Installation, Operation and Maintenance Manual
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GVO-LP-DA Linear Valve Operator

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.

Before attempting to install or service, block power gas supply and depressurize system. Isolate the power gas from controls if operator is supplied with control system.

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

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

It is required to go through the above instructions which will help to 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 GVO Series Pneumatic Double Acting Linear Valve Operators. 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 Series
LP	Low Pressure Pneumatic
DA	Double Acting
TDM	Tandem Power Cylinder
ID	Inside Diameter [inch]
OD	Outside Diameter [inch]
BCD	Bolt Circle Diameter
MOT	Maximum Operator Travel
MVT	Maximum Valve Stem 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.

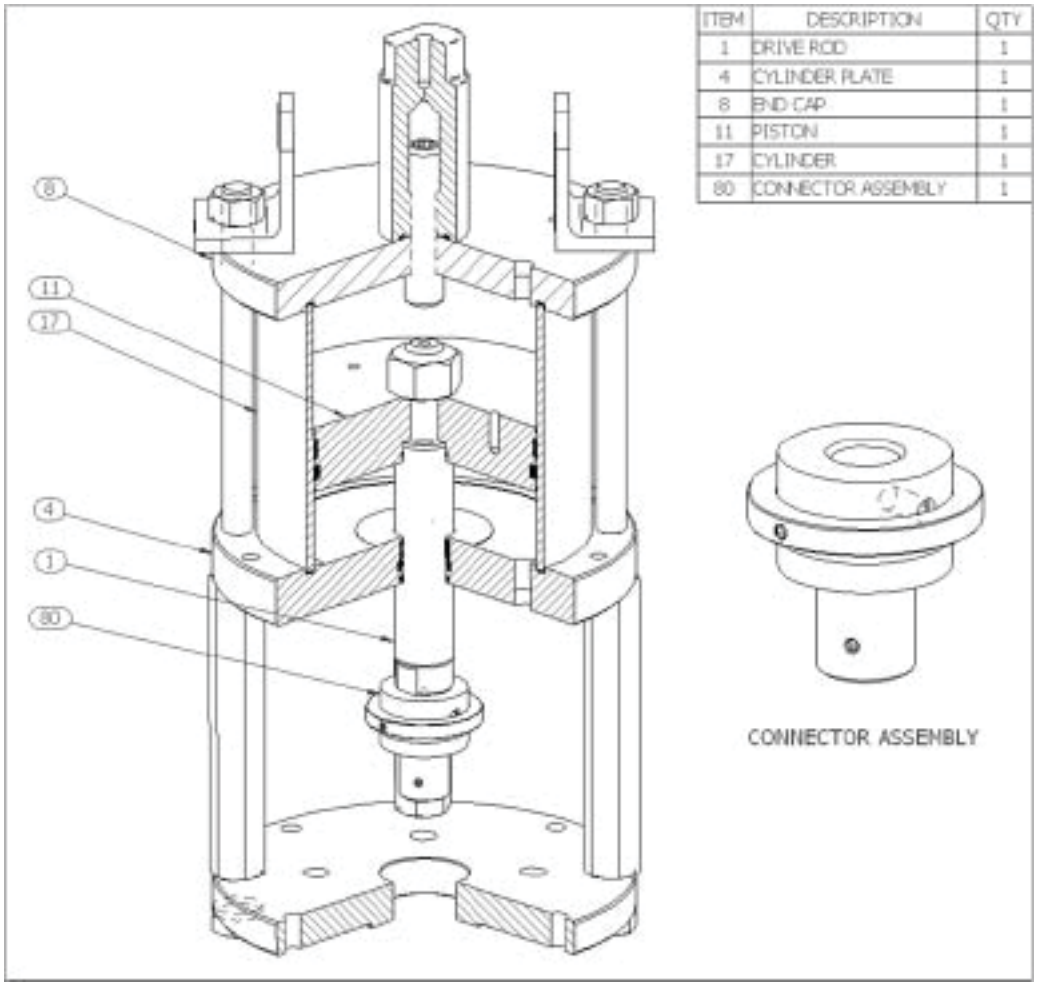
2.3 Scope

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

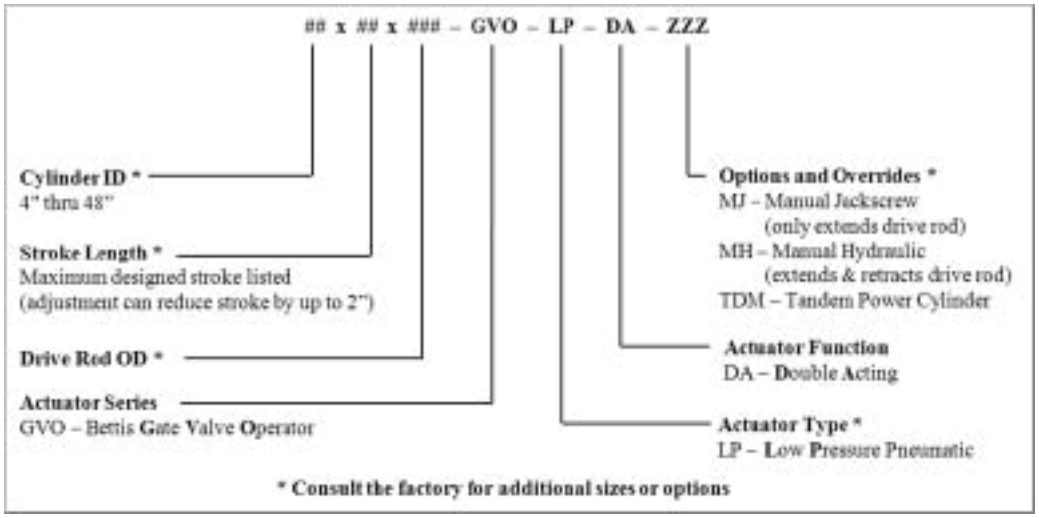
The Bettis GVO Pneumatic Series represents a broad range of field-proven linear valve operators suitable for automating most types of rising stem valves in safety shutdown and control applications. Figure 1 shows the typical assembly drawing of GVO-LP-DA operator with an open pedestal with the key terminology. For a full listing of items, refer to the typical sectional assembly drawing Figure 7. GVO-LP-DA with Open Pedestal.

Figure 1 Typical Assembly of GVO-LP-DA on Valve



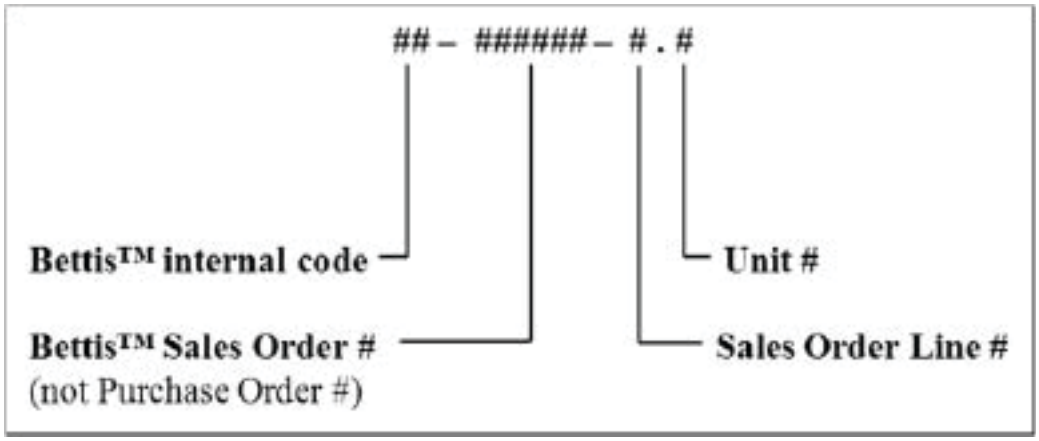
The catalog lists standard models intended to cover a wide range of sizes and applications. Customers can use Figure 2. Linear Valve Operator Model Designation to identify the key operator characteristics. If not included in the catalog lists, custom designed models are also available for specialized 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-DA-MH is an operator with a 16 [inch] inside diameter cylinder (17), a 10 [inch] maximum stroke (adjustable down to 8 [inch] stroke), a 2.5 [inch] OD drive rod (1) and is low-pressure pneumatic double acting 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 of the operator is required when the operator will not be put into immediate service.

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. Retract the drive rod (1) into the operator by applying the air supply/Nitrogen to the port(s) on the cylinder plate (4). Lightly grease portion of drive rod that remains exposed.
3. The plastic plugs used to plug the pressure ports during assembly should be removed and replaced with steel plugs. Any controls present should also be plugged with steel plugs.

NOTE:

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

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

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

Section 4: Operation

The Double Acting operator functions when supply pressure is applied to the piston (11). To extend the drive rod (1), pressure is applied through ports on the end cap (8) to exert force on the cap side of the piston (11), pushing the drive rod (1) out of the operator. To retract the drive rod (1), pressure is applied through ports on the cylinder plate (4) to exert force on the drive rod side of the piston (11), pulling the drive rod (1) into the operator. This will push in or pull out the connected valve stem. Upon loss of supply pressure, the operator will stop wherever it is in its travel position. It has no predetermined failed position unless there are some control components to command such a position.

Section 5: Preparation

Before beginning to work (installation, operation or maintenance) on an operator, please 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. Depending upon specific operator/task, additional tools and materials may be required.

- 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 (e.g., Teflon tape, pipe dope)
- Commercial solvent (e.g., Varsol)

5.2 Pre-Installation Verification

NOTE:

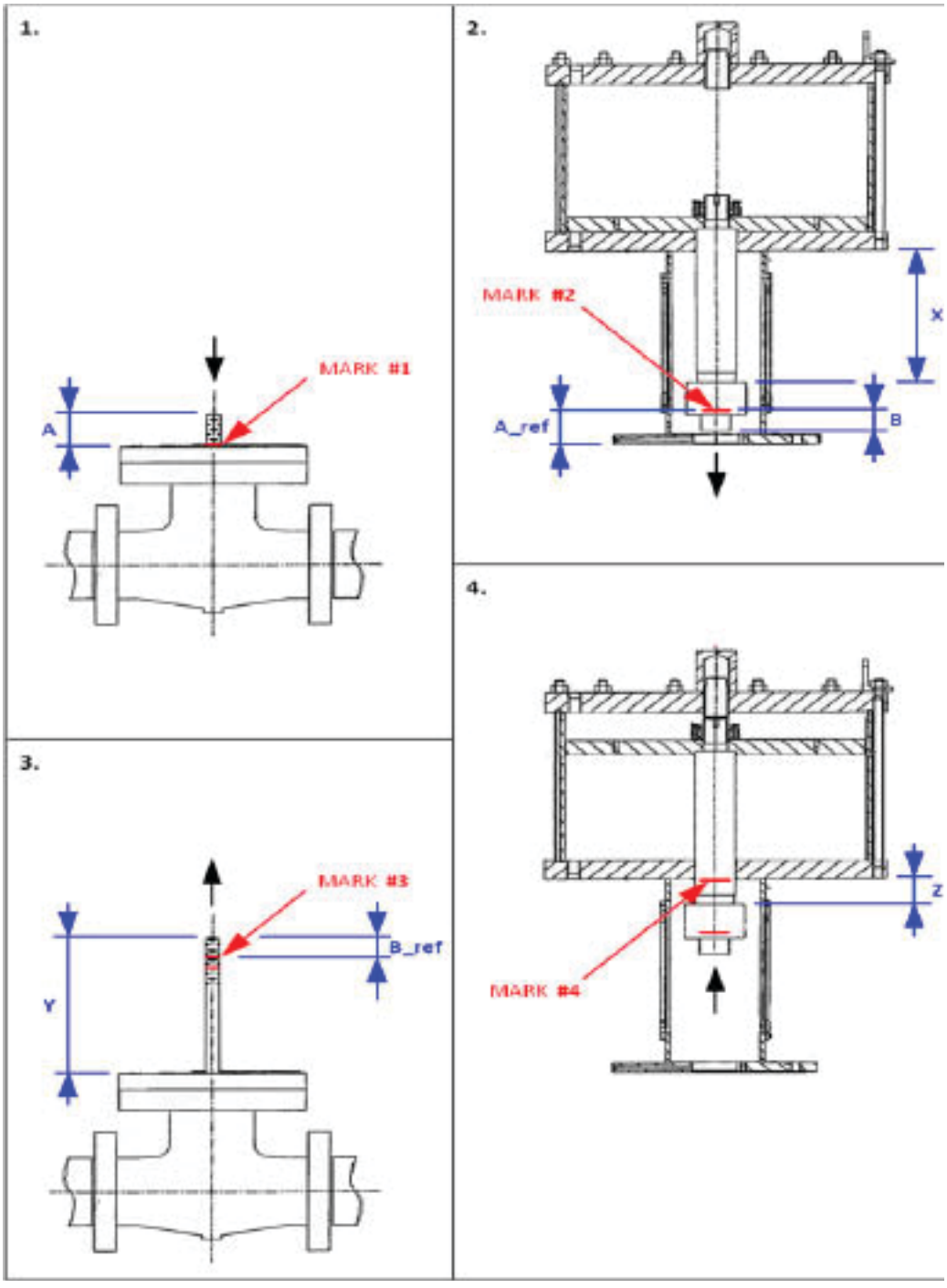
GVO linear operators shipped mounted to valves have their travel adjusted properly by the manufacturer and do not require further adjustment. Install valve with GVO linear operator directly in line. GVO linear operators shipped without a valve have their travel adjusted based on the valve topworks (if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

Before initial installation of the operator on the valve, there are several critical measurements and markings to make. These measurements and markings cannot be made after the operator is installed and are helpful for checking or adjusting travel. 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.

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. Use a soft mallet if striking the valve stem's threaded end to retract valve stem fully. Mark on the valve stem where it and the top of the valve flange align. This is "**MARK #1**".

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

   A = _____

2. Actuate the operator 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**".

   Using the Vernier/measurement ruler, measure from the mark to the bottom of the stem nut. 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**".

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

   Y = _____

4. Actuate the operator 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 OD sealing surface). This is "**MARK #4**".

   Using the Vernier/measurement ruler, measure from the top of the body of the swivel connector (80) to the bottom of the cylinder plate (4). Record value "**Z**".

   Z = _____

CHECK: Perform the below calculations:

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: PINCH POINTS AROUND CONNECTOR

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 (e.g., handwheel or stem nut) must be removed. Consult valve manufacture for instructions.
- When connecting to supply, be sure to use internally clean pipe or tubing, and assure appropriate pressure and flow capacity for the operator. Clean, dry supply gas will help to ensure trouble-free operation.
- Before beginning installation check valve and operator for compatibility. Verify connector thread matches valve stem. Verify operator mounting plate/valve gear flange connection (e.g. bolt pattern, and alignment bosses). Verify mounting hardware bolts, studs, lock washers, etc. are the proper amounts, lengths, and sizes.
- Ensure threads and mating surfaces are free of dirt and debris.

6.2 Lifting

⚠ CAUTION: USE PROPER LIFTING EQUIPMENT

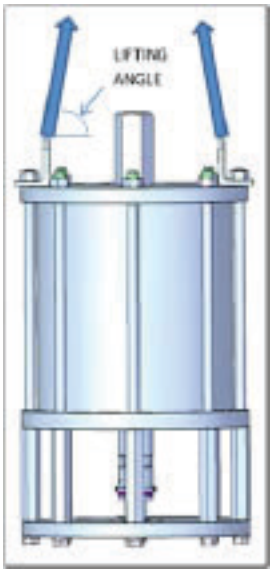
The operator's built-in lifting lugs/eyes are designed with the capacity to lift the GVO operator and the pedestal. Additional lifting support is required to lift the operator with a valve attached. Always use an appropriately rated crane/hoist and appropriate straps/chains when raising and lowering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

VERTICAL LIFTING:
Before lifting the operator, make sure that the valve has been disconnected from the operator. When handling and installing the operator, care must be taken, especially when rigging and lifting the operator. The operator should only be lifted from the lifting lugs located on the end cap, 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. Removal of the window(s) from the operator pedestal is required to provide access to the connector on closed pedestal operators.
2. Complete measurements in section 5.2 Pre-installation Verification to aid in assembly of operator to valve and 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 while screwing/rotating 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

b. **Condition B.** Valve Stem Retracted/Operator Drive Rod Extended

⚠ CAUTION: CAREFULLY HANDLE VALVE STEM AND NUT

Jamming the stem nut into the top of the valve stem may damage the threads; if damage occurs repair is required before attempting to screw the stem nut 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 location and speed at which the operator is lowered onto the valve.

LEFT HAND ROTATION of the stem nut is most common. Determine thread rotation before attempting to screw the stem nut sections onto the valve stem.

Condition A: Valve Stem Extended/Operator Drive Rod Retracted

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 swivel connector (80) contacts the valve stem.
3. Continue to lower the operator as you spin/rotate the operator about the valve stem to 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 the 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 the fully extended position.

4. Once full engagement is achieved advance the stem nut a half turn (pushing stem nut down) to ensure operator stroke is controlled by internal stop of operator and is not limited by valve stroke.
5. At the point the adapter plate is in full contact with the valve gear flange, position the controls and windows to the required location and install mounting hardware.
6. Slowly extend the drive rod when it is fully extended and verify the connector can rotate a few degrees. This confirms the valve travel is controlled by the internal stop of the operator and operator is not jamming the gate in the valve body.
7. If operator end stop needs adjustment please refer to SECTION 8. OPERATOR END STOP ADJUSTMENT.
8. Once operator travel is confirmed, the set screws (98) can be tightened in the connector assembly locking into position.

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.

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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 one inch away.
3. Holding the operator in position 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 contact is made between the adapter plate and the valve gear flange.

NOTE:

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

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5. Check against Measurement “B” taken in section 5.2 Pre-installation Verification for 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. When the pedestal plate and the valve gear flange are in contact, make sure the control assembly/plate is oriented in the required position. Then install the mounting hardware.
8. Slowly extend the drive rod when it is fully extended and verify the connector can rotate a few degrees. This confirms the valve travel is controlled by the internal stop of the operator and operator is not jamming the gate in the valve body.

9. Once operator travel is confirmed the set screws (98) can be tightened in the connector assembly locking into position.

Condition B: Valve Stem Retracted/Operator Drive Rod Extended

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. The stem nut may have to be retained to the operator by 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 a half a turn to ensure operator stroke is controlled by internal stop of operator and is not limited by valve stroke.
4. Once full contact is made between the adapter plate and gear flange, position the control/windows as required. 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 the valve travel is controlled by the end stop of the operator and operator is not jamming the gate in the valve body.
6. Once operator travel is confirmed the set screws (98) can be tightened in the connector assembly locking into position.

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. While slowly lowering the operator screw/rotate the stem nut section 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 the valve travel is controlled by the end stop of the operator and operator is not jamming the gate in the valve body.
6. Once operator travel is confirmed the set screws (98) can be tightened in the connector assembly locking into position.

Section 7: Maintenance

7.1 Regular Maintenance

- If possible, remove line pressure prior to any maintenance.
- Under normal operating conditions, the only servicing required is seal and gasket replacement.
- In addition to the standard recommended tools and materials (5.1 Tools), the following tools and materials are recommended for maintenance:
  - Dow corning #111 grease or equivalent
  - A tube of sealant (e.g., silicone)
  - Leak detecting fluid (e.g., 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.

All parts described below are indicated by a corresponding number in parenthesis. Please refer to Figure 7. GVO-LP-DA with Open 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.

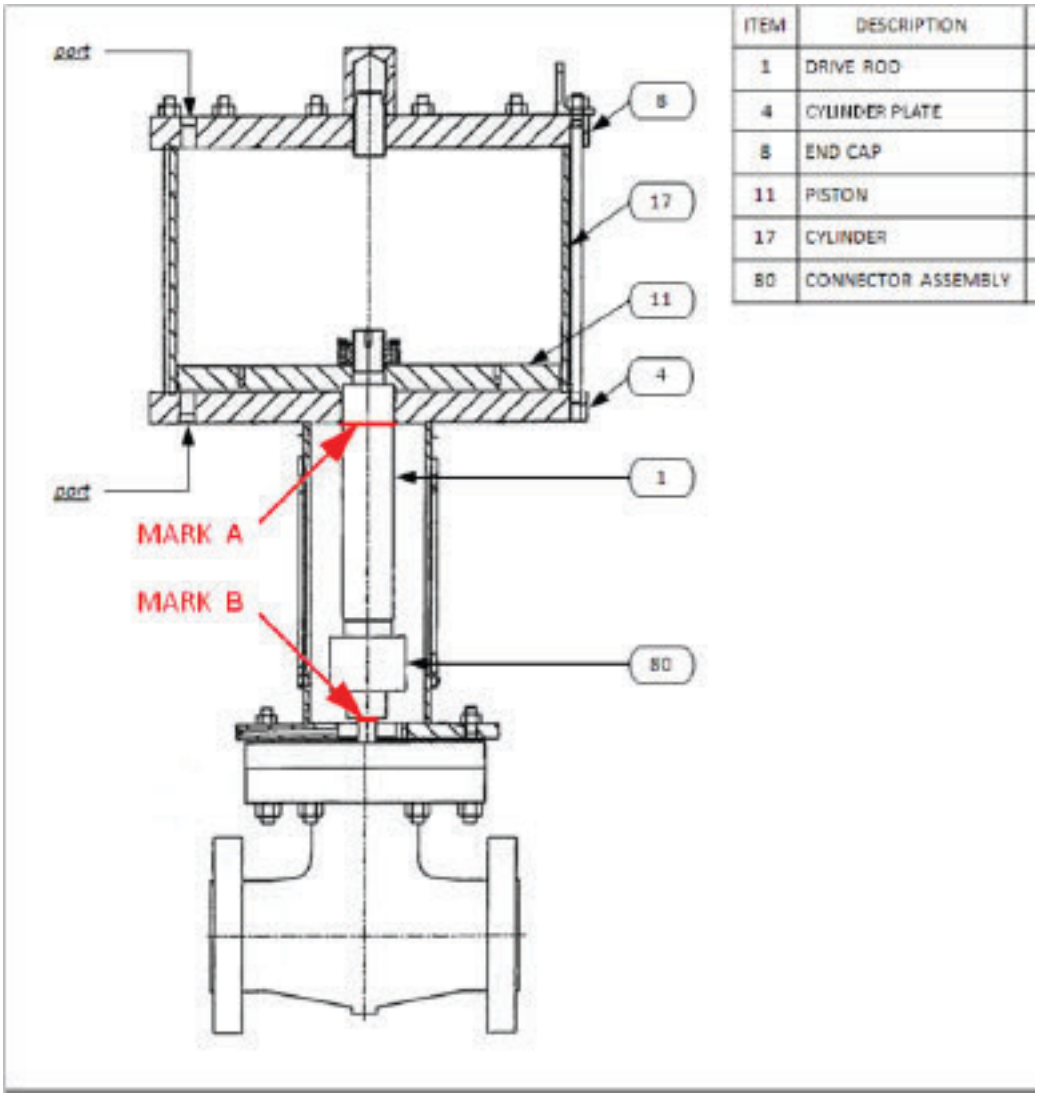
Please follow the steps below for DA Operators:

1. Actuate the operator by applying the pressure through the cylinder plate ports to fully retract the drive rod (1). Refer to Figure 6. Markings for Maintenance and mark the following locations:
   a. On the drive rod (1), mark where the bottom of the cylinder plate (4) falls. This is "**MARK A**" which is current operator stroke (operator stop setting).
   b. On the valve stem, mark the bottom of the stem nut. This is "**MARK B**" which is the existing valve stem engagement.

NOTE:

"MARK A" and "MARK B" is to facilitate re-assembly 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



2. Now, remove pressure from the operator and/or systems.
3. Mark or note the port and tubing locations to facilitate reassembly.
4. Disconnect all tubing from the operator.
5. Loosen set screw (97), (98), and (99) in swivel connector (80).
6. Unthread the stem nut from the valve stem and unthread the swivel connector (80) from the drive rod (1). This will allow the drive rod and piston to be removed completely from the operator.

7. Remove end stop cover (33) and end stop cover seal (57) from the top end cap (8).

NOTE:
Leave end stop installed in end cap if possible to maintain correct operator travel for reinstalling on the valve. If you must remove the end stop make a mark to aid in reassembly.

8. Remove stay rod nuts (91), lift lugs (35), end cap (8), upper cylinder gasket (46) and/or upper cylinder seal (if supplied).
9. Remove only enough stay rods (23) to allow access for removal of the cylinder (17) and piston (11).
10. 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.
11. 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.
12. Remove drive rod hex nut/jacknut (90), piston (11), piston seal (47), piston wear ring (42) and piston center seal (52). When removing a hex nut, be sure to fix the drive rod by clamping the flat surface at its bottom securely with some mechanical means (e.g., bench vise) to prevent the drive rod turning with the nut. When removing a jacknut, first remove all jackscrews then unthread the jacknut.
13. 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 pedestal and cylinder plate (4) remained on the valve.

7.3 Inspection and Cleaning

All parts indicated are noted in Figure 7. GVO-LP-DA with Open Pedestal. Before starting the reassembly process, perform the following:

- Thoroughly clean all parts except gaskets with Varsol or equivalent.
- Inspect all parts, checking in particular any parts or 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:

Reassemble the unit in the reverse order of disassembly refers to SECTION 7.2 (Disassembly). Be careful to reassemble parts in the same orientation as before.
Extra attention should be paid to the following:
Make sure all operator component parts are cleaned and lubricated (if required) prior to installing seals

- ATTENTION: Be sure to use only new replacement seals (available as an operator- specific kit from Emerson).
- Lubricate seals, rods and cylinder bore with a generous amount of the recommended grease.
- Lubricate bushing and guides with a light coating of the recommended grease.
- When installing the drive rod (1) & piston (11) to the cylinder plate (4), make sure to apply recommended grease/lubricant to the sealing surfaces and around cylinder plate (4) opening. Please exercise with care to avoid rubbing against the bore on cylinder plate.
- Lock piston (11) and drive rod (1) into position by installing either a hex nut or a jacknut (90). Apply thread locking adhesive (e.g., Loctite) to thread(s) of hex nut or jackscrews.

  a. If using a hex nut, be sure to fix the drive rod by clamping the flat surface at its bottom securely with some mechanical means. Torque per specifications listed in Table 2. Specification of Piston Hex Nut Tightening Torque.

Table 2. Specification of Piston Hex Nut Tightening Torque

Heavy 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. If using a jacknut, install nut hand tight. Then install jackscrews in a diagonal pattern and torque per specifications listed in Table 3. Specification of Jackscrew in Jacknut Tightening Torque.

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

- When installing the cylinder (17), grease (with recommended grease/lubricant) the cylinder internal surface prior to install 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).
- When installing the end cap (8), make sure to install the gasket beforehand, apply grease to the gasket to aid in maintaining the gasket position while lowering the end cap (8) to position. Make sure gasket is seated properly on the cylinder during the installation of stay rods .
- Apply anti-seize compound on the threads of stay rod (23) detached. Install stay rods (23) into 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

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

- Apply anti-seize to threads and install swivel connector assembly (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 farther. Secure connector body with hex socket setscrews (97).
- Refer to SECTION 8. (OPERATOR END STOP ADJUSTMENT) for operator stop adjustment (if needed) and verify operator travel and valve stem engagement refer to SECTION 5.2 (Preinstallation Verification).

NOTE:

Apply anti-seize and thread stem nut onto valve stem to "MARK B" (made in SECTION 5.2 Preinstallation Verification).

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**" (outlined in disassembly) aligns with the bottom of the cylinder plate (4) and;

b. Verify that "**MARK B**" aligns with the top of the pedestal plate.

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) and end stop cap (33). Monitor for leaks at a minimum of 10 [minutes]. A leak at the gaskets (46) may indicate that stay rod nuts (91) must be retightened (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 preinstallation verification (SECTION 5.2) indicate MOT is larger than MVT.

Typically, valve with operator should have its travel limited by operator stops in order to avoid/prevent any damage to the valve; preference is MVT is 1/8 inch more than MOT. Refer to 8.1 End Stop Adjustment Conditions if adjustment is needed.

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 5.2 (Preinstallation 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, there is potential leakage due to under travel of valve.

8.1 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 per SECTION 6. INSTALLATION, adjusting the stem nut as directed.
2. Applying power gas slowly through 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 loose 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. Jog the operator to slightly extend the drive rod (1), moving it away from the end stop (32).
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. Apply and hold the power gas 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) to lock-in the travel adjustment.
10. Remove the existing "**MARK #4**". Mark on the drive rod (1) where 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, 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 per SECTION 6. INSTALLATION, adjusting the stem nut as directed.
2. If the drive rod (1) is fully retracted, MAKE SURE to pressurize the end cap (8) side of the operator to allow the piston rod 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, unscrew it from the end cap (8) two to four turns.
5. Applying power gas 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. Jog the operator to slightly extend the drive rod (1), moving it away from the end stop (32).
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.

Section 9: Testing and Troubleshooting

9.1 Testing

System operation should be tested at regular intervals and performance noted to catch any problems early. Use the following section to trace the source of problems before proceeding to a major operator overhaul, since 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 is mainly focused on the most common symptoms and their possible solution for operator only, 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 due to leakage. Please contact manufacturer for more detailed information regarding to your requirements.

1. NO MOVEMENT, SLOW, JERKY OR PARTIAL STROKE?
   - Check for sufficient supply pressure and flow, that is, check upstream accessories, such as filter, to ensure filter element is not blocked.
   - 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 that manual override (if applicable) has not been left in locked position and is interfering. Ensure that it has been fully disengaged to allow movement of the operator.

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

2. CHECK FOR EXTERNAL LEAKAGE

NOTE:
The assumption below is control components and all joining fittings have been verified and confirmed that the symptoms (leakage) are not caused by control components and all joining fittings. The purpose of suggestions below is to identify is there any external leakage from the operator and the location of leakage. Usually, soapy water is 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.
  - If leakage is detected around the cylinder ends, verify torque on stay rod (nuts), tighten if necessary on nuts to see if leakage stopped. If leakage continues, the gaskets at cylinder ends need be replaced.

NOTE:

Please refer to Table 4. Specification of Stay Rod Nut Tightening Torque to identify the maximum recommended torque.

  - If leakage is around the end stop or manual override (if applicable), tighten the lock nuts or end stop cover to see if leakage stops. If leakage continues, the seal needs to be replaced.
  - If leakage is around the drive rod, cycle the operator a couple of times, to see if leakage has stopped. If leakage continues, the seal is likely damaged and needs to be replaced.

NOTE:

If the external leakage is not found and the problem persists, please continue section below to check the internal leakage.

3. CHECK FOR INTERNAL LEAKAGE (BLOW-BY)

- With pressure applied to one side of the operator, check for leakage (blow-by) from supply port of the opposite side.
  - If leakage is found and the operator has not been operated or stroked for a long period of time, some leakage past piston seals may be observed. Operating the operator a few times should cause the O-ring to regain their resiliency and eliminate the problem.
  - If leakage persists, then the seals need to be replaced accordingly.

NOTE:

If the problem persists, please continue to the section below.

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4. VALVE LEAKAGE OR UNABLE TO CLOSE COMPLETELY

- If leakage is through line valve itself (the valve can't be closed completely), check the 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 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

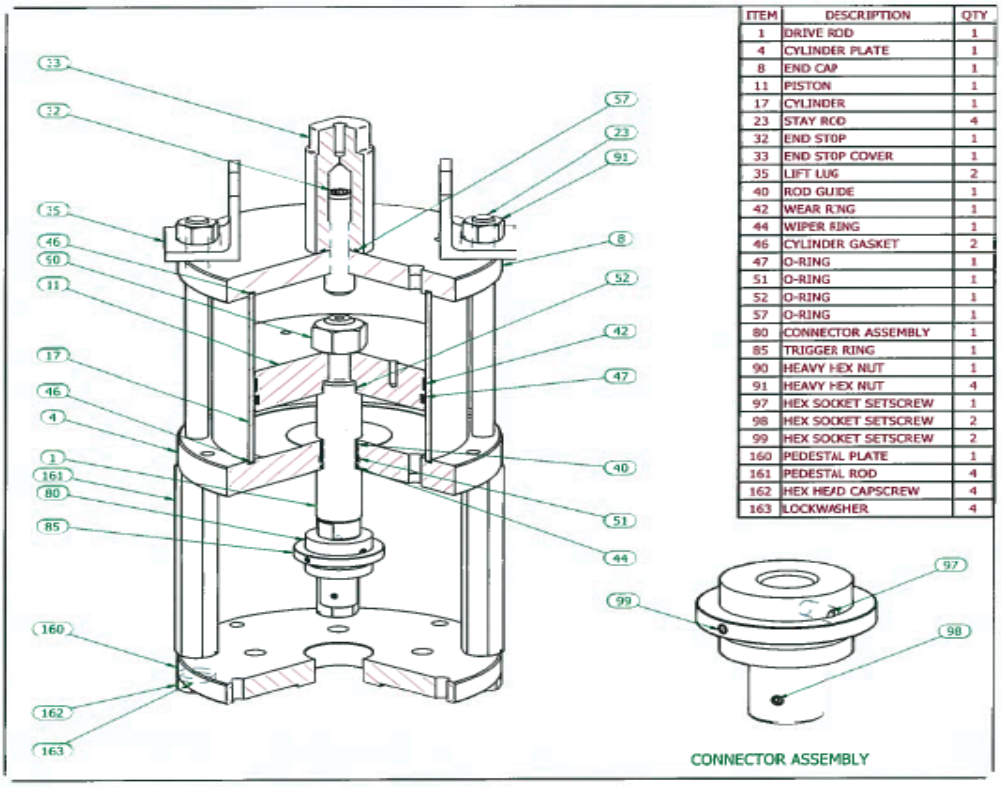
Table 5. Revision Overview

ECN	DATE	REV		BY *	DATE
Released	September 2013	A	COMPILED	C. Rico	September 2013
Reviewed			CHECKED	P. Lok	September 2013
Approved			APPROVED	P. Lok	September 2013

Appendix A: List of Tables

Appendix B: List of Figures

Figure 7 GVO-LP-DA with Open Pedestal



An assembly drawing of Bettis™ GVO Series Pneumatic Double Acting (DA) Valve Operator is shown above.

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