Becker

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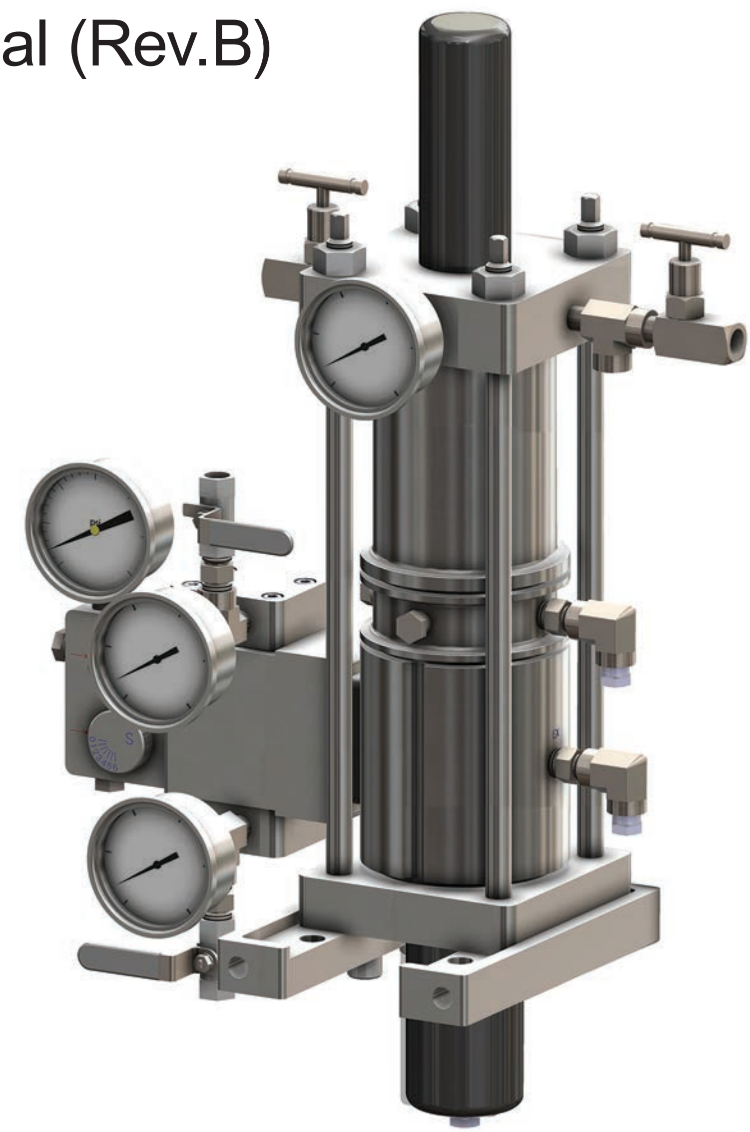
VRP-CH Series 3rd Generation

Valve Regulator Pilots

Instruction Manual (Rev.B)



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Introduction

The Becker™ VRP-CH Series double-acting pilot represents a breakthrough in valve control technology for the natural gas industry. Built to exacting specifications, these easily maintained units offer highly accurate control characteristics over a wide range of operating environments. Furthermore, the VRP-CH Series pilots are designed to allow bleed gas to be routed to a lower pressure system, or downstream, for complete elimination of bleed gas. The elimination of this expensive bleed gas ultimately saves a significant amount of money for the operating company and reduces the environmental impact of atmospheric hydrocarbons and diminishing natural resources.

Description

The Becker VRP-CH double-acting pilot provides pressure control when used with a double-acting piston-actuated control valve. The VRP-CH measures downstream sensing pressure and positions the double-acting actuator to maintain the desired downstream pressure. The VRP-CH pilot may be used for pressure control applications with setpoints ranging from 1 psig to 1500 psig. The Becker CH pilot design represents Baker Hughes commitment to continually develop new products and update existing ones to increase their performance while retaining simple operation and low maintenance.

Scope of Manual

This manual provides information on the installation, operation, adjustment, and maintenance of the Becker VRP-CH double-acting pilot. For information concerning actuators, valves, and accessories, refer to the instruction manuals provided with the specific product.

Note: Only those qualified through training or experience should install, operate, or maintain Becker pilots. If there are any questions concerning these instructions, contact your Baker Hughes sales representative or sales office before proceeding.

Guidelines for Usage

Large volume control valve actuators: Control valves that require large volume actuators also may require volume boosters to help ensure adequate stroking speed. Volume boosters typically are required for Becker RPDA and LPDA Series actuators size 10L or larger (940 in^3).

Bleed to pressure system: The VRP-CH pilot is typically is used for applications with a discharge pressure of 350 psig or less to help ensure adequate operating speed. The bleed to pressure system eliminates atmospheric emissions by keeping discharge gas in the piping system.

High gain systems: Power plant feeds and other similar systems require a fast stroking speed to satisfy required “gain” of the system. Volume boosters are applied based on actuator size and required stroking speed.

Compatible Actuators:

• Becker RPDA actuators (rotary piston double-acting)

• Becker LPDA actuators (linear piston double-acting)

• Other manufacturers’ double-acting piston actuators(1)

Retrofit Compatibility:

Advanced performance is achieved by pairing the VRP-CH with genuine Becker control valve actuators. Should you already have existing control valve actuators in service, the addition of a VRP-CH can improve performance and lower atmospheric bleed emissions. Some compatible actuators:

• Bettis T Series piston actuators

• Fisher Type 470 piston actuators

• Fisher Type 1061 piston actuators

(1) Consult Baker Hughes for additional information.

Technical Specifications

Technical Specifications	
Steady State Gas Consumption	See table in Appendix, page 13
Supply Gas	Dry, filtered (100 micron gas)
Maximum Flow Capacity	850 scfh (24 scmh)
Maximum Supply Pressure	400 psig (2758 kPa)
Maximum Supply-Discharge Differential	250 psig (1724 kPa)
Minimum Supply-Discharge Differential	50 psig (348 kPa)
Operative Ambient Temperature Range	-20 to 160°F -29 to 71°C
Minimum Deadband	0.2% instrument signal
Control Accuracy	± 0.75% of setpoint
Maximum Sensing Pressure	1500 psig
Setpoint Range	3 psig - 1500 psig (20 kPa - 10,342 kPa)
Housing	Meets NEMA 3 classification
Installation Orientation	• Vertical position recommended. Custom bracket supplied with Becker actuators from Baker Hughes

Materials of Construction

Materials of Construction	
External Parts	316 Stainless Steel
Internal Parts	316 Stainless Steel
Springs	Plated steel
Diaphragm	Buna-N with nylon reinforcement
Seats and O-Rings	Buna-N
Tubing and Tubing Fitting	316 Stainless Steel
Gauges	$2^1/_2$-inch dial liquid-filled brass connection w/ stainless steel case(1) (standard issue with dual units of psig/kPa available.)

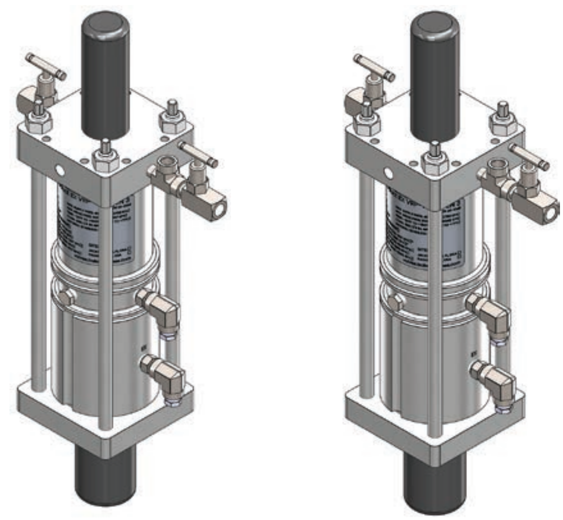
Pilot Selection

VRP-CH Pilot Selection Chart		
Model Number	**Control Range (psig/kPa)**	**Spring Color (Part Number)**
VRP-600-CH	5 - 40 psig 34 - 246 kPa	Gold (25-8236)
	25 - 140 psig 172 - 965 kPa	Beige (25-8238)
	50 - 175 psig 345 - 1207 kPa	Burgundy (25-8239)
	135 - 300 psig 931 - 2069 kPa	Pink (25-8240)
	275 - 600 psig 1896 - 4137 kPa	Yellow (25-1306)
VRP-1500-CH	550 - 1000 psig 3792 - 6895 kPa	Yellow (25-1306)
	800 - 1300 psig 5516 - 8964 kPa	Grey (25-1562)
	900 - 1500 psig 6205 - 10342 kPa	Violet (25-8073)

Model Number Explanation

- The VRP-CH pilot is available in two different models to cover sensing pressures from 5 psig to 1500 psig (0.3 barg to 103 barg).
- The number expressed in the VRP model designation is the maximum sensing pressure (for example, a VRP-600-CH has a maximum sensing pressure of 600 psig).

(1) Consult Baker Hughes for additional information.



VRP-600-CH VRP-1500-CH

VRP-CH pilots - model numbers

Remote Setpoint Change Options

- VRP-CH pilots may be equipped with remote setpoint adjustment motors, which accept a 4-20 MA signal and require a separate 24 VDC or 120 VAC power connection.
- The total motor rotation is adjustable. The maximum number of motor rotations possible coupled with the spring rate determines the total setpoint range.

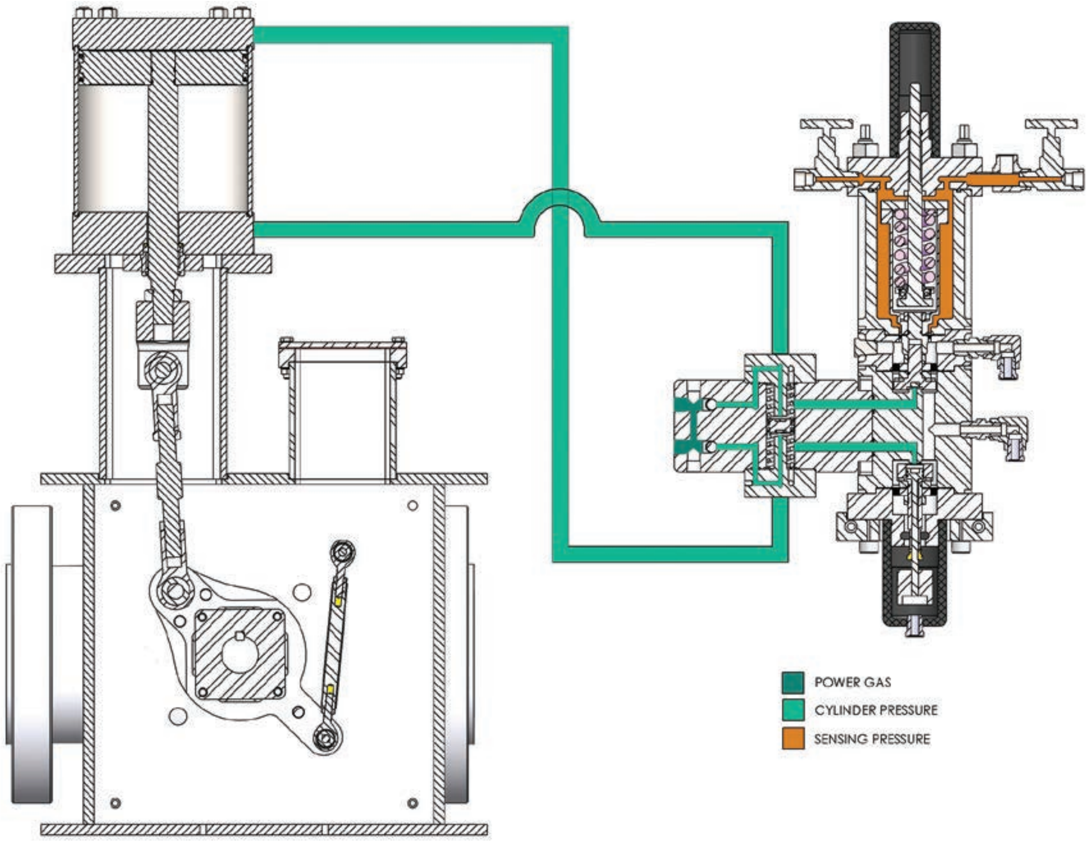


Figure 1 - VRP-CH Pilot Principles of Operation

Principles of Operation

The Becker VRP-CH pilot and double-acting cylinder actuator can be used in conjunction with varying valve types to provide a complete package for stable, accurate pressure control over a wide range of applications. The energy for control valve operation comes from the pressure differential between the pilot supply and discharge pressures.

The power gas channels through two adjustable orifices that independently feed the top and the bottom portion of the cylinder. After passing through each adjustable orifice, gas flow is divided. One passage leads to the respective port of the cylinder while the other is exhausted through the internal nozzle of the pilot.

At equilibrium, distances between each internal nozzle and its respective seat are equal, resulting in equal amounts of pilot output pressure to the top and to the bottom of the cylinder, as well as bleed gas. The control valve remains stationary.

When the control pressure rises above the setpoint, the pilot pistons move downward. As the distance between the bottom internal nozzle and its seat increases, the distance between the top internal nozzle and its seat decreases. The bottom nozzle starts to bleed more gas, and the top nozzle starts to bleed less. This causes an increase in cylinder bottom pressure and a decrease in cylinder top pressure. The pressure differential creates the force needed to close the valve and lessen the flow of gas. When the control pressure returns to the setpoint, the pilot output pressures automatically return to equilibrium at the new valve position. If the control pressure falls below the setpoint, the opposite reaction takes place.

Your VRP-CH pilot will come factory adjusted for your particular application. The use of the adjustment procedures will be necessary upon installation of a rubber goods replacement kit or any other disassembly or reassembly of the pilot.

Adjustment Procedure

The sensitivity adjustment drum in the center of the pilot determines the sensitivity of the unit. The setpoint adjustment screw determines the setpoint at which the pilot operates. The variable orifices determine the speed of response of the pilot.

Initial Adjustment

1. Adjust the supply regulator to the desired power gas pressure. Refer to the original invoice paperwork supplied with the product for the appropriate power gas pressure setting. It is imperative that adequate supply gas pressure be supplied to the VRP-CH for proper operation of the system and all accessories. The adjustable orifices are used to control the volume of gas that is supplied to the VRP-CH. The stroking speed of the system is proportional to the numerical value of the adjustable orifice. Adjustable orifice settings are typically equal for both orifices. However, a few applications may require unequal settings for each adjustable orifice. Refer to Fine Tuning Procedure on page 8 for more information on using unequal adjustable orifice settings. Set both orifices according to the table on page 7.

Notes:

- If the VRP-CH is NOT equipped with volume boosters, set the variable orifices to the recommended value per the table on page 7. If equipped with volume boosters, see note below the table on page 7. To determine the cylinder, refer to the valve or actuator specification sheet, model number data, or other documentation.
- If equipped with a PS sensor and volume boosters, see page 14.

2. Set the orifice per table below.

Supply Pressure (psig)	Cylinder Bore (in.)						
	4	5	6	8	10	12	14
	Variable Orifice Number						
Up to 50	3	3	3	4	4	5	6
51-200	2	2	3	3	4	5	5
201-600	2	2	2	3	3	4	5

Note: For VRP-CH equipped with volume boosters, set variable orifices between number 1 and 2, regardless of the cylinder size. Steady state gas consumption is minimized at 1.

3. Disable PS-2 Series non-bleed sensor (if equipped): The PS-2 non-bleed sensor should be disabled prior to commencing initial adjustment procedures. Failure to disable the sensor may prevent the proper completion of initial adjustments. To disable the PS-2 Series non-bleed sensor, rotate the adjustment screw of the PS-2 clockwise until it extends approximately 1.75-inch from the top surface of the PS-2 spring cartridge.
4. Disable AB Series atmospheric bleed control (if equipped): The AB Series atmospheric bleed control should be disabled prior to commencing initial adjustment procedures. Failure to disable the control may prevent the proper completion of initial adjustments. To disable the AB control, rotate the adjustment screw of the AB control counterclockwise until it disengages. Then, tighten the nut on the AB sensor adjustment screw to seal threads on the cap.
5. Close cylinder block valves: Closing the cylinder block valves will isolate the VRP-CH from the control valve actuator. This prevents unintended stroking of the control valve and simplifies setting the VRP-CH.
6. Close the valve on the sensing line: A shutoff valve must be installed as close to the sensing port of the VRP-CH as possible. The volume of gas between the VRP-CH sensing port and the block valve on the sensing line should be minimized. It is also imperative that the fittings between the VRP-CH sensing port and the sensing line block valve be bubble tight to facilitate adjustment. It is recommended that a quarter-turn (locking) ball valve be used to isolate the VRP-CH sensing line. Confirm that the VRP-CH exhaust (discharge) line is open. The discharge line is connected to the port marked “EX”. Should flow from the exhaust port be blocked, adjustment of the VRP-CH will not be possible.
7. Apply a “False Signal” to the sensing port of the VRP-CH: The “False Signal” pressure should be equivalent to the desired setpoint pressure. Refer to the original invoice paperwork supplied with the product for the appropriate setpoint pressure setting. If the adequate gas pressure is not available from the pipeline, a nitrogen bottle with regulator may be used to introduce the proper “False Signal” pressure. Additionally, an SP Series setpoint adjustment pump may be used to provide a “False Signal” pressure above the available pipeline gas pressure.

   Note: It is recommended that a calibrated pressure gauge be used to help ensure accuracy of the “False Signal” pressure.

   WARNING: DO NOT turn the sensitivity adjustment drum without first applying a sensing pressure and initial spring tension on the adjusting screw. If these forces are not present, one of the two pilot seats will be “cut” on the internal nozzle due to the pressure between the seat and nozzle.
8. Initialize the sensitivity adjustment:
   Turn the sensitivity adjustment drum to the right (decreasing numbers on the scale) as far as it will turn. Then turn it one (1) complete rotation to the left (increasing numbers on the scale).
9. Adjust the setpoint adjustment screw:
   Turn the setpoint adjustment screw on top of the VRP-CH unit until cylinder top and cylinder bottom pressure gauges show equal pressure. Clockwise rotation increases cylinder top pressure. Turn setpoint adjustment only when pressures are not equal.
10. Final sensitivity drum adjustment:
   Turn the sensitivity adjustment to set the cylinder top and cylinder bottom at the proper cylinder balance pressure (P_c), see equations 1 and 2 below. Turn sensitivity adjustment to the right (decreasing numbers on the scale) to increase the cylinder top and cylinder bottom pressures. Turn sensitivity adjustment to the left (increasing numbers on the scale) to decrease the cylinder top and cylinder bottom pressures.

The correct cylinder balance pressure (P_c) is found using the cylinder balance pressure equations:

VRP-CH discharge to PRESSURE SYSTEM
(No volume boosters)

$P_c = P_d + [0.4*(P_s - P_d)]$ (Equation 1.a)

VRP-CH discharge to ATMOSPHERE
(No volume boosters)

$P_c = 0.4*P_s$ (Equation 1.b)

VRP-CH discharge to PRESSURE SYSTEM
(EQUIPPED with volume boosters)

$P_c = P_d + [0.2*(P_s - P_d)]$ (Equation 2.a)

VRP-CH discharge to ATMOSPHERE
(EQUIPPED with volume boosters)

$P_c = 0.20*P_s$ (Equation 2.b)

Variables:

P_c = Cylinder balance pressure (psig)

P_d = Discharge pressure (psig)

P_s = Power gas (supply) pressure

11. Typically, only one of the cylinder output gauges will respond at first. Continue rotating sensitivity adjustment until at least one of the gauges indicates a pressure equivalent to the proper cylinder balance pressure (P_c).
12. At this point, rotate the setpoint adjustment to equalize cylinder top and cylinder bottom pressures. Repeat steps 10 and 11 until the proper cylinder output pressures are achieved. As the VRP-CH nears the proper adjustment, both cylinder top and cylinder bottom gauges will respond simultaneously when the sensitivity drum is turned.

   VRP-CH setpoint is achieved when both cylinder top and cylinder bottom equalize at a pressure equivalent to the proper cylinder balance pressure (P_c).
13. Verify “False Signal”:
   Upon achieving setpoint, inspect the gage that measures the “False Signal.” If the “False Signal” has deviated,

readjust it to attain proper pressure. Remember that the “False Signal” applied to the VRP-CH sensing port should be equivalent to the desired pressure setpoint of the VRP-CH. Upon readjustment of the “False Signal,” repeat step 12 until setpoint is achieved.

14. Remove “False-Signal” pressure from sensing port of VRP-CH.
15. Open the valve on the sensing line.
16. Open the cylinder block valves:
    Opening the cylinder block valves will reestablish communication between the VRP-CH and the control valve actuator and put the system back into service. Exercise caution when putting the VRP-CH into service to prevent unintended closure/opening of the control valve.

    The regulator is now ready for service. The Initial Adjustments are used to set the VRP-CH at a point approximating the desired setpoint. To achieve optimum accuracy of setpoint and sensitivity, the Fine Tuning Procedures hereafter need to be completed.

Fine Tuning Procedures

To change the VRP-CH setpoint only:
In the case where the VRP-CH only requires a change in setpoint, the setpoint adjustment may be rotated to achieve a new setpoint while the VRP-CH is in service. No other adjustments need to be made. Baker Hughes recommends noting the setpoint change per revolution of the control spring installed in the pilot. Setpoint change per revolution of the control spring can be found in the table on page 8 of this manual.

To change the VRP-CH sensitivity:
In the event that the VRP-CH requires a change in the sensitivity adjustment, the setpoint adjustment also will require adjustment. Any changes in the sensitivity adjustment affect the setpoint adjustment. An increase (lower numbers) in the sensitivity of the pilot will require the setpoint adjustment to be decreased. A decrease (higher numbers) in the sensitivity of the pilot will require the setpoint adjustment to be increased.

Note: After the pilot is put into service, the cylinder top and cylinder bottom pressures may not remain at the originally adjusted cylinder balance pressure. Typically, the pressure will rise above the appropriate cylinder balance pressure. This occurs due to the recovery process of the rubber seats. The pressure also may rise if the temperature of the incoming gas changes. After initial installation, allow the unit to operate for a few hours, then bring the cylinder top and cylinder bottom pressures back to the appropriate values by turning the sensitivity adjustment drum in the proper direction.

While the regulator is in control, the cylinder top and cylinder bottom gauges may not be equal: The cylinder balance pressure (P_c) is attained by averaging the pressures of the cylinder top and bottom.

Example:

Power gas = 100 psig
Discharge gas = 0 psig (bleed to atmosphere)

While in control, gauges read:
Cylinder top = 65 psig
Cylinder bottom = 35 psig

The average pressure is: **(65 + 35)/2 = 50 psig**

The average pressure needs to be readjusted according to Equation 1.b

$P_c = 0.4*P_s$ (Equation 1.b)

While the VRP is still in control, turn the sensitivity adjustment until the average cylinder pressure is equal to cylinder balance pressure (P_c) in the appropriate equation. The cylinder top and cylinder bottom pressures change at the same rate. Note that adjusting the sensitivity drum will require a re-adjustment to the pilot setpoint.

Note: Cylinder balance pressure (P_c) may fluctuate after VRP-CH is put into service!

After the adjustment is completed, it is normal for the cylinder top and cylinder bottom to fluctuate during a 24-hour cycle. When the control valve changes its position due to change in demand (typically found in early morning conditions) the cylinder top and cylinder bottom start to settle at only 10 to 30 percent of the difference in supply and discharge pressures. This occurs due to frequent contact of seats and internal nozzles of the pilot (seats do not have enough time to recover).

The VRP pilot does not require readjustment unless the balance pressures are found to be outside the range of 30 to 70 percent of the power gas pressure.

Once adjusted, the Becker VRP pilot typically requires very little or no readjustment.

Troubleshooting

Control problems generally fall into one of the following three categories:

1. Regulator is too sensitive: Position of the regulator will change frequently while control pressure is stable.
2. Regulator is not sensitive enough: Control pressure fluctuates while position of the regulator does not change (or changes very little).
3. Regulator is lagging behind changes in the control pressure: The control pressure fluctuates while the regulator is constantly changing its position.

Case # 1 – Regulator is too sensitive:

Turn the sensitivity adjustment drum to the left (increasing numbers on the scale) by small increments below the 40 percent range. The cylinder pressures will go down. Typically, good control is achieved within one or two numbers on the sensitivity adjustment drum.

WARNING: Do not turn the sensitivity adjustment drum to the left (increasing numbers on the scale) more than one full turn (11 numbers) from the initial 40 percent range position. While certain VRP models will become insensitive on even minimal rotation, turning more than one full turn will guarantee excessive deadband on any VRP model.

Case #2 – Regulator is not sensitive enough:

The average value of the cylinder top and cylinder bottom pressures should be as specified in Step 10 on page 7 of the Initial Adjustment. To further improve sensitivity, the system supply pressure must be increased.

Note: Check with Baker Hughes before increasing originally specified power gas to prevent equipment failure due to overpressure.

Case #3 – Regulator is lagging behind changes in the control pressure:

Increase both inlet orifice settings. This will cause the regulator to move faster. Turn the sensitivity adjustment drum to the left (increasing numbers on the scale) to maintain the desired cylinder top and cylinder bottom pressures. Finally, turn the setpoint adjustment screw clockwise to increase the setpoint for the original desired pressure. Changing the setpoint will not change the sensitivity.

If the simultaneous increase of both adjustable orifices did not produce the desired result (i.e., the regulator is still unstable), it is necessary to set the adjustable orifices to open and close at different rates. This can be achieved by doing the following:

1. Open both adjustable orifices to #6 and note the total swing of the regulator. Leave the bottom adjustable orifice (controlling the opening speed of the regulator) at #6, and reduce the top adjustable orifice (controlling the closing speed of the regulator) to #3. If the swing has stopped, or at least reduced, the direction of speed adjustment is correct (the closing speed should be smaller than the opening speed). To find the optimum setting, try several combinations of adjustable orifice settings.
2. If the swing of the regulator has increased, change the direction of speed adjustment. Reduce the bottom adjustable orifice (controlling opening speed of the regulator) to #3, and increase the top adjustable orifice to #6.
3. If stability of the unit cannot be achieved through different adjustable orifice setting combinations, the gain of the pilot is too high. Leave the adjustable orifices at the setting combination that generates the smallest swing. Turn the sensitivity adjustment drum to the left (decreasing numbers on the scale) by small increments until stability is achieved.
4. Finally, turn the setpoint adjustment screw clockwise to increase the setpoint. Changing the setpoint will not change the adjusted mode.

Inspection Procedure

As with all precision equipment, it is necessary to periodically test the pilot to help ensure optimum performance. We recommend the following procedure once a year:

1. Close the cylinder block valves to prevent the control valve from moving.
2. Close the valve on the sensing line.
3. Shut off supply pressure and bleed down at the pilot. Note the settings of the adjustable orifices before removing them from the orifice assembly. Remove adjustable orifices and clean them thoroughly. Reinstall using new O-rings, being sure to install each orifice into the hole from which it was removed (the orifice and block have matching numbers for this purpose). Reset adjustable orifices to original settings.
4. Turn on supply pressure.
5. Check the integrity of the pilot seats by changing the sensing pressure 5 percent above and 5 percent below the setpoint. One cylinder pressure gauge should climb to full power gas and the other to zero when the pressure is raised. If the VRP-CH is equipped with the NBV sensor, the “EX” port should be bubble tight. The gauge output should reverse when the pressure is dropped. Failure to build output pressure to full supply pressure is a sign of a worn pilot seat. Shut off the power gas supply, bleed off all remaining pressure, and rebuild the pilot according to procedure in the Assembly section.
6. Reinstate power gas and soap test around all diaphragms, vents and orifice assembly. Unless a leak is found, it is not necessary to disassemble the pilot. If any leaks are found around the diaphragms, all rubber goods must be replaced.
7. Apply a “False Signal” pressure to the sensing chamber. Observe operation of the gauges. If any gauges are defective, replace them.
8. Perform the internal friction test.

Internal Friction Test

Friction may occur if the diaphragms were not centered properly during installation or dirt has accumulated inside the pilot. To test for this friction:

1. Adjust the pilot using the initial adjustment procedure.
2. With both cylinder output gauges balanced, turn the adjusting screw slightly clockwise to decrease cylinder bottom pressure. Once the pressure reading on the gauge stops falling, turn the screw back in the opposite (counterclockwise) direction. The gauge arrow should immediately reverse.
3. Follow the reverse procedure on the cylinder top gauge.
4. If either of the gauge needles dips first before climbing, the pilot has friction and must be take apart and reassembled.

Control Valve Type	Opening Orifice (#)	Closing Orifice (#)	Sensitivity Drum (%)
Ball valve regulator with volume booster bleeds to atmosphere	1-1/2	4-1/2	0
Ball valve regulator with volume booster bleeds to a pressure system	2	5	50
Globe valve regulator with or without volume booster bleeds to a pressure system	2	6	80

Annual Maintenance Checklist

Refer to Inspection Procedure on page 9.

1. ________ Clean and inspect the adjustable orifice assemblies. Refer to number 3, page 9.
2. ________ Check integrity of VRP-CH pilot seats. Refer to number 5, page 9.
3. ________ Soap test all diaphragm mating surfaces and the adjustable orifice assembly to check for leaks. Refer to number 6, page 9.
4. ________ Replace rubber goods using the Becker VRP-CH pilot seal kit if necessary.
5. ________ Confirm power gas supply pressure is correct. Refer to original Baker Hughes invoice paperwork for proper power gas setting.
6. ________ Check sensitivity of the VRP-CH pilot. Confirm proper cylinder balance pressures. Refer to Adjustment Procedures, equation 1 or equation 2, on page 6 and page 6page 7.
7. ________ Observe operation of gauges and replace if defective.
8. ________ Perform an internal friction test. Refer to page 9.
9. ________ Inspect and verify proper operation of all VRP-CH accessories. Refer to technical manual included with each specific instrumentation accessory for further instruction.

Note: It is not necessary to replace any rubber goods in Becker instrumentation or instrumentation accessories on a regular basis. However, common practice suggests that replacement of rubber goods on a five-year cycle provides adequate preventative maintenance.

Seal Kit

A seal kit containing diaphragms, O-rings and seats for the Becker VRP-CH pilot is available directly from Baker Hughes. Simply contact Baker Hughes and refer to the following part number:

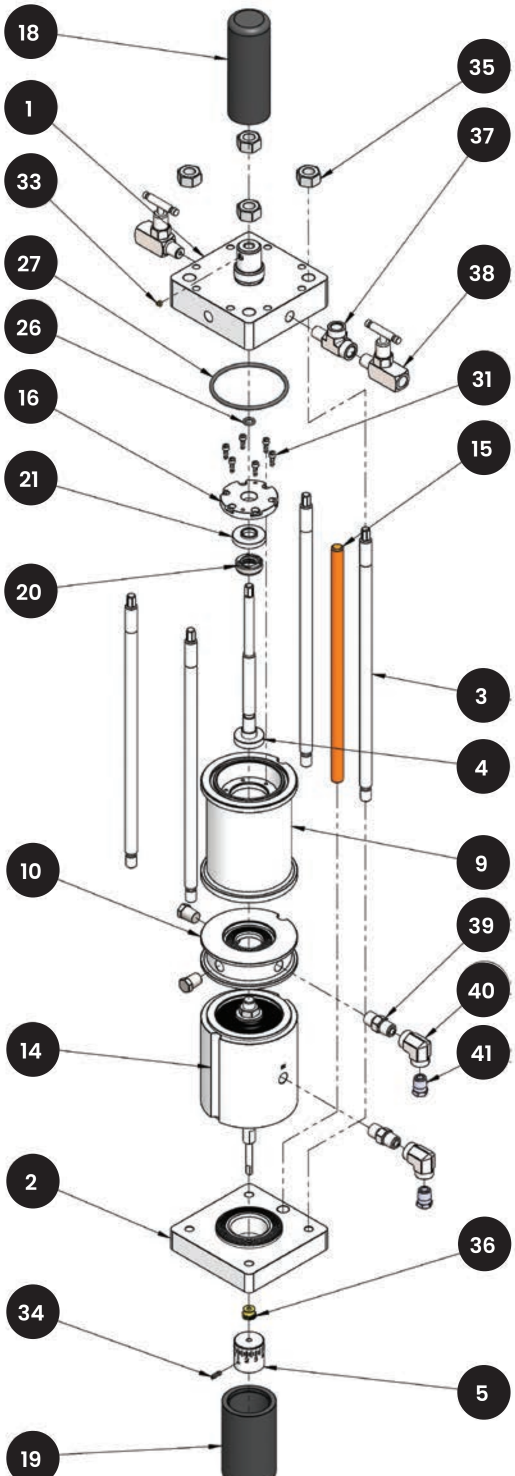
VRP-CH Pilot Model	Repair Kit Part No.
VRP-175-CH	30-9002
VRP-600-CH	30-9401
VRP-1000/1500-CH	30-9402

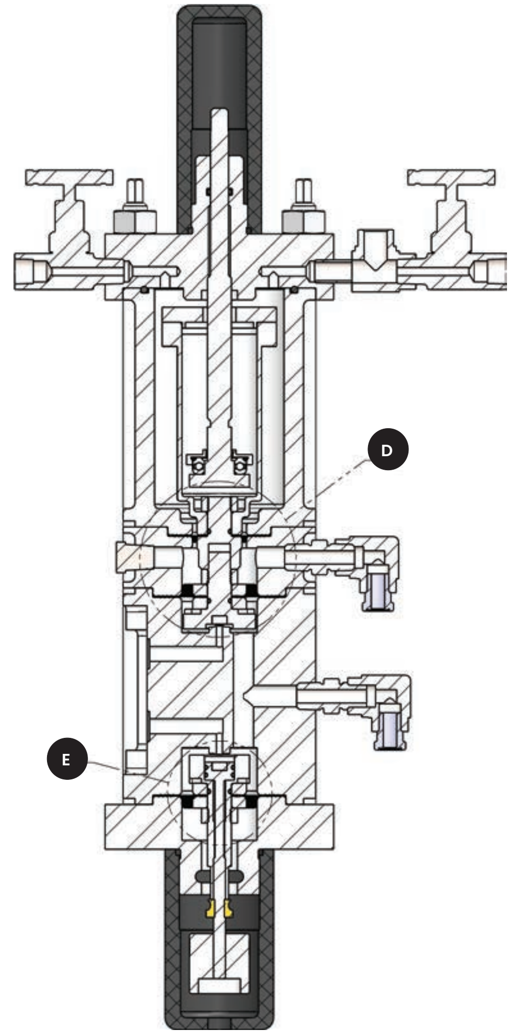
Parts Ordering

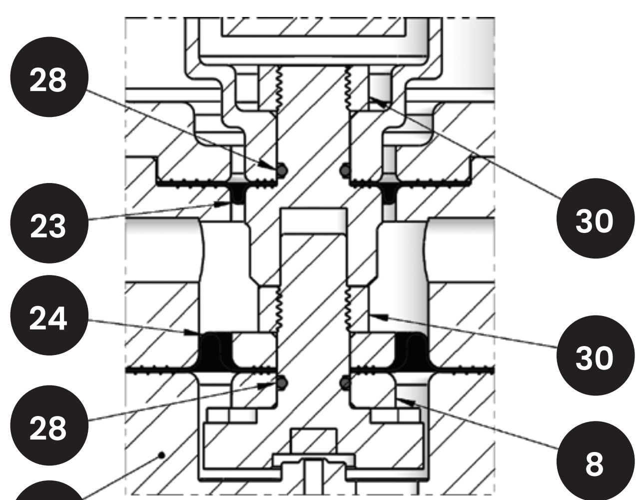
The following is provided to allow the ordering of replacement parts. Please specify the Becker instrument serial number when ordering parts. This can be found on the stainless steel tag attached to the pilot by the tie rods. If the instrument was supplied as a complete valve regulator package, the stainless tag attached to the actuator piston also can provide the serial number. See drawing #30-0010 RV4-0001 or RV4-0002, as applicable, or refer to the parts lists and images on the following pages.

Key	Description	Part No.	
		VRP-1500-CH	VRP-600-CH
1	Pilot Top Flange w/ Set Screw	28-0000	
2	Pilot Bottom Flange	28-0001	
3	Pilot Tie Rod	28-0002	
4	Adjusting Screw, Spring	28-0003	
5	Calibration Drum	28-0004	
6	Outside Piston	28-0005	
7	Inside Piston	28-0006	
8	Washer	28-0007	
9	Hi Pressure Spring Cartridge	28-0008	28-0009
10	Bottom Spacer	28-0010	28-0011
11	Adjusting Screw, Valve	28-0012	
12	Inner Tube Combination Chamber	28-0014	28-0015
13	Spring Chamber Piston Coupling	28-0016	28-0017
14	Body	28-0018	
15	Indexing Rod	28-0020	
16	Tube Cap	28-0021	
17	Pilot Post Top Mount	28-0022	
18	Pilot Cap, Top	28-0024	
19	Pilot Cap, Bottom	28-0025	
20	Thrust Bearing	25-1062	
21	Bearing Case	28-0030	
22	ID Tag	26-0145	26-0144
23	Sensing Diaphragm	30-7011	25-1027
24	Actuating Diaphragms	25-1027	
25	Seat	25-1031	
26	O-Ring - 109	9452K172	
27	O-Ring - 234	9452K163	
28	O-Ring - 012	9452K21	
29	O-Ring - 014	9452K58	
30	Hex Nut	94805A224	
31	#8-32 x 1/2 SHCS	96209A413	
32	#8-32 x 5/8 BHCS	98164A450	
33	1/4”-20 x 3/16 Set Screw, Brass	92991A124	
34	#8-32 x 1/2 Set Screw, SST	92158A205	
35	1/2”-13 Heavy Hex Nut	97619A440	
36	1/4”-28 Thumb Nut	92741A204	
37	1/4” Street Tee	94-2771	
38	1/4” MXF Needle Valve	20-2926	
39	1/4” Male Hex Nipple	94-2705	
40	1/4” Female Elbow	94-2795	
41	Fitting, Mud Dauber	SS-MD-4	
42	1/4” NPT Hex Head Plug	94-2704	

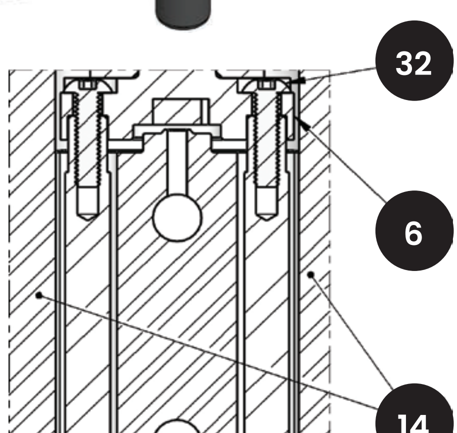
VRP-CH Assembly



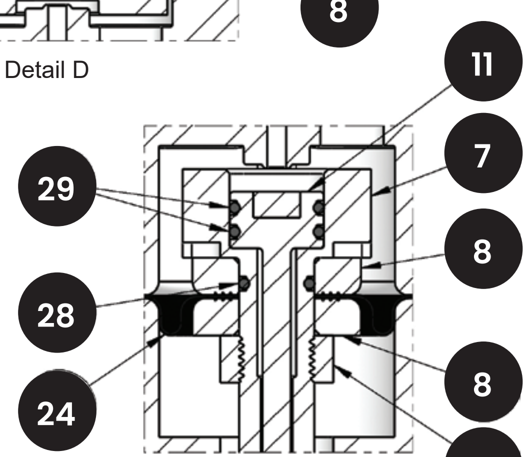




Detail D

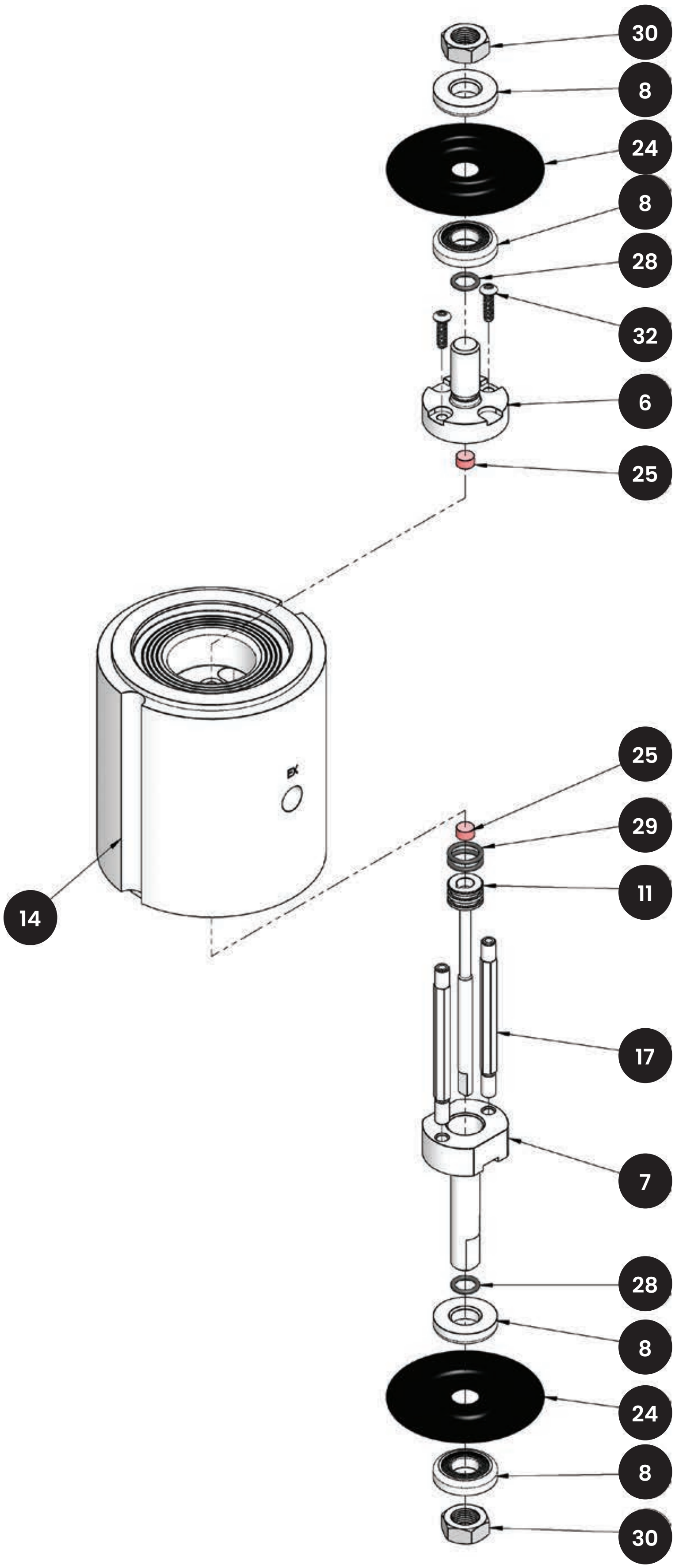


Detail C

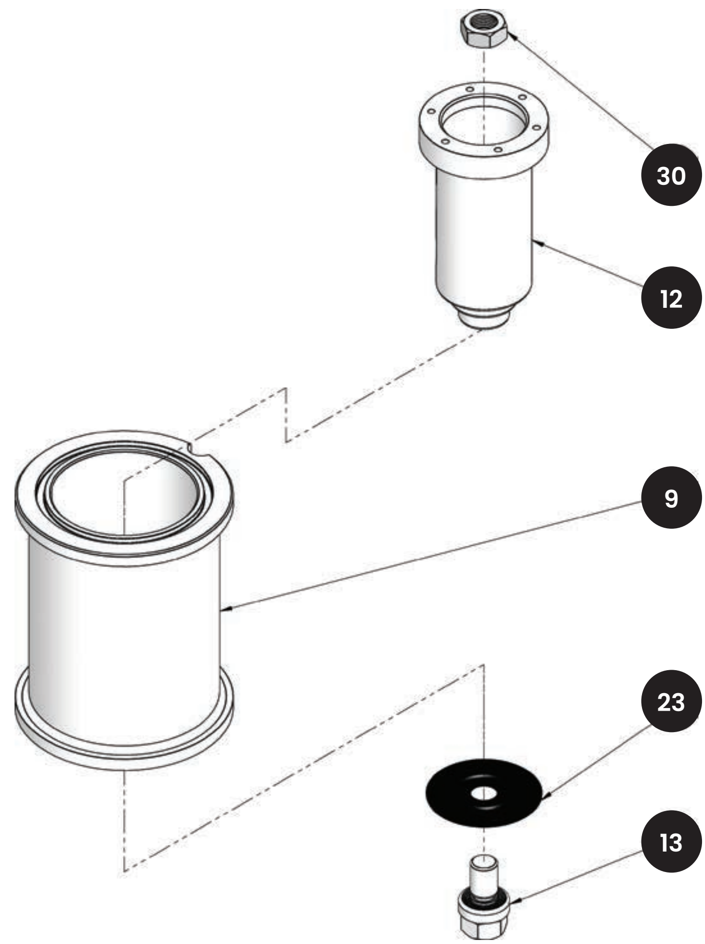


Detail E

VRP-CH Center Section and Spring Chamber Assembly



Center Assembly



Spring Chamber Assembly

Appendix

Flow Calculations

$$Q_c = 312.8 \times P_1 \times C_V \times \sqrt{\frac{1}{G \times (T + 460)}}$$

Critical Flow

Variables:

Q_c = critical flow across the inlet orifice in scfh

P_1 = supply pressure to the pilot in psig

C_v = flow factor

G = specific gravity of the gas

T = temperature of the gas in °F

Steady State Consumption

Variables:

Q_{ssc} = steady state consumption

Q_{c1} = critical flow across the top orifice in scfh

Q_{c2} = critical flow across the bottom orifice in scfh

C_v = 0.00447 x n1.656242

n = number of the orifice setting on orifice block (1 through 6)

$Q_{ssc} = Q_{c1} + Q_{c2}$

Supply Regulator Capacity

$Q_{src} = 2Q_c$

Variables:

Q_{src} = supply regulator capacity

C_v = 0.0869 (calculated with n = 6)

Travel Time

Minimum travel time (the time the valve takes to move from one extreme position to another) is achieved when the signal deviates 5 percent or operation.

a) Pilot bleeds to the atmosphere:

$$t_1 = 0.148 \times \frac{S \times D^2}{C_v} \sqrt{\frac{G}{T + 460}}$$

Variables:

t = time in seconds

S = cylinder stroke in inches

D = cylinder diameter in inches

C_v = flow factor (for orifice or booster)

$C_{v\ (Booster)}$ = 3.13

b) Pilot bleeds to a pressure system:

$$T = t_1 + 0.0003906 \times S \times D^2 \times P_2$$

Gas Consumption Table

Supply Gas Pressure (psig or psid)	Orifice Number				
	2	3	4	5	6
100	**29**	**56**	**90**	**130**	**176**
150	41	80	130	187	253
200	54	105	169	244	330
250	66	129	210	301	407

Consumption (SCFH) for monitor and standby valve. For pilot gas consumption while in control, multiply by 2.

Accessories

The following accessories are available to enhance the operation or provide additional features to your VRP-CH Series double-acting pilot control system. For additional information regarding a specific VRP-CH accessory, contact Baker Hughes.

SP Series Setpoint Change Pump:

Provides a simple and accurate method of applying false signal pressure during initial adjustment of the VRP pilot. The pump can provide a false signal pressure of 10 percent to 20 percent in excess of working pipeline pressure, eliminating the need for nitrogen bottles or electronic calibration devices.

Remote Setpoint Module:

Provides remote adjustment of VRP-B pilot setpoint via an electrical signal. Standard input signals are 24 VDC pulse and 120 VAC pulse. A 4-20 mA input signal motor is available. All motors provide 4-20 mA setpoint feedback.

AB Series Atmospheric Bleed Control:

Maintains minimum pressure differential across the cylinder. AB control is required to provide the necessary output to operate the control valve under all design conditions. See page 6 for adjustment information.

NBV Series No Bleed Valve:

Achieves non-bleeding conditions at both full open and full closed positions without any adjustment. Selection based upon power gas pressure and discharge gas pressure.

PS Series Non-Bleed Sensor:

Achieves non-bleeding conditions in either full open or full closed positions. Selection based upon power gas pressure and discharge gas pressure. See page 6 for initial pilot adjustment information.

Note: DPS Series sensors must be used with Becker CV Series globe valves.

Volume Boosters:

Provides additional volume capacity to the VRP-CH for use with large volume control valve actuators. The volume boosters also may be used for applications that require additional operating speed. The volume booster offers no adjustments. All adjustments to the boosters' response are controlled through the pilot orifice and sensitivity drum. Refer to the pilot initial adjustment procedures for further information.

PS-2 Series Sensor Adjustments

1. Turn the adjusting screw of the PS-2 sensor clockwise until it extends about $1^3/_4$-inch from the top of the spring cartridge.
2. Adjust the VRP-CH according to the pilot adjustment procedures.

For a normally open regulator (monitor):

3. Bleed off the sensing pressure.
4. Wait until the pressure reading on the cylinder top gauge is equal to power gas.

For normally closed (standby) regulator:

5. Increase the sensing pressure 5 percent above setpoint.
6. Wait until the pressure reading on the cylinder bottom gauge is equal to power gas.
7. Turn the adjusting screw of the PS-2 sensor counterclockwise until the exhaust port of the VRP-CH stops bleeding gas. Then turn the adjusting screw an additional half turn in the same direction.
8. The pressure sensor is now set for the existing supply pressure. If the supply pressure to the VRP-CH is changed, the sensor must be reset. Refer to the pilot initial adjustment procedures for further information.

Troubleshooting

If the volume boosters bleed gas even when the control valve is not moving, or if the control valve continually cycles, turn the pilot sensitivity adjustment drum to the left (increasing numbers on the scale) by small increments until stability is achieved and the exhaust ports of the volume boosters do not bleed gas. To help ensure maximum sensitivity of the system, make the control valve slightly unstable by turning the pilot sensitivity adjustment drum to the right (decreasing numbers) and then turn it back to the left (increasing numbers) by small increments until stability is achieved.

Assembly Procedures

General

These instructions shall apply where applicable throughout this manual.

To avoid damage to sealing surfaces, use only brass, plastic, or other soft tools to remove O-rings or other seals. The optional O-ring tool supplied by Baker Hughes may also be used as specified in this manual.

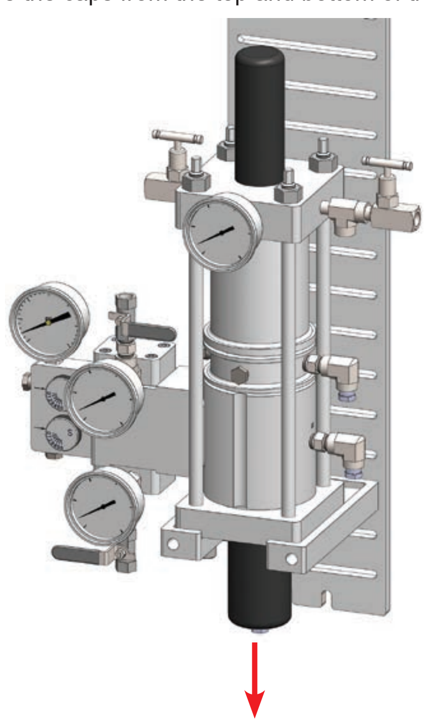
O-rings, threads, and bearings must be properly lubricated prior to installation. The following lubricants (or equivalents) are recommended for these components:

- O-Rings: Parker Super-O-Lube
- Threads: Bostik Never-Seez (regular grade)
- Thrust Bearing, Bearing Case, and Tube Cap: Mobil Mobilith SHC Red

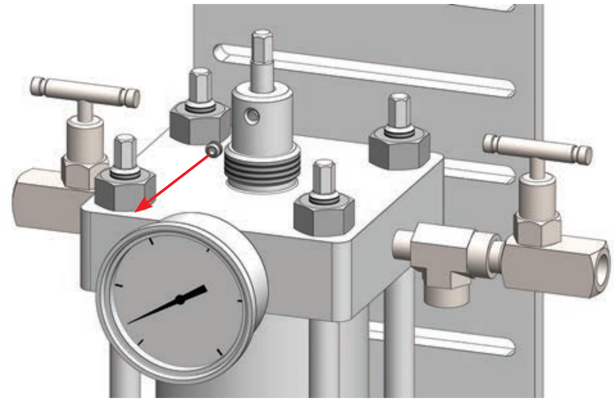
Where specified, optional tooling spacers supplied by Baker Hughes may be used to allow diaphragm assemblies to rotate freely and avoid damage to the diaphragms. Their use is optional, but may aid in the disassembly process. If the tooling spacers are not used, the appropriate parts or assemblies must be lifted slightly during torque application to avoid damage to the diaphragms.

Disassembly Procedures:

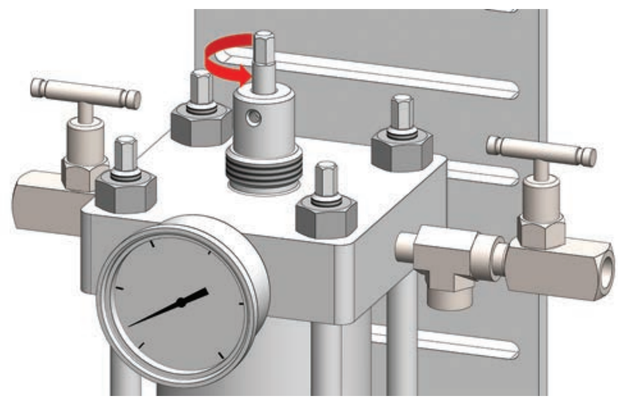
1. Remove the caps from the top and bottom of the pilot.



2. Remove the set screw from the top spring adjusting screw cap.

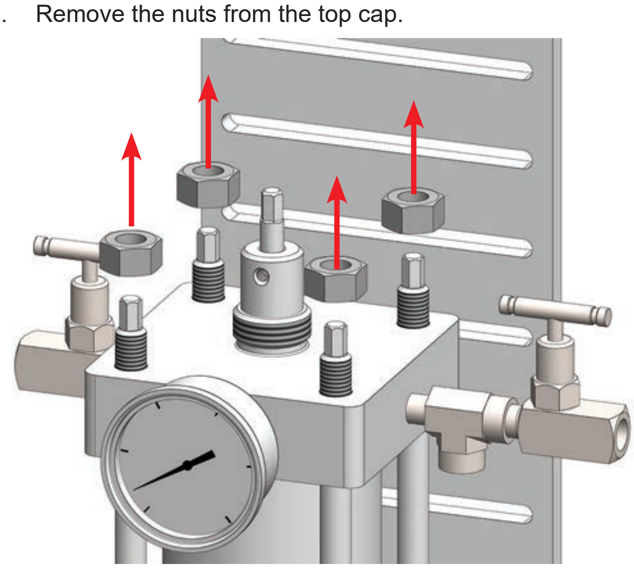


3. Disengage the spring adjusting screw by rotating counterclockwise until the spindle can move freely.

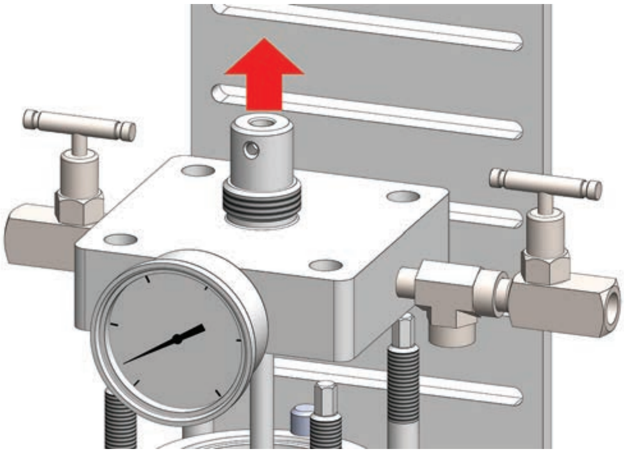


The spindle should be able to move slightly up and down when it is fully disengaged.

4. Remove the nuts from the top cap.

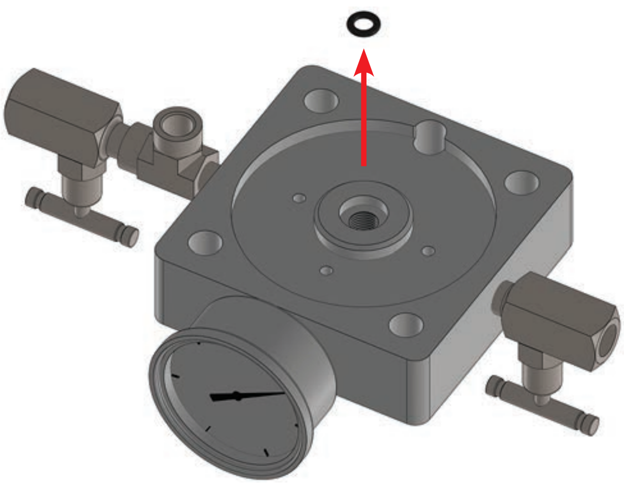


5. Remove the top flange assembly.

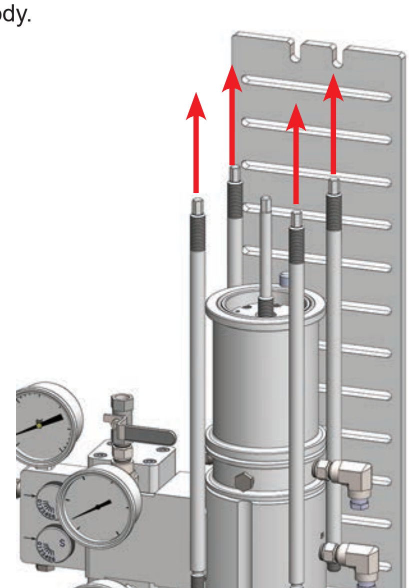


Note: it is generally not necessary to remove the isolation valves and other fittings from the flange assembly – these may be removed as a single unit.

6. Remove the O-ring from the top flange assembly.

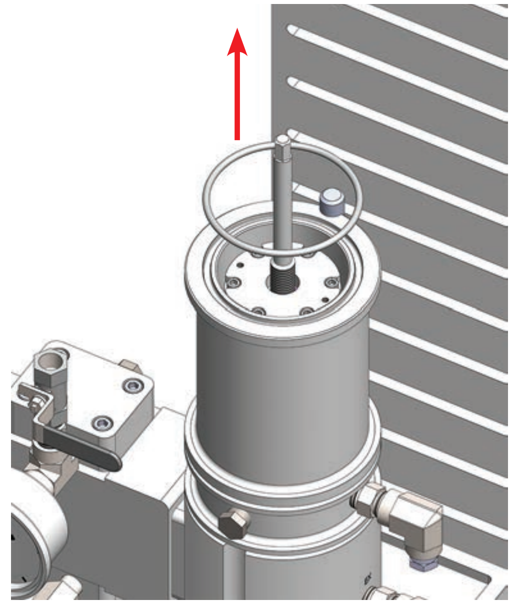


7. (Optional step) remove the four tie rods surrounding the pilot body.

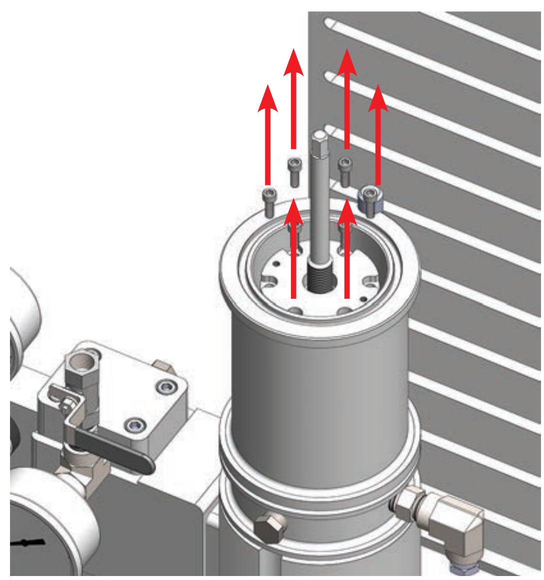


Note: the tie rods may be left in place if the user prefers, but removing the tie rods will allow easier access to the pilot body and internal components. To use the recommended tooling spacers (see steps 12, 53, 64, and 72), at least one tie rod must be removed.

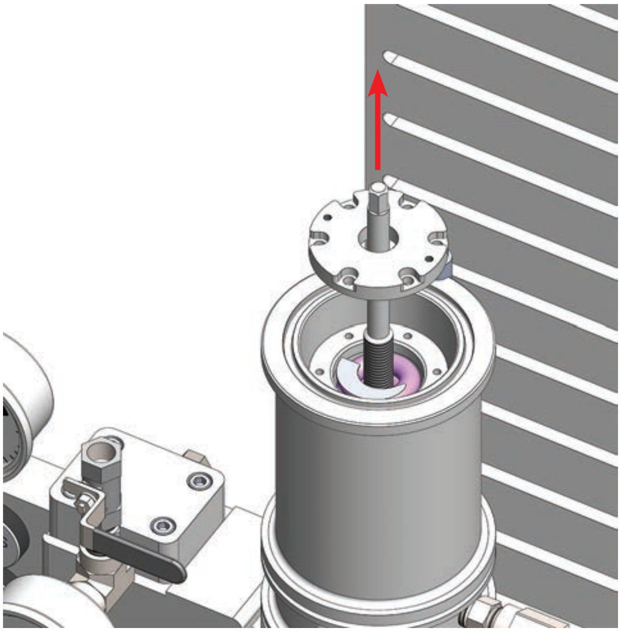
8. Remove the O-ring from the top of the spring chamber.



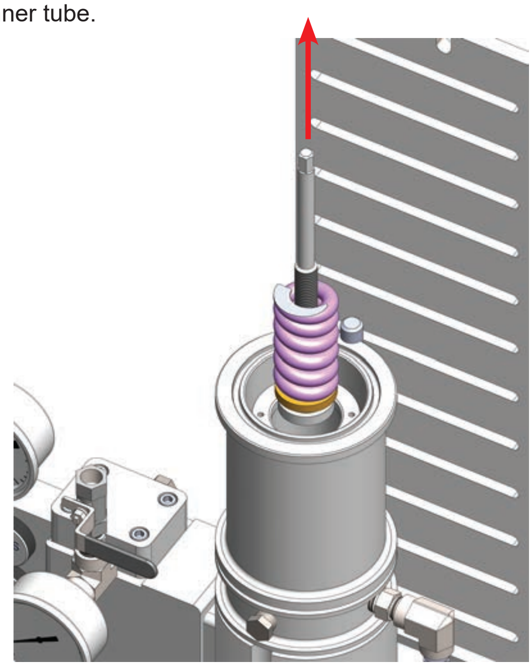
9. Remove the cap screws from the inner tube cap.



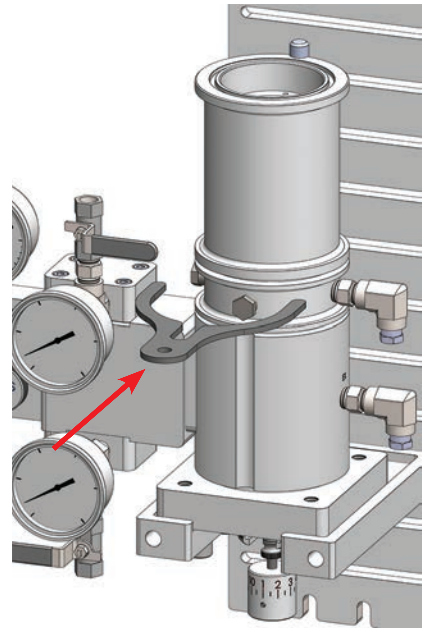
10. Remove the tube cap from the inner tube.



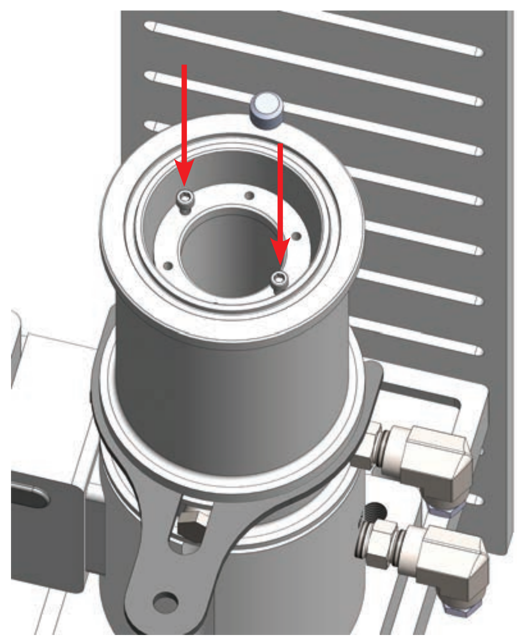
11. Remove the spring adjusting screw assembly from the inner tube.



12. (Optional step) insert the tooling spacer between the spring chamber and spacer.

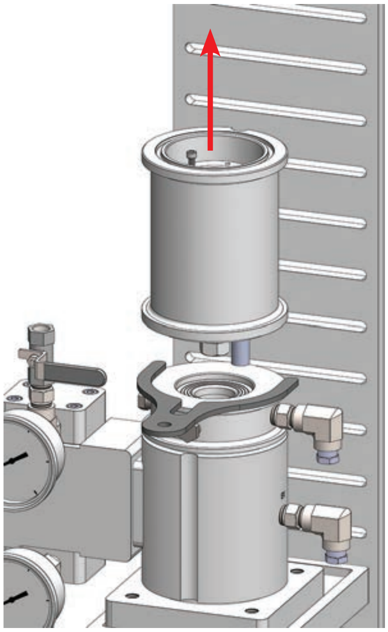


13. (Optional step) re-insert two cap screws into the inner tube threaded holes.



The cap screw heads can be used for leverage to remove the spring case assembly.

14. Remove the spring case assembly by rotating the inner tube to disengage it from the threaded piston below.



15. Remove the nut from inside the inner tube.

16. Remove the piston and diaphragm from the spring case.

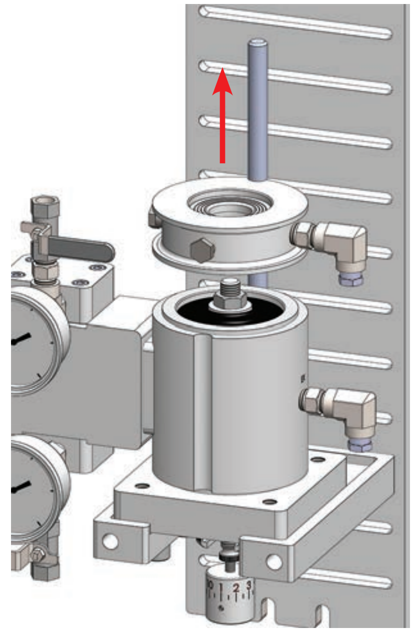
17. Remove the inner tube from the spring case.

18. Remove the diaphragm from the piston.

19. Remove the O-ring from the piston.

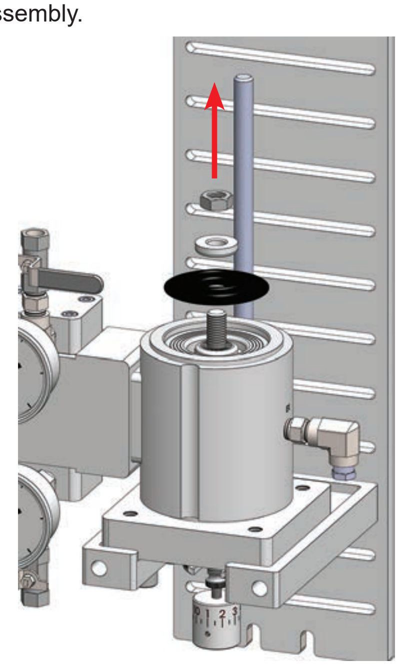
CAUTION: to avoid damage to the sealing surfaces, use only brass, plastic, or other soft tools to remove O-rings and other seals.

20. Remove the spacer from the pilot assembly.

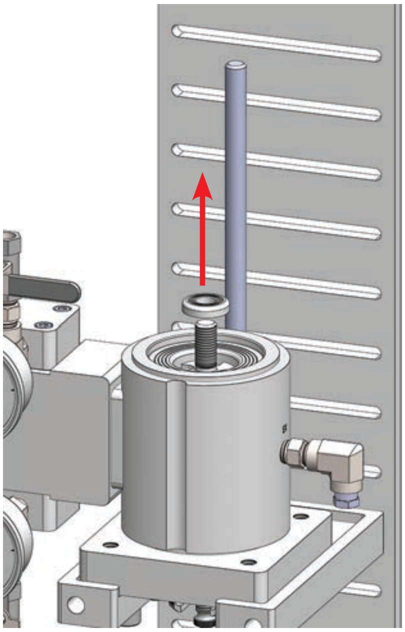


Note: it is generally not necessary to remove any fittings or plugs from the spacer.

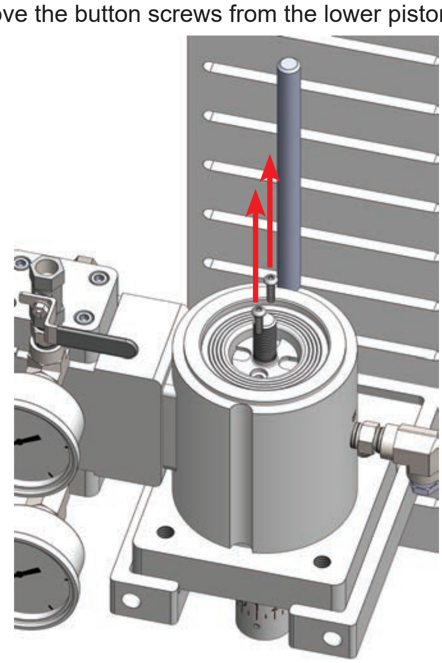
21. Remove the nut, serrated washer, and diaphragm from the body assembly.



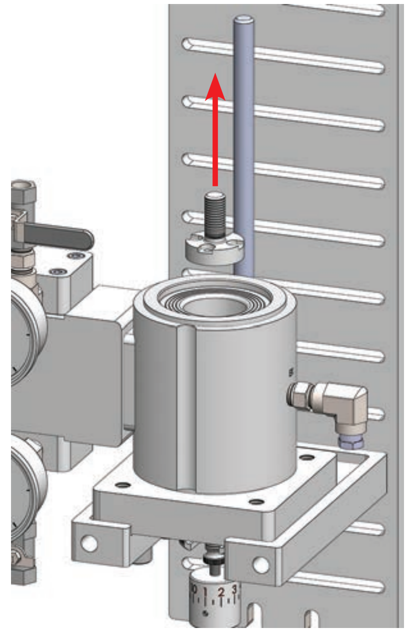
22. Remove the serrated washer from beneath the diaphragm.



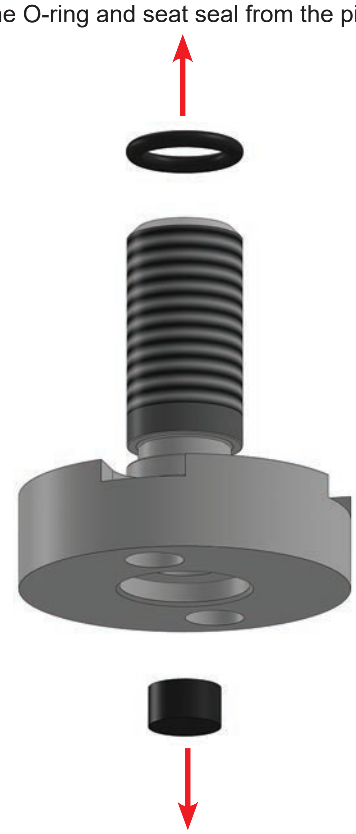
23. Remove the button screws from the lower piston.



24. Remove the lower piston.

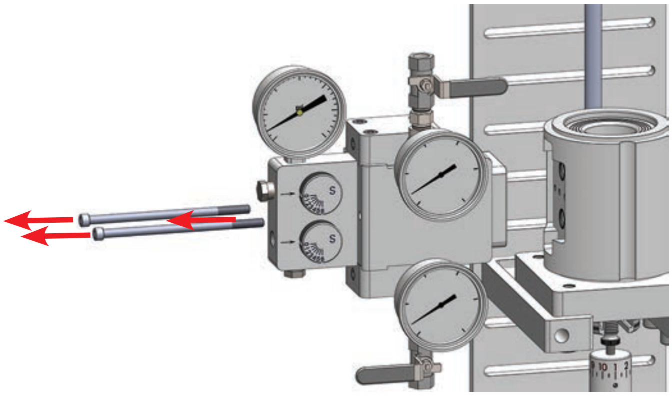


25. Remove the O-ring and seat seal from the piston.

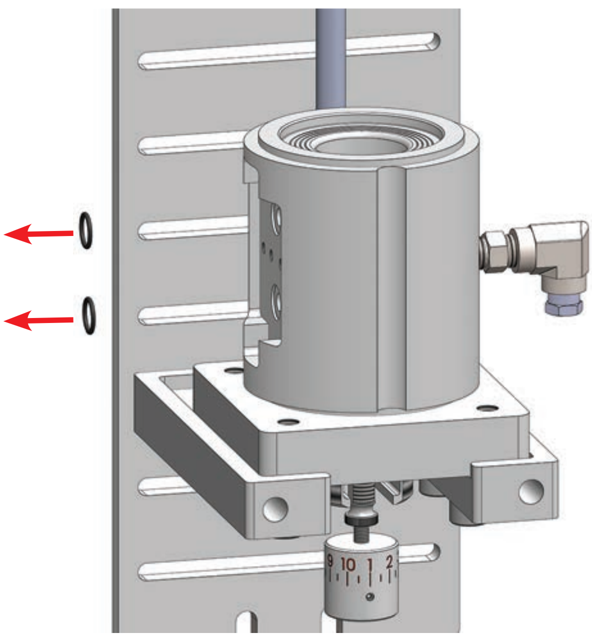


CAUTION: to avoid damage to the sealing surfaces, use only brass, plastic, or other soft tools to remove O-rings and other seals.

26. (Optional step) remove the cap screws and orifice manifold from the side of the pilot body.

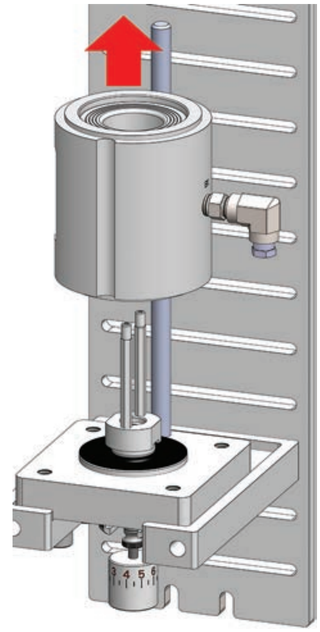


27. If the manifold was removed, remove the O-rings from the manifold interface.

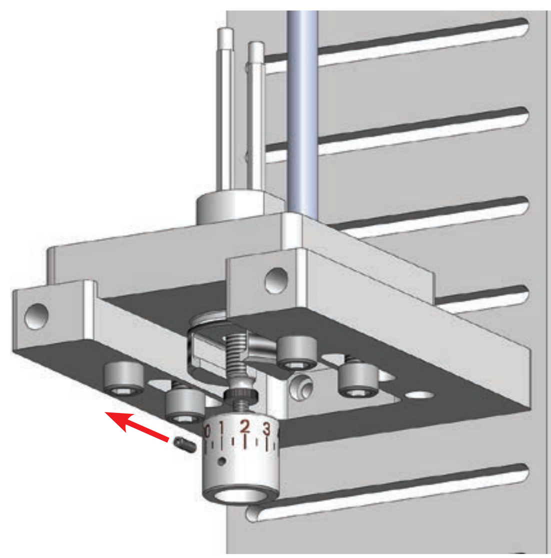


CAUTION: to avoid damage to the sealing surfaces, use only brass, plastic, or other soft tools to remove O-rings and other seals.

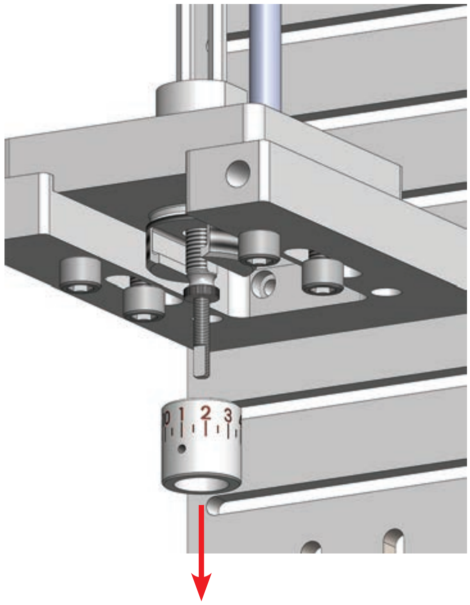
28. Remove the pilot body from the base.



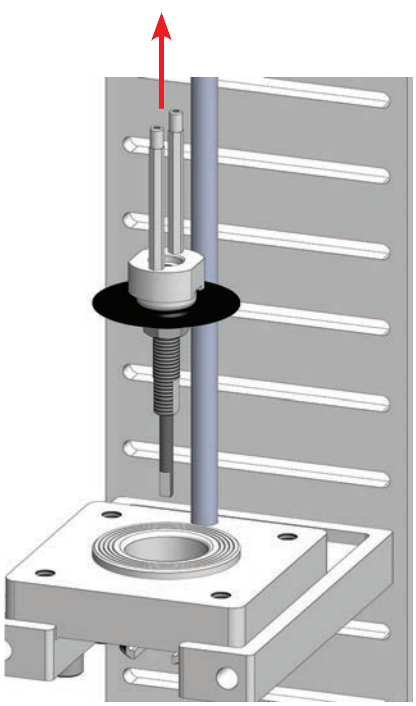
29. Remove the set screw from the adjusting drum.



30. Remove the adjusting drum.



31. Remove the post assembly from the base.

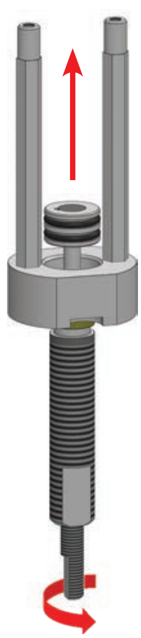


32. Remove the thumb nut from the post assembly.

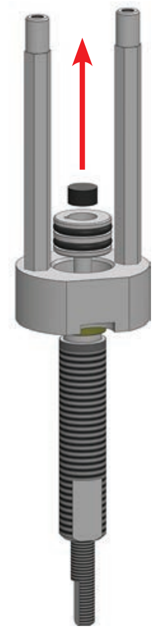
33. Remove the retaining nut, diaphragm, and serrated washers from the post assembly.

34. Remove the O-ring from the post assembly.

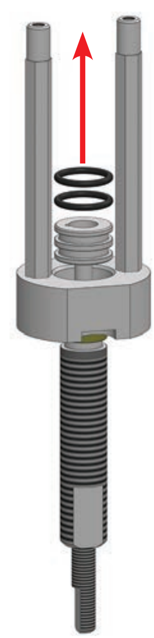
35. Rotate the valve adjusting screw clockwise to expose the O-rings.



36. Remove the seat from the valve adjusting screw.



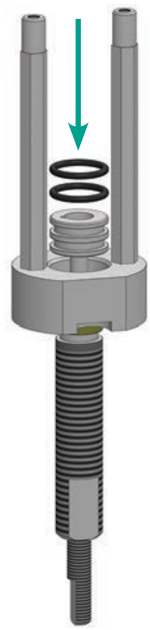
37. Remove the O-rings from the valve adjusting screw.



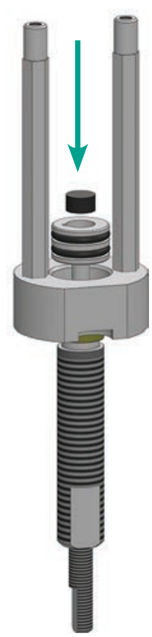
CAUTION: to avoid damage to the sealing surfaces, use only brass, plastic, or other soft tools to remove O-rings and other seals.

Reassembly Procedures:

1. Install the O-rings onto the valve adjusting screw.

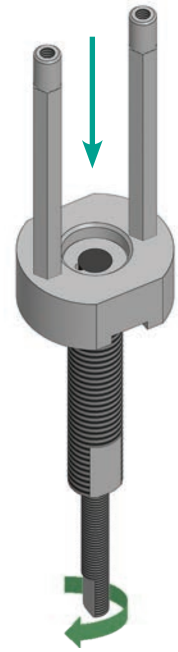


2. Install the seat into the valve adjusting screw.

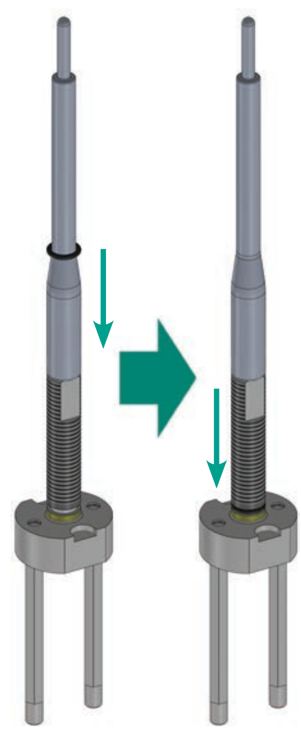


CAUTION: do not use metal tooling to insert the seat.

3. Rotate the valve adjusting screw counterclockwise until the seat is fully retracted.

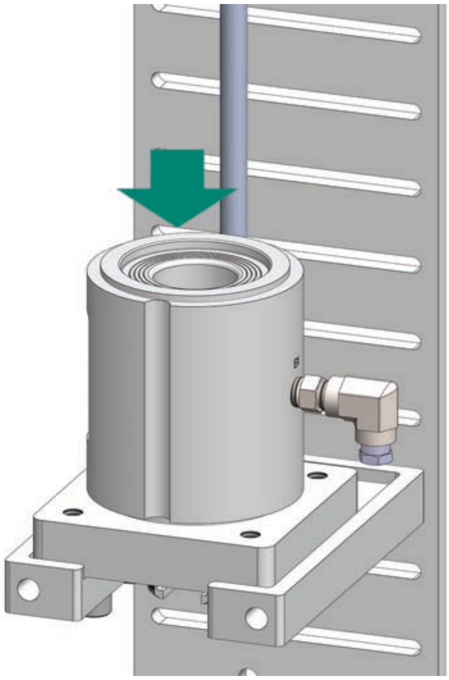


4. Install the O-ring onto the inside piston.



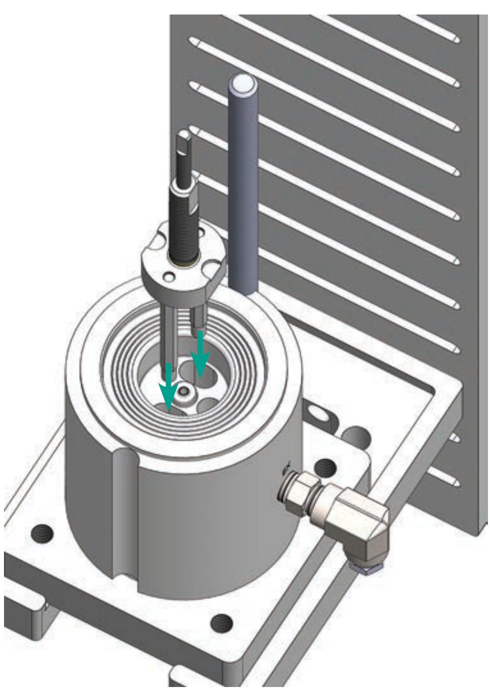
Note: the optional O-ring installation tool (Becker part no. 77 0021, shown here) may aid with O-ring installation

5. (Optional step) place the pilot body onto the base so that the notch along the outside diameter aligns with the indexing rod.

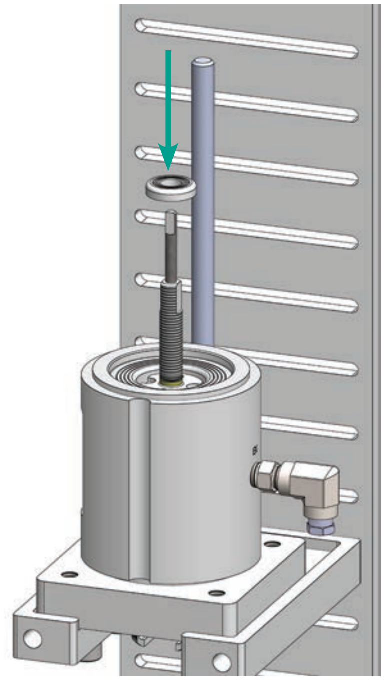


Note: if installed in this way, the body may be used as a fixturing tool for steps 43-50 as shown in this document. If preferred, an alternate fixturing method may be used. The body is symmetrical, so the direction of installation does not matter at this stage.

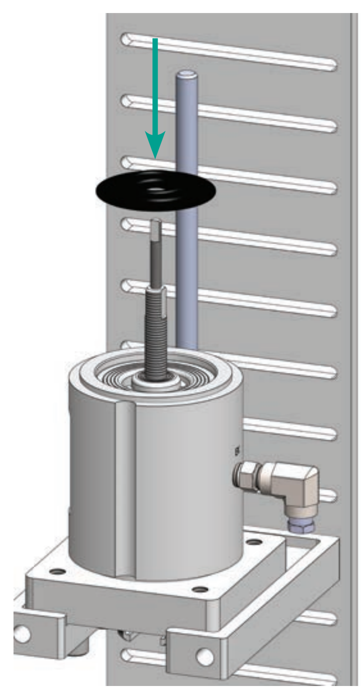
6. Insert the post assembly into the elongated body holes.



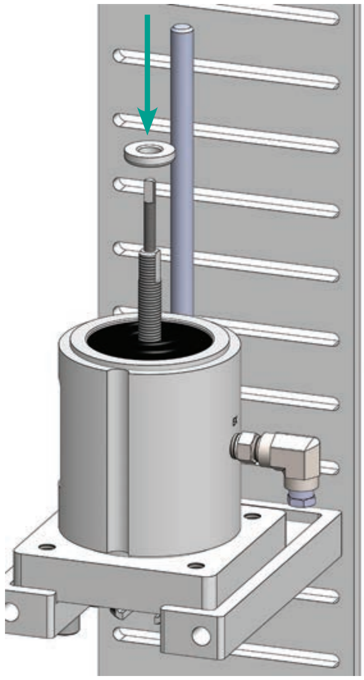
7. Install the serrated washer with the serrations pointing upward (away from the piston and body).



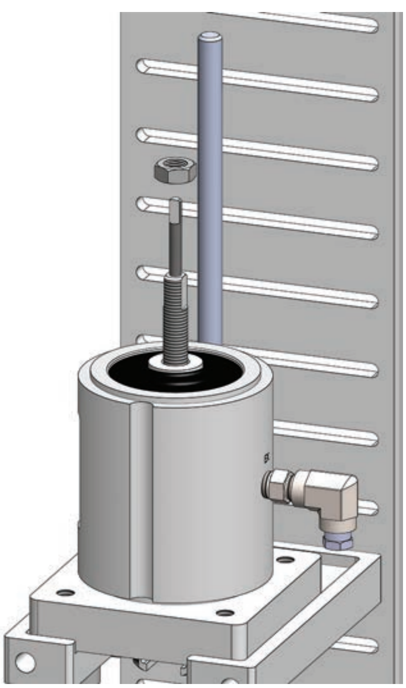
8. Install the diaphragm with the raised and convoluted feature pointing upward (away from the piston and body).



9. Install the second serrated washer with the serrations facing toward the diaphragm.

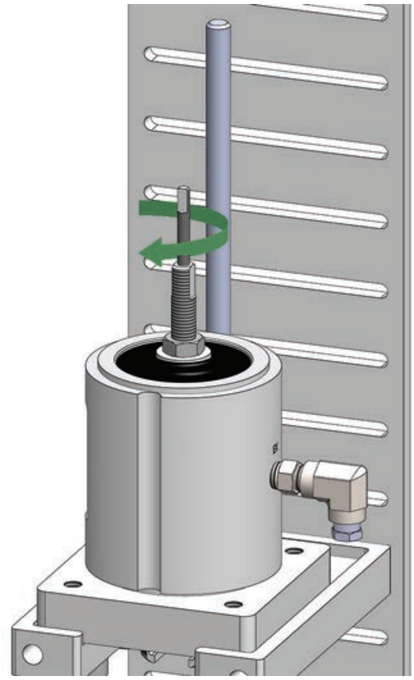


10. Install the nut onto the piston.

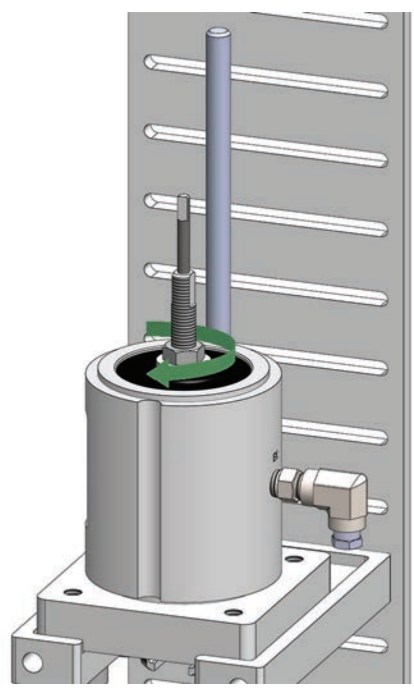


Note: the nut should be installed so that it is flush with the serrated washer, but should be finger tight only at this stage.

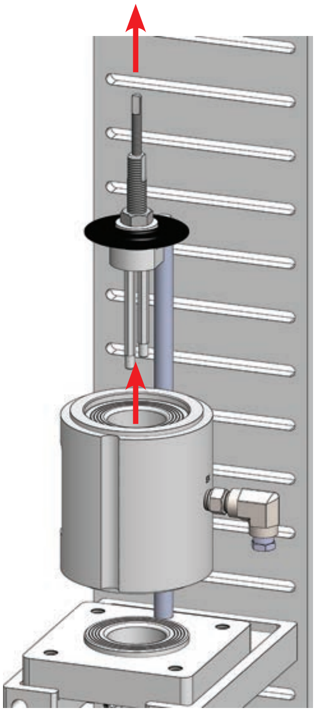
11. Gently rotate the spindle assembly clockwise until the posts contact the walls of the elongated holes in the body.



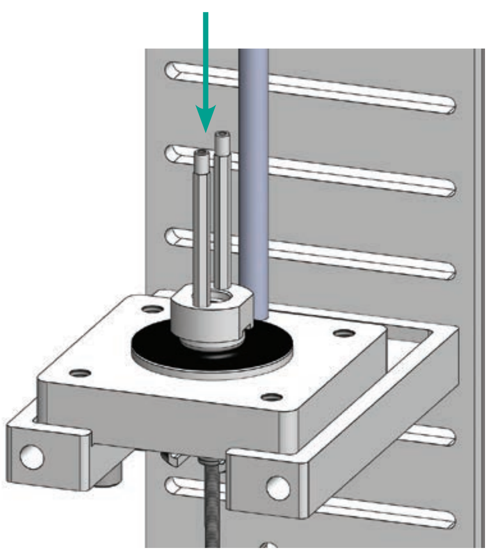
12. While securing the pilot body (or other assembly fixture), torque the nut to 180 in-lbs (20.3 N-m).



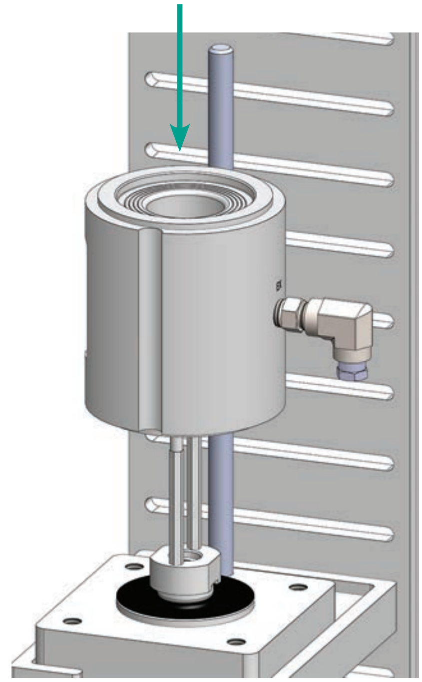
13. Remove the spindle assembly and pilot body (if applicable).



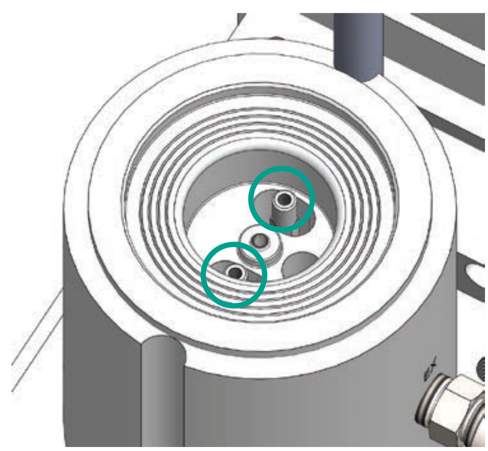
14. Install the spindle assembly on the pilot base with the two (2) posts pointing upward and in line with the indexing rod.



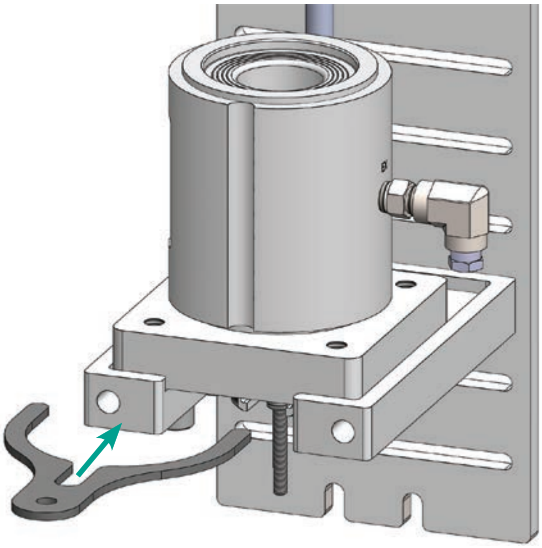
15. Install the body on the pilot base with the two (2) spindle posts inserted through the elongated holes in the pilot body and the NBV pocket facing to the left. If an exhaust fitting with an elbow is included, the exhaust vent should be pointing downward.



Note: the spindle posts should be approximately centered inside the elongated holes.

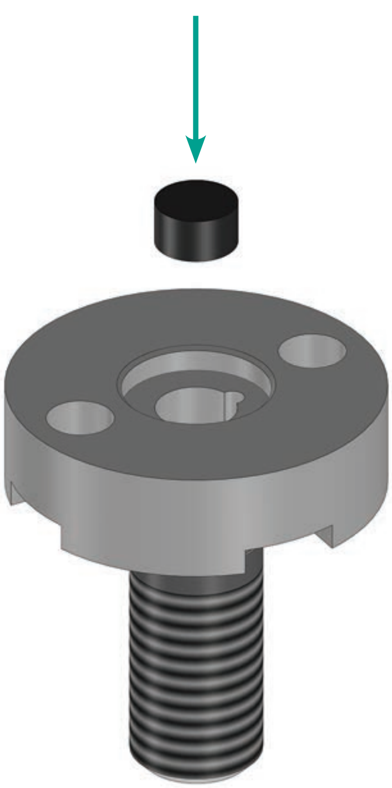


16. (Optional step) insert a diaphragm separation tool between the pilot base and body.

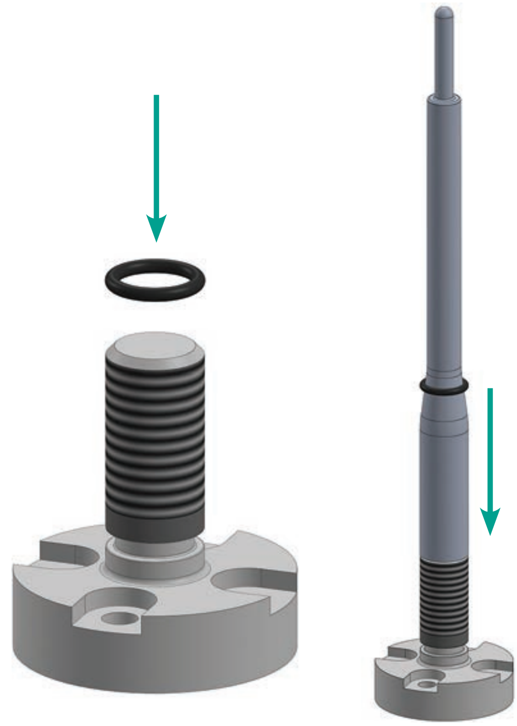


Note: this tool prevents abrasion damage to the diaphragm by creating a gap between the parts and allowing the diaphragm to rotate freely during subsequent steps where parts are torqued into place. If the diaphragm separation tool is not used, caution should be exercised to ensure enough separation between the parts to allow the diaphragm to rotate freely.

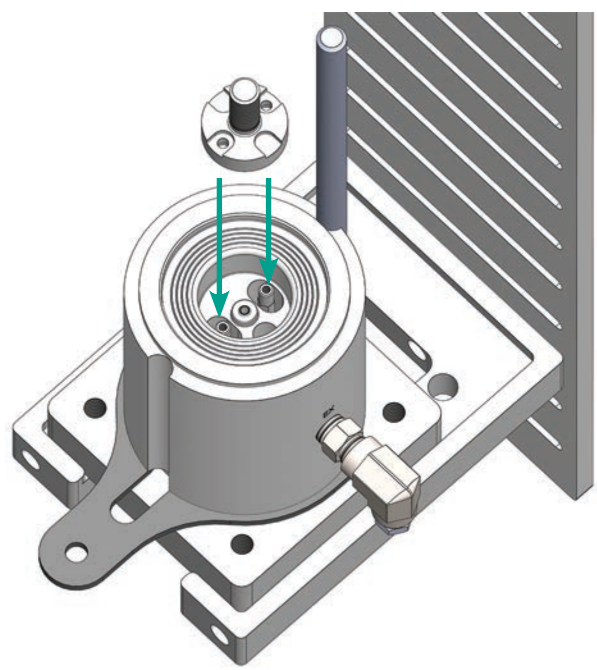
17. Insert the seat into the outside piston.



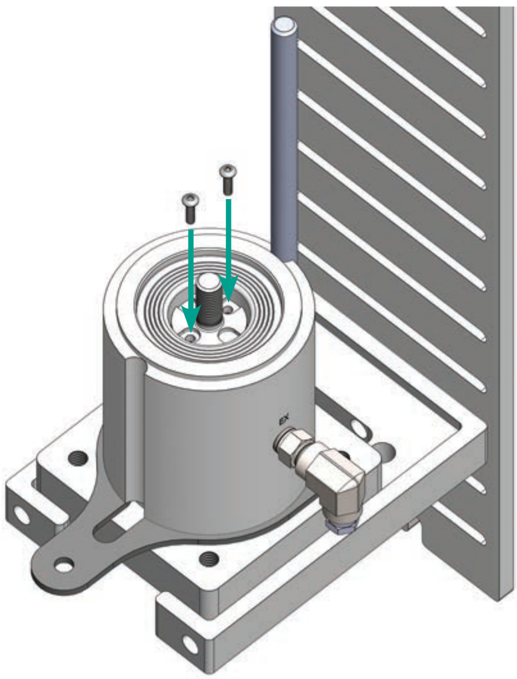
18. Install the O-ring onto the outside piston. The optional O-ring installation tool may be used to aid installation.



19. Place the piston assembly onto the pilot body with the holes aligned with the posts protruding through the elongated holes in the body.

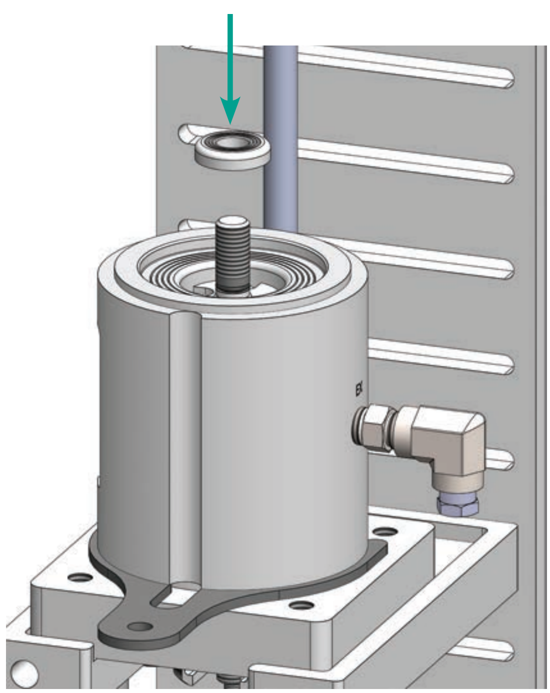


20. Install the button head cap screws into the posts.

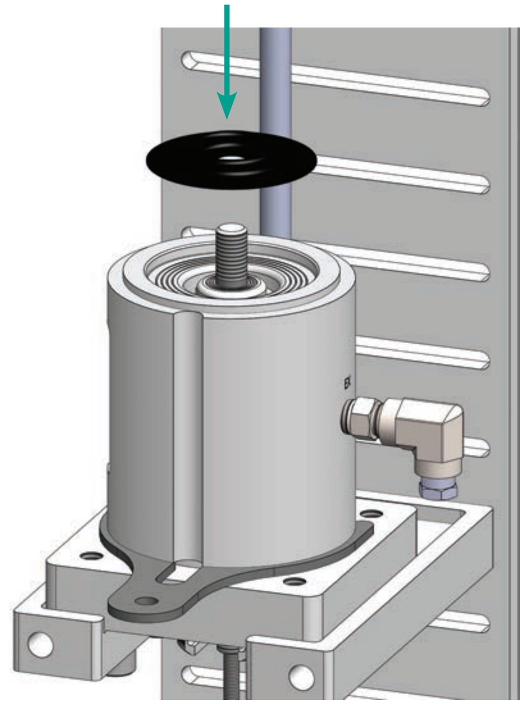


Note: screws should be installed wrench tight, but no specific torque setting is required.

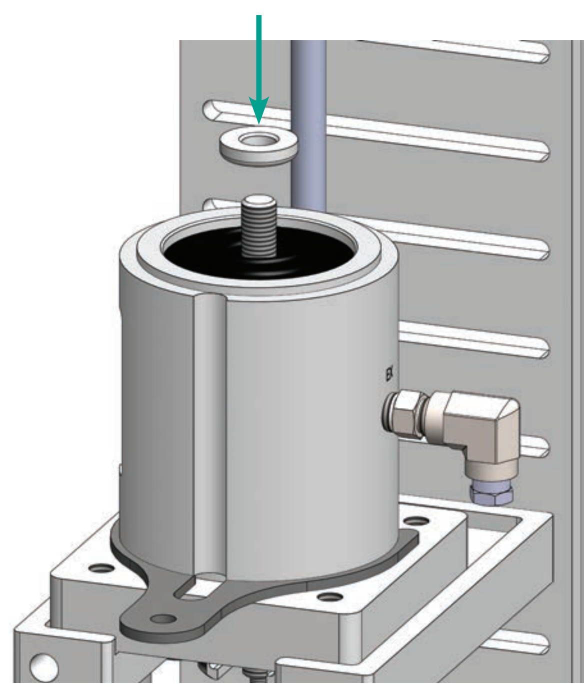
21. Install a serrated washer with the serrations facing upward (away from the body).



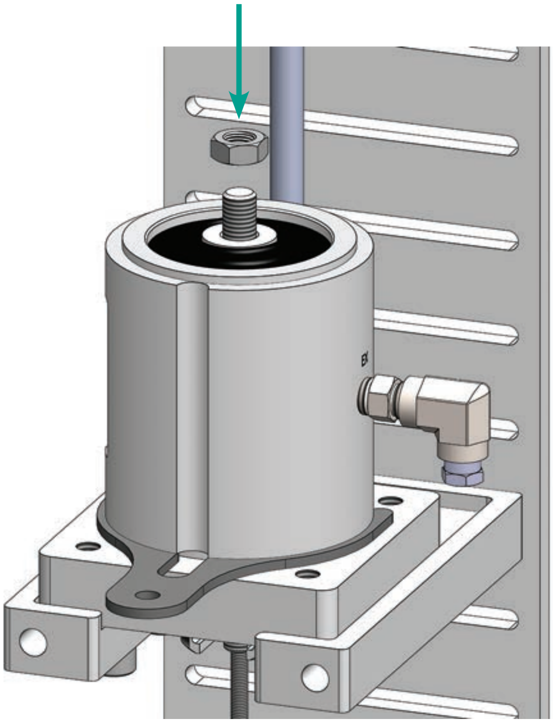
22. Install the diaphragm with the convoluted and raised portion pointing upward (away from the pilot body).



23. Install a serrated washer with the serrations facing toward the diaphragm.

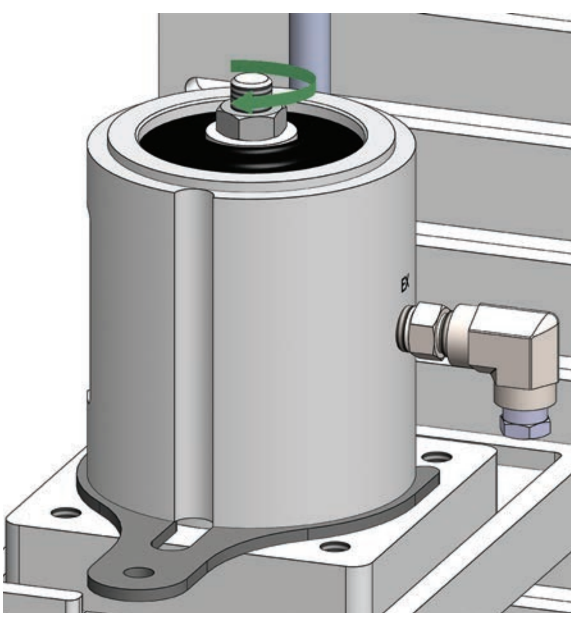


24. Install the nut on the piston.

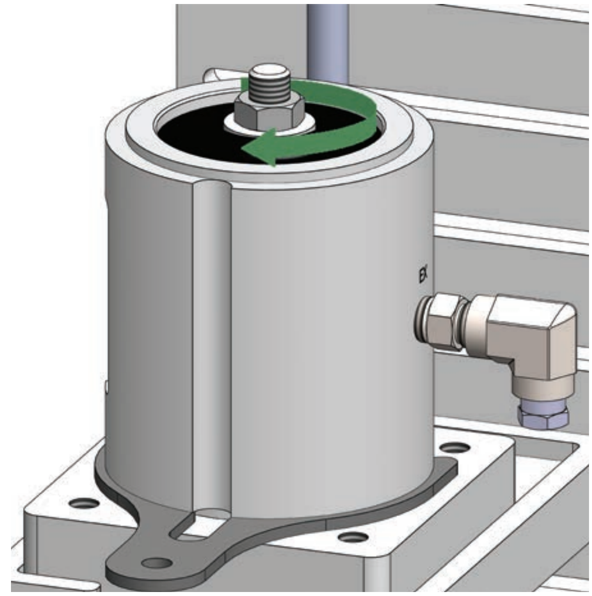


Note: the nut should be finger tight at this stage.

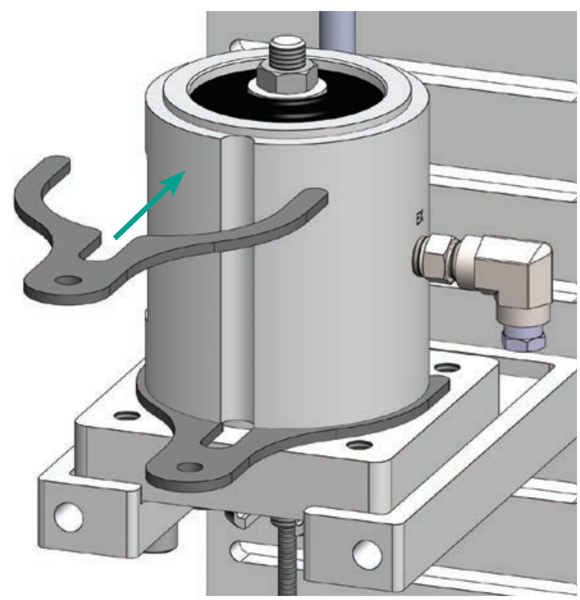
25. Gently rotate the piston and spindle assembly until the posts contact the walls of the elongated body holes.



26. While holding the pilot body and gently pushing toward the alignment rod, torque the nut to 180 in-lbs (20.3 N-m).

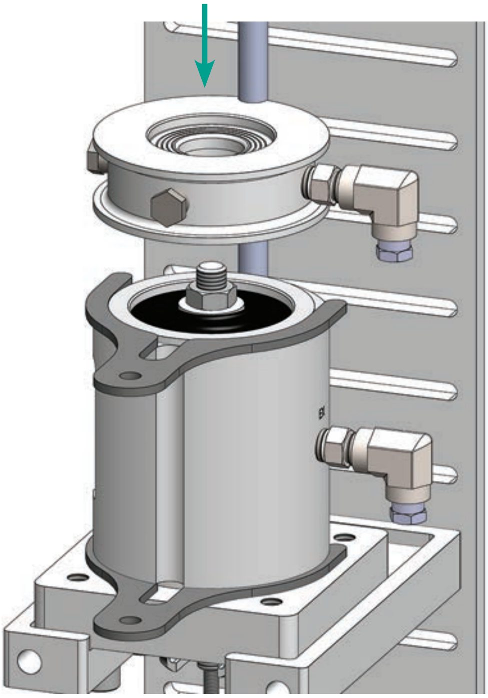


27. (Optional step) install a diaphragm spacer tool on top of the body assembly.



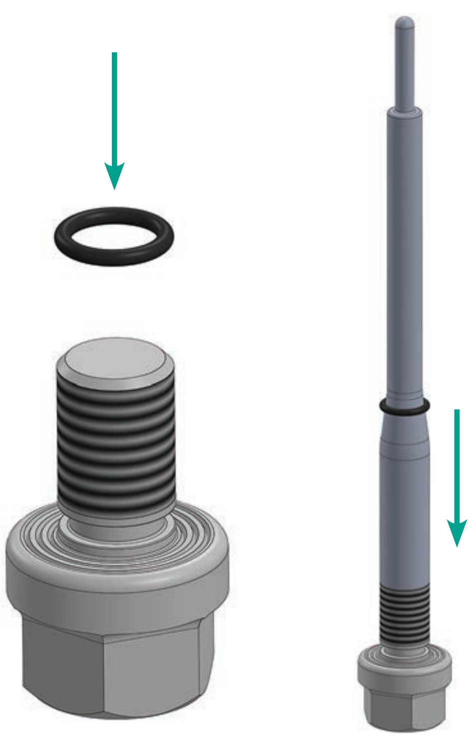
Note: this tool prevents abrasion damage to the diaphragm by creating a gap between the parts and allowing the diaphragm to rotate freely during subsequent steps where parts are torqued into place. If the diaphragm separation tool is not used, caution should be exercised to ensure enough separation between the parts to allow the diaphragm to rotate freely.

28. Install the spacer assembly on the pilot body.



Note: if installed with an elbow, the exhaust vent should point downward.

29. Install the O-ring onto the upper piston. The optional O-ring installation tool may be used to aid installation.

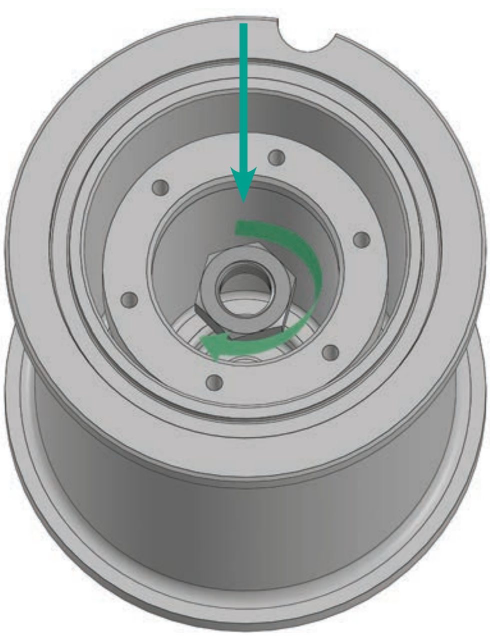


30. Install the diaphragm onto the piston with the convoluted Series raised feature pointing toward the piston nut and serrations.

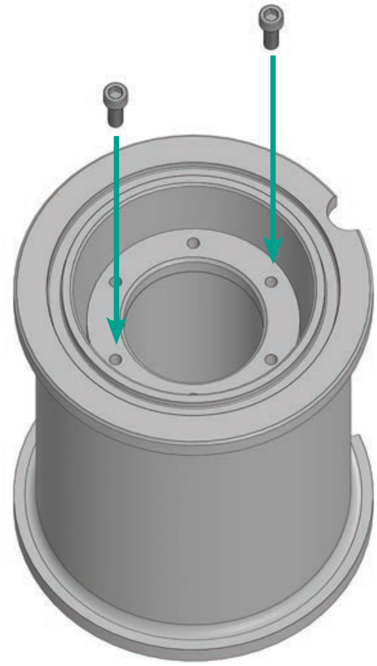
31. Insert the inner tube into the spring chamber.

32. Insert the piston and diaphragm assembly into the spring case and inner tube.

33. Install the nut onto the piston post inside the inner tube. Torque to 200 in-lbs for VRP-1500-CH or 180 in-lbs for VRP-600-CH.

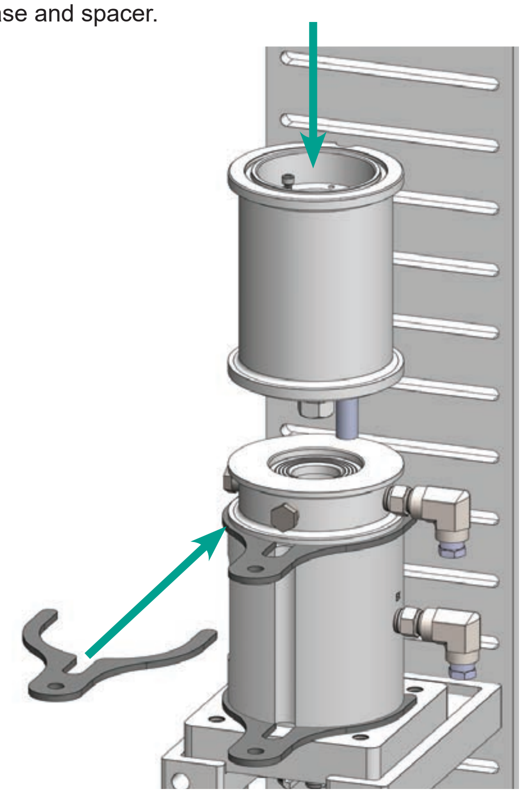


34. (Optional step) install two cap screws into the spring case.



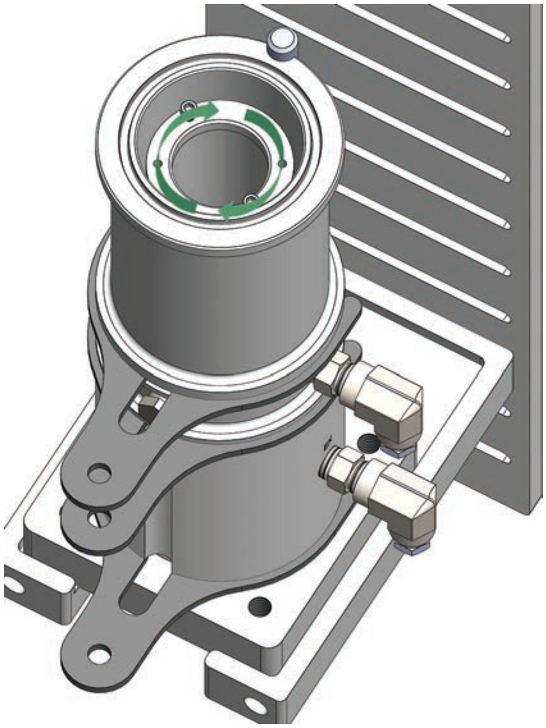
Note: the cap screws may be used for leverage to install the spring case in step 37.

35. Place the spring case assembly onto the spacer and insert a diaphragm spacer tool (optional) between the spring case and spacer.



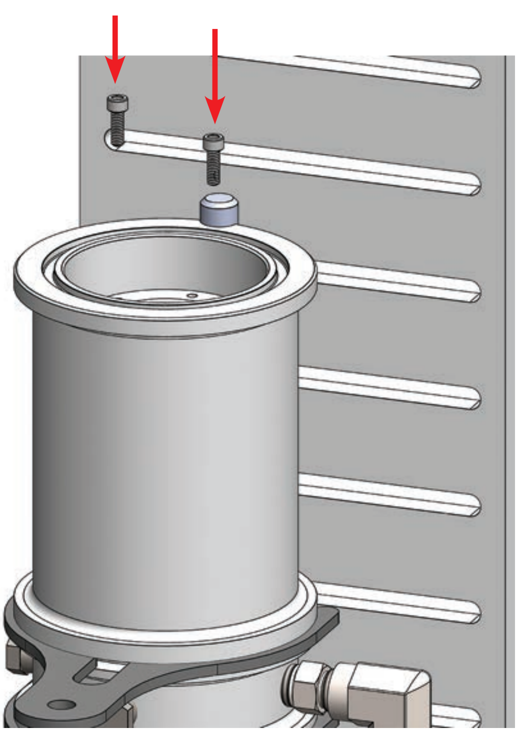
Note: this tool prevents abrasion damage to the diaphragm by creating a gap between the parts and allowing the diaphragm to rotate freely during subsequent steps where parts are torqued into place. If the diaphragm separation tool is not used, caution should be exercised to ensure enough separation between the parts to allow the diaphragm to rotate freely.

36. Thread the inner tube combination chamber onto the spring chamber piston coupling.



Note: the inner tube combination chamber should be fully threaded onto the piston coupling until snug, but a precise torque is not required.

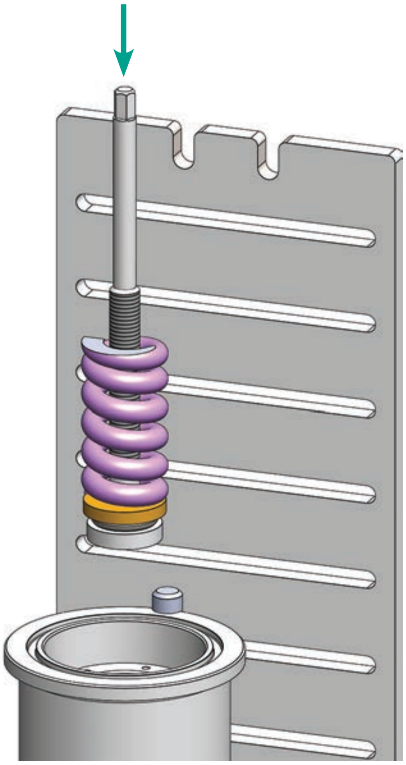
37. If used to install the spring case assembly, remove the cap screws from the inner tube combination chamber.



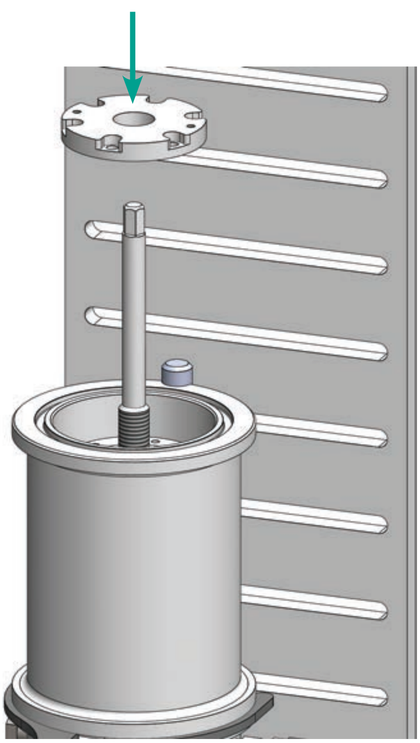
38. If necessary, lubricate the thrust bearing and the top surface of the bearing case with Mobil Mobilith SHC Red or an equivalent lubricant and reinstall the thrust bearing, bearing case, and spring onto the spring adjusting screw.

Note: install the thrust bearing with the curved side facing toward the base of the spring adjusting screw, away from the bearing case.

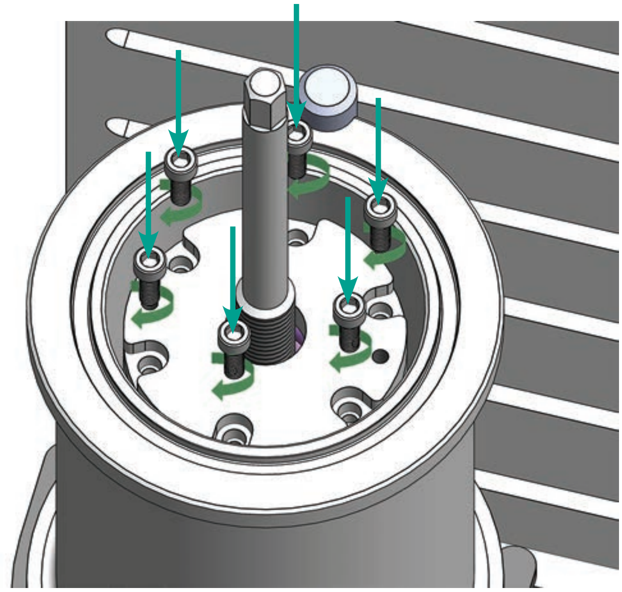
39. Insert the spring adjusting screw assembly into the inner tube.



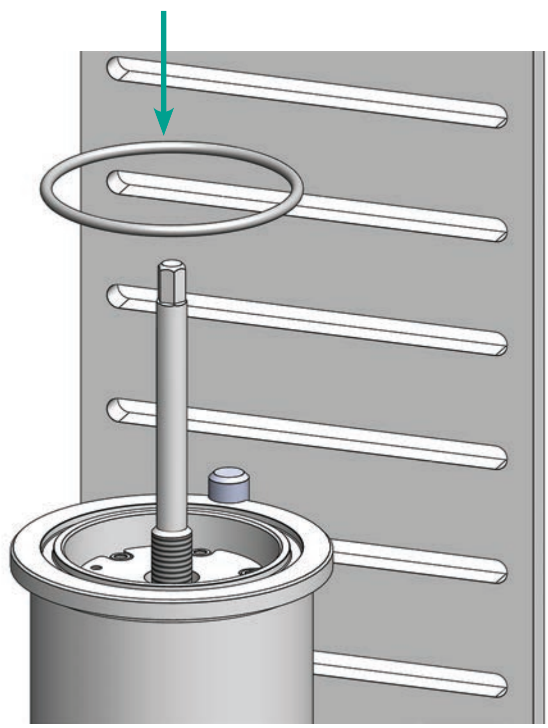
40. Verify that the tube cap is properly lubricated with Mobil Mobilith SHC Red or an equivalent lubricant and install the cap onto the inner tube.



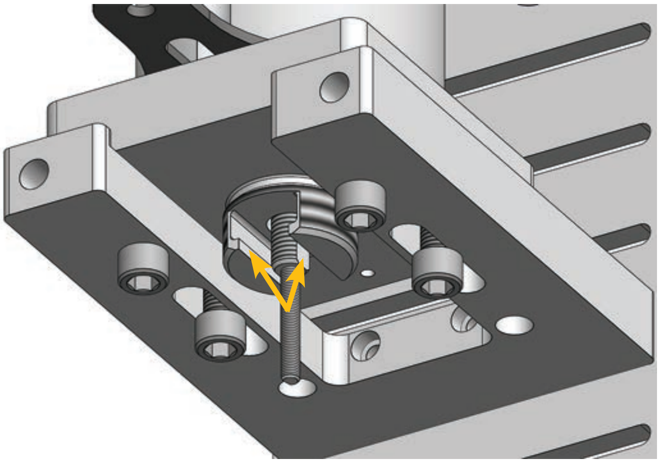
41. Insert the six (6) cap screws into the cap and torque hand tight**.**



42. Install the O-ring on the top of the spring case.

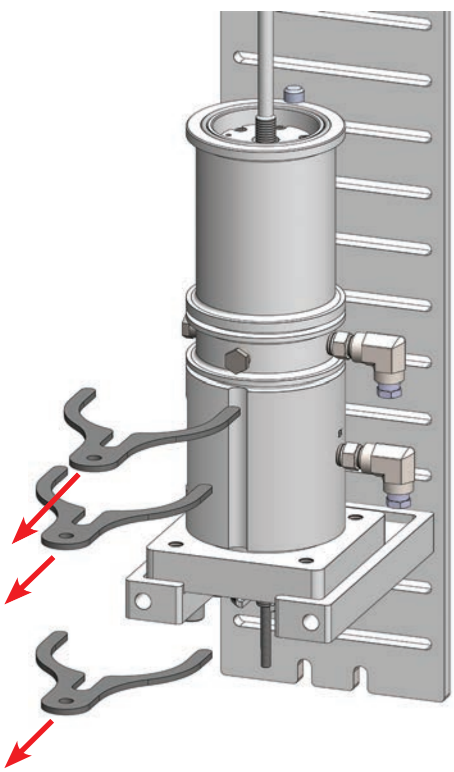


43. Rotate the bottom adjustment spindle so that the flats on the spindle are approximately parallel with the slot faces.

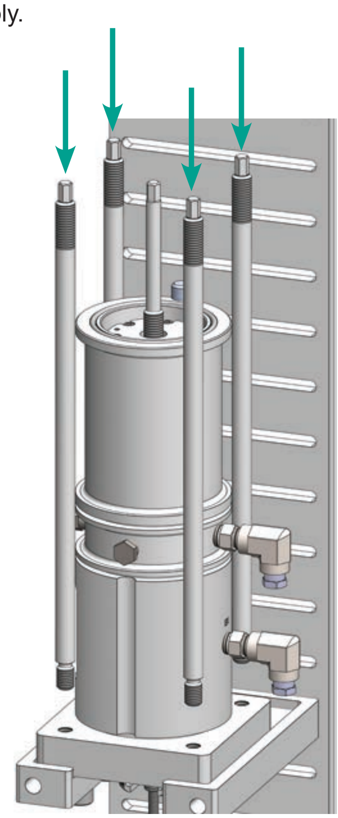


Note: this will center the pilot posts relative to the elongated slots in the pilot body.

44. If used, remove the tooling spacers, beginning at the top of the assembly.

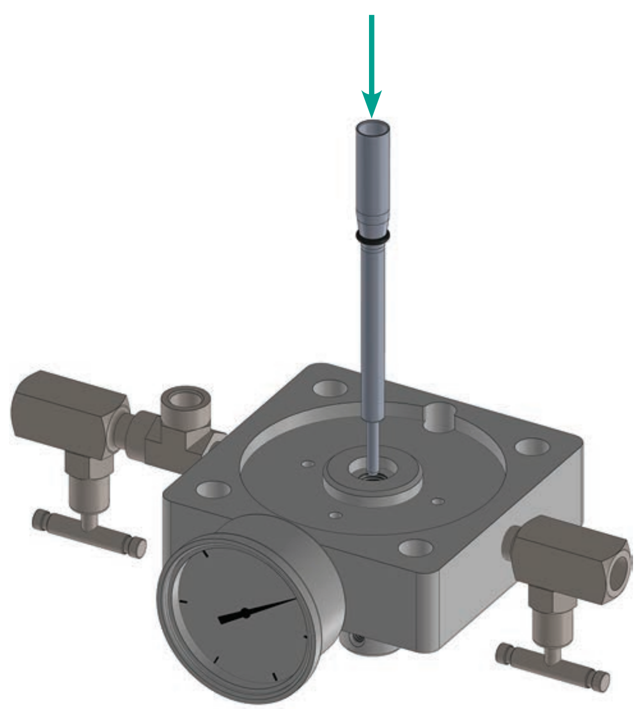


45. Reinstall any tie rods that were removed during disassembly.

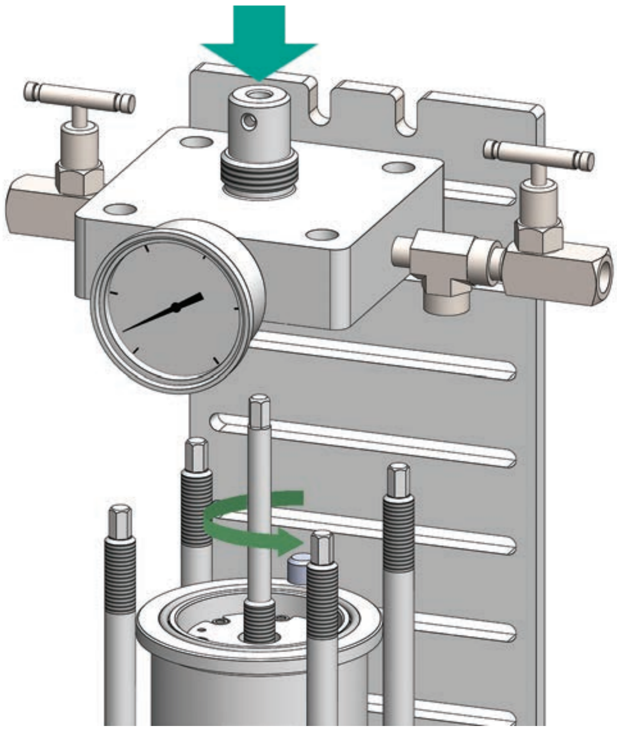


Note: the tie rods should thread smoothly into the base until fully engaged. Do not force. If resistance is encountered while installing the tie rods, the tie rod(s) may require replacement.

46. Insert the O-ring into the top cap assembly. The optional O-ring installation tool may be used to aid installation. If the O-ring installation tool is used, the tool should be fully inserted into the hole and then removed to install the O-ring into the internal gland.

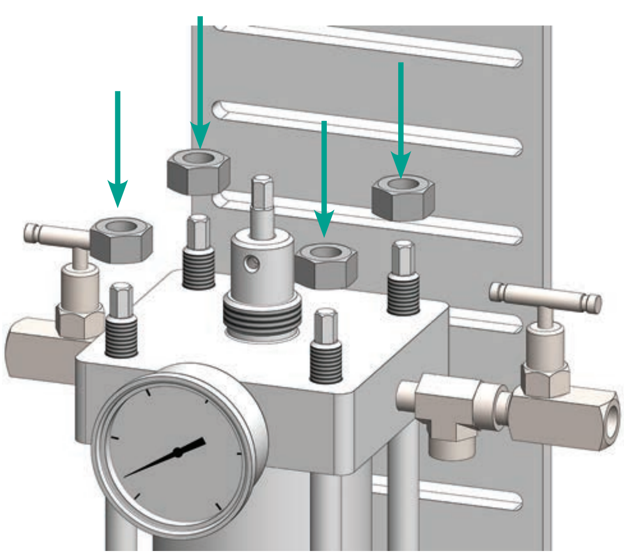


47. Install the top cap assembly onto the pilot body assembly. While lowering the top cap assembly, once the spring adjusting screw protrudes through the hole in the top cap, rotate the spring adjusting screw counterclockwise to engage the adjusting screw with the top cap internal threads.

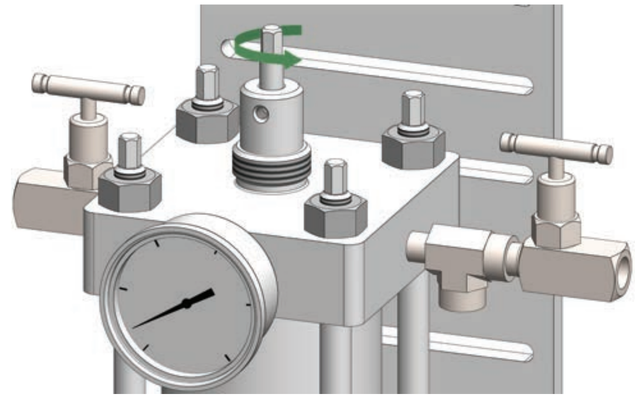


Note: it may be necessary to lift the top cap slightly while rotating the adjusting screw to begin engaging the threads.

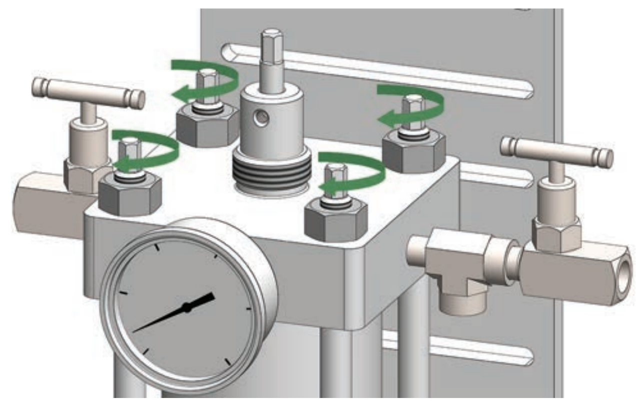
48. Install the nuts onto the tie rods until finger tight only.



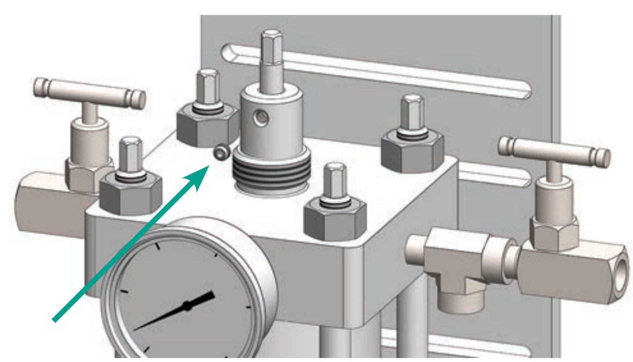
49. Continue to rotate the spring adjusting screw counterclockwise until fully engaged.



50. Torque the nuts on the top cap to 20 ft-lbs. in a crossing pattern.

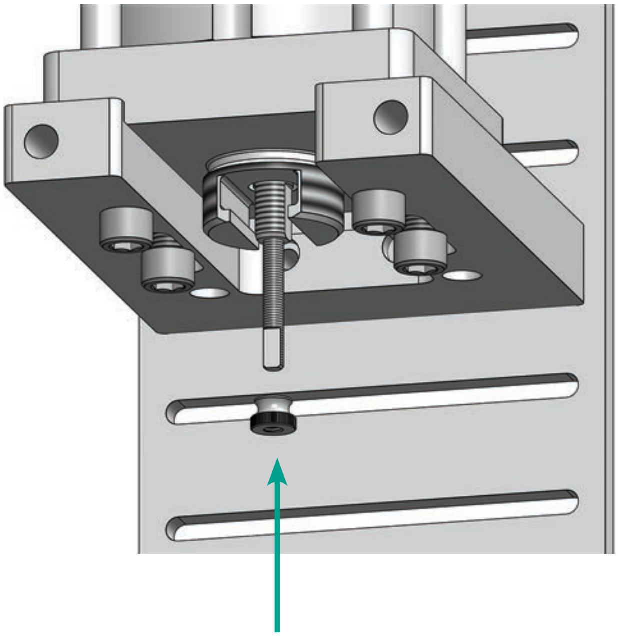


51. Insert the set screw into the top cap.

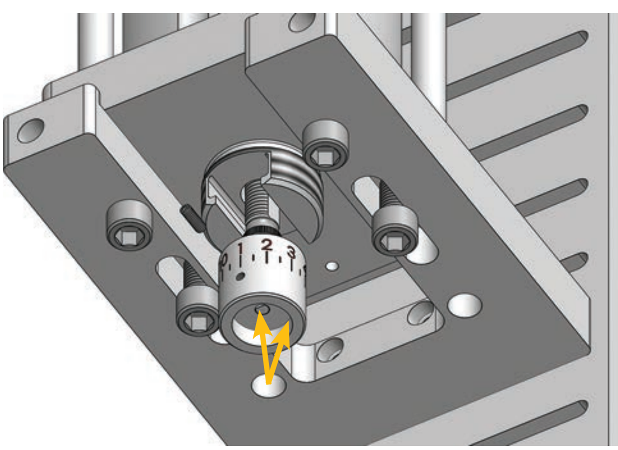


Note: the set screw should be installed wrench tight, but no specific torque value is required.

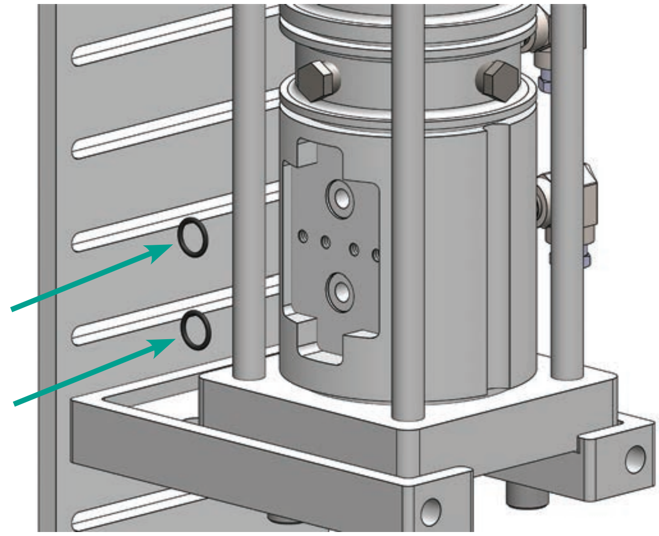
52. Install the thumb nut onto the calibration drum spindle until fully engaged.



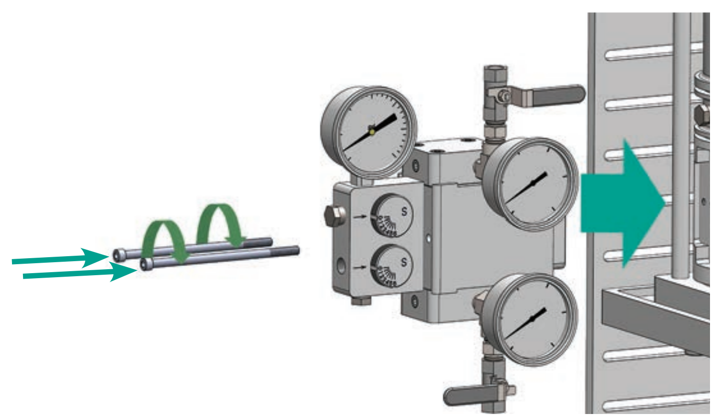
53. Position the calibration drum so that the counterbored surface is flush with the bottom face of the spindle and install the set screw to hold the adjusting drum in place.



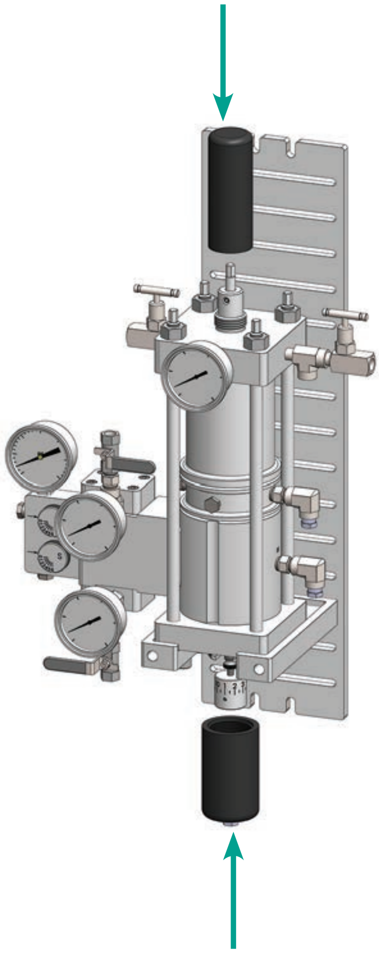
54. If the NBV manifold was removed during disassembly, insert one (1) O-ring into each of the two (2) manifold glands on the pilot body.



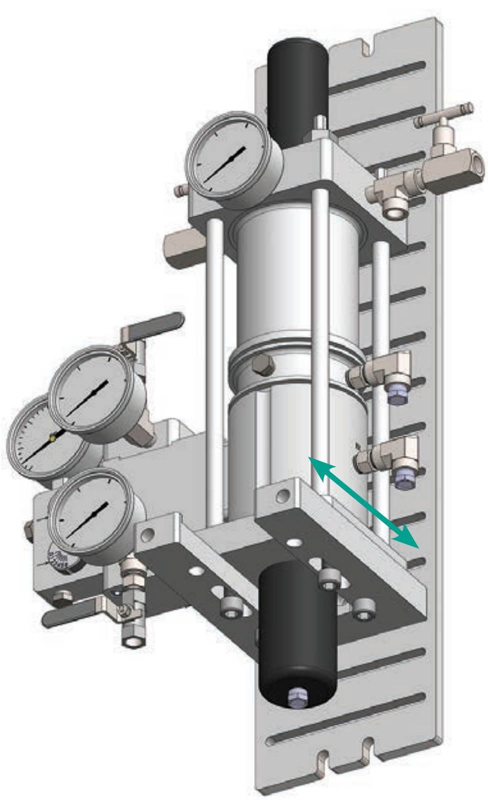
55. Place the NBV manifold onto the pilot body and secure it by inserting the cap screws through the manifold body and threading them into the corresponding holes on the pilot body. Torque hand tight.



56. Replace the top and bottom caps.



57. Position the pilot as desired relative to the base and secure in place with the bottom mounting cap screws.



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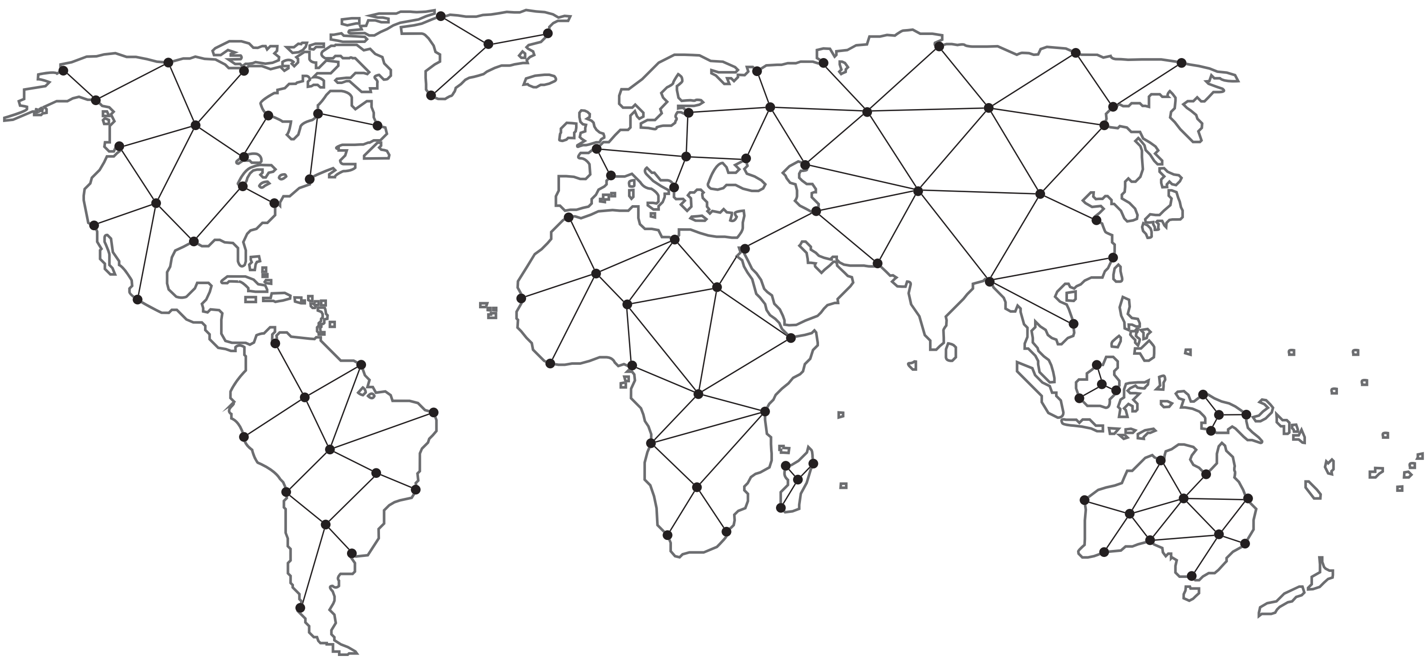

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