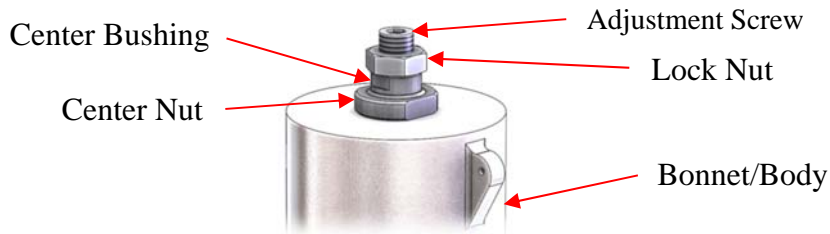


Figure 17: 2" Body Outer Bonnet

3. Relieve the compression on the spring by turning the adjustment screw counter clockwise. This is important so that components will not spring out and pose a hazard. If the adjustment screw begins to appear as receding back into the bonnet during the relieving of the preload, then the spring compression has been completely removed and the adjustment bushing is beginning to re-compress the spring.
4. Remove the inlet base:
 - a) For threaded valves,
 - i) Rigidly support the body to prevent movement during disassembly.
 - ii) Unscrew the inlet using the appropriate wrenching flats. See Figure 1.
 - b) For flanged valves,
 - i) Flanged valves will have a flange keeper that must be removed before the inlet base can be unscrewed. See Figure 18. Remove the flange keeper by unscrewing the keeper bolts first.
 - ii) Remove the keeper.

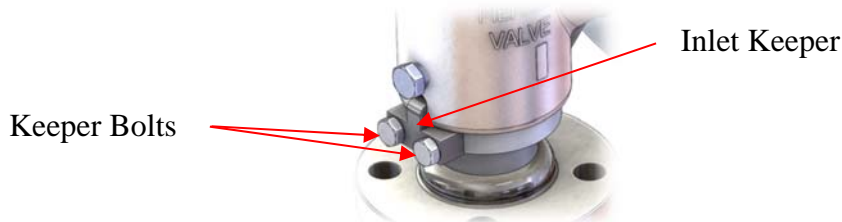


Figure 18: Inlet Keeper

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- iii) Rigidly support the body to prevent movement during disassembly.
- iv) Unscrew the inlet using a flange wrench.
- 5. Remove the set spring and lower spring guide (if one is present) and discard the disk subassembly. See Figure 19.
 - i) A replacement disk is included in the repair kit.
 - a) Not all 9100 Series valve configurations have a lower spring guide. This component is used to guide the bottom of the spring on the top side of the disk.

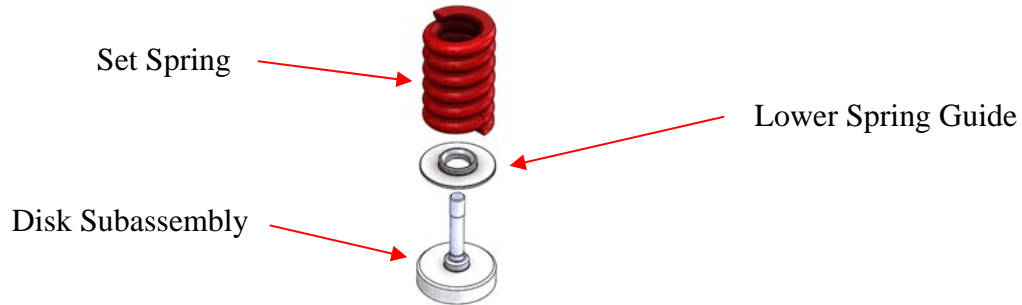


Figure 19: Body Internal Components

- 6. Remove and discard the inlet base seal. See Figure 13.
 - i) A replacement base seal is included in the repair kit.
- 7. Rigidly support the inlet base to prevent movement during disassembly.
- 8. Unscrew and discard the nozzle subassembly using the appropriate tool. See Table 1. The nozzle will have thread retainer on its thread.
 - i) A replacement nozzle subassembly is included in the repair kit.
- 9. Remove and discard the nozzle base o-ring. See Figure 14.
 - i) A replacement o-ring is included in the repair kit.
- 10. If not already done, unscrew the lock nut and set it aside. See Figure 20.

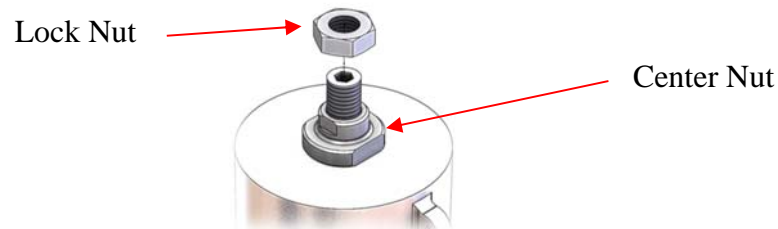


Figure 20: 2" Upper Bonnet Components

- 11. Push downwards on the adjustment screw to remove inner bonnet components.
- 12. Remove and discard the adjustment screw o-ring. See Figure 21.
 - i) A replacement o-ring is included in the repair kit.
- 13. Unscrew the adjustment bushing. This has left handed threads.

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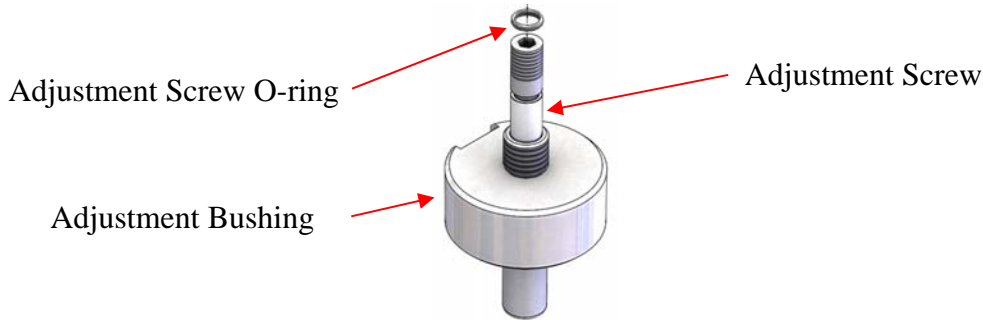


Figure 21: 2" Body Inner Bonnet Components

If the center bushing is being removed, continue with the following. Otherwise, skip to step 19.

14. If necessary*, the center bushing can be removed by using wrenches on the center nut and the flats of the center bushing. One wrench should remain stationary while the other is applied on the other component to break the two parts loose.
 - a) *These components do not have to be disassembled unless the center bushing o-ring is suspected to be leaking. This o-ring must be specially ordered and is not included in the repair kit. The center nut will likely become damaged by removing it; this can be specially ordered as well. Removing these parts is not recommended.
 - b) These parts are used to lock in the index bracket.
 - c) The center bushing has high strength thread retainer on its threads.
 - d) If the valve has a lift lever, this step has already been completed in section 12 d).
15. Once loose, unscrew the center nut from the center bushing if not already done so. Set aside the center nut. See Figure 22.

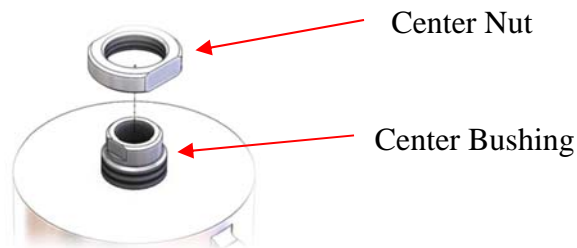


Figure 22: 2" Body Center Nut and Bushing

16. Push downwards on the center bushing to remove.
17. Remove and set aside the index bracket. See Figure 23. Be careful not to bend the index bracket.
18. Remove the center bushing o-ring. See Figure 23.
 - i) A replacement o-ring is not included in the repair kit.

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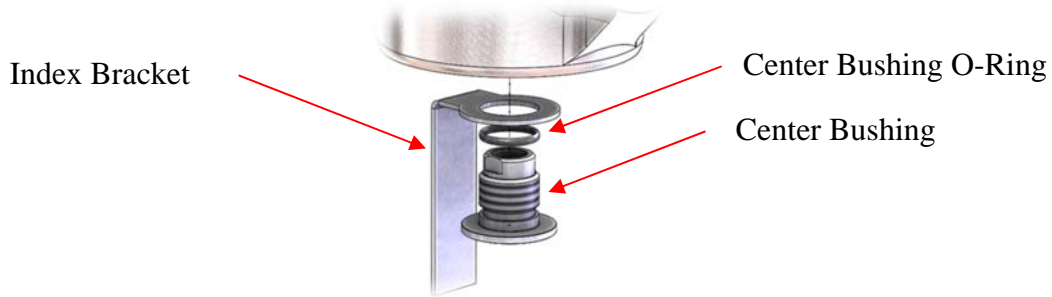


Figure 23: 2" Body Index Bracket

19. PRV is disassembled.

c) Top Entry

1. Cut and remove the seal wire and unscrew the cap to expose the adjustment screw. See Figure 3.
 - i) Go to section 12 e) if the valve is a lift lever configuration.
2. Loosen the lock nut from the adjustment screw. See Figure 24.

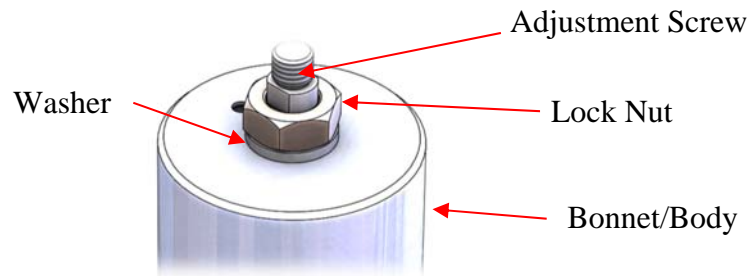


Figure 24: Top Entry Upper Bonnet

3. Relieve the compression on the spring by turning the adjustment screw counter clockwise. This is important so that components will not spring out and pose a hazard. If the adjustment screw begins to appear as receding back into the bonnet during the relieving of the preload, then the spring compression has been completely removed and the adjustment bushing is beginning to re-compress the spring.
4. Remove the bonnet:
 - a) H Orifice - The 9100 Series H orifice has a threaded bonnet.
 - i) Rigidly support the body to prevent movement during disassembly.
 - ii) Unscrew the bonnet from the body using the wrenching flats. The wrench flat width is 3-1/4". See Figure 25.

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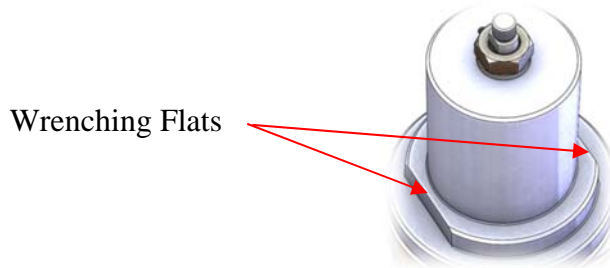


Figure 25: 9100 Series Threaded H Bonnet

- b) J Orifice and Larger – The 9100 Series J orifice and larger has a bolted bonnet.
 - i) Loosen each of the bonnet bolts in an alternating “star” pattern.
 - ii) Remove and set aside all the bonnet bolts.
- 5. Remove the set spring and lower spring guide (if one is present) and discard the disk subassembly. See Figure 26.
 - i) A replacement disk is included in the repair kit.
 - a) Not all 9100 Series valve configurations have a lower spring guide. This component is used to guide the bottom of the spring on the top side of the disk.

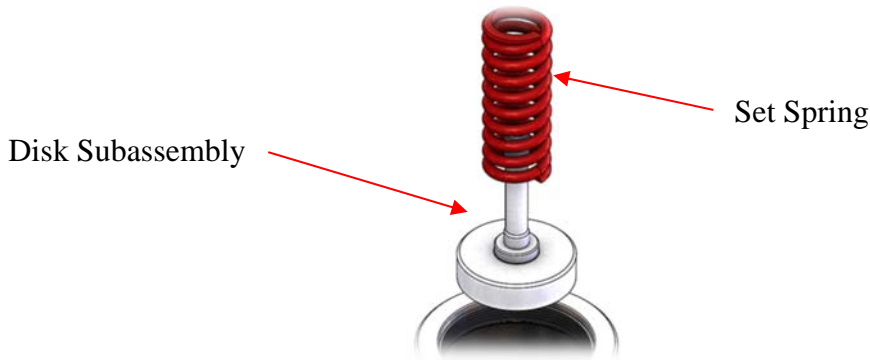


Figure 26: Top Entry Internal Components
(Lower Spring Guide Not Shown)

- 6. Rigidly support the body to prevent movement during disassembly.
- 7. Unscrew and discard the nozzle subassembly from the body cavity using the appropriate tool. See Table 1 and Figure 27.
 - i) A replacement nozzle subassembly is included in the repair kit.
 - a) H though M orifice sizes will have a nozzle subassembly that is screwed into the body.
 - b) N and P orifice sizes will have a nozzle subassembly that is bolted to the body.
- 8. Remove and discard the nozzle base o-ring. See Figure 27.
 - i) A replacement o-ring is included in the repair kit.

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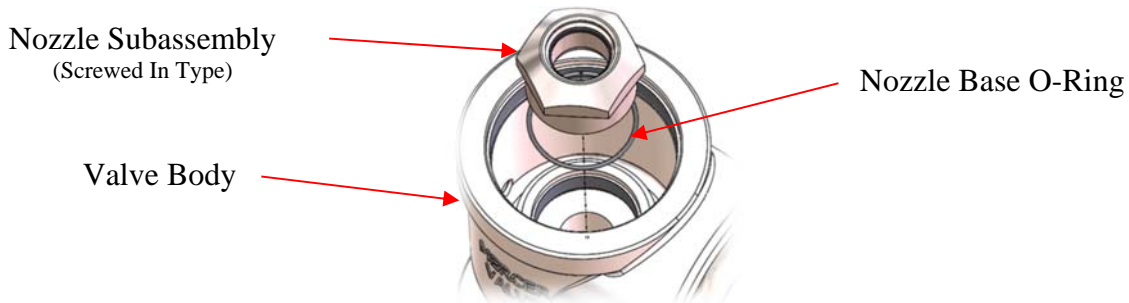


Figure 27: Top Entry Inner Components

9. Remove and discard the bonnet o-ring. This is located on the bottom side of the bonnet. See Figure 28.
 - i) A replacement bonnet o-ring is included in the repair kit.

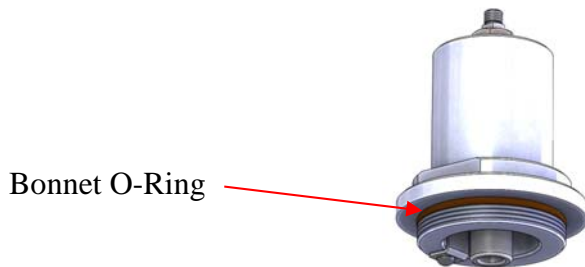


Figure 28: Bonnet O-Ring

10. In some N and P configurations, there may be a guide sleeve bolted to the bonnet that must be removed to service the adjustment screw and bushing. See Table 1.
11. Remove the lock nut and washer. See Figure 29.

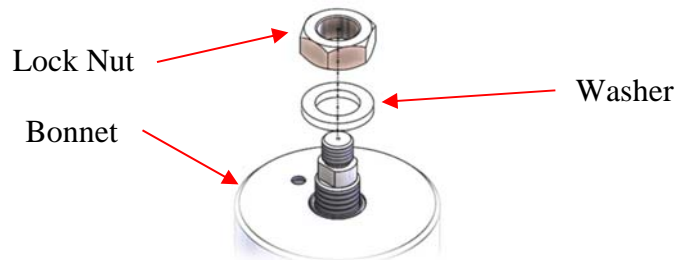


Figure 29: Top Entry Upper Bonnet Components

12. Push downwards on the adjustment screw to remove from the bonnet.
13. Remove the adjustment screw o-ring and discard. See Figure 30.
 - i) A replacement o-ring is included in the repair kit.

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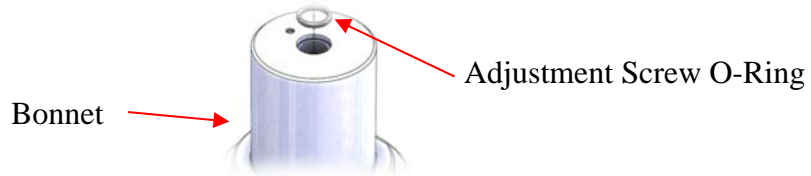


Figure 30: Top Entry Adjustment Screw O-Ring

14. Unscrew the adjustment bushing from the adjustment screw. The adjustment bushing has left handed threads. See Figure 31.

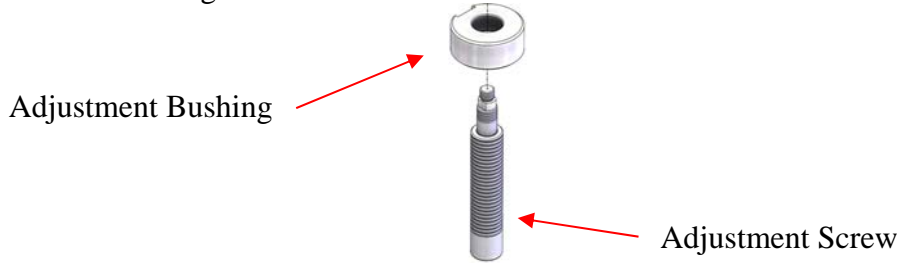


Figure 31: Adjustment Screw and Adjustment Bushing

15. PRV is disassembled.

d) Lift Levers – Bottom Entry

The 1” and 2” bodies have identical lift lever designs. Conduct the following steps to remove the lift lever and then continue with the aforementioned instructions to complete the disassembling.

1. Cut and remove the seal wire. See Figure 32.

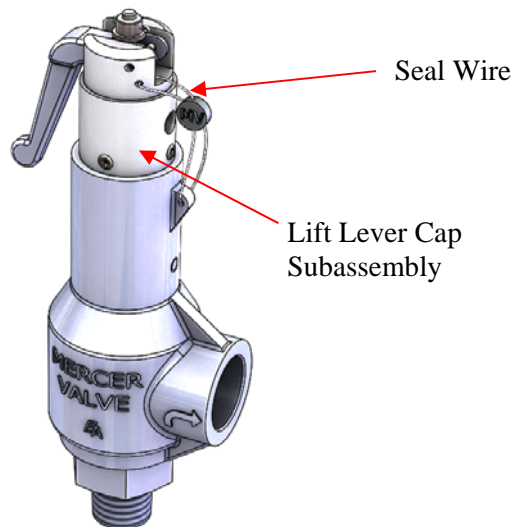


Figure 32: Lift Lever Cap – Bottom Entry

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2. Bend straight and pull out the cotter pin. See Figure 33. Set it aside.
 - i) A replacement cotter pin is not provided in the repair kit.
3. Unscrew and remove the stem lift nut. See Figure 33.

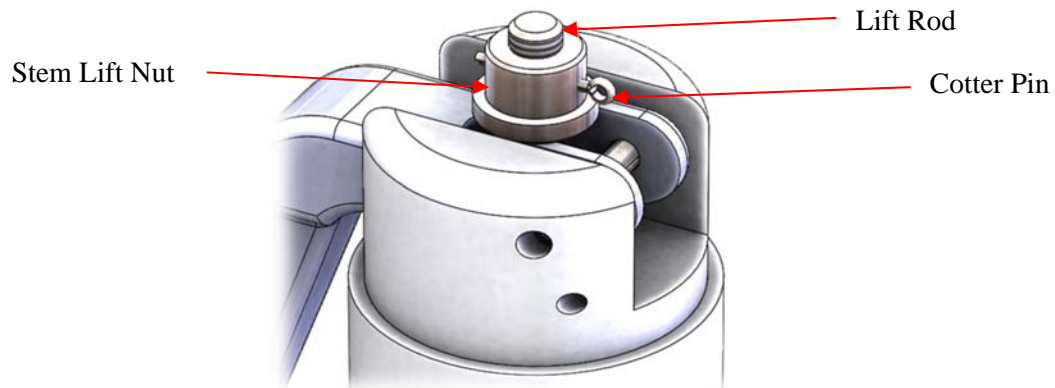


Figure 33: Upper Portion of Lift Lever Cap

4. Loosen the three lift lever cap set screws. See Figure 34. These must be unscrewed enough so that they no longer engage the lift lever lock nut.

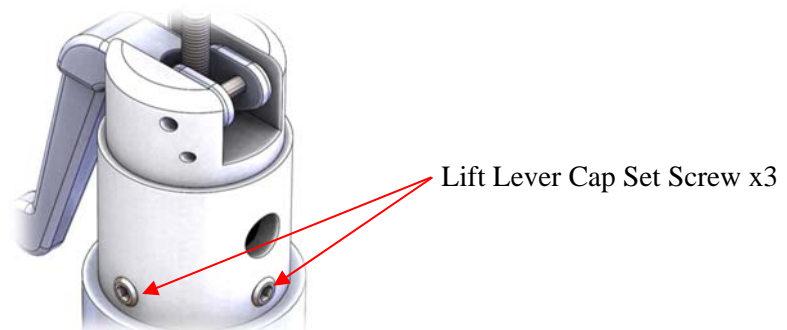


Figure 34: Lift Lever Cap Set Screws

5. Raise the entire lift lever cap to remove it from the bonnet.
6. Unscrew and remove the seal adjustment nut. See Figure 35.
 - a) If the valve has a closed lift lever configuration, there will be an o-ring under this nut. Remove and discard this o-ring.
 - i) A replacement o-ring is included in the repair kit.
 - b) If the valve has an open lift lever configuration, there won't be an o-ring.

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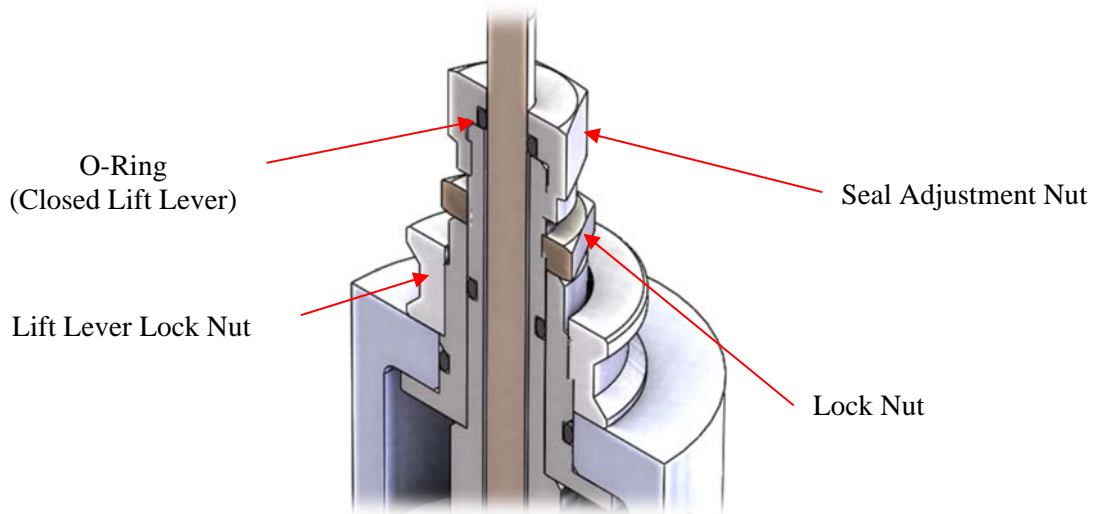


Figure 35: Removed Lift Lever Cap

7. Loosen the lock nut by using two additional jam nuts on the adjustment screw to prevent it from turning. See Figure 36.
 - i) The additional jam nuts are not included in the repair kit.

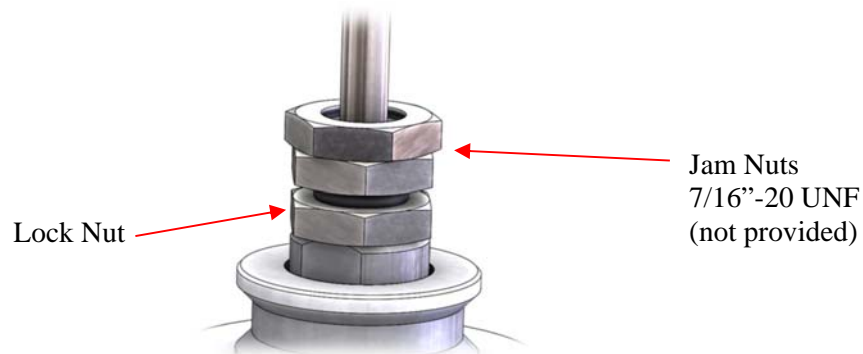


Figure 36: Jam Nuts Used on Adjustment Screw

8. Turn the adjustment screw counter clockwise to remove the spring load. Use the jam nuts to apply torque to the adjustment screw.
9. Remove the jam nuts.

If removing the center bushing, continue with the following. Otherwise, skip to step 11.

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. One wrench should remain stationary while the other is applied on the other component to break the two parts loose.

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- a) *These components do not have to be disassembled unless the center bushing o-ring is suspected of leaking. Removing these parts is not recommended.
- b) This lock nut has high strength thread retainer applied and can be difficult to remove.

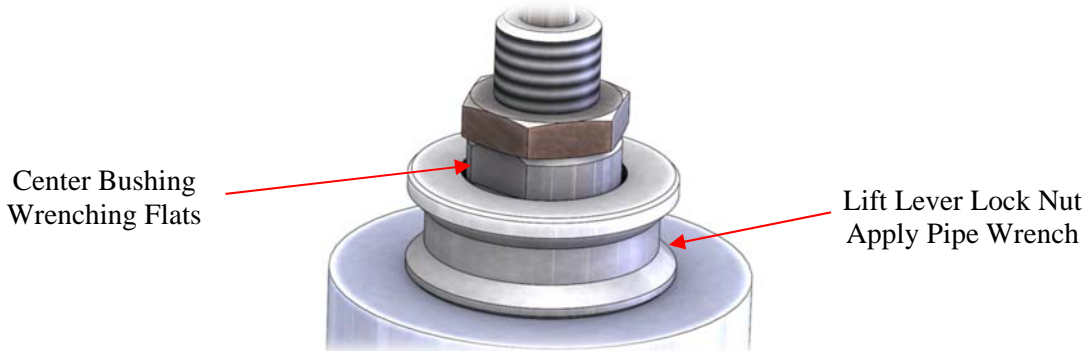


Figure 37: Lift Lever Lock Nut Removal

- 11. The disassembly is now typical of the process described for non-lift lever configurations. Return to step 4 in the aforementioned instructions.

e) Lift Levers – Top Entry

- 1. Cut and remove the seal wire. See Figure 38.

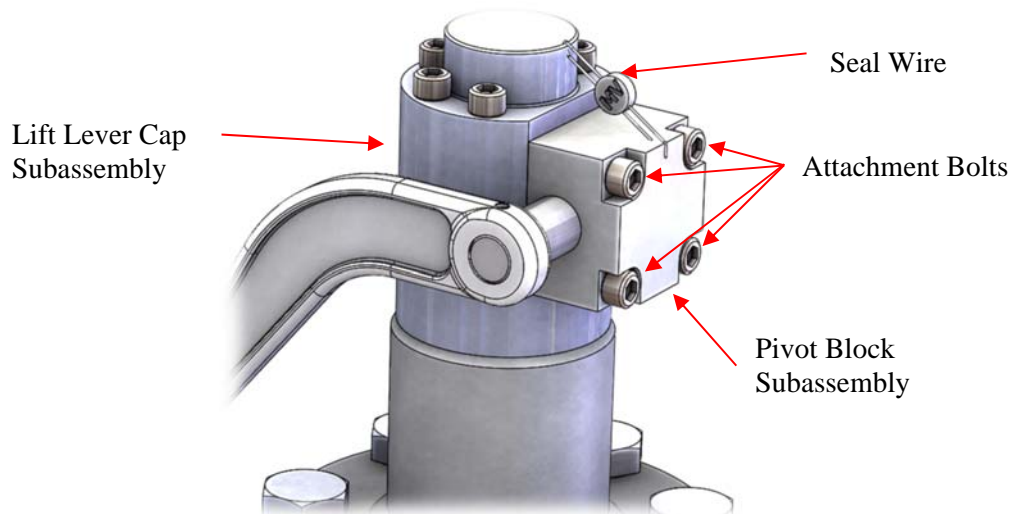


Figure 38: Lift Lever Cap - Top Entry

- 2. Unscrew the four bolts attaching the pivot block subassembly to the lift lever cap. See Figure 38.
- 3. Remove the pivot block. There will be an o-ring between the pivot block and the cap. Remove this o-ring and discard. See Figure 39.

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- a) A replacement o-ring is included in the repair kit.

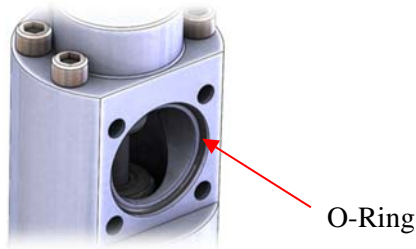


Figure 39: Pivot Block O-ring

4. Unscrew and remove the bolts attaching the lift lever cap to the bonnet. See Figure 40.

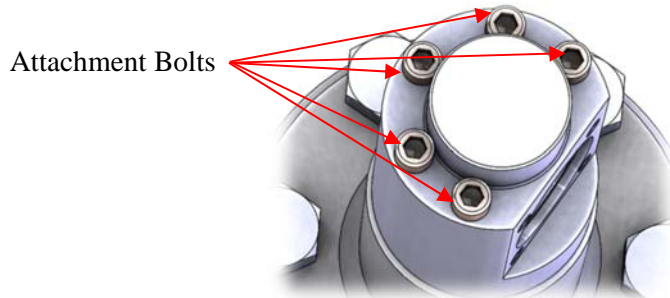


Figure 40: Lift Lever Cap Mounting Bolts

5. Remove and set aside the cap. There will be an o-ring under the cap. Remove and discard this o-ring. See Figure 41.

- a) A replacement o-ring is included in the repair kit.

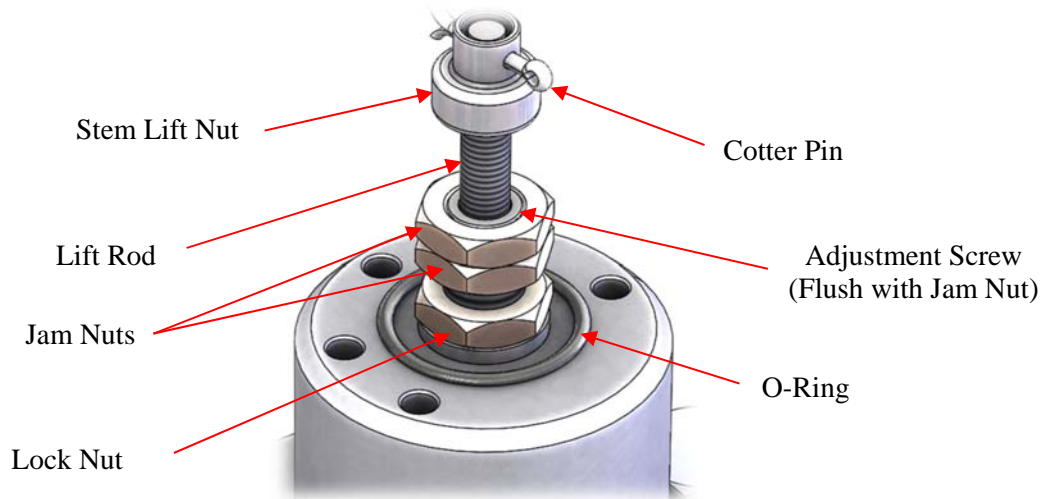


Figure 41: Removed Lift Lever Cap

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6. Bend straight and pull out the cotter pin. Figure 41. Set it aside.
 - i) A replacement cotter pin is not provided in the repair kit.
7. Unscrew the stem lift nut from the lift rod. See Figure 41.
8. Loosen and remove the lock nut by using the two jam nuts on the adjustment screw. Hold the jam nuts with one wrench and use another wrench on the lock nut. This will prevent the adjustment screw from turning.
9. Turn the adjustment screw counter clockwise to remove the spring load. Use the jam nuts to apply torque to the adjustment screw.
10. Remove the jam nuts.
11. The disassembly is now typical of the process described for non-lift lever configurations. Return to step 4 in the aforementioned instructions.

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13. Component Inspection

The following general procedure is recommended in the inspection of a 9100 Series PRV. New parts should be inspected.

1. Inspect the seat for cuts and abrasions. The seat is the non-metallic element in the nozzle subassembly.
 - a) If there are only minor scratches or abrasions, the seat may be polished and restored.
 - b) Polish the seat area lightly with a fine grade abrasive pad. Be careful not to damage the soft seat.
 - c) If the seat is damaged with deep abrasions and cuts, it should be replaced.
2. Referring to Figure 42, measure the diameter, D_s , of the nozzle. This diameter must be in the range of values listed in Table 3.

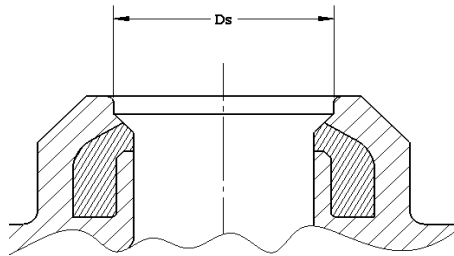


Figure 42: Critical Seat Dimension

Table 3: Critical Seat Dimension Values

ORIFICE SIZE	NOZZLE DIAMETER D_s , in (mm)	
	MINIMUM	MAXIMUM
C	0.335 (8.51)	0.337 (8.56)
D	0.478 (12.14)	0.480 (12.19)
E	0.620 (15.75)	0.622 (15.80)
F	0.778 (19.76)	0.780 (19.81)
G	0.914 (23.22)	0.916 (23.27)
H	1.243 (31.57)	1.246 (31.65)
J	1.599 (40.61)	1.603 (40.72)
K	1.899 (48.23)	1.903 (48.34)
L	2.394 (60.81)	2.398 (60.91)
M	2.676 (67.97)	2.680 (68.07)
N	2.930 (74.42)	2.940 (74.67)
P	3.580 (90.93)	3.590 (91.18)

3. Inspect the disk subassembly. Especially examine the spherical surface portion that engages the seat; this surface must be clean and smooth.
 - a) This surface may be polished with a fine grade abrasive to restore the disk if only minor imperfections exist. Any form of heavier cutting must not be done.

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- b) If the spherical surface is damaged or scratched, the disk needs to be replaced.
4. Referring to Figure 43, measure the diameter, D_d . This diameter must be within the range of values listed in Table 4.

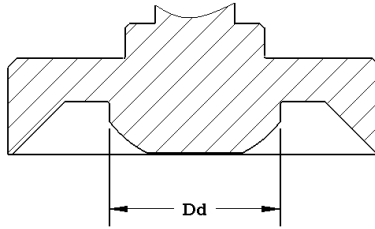


Figure 43: Critical Disk Dimension

Table 4: Critical Disk Dimension Values

ORIFICE SIZE	DISK DIAMETER D_d , in (mm)	
	MINIMUM	MAXIMUM
C	0.329 (8.36)	0.333 (8.46)
D	0.472 (11.99)	0.476 (12.09)
E	0.614 (15.60)	0.616 (15.65)
F	0.768 (19.51)	0.771 (19.58)
G	0.904 (22.96)	0.906 (23.01)
H	1.228 (31.19)	1.231 (31.27)
J	1.580 (40.13)	1.583 (40.21)
K	1.876 (47.65)	1.880 (47.75)
L	2.372 (60.25)	2.376 (60.35)
M	2.650 (67.31)	2.655 (67.44)
N	2.895 (73.53)	2.900 (73.66)
P	3.540 (89.91)	3.545 (90.04)

5. Check the portion of the disk stem that slides inside the adjustment screw bore. Verify that its surface is smooth. The surface must not have severe wear. See Figure 44 for an example.

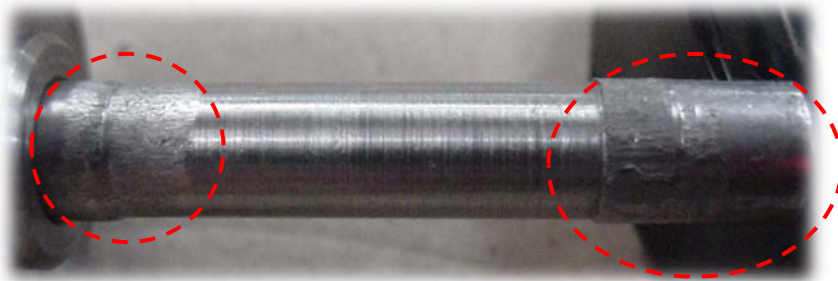


Figure 44: Example of Severe Wear on a Disk Stem

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6. Inspect the set spring for damage. Clean or replace the spring, if necessary. Check that the spring appears square. A spring with too much curvature can cause the valve to leak.
7. Verify that the correct spring is being used for the intended service and set pressure. This is checked by measuring the wire diameter and the inside diameter of the spring. Cross reference these values to the spring chart. This is a separate document.
8. Swab out the internal bore of the adjustment screw to ensure that it is clean and free from obstructions, such as dirt or grease. Also, examine for severe wear within this part.

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14. Reassembly

The following general procedure is recommended for the reassembling of a 9100 Series PRV. Parts should not be difficult to put back together and excessive force should **never** be used.

a) Cleaning & Lubrication

Cleaning:

- All of the valve's parts **except** the o-rings and nozzle subassemblies may be cleaned using a solvent bath. **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 may be re-lubricated.

Lubricating:

- All o-rings should be lubricated with silicone grease similar to Molykote® 33 grease.
- The adjustment screw threads should be lubricated with a small amount of anti-seize, preferably a nickel base type. 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.
- **Never apply grease, oil, or other lubricants on seats, seal faces, or sliding components.**

b) Valve Reassembly

i) 1" Bodies – Bottom Entry

1. Lightly apply a small amount of anti-seize to the threads of the adjustment screw. See Figure 45.
2. Thread the adjustment bushing onto the adjustment screw. This has left handed threads. Screw the adjustment bushing down onto the adjustment screw until approximately 2 threads of the adjustment screw are visible from the top. See Figure 16.
3. Lightly lubricate the outer surface of the adjustment bushing. See Figure 50 or Figure 54.
4. Lightly lubricate the adjustment screw o-ring.
5. Carefully place the adjustment screw o-ring onto the adjustment screw, making sure not to cut the o-ring. The o-ring should reside in a notch groove below the upper threads of the adjustment screw. See Figure 45.

If the valve has a lift lever, go to section 14 c).

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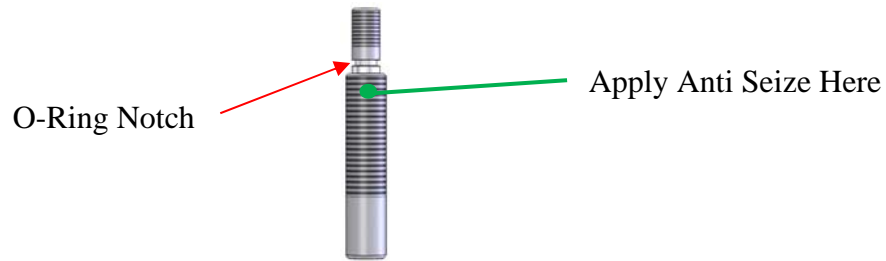


Figure 45: Adjustment Screw O-Ring Notch

6. Lightly lubricate the center bushing o-ring.
 - a) Older 9100 Series may have two o-rings and two notches on the center bushing.
7. Carefully place the center bushing o-ring onto the center bushing. The o-ring should reside in a notch on the center bushing. See Figure 46.

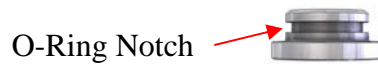


Figure 46: Center Bushing O-Ring Notch

8. Install the center bushing over the top of the adjustment screw. See Figure 16 for the proper orientation.
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. The center bushing should end against the top of the inner bonnet.
 - a) The adjustment bushing must slip into the valve bore freely but with little radial play.
 - 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.**
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). See Figure 12.
11. 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 finger tight at this point, as it is only to retain the inner bonnet components.
 - b) The lock nut will be tightened once the setting process is completed.
12. Lightly lubricate the nozzle base o-ring.
13. Install the nozzle base o-ring into the lower corner of the nozzle pocket. See Figure 47.

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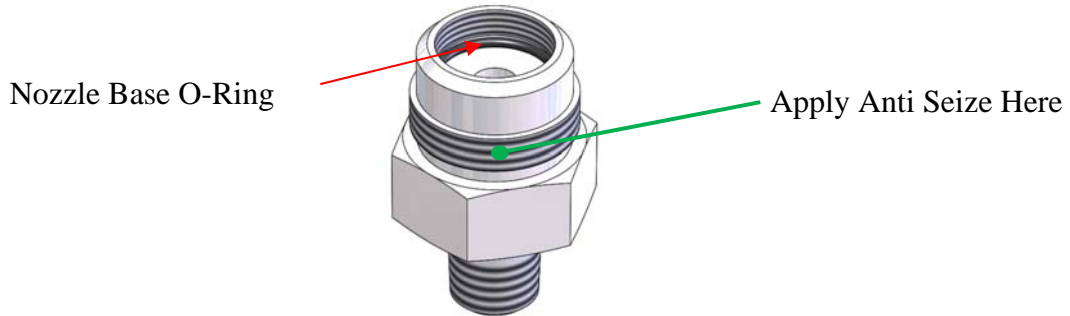


Figure 47: Nozzle Pocket of Bottom Entry Valve

14. Put a dot of medium strength thread retainer onto the bottom of the threads of the nozzle. See Figure 52.
15. Thread the nozzle subassembly into the nozzle base.
 - a) Do not put any lubricant on the seat.
16. Rigidly hold the inlet base.
17. Tighten the nozzle to the appropriate value as shown in Table 5.

Table 5: Nozzle Torque Values

Nozzle Orifice	Torque, lbf-ft (N-m) \pm 5%
C to G	100 (136)
Conversion Adapter (C, D, E)	100 (136)
E orifice 316 SS <small>(see section 17)</small>	No Torque – use channel lock pliers to snug down
H	250 (339)
J	350 (475)
Conversion Adapter (J)	250 (339)
K	400 (542)
L	500 (678)
M	600 (813)
N & P (Nozzle and Guide Sleeve Bolts)	50 (68) per bolt

18. Hold the valve body upside down.
19. Before reinstalling the spring, insert the disk subassembly's stem into the bore of the adjustment screw and simulate the valve opening operation. The disk stem must slide freely within the bore of the adjustment screw.
20. Remove the disk subassembly.
21. Check and make sure the set spring slides over the disk freely without sticking.
22. Install the spring over the adjustment screw so it is resting on the lower portion of the adjustment bushing.
23. Install the disk subassembly into the adjustment screw and spring.
 - a) Do not put any lubricant on the disk or disk stem.

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24. Place the base seal onto the inlet base. See Figure 13.
25. Put a small amount of anti-seize on the threads of the inlet base that get screwed into the body. See Figure 47.
26. While still holding the body of the valve upside down, finger tighten the inlet base subassembly threads into the body while making sure all internal parts remain aligned. Also, make sure that the inlet base seal is centered on the inlet base and body and is not getting bent or caught on the inlet threads.
27. Tighten the inlet base to the body:
 - a) For threaded valve bodies,
 - i) Tighten the inlet base to the appropriate value as shown in Table 6.

Table 6: Inlet Base Torque Values

Body Size (Thread Size)	Torque, lbf-ft (N-m) ± 5%
1" (1-1/2"-12)	350 (475)
2" (2-3/8"-12)	450 (610)

- b) For flanged valve bodies,
 - i) Tighten the inlet flange into the valve body so that the reference marks made in section **"12 Disassembly; a) 1" Body - Bottom Entry; 4.b)"** are aligned. Or, tighten to the proper flange timing/ alignment.
28. Turn the valve upright.
29. If any pipe plugs/ fittings were removed, wrap their threads with 3 wraps of PTFE pipe fitting tape, reinstall them, and then tighten them approximately 2-3 turns past finger tight.
30. Turn the adjustment screw clockwise until resistance is felt; the spring is engaged. Turn the adjustment screw an additional 4-5 more times. This is increasing the compression on the spring.
 - a) If the PRV has a lift lever option, utilize two jam nuts to turn the adjustment screw. See Figure 36. The jam nuts are tightened against each other to 100 lbf-ft (136 N-m).
31. Check the lift of the valve. Refer to section **"9 Test Equipment e) Lift Checking"**. The measured lift of the PRV should meet or exceed the minimum lift denoted in the NB-18 publication. If valve does not meet lift, disassemble and inspect parts.
32. Adjust the set pressure of the valve. See section **"15 Valve Setting Procedure"**.
33. Tighten the lock nut to the appropriate value listed in Table 7. Tighten by utilizing two wrenches, one on the lock nut and the other on the adjustment screw (or jam nut). The wrench on the adjustment screw (or jam nut) should be held stationary during tightening so that the adjustment screw does not turn and alter the spring compression.
 - a) If the PRV has a lift lever and jam nuts were used to turn the adjustment screw, the jam nuts will be removed once set pressure adjustment is finalized.

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Table 7: Lock Nut Torque Values

Orifice Sizes	Torque, lbf-ft (N-m) ± 5%
C to G Lock Nut	25 (34)
1" & 2" Body Center Nut (Lift Lever Lock Nut)	80 (108)
Top Entry - Short Bonnet Lock Nut	35 (47)
Top Entry - Tall Bonnet Lock Nut	50 (68)
N & P Lock Nut	90 (122)

34. Re-check the set pressure to verify set pressure is still as intended.
35. Conduct a leak check. See section “**8 Inspections; c) Leak Inspection**”.
36. Install cap and seal with lock wire. See Figure 3.
 - a) If the PRV has a lift lever option, use the instructions listed in 14 c) step 9.
37. Reassembly is complete.

ii) 2" Bodies – Bottom Entry

1. Lightly apply a small amount of anti-seize to the threads of the adjustment screw. See Figure 48.
2. Thread the adjustment bushing onto the adjustment screw. This has left handed threads. Screw the adjustment bushing down onto the adjustment screw until approximately 2 threads of the adjustment screw are visible from the top. See Figure 21.
3. Lubricate the outer surface of the adjustment bushing. See Figure 50.
4. Lightly lubricate the adjustment screw o-ring.
5. Carefully place the adjustment screw o-ring onto the adjustment screw, making sure not to cut the o-ring. The o-ring should reside in a notch groove below the upper threads of the adjustment screw. See Figure 48.

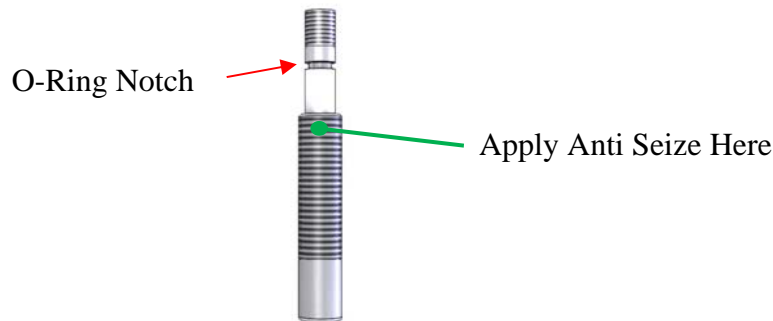


Figure 48: 2" Body Adjustment Screw O-Ring Notch

*If center bushing was removed, continue with the following. Otherwise, skip to step 10.
 If the valve has a lift lever, go to section 14 c).*

6. Place the index bracket over the center bushing. The bracket should be pointing downwards.

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7. Lightly lubricate the center bushing o-ring.
8. Carefully place the center bushing o-ring onto the center bushing making sure not to cut the o-ring. The o-ring should reside in a notch on the center bushing. See Figure 49.



Figure 49: Center Bushing O-Ring Notch

9. Install the center bushing and index bracket over the top of the adjustment screw. The center bushing should be oriented with its wrenching flats towards the top of the adjustment screw. The angle portion of the index bracket should be pointed downwards and be aligned with the notch of the adjustment bushing. The current subassembly should look like Figure 50.

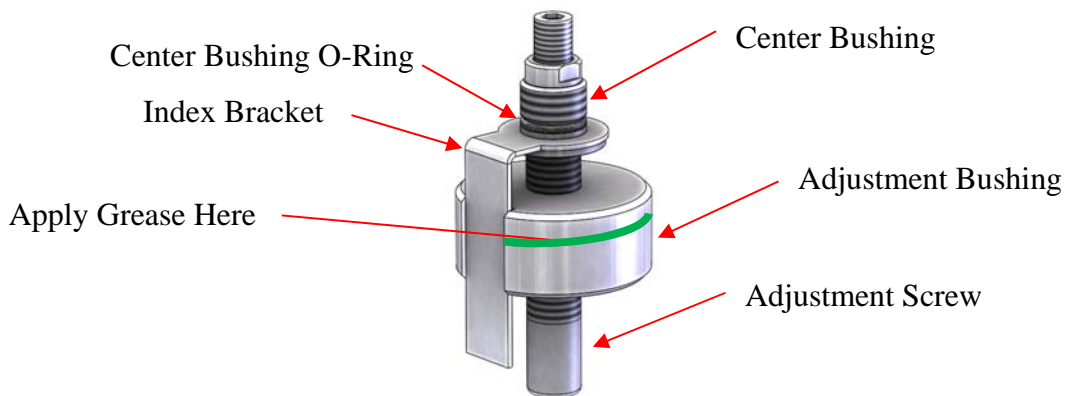


Figure 50: 2" Inner Bonnet Components

10. Carefully slip fit the adjustment screw and other parts into the bore of the bonnet so that the center bushing is against the top of the inner bonnet.
 - 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 the following. Otherwise, skip to step 13.

11. Apply a small amount of high strength thread retainer on the threads of the center bushing only if it was removed during disassembly. See Figure 51.

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Figure 51: Thread Retainer on Center Bushing

12. Tighten the center nut against the center bushing. When tightening, use the flats on the center bushing to stop the center bushing from turning. Tighten to the appropriate value shown in Table 7.
13. Thread the lock nut onto the adjustment screw finger tight against the center bushing. Do not tighten fully.
14. Lightly lubricate the nozzle base o-ring.
15. Install the nozzle base o-ring into the lower corner of the nozzle pocket. See Figure 47.
16. Put a dot of medium strength thread retainer onto the bottom threads of the nozzle. See Figure 52.



Figure 52: Thread Retainer Location on Nozzle

17. Thread the nozzle subassembly into the nozzle base.
 - a) Do not put any lubricant on the seat.
18. Rigidly hold the inlet base.
19. Tighten the nozzle to the appropriate value as shown in Table 5.
20. Hold the valve body upside down.
21. Before reinstalling the spring, insert the disk subassembly's stem into the bore of the adjustment screw and simulate the valve opening operation. The disk stem must slide freely within the bore of the adjustment screw.
22. Remove the disk subassembly.
23. Check and make sure the set spring slides over the disk or lower spring guide freely without sticking.
24. Install the spring over the adjustment screw so it is resting on the lower portion of the adjustment bushing.
25. Place the lower spring guide on top of the disk subassembly if the configuration has a lower spring guide.

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26. Install the disk subassembly into the adjustment screw and spring.
 - a) Do not put any lubricant on the disk or disk stem.
27. Place the base seal onto the inlet base. See Figure 53.

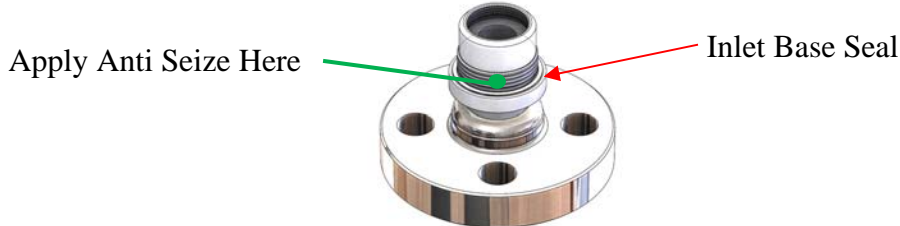


Figure 53: Bottom Entry Inlet Base

28. Put a small amount of anti-seize on the threads of the inlet base that get screwed into the body. See Figure 53.
29. While still holding the body of the valve upside down, finger tighten the inlet base subassembly threads into the body while making sure all internal parts remain aligned. Also, make sure that the inlet base seal is centered on the inlet base and body and is not getting bent or caught on anything.
30. Tighten the inlet base to the body:
 - a) For threaded valve bodies,
 - i) Tighten the inlet base to the appropriate value as shown in Table 6.
 - b) For flanged valve bodies,
 - i) Tighten the inlet flange into the valve body to the point where the notch in the body for the inlet flange keeper aligns with the center of the inlet keeper holes in the inlet base. The inlet base seal should be getting squeezed between the body and inlet base at this point.
 - ii) Install the inlet keeper onto the inlet base.
 - iii) Screw in and tighten the two keeper bolts into the inlet keeper and inlet base. If the keeper bolts do not easily fit into the keeper, then the inlet flange alignment may still be askew. These bolts are tightened to the value shown in Table 8.

Table 8: Keeper Bolt Torque

Part	Torque, lbf-ft (N-m) \pm 5%
Keeper Bolt	25 (34)

31. Turn the valve upright.
32. If any pipe plugs/ fittings were removed, wrap their threads with 3 wraps of PTFE pipe fitting tape, reinstall them, and then tighten them approximately 2-3 turns past finger tight.
33. Turn the adjustment screw clockwise until resistance is felt; the spring is engaged. Turn the adjustment screw an additional 4-5 more times. This is increasing the compression on the spring.

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- a) If the has a lift lever option, utilize two jam nuts to turn and adjust the adjustment screw. See Figure 36. The jam nuts are tightened against each other to 100 lbf-ft (136 N-m).
34. Check the lift of the valve. Refer to section “**9 Test Equipment e) Lift Checking**”. The measured lift of the PRV should meet or exceed the minimum lift denoted in the NB-18 publication. If valve does not meet lift, disassemble and inspect parts.
35. Adjust the set pressure of the valve. See section “**15 Valve Setting Procedure**”.
 - a) If the PRV has a lift lever and jam nuts were used to turn the adjustment screw, the jam nuts are removed once set pressure is finalized.
36. Tighten the lock nut to the appropriate value listed in Table 7. Tighten by utilizing two wrenches, one on the lock nut and the other on the adjustment screw (or jam nut). The wrench on the adjustment screw (or jam nut) should be held stationary during tightening so that the adjustment screw does not turn and alter the spring compression.
 - a) If the PRV has a lift lever and jam nuts were used to turn the adjustment screw, the jam nuts will be removed once set pressure is finalized. See Figure 36.
37. Re-check the set pressure to verify set pressure is still as intended.
38. Conduct a leak check. See section “**8 Inspections; c) Leak Inspection**”.
39. Install cap and seal with lock wire. See Figure 3.
 - a) If the PRV has a lift lever option, use the following instructions listed in 14 c) step 9.
40. Reassembly is complete.

iii) Top Entry

1. Lightly apply a small amount of anti-seize to the threads of the adjustment screw. See Figure 45.
2. Thread the adjustment bushing onto the adjustment screw. This has left handed threads. Screw the adjustment bushing down onto the adjustment screw until approximately 2 threads of the adjustment screw are visible from the top. See Figure 54.

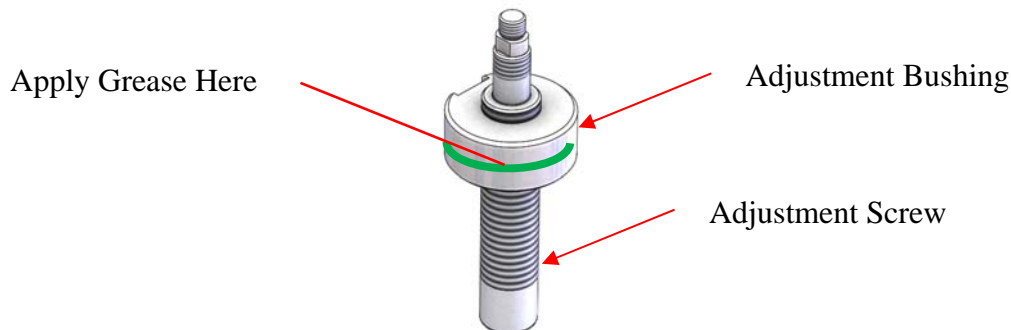


Figure 54: Adjustment Screw and Adjustment Bushing

3. Lightly lubricate the outer surface of the adjustment bushing. See Figure 54.
4. Carefully, slip fit the adjustment screw subassembly into the bore of the bonnet by aligning the index bracket (or pin) of the body with the notch of the adjustment bushing. The top shoulder of the adjustment screw should be against the top of the inner bonnet.

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- a) The adjustment bushing must slip into the valve bore freely but with little radial play.
 - 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.**
5. Lightly lubricate the adjustment screw o-ring.
 6. Carefully place the adjustment screw o-ring onto the adjustment screw making sure not to cut the o-ring. The o-ring should reside in a notch on the bonnet. See Figure 55.

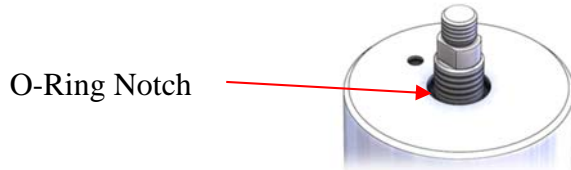


Figure 55: Top Entry Adjustment Screw O-Ring Notch

7. 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). See Figure 24.
8. Thread the lock nut onto the adjustment screw finger tight against the washer. Do not tighten fully.
9. Lightly lubricate the bonnet o-ring.
10. Place the bonnet o-ring over the bonnet. Be careful to not cut the o-ring. The o-ring should reside in a notch towards the bottom of the bonnet. See Figure 56.

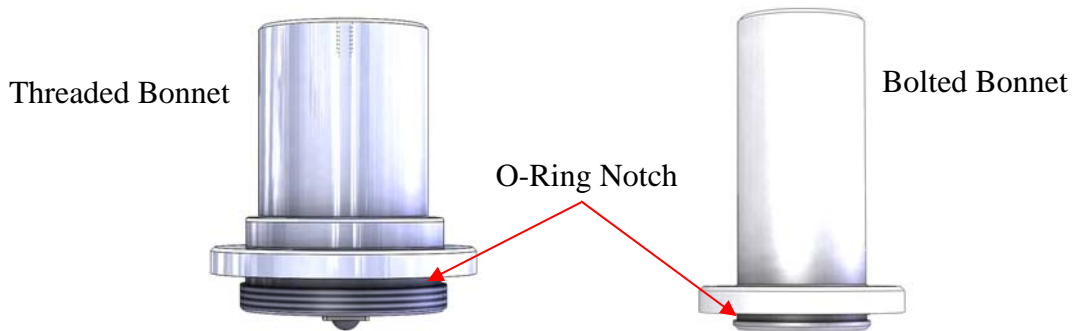


Figure 56: Top Entry Bonnet O-Ring Notch

11. If there was a guide sleeve removed during the disassembly of an N or P, this would need to be reattached to the bonnet.
 - a) Align the bolt holes of the guide sleeve and bonnet.
 - b) Apply a small amount of medium strength thread retainer to each mounting bolt.
 - c) Finger tighten all the guide sleeve bolts into the bonnet.
 - d) Tighten the guide sleeve bolts in an alternating star pattern to the appropriate value shown in Table 5.

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12. If you are converting from a K orifice to a J orifice, a conversion adapter will be required. This will need to be purchased separately and requires a special tool.
 - a) Apply a drop of high strength thread retainer to the outside threads of the conversion adapter.
 - b) Tighten the adapter to the appropriate value as shown in Table 5.
13. Lightly lubricate the nozzle base o-ring.
14. Install the nozzle base o-ring into the lower corner of the nozzle pocket. See Figure 57.

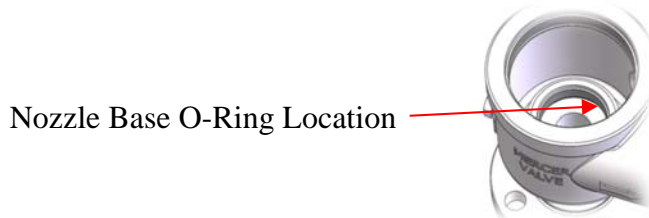


Figure 57: Top Entry Nozzle Base O-Ring Location

15. Lubricating the nozzle:
 - a) Threaded Nozzle – Put a small amount of anti-seize onto the bottom of the threads of the nozzle. See Figure 58.
 - b) Bolted Nozzle – Apply medium strength thread retainer to the bottom threads of each nozzle mounting bolt.



Figure 58: Anti-Seize Location on Nozzle

16. Installing the nozzle:
 - a) Threaded Nozzle – Finger tighten the nozzle into the nozzle base.
 - b) Bolted Nozzle – Place the nozzle into the nozzle base and align the mounting holes. Finger tighten each nozzle mounting bolt into the aligned holes.
17. Rigidly hold the body.
18. Tighten the nozzle:
 - a) Threaded Nozzle – Tighten the nozzle to the appropriate value as shown in Table 5.
 - b) Bolted Nozzle – Tighten each bolt in a star pattern to the appropriate value as shown in Table 5.
19. Hold the valve bonnet upside down.
20. Insert the disk subassembly's stem into the bore of the adjustment screw and simulate the valve opening operation. The disk stem must slide freely within the bore of the adjustment screw.
 - a) Do not put any lubricant on the disk or disk stem.
21. Remove the disk subassembly.

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22. Check and make sure the set spring slides over the disk or lower spring guide freely without sticking or binding.
23. With the body positioned upright, place the disk subassembly on the nozzle subassembly within the body cavity. The spherical portion of the disk should be in contact with the seat.
24. Place the lower spring guide on the disk (if one is present).
25. Place the set spring over the disk subassembly or lower disk guide.
26. If the bonnet is threaded type, place a small amount of anti-seize on the bonnet threads, which are used to connect the bonnet to the body. If the bonnet is bolted, skip this step.
27. Place the bonnet subassembly over the top of the body, making sure that the disk stem is inserted into the bore of the adjustment screw and the set spring is located around the adjustment screw. All parts should be axially aligned.
28. Attach the bonnet to the body.
 - a) Threaded Bonnet:
 - i) Finger tighten the bonnet to the body.
 - ii) Tighten the bonnet using the wrenching flats to the torque value specified in Table 9.

Table 9: Threaded Bonnet Torque Value

Orifice Sizes	Torque, lbf-ft (N-m) \pm 5%
H	500 (678)

- b) Bolted Bonnet:
 - i) Align the bolt holes of the bonnet and body.
 - ii) Apply anti-seize to each mounting bolt.
 - iii) Finger tighten all the bonnet bolts into the bonnet and body.
 - iv) Tighten the bonnet bolts in an alternating star pattern to the appropriate value shown in Table 10.

Table 10: Bonnet Bolt Torque Values

Bolt Size	Torque, lbf-ft (N-m) \pm 5%
5/8"-11	93 (126)
1"-8	287 (389)

29. If any pipe plugs/ fittings were removed, wrap their threads with 3 wraps of PTFE pipe fitting tape, reinstall them, and then tighten them approximately 2-3 turns past finger tight.

If the valve has a lift lever, go to section 14 d).

30. Turn the adjustment screw clockwise until resistance is felt; the spring is engaged. Turn the adjustment screw an additional 4-5 more times. This is increasing the compression on the spring. Use the flats of the adjustment screw to turn it.
 - a) If the PRV has a lift lever option, utilize two jam nuts to turn and adjust the adjustment screw. See Figure 41.

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31. Check the lift of the valve. Refer to section “**9 Test Equipment e) Lift Checking**”. The measured lift of the PRV should meet or exceed the minimum lift denoted in NB-18 publication. If valve does not meet lift, disassemble and inspect parts.
32. Adjust the set pressure of the valve. See section “**15 Valve Setting Procedure**”.
33. Tighten the lock nut to the appropriate value listed in Table 7. Tighten by utilizing two wrenches, one on the lock nut and the other on the adjustment screw (or jam nut). The wrench on the adjustment screw (or jam nut) should be held stationary during tightening so that the adjustment screw does not turn and alter the spring compression.
34. Re-check the set pressure to verify that the set pressure is as intended.
35. Conduct a leak check. See section “**8 Inspections; c) Leak Inspection**”.

If the valve has a lift lever, go to section 14 d) step 3.

36. Install cap and seal with lock wire. See Figure 3.
37. Reassembly is complete.

c) Lift Levers – Bottom Entry

If the center bushing was removed, begin with step 1. Otherwise, skip to step 5.

1. Place the index bracket over the center bushing. The bracket should be pointing downwards.
 - a. This only applies to 2” bodies.
2. Lightly lubricate the center bushing o-ring.
3. Carefully place the center bushing o-ring onto the center bushing, making sure not to cut the o-ring. The o-ring should reside in a notch on the center bushing. See Figure 49.
4. Install the center bushing and index bracket (for 2” bodies) over the top of the adjustment screw. See Figure 50.
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. See Figure 51.
7. Install and tighten the lift lever lock nut against the center bushing. When tightening, use the flats on the center bushing to stop the center bushing from turning. Tighten to the appropriate value shown in Table 7.
8. Thread the lock nut onto the adjustment screw finger tight against the center bushing. Do not tighten fully.

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Continue with assembling the bottom portion of the PRV in section 14 b)i) step 12 for 1” and in section 14 b)ii) step 14 for 2” bodies.

To install a lift lever cap, the PRV must have its set pressure adjusted first. Remove any jam nuts used.

9. Remove the two jam nuts.
10. Lubricate and place the seal adjustment nut o-ring over the lift lever rod. See Figure 59. If the valve has an open lift lever configuration, this step is omitted since there will not be an o-ring used.

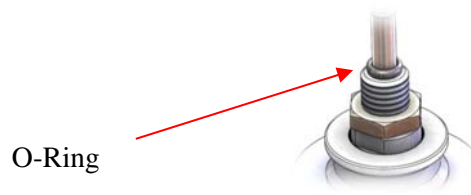


Figure 59: Lift Lever O-ring

11. Slip the seal adjustment nut over the lift rod and thread it onto the adjustment screw. The seal adjustment nut should be finger tightened so that the adjustment screw does not get turned.
12. Place the lift lever cap subassembly over the adjustment screw and lift lever lock nut with the orientation shown in Figure 60.
13. Insert and tighten the three lift lever cap set screws to the value listed in Table 11. See Figure 34.

Table 11: Lift Lever Cap Set Screw Torque

	Torque, lbf-ft (N-m) ± 5%
1/4”-20 Lift Lever Cap Set Screw	6.3 (8.6)

14. Thread the stem lift nut on the lift rod until its pin hole is aligned with the lift rod’s pin hole. It will be in light contact with the lift lever. Once installed, the lift lever should have some play in its action.
15. Insert the cotter pin through the two pin holes.
16. Slightly bend the end of the cotter pin so that it is captured within the lift rod and stem lift nut assembly.
17. Attach the seal wire through the small unused hole of the lift lever cap as shown in Figure 60.

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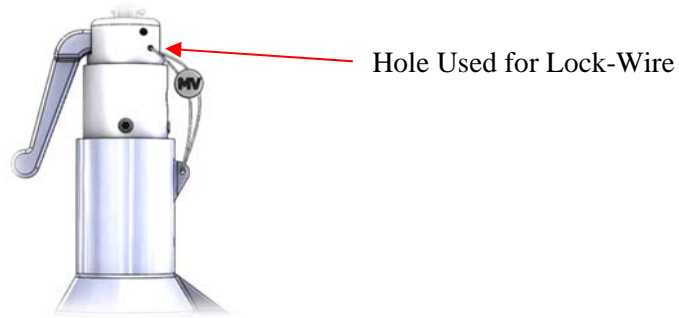


Figure 60: Lift Lever Orientation and Lock Wire

18. Reassembly is complete.

d) Lift Levers – Top Entry

1. Screw the two jam nuts onto the lift rod until the upper jam nut is flush with the top of the lift rod. See Figure 41.
2. Tighten them together by using two wrenches, one on each jam nut. Tighten these against each other to approximately 100 lbf-ft (136 N-m).

Return to section 14 b)iii) step 28.

3. Screw the stem lift nut onto the lift rod so that the cross holes of the lift rod and the stem nut are aligned.
4. Insert the cotter pin through the aligned hole and bend the sharp edge of the pin. See Figure 41.
5. Lubricate and place the lift cap o-ring over the lift rod and other parts so that it rests on top of the bonnet. See Figure 41.
6. Carefully, place the lift lever cap over the lift rod and other parts so that the o-ring and the bolt holes are all aligned with the cap.
7. Install the lift cap mounting bolts and tighten to the appropriate value shown in Table 12. See Figure 40. Apply anti-seize to each mounting bolt.

Table 12: Lift Lever Mounting Torque

	Torque, lbf-ft (N-m) ± 5%
1/4”-20 Mounting Bolts	6.3 (8.6)

8. Lubricate and place the pivot block o-ring in the lift lever cap as shown in Figure 39.
9. Carefully, place the pivot block on the lift cap by aligning the bolt holes.
10. Install the pivot block bolts and tighten to the appropriate value shown in Table 12. See Figure 38. Apply anti-seize to each mounting bolt.
11. Attach the lock wire and seal through the small holes as shown in Figure 38.
12. Reassembly is complete.

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15. Valve Setting Procedure

a) Cold Differential Set Pressure (CDTP)

High temperatures cause materials to relax and results in a set pressure change. Additionally, because the 9100 Series PRV is a conventional design, superimposed backpressure affects its set pressure. The Cold Differential Test Pressure (CDTP) is a compensation made to the set pressure for the temperature and any constant superimposed backpressure of the application's conditions. The CDTP is the pressure that the valve will open at when it's not exposed to the backpressure and temperature conditions, i.e. when the valve is being set on a test stand. The PRV will open at its set pressure in the service conditions. Variable superimposed backpressure cannot be accounted for with a CDTP.

The CDTP will be listed on the PRV's nameplate for the original set pressure conditions. If the valve's service has changed, the CDTP might need to be recalculated. For more information on calculating CDTP, contact Mercer Valve. When examining and calibrating the set pressure on a test bench, the CDTP is used. If the CDTP line on the nameplate is blank, there is not a CDTP for that PRV and it should be calibrated to its set pressure.

b) Setting the Valve

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

1. Rigidly connect the valve to a test fixture.
2. For Mercer 9100 Series PRVs, a crisp "pop" is the definition of set pressure for both liquid and gas/ vapor valves.
3. Increase the spring tension by turning the adjustment screw in the clockwise direction.
4. Slowly increase the pressure on the inlet side until it reaches the bench test pressure. If the valve pops before the bench test pressure is reached, increase the spring tension and again increase the pressure to the bench test pressure.
5. Slowly reduce the spring tension by turning the adjustment screw counter clockwise while keeping the system pressure at the bench test pressure. Turn until the valve "pops".
6. Verify the bench test pressure 3-4 more times, making any adjustments as needed. Verifying each "pop" should be no more than $\pm 1\%$ or ± 0.5 psi (3.5 kPa), whichever is greater, of the average of all the verifying pops.
7. While holding the adjustment screw still, tighten the locknut to the appropriate value listed in Table 7.
8. Re-verify the setting after the locknut has been tightened. Make any adjustments, as needed.
Install the cap and seal wire after leak check and back pressure checking.

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16. 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 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.



 UV	MERCER VALVE CO., INC.		
	PATENT # 4,799,506		
PN 91-55H11V78U1			
SIZE	1-1/2	IN	SET P. 100 PSI
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 61: Example Tag

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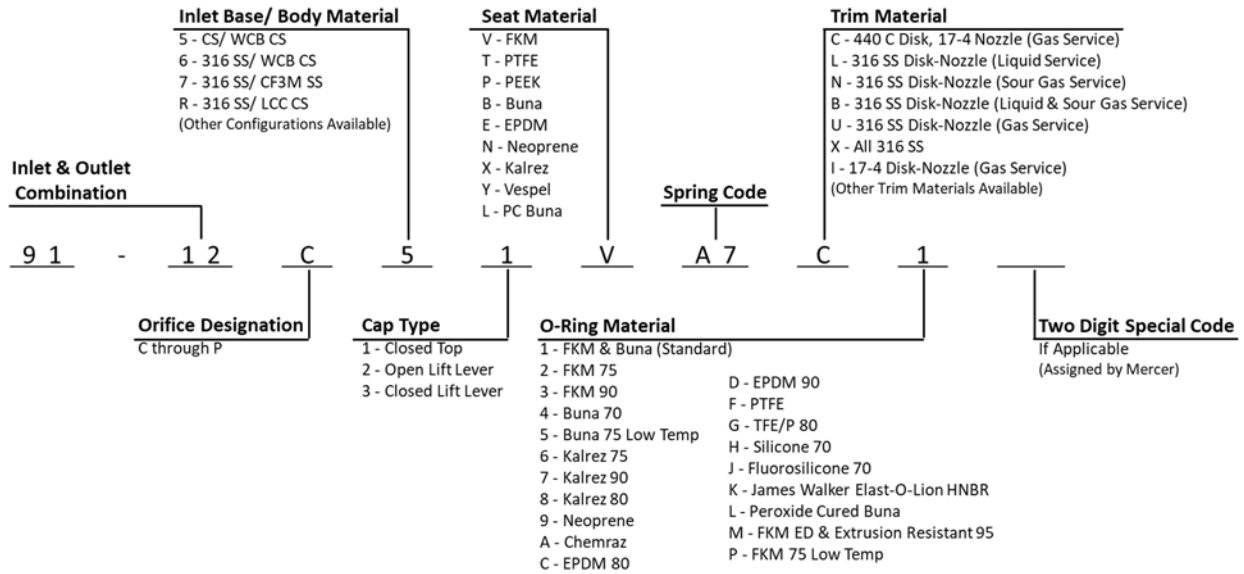
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17. Product Number System

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.

a) Valve Product Numbering

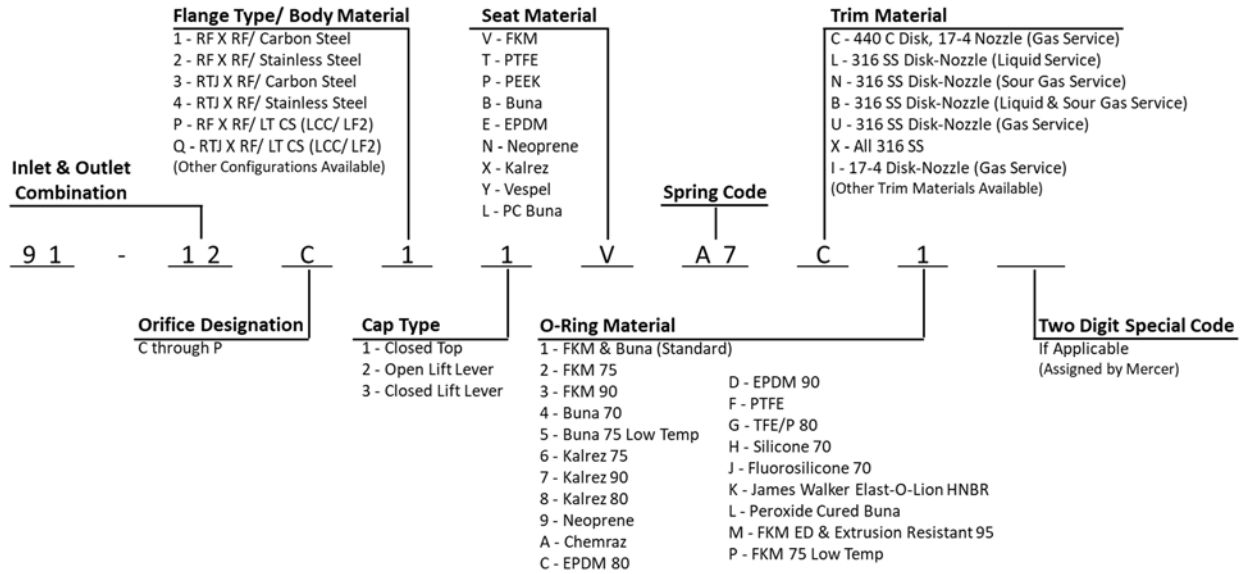
9100 Series Threaded



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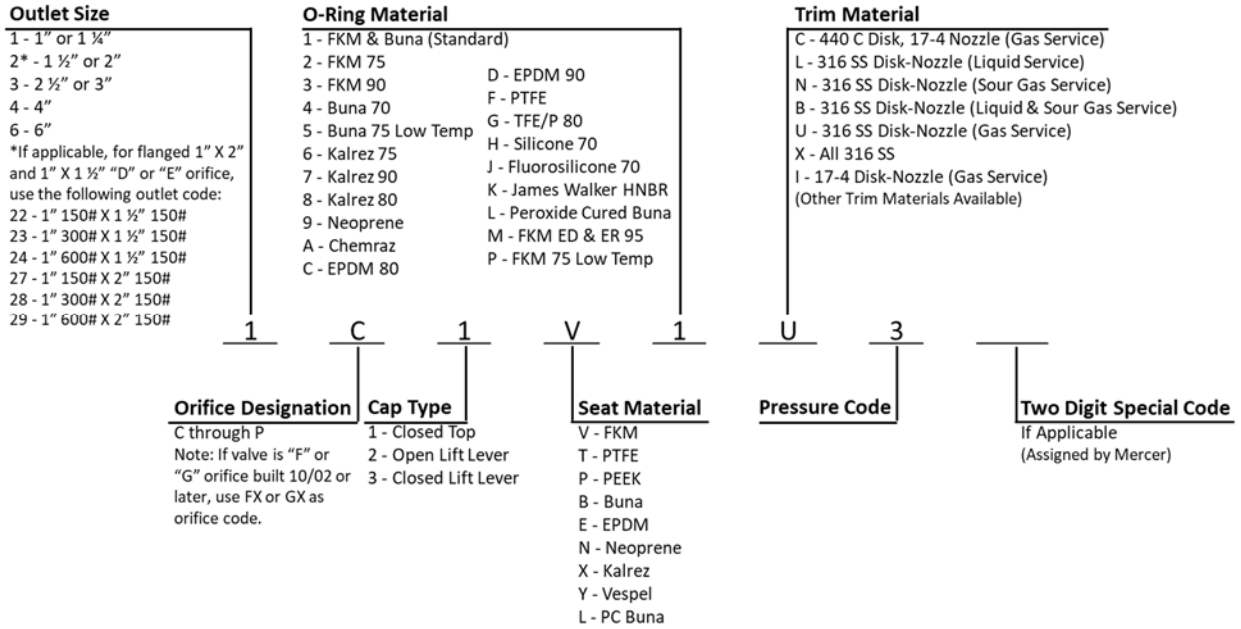
9100 Series Flanged



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b) Repair Kit Product Numbering



Parts Included in Repair Kit:

1. Nozzle Subassembly
2. Disk Subassembly
3. Base Seal (Bottom Entry Only)
4. O-ring Set

Parts Not Included in Repair Kit:

- Socket for installing/ removing nozzle subassembly
 - This may be specially ordered.
- Lubricants and adhesives

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18. Exploded Views

Bottom Entry - 1" Body

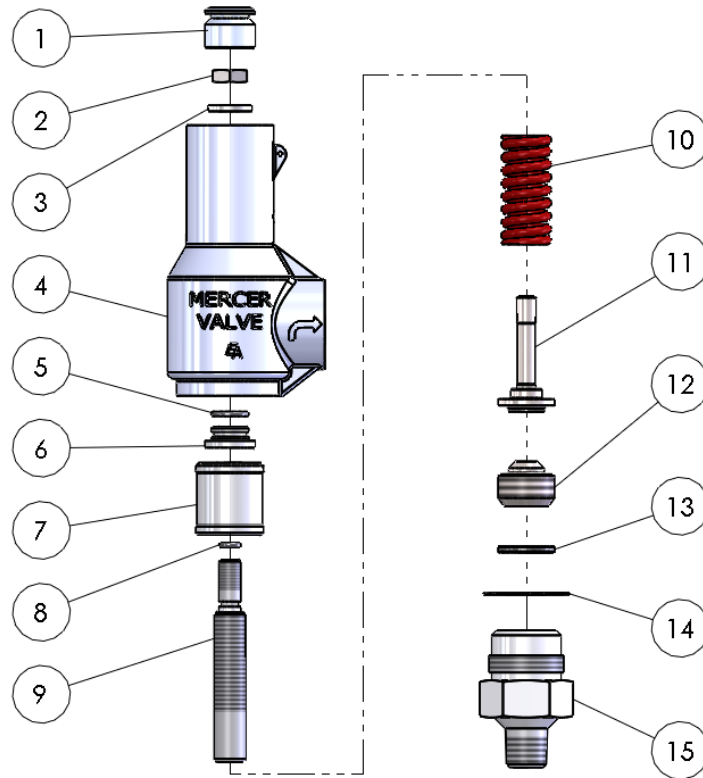


Figure 62: Exploded View of 1" Body

See Table 13 for part identification.

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Bottom Entry - 2" Body

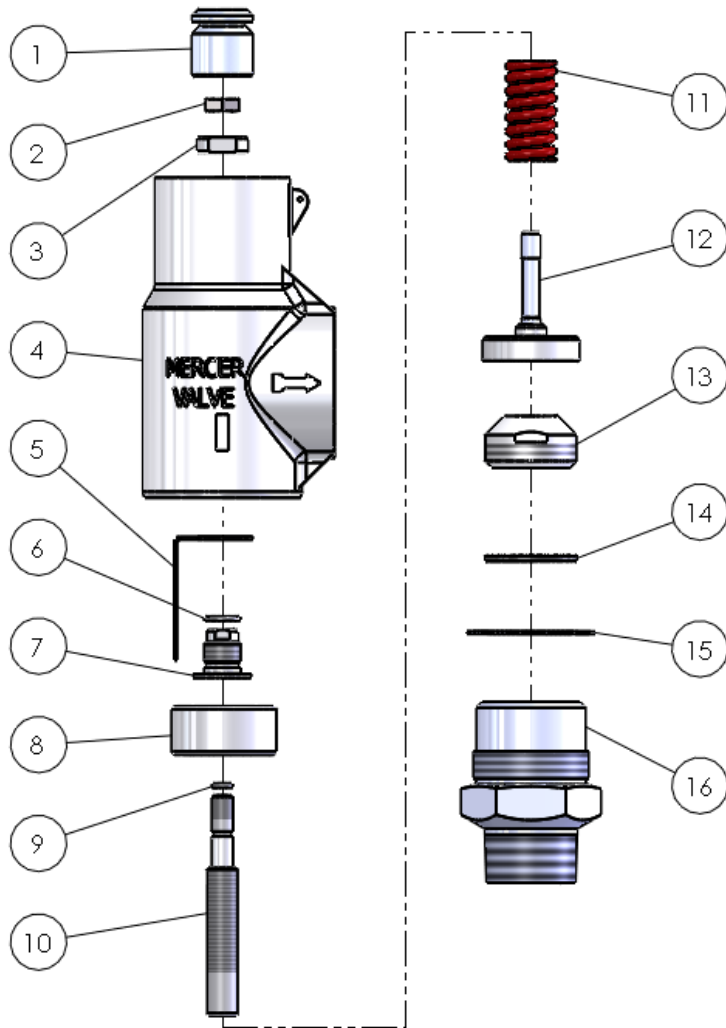


Figure 63: Exploded View of 2" Body

See Table 14 for part identification.

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Top Entry – Threaded Bonnet

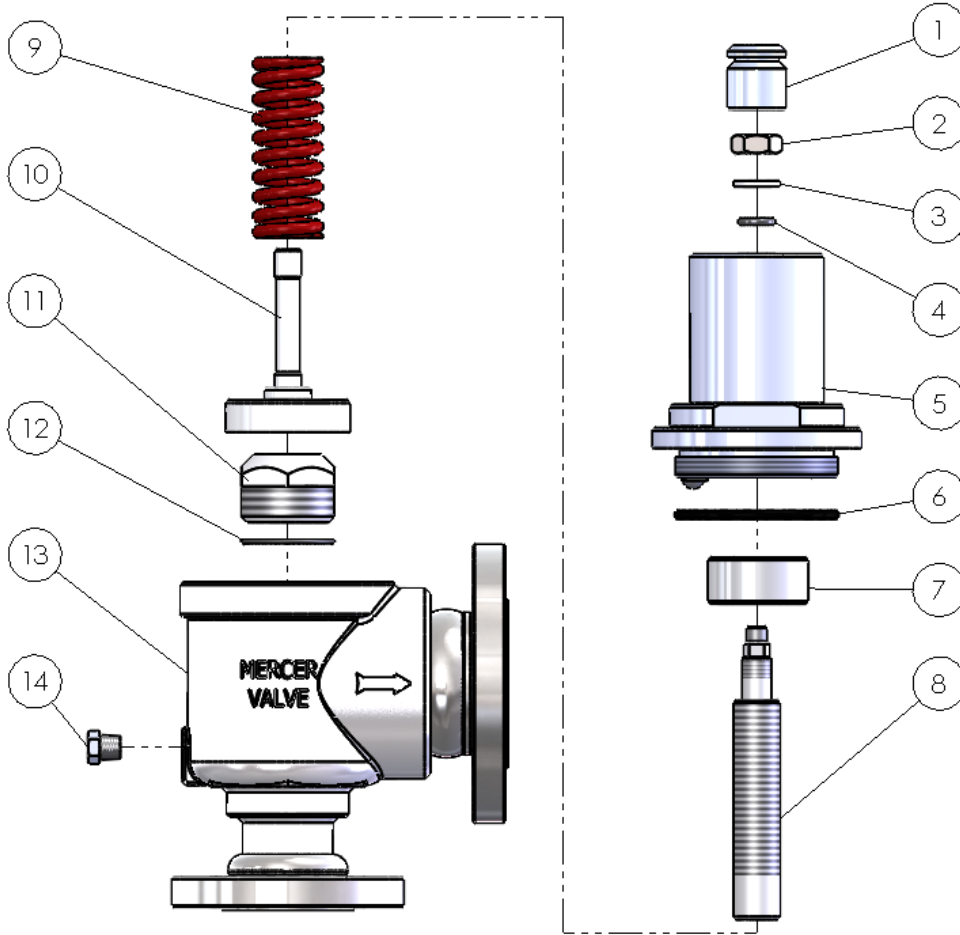


Figure 64: Exploded View of Top Entry Threaded Bonnet

See Table 15 for part identification.

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Top Entry – Bolted Bonnet

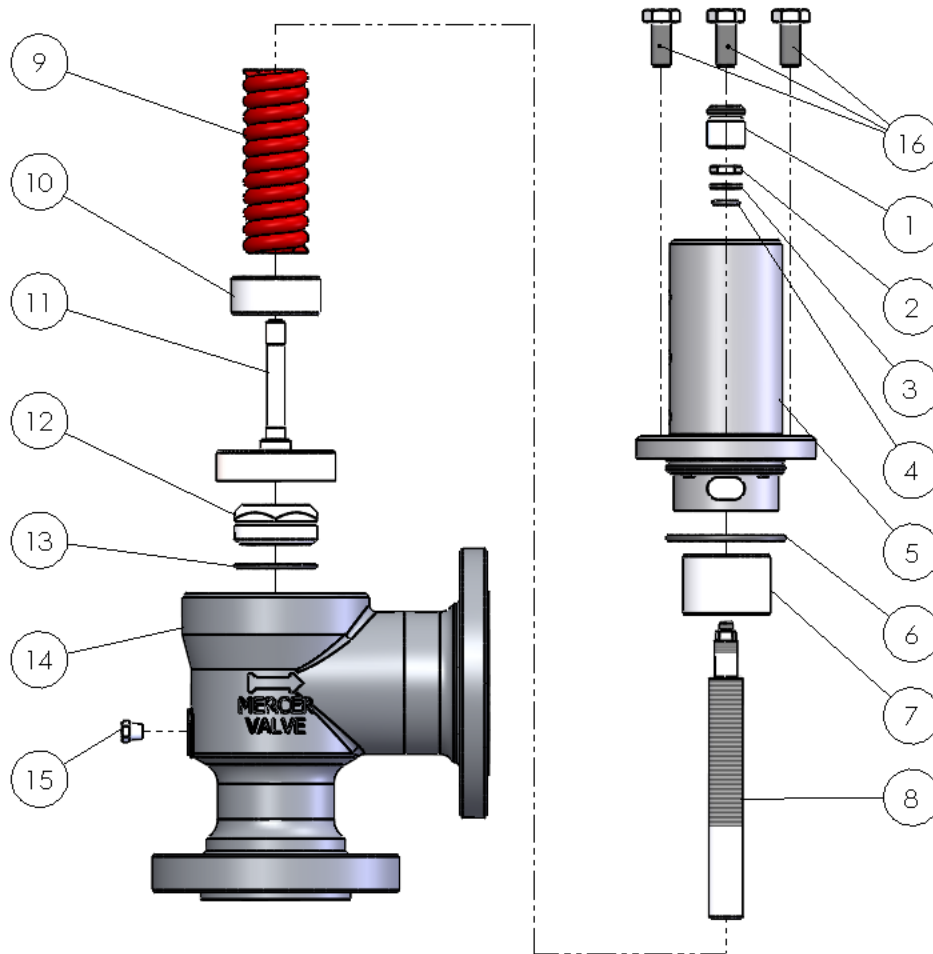


Figure 65: Exploded View of Top Entry Bolted Bonnet

See Table 16 for part identification.

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19. Cutaway View

Bottom Entry - 1" Body

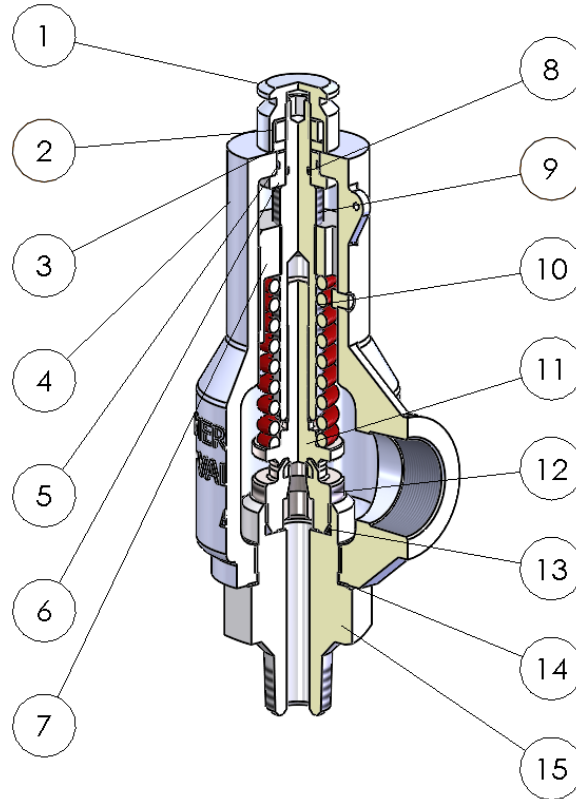


Figure 66: Cutaway View of 1" Body

Table 13: Part Identification of 1" Body

ITEM NO	PART NAME	ITEM NO	PART NAME
1	CAP	9	ADJUSTMENT SCREW
2	LOCKNUT	10	SET SPRING
3	WASHER	11	DISK SUBASSEMBLY
4	BONNET/BODY	12	NOZZLE/SEAT SUBASSEMBLY
5	CENTER BUSHING O-RING	13	NOZZLE BASE O-RING
6	CENTER BUSHING	14	INLET BASE SEAL
7	ADJUSTMENT BUSHING	15	INLET BASE
8	ADJUSTMENT SCREW O-RING		

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Bottom Entry - 2" Body

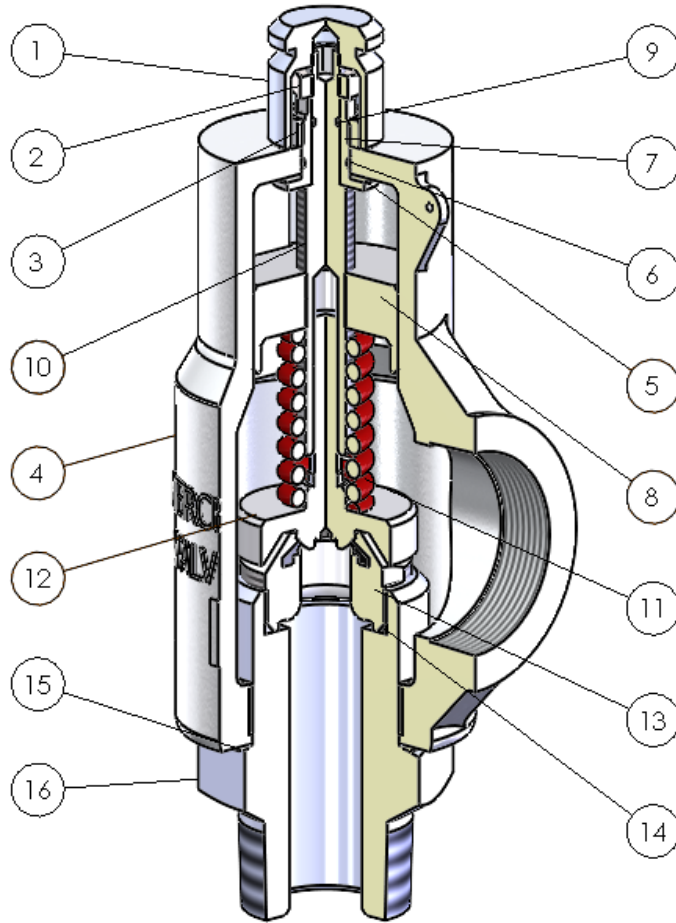


Figure 67: Cutaway View of 2" Body

Table 14: Part Identification of 2" Body

ITEM NO	PART NAME	ITEM NO	PART NAME
1	CAP	9	ADJUSTMENT SCREW O-RING
2	LOCKNUT	10	ADJUSTMENT SCREW
3	CENTER NUT	11	SET SPRING
4	BODY/BONNET	12	DISK SUBASSEMBLY
5	INDEX BRACKET	13	NOZZLE/SEAT SUBASSEMBLY
6	CENTER BUSHING O-RING	14	NOZZLE BASE O-RING
7	CENTER BUSHING	15	INLET BASE SEAL
8	ADJUSTMENT BUSHING	16	INLET BASE

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Top Entry – Threaded Bonnet

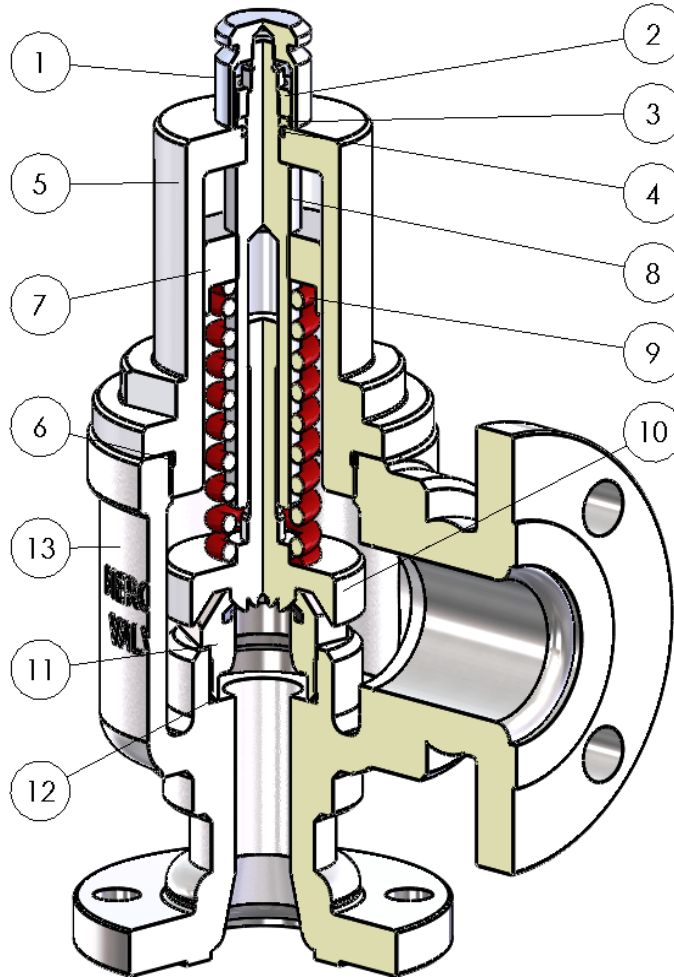


Figure 68: Cutaway View of Top Entry Threaded Bonnet

Table 15: Part Identification of Top Entry Thread Bonnet

ITEM NO	PART NAME	ITEM NO	PART NAME
1	CAP	8	ADJUSTMENT SCREW
2	LOCKNUT	9	SET SPRING
3	WASHER	10	DISK SUBASSEMBLY
4	ADJUSTMENT SCREW O-RING	11	NOZZLE/SEAT SUBASSEMBLY
5	BONNET	12	NOZZLE BASE O-RING
6	BONNET O-RING	13	BODY
7	ADJUSTMENT BUSHING	14	BODY PLUG

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Top Entry – Bolted Bonnet

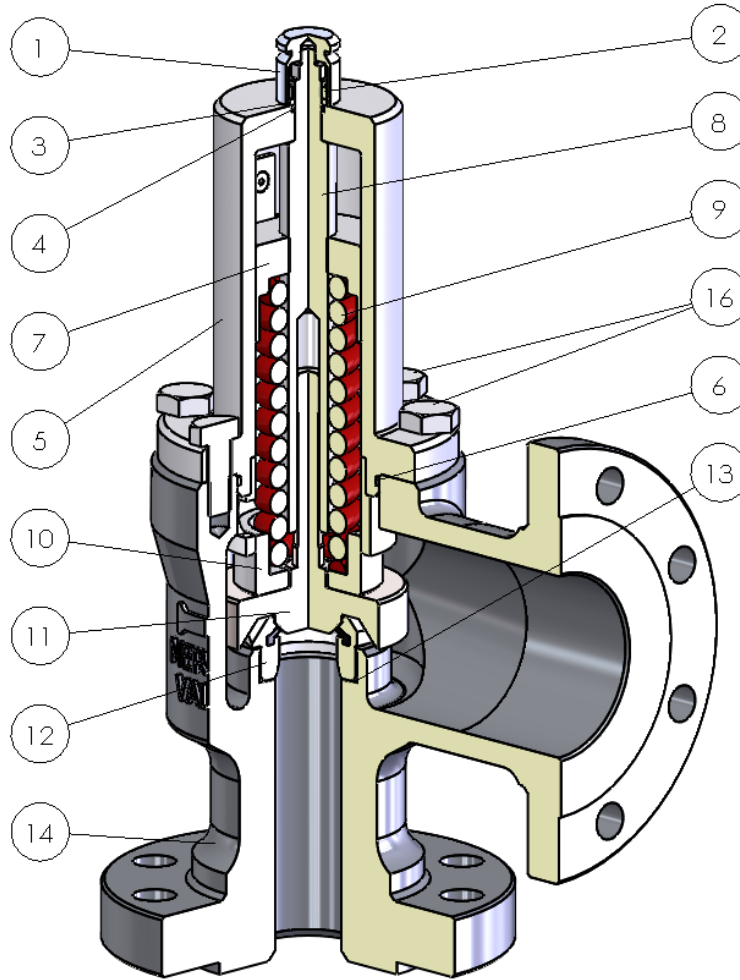


Figure 69: Cutaway View of Top Entry Bolted Bonnet

Table 16: Part Identification of Top Entry Bolted Bonnet

ITEM NO	PART NAME	ITEM NO	PART NAME
1	CAP	9	SET SPRING
2	LOCKNUT	10	LOWER SPRING GUIDE
3	WASHER	11	DISK SUBASSEMBLY
4	ADJUSTMENT SCREW O-RING	12	NOZZLE/SEAT SUBASSEMBLY
5	BONNET	13	NOZZLE BASE O-RING
6	BONNET O-RING	14	BODY
7	ADJUSTMENT BUSHING	15	BODY PLUG
8	ADJUSTMENT SCREW	16	BONNET BOLTS

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20. 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 valve.

- a) The disk is not initially fully seated against the nozzle.
 - i) Check for debris between the seat and disk.
- b) The soft seat or disk is damaged.
 - i) Inspect the disk and seat for any signs of abrasions or damages. Repair or replace, as necessary.
 - ii) Check media-material chemical compatibility.
- c) The nozzle base o-ring is leaking.
 - i) Disassemble and inspect the nozzle/ seat subassembly. Replace, as necessary.
- d) Valve is beginning to open (warning) because the operating pressure is approaching the set pressure.
 - i) Check the operating conditions.

2) The valve is relieving at a pressure lower than the set pressure tolerance allows. (Tolerance: -2 psi/ 15 kPa or -3% of set pressure, whichever is greater).

- a) The valve's settings are not correct.
 - i) Re-check the set pressure and adjust accordingly.
- b) The valve's seat is leaking.
 - i) Inspect the disk and seat for damages. Replace or repair, as necessary.
- c) Pressure pulses/ spikes are causing the valve to relieve.
 - i) Check and make sure the operating conditions are suitable for the valve.
- d) Vibrations are causing the valve to relieve.
 - i) Check and make sure the operating conditions are suitable for the valve.

3) The valve is relieving at a pressure higher than the set pressure tolerance allows. (Tolerance: +2 psi/ 15 kPa or +3% of set pressure, whichever is greater).

- a) The valve's settings are not correct.
 - i) Re-check the set pressure and adjust accordingly.
- b) The disk's movement is being impeded.

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- i) Inspect the inside of the valve, the set spring, and the bore of the adjustment screw for build up or damages.
 - c) Superimposed back pressure is causing the valve to remain closed.
 - i) Check and make sure the operating conditions are suitable for the valve.
- 4) The valve is remaining open after it relieves and won't return to the operating pressure.**
- a) Check and make sure the operating conditions are suitable for the valve. The recommended target maximum operating pressure is 15% below set pressure for gas service and 20% below for liquid service.
 - b) The disk's movement is being impeded.
 - i) Inspect the inside of the valve, the set spring, and the bore of the adjustment screw for debris build up or damages.
 - c) The disk or seat is damaged and is allowing large amounts of leakage.
 - i) Inspect the disk and seat for damages. Replace or repair, as necessary.
- 5) Valve is chattering.**
- a) Restrictions in either the inlet piping, outlet piping, or a combination of both are causing a pressure drop or build up.
 - i) Check and make sure that there are no restrictions within the inlet piping that would cause a pressure loss greater than 3% of the set pressure.
 - ii) Check and make sure that there are no restrictions within the outlet piping that would cause a pressure build up greater than the allowable over pressure of the valve.
- 6) Set pressure has too much variation.**
- a) Valve's components are dimensionally out of tolerance.
 - i) Check the critical dimensions.
 - ii) Check the spring to make sure it is correct for the set pressure and orifice.
 - b) Test equipment is providing false pressure readings.
 - i) Make sure the pressure gauges are calibrated.
 - ii) Verify that the test equipment is producing correct results. Consult NB23, Part 4, section 3.2.5.

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"AUTO SEAT TECHNOLOGY"®

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