MILTON ROY

Metallic Diaphragm Liquid End

INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

339-0077-000

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SECTION 1 – FUNCTIONAL DESCRIPTION

Milton Roy pumps are composed of two main assemblies: the pump drive and the pump liquid end. The drive generates the mechanical energy and the liquid end displaces the process chemical. This is an instruction manual for Milton Roy's Metallic Diaphragm liquid ends. This manual is designed to serve as a supplement to the appropriate pump drive instruction manuals: Milroyal B (339-0007-000), Milroyal C (339-0009-000) and Primeroyal R (339-0078-000), which provide both general information and specific instructions for installing, operating, and maintaining Milton Roy pumps. Do not rely on this manual alone when installing, maintaining and operating Milton Roy pumps.

1.1 PHYSICAL DESCRIPTION

The Metallic Diaphragm liquid ends combine all of the best characteristics of traditional liquid ends, with a sufficiently increased pressure and temperature capability, resulting in one technologically advanced design. These liquid ends are manufactured with a totally sealed hydraulic chamber, in combination with integral air bleed, high pressure relief and vacuum actuated refill systems. The metallic diaphragm liquid ends also come with an optional leak detection system that prevents process chemical contamination. These liquid ends can be constructed in variable materials, providing compatibility with a wide range of process liquids and chemicals. Along with serviceable diaphragms and removable check valves, the liquid end's design assures relatively simple maintenance and operation, making it the ideal choice for high temperature and high pressure processes in which downtime is critical.

1.2 PRINCIPLE OF OPERATION

The mechanical drive system of the pump drives the piston back and forth in the Metallic Diaphragm liquid end of the pump. The pump operating cycle consists of fluid being discharged from the liquid end and suctioned into it.

At the start of a suction stroke, the plunger is pulled out of the liquid end, increasing the volume of the chamber and thus lowering the pressure of the chamber fluid. This lower pressure causes the balls in the discharge check valve to seat and causes chemical to flow through the suction check valve into the liquid end. As the plunger is drawn back, the flexible diaphragm follows. With the discharge ball check closed, flow is prevented from flowing into the discharge line.

At the end of the suction stroke, the process reverses, beginning the discharge stroke. The plunger is then pushed into the liquid end, decreasing the volume of the chamber and thus raising the pressure in the chamber fluid. This higher pressure causes the balls in the suction check valve to seat and causes chemical to flow through the discharge check valve into the discharge line. The hydraulic oil presses against the diaphragm, flexing it forward. With the suction ball check closed, flow is prevented from flowing into the suction line. This suction/ discharge action is repeated with every stroke of the pump plunger.

With each stroke of the plunger, a small quantity of hydraulic oil is bled through the air bleed. In addition, a small amount of hydraulic oil leaks through the narrow clearance between the plunger and the plunger bore into the catch-all of the pump. This results in a shortage of hydraulic oil in the displacement chamber. On the suction stroke, the diaphragm will follow the plunger as it is pulled out of the chamber until the diaphragm hits the reverse side of the contoured cavity. At this point, the plunger will continue to be pulled out of the chamber causing a vacuum to be drawn in the hydraulic oil. This vacuum causes the refill valve to open, which replenishes the lost oil. In this manner, proper hydraulic balance is constantly maintained in the displacement chamber.

1.3 MODEL CODING

The presence of a Metallic Diaphragm liquid end on a Milton Roy pump is indicated by an "M" in the third position of the pump model code (xxM-xxx-xxxxxx). This model code can be found on the data plate attached to the pump. For more information on pump model coding and data plates, see the appropriate pump instruction manual.

1.4 SPECIFICATIONS

Steady State Accuracy/Turndown Ratio:
± 1% of pump full rated capacity over 10:1 turndown ratio

Liquid Temperature:
From -40°F to 800°F, dependent on liquid end

Minimum Suction Pressure:
Dependent on specific liquid end

Minimum Discharge Back Pressure:
35 psi above suction pressure

Maximum Discharge Back Pressure:
Up to 30,000 psi, depending on specific liquid end

Hydraulic Fluid:
Zurnpreen 15A - - Type A, ATF

Ball Checks:
Double ball checks in suction and discharge.

SECTION 2 - INSTALLATION

2.1 UNPACKING

Pumps are shipped f.o.b. from the factory and the title passes to the customer when the carrier signs for receipt of it. In the event that damages occur during shipment, it is the responsibility of the customer to notify the carrier immediately and to file a damage claim. The shipping crate should be carefully examined upon receipt from the carrier to be sure there is no obvious damage to the contents. Open the crate carefully, as there are sometimes accessory items fastened to the inside of the crate that may be lost or damaged. Examine all material inside crate and check against the packing list to be sure that all items are accounted for and undamaged.

2.2 STORAGE

Short Term Storage (Less than 6 Months)

It is preferable to store the material under a shelter in its original package to protect it from adverse weather conditions. In condensing atmospheres, follow the long-term storage procedure.

Long Term Storage (Longer than 6 Months)

The primary consideration in storage of pump equipment is to prevent corrosion of external and internal components. This corrosion is caused by natural circulation of air as temperature of the surroundings change from day to night, day to day, and from season to season. It is not practical to prevent this circulation which carries water vapor and other corrosive gasses, so it is necessary to protect internal and external surfaces from their effects to the greatest extent possible. When the instructions given in this section are completed, the equipment is to be stored in a shelter; protected from direct exposure to weather. The prepared equipment should be covered with a plastic sheet or a tarpaulin, but in a manner which will allow air circulation and prevent capture of moisture. Equipment should be stored 12 inches or more above the ground. If equipment is to be shipped directly from Milton Roy into long-term storage, contact Milton Roy to arrange for factory preparation.

Pump Drive

1. Remove motor and flood the gearbox compartment with a high grade lubricating oil/ rust preventative such as Mobile Oil Corporation product Mobilarma 524. Fill the compartment completely to minimize air space and water vapor condensation. After storage, drain this material and refill the equipment with the recommended lubricant for equipment commissioning.

2. Brush all unpainted metal surfaces with multi-purpose grease (NLGI grade 2 or 3). Store these unattached.

Electrical Equipment

1 Motors should be prepared in the manner prescribed by their manufacturer. If information is not available, dismount and store motors as indicated in step 3 below.

2 Dismount electrical equipment (including motors) from the pump.

3 For all electrical equipment, place packets of Vapor Phase Corrosion Inhibitor (VPCI) inside of the enclosure, then place the entire enclosure, with additional packets, inside a plastic bag. Seal the bag tightly closed. Contact Milton Roy Service Department for recommended VPCI materials.

2.3 SAFETY PRECAUTIONS

WARNING

WHEN INSTALLING, OPERATING, AND MAINTAINING A METALLIC DIAPHRAGM PUMP, KEEP SAFETY CONSIDERATIONS FOREMOST. USE PROPER TOOLS, PROTECTIVE CLOTHING, AND EYE PROTECTION WHEN WORKING ON THE EQUIPMENT AND INSTALL THE EQUIPMENT WITH A VIEW TOWARD ENSURING SAFE OPERATION. FOLLOW THE INSTRUC-

TIONS IN THIS MANUAL AND TAKE ADDITIONAL SAFETY MEASURES APPROPRIATE TO THE LIQUID BEING PUMPED. BE EXTREMELY CAREFUL IN THE PRESENCE OF HAZARDOUS SUBSTANCES, (E.G. CORROSIVES, TOXICS, SOLVENTS, ACIDS, CAUSTICS, FLAMMABLES, ETC.).

CAUTION

THE PERSONNEL RESPONSIBLE FOR INSTALLATION, OPERATION AND MAINTENANCE OF THIS EQUIPMENT MUST BECOME FULLY ACQUAINTED WITH THE CONTENTS OF THIS MANUAL.

ANY SERVICING OF THIS EQUIPMENT MUST BE CARRIED OUT WHEN THE UNIT IS STOPPED AND ALL PRESSURE HAS BEEN BLED FROM THE LIQUID END. SHUT-OFF VALVES IN SUCTION AND DISCHARGE SIDES OF THE LIQUID END SHOULD BE CLOSED WHILE THE UNIT IS BEING SERVICED. ACTIONS SHOULD BE TAKEN TO ELIMINATE THE POSSIBILITY OF ACCIDENTAL START-UP WHILE SERVICING IS TAKING PLACE. A NOTICE SHOULD BE POSTED BY THE POWER SWITCH TO WARN THAT SERVICING IS BEING CARRIED OUT ON THE EQUIPMENT. SWITCH OFF THE POWER SUPPLY AS SOON AS ANY FAULT IS DETECTED DURING OPERATION (EXAMPLES: ABNORMALLY HIGH DRIVE TEMPERATURE, UNUSUAL NOISE, AND DIAPHRAGM FAILURE).

2.4 MOUNTING

The Metallic Diaphragm liquid end is shipped already mounted to the appropriate pump. Mounting, therefore, is simply a matter of securing the pump to a safe, level surface. For further information on proper pump mounting, see the appropriate pump instruction manual:

Milroyal B..... 339-0007-000
Milroyal C 339-0010-000
Primeroyal 339-0078-000

2.5 PIPING CONNECTIONS

2.5.1 General

General piping instructions are given in the pump drive instruction manual. No reciprocating plunger pump can be expected to perform satisfactorily unless those recommendations are followed.

NOTE: Maximum safety and reliability may be ensured by protecting liquid ends and piping with an external relief valve installed in the system discharge line.

2.5.2 NPSH Considerations

Size the piping to accommodate peak instantaneous flow. Because of the reciprocating motion of the pump diaphragm, peak instantaneous flow is approximately equal to 5 times the average flow. For example, a pump rated for 16 gallons per hour (61 L/hr.) requires piping sufficient for 5 x 16 gph, or 80 gph (303 L/hr.).

To minimize viscous flow losses when handling viscous liquids, it may be necessary to use suction piping up to four times larger than the size of the suction connection on the pump. If in doubt, contact your nearest Milton Roy Company representative to determine the necessary pipe size.

2.6 TYPICAL PIPING

In order to adjust the Metallic Diaphragm relief valve, it is necessary to have a pressure gauge and a shut off valve installed in the discharge line. The pressure gauge must have a higher range than the desired pump relief pressure, and should be installed as close to the pump discharge connection as possible. The shut off valve should be installed downstream of the pressure gauge. These items are not required for normal operation, but for ease of pump maintenance and adjustment, it is suggested that they be permanently piped into the line.

Due to high system pressures, all metallic diaphragm pumps must have a filter installed in the suction line in order to protect the diaphragms from premature failure. The filter should be able to trap particles as small as 40 µm, and should have a pressure drop across the filter that is no greater than ½ psi at peak instantaneous flow.

Also see the instructions in the appropriate pump instruction manual for additional typical piping instructions.

SECTION 3 - OPERATION

3.1 INITIAL START-UP

After installing the pump and the Metallic Diaphragm liquid end, perform the following operations before placing the pump into service. The numbers in parenthesis refer to the bubble numbers shown in the attached figures.

WARNING

The pump could be damaged if the motor is run before all of the start-up steps have been completed. Do not run the motor until all start-up steps have been completed.

1. Parts may have shifted during shipping, so it is crucial that all pump, motor and liquid end attachment bolts be retightened prior to start-up. It is also crucial to realign the motor prior to starting, or damage could be done to the motor and coupling.

2. Disconnect the outlet tube from the air bleed valve (See Figure 1) and remove the air bleed valve from the liquid end. Make sure that the O-ring between the displacement chamber and the air bleed valve does not get lost or damaged, and that the opening in the displacement chamber remains clean.

3. Make sure that the capacity adjustment (hand knob or automatic control) is set at 100%.

4. Rotate the motor coupling until the piston and crosshead are in the full forward position (closest to pump liquid end).

   NOTE: It is important that the plunger be in the full forward position when the displacement chamber is filled with oil. If the displacement chamber is filled with the plunger fully rearward, the diaphragms could rupture at startup.

5. Fill the displacement chamber through the port uncovered by the removal of the air bleed valve in step 1 with the hydraulic oil furnished with the pump (Zurnpreen 15A). Fill the chamber slowly, allowing air bubbles to escape, until the oil level reaches the very top. It may be helpful to pulse the motor for a few seconds to dislodge any air that may be in the displacement chamber. Repeat this process until air bubbles cease to come out of the port.

CAUTION

This process could cause oil to shoot out of the open port. Take appropriate pre-cautions.

6. If the motor was pulsed, make sure to rotate the coupling so that the plunger and crosshead are returned to their full forward position. Replace the air bleed valve and tighten snugly.

7. Remove the catch-all cover (see Figure 1), which is a small square cover over the front chamber of the pump, and fill the chamber with hydraulic oil (same oil as used in step 4) to a level equal to the top of the oil seal which surrounds the crosshead.

8. Replace the air bleed valve outlet tube and the front chamber cover. The gasket has an adhesive backing that should be removed, and the gasket should be firmly attached to the cover using this adhesive.

9. The pump liquid end hydraulic oil servicing is now complete.

10. Before placing pump into operation, please refer to the drive instruction manual furnished along with this manual, which covers the lubrication instructions for the pump gear box, the instructions for bleeding all air from the suction piping and pump head, and for proper direction of motor rotation.

11. Do not start up pump drive motor before filling gearbox with oil or serious damage will occur.

12. If your particular metallic diaphragm liquid end has a minimum suction pressure requirement, **make sure that the priming pump is running prior to starting your metallic diaphragm pump.** Failure to do so could result in premature failure of the diaphragms.

3.2 RELIEF VALVE ADJUSTMENT

All Metallic Diaphragm liquid ends have a built in relief valve that allows hydraulic fluid to return to the hydraulic fluid reservoir if excessive pressure builds up in the discharge line or inside the liquid end. This effectively stops the pump from pumping, since the forward stroke of the piston will not displace the hydraulic fluid and force the diaphragm to flex. Please read the "Principle of Operation" for more information.

The relief valve may be adjusted to operating conditions by the following procedure. Adjust the relief valve after first installing the pump and after any maintenance procedures.

WARNING

The pressure relief valve (see Figures 1 and 9) is factory set to open at a pressure slightly above the pump maximum operating discharge pressure; never set the valve at any greater pressure.

1. A pressure gauge and shut off valve must be installed in the discharge line to complete this procedure. If the necessary equipment is not installed, refer to the "Typical Piping" instructions in Section 2.

2. Make sure the shut off valve is open. Start the pump and pump the process liquid to a drain or other safe point to establish proper pumping action.

3. Slowly throttle the shut off valve, while observing the pressure increasing on the gauge. Continue to throttle the shut off valve until the desired relief pressure is obtained. If you are unable to reach the desired pressure due to leakage past the relief valve, tighten the relief valve adjustment nut (50-12) in the clockwise direction to increase its setting. If you obtain the desired pressure without any leakage past the relief valve, then loosen the adjustment nut in the counter-clockwise direction until the gauge pressure begins to decrease. Continue throttling the shut off valve to determine the peak pressure. If the pressure exceeds the desired value, quickly open the shut off valve to relieve pressure and loosen the adjustment nut. **It is recommended that the relief valve be set at a pressure of 15% over the operating pressure.**

   Note: The relief valve may begin leaking at pressures less than the maximum setting, so do not assume that the maximum pressure has been obtained when leakage begins.

WARNING

Do not leave the pump operating unattended with the shut off valve closed! Excessive pressure can build quickly, possibly causing severe damage to the pump and/or piping. Since the relief valve is not yet properly adjusted, it can not be relied on to limit excessive pressure build-up. Be sure to watch the pressure gauge very carefully and open the shut off valve immediately if excessive pressure develops.

4. After setting the relief valve, make sure that the shut off valve is fully opened. Remove the pressure gauge from the line or leave it in place, as desired.

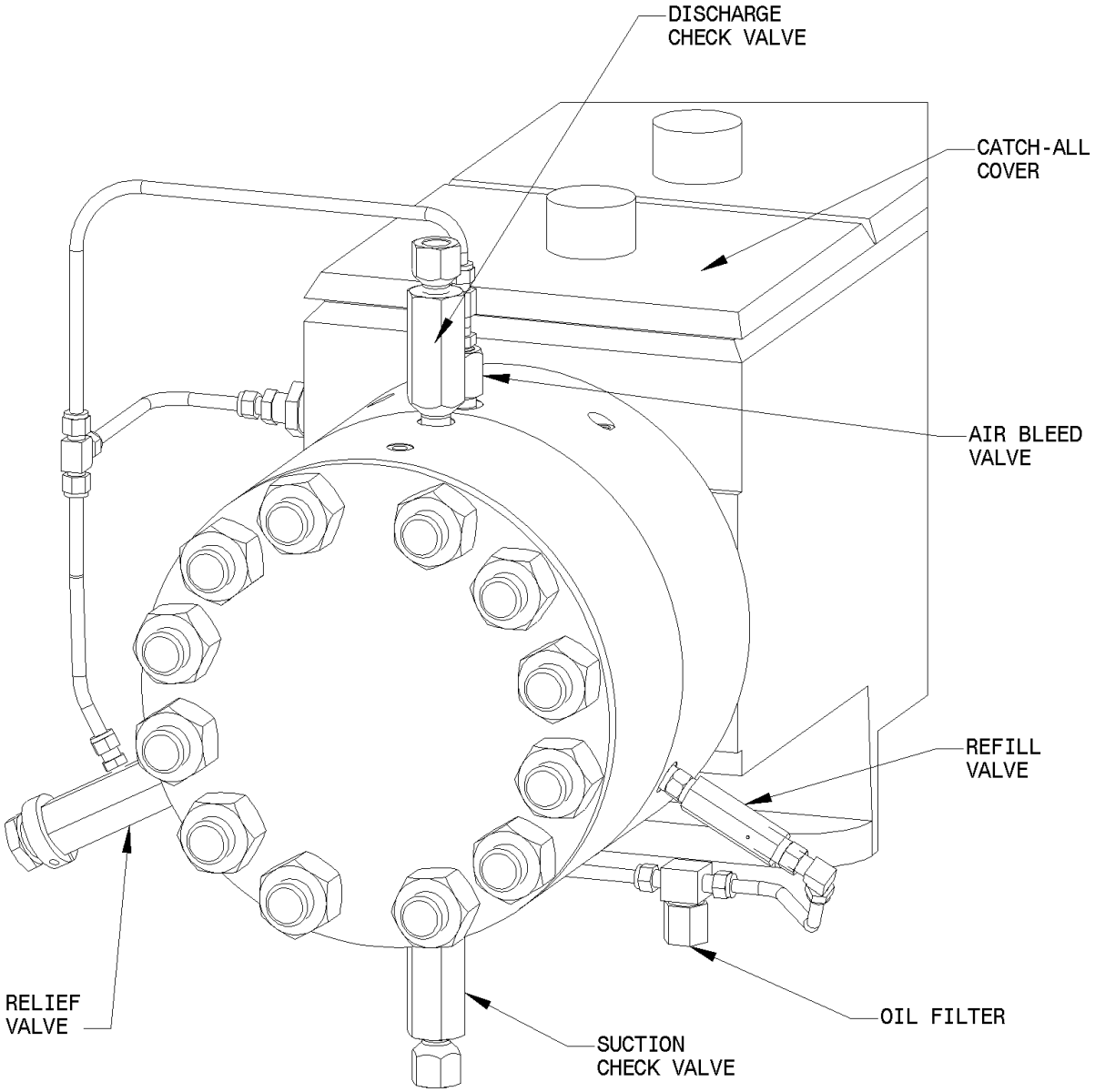


Figure 1: Metallic Diaphragm Liquid End

SECTION 4 - MAINTENANCE

This section contains procedures for disassembly and assembly of the Metallic Diaphragm liquid end, plus procedures for preventive and corrective maintenance. To maintain the reliability, durability, and performance of your pump and related components, it is essential to follow these procedures exactly and carefully. For consistent, reliable performance, replace any O-rings or other seals that you remove. Whenever you disconnect any fluid piping, cover all open ports in the pump assembly to prevent dirt from entering.

4.1 RECOMMENDED SPARE PARTS

Be Prepared. To avoid delays in repairs, Routine Preventive Maintenance (RPM) Kits should be ordered for each pump. The RPM kits contain replacements for those parts that are subject to wear; specifically the ball checks, check valve seats, gaskets, O-rings, diaphragms and the hydraulic fluid strainer. Replacing these parts annually with an RPM kit can reduce the possibility of unexpected downtime and will help to extend the pump life.

Parts orders must include the following information:

1. Quantity required
2. Part number
3. Part description
4. Serial number (found on nameplate)
5. Model number (found on nameplate)

Always include the serial and model numbers in all correspondence regarding the unit.

4.2 RETURNING UNITS TO THE FACTORY

Pumps will not be accepted for repair without a Return Material Authorization, available from the factory or other authorized Customer Service Department. Pumps returned to the factory for repairs should be clearly labeled to indicate the liquid being pumped. Process liquid should be flushed from the pump liquid end before the pump is shipped.

NOTE: Federal law prohibits handling of equipment that is not accompanied by an OSHA Material Safety Data Sheet (MSDS). A completed MSDS must be packed in the shipping crate with any pump returned to the factory. These safety precautions will aid the troubleshooting and repair procedure and preclude serious injury to repair personnel from hazardous residue in pump liquid end. A Material Safety Data Sheet must accompany all returns.

All inquiries on part order should be addressed to your local Milton Roy sales representative or sent to:

Parts Department
Milton Roy Company
Flow Control Division
201 Ivyland Road
Ivyland, PA 18974-0577
Phone: (215) 441-0800
Fax: (215) 441-8620

4.3 ROUTINE PREVENTIVE MAINTENANCE

WARNING

Before any maintenance, relieve all pressure from the system, isolate the liquid end from all sources of process liquid with appropriate valving, and purge the liquid end of all process liquid.

4.3.1 HYDRAULIC OIL REPLACEMENT

Inspect and replace the hydraulic oil and oil filter (See Figure 1) on the same schedule as the pump's gear drive lubricant (see the appropriate pump drive instruction manual for this information). The oil filter strainer is included in the RPM Kit, but can be ordered separately, if required. Semiannual replacement is recommended, and can be scheduled to coincide with seasonal oil changes.

To replace the hydraulic oil:

1. Remove the catchall cover by unscrewing the four screws which hold it on (see Figure 1).

2. Place a container under the pump catchall to catch the oil and unscrew the catchall drain plug.

3. When the oil has finished draining, make sure that the area around the drain hole is clean. Apply thread sealant to the drain plug and screw it back in securely.

4. Replace the strainer in the inline oil filter. See section 4.3.2.

5. Fill the catchall to the top of the oil seal that surrounds the crosshead with new, clean oil. Use Zurnpreen 15A hydraulic oil or an equivalent replacement.

6. Replace the catchall cover and screw it firmly in place.

NOTE: It is not necessary to purge the liquid end displacement chamber of oil during annual oil replacement.

7. Dispose of oil according to federal, state, or local codes that may apply.

4.3.2 HYDRAULIC OIL STRAINER REPLACEMENT

1. Drain the hydraulic oil according to steps 1-3 of section 4.3.1.

2. The oil filter (See Figure 1) is piped in-line just before the refill valve. Support the oil filter and loosen the large union nut with an open-end wrench.

3. Unscrew the union nut and remove the assembly. (Note: union nut, bonnet, spring and retaining ring remain together as an assembly.) Be careful not to loose the small metallic gasket.

4. Tap the strainer element lightly on the side with a nonmetallic object to break it loose from the tapered seating area.

5. Insert a new strainer element. Tap it lightly with a smooth faced tool to reseat the element in the tapered bore.

6. Inspect the gasket and mating surfaces on the bonnet and body. Clean as required.

7. Replace the bonnet assembly and tighten securely.

8. Refill the catchall with fresh hydraulic oil according to steps 5-7 of section 4.3.1.

4.3.3 CHECK VALVE MAINTENANCE

WARNING

Before performing any maintenance on the check valves, relieve all pressure from the system, isolate the liquid end from all sources of process liquid with appropriate valving, and purge the liquid end of all process fluid.

Refer to Figures 2-5 for the following procedures.

Disassembly

1. After insuring that all system pressure has been relieved and that all hazardous process liquids have been flushed from the liquid end, disconnect both the suction inlet and discharge outlet from the system piping.

2. Remove the check valves from the pump liquid end (see Figure 1).

3. Clamp the check valve body (290) in a vice and remove the retaining nut (250).

4. Remove the check valve body (290) from the vice and using a narrow rod, tap out the ball seats (220), ball cages (270), balls (280) and washer (245). The washer is not used in all designs, so it may not be found in your check valve. With the check valve body standing vertically on a flat surface, it will be necessary to tap out some of the components, remove them, and then continue taping out the rest.

5. Once disassembled, the O-rings (230) and back-up rings (240) on both of the seats (220) and the retaining nut (250) should be discarded.

6. Inspect the balls (280) carefully. If they are smooth, round and free of deposits or pits, then they are suitable for continued use. Examine the check valve seats (220). The area of the seat where it meets the ball (the un-chamfered side) must be in near perfect condition for continued use. Any imperfection visible on the seating surface (pits, erosion, cracks, or a ball shaped contour greater than 0.030 deep) makes

the seat unusable. If both the balls and seats are in good condition, then the length of time between parts replacement may be lengthened. If the balls and seats are severely damaged, then the length of time between parts replacement should be shortened. Note that the ball cages (270) are not included with the RPM kit. If these parts are damaged, they must be ordered separately.

Re-assembly

1. Install new O-rings (230) and back-up rings (240) onto the ball seats (220) and onto the retention nut (250), being sure to apply O-ring lubricant to the O-rings. **Note: some of the check valves use two back-up rings for each O-ring and others only use one back-up ring. Be sure to install the back-up rings as shown in the appropriate figure.**

2. Insert the washer (245), if applicable, ball seats (220), ball guides (270) and balls (280) into the check valve body (290), being sure to maintain the orientation as shown in the appropriate figure.

3. Apply anti-seize thread lubricant to the back-up nut (250) and insert it into the check valve body (290). Insert the check valve body in a vice and tighten the back-up nut. Do not over-tighten this nut.

4. Insert the O-ring (260) into the groove at the bottom of the check valve body (290), using O-ring lubricant.

5. Apply anti-seize thread lubricant to the check valve body (290) and insert the check valve into the diaphragm head, tightening snugly.

4.3.4 DIAPHRAGM AND SEAL REPLACEMENT

The metallic diaphragms are extremely durable and often last for many years of service. As a preventive measure, however, Milton Roy Company recommends that the diaphragms be replaced yearly to coincide with annual check valve replacement. Refer to Figures 6 and 7 for the following diaphragm replacement procedure.

Disassembly:

1. Stop the pump and relieve all pressure from the system. Isolate the liquid end from all sources of process liquid with appropriate valving and purge the liquid end of all process fluid.

2. Disconnect both the suction inlet and discharge outlet from the piping system.

3. Remove the catchall cover of the pump drive and drain the catchall of the hydraulic oil by removing the pipe plug at the bottom of the housing. (Note: Some oil will still be present in the displacement chamber, which will be released when the diaphragms are removed. Prepare your work area accordingly.)

4. Remove the check valves to prevent any damage.

5. Remove the diaphragm head nuts or bolts (90, 100) that hold the diaphragm head (120) to the displacement chamber (130) and remove the diaphragm head. Note: the diaphragm head can weigh several hundred pounds, so it should not be removed by hand. There are threaded holes provided in the head and displacement chamber for lift eyes.

6. Place the diaphragm head (120) on a flat surface, with the side containing the diaphragms at the top. Remove the 4 screws (370), which hold the diaphragms in place. Remove the diaphragms (380, 390, 380), O-ring (410) and back-up ring (400). Inspect and clean all sealing surfaces on the diaphragm head (120) and the displacement chamber (130).

Reassembly:

1. It is recommended that all O-rings, back-up rings and diaphragms be replaced when the diaphragm head (120) is removed. Install a new O-ring (410)—**do not apply any lubricant to the O-ring**. Install a new back-up ring (400) being sure that it fully fits into the groove and does not hang over the edge of the groove.

2. Place new diaphragms (380, 390, 380) into the recessed pocket one at a time, applying a thin layer of clean hydraulic oil between each

diaphragm. If the diaphragms have a slight curvature to them, orient them such that they create a cavity between themselves and the diaphragm head (120). **Be sure to put the diaphragm, which has small scribe lines on it (390), in the middle.** Orient the scribes about 22.5 degrees from the 4 bolt holes.

3. Secure the diaphragms with the 4 screws (370), tightening the screws finger tight only. **Be sure that the diaphragms are approximately centered in the cavity and that they do not hang over the edge of the recessed pocket.**

4. Install a new O-ring (430) into the displacement chamber (130)—**do not apply any lubricant to the O-ring**. Install a new back-up ring (420) being sure that it fully fits into the groove and does not hang over the edge of the groove.

5. Install a new O-ring (360) into the displacement chamber.

6. If the diaphragm head (120) is attached with studs (90) and nuts (100), as in Figure 6, then reinstall the diaphragm head (120) on the displacement chamber (130), using the studs as a guide. If the diaphragm head is attached with cap screws (90), as in Figure 7, then line up the diaphragm head with the displacement chamber, keeping a gap between the parts, and insert a few of the screws to act as a guide. Then slide the head against the chamber. It is important to line up the parts before they contact each other so that the diaphragms are not dislodged.

   Note: Be sure to apply anti-seize thread lubricant to the threads of the studs or screws.

7. Torque the nuts or screws (90, 100) in sequence, to one half of the final torque value, which is stamped on the diaphragm head (120) or found on the assembly drawing included with your pump. Follow the bolt torque pattern which may be stamped on the head, or according to Figure 8. Repeat the torque sequence with the full torque value two times. Do to the large torque values on many of the metallic diaphragm designs, it is recommended that the final torque value be applied twice, following the appropriate pattern.

   NOTE: It is essential that the correct torque value is used. Over-torquing can cause the diaphragms to seize up and can cause yielding of the diaphragm head. Under-torquing can cause the diaphragm head to separate, resulting in a failure of the O-ring seals.

8. If the check valves were removed, make sure that they were not switched and that the directional arrows on the check valve bodies (290) are pointing up. Verify that the O-rings (260) are in their grooves. Insert the check valves, being sure to apply anti-seize thread lubricant, and tighten snugly.

9. Reconnect the suction inlet and discharge outlet to the piping system.

10. Fill the liquid end with hydraulic oil (refer to the above "INITIAL START-UP" procedure).

4.4 CORRECTIVE MAINTENANCE

4.4.1 Relief Valve Assembly

The relief valve assembly operates in filtered hydraulic oil and should require maintenance only if unusual circumstances occur, such as if corrosive media contaminates the fluid, or if the relief valve was operating excessively. Refer to Figure 9 for the following procedures.

Disassembly:

CAUTION

The relief valve contains a compressed spring (50-7). The spring is normally completely unloaded when the adjustment nut (50-12) is unthreaded, but care should be used as the adjustment nut is removed.

1. Unlock the lock nut (50-10) and unthread the adjustment nut (50-12). Observe the precaution about the internal spring.

2. Remove the ball (50-9), spring retainer (50-8), spring (50-7), poppet (50-6) and ball (50-5) from the body (50-4).

3. Remove the back-up nut (50-1) at the valve inlet. Carefully remove the tungsten carbide seat (50-2) which is very hard and brittle. Do not drop the seat.

4. Inspect all parts, paying special attention to the seat (50-2) and ball (50-5) for wear and erosion. Replace any parts if necessary.

Reassembly:

1. Slide the tungsten carbide seat (50-2) into the body (50-4). Carefully tighten the back-up nut and torque to 70-75 ft.-lbs.

2. Assemble the spring retainer (50-8), spring (50-7) and poppet (50-6). Carefully place the ball (50-5) into the poppet. Carefully insert this assembly into the body (50-4), so as not to damage the seat (50-2).

3. Thread the adjustment nut (50-12), complete with the lock nut (50-10) and O-ring (50-11), into the body (50-4). Load the spring lightly.

4.4.2 Refill Valve Assembly

The refill valve assembly operates in filtered hydraulic oil and should require maintenance only if unusual circumstances occur, such as if corrosive media contaminates the fluid. See Figure 10 for the following procedure.

Disassembly:

1. Unscrew the retaining nut (80-6) from the body (80-1). Remove the spring (80-2), poppet (80-3), O-ring (80-4) and seat (80-5).

2. Clean and inspect all parts, paying special attention to the poppet (80-3) and seat (80-5) for wear. Replace any worn parts.

Reassembly:

1. Insert the poppet (80-3) and spring (80-2), making sure that the spring rests in the pocket of the body (80-1).

2. Insert the seat (80-5) and retaining nut (80-6). Torque to 50-55 ft.-lbs.

4.4.3 Air Bleed Valve Assembly

The air bleed valve assembly operates in filtered hydraulic oil and should require maintenance only if unusual circumstances occur, such as if corrosive media contaminates the fluid. See Figure 11 for the following procedure.

Disassembly:

1. Unscrew the inner body (320) from the outer body (340). Be careful not to lose the ball (310) and ball stem (330).

2. Remove the ball retainer (300) and ball (310).

3. Clean and inspect all parts, paying special attention to the balls (310) and the corresponding seats in the inner body (320). Replace any worn parts.

Reassembly:

1. Carefully drop the upper ball (310) into the inner body (320). Screw in the ball retainer (300) snugly.
2. Hold the inner body (320) upside down and drop in the ball stem (330), followed by the ball (310). Insert the O-ring (315).

3. While continuing to hold the subassembly upside down, screw it into the outer body (340). Torque to 50-55 ft.-lbs.

4.4.4 Liquid End Removal

Under normal operating conditions, it should not be necessary to remove the liquid end. If, however, corrosive media contaminates the hydraulic oil, causing excessive wear or ceasing of the plunger, this may be necessary. See Figures 6 and 7 for the following procedure.

Disassembly:

1. Stop the pump and relieve all pressure from the system. Isolate the liquid end from all sources of process liquid with appropriate valving and purge the liquid end of all process fluid.

2. Disconnect both the suction inlet and discharge outlet from the piping system.

3. Remove all tubing which connects the liquid end to the pump housing.

4. Remove the catchall cover of the pump drive and drain the catchall of the hydraulic oil by removing the pipe plug at the bottom of the housing.

5. Set the stroke adjuster to 100% and manually turn the motor until the plunger is at bottom dead center (the crosshead is furthest from the liquid end).

6. Remove the air bleed valve to relieve any hydraulic pressure. Cover the port to prevent any contaminates from entering the hydraulic system.

7. The Milroyal B drive uses a different plunger attachment mechanism than the Milroyal C and Primeroyal drives. For the Milroyal C and Primeroyal drives, unscrew the set-screws (170). On all drives, unscrew the plunger adapter nut (180) and move it away from the crosshead. Disengage the plunger (195, 200) from the crosshead and push the plunger into the liquid end until it bottoms out. Oil may be pumped out of the air bleed port. For Milroyal B drives, the thrust disk (165) will be loose inside the crosshead. Be careful not to loose it.

8. Attach an overhead crane to the liquid end, using lift eyes. Remove the nuts or screws which attach the liquid end to the pump housing and remove the liquid end, being careful not to bump the plunger into anything.

9. Withdraw the plunger (195, 200) from the liquid end. Inspect the plunger and the bore of the plunger sleeve (190). Both surfaces should be smooth and free of scoring (longitudinal grooves), excessive wear, or other irregularities. Replace any worn parts. The plunger and plunger sleeve are machined as a set and must be ordered together.

Reassembly:

1. Verify that the stroke adjuster is set at 100% and manually turn the motor until the plunger is at bottom dead center (the crosshead is furthest from the liquid end).

2. Coat the plunger (200) with clean hydraulic oil and insert it into the liquid end. The plunger should be free to slide in and out of the liquid end, but there should not be any noticeable side-to-side motion. Insert the plunger until it bottoms out in the liquid end.

3. Using an overhead crane, carefully lift the liquid end and mount it onto the pump housing. Attach it with the supplied hardware and tighten snugly.

4. **For Milroyal C and Primeroyal drives (See Figure 6):** Slide the plunger (200) into the crosshead and tighten the plunger adapter nut (180) until it bottoms out. Back the plunger adapter nut out about 1/8 of a turn and tighten the set-screws (170). The plunger should be free to rotate, and there should be minimal axial play (less than 1/64”). If the plunger does not rotate, remove the assembly and check for any foreign material.

5. **For Milroyal B drive (See Figure 7):** Arrange the thrust disk (165), floating retainer (160), plunger (195, 200) and plunger adapter nut (180) so that the thrust disk, plunger and floating retainer are contained inside the plunger adapter nut. Slide this assembly into the crosshead and tighten the plunger adapter nut until it has 2-3 threads of engagement. Using a small screwdriver, knock the floating retainer until it bottoms out inside the crosshead. Tighten the plunger adapter nut snugly. The plunger should be free to rotate, and there should be minimal axial play (less than 1/64”). If the plunger does not rotate, remove the assembly and check for any foreign material.

6. Install any tubing that was previously removed.

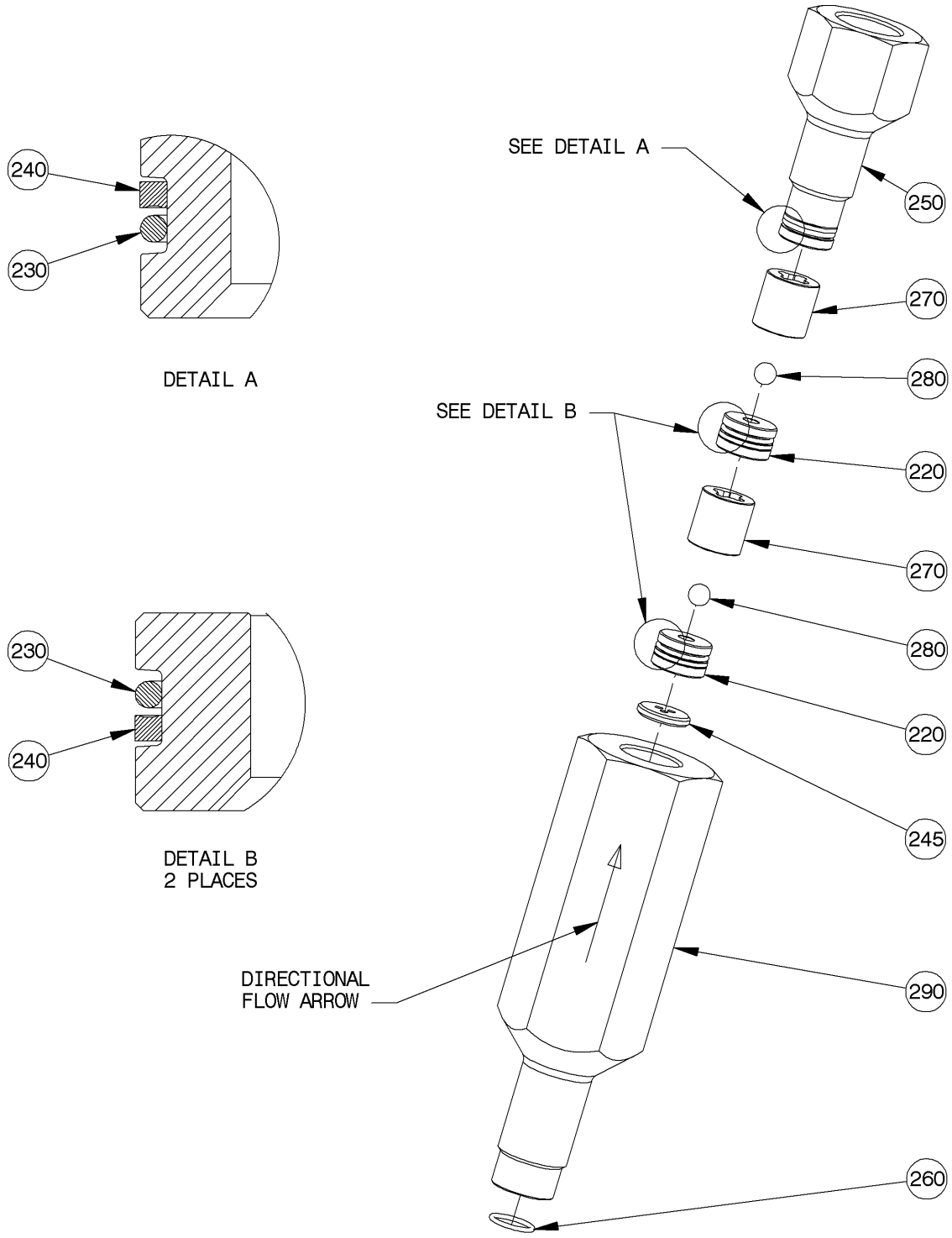


Figure 2: Discharge Check Valve, One Back-Up Ring

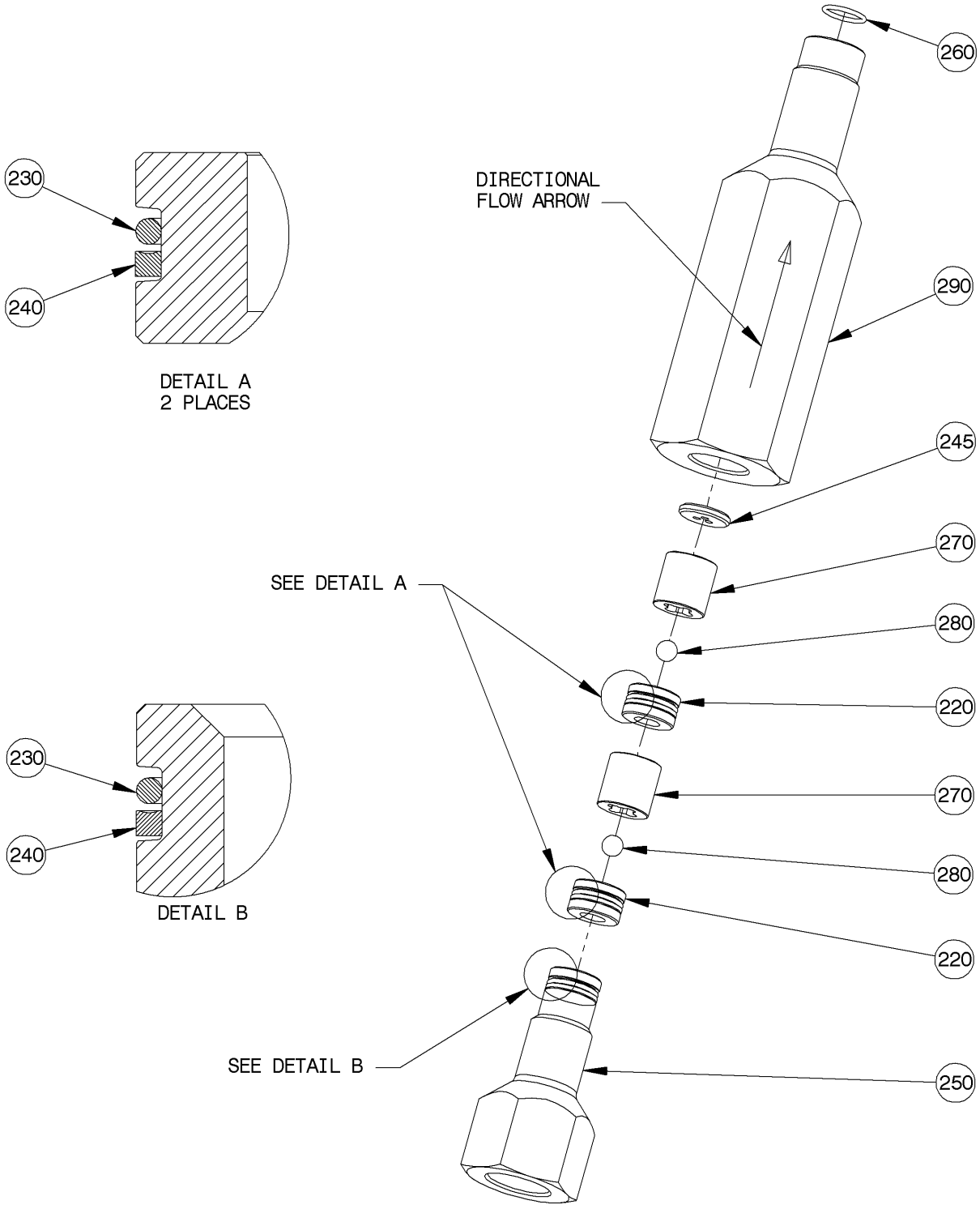


Figure 3: Suction Check Valve, One Back-Up Ring

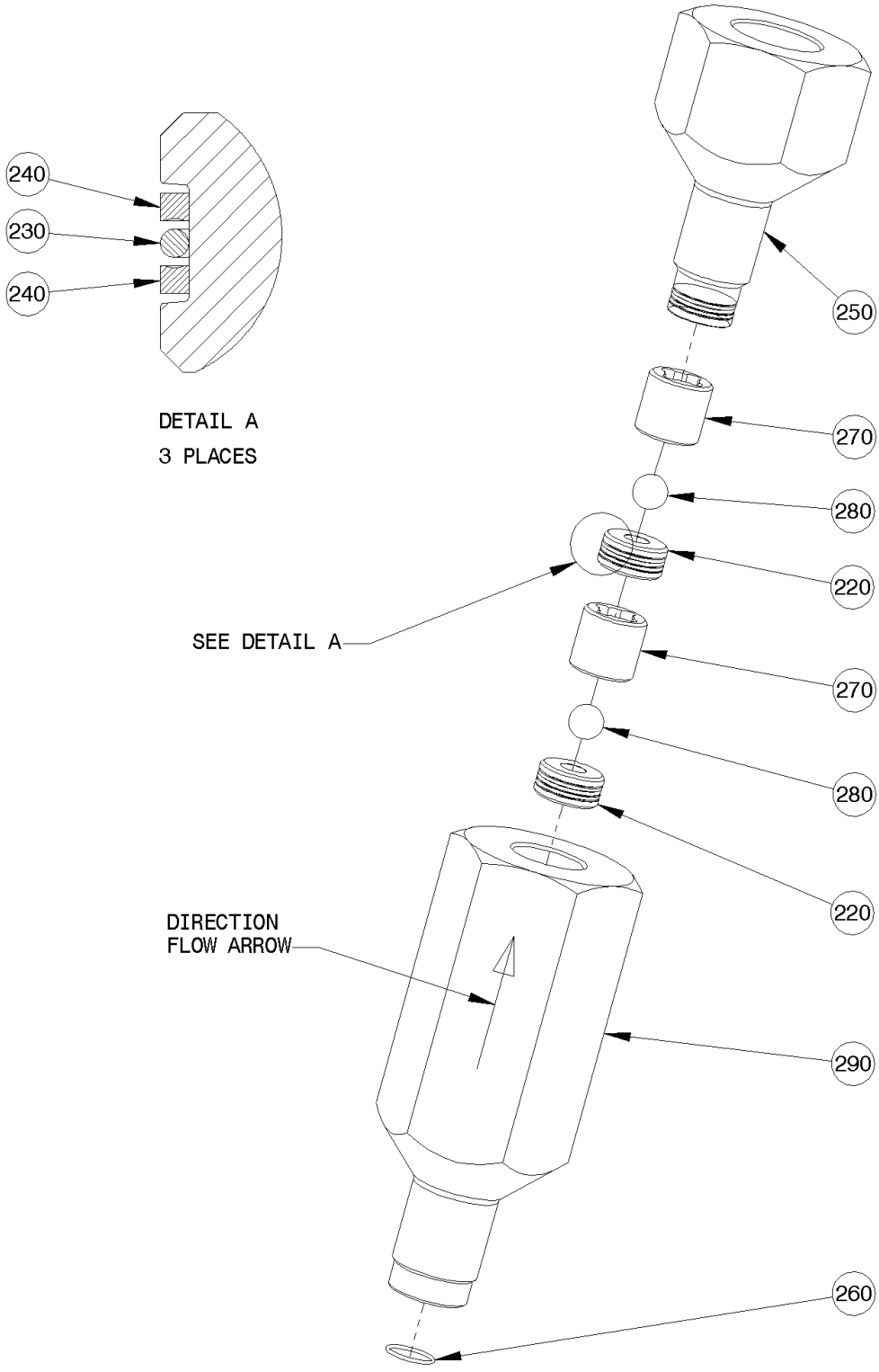


Figure 4: Discharge Check Valve, Two Back-Up Rings

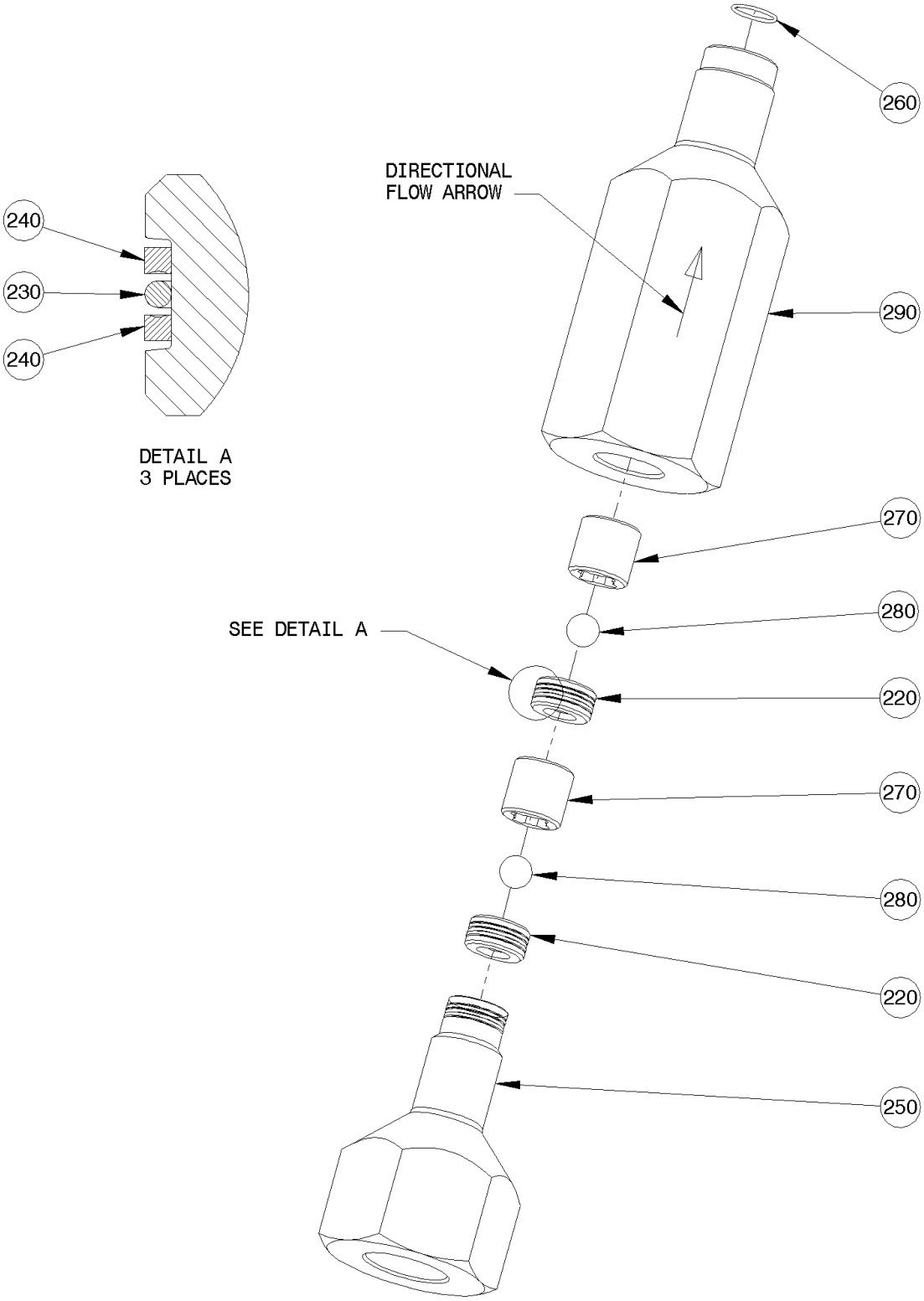


Figure 5: Suction Check Valve, Two Back-Up Rings

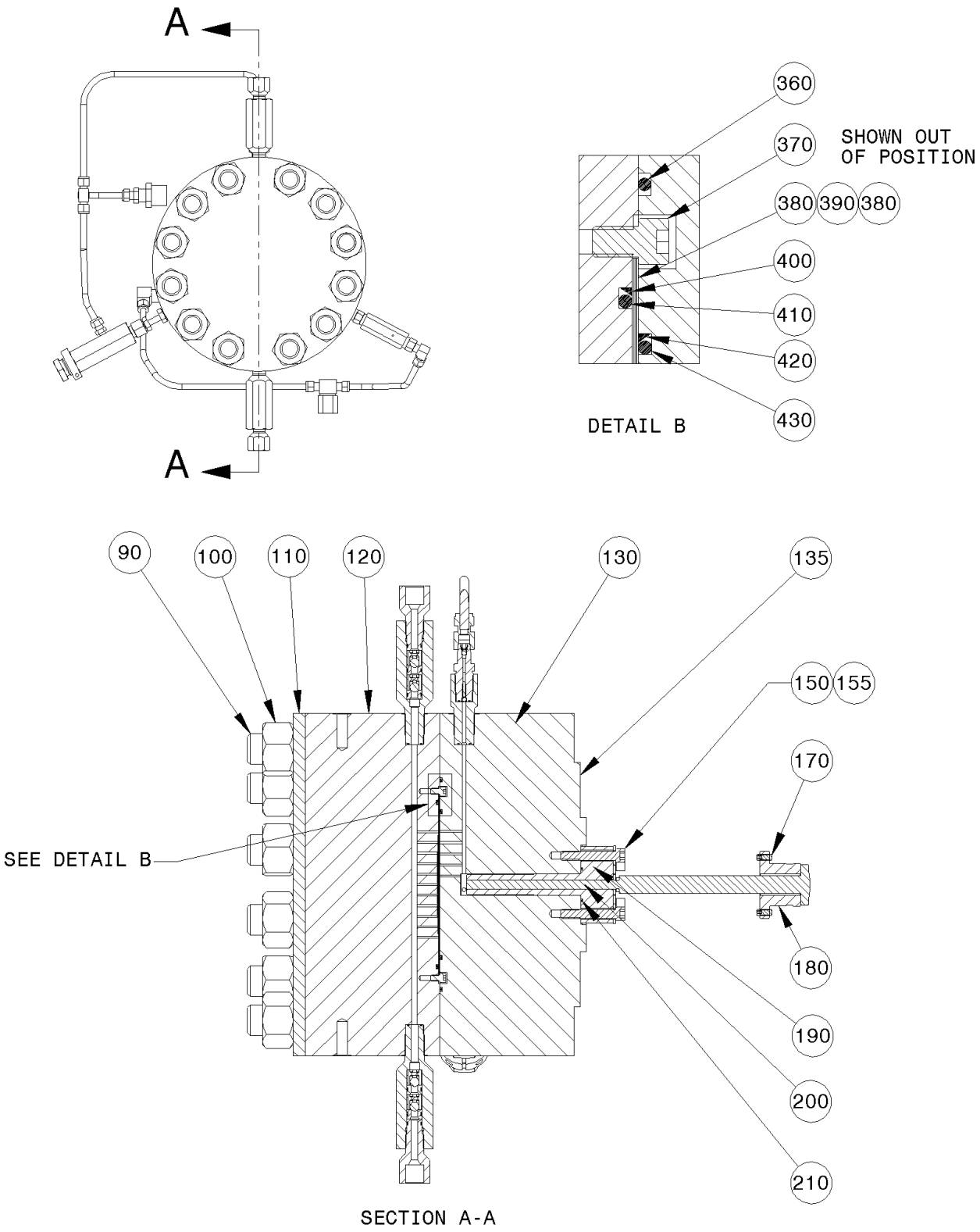


Figure 6: Cross Section of Liquid End (Milroyal C and Primeroyal)

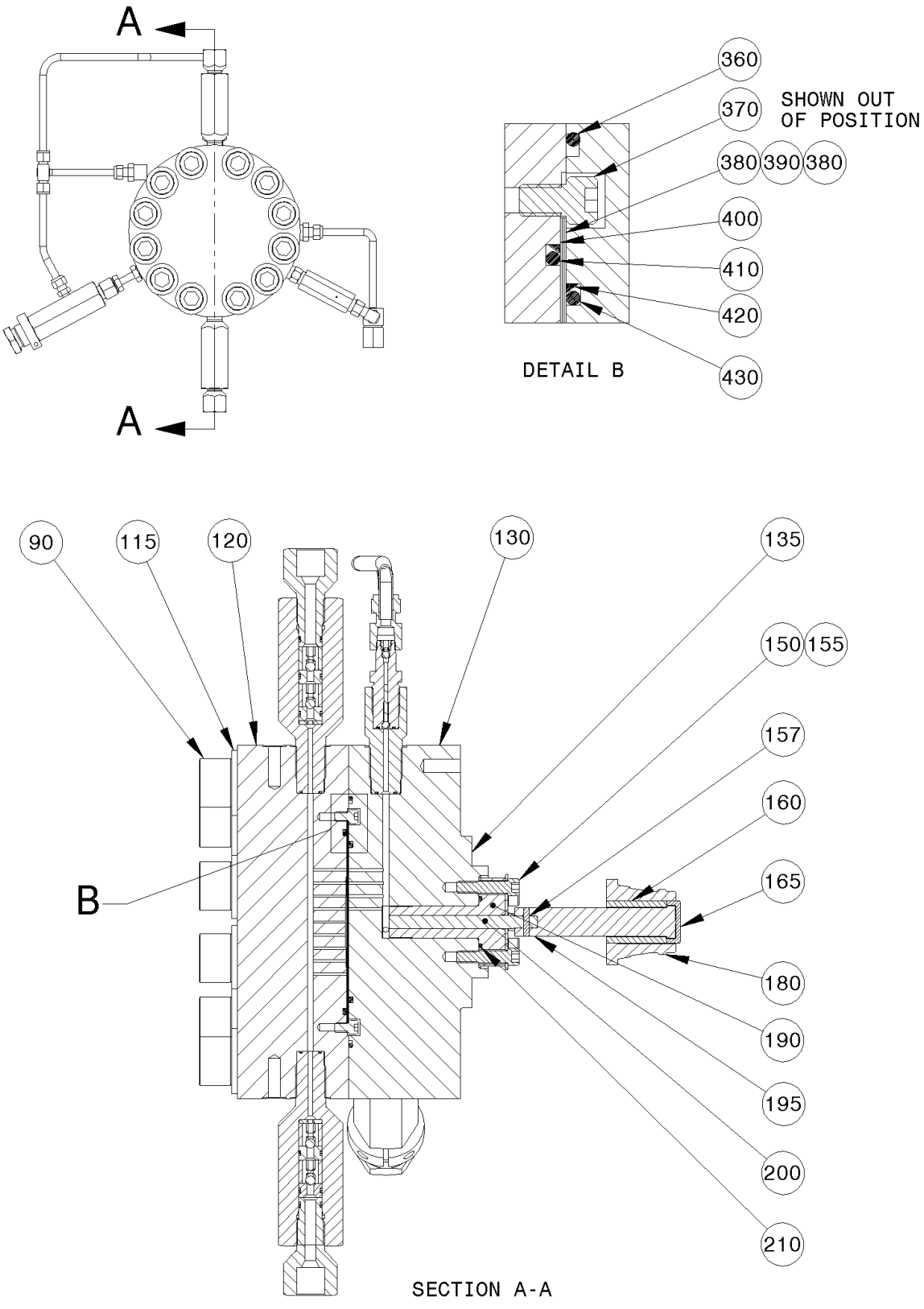
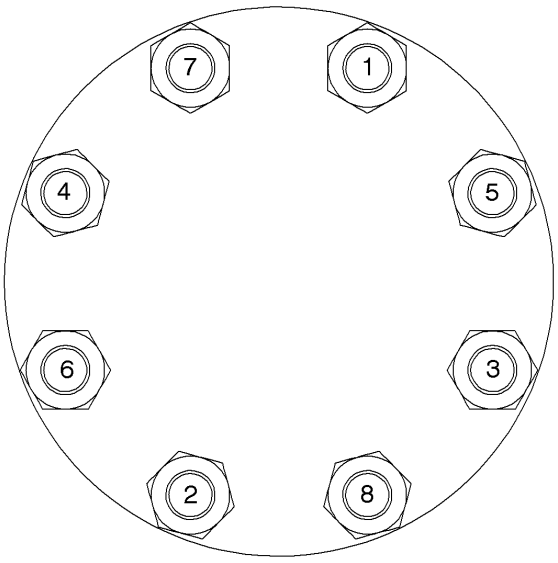
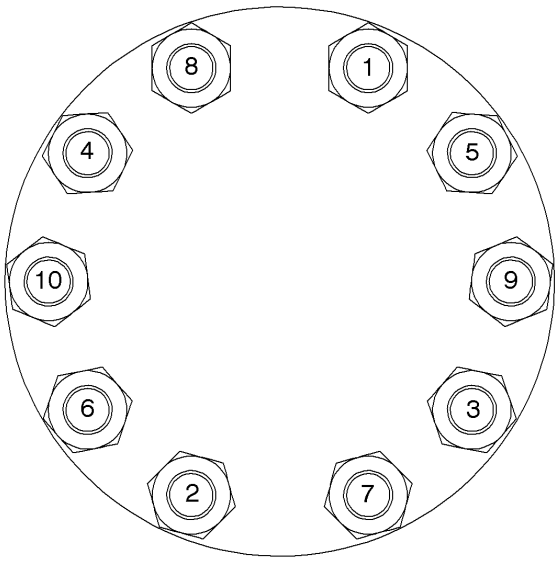


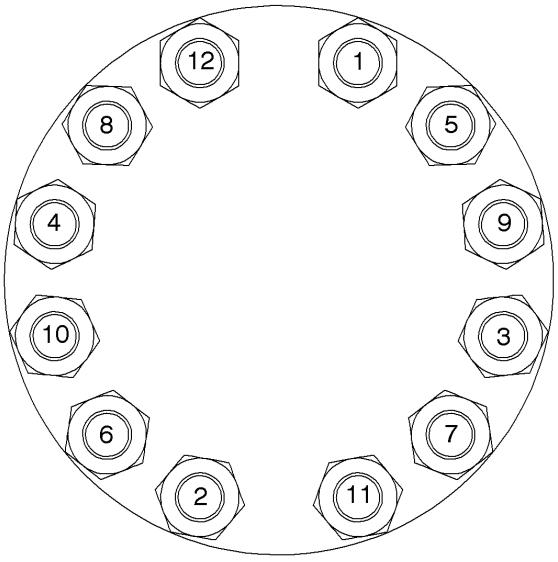
Figure 7: Cross Section of Liquid End (Milroyal B)



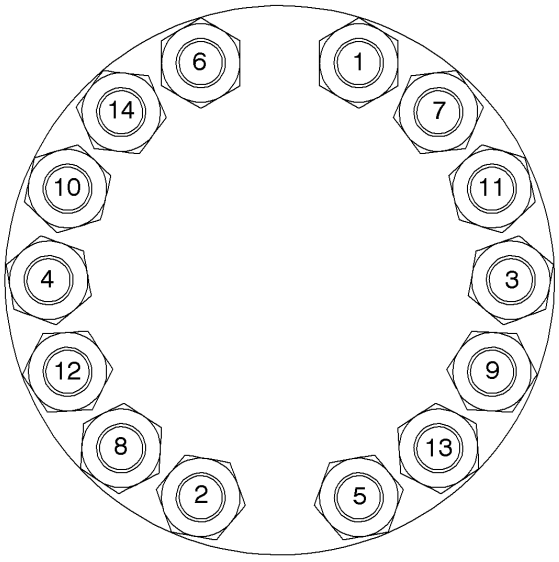
Eight Bolt Tightening Sequence



Ten Bolt Tightening Sequence



Twelve Bolt Tightening Sequence



Fourteen Bolt Tightening Sequence

Figure 8: Bolt Tightening Sequence

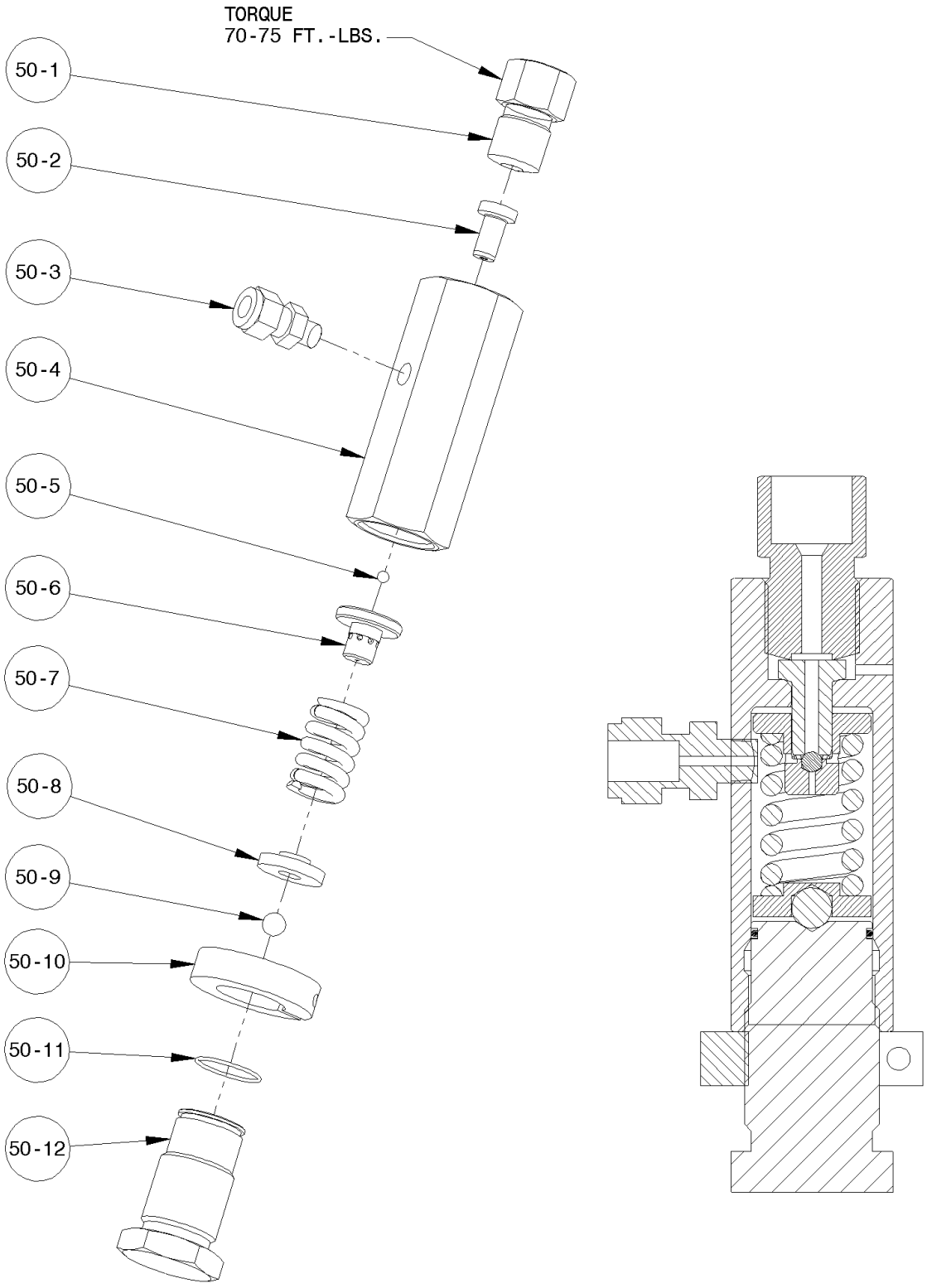


Figure 9: Relief Valve Assembly

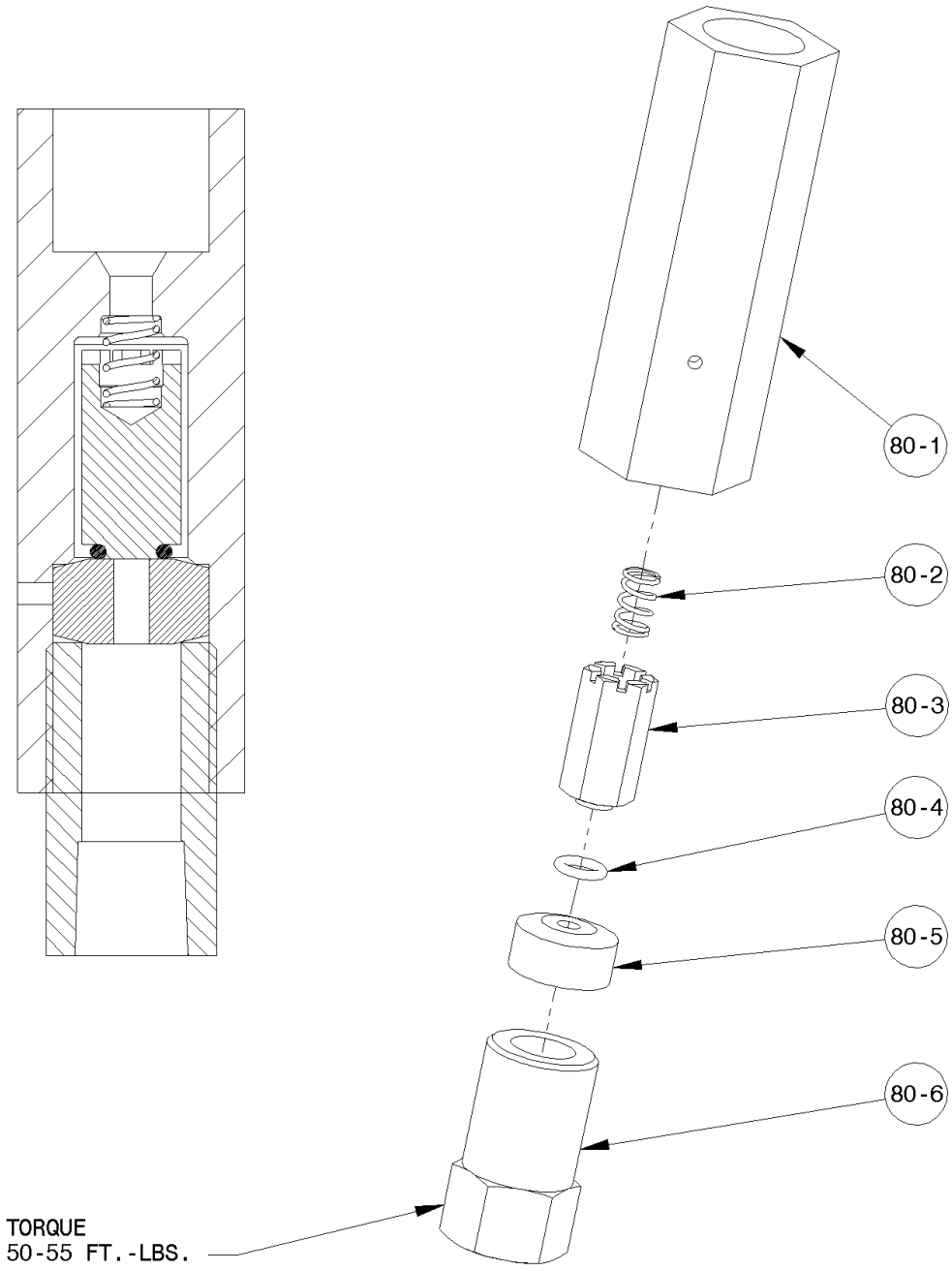


Figure 10: Refill Valve Assembly

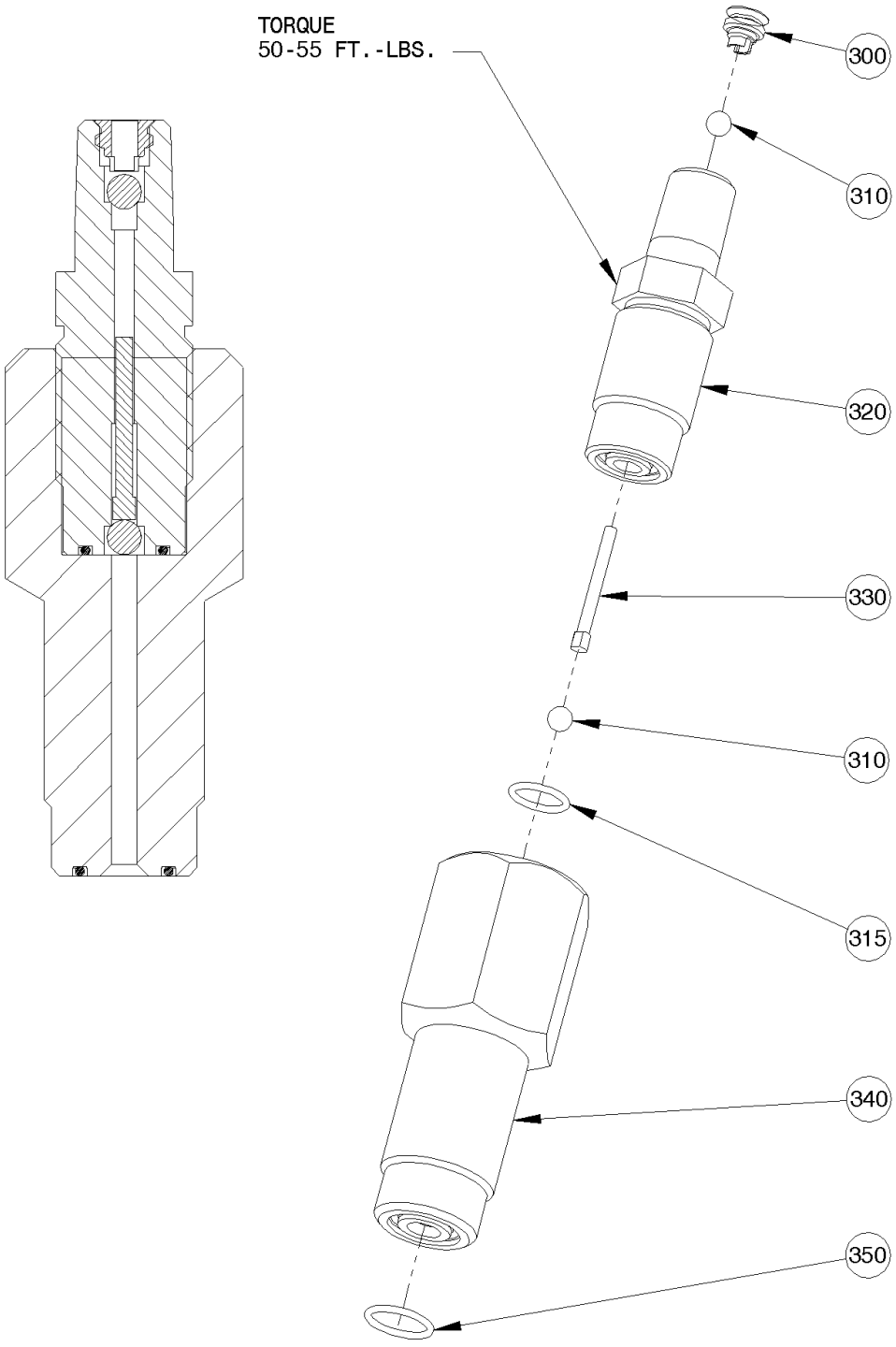


Figure 11: Air Bleed Valve

SECTION 5 –TROUBLESHOOTING

The pump drive instruction manuals list the most possible malfunctions, their causes and cures. The following problems peculiar to Metallic Diaphragm liquid ends may be remedied as indicated below.

Excessive delivery. . . . . • Low discharge line pressure. Increase line pressure (e.g., install a back pressure valve).

Insufficient delivery. . . . . • Air in hydraulic system. Stop pump and relieve system pressure, isolate liquid end from system. Remove the air bleed valve. Oil should reach the top of the through hole. If oil is low, follow the instructions in Section 3.1, items 2-6.

- Flow increases after performing the above step and then the flow drops off again.

  — Bad refill valve. Stop the pump. Disconnect the piping that connects refill valve to pump housing. Attach a section of 3/8" OD clear tubing (5-6 ft long) to the refill valve; elevate it and fill it with clean hydraulic oil. Restart the pump. The oil level in the tube may drop rapidly for a few pump strokes, but it should then stabilize and drop a small amount with each stroke. The flow may be too small to notice—make a mark on the tubing and observe the oil level after several minutes. If the oil level oscillates back and forth, service the refill valve as per Section 4.4.2. **Be sure to stop the pump before the oil in the line depletes or else air will be introduced into the hydraulic system.**

  — Bad air bleed valve. Disconnect the piping that connects the air bleed valve to the pump. Attach a section of 3/8" OD clear tubing to the air bleed valve. Fill it with enough oil to fill the tubing connector, so that the oil level can be seen through the tubing. If the oil level in the tubing increases a small amount with each stroke, it is performing correctly. However, oil does not always flow out through the valve. Depending on the suction conditions of your pump, you may not notice oil flowing through the air bleed valve. Over time, you should see small air bubbles coming up the tubing. Make a mark on the tubing and observe the oil level after several minutes. If the oil level does not change and you do not notice any air bubbles coming out, the air bleed valve could be clogged—service it according to Section 4.4.3. If an excessive amount of oil is flowing through the air bleed valve, it may not be sealing properly—service it as per Section 4.4.3.

  — Clogged refill line. Remove strainer from oil filter and clean or replace, as per Section 4.3.2.

Insufficient delivery (cont'd).	• Relief valve relieving. — System shut-off valve closed. Open valve. — Blocked discharge piping. Clear line. — External back pressure valve set too high. Reset valve. — Internal relief valve set too low. Adjust valve to operating conditions. See Section 3.2. — Diaphragms are stuck forward. Relieve system pressure from the pump. Install a pressure gauge and back pressure valve into the discharge line and bypass the system by pumping into a bucket or other temporary container. Set the back pressure valve so that it develops at least 35 psi more than the suction pressure, but make sure that the pressure setting is much less than the normal operating pressure of the pump. If the relief valve continues to relieve, replace the diaphragms and seals according to Section 4.3.4. Make sure that you tighten the head bolts to the appropriate torque value—over torqueing can cause the diaphragms to stick forward.
	• Leaky check valves. Install a shut off valve and column in the suction line, near to the inlet of the pump. Close the shut off valve so that the pump draws from the column. The chemical should drop with each pump stroke. If the level drops and then rises a little, the check valves could be leaking. Service the check valves according to section 4.3.3.
	• Oil contamination. Condensation or gear oil may have mixed with the hydraulic oil. It is necessary that the appropriate synthetic hydraulic oil be used in the catch-all of the pump. Replace oil as per Section 4.3.1.
Leak detection port leaking	• Diaphragm failure. Leak detection switch is tripped and/or chemical is being pumped out of the leak detection port. Replace the diaphragms and seals according to Section 4.3.4.
Leaky valve	• Chemical or oil is leaking from the joint between the pump and one of the valves. Remove the valve and inspect the seal. Some of the valves are attached with HIP style coned tubing. Inspect and clean the sealing surface. Some of the valves have face seal O-rings. Inspect and replace the O-ring.
Erratic delivery	• Leaky relief valve. Repair or replace valve. • Blocked suction line. Clean line, particularly the line strainer. • Insufficient NPSH. Most common with long suction lines, small diameter suction lines, acid pumping, polymer (viscous) liquids, or drawing from a source lower than the pump. Consult your local representative or the Milton Roy factory.

SECTION 6 – PARTS

Please refer to the bill of material and assembly drawing for spare parts. Use the assembly drawing to identify the sequence number for the desired part. The sequence number is used on the drawing and the Bill of Material. When ordering parts, please refer to the parts ordering instructions listed under "Recommended Spare Parts" in the Maintenance Section (Section 4.1). Be sure to include all required information with your parts order, or Milton Roy Company may be unable to process your order.

SECTION 7 - LIMITED WARRANTY

The Milton Roy Company ("Company") warrants that its pumping products will be free from defects in title, and so far as of its own manufacture, will be free from defects in materials and workmanship for a period of thirty six months from shipment by the Company. The Company additionally warrants that all of its other products, including actuators, will be free from defects in title, and so far as of its own manufacture, will be free from defects in materials and workmanship for a period of twelve months from shipment by the Company. The Company will, at its option, repair or replace its products provided the Company's inspection reveals the products to have been defective or nonconforming within the terms of this warranty. This warranty is expressly conditioned upon the following: (a)proper installation, maintenance, and use under the Company specified service conditions, (b)prompt notice of nonconformance or defect, (c)the Company's prior written authorization for return, (d)the products being returned to the Company, or at the Company's discretion, to a Factory Authorized Service Center, all at no cost to the Company. The Company will deliver repaired or replacement products Ex Works its factory or Factory Authorized Service Center. Products not of the Company's manufacture are warranted only to the extent provided by the original manufacturer. The Company shall not be liable for damage of any kind resulting from erosive, corrosive or other harmful action of any liquids, gases, or any other substance handled by the Company's products.

THE FOREGOING IS IN LIEU OF ALL OTHER WARRANTIES, OBLIGATIONS, OR LIABILITIES, WHETHER EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

UNDER NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES, LOSSES, OR EXPENSES ARISING FROM THIS CONTRACT, ITS PERFORMANCE, OR IN CONNECTION WITH THE USE OF, OR INABILITY TO USE THE COMPANY'S PRODUCTS.

The liability of the Company in respect of all damages, losses, costs or expenses, whether suffered or incurred by the Purchaser or any third party arising in any manner or incident related to this contract or the performance hereunder, shall be limited in the aggregate to the actual price paid by the Purchaser to the Company.

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