Installation, Operation and Maintenance Manual
E-90090003 Rev. A
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GVO-LP-SR/FS Spring Return

BETTIS™

EMERSON™

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Section 1: Safety Warning

All personnel involved should read and understand all applicable sections of this manual before attempting to install, operate, service, or perform maintenance on any operators. Adhere to any tags, warning labels, or instructions present on the operator. These may provide information more specific and significant regarding the operator than this general manual can.

It is the responsibility of the user to ensure proper safety. Always take necessary precautions and utilize proper personal protective equipment when dealing with compressed air, compressed hydraulic fluid, pinch points, and electricity.

It is necessary to rig and lift valve and operator separately. Service personnel need to ensure the lifting capacity of the crane/hoist/rigging is appropriate for the desired load.

Block the pressure supply and depressurize the system before attempting to install or service. Isolate the pressure from controls if the operator is supplied with control system.

Caustic gases and fluids may be contained in the operators and valves in most applications. Vent all poisonous or flammable gases and store all liquids in a safe location to prevent personnel injury. Discharge at sonic velocity may occur when venting or releasing pressure; service personnel must utilize proper hearing protection.

CAUTION: DO NOT DISASSEMBLE SPRING CARTRIDGE

Springs are under compression. Do not disassemble any part of the spring cartridge.

The following are general instructions since there are variations of linear operators and valves. It is critical to install the operator properly so that performance and safety are guaranteed. Any technicians using the following instructions must be trained and knowledgeable regarding valve operators and valves.

CAUTION: DISASSEMBLE OPERATOR CAREFULLY

Go through the above instructions to help prevent personnel injury, property damage, and damage to operator.

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

Section 2: Introduction

2.1 General Service Information

This Installation, Operation, and Maintenance (IOM) manual is for Bettis™ GVO Series Pneumatic Spring Return Valve Operator (type SR or FS). Failure to comply with installation, operation, and maintenance instructions will void the warranty and may result in severe injury and/or property damage.

2.2 Definition of Terms

The abbreviations included in this IOM manual are listed in the table below:

Table 1. Definition of Terms

Abbreviated Term	Definition
IOM	Installation, Operation, and Maintenance
GVO	Gate Valve Operator
LP	Low Pressure Pneumatic
SR	Spring Stroke - Drive Rod (or Piston Rod) in Extension
FS	Spring Stroke - Drive Rod (or Piston Rod) in Retraction
TDM	Tandem Power Cylinder
ID	Inside Diameter [inch]
OD	Outside Diameter [inch]
BCD	Bolt Circle Diameter
MVT	Maximum Valve Stem Travel
MOT	Maximum Operator Travel
MAWP	Maximum Allowable Working Pressure

⚠ WARNING

If not observed, user incurs a high risk of severe damage to operator and/or fatal injury to personnel.

⚠ CAUTION

If not observed, user may incur damage to operator and/or injury to personnel.

NOTE:

Advisory and information comments provided to assist maintenance personnel to carry out maintenance procedures.

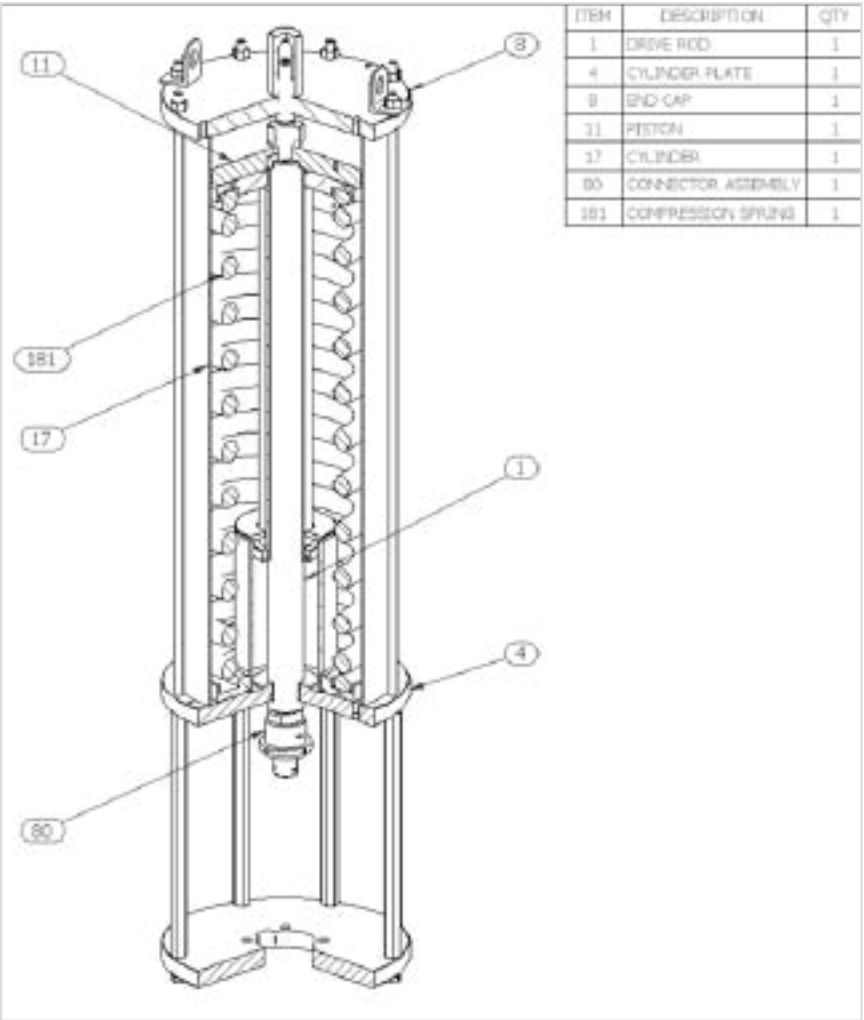
2.3 Scope

This manual is a resource for technicians involved in the installation, operation, and maintenance of Bettis™ Gate Valve Operator (GVO) Series Pneumatic Linear Valve Operators. It serves as a guide and must be thoroughly understood prior to any work on the operators such as installation, operation, or maintenance. For any questions, please contact the manufacturer.

2.4 Model Identification

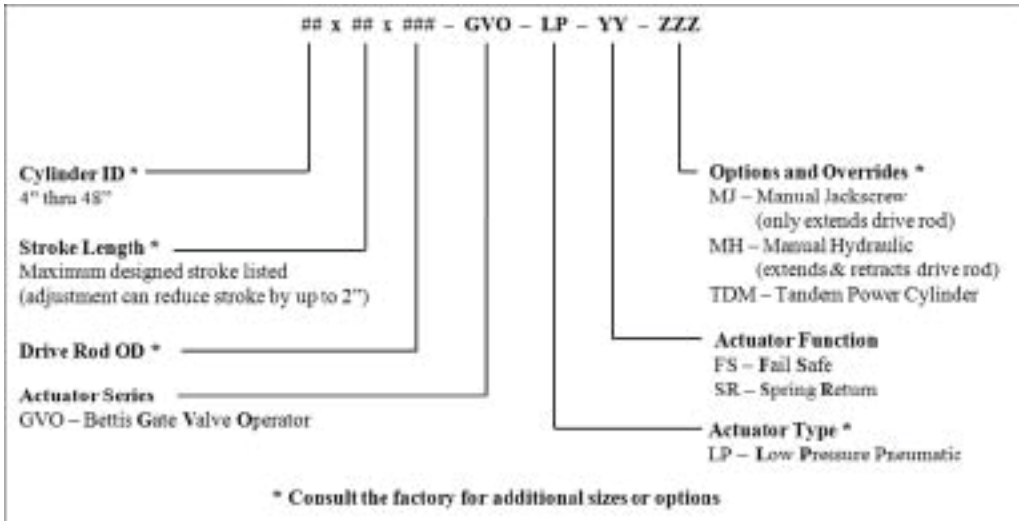
The Bettis GVO Pneumatic Series represents a broad range of field-proven linear valve operators suitable for automating most types of rising stem valves in safety shutdown and control applications. Figure 1. *(Typical Assembly of GVO-LP-FS)* shows the typical assembly drawing of Bettis™ GVO-LP-FS operator.

Figure 1 Typical Assembly of GVO-LP-FS



The catalog lists standard models intended to cover a wide range of sizes and applications. Customers can use Figure 2. *(Linear Valve Operator Model Designation)* to identify the key operator characteristics. If not included in the catalog lists, custom designed models are also available for specialized thrust or stroke requirements or those beyond the scope of this listing (including linear hydraulic operated operators).

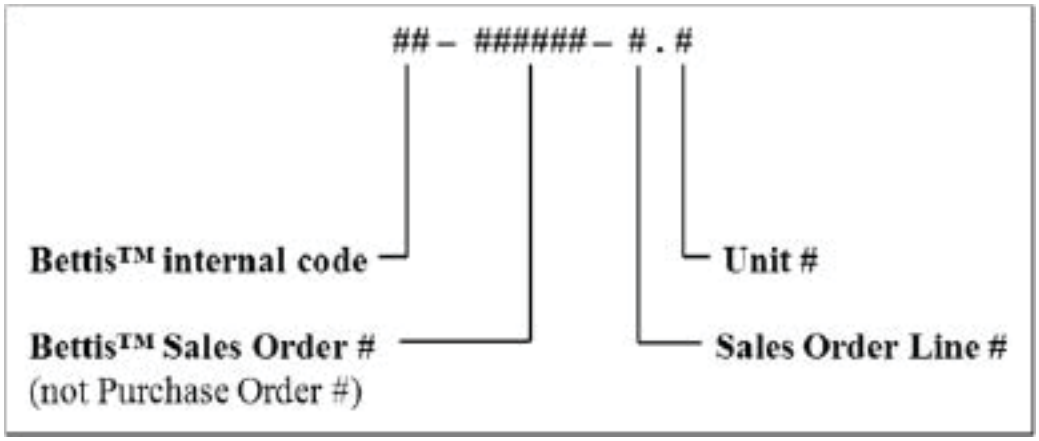
Figure 2 Linear Valve Operator Model Designation



To illustrate, a model number of 16x10x2.50-GVO-LP-SR-MH is an operator with a 16 [inch] inside diameter cylinder, a 10 [inch] maximum stroke (adjustable down to 8 [inch] stroke), a 2.50 [inch] outside diameter drive rod, and is low-pressure pneumatic spring return with a manual hydraulic override.

Operators will also be identified with an individual serial number.
Figure 3. *(Linear Valve Operator Serial Number)* shows the form of the Bettis™ serial number.

Figure 3 Linear Valve Operator Serial Number



For example, a serial number of 00-123456-2.1 represents the first unit on the second line of sales order 123456.

Section 3: Storage Instructions

Proper storage is required when the operator will not be used immediately.

1. Remove all dirt, dust, grease, and contaminants from the exposed drive rod (1) surface by using a soft cloth dampened with an appropriate oil-based solvent. Avoid using abrasive material when cleaning rod surfaces.
2. Exposed drive rod (1) must be protected to avoid damage to the surface.
    a. FS style operator: Drive rod is retracted into the cylinder (only a portion of the rod is exposed). Lightly grease the exposed surface and wrap with protective material if necessary.
    b. SR style operator: Drive rod is fully extended from the cylinder. User must protect the rod surface to avoid damage (which in turn will compromise and/or damage the sealing capability during operation). Lightly grease and wrap the rod surface with protective material.
3. Remove the plastic plugs (used to plug the pressure ports during assembly) and replaced with steel plugs. Any controls present should also be plugged with steel plugs.

NOTE:

Sealants such as pipe dope or Teflon tape should be applied to steel plug threads.

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4. Lightly lubricate all exposed threads and unpainted surfaces (for example, bottom of pedestal plate).
5. Cover the operator to prevent accumulation of dirt and debris.
6. Repeat the storage steps listed above to ensure the proper storage condition (in case the operator will be moved and stored again).

Indoor environment is the ideal storage condition for the operator.
For additional information on storage, please contact the manufacturer.

Section 4: Operation

4.1 SR Operator

SR type operator contains spring which is located above the piston. Therefore, under spring stroke, spring force will act on the piston to push the drive rod (1) into fully extended position. To retract the drive rod (1), supply compressed air/Nitrogen to the piston (11) through the port in the cylinder plate (4). Upon loss of supply pressure, the operator will fully extend the drive rod (in other words, valve stem in retraction).

4.2 FS Operator

FS type operator contains spring which is located below the piston. Therefore, under spring stroke, spring force will act on the piston to pull the drive rod (1) to fully retracted position. To extend the drive rod (1), supply compressed air/Nitrogen to the piston (11) through the port in the end cap (8). Upon loss of supply pressure, the operator will fully retract the drive rod (in other words, valve stem in extension).

Section 5: Preparation

Before working (installation, operation, or maintenance) on the operator, be sure to read through all the applicable sections of the manual to ensure that you are familiar with the expected sequence of events.

5.1 Tools

Listed are the recommended tools and materials that may be required when working on the operator. Additional tools and materials may be required depending upon specific operator and/or task.

- Vernier/measurement ruler
- A set of SAE combination wrenches and sockets
- A set of SAE hex keys
- Strap or pipe wrench (small to medium sizes)
- Large size ring wrench/hammer wrench
- Torque wrench with suitable rating
- Lifting device or a crane (complete with slings, a pair of shackles or clevises)
- Air supply or nitrogen not exceeding the MAWP of the operator
- Block and bleed test valve assembly for air supply/Nitrogen
- Anti-seize (lubricant) compound
- Pipe thread sealant (for example, Teflon tape, pipe dope)
- Commercial solvent (for example, Varsol)

5.2 Pre-Installation Verification

NOTE:

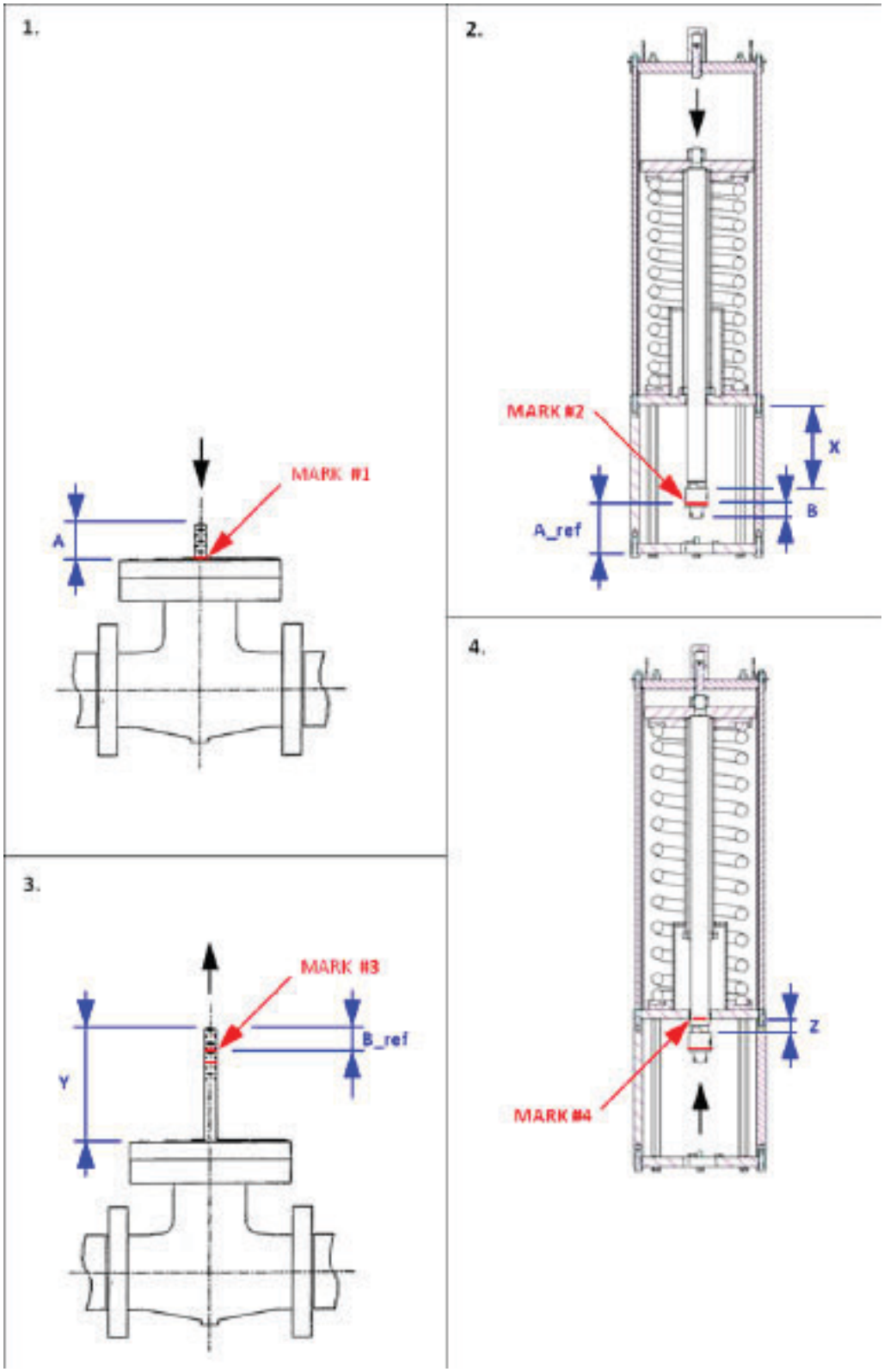
GVO linear operators shipped mounted to valves have their travel adjusted properly by the manufacturer and do not require further adjustment. Install valve with GVO linear operator directly in line. GVO linear operators shipped without a valve have their travel adjusted based on the valve topworks (if available). Verify and fine-tune (if needed) the travel adjustment when installing operator on the valve.

There are several critical measurements and markings to make before initial installation of the operator on the valve. These measurements and markings are helpful for checking or adjusting travel, however, it cannot be made after the operator is installed. Please refer to Figure 4. *(Measurement of Travel Adjustment for Valve and Operator)* when making measurements.

NOTE:

Marks should be made with a marker, wax pen, or other tool that will not damage the sealing surfaces of the operator. Type FS style operator is used for illustration.
Follow the same instruction for SR style operator (with the exception of spring function).

Figure 4 Measurement of Travel Adjustment for Valve and Operator



1. Drive the valve stem fully into the valve body, ensuring that it is fully retracted (consult valve manufacturer for procedure if required). If so equipped, remove valve lever, handwheel, gear and/or jam nut/stop nut per valve-manufacturer instructions. Strike the valve stem's threaded end using a soft mallet to retract valve stem fully. Mark on the valve stem where it and the top of the valve flange align.
This is "**MARK #1**".

   Measure from the top of the valve flange to the end of the valve stem using the Vernier/measurement ruler. Record this value as "**A**".

   A = _____

2. Actuate the operator (apply air to end cap side) to fully extend the drive rod (1). Mark on the swivel connector (80) the distance "**A**" up from the bottom of the adapter plate. This is "**MARK #2**".

NOTE:

This will be spring stroke to fully extend the drive rod (if the operator is “SR” type).

Measure from the mark to the bottom of the stem nut using the Vernier/measurement ruler. Record this value as "**B**".

B = _____

Also measure from the top of the body of the swivel connector (80) to the bottom of the cylinder plate (4). Record this value as "**X**".

X = _____

3. Pull the valve stem fully out of the valve body, ensuring that it is fully extended. Mark on the valve stem a distance "**B**" down from the top of the valve stem. This is "**MARK #3**".

   Measure from the top of the valve flange to the top of the valve stem using the Vernier/measurement ruler. Record this value as "**Y**".

   Y = _____

4. Actuate the operator (spring stroke) to fully retract the drive rod (1). Mark on the drive rod (1) where it and the bottom of the cylinder plate (4) align (do not damage the drive rod's outside diameter sealing surface). This is "**MARK #4**".

NOTE:

This will be power stroke by applying air through cylinder plate port (if the operator is “SR” type).

Measure from the top of the body of the swivel connector (80) to the bottom of the cylinder plate (4) using the Vernier/measurement ruler. Record this value as "**Z**".

Z = _____

To check: Perform the calculations below:

Y - A = Maximum Valve Stem Travel (MVT) = _____

X - Z = Maximum Operator Travel (MOT) = _____

If maximum operator travel (MOT) is less than or equal to maximum valve stem travel (MVT), that means end stop (32) is factory set properly. Further verification is required during the valve installation. If MOT is larger than MVT, refer to Section 8. *(Operator End Stop Adjustment)* for details on how to adjust the operator travel stop during valve installation.

Section 6: Installation

6.1 Notes

⚠ CAUTION: BE CAREFULL ON PINCH POINTS

The areas inside the pedestal around the connector are pinch points for hands and fingers.

⚠ CAUTION: REMOVE LINE PRESSURE

Line pressure can cause a valve to open or close unexpectedly. It is recommended for the installation to be performed on the valve with no pressure in the line.

- GVO linear operators shipped mounted to valves have their travel adjusted properly by the manufacturer and do not require further adjustment. Install valve with GVO linear operator directly in line.
- If the valve is not shipped with the operator, the valve might need to be prepared for installation. Any device that would restrict the free movement of the valve stem or prevent installation of the operator (for example, handwheel or stem nut) must be removed. Consult valve manufacturer for instructions.
- Be sure to use internally clean pipe or tubing when connecting to supply and assure appropriate pressure and flow capacity for the operator. Clean dry-supply gas will help ensure trouble-free operation.
- Check the valve and operator for compatibility before beginning installation. Verify if the connector thread matches valve stem. Verify operator mounting plate/valve gear flange connection (for example, bolt pattern, and alignment bosses). Verify the proper amount, lengths, and sizes of mounting hardware bolts, studs, lock washers, and others.
- Ensure threads and mating surfaces are free of dirt and debris.

6.2 Lifting

⚠ CAUTION: USE PROPER LIFTING EQUIPMENT

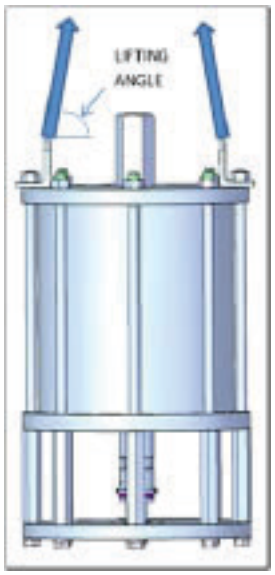
The operator's built-in lifting lugs/eyes are designed with the capacity to lift the Bettis™ GVO operator and the pedestal. Additional lifting support is required to lift the operator with a valve attached. Always use an appropriately rated crane/hoist and appropriate straps/chains when raising and lowering the operator.

Vertical Lifting:
Make sure that the valve is disconnected from the operator before lifting the operator. Care must be taken when handling and installing the operator especially during rigging and lifting. The operator should only be lifted from the lifting lugs located on the end cap as shown in Figure 5. *(Lifting Method)*.

NOTE:

Operators should be lifted with force acting as vertically as possible. Spreader bars or other lifting aids may be required to maintain a vertical lift on the lugs or eyebolts. Always lift the operator with a 60° or greater lifting angle measured from the horizontal plane.

Figure 5 Lifting Method



6.3 Procedures of Installation

6.3.1 Operator Installation

1. For closed pedestal operators, removal of the window(s) from the operator pedestal is required to provide access to the connector.
2. Complete the measurements in Section 5.2 *(Pre-installation Verification)* to aid in the assembly of operator to valve and to ensure that the end stop is set properly.
3. Disconnect the tubing (if applicable) and connect the air supply/Nitrogen (a block and bleed valve can be used to maintain pressure in the cylinder, locking the drive rod in position). Do not exceed operator MAWP.
4. While extending the drive rod (1), a controlled stroking speed can be used to travel the operator as you screw/rotate the stem nut section of the connector onto the valve stem.

6.3.1.1 Operator Installation Conditions:

a. **Condition A.** Valve Stem Extended/Operator Drive Rod Retracted (typically FS style operator with drive rod retracted into cylinder)

b. **Condition B.** Valve Stem Retracted/Operator Drive Rod Extended (typically SR style operator with drive rod fully extended from cylinder)

⚠ CAUTION: CAREFULLY HANDLE VALVE STEM AND NUT

If compressed Air/Nitrogen is used to assist the installation, care must be taken to avoid sudden movement on end cap (32) if losing the supply power too quickly.

Jamming the stem nut into the top of the valve stem may damage the threads; repair the stem nut if damage occurs before attempting to screw it onto the valve stem.

Side loading of the valve stem while lowering the operator onto the valve can cause damage to the valve or operator. Ensure rigging will allow sufficient control of the position and speed at which the operator is lowered onto the valve.

NOTE:

Left Hand Rotation of the stem nut is most common. Determine thread rotation before attempting to screw the stem nut sections onto the stem.

Condition A: Valve Stem Extended/Operator Drive Rod Retracted
(typically FS style operator with drive rod retracted into cylinder)

Method 1:

1. Apply anti-seize to valve stem thread.
2. With the operator's drive rod (1) fully retracted, lower the operator until the stem nut section contacts the valve stem.
3. Continue to lower the operator by spinning/rotating it onto the valve stem (this will engage the stem nut onto the valve stem). Measurement “B” taken in Section 5.2 *(Pre-installation Verification)* will provide the required engagement of the stem nut onto the valve stem.

NOTE:

The stem nut may have to be held/restrained by a vise grip/pipe wrench inside the pedestal so it will rotate with the operator.

The valve stem may not remain in fully extended position due to the weight of the operator. Threading the swivel connector (80) onto the valve stem will bring the valve stem back to fully extended position.

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4. Once full engagement is achieved, advance the stem nut a half turn to ensure operator stroke is controlled by internal stop of operator and is not limited by valve stroke.
5. Position the controls and windows to the required location and install the mounting hardware at the point where the adapter plate is in full contact with the valve gear flange.
6. Slowly extend the drive rod. When it is fully extended, verify the connector can rotate a few degrees. This confirms that the valve travel is controlled by the internal stop of the operator and operator is not jamming the gate of the valve body.
7. Refer to Section 8. *(Operator End Stop Adjustment)* if the operator end stop needs adjustment.
8. Tighten the set screws (98) in the connector assembly to locked into position once operator travel is confirmed.

Method 2:

NOTE:

The following **Method 2** may be used if it is possible to get a hand/wrench into the pedestal (if so equipped) to turn the stem nut section onto the valve stem. Use **Method 1** above if this is not possible.

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1. Apply anti-seize to valve stem thread.
2. Guide and lower the operator over the valve stem until the stem nut section is about an inch away.
3. Hold the operator in position to slowly extend the drive rod (1) until the stem nut makes contact with the valve stem.
4. Lower the operator while simultaneously retracting the drive rod (1) as you thread the connector onto the valve stem. Continue this process until the adapter plate contacts the valve gear flange.

NOTE:

The valve stem may not remain in fully extended position due to the weight of the operator. Threading the connector onto the valve stem will bring the valve stem back to fully extended position.

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5. Measurement "**B**" taken in Section 5.2 *(Pre-installation Verification)* will provide the required engagement of the stem nut onto the valve stem.
6. Once full engagement is achieved, advance the stem nut a half turn to ensure operator stroke is controlled by internal stop of operator and is not limited by valve stroke.
7. With the controls and windows in the required position, install mounting hardware.
8. Slowly extend the drive rod. When it is fully extended, verify the connector can rotate a few degrees. This confirms that the valve travel is controlled by the internal stop of the operator and operator is not jamming the gate of the valve body.
9. Tighten the set screws (98) in the connector assembly to locked into position once operator travel is confirmed.

Condition B: Valve Stem Retracted/Operator Drive Rod Extended (typically SR style operator with drive rod fully extended from cylinder)

Method 1:

1. Apply anti-seize to valve stem thread.
2. Spin/rotate the operator around the valve stem to engage the valve stem in the stem nut while slowly lowering the operator. Retain the stem nut to the operator using a vise grip or pipe wrench.
3. Measurement "**B**" taken in Section 5.2 *(Pre-installation Verification)* will provide the required engagement of the stem nut onto the valve stem. Once full engagement is achieved, advance the stem nut half a turn to ensure operator stroke is controlled by internal stop of operator and is not limited by valve stroke.
4. Position the control/windows as required once full contact is made between the adapter plate and gear flange. Install mounting bolts and tie rods.

5. Slowly retract the drive rod. When it is fully retracted, verify the connector can rotate a few degrees. This confirms that the valve travel is controlled by the internal stop of the operator and operator is not jamming the gate of the valve body.
6. Tighten the set screws (98) in the connector assembly to locked into position once operator travel is confirmed.

Method 2:

NOTE:

The following **Method 2** may be used if it is possible to get a hand/wrench into the pedestal (if so equipped) to turn the stem nut section onto the valve stem. If this is not possible, then use **Method 1** above.

1. Apply anti-seize to valve stem thread.
2. Lower the operator onto the valve until the valve stem contacts the stem nut section of the connector.
3. Screw/rotate the stem nut section (while slowly lowering the operator) to engage it onto the valve stem until the adapter plate fully contacts the gear flange.
4. Measurement "B" taken in section 5.2 Pre-installation Verification will provide the required engagement of the stem nut onto the valve stem. Once full engagement is achieved, advance the stem nut a half a turn to ensure operator stroke is controlled by internal stop of operator and is not limited by valve stroke.
5. Slowly retract the drive rod. When it is fully retracted, verify the connector can rotate a few degrees. This confirms that the valve travel is controlled by the internal stop of the operator and operator is not jamming the gate of the valve body.
6. Tighten the set screws (98) in the connector assembly to locked into position once operator travel is confirmed.

Section 7: Maintenance

7.1 Regular Maintenance

- Remove line pressure prior to any maintenance if possible.
- The only servicing required is seal and gasket replacement under normal operating conditions.
- In addition to the standard recommended tools and materials Section 5.1 *(Tools),* the following tools and materials are recommended for maintenance:
  - Dow corning #111 grease or equivalent
  - A tube of sealant (for example, silicone)
  - Leak detecting fluid (for example, soapy water)
- Seals, gaskets, and other applicable soft parts are available from the manufacturer as repair kits. Lubricant, sealant and/or other materials are also available from the manufacturer.

NOTE:
This product is only intended for use in large-scale fixed installations excluded from the scope of Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS 2).

7.2 Disassembly

NOTE:
Refer to this section only when seals need to be replaced. Refer to Section 9. *(Testing and Troubleshooting)* to determine when seals need to be replaced.

⚠ CAUTION: DO NOT DISASSEMBLE SPRING CARTRIDGES

Spring is under load. To avoid personal injury, Do not attempt to disassemble or tamper with spring cartridge assembly during regular maintenance. For questions regarding the spring cartridge, please contact the manufacturer.

All parts described are indicated by a corresponding number in parenthesis. Please refer to Figure 7. *(GVO-LP-SR with Open Pedestal)* or Figure 8. *(GVO-LP-FS, Less Pedestal)* to identify the specified components. The parts cited are typical to linear operators. A special operator might have different parts which should be installed in the same manner as they are removed.

NOTE:
Type FS style operator is used for illustration. Follow the same instruction for SR style operator (with the exception of spring function).

Please follow the steps below for FS/SR Operators:

1. Make sure pressure supply is shut off and all pressure is released from the operator and controls prior to disassembly.
2. For FS style operator: Remove power supply to fully retract the drive rod (1). For SR style operator: Apply the pressure on cylinder plate (4) side to fully retract the drive rod.

   Refer to Figure 6. *(Markings for Maintenance)* and mark the following locations:

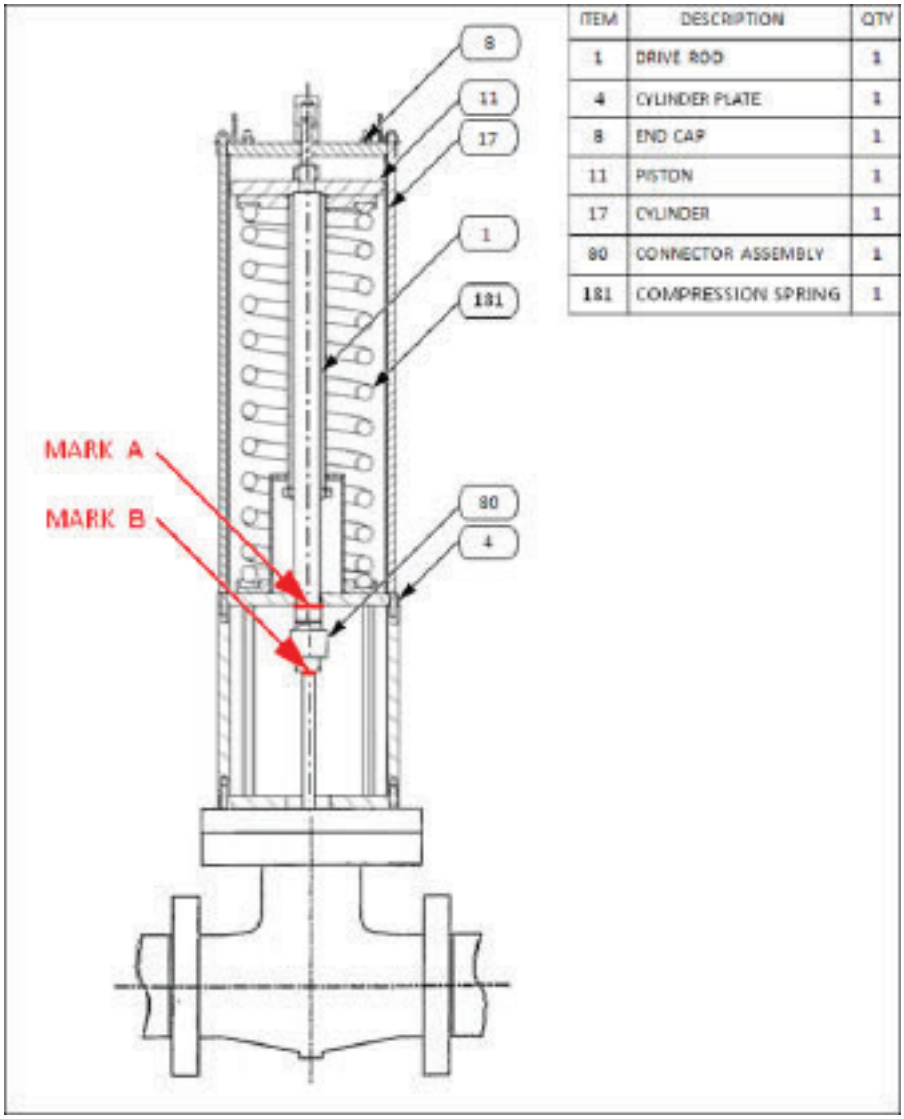
   a. Mark where the bottom of the cylinder plate (4) falls on the drive rod (1). This is "**MARK A**".

   b. Mark the bottom of the stem nut on the valve stem. This is "**MARK B**".

NOTE:
"**MARK A**" and "**MARK B**" will facilitate the reassembly to match original valve/operator setting.

Marks should be made with a marker, wax pen, or other tool that will not damage the sealing surfaces of the operator.

Figure 6 Markings for Maintenance



ITEM	DESCRIPTION	QTY
1	DRIVE ROD	1
4	CYLINDER PLATE	1
8	END CAP	1
11	PISTON	1
17	CYLINDER	1
80	CONNECTOR ASSEMBLY	1
181	COMPRESSION SPRING	1

3. Mark the end stop (32) engaged position and remove the end stop.

A. For FS Type Operator:

NOTE:

Operator is under spring load. Remove the end stop completely to reduce the spring load during disassembly to avoid injury.

Do not rotate/remove end stop (32) under spring load. Move piston away prior to removal.

a. Apply and hold pressure on end cap (8) side to move piston rod (that is drive rod) away from end cap.

b. Remove the end stop cover (33) and end stop cover seal (57) with the piston held in position.

NOTE:

Remember to mark the end stop (32) with the current engaged position in order to aid in reassembly.

⚠ CAUTION: REMOVE END STOP COVER CAREFULLY

Remove the end stop cover carefully (33). Supply air may escape between the threads in the end stop (32) and end cap (8).

c. Unscrew the end stop (32) slowly while end cap (8) side is still pressurized [in order to maintain the piston in position, provide continuous supply to the end cap (8) side in order to allow enough time to retract the end stop (32)].

⚠ CAUTION: DO NOT REMOVE END STOP COMPLETELY

Do not remove the end stop (32) completely. Supply air may escape if end stop (32) is completely removed too quickly.

NOTE:

Unscrew the end stop in stages (approximately 4 to 5 turns in first trial, then reduce the number of turns to 2 to 3 if more steps are needed), then release pressure in the end cap (8) to verify if spring force is still acting on end stop (32). Repeat step 3.c until end stop (32) is free from spring load.

d. Make sure pressure is completely released from the unit before proceeding to next step (that is step 4).

B. For SR Type Operator:

a. No pressure is required since spring load is not acting on end stop (32). Remove end stop cover (33) directly then mark the end stop (32) engaged position to facilitate reassembly.

4. Mark the port and tubing locations to facilitate reassembly. Disconnect tubing if required (but can leave the fitting on the operator components to ease the reassembly).

5. Loosen set screws (97), (98), and (99) in swivel connector (80). Unthread the stem nut from the valve stem to disengage valve stem from operator connector (if removal of the operator from the valve is required). Free the operator from valve by removing the mounting bolt. Then, unthread the connector assembly (80) from the drive rod (1) to remove the piston rod from the operator. This will allow the drive rod (1) and piston (11) to be removed completely from the operator.
6. Remove stay rod nuts (91), lift lugs (35), end cap (8), upper cylinder gasket (46), and/or upper cylinder seal (if supplied).

⚠ CAUTION: DO NOT REMOVE STAY ROD NUTS COMPLETELY

Do not remove stay rod nuts (91) completely from stay rod (23) until spring load is cleared. Allowing the end cap to move up slightly will release the spring preload inside the operator. Loosening stay rod nuts (91) in pairs (with one across the other) will prevent sudden movement of the end cap (8).

7. Remove only enough stay rods (23) to allow access for the removal of cylinder (17) and piston (11).
8. Remove cylinder (17) from the operator. When removing the cylinder, ensure the cylinder is not tilted and the inside surface of the cylinder is not rubbing against the piston.

NOTE:

Remove the spring cartridge prior to lifting the cylinder for SR operators.

9. Remove the piston (11) with the drive rod (1) attached to it. Ensure that the drive rod (1) is not rubbing against the cylinder plate (4) when removing it.

NOTE:

For FS operator, the spring cartridge located below the piston can only be removed after piston and drive rod is removed from the operator.

10. Go to the next step (that is step 11) if the piston (11) center seal will not be replaced. There is no need to separate the piston (11) and drive rod (1).

    Remove drive rod hex nut/jacknut (90), piston (11), piston seal (47), piston wear ring (42), and piston center seal (52). To remove a piston hex nut, fix the drive rod by securely clamping the flat surface on its bottom using some mechanical means (for example, bench vise) to prevent the drive rod (1) from turning with the nut. To remove a jacknut, remove all jackscrews first then unthread the jacknut.

11. Remove lower cylinder gasket (46), lower cylinder seal (if applicable), drive rod guide (40), drive rod seal (51), and wiper (44) from cylinder plate (4).

NOTE:
Operator seal can be replaced with the pedestal and cylinder plate (4) remained on the valve.

7.3 Inspection and Cleaning

All parts indicated are noted in Figure 7. *(GVO-LP-SR with Open Pedestal)* and Figure 8. *(GVO-LP-FS, Less Pedestal)*. Perform the following before starting the reassembly process:

- Thoroughly clean all parts except gaskets with Varsol or equivalent.
- Inspect all parts, checking in particular any parts/features on parts that seal or rub against another part.
  - Check internal surface of the cylinder (17) for scoring, scratches, or other wear.
  - Check all metal parts for wear, corrosion, and physical damage.
- Ensure cleaned parts are covered if stored outside.

7.4 Reassembly

NOTE:
Refer to Section 7.2 *(Disassembly)* and reassemble the unit in reverse order.
Make sure to reassemble parts in the same orientation as before.
Pay extra attention to the following items below.

Make sure all operator component parts are cleaned and lubricated (if required) prior to installing seals.

1. Use only new replacement seals (available as an operator-specific kit from Emerson).
2. Lubricate seals, rods, and cylinder bore with a generous amount of recommended grease.
3. Lubricate bushing and guides with a light coating of recommended grease.
4. Apply recommended grease/lubricant to the sealing surfaces and around the cylinder plate (4) opening when installing the drive rod (1) and piston (11) to the cylinder plate (4). Do not rub the bore on cylinder plate.
5. If piston (11) and drive rod (1) are disassembled, (which means piston center seal (52) will be replaced) make sure to apply recommended grease prior to attaching the drive rod (1) to the piston (11). Apply thread locking adhesive (for example, Loctite) to thread(s) of hex nut or jackscrews.
   a. Fix the drive rod by securely clamping the flat surface on its bottom using some mechanical means if using a hex nut. Refer to Table 2. *(Specification of Piston Hex Nut Tightening Torque)* for torque per specifications).

Table 2. Specification of Piston Hex Nut Tightening Torque

Piston Hex Nut Size [-]	Tightening Torque [ft-lb]
1/2 NC	50
5/8 NC	90
3/4 NC	160
7/8 NC	240
1 - 8UN	370
1-1/4 - 8UN	800
1-1/2 - 8UN	1500
1-3/4 - 8UN	2400

b. Install nut by hand and tighten manually if using a jacknut. Then, install the jackscrews (make sure to apply Loctite or equivalent) in a diagonal pattern and refer to Table 3. *(Specification of Jackscrew in Jacknut Tightening Torque)* for torque specifications.

Table 3. Specification of Jackscrew in Jacknut Tightening Torque

Jackscrew Size [-]	Tightening Torque [ft-lb]
1/2 NC	100
5/8 NC	185
3/4 NC	300
7/8 NC	450

6. When installing the cylinder (17), grease its internal surface with the recommended grease/lubricant prior to installing over piston (11). Make sure to install the gasket prior to lowering the cylinder onto the cylinder plate. Ensure that the cylinder end is seated properly on cylinder plate (4). Be careful not to damage the piston seal when passing over the piston (11). Try to maintain as vertical as possible when lowering down the cylinder).
7. Make sure to install the gasket prior to installing the end cap (8). Apply grease to the gasket to aid in maintaining the gasket position while lowering the end cap (8). Make sure gasket is seated properly on the cylinder during installation of stay rods.

NOTE:

For spring return operator, the end cap will be sitting on top of drive rod (for FS operator) or on top of spring cartridge (for SR operator), not on cylinder due to spring preload.

8. Apply anti-seize compound on the threads of stay rods (23) before installing to cylinder plate (4). Tighten stay rod nuts (91) evenly, progressing from nut to nut diagonally (not to adjacent nuts) until all nuts are torqued. Table 4. *(Specification of Stay Rod Nut Tightening Torque)* provides the required tightening torques for the stay rod nuts (91).

Table 4. Specification of Stay Rod Nut Tightening Torque

Stay Rod Nut Size [-]	Tightening Torque [ft-lb]
3/8 NC	22
1/2 NC	40
5/8 NC	80
3/4 NC	120
7/8 NC	160
1 NC	240
1-1/8 – 8 UN	385
1-1/4 – 8 UN	540
1-3/8 – 8 UN	725

⚠ CAUTION: PROPERLY TIGHTEN STAY ROD NUTS

Ensure that grooves on cylinder plate (4) and end cap (8) are lining-up and seating properly with ends of cylinder (17) while tightening stay rod nuts (91).

9. When installing the end stop to the end cap:

   a. For SR operator: Engaged the end stop to previously marked position.

   b. For FS operator: Engaged the end stop until it makes contact with the drive rod. Further steps are required to reach previously marked position.

10. Apply anti-seize to threads and install swivel connector (80) onto drive rod (1). Ensure that the top of the connector body fits tight against the shoulder on the drive rod (1) and it cannot be threaded any further. Secure connector body with hex socket set screws (97).

11. Refer to Section 8. *(Operator End Stop Adjustment)* for operator stop adjustment (if needed). Refer to Section 5.2 *(Pre-installation Verification)* to verify operator travel and valve stem engagement.

NOTE:

Apply anti-seize and thread stem nut onto valve stem to "**MARK B**" [made in Section 7.2 *(Disassembly)]*.

Secure stem nut with two hex socket set screws (98).

Check operator travel by slowly moving the operator to fully retract drive rod (1).

a. Verify that "**MARK A**" [made in Section 7.2 *(Disassembly)*] aligns with the bottom of the cylinder plate (4) and;

b. Verify that "**MARK B**" aligns with the bottom of the stem nut.

If both '**A**' and '**B**' above are true, this indicates that the adjustment of the travel was not disturbed during maintenance.

NOTE:

Perform leak tests upon initial reapplication of supply pressure. Leak test should be performed with a minimum of (1.2 x Maximum Operator Pressure). With pressure applied to the operator, apply soapy water or another leak-indicating fluid to gaskets (46), between the drive rod and cylinder plate and end stop cap (33). Monitor leaks for a minimum of 10 minutes. A leak at the gaskets (46) indicates that stay rod nuts (91) must be tightened [refer to Table 4. *(Specification of Stay Rod Nut Tightening Torque)*] or gaskets/seals need to be replaced.

Section 8: Operator End Stop Adjustment

NOTE:
GVO linear operators are shipped with their travel adjusted based on the valve topworks (if available). Adjustment may require if the pre-installation verification *(Section 5.2)* indicates that MOT is larger than MVT.

Each type of operator (SR and FS) will fall into one of two conditions (A or B) if the end stop is out of adjustment.

NOTE:
Valve with operator typically should have its travel limited by operator stops (preferably, MVT is 1/8 inch more than MOT) in order to avoid/prevent any damage to the valve. Refer to Section 8.1 *(SR - End Stop Adjustment Conditions)* and Section 8.2 *(FS - End Stop Adjustment Conditions)* if adjustment is needed.

Refer to Section 4. *(Operation)* to confirm the operational style of the (fully) extended/retracted position of each type of operator (SR and FS).

If the end stop is out of adjustment, the operator will fall into one of two conditions [with the assumption that valve stem engagement is according to Section 5.2 *(Pre-installation Verification)* measurement "**B**" plus 0.5 to 1 stem pitch]:

Condition A: MOT is more than MVT, which means travel stops on valve instead of operator

Condition B: MOT is less than MVT by more than 1 full pitch of valve stem thread, which means there is potential leakage due to under travel of valve.

8.1 SR - End Stop Adjustment Conditions

Condition A: MOT is more than MVT, which means travel stops on valve instead of operator.

NOTE:
In **Condition A**, the operator travel needs to be decreased to have valve stroke limited by operator internal stops.

1. Install operator on valve and adjust the stem nut as directed in Section 6. *(Installation)*.
2. Apply pressure slowly through the cylinder plate (4) supply ports to fully retract the drive rod (1) until the operator stops.
3. Remove the end stop cover (33) and end stop cover seal (57) to access the end stop (32).
4. The end stop (32) will be loosened up in the end cap (8).
5. Screw the end stop (32) into the end cap (8) until it stops by contacting the drive rod (1).
6. Release the pressure through cylinder plate (4) ports to allow piston to move away from end stop (enough to allow one full turn of the end stop).
7. Screw the end stop (32) further into the end cap (8) by 1/8 [inch] which is a one full turn of the end stop.
8. Re-apply pressure to move the piston against end stop. Check that the end stop (32) is jammed and locked in place by the drive rod (1).
9. Install and tighten the end stop cover (33) and end stop cover seal (57) to lock-in the travel adjustment.
10. Remove the existing "**MARK #4**". Mark on the drive rod (1) where it and the bottom of the cylinder plate (4) align. This is the new, correct, "**MARK #4**".

Condition B: MOT is less than MVT by more than 1 full pitch of valve stem thread, which means potential leakage due to under travel of valve.

NOTE:
In **Condition B**, the operator travel needs to be increased to maximize valve travel.

1. Install operator on valve and adjust the stem nut as directed in Section 6. *(Installation)*.
2. Make sure to release the pressure through cylinder plate (4) ports if the unit is pressurized to allow piston (11) to move away from end stop (32).
3. Remove the end stop cover (33) and end stop cover seal (57) to access the end stop (32).
4. When the end stop (32) is free, remove it from the end cap (8) two to four turns.

5. Re-apply pressure slowly through cylinder plate (4) supply ports to fully retract the drive rod (1) until the operator stops.
6. Screw the end stop (32) into the end cap (8) until it stops by contacting the drive rod (1).
7. Release pressure through cylinder plate (4) ports to allow piston to move away from end stop (enough to allow one full turn of the end stop).
8. Repeat steps 7 to 10 of **Condition A** above to complete the adjustment.

NOTE:
The fully retracted end of the operator travel has now been set.

8.2 FS - End Stop Adjustment Conditions

The operator needs to be pressurized to remove the spring load against the end stop (32) during the adjustment of FS style operator (ensure end stop cover (33) is intact during the pressurization). The pressure will reduce the force applied to the end stop by compressing the spring, thus allowing the end stop (32) to be adjusted.

⚠ CAUTION: DO NOT REMOVE END CAP COMPLETELY

The end stop will release air once the cover is removed. The end stop (32) should not be completely removed from the end cap (8) while the cylinder is pressurized.

Condition A: MOT is more than MVT, which means travel stops on valve instead of operator.

NOTE:
In **Condition A**, the operator travel needs to be decreased to have valve stroke limited by operator internal stops.

1. Install operator on valve and adjust the stem nut as directed in Section 6. *(Installation)*.
2. Release pressure slowly through end cap (8) ports to fully retract the drive rod (1) until the operator stops.
3. Remove the end stop cover (33) and end stop cover seal (57) to access the end stop (32).

⚠ CAUTION: ACCESS END STOP CAREFULLY

Air might leak through near the end stop (32) threads.

4. The end stop (32) will be loosened up in the end cap (8).
5. Screw the end stop (32) into the end cap (8) until it stops by contacting the drive rod (1).

6. Re-apply pressure through the end cap (8) ports to move the drive rod (1) away from the end stop (32) to the fully extended position to ensure sufficient time to adjust the end stop (32).

⚠ CAUTION: ACCESS END STOP CAREFULLY

Air might leak through near the end stop (32) threads.

Move the piston (11) away from the end stop (32) as far as possible (which is the piston rod's fully extended position) to finish the following steps to adjust the end stop (32).

7. Screw the end stop (32) further into the end cap (8) by 1/8 [inch] which is one full turn of the end stop.
8. Depressurize the operator to fully retract the drive rod (1). Check that the end stop (32) is jammed and locked in place by the drive rod (1).
9. Install and tighten the end stop cover (33) and end stop cover seal (57) to lock-in the travel adjustment.
10. Remove the existing "**MARK #4**". Mark on the drive rod (1) where it and the bottom of the cylinder plate (4) align. This is the new, correct, "**MARK #4**". **Condition B:** MOT is less than MVT by more than 1 full pitch of valve stem thread, which means potential leakage due to under travel of valve.

NOTE:

In **Condition B**, the operator travel needs to be increased to maximize valve travel.

1. Install operator on valve and adjust the stem nut as directed in Section 6. *(Installation)*.
2. Release pressure slowly through end cap (8) ports to fully retract the drive rod (1) until the operator stops.
3. Remove the end stop cover (33) and end stop cover seal (57) to access the end stop (32).

⚠ CAUTION: ACCESS END STOP CAREFULLY

Air might leak through near the end stop (32) threads.

4. The end stop (32) will be tightened/jammed against the drive rod (1).
5. Apply pressure through the end cap (8) ports to move the drive rod (1) away from the end stop (32) to the fully extended position to ensure sufficient time to adjust the end stop (32).

⚠ CAUTION: MOVE PISTON AS FAR AS POSSIBLE

Air might leak through near the end stop (32) threads.

Move the piston (11) away from the end stop (32) as far as possible (which is the piston rod's fully extended position) to finish the following steps to adjust the end stop (32).

6. When the end stop (32) is free, remove it from the end cap (8) two to four turns.

⚠ CAUTION: POSSIBLE LEAKAGE NEAR END STOP

Air might leak through near the end stop (32) threads.

7. Release pressure slowly through end cap (8) ports to fully retract the drive rod (1) until the operator stops.
8. Screw the end stop (32) into the end cap (8) until it stops by contacting the drive rod (1).
9. Re-apply pressure through the end cap (8) ports to slightly extend the drive rod (1), moving it away from the end stop (32) (enough to allow one full turn of the end stop (32)).
10. Repeat steps 7 to 10 of **Condition A** above to complete the adjustment.

NOTE:
The fully retracted end of the operator travel has now been set.

Section 9: Testing and Troubleshooting

9.1 Testing

System operation and performance should be tested and noted regularly to detect the problem in early stage. Use the following section to trace the source of problems before proceeding to a major operator overhaul (the operator itself is generally the least likely component to malfunction and requires the most time and effort to service).

9.2 Troubleshooting

NOTE:
This section focuses mainly on the most common problems and possible solutions of an operator. The control and control component troubleshooting is not part of the scope. In general, unsatisfactory operation of the operator is usually due to insufficient supply caused by leakage. Please contact the manufacturer for more detailed information regarding your requirements.

1. No Movement, Slow, Jerky or Partial Stroke
   - Check for sufficient supply pressure and flow. Ensure filter element is not blocked by checking the upstream accessories such as filter.
   - Check to ensure that speed control valve and shutoff valve are not fully closed.
   - Check for change in operating conditions, that is, higher line pressure, different fluid, valve packing tightened excessively.
   - Check if manual override is interfering and not left in a locking position. Ensure that it is fully disengaged to allow movement of the operator.

NOTE:
If the problem persists, please continue to the next section.

2. Check for External Leakage

NOTE:

The assumption below is that the symptoms (leakage) are not caused by control components and all joining fittings. The purpose of these suggestions below is to identify if there is any external leakage from the operator and the location of leakage. Soapy water is generally used to facilitate the inspection.

- With pressure applied to the operator, check cylinder ends, end stop, drive rod and/or manual override (if applicable) with soapy water.
  - Check the torque value on stay rod (nuts) if leakage is detected around the cylinder ends. Tighten the nuts if necessary. Replace the gasket at the cylinder ends if leakage continues.

NOTE:
Please refer to Table 4. *(Specification of Stay Rod Nut Tightening Torque)* to identify the maximum recommended torque.

  - Tighten the lock nuts or end stop cover if leakage is around end stop or manual override (if applicable). Replace the seal if leakage continues.
  - Run the operator for a couple times if leakage is around drive rod. Replace the seal if leakage continues (the seal is likely damaged).

NOTE:
If there is no external leakage and the problem persists, refer to the next section to check for internal leakage.

3. Check for Internal Leakage (Blow-by)

- With pressure applied to the power stroke side of the operator (end cap side for style FS operator and cylinder plate side for style SR operator), check for leakage (blow-by) from breather/vent port of the opposite (spring) side.
  - Check the piston seals if leakage is found on an operator that is not used for a long period time. Running the operator a few times will cause the O-ring to regain its resiliency and may eliminate the problem.
  - If leakage persists, then the seals need to be replaced accordingly.

NOTE:
If the problem persists, please continue to the next section below.

4. Valve Leakage or Unable to Close Completely

   — If leakage is through the line valve itself (the valve will not close completely), check operator maximum travel (MOT) and valve maximum travel (MVT). Refer to Section 5.2 *(Pre-installation Verification)* and Section 8. *(Operator End Stop Adjustment)* if the operator stop adjustment is required, particularly if the operator was recently installed or serviced.

Please contact manufacturer should problem persist or have any other issues:

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Section 10: Document Revision

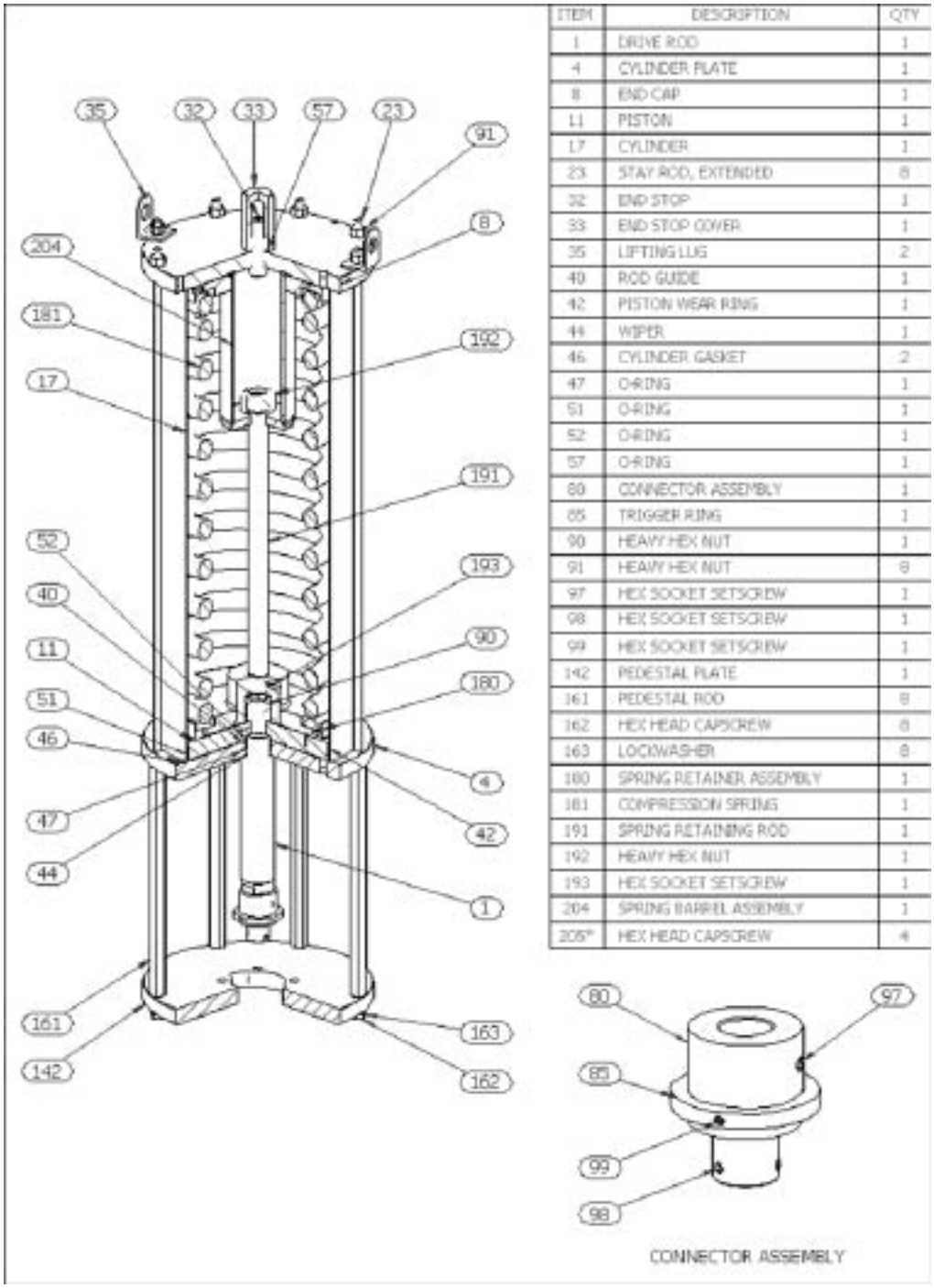
Table 5. Revision Overview

ECN	DATE	REV		BY *	DATE
Released	March 2014	A	COMPILED	J. Quilon	March 2014
Reviewed			CHECKED		
Approved			APPROVED	E. Carrillo	May 2014

Appendix A: List of Tables

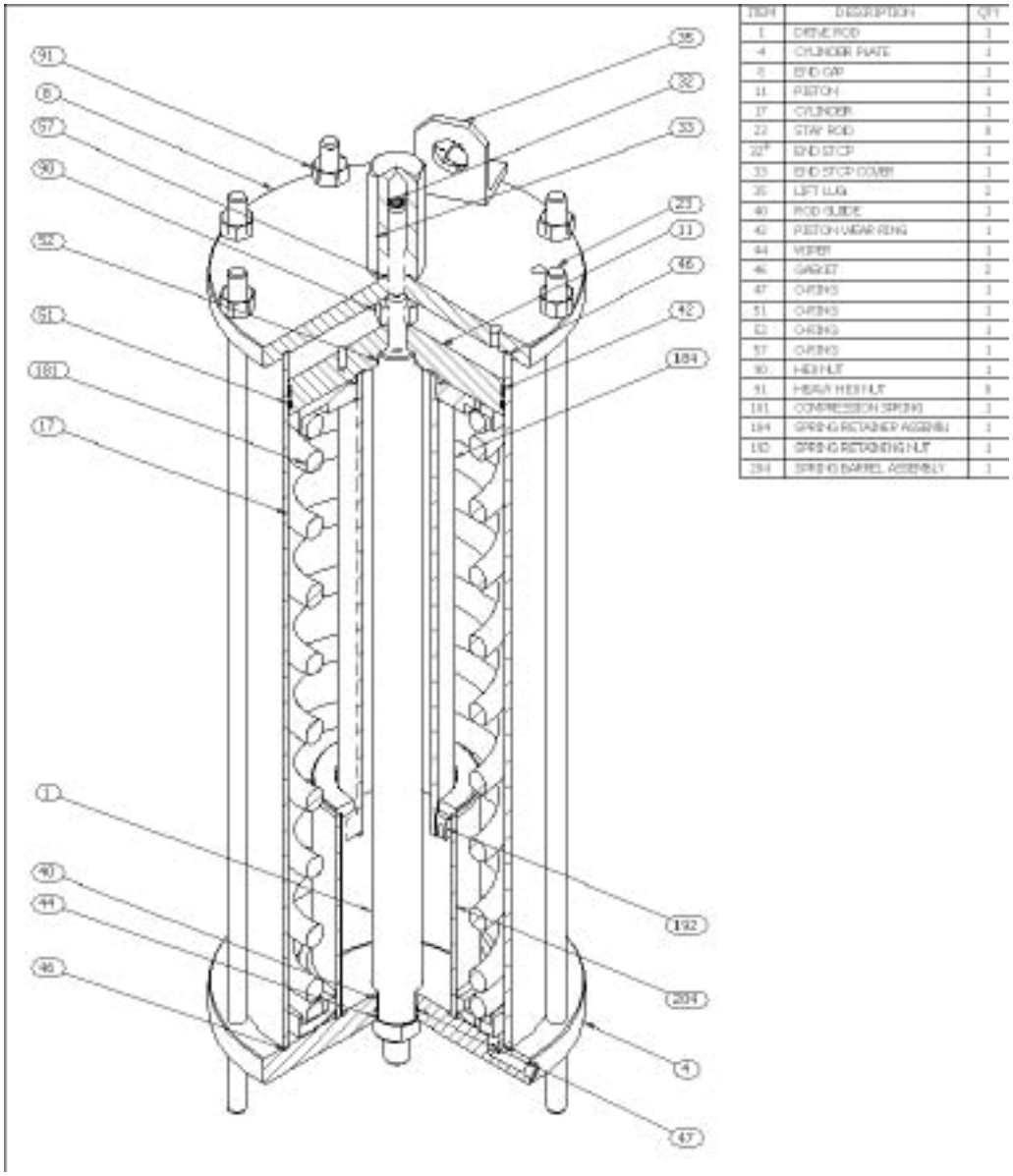
Appendix B: List of Figures

Figure 7 GVO-LP-SR with Open Pedestal



ITEM	DESCRIPTION	QTY
1	DRIVE ROD	1
4	CYLINDER PLATE	1
8	END CAP	1
11	PISTON	1
17	CYLINDER	1
23	STAY ROD, EXTENDED	8
32	END STOP	1
33	END STOP COVER	1
35	LIFTING LUG	2
40	ROD GUIDE	1
42	PISTON WEAR RING	1
44	WIPER	1
46	CYLINDER GASKET	2
47	O-RING	1
51	O-RING	1
52	O-RING	1
57	O-RING	1
80	CONNECTOR ASSEMBLY	1
85	TRIGGER RING	1
90	HEAVY HEX NUT	1
91	HEAVY HEX NUT	8
97	HEX SOCKET SETSCREW	1
98	HEX SOCKET SETSCREW	1
99	HEX SOCKET SETSCREW	1
142	PEDESTAL PLATE	1
161	PEDESTAL ROD	8
162	HEX HEAD CAPSCREW	8
163	LOCKWASHER	8
180	SPRING RETAINER ASSEMBLY	1
181	COMPRESSION SPRING	1
191	SPRING RETAINING ROD	1
192	HEAVY HEX NUT	1
193	HEX SOCKET SETSCREW	1
204	SPRING BARREL ASSEMBLY	1
205*	HEX HEAD CAPSCREW	4

Figure 8 GVO-LP-FS, Less Pedestal



ITEM	DESCRIPTION	QTY
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4	CYLINDER PLATE	1
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11	PISTON	1
17	CYLINDER	1
23	STAY ROD	8
23*	END STOP	1
33	END STOP COVER	1
35	LIFT LUG	2
40	ROD GUIDE	1
42	PISTON WEAR RING	1
44	VERIT	1
46	GASKET	2
47	O-RING	1
51	O-RING	1
52	O-RING	1
57	O-RING	1
90	HEX NUT	1
91	HEAVY HEX NUT	8
181	COMPRESSION SPRING	1
184	SPRING RETAINER ASSEMBLY	1
192	SPRING RETAINING NUT	1
204	SPRING BARREL ASSEMBLY	1

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