

# Bettis Rotary Gas/Hydraulic Operator

Scotch Yoke Valve Operator



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# Section 1: Safety Warning

Please refer to the applicable section for details and further information.

## 1.1 Operating Instructions

This equipment exhausts gas as part of its operating cycle. Wear hand, ear, and eye protection, and keep sparking devices and open flames away.

## 1.2 Installation

For final assembly over stem to valve: to lift the operator only, use lifting eyes with a 3 leg sling and one shortening hook.

Excess operator travel can cause damage to end of stroke (trigger) valve if over-travel occurs and the trigger interferes with the component. The operators mechanical end-stops are preset at the factory for 90° travel.

## 1.3 Start-Up Checks

If unit has a fail or ESD (Emergency Shut Down) position, the fail-safe or ESD controls may have to be temporarily disabled, bypassed or overridden by AUTO/MANUAL selector to prevent inadvertent valve operation.

## 1.4 Maintenance and Operational Testing

De-pressurize operator before attempting to service power gas filter, check tank fluid level or check manual operation of handpump.

## 1.5 End of Stroke Valve Instructions

Changing operator travel can cause damage to end of stroke (trigger) valve if over travel occurs and trigger strikes component.

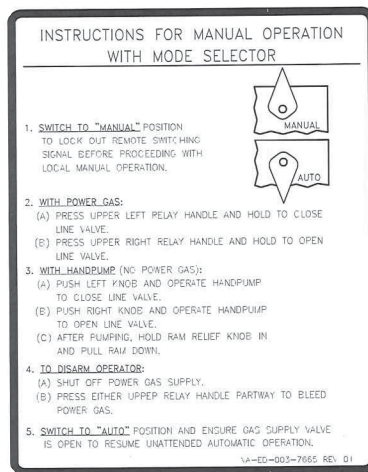
## 1.6 Operator Maintenance

Gas/Hydraulic tanks should be drained and flushed if fluid is contaminated with scale, rust, particulates, water, foam, or etc. Flush only with hydraulic fluid. Refill with filtered fluid.

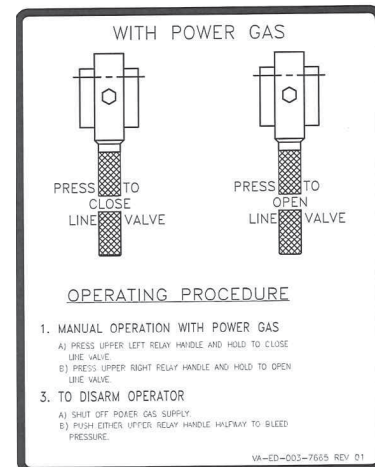
## 1.7 Operating Procedure

1. Manual Operation with Power Gas:
  - a. Press upper left relay handle and hold to close line valve.
  - b. Press upper right relay handle and hold to open line valve.
2. To Disarm Operator:
  - a. Shut off power gas supply.
  - b. Push either upper relay handle halfway to bleed pressure.

**Figure 1** Instruction sticker for gas/hydraulic operation with manual selector, safe operation with power gas and operating procedure



STICKER-1



STICKER-2

**Note:**  
Red characters on white background, easy release backing.

## Section 2: Operating Instructions

Refer to specific schematic drawing and list of components at the end of this document and "Operating Procedure" diagram which is located inside the control package cover on the unit.

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### NOTE:

Operating procedures for equipment with automatic switching capability vary with particular applications. Refer to Owners Procedures for operators with automatic or remote switching devices.

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### NOTE:

The two gas switching relays used for local manual operation are located on the control plate filter manifold assembly inside the control cover. The hand pump is located below the control box.

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### CAUTION

This equipment exhausts gas as part of its operating cycle. Wear hand, ear and eye protection, and keep sparking devices and open flames away.

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1. **WITH POWER GAS** or auxiliary nitrogen bottle present, appropriate shut off valves open, and both selector knobs located on the handpump pulled out into the auto position.
  - a. To close the line valve, press and hold the left side closing handle on the gas switching relay. Release handle after the line valve is closed.
  - b. To open the line valve, press and hold the right side opening handle on the gas switching relay. Release the handle after the line valve is open.
2. **WITHOUT POWER GAS**, and supply shut off valve closed.  
Refer to [Shafer Manual Handpump IOM](#) (Document Number: MHP-01102001).
  - a. To close the operator using the handpump, push the left side selector knob in and start pumping the operator closed. Upon completion of the stroke, pull the selector knob out and press the small manual relief valve to retract the handpump upper ram back into the pump body.
  - b. To open the operator using the handpump, push the right side selector knob in and start pumping the operator open. Upon completion of the stroke, pull the selector knob out and press the small manual relief valve to retract the handpump upper ram back into the pump body.
3. **TO DISARM OPERATOR**, shut off the supply valve and press either handle on the gas switching relays approximately halfway to vent power gas.

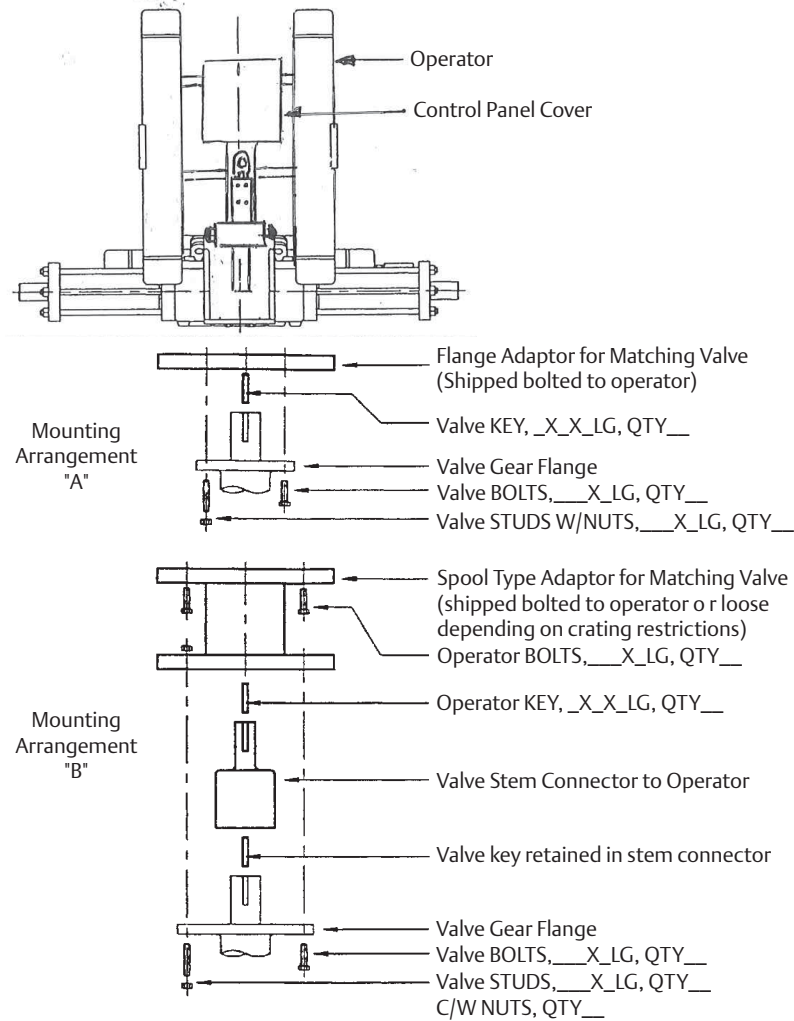
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### NOTE:

Read this document thoroughly to understand the general arrangement and functioning, and to be able to proceed safely and efficiently using the necessary tools and equipment required.

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Figure 2 Mounting instructions for valves with gear flanges



**NOTE:**

Operator is typically shipped in OPEN position. Mounting hardware is located on a pallet or inside the control panel cover.



## Section 3: Installation

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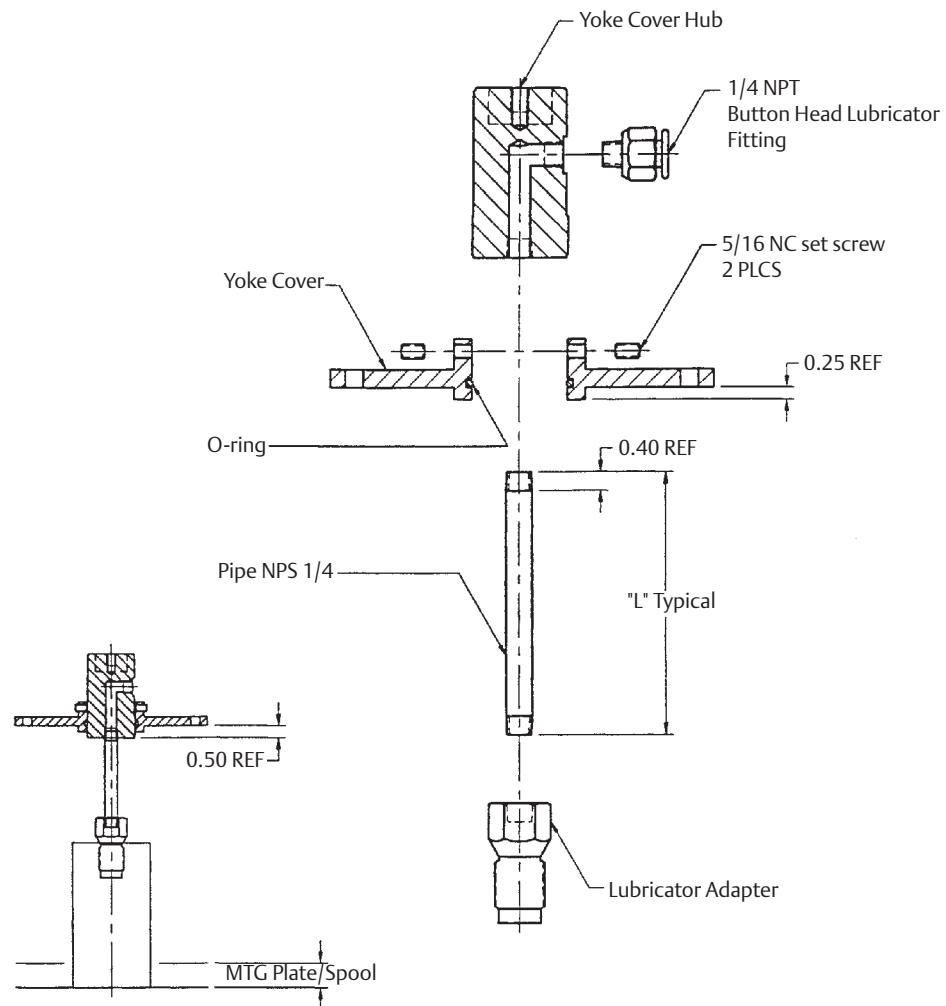
**NOTE:**

Mounting hardware is usually located on the shipping pallet/crate or inside panel cover of unit. Gas/Hydraulic tanks must remain generally vertical, regardless of valve and valve stem orientation. Lifting eyes are to be used in combination, with a 3 leg sling with one shortening hook, to lift the operator only.

---

### 3.1 Field Mounting

1. Determine actuator orientation in relation to the pipeline and valve stem.
2. Place operator and valve in the same position (both open or both closed). Damage to valve and/or operator can be caused if operator tries to open or close a valve against valve internal stops. Operator position can be confirmed safely by operation with handpump.
3. Check mounting surfaces, valve stem, operator bore and orientation for any dimensional discrepancy, dirt, rust, etc.
4. It is recommended that the stem key be set in place at this point before actuator is installed on the valve stem.
5. Set operator in position on the valve. Keep hooks and chains clear of tubing and accessories.
6. Install mounting bolts to fasten operator to valve. Align operator to valve while bolts are slightly loose, then tighten mounting bolts evenly and thoroughly to industry standard for the grade and size of bolt.
7. If necessary, temporarily remove yoke cover and install key using tapped hole and eyebolt.

**Figure 3** Typical lubricator extension to lubricator plug valve with rotary limit switch

8. If necessary, adjust operator end stops for line valve fully open and fully closed positions. (Stops are factory set for approximately 90° rotation). Refer to Figure 5.
  - a. Position operator against the appropriate stop to be adjusted.
  - b. Remove stop cover.
  - c. Adjust end-stop into or away from operator as required.
  - d. Position operator against stop if adjustment (c) was away.
  - e. Install and tighten stop cover, not to damage the o-ring.

Notice the end stop adjustment table below. The stop cover must be tightened firmly to seal against full rated pressure.

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**NOTE:**

If equipped, the end of stroke valve can be damaged by overtravel of the actuator. Refer to Section 9 for adjustment of end of stroke valve.

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**Table 1. End Stop Movement vs. Degrees Rotation**

	Series 3	Series 6	Series 7
End Stop Movement per turn (inches)	0.125	0.125	0.125
Stem/Shaft Rotation per turn (degrees)	2.05	1.30	1.02
End Stop Location	Cylinder		
Cover or Jam Nut Torque (ft-lb)	45	130	360

9. Re-install yoke cover and gasket if removed and proceed to Section 4.

## 3.2 Extended Storage

1. Indoor storage, if available, is recommended. Actuators can be stored under normal warehouse conditions up to a year providing they are stored in the original packaging and orientation with the ambient temperature not exceeding 125 °F (52 °C).
2. Storage conditions should be such that the actuators are protected from excessive moisture, dirt, fire, salt spray, corrosive liquids, paint over-spray, etc. Actuators should not be stored in an atmosphere harmful to resilient seals.
3. Nothing should be stacked on top of the equipment during storage and the equipment should be stored away from large moving equipment where damage would result from contact.
4. After long term storage, the actuator may require the installation of a service kit before being placed into service.

## Section 4: Install Connections

1. Supply gas take-off should be from top or side of header. Supply gas connection is as per schematic drawing. User should provide a shut off valve on supply, and size lines to ensure draw down when operating valve does not interfere with pressure sensing devices, that is, use proper size of tubing for flow and pressure purposes.
2. In the case of a volume tank (power gas storage bottle) with inlet check, user should confirm that the tank is rated and/or protected against any possible supply overpressure or thermal expansion overpressure.
3. Electrical connection(s), to junction box if any, are as per wiring diagram and electrical drawings.
4. Conduit connection to limit or pressure switch, if field installed, are to comply with all local regulations (seal within 18 inches for explosionproof).

## Section 5: Prestart-Up Checks

### A. Check Operator

1. Unit has been mounted on valve properly. Gear flange mounting bolts, stem key, set screw(s) installed and secured.
2. No tubing damaged or accessories dislodged during shipping or installation.
3. Indicated position confirms valve position.
4. All control components in normal operating position as per schematic and wiring diagram.
5. If removed, yoke cover, limit switch, or end of stroke valve must be re-installed and secured.
6. Limit switch shaft centerline aligned with yoke cover/operator stem centerline.
7. In case of valve stem lubricator, two piece yoke cover set screws are secured and stem section is centered in yoke cover. There is a gap between top of yoke cover hub and limit switch adapter. Refer to Figure 3.

### B. Check Connections

1. Pneumatic/hydraulic connections are tight.
2. Power gas/signal gas connected to identified ports as per schematic.
3. If equipped, electrical connections are secured.
4. Wiring connections as per wiring diagram.

## Section 6: Start-Up Checks

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**NOTE:**

If unit has a fail or ESD (Emergency Shut Down) position, the fail-safe or ESD controls may have to be temporarily disabled, bypassed, overridden by the control room or AUTO/MANUAL selector to avoid inadvertent valve operation.

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To check operation in AUTO or MANUAL mode, temporarily disconnect the ESD control component (pilot, solenoid, switching relay) signal line, and plug or cap it so it does not bleed the system during check out procedures.

1. If possible, with power gas supply off, manually operate unit to full open and close positions by the handpump on unit. When each position has been reached, Check:
  - a. Operator stop settings. If adjustment is required, refer to Section 3.
  - b. Fluid levels in tanks. Refer to Figure 6 and the decal on the manifold plate for correct level for each position.
  - c. If equipped, limit switches and end of stroke valves are actuated the correct position, refer to Sections 8 and 9.
2. Apply power gas supply. Confirm power gas supply pressure.
  - a. Gas/Hydraulic rotary or linear maximum operating pressure as per tank and operator Nameplates, minimum as specified by user. Consult factory for minimum pressures lower than 300 psi.
3. Check connections for leaks with soapy water. Check:
  - a. For leaks at supply points/fittings in supply line.
  - b. For hydraulic/pneumatic leaks at fittings.
4. To check manual and automatic operation:
  - a. If equipped with an auto/manual selector, place selector in "MANUAL" position.
  - b. Manually operate relay handles as per instructions to stroke the actuator to the "open" or "close" position. Check for leaks at connections and check exhaust gas blowby after stroke is completed.  
**Note:** There will be exhaust gas present after the stroking of the operator.
  - c. If equipped, put selector in "AUTO" position.
  - d. Simulate automatic operation by energizing or de-energizing solenoid(s), and/or pneumatic pilot signals.
  - e. Check for leaks and blowby at the exhaust port of components during operation, check limit switch contacts and end of stroke adjustment.

5. Shut off power gas supply and disarm operator as per instructions.
  - a. Replace any tubing that was removed or disconnected that bypassed pneumatic pilot signals for above test. Refer to schematic.
  - b. Remove electrical jumper(s) installed to simulate "AUTO" operation unless required to operate ESD device. Refer to wiring diagram.
6. Emergency shutdown/fail position operation check out.
  - a. Ensure operator is in normal operating position.
  - b. Apply/remove the required ESD signal to operate the unit.
  - c. Apply power gas supply to the unit, it should operate to ESD/Fail position.
7. Restore all tubing and wiring as per normal operating conditions.
  - a. Apply power gas supply to the unit.
  - b. If equipped, place AUTO/MANUAL selector to "AUTO" position.
  - c. Actuator is ready to operate in normal operating conditions.

# Section 7: Scheduled Maintenance and Operational Testing

A program of scheduled maintenance and operational testing of the operator by a trained technician is recommended.

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**NOTE:**

De-pressurize operator before attempting to service power gas and pilot gas filter/strainer, draw contamination from the tanks, or check tank fluid level.

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The following test and maintenance procedure should be performed at least once per year.

1. Drain accumulated moisture and contaminants from gas filter/strainer, refer to Figure 15. The two filter/strainer elements can be removed from the manifold body without removing any other component or assembly including tube fittings and tubing runs. Small pipe and flush plugs do not need to be removed for filter maintenance.
  - a. Before replacing or cleaning the filter/strainer elements ensure the power gas is blocked and or vented to atmosphere.
  - b. The two filter/strainer elements items (3) and (4) can be easily replaced by removing the two hex head end caps item (5). The hex caps can be removed using conventional tools such as 1-7/16 inch socket wrench or standard adjustable wrench.
  - c. Carefully remove the filter/strainer elements items (3) and (4) including the strainer seals item (2) from the manifold body item (1).  
**Note:** item (3) element is 25 microns, item (4) is 140 microns. Item (4) (140 microns) is the inlet high pressure power gas filter, item (3) (25 microns) is the highpressure instrument gas filter and is used to protect the instrument regulator inlet gas to the regulator and all downstream elements from the regulator such as solenoid and pilot valves if applicable.
  - d. The strainer/filters elements can be replaced at this time or cleaned using conventional solvents that are typically used to clean hydrocarbon wetted components.  
**Note:** the strainer/filter elements are constructed from two parts; the outer stainless steel shell with multiple perforated holes, and the inner stainless-steel mesh screen with the screen formatted for either 25 or 140 microns. Both parts can be cleaned with the same solvent. Be sure to carefully remove any solid particulates from the inner mesh screen before re-installing into outer shell of the filter/strainers.



- e. Place both filter/strainer seals item (2) on to the ends of the reassembled outer and inner filters and insert into the manifold body item (1).
- f. Using a generous amount of grease or hydraulic fluid on the two hex cap o-rings item (6) screw the hex caps into the body until the hex cap bottoms out. No specific torque is required for tightening since the hex cap design is a straight thread/o-ring sealing designed component.  
**Note:** before re-installing the hex caps (2) and o-rings (6), visually inspect the o-rings (6) for any nicks or abrasions. Replace o-rings if worn or cuts are observed.

**Notes:**

- Recommended replacement period for both filter/strainer elements 5 years.
  - Recommended cleaning for both filter/strainer elements annually, or more often based on power gas cleanliness.
2. Drain contaminants from gas/hydraulic tank(s) and refill to proper tank levels. Refer to Figure 6.

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**NOTE:**

If equipped with additional gas filters, check elements and consider replacing them as it may be clogged with contaminants.

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3. Refer to Section 2 to ensure that proper method of operation is followed.
4. Check manual operation with handpump, refer to Section 2.
  - a. There should be noticeable suction on the suction stroke, decreasing as the pump cylinder fills, indicating suction lines are open and full of fluid.
  - b. Handle effort on the pressure stroke will depend on line pressure and line valve position.
  - c. Pressure stroke should be smooth and feel solid, not spongy, indicating pressure lines are open and full of fluid.
  - d. At the end of operator stroke (line valve open or closed) the handle should stop solid on the pressure stroke, indicating no bypass flow in operator or hydraulic components.
  - e. Test by applying 150 lb force for two minutes to the pump handle provided with the unit.
  - f. Press relief knob to move clevis and handle in the down position.

5. Check manual operation with power gas.
  - a. Depress appropriate relay handle. There should be a steady flow of gas entering the gas/hydraulic tank.

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**NOTE:**

Some effort (up to 50 lb) should be required to fully depress handle, indicating adequate supply pressure.

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- b. The operator should stroke smoothly, indicating gas/hydraulic tank levels are okay and operator mechanicals are okay.
  - c. Fluid returning to the opposite tank during stroking will cause a continuous slight exhaust gas flow from exhaust port, but which stops when the operator reaches end of stroke. This indicates proper relay function and no bypass flow in operator or gas/hydraulic components.
  - d. There should be no leaks of gas or hydraulic fluid.
  - e. Upon releasing relay handle, there should be a momentary rush of gas from exhaust port as the pressurized gas/hydraulic tank is vented.
6. Operating with power gas, check remote/automatic operation.

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**NOTE:**

Ensure that adequate pressure and flow of gas, and correct hydraulic fluid levels are present.

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- a. Shut off valve should be open.
  - b. There should be no gas leaks.
  - c. Hydraulic speed control valves should be partially open.
  - d. With appropriate meter or gauge, check for correct signal condition.
  - e. Simulate remote or automatic switching.
  - f. During stroking of the operator, there should be no signal gas leakage indicating that the signal section of the switching relay is okay.
  - g. Test the handpump safety feature. With the handpump handle in place and the handpump in manual mode, while standing well clear, apply power gas manually in the same direction (open/close) as handpump handle movement.

## Section 8: Instructions for the SW-4 Limit Switch

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**NOTE:**

In hazardous locations, install sealing fitting(s) in accordance with local regulations and national code. Secure ground wire(s) to ground screw. Ensure that all wires are free of strain and located to clear cover.

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**NOTE:**

Operator stops must be set for valve travel before attempting adjustments. Determine operator/valve position (open/closed position) before making adjustments.

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**A. Installation**

Refer to [SW-4 Series Limit Switch Installation Procedure](#) (Document Number: Mod R40).

**B. Adjustments**

Refer to [SW-4 Series Limit Switch Adjustment Procedure](#) (Document Number: RAP R61).

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**NOTE:**

Limit switch is wired as per wiring diagram.

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**C. Sensitivity Adjustment**

Sensitivity is normally factory set. To adjust, turn trigger screw (13) out to advance and lengthen signal. Turn in to shorten and delay. Use 0.001" feeler (gap) gauge to ensure no switch lever contact with switch body.

**D. Microswitch Replacement**

1. Remove electrical power supply before removing cover.
2. Rotate cam shaft to intermediate (microswitches unactuated) position.
3. Remove top plate of switch arrangement.
4. Note microswitch arrangement, number of stacks and spacers for reassembly.
5. Remove microswitch mounting screws.
6. Disconnect microswitch wires noting wire connections for reassembly.
7. Install new microswitch.
8. Connect wires per previous arrangement.
9. Re-install top plate of switch arrangement.
10. Rotate cam shaft back to normal position, install cover and restore power.

** CAUTION**

Ensure cover joint threads and o-ring are free of debris and lubricated before replacing cover. In hazardous locations, keep cover tightly closed while circuits are alive.

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## Section 9: Instructions to Set End of Stroke

Refer to Figure 4.

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### NOTE:

Operator stops must be set for valve travel before attempting adjustments.  
Determine operator/valve position (open/closed position) before making adjustments.

---

### **⚠ CAUTION**

Changing operator travel can cause damage to end of stroke (trigger) valve if over travel occurs and trigger strikes component.

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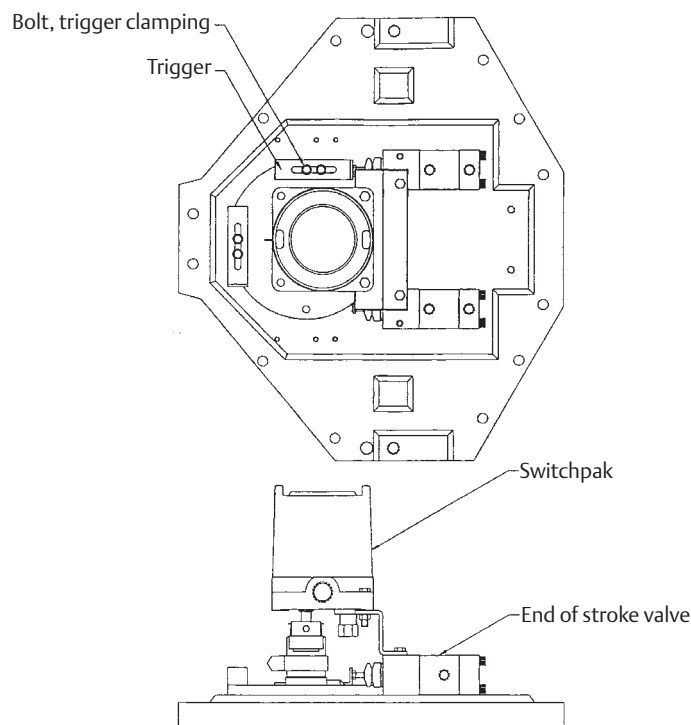
The "End of Stroke" (Trigger Valve) ensures that gas/hydraulic tanks and cylinders are de-pressurized at the end of each automatic operation as required.

1. Loosen trigger bolts, so trigger can be slid forward to actuate trigger valve.
2. Holding trigger in position such that trigger valve has switched and sealed, tighten bolts.
3. Operate operator to check trigger valve operation. At the end of the stroke, the trigger valve should switch and seal properly.
4. If trigger valve is not sealing properly after operation, loosen bolts, adjust trigger forward and re-tighten.

Approximately 1/4 inch minimum of trigger travel is required.

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**Figure 4** Typical limit switch layout for switchpak with end of stroke valve



# Section 10: Operator Information

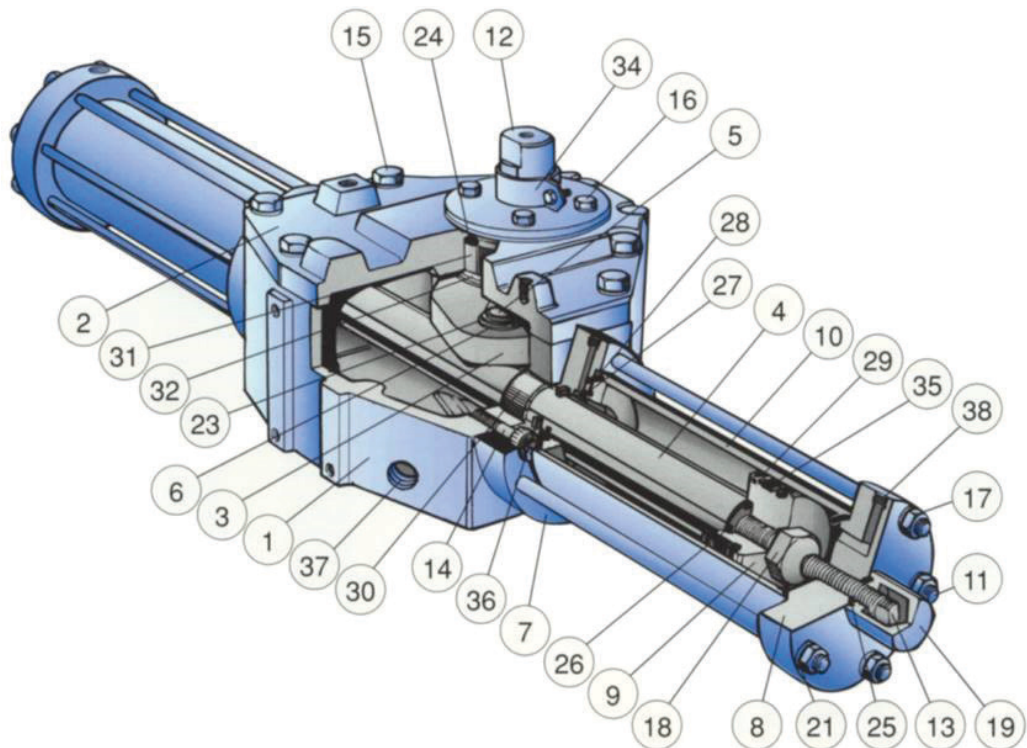
Refer to Figure 5 and Table 3.

**Table 2. Bettis Series and Model**

Bettis Series	Bettis Model
Series 3	23 SH
	33 DH
	43 DH
	53 DH
Series 6	46 DH
	56 DH
	66 DH
Series 7	67 DH
	77 DH
	87 DH
	97 DH
	107 DH
	107DH-8B

The operator has a hydraulic cylinder at each end of the drive case. A scotch yoke mechanism is used to convert the linear piston motion to quarter-turn rotation.

**Figure 5 Typical gas/hydraulic assembly drawing (quarter-turn operators)**



**Table 3. Typical gas/hydraulic Parts List (Quarter-turn Operators)**

Item	Description	Material	Qty.	Note
1	Drive Case	Tenzaloy 713	1	
2	Cover	Tenzaloy 713	1	
3	Yoke	ASTM A148 or DI	1	
4	Drive Rod	AISI 4140 HTSR QPQ Liquid Nitriding	1	
5	Drive Pin	AISI 4140 Heat Treated	1	
6	Drive Roller	AISI4140 Carburized	2	
7	Cylinder Plate	ASTM A516-70	2	
8	End Cap	ASTM A516-70	2	
9	Piston	ASTM A516-70	2	
10	Cylinder	C1026	2	
11	Tie Rod	AISI 4140	16	(V)
12	Yoke Cover	Tenzaloy 713	1	
13	End Stop	ASTM A193 GR. B7	2	
14	Cylinder Plate Capscrew	SAE Gr. 5 Plated	6	(V)
15	Cover Capscrew	SAE Gr. 5 Plated	10	
16	Yoke Cover Capscrew	SAE Gr. 5 Plated	4	
17	Tie Rod Nut	ASTM A194 Gr. 2H	16	
18	Piston Capscrew	SAE Gr. 8 Plated	2	(V)
19	End Stop Cover	ASTM A194 Gr. 2H	2	
21	Tie Rod Lockwasher	SAE 1060 Plated	16	(V)
23	Snap Ring	SAE 1075 Heat Treated	2	
24	Yoke O-Ring	Nitrile	1	(Y)
25	End Stop O-Ring	Nitrile	2	(Y)
26	Piston Center O-Ring	Nitrile	2	(Y)
27	Drive Rod Seal	Urethane/MoS <sub>2</sub> /Nitrile	2	(Y)
28	Cylinder O-Ring	Nitrile	4	(Y)
29	Piston Seal	Urethane/MoS <sub>2</sub> /Nitrile	4	(Y)
30	Drive Rod Guide	Acetal	2	
31	Yoke Bushing	C1020	2	(C)
32	Yoke Bearing	Nylon	1	
34	Position Indicator	C1010	1	
35	Piston Wear Ring	Nylon/MoS <sub>2</sub>	2	
36	Cylinder Plate Polypak	Molythane	2	(Y)
37	Inspection Hole Plug	Polythylene	1	(V)
38	NPT Port	-	4	

**Table 4. Pressure Vessels Specifications**

Pressure Vessels				Note
A	-50 °F to 150 °F (-46 °C to 65 °C)	Shell	ASME SA-333 Gr. 6	(N)
		Head	ASME SA-420-WPL6/ASME SA-516-70	(**)
		Fittings	ASME SA-350-LF2	
B	-20 °F to 150 °F (-29 °C to 65 °C)	Shell	ASME SA-106 Gr. B	
		Head	ASME SA-234-WPB/ASME SA-516-70	
		Fittings	ASME SA105/ASME SA-350-LF2	

**NOTE:**

- (C) Chrome Plated
- (N) Not Shown
- (Y) Spare Parts Kit
- (V) Quantity may vary depending on model
- (\*\*) Impact tested as per ASTM A370 18J average, 14J minimum, -50 °F (-46 °C), CVN full size
- All metal parts coated with corrosion inhibitor.
- All specifications are subject to change or upgrade.

**NOTE:**

Please provide the:

- MODEL identification and unit
- SERIAL NO. when ordering operator repair parts

(The information from gas/hydraulic tank tag will help and may suffice if no other information is obtainable. Any other identification cast into drive case cover or stamped on manufactured metal parts may help if all else fails and location is noted or sketched).

**Table 5. Description - Operator Repair Kit - Minor Soft Parts**

Item	Qty.	Description	Material
24	1	O-Ring, Yoke	Nitrile
26	2	O-Ring, Piston Center	Nitrile
27	2	Drive Rod Seal	Nitrile
25	2	O-Ring, End Stop	Nitrile
36	2	Polypak, Cylinder Plate	Molythane
28	4	O-Ring, Cylinder	Nitrile
29	4	Piston Seal	Molythane

**Table 6. Description - Operator Repair Kit - Major**

Item	Qty.	Description	Material
35	2	Piston Wear Ring	Nylon/MoS <sub>2</sub>
30	2	Drive Rod Guide	Acetal
31	2	Yoke Bushing	AISI C1020/Acetal
32	2	Yoke Bearing	Nylon

**Note:**

Major operator repair kit includes minor repair kit.

## Section 11: Operator Disassembly

### Tools and equipment required are:

- For Series 3
  - 1-1/2 Impact or hammer wrench
  - 1-1/2 Hex socket and long extension
  - 3/8 Socket Hex Key
- For Series 6
  - 2-1/2 Impact or hammer wrench
  - 2-3/8 Hex socket and long extension
  - 5/8 Hex Key
- For Series 7
  - 3-1/8 Impact or hammer wrench
  - 3-1/8 Hex socket and long extension
  - 3/4 Hex Key

### Other tools that are also required includes:

- A set of standard imperial size wrenches and sockets through 1-1/2" Hex keys, size 1 /16" through 5/8"
- A pair of 8" or longer screwdrivers
- A container, funnel, 10 micron filter, flexible hose and fittings to drain and salvage hydraulic fluid
- Solvent
- Sealant (eg. Silicone)
- Lubricant (petroleum grease, petroleum jelly, hydraulic fluid)
- Anaerobic adhesive (eg. "Loctite")

1. Shut off power gas supply; disarm automatic control and blowdown power gas.
2. Using the handpump, stroke operator against the stop, remove end stop cover, then replace o-ring. Re-install cover and tighten.

---

### NOTE:

When end stop cover is removed, some fluid will run out.

---



3. Connect flexible hoses to the ports of the cylinder to be repaired at the tee connection. Use the handpump to cycle the operator to push the fluid out of the repair cylinder.
4. Position the operator that the piston cap screw is against the end stop of the cylinder to be repaired.

---

**NOTE:**

If necessary to remove all piping, fitting plugs/caps will need to be installed to prevent oil spills.

---

**Cylinder disassembly**

1. Mark the cylinder parts for reinstallation on the same end and orientation of the operator.
2. Remove stay rod nuts and end cap (it is not necessary to remove end stop and cover if no seal is replaced).
3. Remove some stay rods for access to cylinder and piston.
4. Slide cylinder back off piston.
5. Remove piston cap screw, piston and seals.
6. Remove cylinder plate ring, cylinder plate bolts and cylinder plate itself. Note the location and number of seals.
7. Remove drive rod seal (polypak) from cylinder plate.

---

**NOTE:**

There is no drive rod seal in the drive case, only a guide.

---

All pressure containing parts can now be inspected and replaced as necessary. It is a good practice to replace all seals even if they appear serviceable. Proceed with cylinder assembly in Section 12, unless complete disassembly is required.

**Drive case disassembly**

1. Remove 10 cover cap screws and lift off the drive case cover.
2. Remove tanks, allowing entry to access hole for lower snap ring removal if necessary.
3. Remove the 2 drive pin snap rings, drive pin and rollers. Lift lower roller for best access to lower snap ring (Series 3 and Series 6 drive pin with its lower snap ring is removed through the access hole in bottom of drive case).
4. Slide the drive rod out of the drive case, careful to avoid damage to the drive rod surface.
5. Lift out the yoke, upper and lower bushings, and bearings. Upper bushing may lift off with the cover.
6. Clean and inspect all parts; replace if necessary.

## Section 12: Operator Assembly

---

**NOTE:**

Gas/hydraulic tanks should be drained and flushed if fluid is contaminated with scale, rust, particulates, water, foam, or etc. Flush only with hydraulic fluid. Refill with filtered fluid.

---

**A. Drive case assembly**

1. Install drive rod guides and lubricate with petroleum jelly.
2. When valve stem is in horizontal position, install lower yoke bushing and upper yoke bushing onto yoke. Lubricate with grease.
3. When valve stem is in vertical position, install upper yoke bushing and o-ring in drive case cover, and lower yoke bushing in drive case. Lubricate with grease.
4. Install yoke into drive case.
5. Install drive rod into drive case.
6. Install drive rollers in yoke slots, drive pin through drive rod and rollers, snap rings to retain. Lubricate with petroleum grease. (Series 3 and Series 6 drive pin with its lower snap ring is installed through access hole in bottom of drive case).

---

**NOTE:**

Check that snap rings are seated.

---

7. Install drive case cover using sealant around perimeter inside bolt pattern to make it weather tight. Torque bolts to specification.
8. Re-install tanks with handpump and manifold assembly.

**B. Cylinder assembly**

1. Install drive rod seal in cylinder plate and slide cylinder plate over drive rod into position with port in correct orientation.
2. Install, tighten, and TORQUE cylinder plate bolts.
3. Install cylinder plate ring(s) and 2 different seals.
4. Lubricating with hydraulic fluid, install wear ring and replace piston seals on piston with seal lip facing outwards. Insert into cylinder using tapered compression tool or install seals one at a time with each groove in turn protruding from cylinder. Press piston back into cylinder in position to match drive rod position.
5. Install piston o-ring in piston.
6. Slide piston/cylinder unit on drive rod against cylinder plate/ring taking care that parts/seals remain in correct position and alignment. Piston seal faces drive rod.
7. Apply anaerobic adhesive on threads, install, tighten and Torque piston nut/bolt.
8. Install stay rods.
9. Install cylinder o-ring on end cap and install end cap with port in correct orientation.
10. Install stay rod nuts and tighten evenly; Torque to specification.
11. Reconnect piping cycle unit with handpump to refill cylinders with fluid. Add fluid to tanks to obtain correct levels for operator positions.
12. Hydrostatic test with handpump. Refer to Section 7, step 5.
13. Replace stem key, yoke cover and gasket, and position flag indicating correct valve position.

**Table 7. Series 3 Operator**

BOLT/NUT TORQUE (ft-lb)	MODEL			
	23 SH	33 DH	43 DH	53 DH
Cover bolts	76	76	76	76
Cylinder plate bolts	100	100	100	100
Piston nut/bolt	-	600	600	600
Stay rod nuts	80	80	80	80
Mounting plate bolts	120	120	120	120

**Note:**  
 Maximum engagement of 5/8 NC bolts into drive case is 1-3/8 inch.

**Table 8. Series 6 Operators**

BOLT/NUT TORQUE (ft-lb)	SERIES 6 MODEL		
	46 DH	56 DH	66 DH
Cover bolts	76	76	76
Cylinder plate bolts	110	110	110
Piston nut/bolt	1500	1500	1500
Stay rod nuts	100	100	100
Mounting plate bolts	120	120	120

**Note:**  
 Maximum engagement of 5/8 NC bolts into drive case is 1-1/2 inch.

**Table 9. Series 7 Operator**

BOLT/NUT TORQUE (ft-lb)	MODEL					
	67 DH	77 DH	87 DH	97 DH	107 DH	107 DH-8B
Cover bolts	180	180	180	180	180	180
Cylinder plate bolts	350	350	350	350	350	350
Piston nut/bolt	2400	2400	2400	2400	2400	2400
Stay rod nuts	180	300	300	300	300	300
Mounting plate bolts	350	350	350	350	350	350

**Note:**  
 Maximum engagement of 1 NC bolts into drive case is 1-3/4 inch.

# Section 13: Hydraulic Fluid

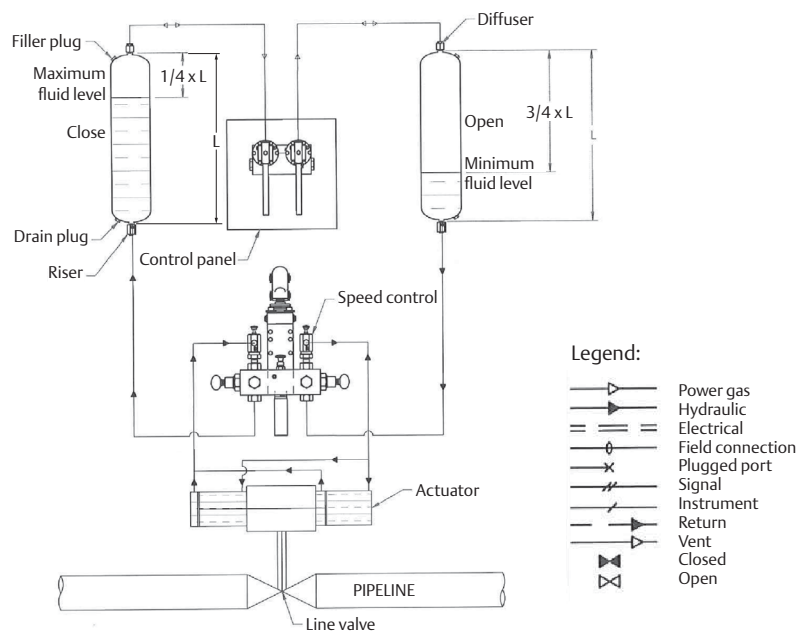
## Acceptable Hydraulic Fluids

- Conoco Megaflo AW HVI 22
- Conoco Megaflo AW HVI 15
- MOBIL UNIVIS HVI 13
- MOBIL UNIVIS N22
- MOBIL DTE 10 EXCEL 22

### NOTE:

All other hydraulic fluids must be approved to use by the manufacturer.

**Figure 6 Gas/Hydraulic tank filling**



### Notes:

1. Actuator shown in open position.
2. Minimum and maximum fluid levels refer to conditions at full open or closed valve position.

## Fluid Maintenance

The hydraulic fluid is an important component of each Bettis Gas/Hydraulic operator system. An aviation grade hydraulic fluid is used unless Customer specified otherwise. Contact the factory for suitable gas/hydraulic system compatible hydraulic fluids.

1. Do not add automatic transmission fluid, brake fluid, methanol or any other solvent to the hydraulic fluid as it can damage the seals of some internal components. Flush the system with recommended fluid only.
2. Operators/systems that cycle more than 2-3 times per week (unit suction/discharge, pig launcher, receiver block valves) should have the hydraulic fluid changed annually.

# Section 14: Troubleshooting

Of all the system components the operator itself is the least likely to malfunction and requires the most time and effort to service. For this reason, a thorough effort should be made to pinpoint the source of trouble before proceeding with operator service.

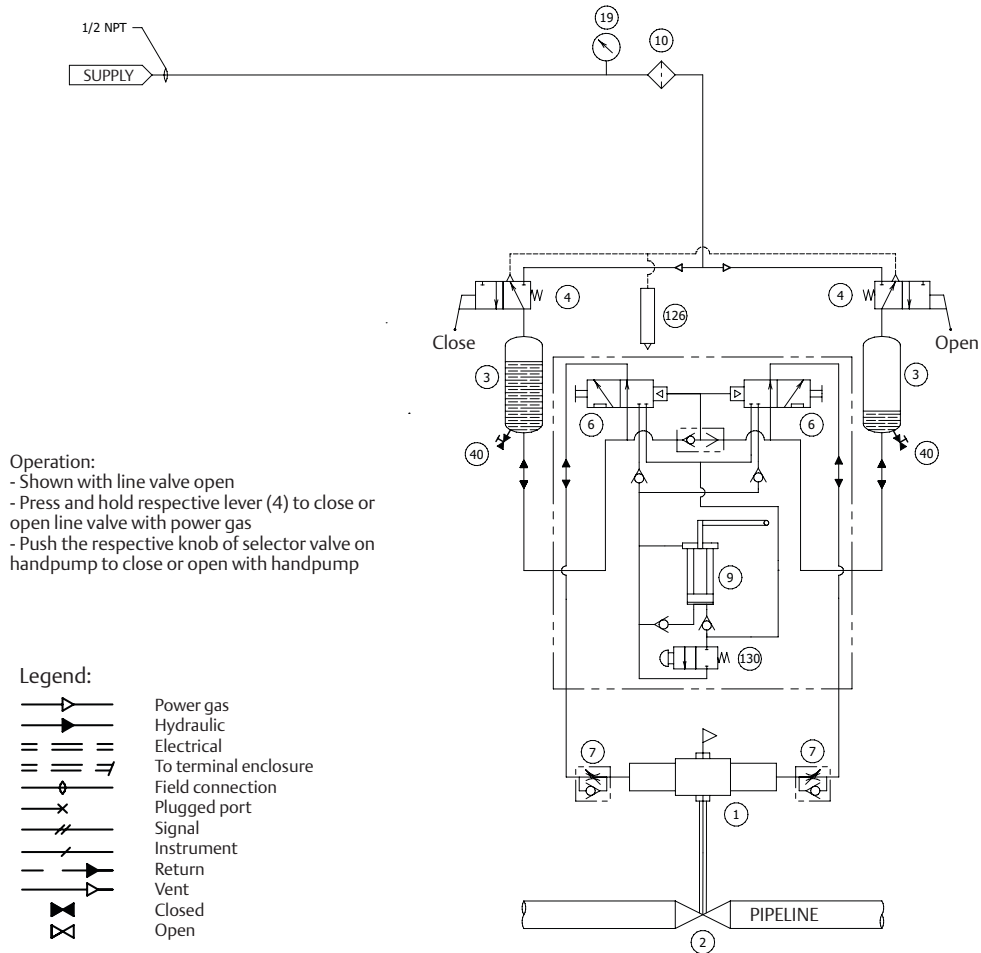
Completion of the operational test steps in Section 7 should confirm operation or indicate the most likely source of a problem.

**Table 10. Troubleshooting Guide**

Problem	Possible Causes	Remedy
Slow jerky or partial stroke on manually controlled gas powered	<ul style="list-style-type: none"> <li>- Low supply pressure</li> <li>- Shutoff/speed control closed</li> <li>- Dirty gas filter element resulting in insufficient flow and pressure to stroke operator</li> <li>- Contaminated fluid; will not flow easily through lines</li> <li>- Operator and valve stops not in same position</li> </ul>	<ul style="list-style-type: none"> <li>- Check and increase</li> <li>- Check and open a few turns</li> <li>- Blow out lines</li> <li>- Disconnect operator from valve if possible</li> <li>- Refer to Section 7</li> </ul>
Slow or no operation with handpump	<ul style="list-style-type: none"> <li>- Tank fluid levels low</li> <li>- Pump suction or discharge check valve malfunction</li> <li>- Speed control or locking valve blockage/malfunction</li> <li>- Dirt, ice in fluid lines</li> </ul>	<ul style="list-style-type: none"> <li>- Make up levels with aviation grade hydraulic fluid (per customer specification)</li> <li>- Remove tubing at cylinder</li> <li>- Check for flow when handpump operated</li> <li>- Refer to Section 2</li> </ul>
Fluid leaking from drive case vents - ROTARY Fluid leaking from cylinder plate - GVO  Fluid leaking from END STOP COVER SEAL  Excessive amounts of fluid from/with exhaust	<ul style="list-style-type: none"> <li>- Damaged rod seal</li> <li>- Damaged seal</li> <li>- High tank levels</li> <li>- Blow by across piston</li> </ul>	<ul style="list-style-type: none"> <li>- Check oil levels</li> <li>- Manual operation with handpump</li> <li>- Refer to Sections 10 to 12</li> </ul>

# Section 15: Drawings and Schematics

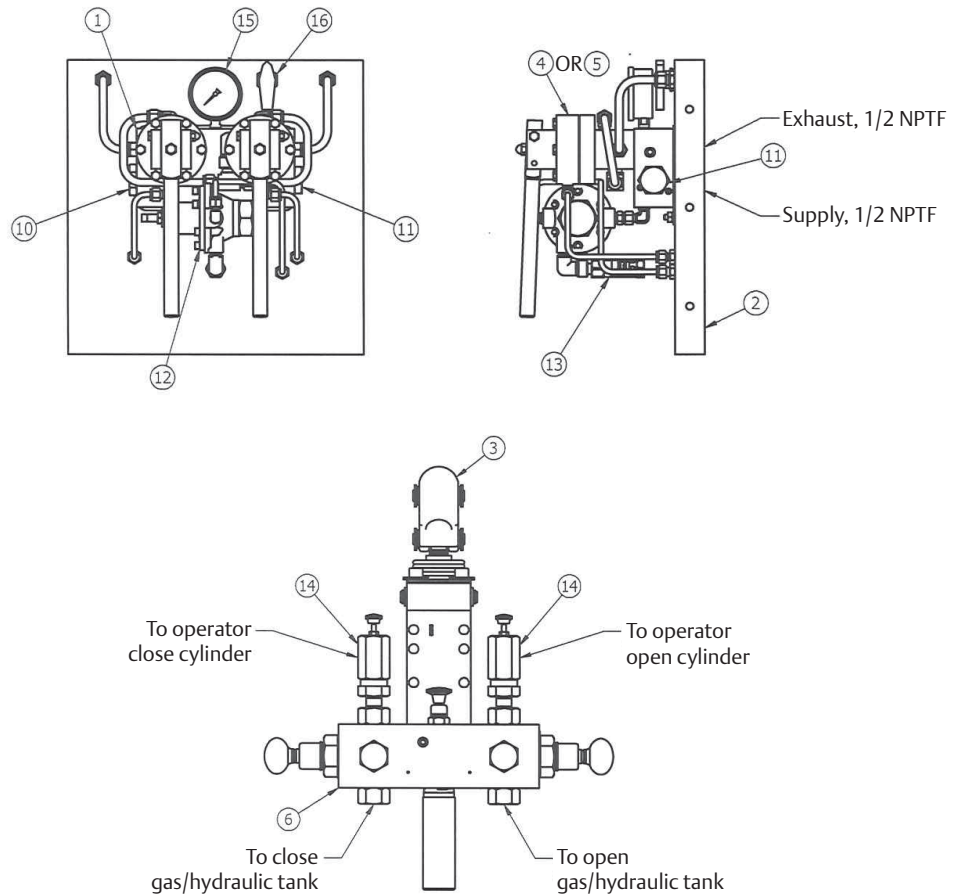
**Figure 7 Gas/Hydraulic operator with two way manual schematic**



**Table 11. Gas/Hydraulic Operator Component**

List of components	
1	Operator
2	Line valve
3	Gas/hydraulic tank
4	3-way valve, manual
6	Selector valve
7	Speed control valve
9	Handpump
10	Filter
19	Pressure gauge
40	Bleed/Drain valve
126	Vent tube
130	Manual relief valve

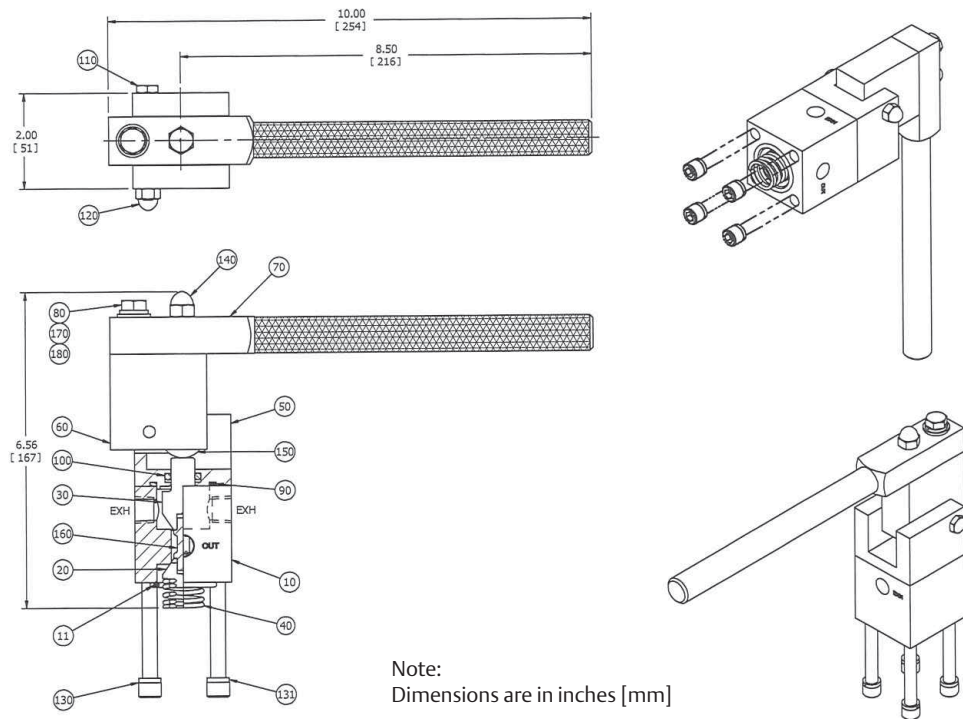
**Figure 8 Typical manifold assembly and handpump for gas/hydraulic operator**



**Table 12. Typical Gas/Hydraulic Operator Parts List**

Item No.	Description
1	Manifold
2	Control panel
3	Handpump
4	3-way manual relay
5	3-way manual with diaphragm relay
6	Selector valve
10	Filter (140 microns)
11	Filter (25 microns)
12	Regulator
13	Relief valve
14	Adjustable speed control
15	Pressure gauge (power gas)
16	Auto/manual selector valve (optional)

**Figure 9 Model A324-M\_E switching relay (3-way, 2-position) assembly drawing**



Note:  
Dimensions are in inches [mm]

**Table 13. Model A324-M\_E switching relay (3-way, 2-position) Parts List**

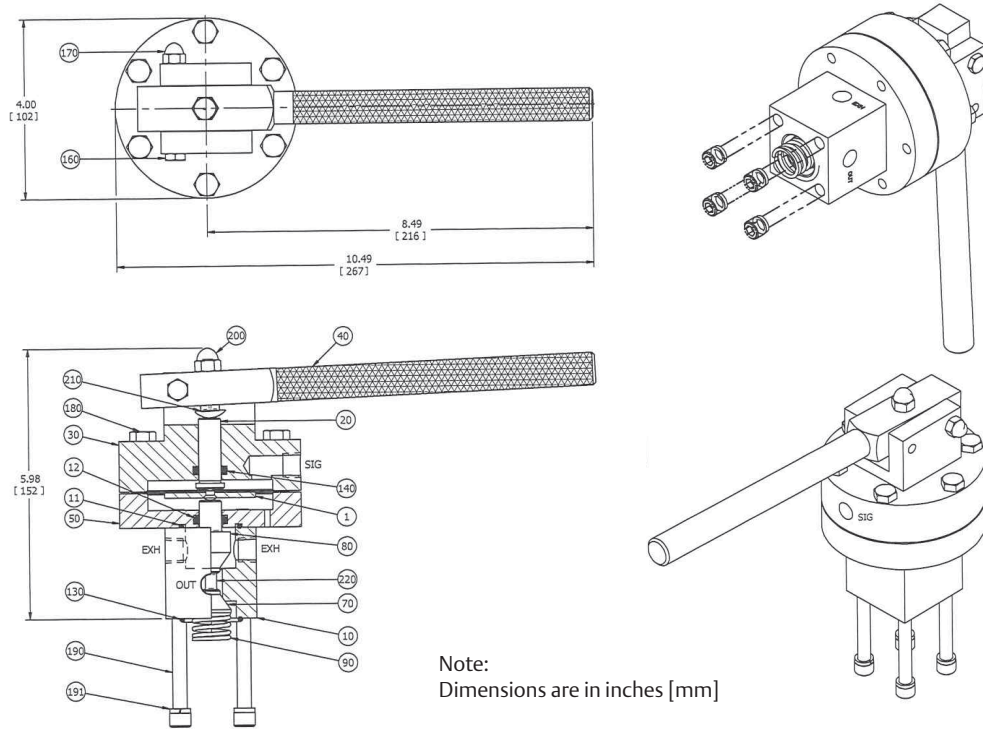
Item	Description	Material	Qty.	Note
10	Upper Body	AL 6061-T6	1	
20	Poppet, Lower	Nylon	1	
30	Poppet, Upper	Nylon	1	(Y)
40	Spring	SS 302	1	(Y)
50	"M" Cylinder Plate	AL 6061-T6	1	
60	Spacer Block	ESMA-2202	1	
70	"M" Lever	ESMA-2202	1	
80	Capscrew, Lever	SS 304	1	
90	O-ring; Body	BUNA N	2	(Y)
100	O-ring; Poppet	BUNA N	1	(Y)
110	Capscrew, Operator	SS 304	1	
120	Nut, Operator	SS 304	1	
130	Capscrew, Body	SS 304	4	
131	High-Collar Lockwasher, Body	SS 18-8	4	
140	Nut, Lever	SS 304	1	
150	Roundheaded Push Bolt	SS 304	1	
160	Poppet Spacer	ESMA-1732	1	
170	Lockwasher, Lever	SS 304	1	
180	Flatwasher, Lever	SS 304	1	

**Notes:**

- (Y) Recommended spare parts
- Fasteners and maintenance tools are ANSI/INCH size
- Recommended maximum 20 psig back pressure at exhaust port



**Figure 10 Model A324-DM-275\_E switching relay (3-way, 2-position, N.C.) assembly drawing**



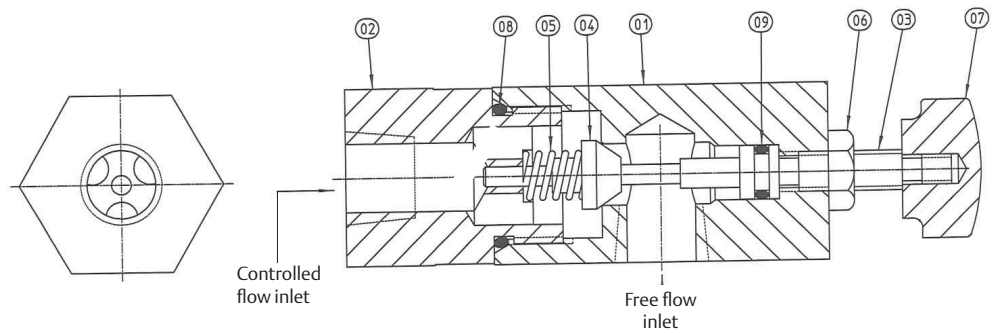
**Table 14. Model A324-DM-275\_E switching relay (3-way, 2-position, N.C.) Parts List**

Item	Description	Material	Qty.	Note
1	Diaphragm Assembly	Fairprene/TFE/CS	1	(Y)
10	Upper Body	AL 6061-T6	1	
20	Plunger	PVC	1	(Y)
30	Diaphragm Cap	AL 6061-T6	1	
40	"M" Lever	AL 6061-T6	1	
50	Cylinder Plate	AL 6061-T6	1	
70	Poppet, Lower	Nylon	1	(Y)
80	Poppet, Upper	Nylon	1	(Y)
90	Spring	SS 302	1	
130	O-ring; Body	Nitrile	2	(Y)
140	O-ring; Poppet	Nitrile	2	(Y)
160	Capscrew, Operator	SS 304	1	
170	Nut, Operator	SS 304	1	
180	Capscrew, Cap	SS 304	6	
190	Capscrew, Body	SS 304	4	
191	High-Collar Lockwasher, Body	SS 18-8	4	
200	Nut, Lever	SS 304	1	
210	Roundheaded Push Bolt	SS 304	1	
220	Poppet Spacer	SS 304	1	

**Notes:**

- (Y) Recommended spare parts
- fasteners and maintenance tools are ANSI/INCH size
- Recommended maximum 20 psig back pressure at exhaust port

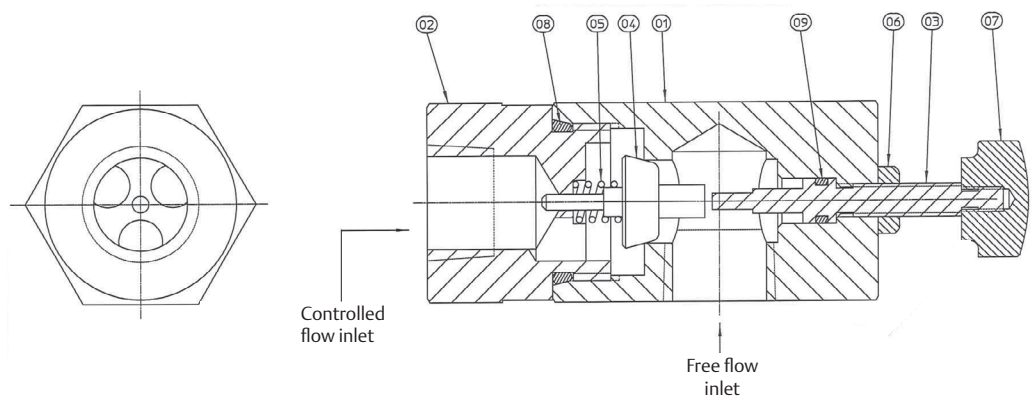
**Figure 11** Flow control assembly - 1/4 NPTF



**Table 15.** Flow Control Assembly - 1/4 NPTF Parts List

Item	Description	Material	Qty.
1	Flow Control Body	AL 6061 Hard Anodized	1
2	Flow Control Cap	AL 6061 Hard Anodized	1
3	Flow Control Stem	SS 303	1
4	Flow Control Poppet	SS 303	1
5	Spring	SS 302	1
6	Hex Nut, 1/4-20 UNC, LH Thread	SS 304	1
7	Knob	Phenolic	1
8	O-Ring	Buna N	1
9	O-Ring	Buna N	1

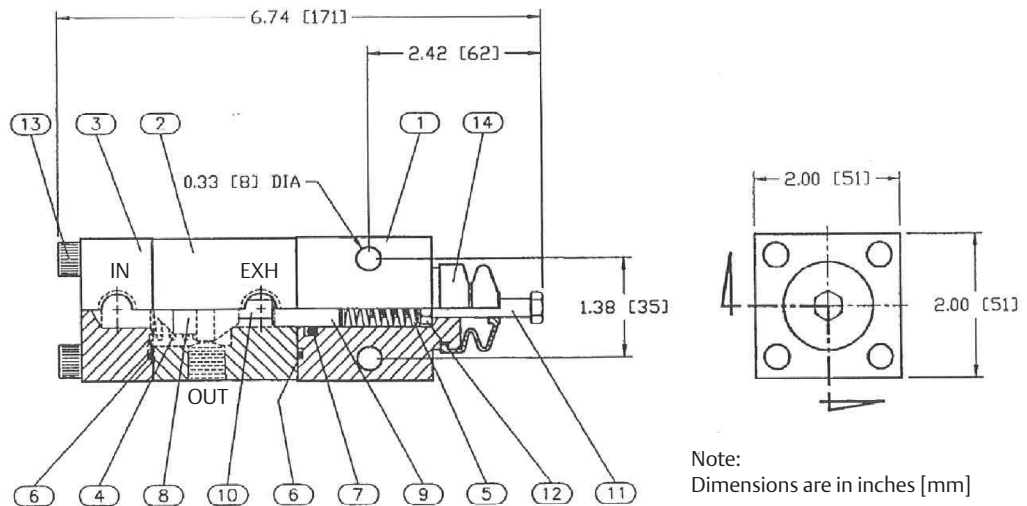
**Figure 12** Flow control assembly - 1/2 NPTF



**Table 16.** Flow Control Assembly - 1/2 NPTF Parts List

Item	Description	Material	Qty.
1	Flow Control Body	AL 6061 Hard Anodized	1
2	Flow Control Cap	AL 6061 Hard Anodized	1
3	Flow Control Stem	SS 303	1
4	Flow Control Poppet	SS 303	1
5	Spring	SS 302	1
6	Hex Nut, 1/4-20 UNC, LH Thread	SS 304	1
7	Knob	Phenolic	1
8	O-Ring	Buna N	1
9	O-Ring	Buna N	1

**Figure 13 Model ES-01 assembly drawing**

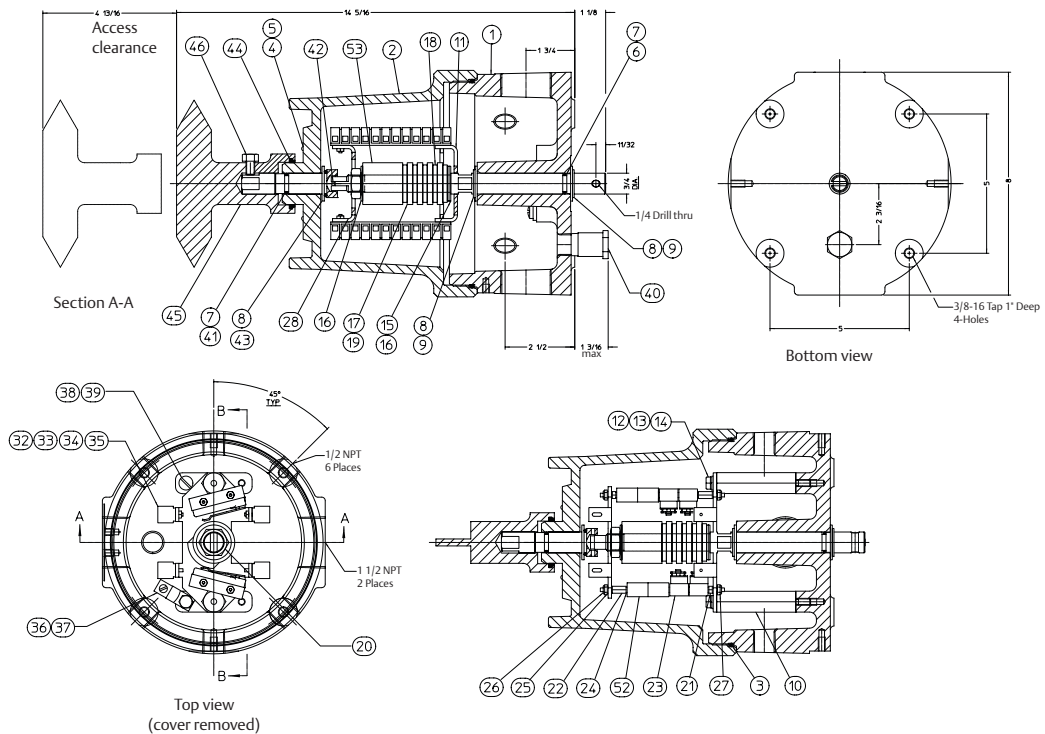


**Table 17. Model ES-01 Parts List**

Item	Part No.	Description	Material	Qty.	Note
1	906-001	Upper Body	AL 6061-T6	1	
2	906-002	Center Body	AL 6061-T6	1	
3	906-003	Lower Body	AL 6061-T6	1	
4	906-004	Lower Spring	SS 302	1	
5	906-005	Upper Spring	CR VAN	1	
6	906-006	O-ring - Body	BUNA N	2	(Y)
7	906-007	O-ring - Poppet	BUNA N	1	(Y)
8	906-008	Poppet	PVC	1	(Y)
9	906-009	Plunger	PVC	1	(Y)
10	906-010	Poppet Spacer	Alloy steel	1	
11	906-011	Capscrew - Trigger	Gr. 5 PL	1	
12	906-012	Nut - Trigger	Gr. 5 PL	1	
13	906-013	Capscrew - Body	Gr. 5 PL	4	
14	906-014	Trigger Boot	Nitrile	1	

**Note:**  
- (Y) soft parts repair kit

**Figure 14** Limit switch SW44 assembly drawing

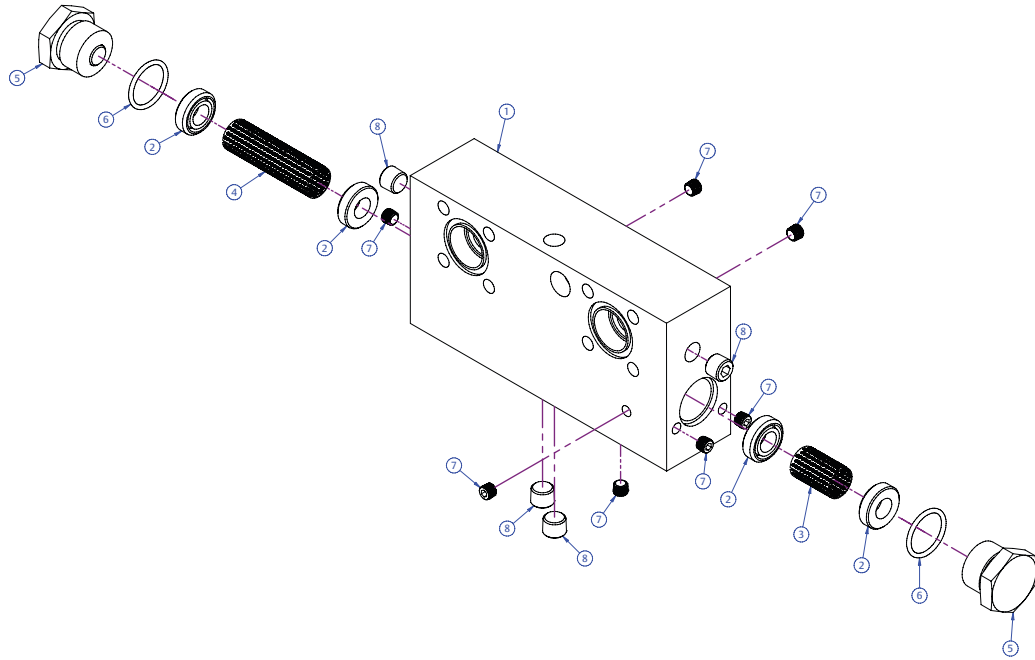


**Table 18.** Limit switch SW44 Parts List

Item	Description	Qty.
1	Limit switch housing	1
2	Limit switch cover	1
3	O-ring	1
5	Drive screw 1/4" SS	4
6	Actuator shaft - limit switch	1
7	O-ring	2
8	Washer, nylon for cam shaft	3
9	Snap ring SS	2
10	Post for limit switch	2
11	Lower bracket for limit switch	1
12	Hex head cap screw, 1/4-20x3/4, SS 304	2
13	Flatwasher, 1/4 SAE, SS 304	2
14	Lockwasher, 1/4, SS 304	2
15	Spring washer	1
16	Flatwasher, 5/8 SAE, SS 304	3
17	Cam for limit switch, delrin	4
18	Spacer for limit switch, delrin	5
20	Hex jam nut	1
21	Hex spacer .125	4
22	Hex spacer .50	4
23	Micro switch w/ 3' leads	4

Item	Description	Qty.
24	Lockwasher, #6, SS 304	20
25	Flatwasher, #6 large o.D., SS 304	16
26	Stud	4
27	Hex locknut	8
28	Upper bracket for limit switch	1
32	Terminal strip	4
33	Round slotted machine screw	8
34	Hex nut, 4-40 unc, SS 304	4
35	Tag numbers	2
36	Ground terminal	1
37	Hex head cap screw, 1/4-20x1/2, SS 304	1
38	Washer, ring terminal cup	1
39	Slotted binding machine screw	1
41	Shaft, top indicator	1
42	Spring pin	1
43	O-ring	1
44	Wiper, tip indicator	1
45	Limit switch top indicator	1
46	Hex head cap screw	1
52	Spacer, limit switch stackup	8
53	Spacer, cam shaft	1

**Figure 15** Manifold/filter assembly drawing



**Table 19.** Manifold Parts List

Item	Description	Qty.
1	Manifold body	1
2	Seal	4
3	Instrument gas filter, 25 microns, SS	1
4	Power gas strainer, 140 microns, SS	1
5	Cap	2
6	O-ring	2
7	Flush plug level seal	7
8	Flush plug level seal	4

**NOTE:**

For Shafer Handpump drawings, please refer to MHP-01102001: [www.emerson.com](http://www.emerson.com)

### Field Service Request

To assist in providing service/assistance with your equipment, the following information is requested:

- A. Contact/Responsible  
 Name \_\_\_\_\_ Company \_\_\_\_\_  
 Position \_\_\_\_\_ Site/Project Identification \_\_\_\_\_  
 Phone \_\_\_\_\_ Fax \_\_\_\_\_ Pager \_\_\_\_\_
- B. Valve Operator                  Rotary                   Linear/Gate   
 Model \_\_\_\_\_ Serial Number \_\_\_\_\_  
 Application:     Mainline Block/Linebreak ESD  
                    Mainline Valve Station Bypass  
                    Unit Suction/Discharge Block  
                    Meter Station Shut In/H<sub>2</sub>S Shut In  
                    PIG Launcher/Receiver  
                    \_\_\_\_\_
- C. Problem Identified During:  
 Installation                   Commissioning                   Operation                   Maintenance
- D. Problem Identified as: \_\_\_\_\_  
 (If operator/valve travel is open/closed fully or partially, how far?) \_\_\_\_\_  
 \_\_\_\_\_
- E. Checklist for often-overlooked causes  
 Tank fluid levels are correct for operation  
 Power gas of sufficient pressure and flow is present  
 ESD/Linebreak system is reset  
 Operator travels fully and smoothly  
 Speed controls are more than 25% open  
 Correctly mounted on valve, ie. valve open/operator open/stops sets  
 Exhausts not restricted or vented to header system with backpressure  
 All relays and solenoids are switching  
 Confirm if signals are being applied and removed as required
- F. Identify Component(s) that may cause the problem  
 List any adjustments that were made by others \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
- G. Conditions under which problem occurs  

<b>Flowline</b>	<b>Operator Gas Supply</b>
Pipeline Pressure _____ psi (kPa)	From Pipeline _____ psi (kPa)
Differential Across Valve _____ psi (kPa)	From Fuel Gas Line _____ psi (kPa)
Pipeline Rate of Drop _____ psi (kPa)/minute	
Other/Weather _____	
- H. Requirements  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_







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