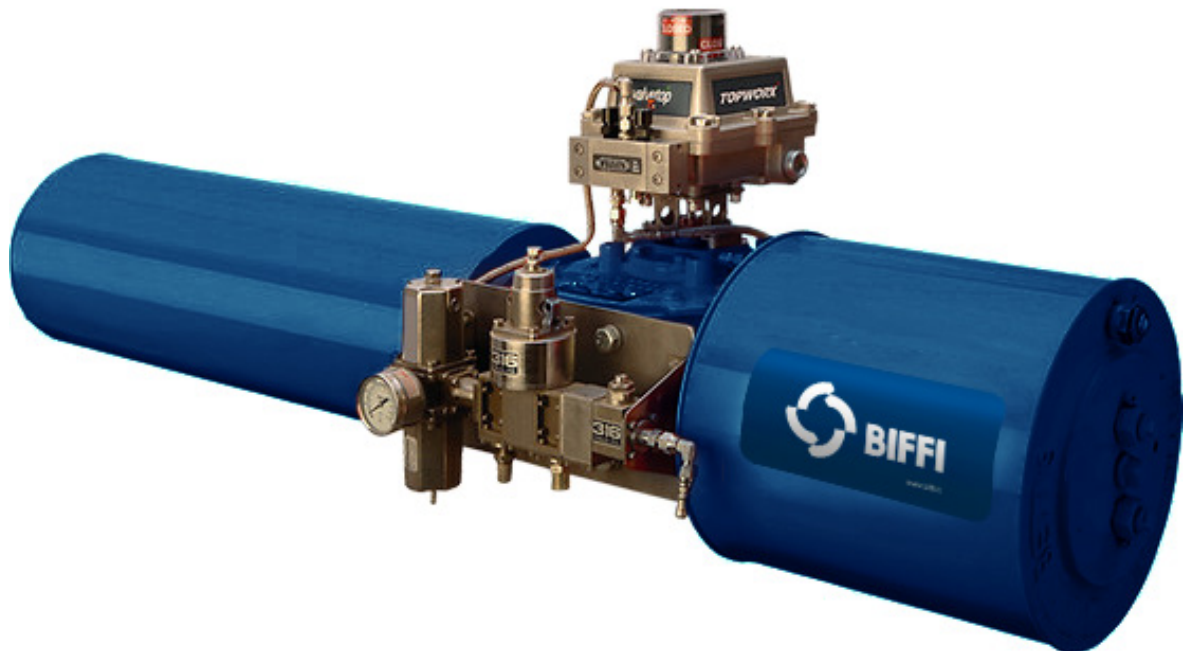


Biffi FG01 Through FG10

Spring-Return Pneumatic Actuators With M18 Hydraulic Override



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Section 1: Introduction

1.1 General Service Information

- This service procedure is offered as a guide to enable general maintenance to be performed on Biffi™ FG01XXX-SR, FG2XXX SR, FG3XXX SR, FG4XXX SR, FG5XXX SR, FG7XXX SR, FG8XXX SR and FG10XXX SR Spring-Return Series Single Pneumatic Power Module Actuators with M18 Hydraulic Override Module.
- Normal recommended service interval for this actuator series is five years.

NOTE:

Storage time is counted as part of the service interval.

- This procedure is applicable with the understanding that all electrical power and pneumatic pressure has been removed from the actuator.
- Remove all piping and mounted accessories that will interfere with the module(s) that are to be worked on.
- This procedure should only be implemented by a technically competent technician who should take care to observe good workmanship practices.
- Numbers in parentheses (), indicate the bubble number (reference number) used on the Biffi Assembly Drawing and Actuator Parts List.
- This procedure is written using the stop screw side of the housing (1-10) as a reference and this side will be considered the front side of the actuator. The housing cover (1-20) will be the top of the actuator.
- Actuator module weights are listed in Section 6, Table 12.
- When removing seals from seal grooves, use a commercial seal removing tool or a small screwdriver with sharp corners rounded off.
- Use a non-hardening thread sealant on all pipe threads.

CAUTION

Apply the thread sealant per the manufacturer's instructions.

- Biffi recommends that disassembly of the actuator components should be done in a clean area on a workbench.

1.2 Definitions

WARNING

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

CAUTION

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

NOTE:

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

1.3 General Safety Information

Products supplied by Biffi, in its “as shipped” condition, are intrinsically safe if the instructions contained within this Service Instruction are strictly adhered to and executed by well-trained, equipped, prepared and competent personnel.

WARNING

For the protection of personnel working on Biffi actuators, this procedure should be reviewed and implemented for safe disassembly and reassembly. Close attention should be given to the WARNINGS, CAUTIONS and NOTES from this procedure.

WARNING

This procedure should not supersede or replace any customer's plant safety or work procedures. If a conflict arises between this procedure and the customer's procedures, the differences should be resolved in writing between an authorized customer's representative and an authorized Biffi representative.

1.4 Biffi Reference Materials

- Assembly Drawing for FG2-SR-M18 through FG5-SR-M18 model actuators with one Pneumatic Power Module and one Spring Module with M18 Hydraulic Override Module: use Part Number 121410.
- Assembly Drawing for FG7-SR-M18 through FG10-SR-M18 model actuators with one Pneumatic Power Module and one Spring Module with M18 Hydraulic Override Module: use Part Number 121411.
- M18 Manual Hydraulic Override System VCIOM-17281-EN, VA-DC-000-1879 with M18 Assembly Drawing Part Number VA-ED-005-1120.
- Assembly Drawing for FG1/2/3/4/5-SRX-H Hydraulic: use Part Number 122588.
- Assembly Drawing for FG Drive Module: use Part Number 138334.

1.5 Service Support Items

- Biffi module service kits
- For rod extension retainer nut tool part number, refer to Table 1.

NOTE:

These tools are required only when extension rod assembly (1-50) or (9-50) is removed or when a new extension rod assembly is installed.

Table 1. FG-Series Models

Actuator Model	Biffi Part Number
FG01	None required
FG2	123616
FG3/FG4	117370
FG5/FG7	117369
FG8/FG10	117368

- Commercial leak testing solution
- Non-hardening thread sealant

1.6 Operating Media

- Recommended to use clean, dry air or inert gas.
- Other gases may be used with direction from Biffi Engineering to evaluate any possible restrictions or modifications which may need to be made for compatibility.

1.7 Lubrication and Fluid Requirements

NOTE:

Lubricants and fluids, other than listed in step 1.7.1 and 1.7.2 should not be used without prior written approval of Biffi Product Engineering.

1.7.1 Lubricants:

All temperature services -20 to 350 °F / -29 to 176 °C use ESL-5 lubricant. ESL-5 lubricant is contained in the module service kit in tubes or cans and they are marked ESL-5 and 10 lubricant. For low temperature service -40 to 150 °F / -40 to 66 °C, use ESL-15 lubricant. ESL-15 lubricant is contained in low temperature Biffi module service kits in tubes or cans and they are marked ESL-15 lubricant.

1.7.2 Fluids:

M18 Manual Hydraulic Override System Fluid Requirements: Standard and high temperature service -20 to 350 °F / -29 to 176 °C use Shell® Tellus T-32 Automatic Transmission Fluid. For low temperature service -40 to 150 °F / -40 to 66 °C, use Univis® J13 or HVI 13 Hydraulic Fluid.

1.8 General Tool Information

Tools: All tools/Hexagons are American Standard inch.

Large adjustable wrench, two (2) large screwdrivers, Allen wrench set, set of open/box-end wrenches, rubber or leather mallet, torque wrench (up to 1200 lb-ft / 1627 Nm), breaker bar, small drift punch and a drive socket set. For recommended tool and wrench sizes refer to Section 6, Tables 6.3 through 6.10.

1.9 Actuator Storage

For applications where the actuator is not placed into immediate service, it is recommended that the actuator be cycled with regulated clean/dry pneumatic pressure at least once per month. Indoor storage, if available, is recommended for all actuators. Care should be taken to plug all open ports on actuator and controls to keep out foreign particles and moisture. Actuators should not be stored in an atmosphere that is harmful to resilient seals. Contact factory for extended storage period.

1.10 Actuator Installation

Since there are many valve and actuator combinations, it is not practical to include detailed instructions for each type. Mountings are designed to be as simple as possible to keep the guess work out of the installation.

Actuators are shipped from the factory with the travel stops adjusted for approximately 90° rotation. Generally, it is necessary to make slight travel stop adjustments once the actuator is installed onto the valve. Refer to the valve manufacturer's recommendations for specific requirements. When the valve has internal stops, the actuator should be adjusted at the same points.

NOTE:

The actual "stopping" should be done by the actuator. If the valve does not have internal stops, adjust the actuator to the full open position. Using this as a reference point, rotate the valve closed and adjust to the valve manufacturer's specifications for total rotation.

Good instrument practices are also recommended. Clean/dry regulated pneumatic pressure is essential for long service life and satisfactory operation. It should be noted that new pneumatic lines often have scale and other debris in them and these lines should be purged of all foreign material.

NOTE:

Scale and debris can damage control valves, solenoids and seals.

1.11 Actuator Start-Up

1.11.1 Prestart-up checks

1. Inspect to ensure the unit has been mounted onto valve properly. Gear flange mounting bolts, stem key, set screw(s) are installed and secured.
2. No tubing damaged or accessories dislodged during the shipping or the installation.
3. Indicated position confirms valve position.
4. All switching valves in normal operating position as per schematic/instructions.

1.11.2 Check connections

1. Pneumatic/hydraulic components connected as per schematic enclosed or in-service manual supplied.
2. Pneumatic supply connected to the identified ports.
3. Electrical connection terminals are secured.
4. Wiring as per enclosed diagram or service manual supplied.

NOTE:

When actuator is first placed into service, it should be cycled with regulated pneumatic pressure. This is necessary because the seals have been stationary causing them to take a "set". Therefore, the actuator should be operated through several cycles to exercise the seals to achieve a service ready condition.

1.11.3 Speed of operation

The actuator's speed of operation is determined by several factors, including:

1. Power supply line length
2. Power supply line size
3. Power supply line pressure
4. Control valve and fitting orifice size
5. Torque requirements of the valve
6. Size of the actuator
7. Setting of speed controls
8. Hydraulic Manual Override (where available)

Due to the interaction of these variables, it is difficult to specify a "normal" operating time. Faster operating time may be obtained by using one or more of the following:

1. Larger supply lines
2. Larger control valve
3. Higher supply pressure *
4. Quick exhaust valves

NOTE: * Not to exceed maximum operating pressure of actuator or control components.

Slower operating time may be obtained by using flow control valves to meter the exhaust. Excessive exhaust flow metering may cause erratic operation.

1.12 Actuator Operation

1.12.1 Controlled operation

Controlled operation is accomplished by pressurizing and/or depressurizing the appropriate cylinder inlet(s) of a double-acting. Do not exceed pressures indicated on actuator nameplate.

1.12.2 Manual operation

All pressure must be vented or equalized on both sides of the pneumatic piston prior to manual operation.

Section 2: Actuator Disassembly

2.1 General Disassembly

WARNING

It is possible that the actuator may contain a dangerous gas and/or liquid. Ensure that all proper measures have been taken to prevent exposure or release of these types of contaminants before commencing any work.

- 2.1.1** Section 2 - Actuator Disassembly is written to either completely disassemble the entire actuator or can be used to disassemble individual modules as needed (pneumatic power module or drive module).

WARNING

Do not remove compressed module. Do not remove spring module while spring is compressed.

- 2.1.2** When the spring module is to be removed, it should be removed from the drive module prior to the pneumatic power module removal or disassembly.
- 2.1.3** The pneumatic power module can be disassembled while still attached to the drive module or the pneumatic power module can be removed from the drive module and disassembled separate to the actuator (refer to Section 5, Module Removal and Installation).
- 2.1.4** To ensure correct reassembly — that is, with pneumatic power module or spring module on same end of drive module as was prior to disassembly — mark or tag right (or left) and mark mating surfaces.
- 2.1.5** For spring module removal and installation, refer to Section 5, steps 5.3 and 5.4.

NOTE:

Use a means of capturing the hydraulic fluid that will be lost during the removal or disassembly of the override power module. Use a bucket, tub or large container, etc.

2.2 Pneumatic Power Module Disassembly

NOTE:

Review Section 2, steps 2.1.1 through 2.1.5 General Disassembly before proceeding with Pneumatic Power Module Disassembly. Refer to Assembly Drawing Part Numbers 121410 or 121411 in Appendix B for details.

WARNING

If not already removed, disconnect all operating pressure from actuator power cylinders.

WARNING

The spring cartridge must be checked to verify that the spring(s) are in their extended position before the pneumatic power module is disassembled from the drive module (refer to Section 5.3, steps 5.3.7 through 5.3.9).

- 2.2.1** Mark and record location of the ports on outer end cap (3-80) and inner end cap (3-10).
- 2.2.2** If actuator is equipped with a power module mounted extended stop (ES) then rotate the ES until clear of the piston rod (3-40).
- 2.2.3** Remove breather assembly (12) from outer end cap (3-80).
- 2.2.4** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "E" in Appendix B. Remove two socket cap screws (3-130), with lock washer (3-140), from outer end cap (3-80).
- 2.2.5** Remove two tie bar hex nuts (3-90) from outboard side of outer end cap (3-80).
- 2.2.6** The fit between cylinder (3-70) and outer end cap (3-80) is very tight. Break end cap free by tapping with a breaker bar on lip provided on the end cap. Remove outer end cap (3-80) from cylinder (3-70).

CAUTION

Do not damage O-ring groove when removing end cap from cylinder.

NOTE:

When removing cylinder (3-70) off piston (3-30), tilt the cylinder 15 to 30° with respect to actuator centerline.

- 2.2.7** Remove cylinder (3-70) from inner end cap (3-10).

⚠ CAUTION

Do not use pipe wrench to remove tie bars.

2.2.8 Tie bar removal:

2.2.8.1 Remove tie bars (3-20) as follows:

NOTE:

FG01, FG2, FG3 and FG4 models have flats on outboard end of tie bars (3-20) for wrench placement. FG5 through FG13 models have a female square on the outboard end of tie bars (3-20) for wrench placement.

2.2.8.2 Unscrew and remove tie bars (3-20) from inner end cap (3-10) and piston (3-30).

2.2.9 Remove piston as follows: (On early FG2 and FG3 models equipped with outboard and inboard tie bar nuts, skip this step and go to step 2.2.10).

2.2.9.1 Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "D" in Appendix B. Remove two split ring halves (3-50) and one retainer ring (3-60) from outboard side of piston (3-30).

NOTE:

Piston (3-30) acts as the retainer for inboard split ring halves (3-50). When removing the piston, be careful to not lose inboard split ring halves (3-50).

2.2.9.2 Remove piston (3-30) and two split ring halves (3-50) from piston rod (3-40).

NOTE:

Step 2.2.10 is used only on early FG2 and FG3 models equipped with outboard and inboard tie bar nuts.

2.2.10 Remove early model FG2 and FG3 pistons as follows:

2.2.10.1 Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "D" in Appendix B. Remove two split ring halves (3-50) and one retainer ring (3-60) from inboard side of piston (3-30).

NOTE:

Piston (3-30) acts as the retainer for outboard split ring halves (3-50).

2.2.10.2 Slide piston (3-30) toward the inner end cap (3-10) until the outboard split ring halves are exposed enough for removal. Remove outboard split ring halves from piston rod (3-40).

2.2.10.3 Remove piston (3-30) and two split ring halves (3-50) from piston rod (3-40).

2.2.11 Remove O-ring seal (4-70) from piston rod (3-40).

2.2.12 Remove hex cap screws (3-100) with lock washers (3-110) from housing (1-10).

2.2.13 Remove inner end cap (3-10) off piston rod (3-40).

NOTE:

On early model FG2 and FG3 actuators, remove two hex nuts (3-90) from housing (1-10). These two nuts will be loose after tie bars (3-20) are removed in step 2.2.8.1 and will be in the area where the piston rod passes through the housing (1-10).

NOTE:

The piston rod (3-40) removal as outlined in step 2.2.14 is only required when the piston rod is being replaced or when the drive module is to be disassembled.

2.2.14 Unscrew and remove piston rod (3-40) from drive module.

2.3 Drive Module Disassembly

NOTE:

Review Section 2, steps 2.1.1 through 2.1.5 General Disassembly before proceeding with Drive Module Disassembly. Refer to Part Number VA138334, FG Drive Module Assembly Drawing.

2.3.1 If not already removed remove piston rod (3-40) from drive module.

2.3.2 Mark stop screws (1-180) left and right. The setting of stop screws (1-180) should be checked and setting recorded before stop screws are loosened or removed.

NOTE:

Stop screws will be removed later in this procedure.

NOTE:

For steps 2.3.3 through 2.3.10, refer to Assembly Drawings Part Number 121410 sheet 2 of 2 Section A-A and Part Number 121411 Detail "F" in Appendix B.

- 2.3.3** Before removing position indicator (1-220), record or mark its position. Remove position indicator (1-220).
-

NOTE:

Step 2.3.4 is used only on FG01, FG2 and FG3 drive modules. Drive modules FG4 through FG10 will skip step 2.3.4 and continue with step 2.3.5.

- 2.3.4** Remove one vent check assembly (13) from top of housing cover (1-20).
- 2.3.5** Unscrew and remove hex cap screws (1-160) with lock washers (1-170) from yoke cover (1-150).
- 2.3.6** Remove yoke cover (1-150) from housing cover (1-20).
- 2.3.7** Mark and record the orientation of the position indicator assembly (1-140) in relation to the top of yoke (1-70).
- 2.3.8** Remove position indicator assembly (1-140) from top of yoke (1-70).
- 2.3.9** Remove spring pin (1-100) from top of yoke (1-70).
- 2.3.10** Remove hex cap screws (1-110), with lock washers (1-115) from housing cover (1-20).
-

NOTE:

Steps 2.3.11 and 2.3.12 are used only on FG7, FG8 and FG10 drive modules. Drive modules FG01, FG2, FG3, FG4 and FG5 will skip steps 2.3.11 and 2.3.12 and continue with step 2.3.13.

- 2.3.11** Remove hex cap screws (1-120) with lock washers (1-115) from housing cover (1-20).
- 2.3.12** Using hex cap screws (1-110), install into holes vacated by hex cap screws (1-120). Use these hex cap screws to jack the housing cover up for removal. Alternately, rotate the hex cap screws clockwise until housing cover (1-20) is clear of housing (1-10).
-

NOTE:

FG01, FG2, FG3 and FG4 model housing cover will have cast tabs for placing prying tools to aid in cover removal.

- 2.3.13** Remove housing cover (1-20) from housing (1-10).

NOTE:

Groove pins (1-130) will remain in housing cover (1-20) when housing cover is removed from housing (1-10). Groove pins (1-130) should not be removed from housing cover (1-20) unless they are damaged and require new replacements.

- 2.3.14** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "B" in Appendix B. Remove guide bar (1-90) from housing (1-10).
 - 2.3.15** Remove top yoke pin thrust bearing (2-10) from top of yoke pin (1-80).
 - 2.3.16** Rotate the arms of yoke (1-70) to the center position of housing (1-10).
 - 2.3.17** Remove yoke (1-70) with yoke pin (1-80), guide block (1-30), two yoke/guide block bushings (2-30) by lifting yoke up and out of the housing (1-10).
 - 2.3.18** Remove bottom yoke pin thrust bearing (2-10) from inside bottom of housing (1-10).
 - 2.3.19** Remove yoke pin (1-80) by inserting 3/8 in.-16 UNC screw into top of the yoke pin and pull straight up and out.
 - 2.3.20** Remove guide block (1-30) from between the arms of yoke (1-70).
 - 2.3.21** Remove yoke/guide block bushing (2-30) from the top of guide block (1-30).
 - 2.3.22** Remove yoke/guide block bushing (2-30) from the top of the lower yoke arm of yoke (1-70).
-

NOTE:

FG01 model actuators skip steps 2.3.23 through 2.3.25 and continue disassembly at step 2.3.26.

- 2.3.23** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "B" in Appendix B. Use Biffi tool part numbers 117368 (FG8/FG10), 117369 (FG5/FG7), 117370 (FG3/FG4) or 123616 (FG2) and remove retention retainer nut assemblies (1-60) and (9-60) from guide block (1-30).
 - 2.3.24** Remove rod extension assemblies (1-50) and (9-50) from guide block (1-30).
-

NOTE:

Spherical washers (1-40) and (9-40) will be removed from guide block (1-30) when the extension rod assemblies are removed.

- 2.3.25** Remove the remaining spherical washers (1-40) and (9-40) from guide block (1-30).
- 2.3.26** Unscrew and remove two stop screw nuts (1-190) from stop screws (1-180).
- 2.3.27** Unscrew and remove two stop screws (1-180) from front of housing (1-10).

- 2.3.28** Housing (1-10) vent check assembly removal as follows:
- 2.3.28.1** FG01, FG2 and FG3 housing (1-10) unscrew and remove one vent check assembly (13) from the front of housing (1-10).
 - 2.3.28.2** FG4 through FG10 housing (1-10) unscrew and remove two vent check assemblies (13) from the front of housing (1-10).
- 2.3.29** The following items do not need to be removed from their assembled locations unless being replaced by new items: Two guide bar bearings, two yoke bearings (2-40), yoke pin bearing, yoke pin thrust bearing (2-10) and spring pin (1-100).

2.4 FG01 Through FG5 M18 Hydraulic Override Cylinder Disassembly

NOTE:

For M18 Hydraulic Override Cylinder removal from spring cartridge, refer to Section 5, step 5.1. Refer to Part Number VA122588, FG1/2/3/4/5-SRX-H Hydraulic Assembly Drawing.

- 2.4.1** Unscrew hydraulic ram cover (7-10) from hydraulic override end cap (7-70).
- 2.4.2** Remove hydraulic ram (7-20) from hydraulic ram cover (7-10).

2.5 FG7 Through FG10 M18 Hydraulic Override Cylinder Disassembly

NOTE:

For M18 Hydraulic Override Cylinder removal from spring cartridge refer to Section 5, step 5.1. Refer to Assembly Drawing Part Number 121411 in Appendix B for details.

- 2.5.1** Unscrew and remove hex cap screws (7-80) with lock washers (7-90) from outer end cap (7-70).
- 2.5.2** Remove outer end cap (7-70) from hydraulic cylinder assembly (7-10).
- 2.5.3** Remove piston rod (7-20) from hydraulic cylinder assembly (7-10).
- 2.5.4** Refer to Assembly Drawing Part Number 121411 sheet 1 of 2 Detail "G" in Appendix B. Remove two split ring halves (7-30) and one retainer ring (7-40) from one side of piston (7-50).
- 2.5.5** Refer to Assembly Drawing Part Number 121411 sheet 1 of 2 Detail "G" in Appendix B. Remove two split ring halves (7-30) and one retainer ring (7-40) from the other side of piston (7-50).
- 2.5.6** Remove piston (7-50) from piston rod (7-20).
- 2.5.7** Remove vent tube (7-60) from the hydraulic cylinder assembly.
- 2.5.8** Pipe plug (7-110) does not require removal for routine service.
- 2.5.9** Pipe plug (7-120) does not require removal for routine service.

2.6 M18 Pump Disassembly

NOTE:

Refer to Assembly Drawing Part Number VA-ED-005-1120 in Appendix B for details.

⚠ WARNING

If not already removed, disconnect all operating pressure from actuator power cylinder.

- 2.6.1** Place the M18 pump control knob (25-200) in the auto position. Use drawing Part Number VA-ED-005-1120 in Appendix B for this section.
-

NOTE:

Control knob (25-200) is in front and at the bottom of the M18 pump manifold (20-10-10). Use a means of capturing the hydraulic fluid that will be lost during the following steps. Use a bucket, tub or large container, etc.

- 2.6.2** Remove all the piping from the M18 override manifold (20-10-10) to the actuator and reservoir (10).
- 2.6.3** Remove mounting bracket (30-90) from the actuator.
- 2.6.4** Remove all counter-sunk cap screws (30-100) from the mounting bracket (30-90).
- 2.6.5** Remove acorn nut (25-450), lock washer (25-460), control knob (25-200) and control pointer (25-150) from the M18 override.
- 2.6.6** Remove socket cap screws (25-240) from the cover (25-140).
-

NOTE:

Note the bottom two access holes to reach socket cap screws are blocked by instruction tag (25-220) and will need to be removed and replaced (new instruction tag is provided in service kit).

- 2.6.7** Pull out quick release pin (20-10-110) from the pump handle lever (20-10-90).
- 2.6.8** Remove socket head cap screws (20-10-100) from the back brace (20-10-130).
- 2.6.9** Remove pipe plug (20-10-210), spring (20-10-360) and ball (20-10-350). If the back plate (20-10-320) is not coming out, use soft mallet to gently tap the open end of stem, control valve (20-10-280) in order to remove the back plate assembly and stem assembly.

NOTE:

The piston, control valve (20-10-310) is under spring tension and it will eventually pop out, user beware and find means to capture the piston (20-10-310), spring (20-10-390), washer bearing (20-10-380) and thrust bearing (20-10-370).

- 2.6.10** Remove flat head screw (20-10-330) from the manifold (20-10-10).
- 2.6.11** Remove disc, control valve (20-10-290) from the manifold (20-10-10).
- 2.6.12** Remove seal O-ring (20-20-40) from the manifold (20-10-10).
- 2.6.13** Remove seal O-ring (20-20-90) and backup ring (20-20-100) from back plate, control valve (20-10-320).
- 2.6.14** Remove seal O-ring (20-20-110) and backup ring (20-20-120) from piston, control valve (20-10-310).
- 2.6.15** Remove seal O-ring (20-20-40) and backup ring (20-20-50) from stem, control valve (20-10-280).
- 2.6.16** Remove pump rod (20-10-50) from pump cylinder (20-10-20).
- 2.6.17** Remove rod wiper (20-20-20), rod bushing (20-20-30) and PolyPak® seal (20-20-10) from the pump cylinder (20-10-20) bore.
- 2.6.18** Remove retainer ring (20-10-80) from manifold (20-10-10).
- 2.6.19** Use 1/4-20 UNC socket cap screw (20-10-240) as provided in service kit to remove the pin, cylinder (20-10-60) from the manifold (20-10-10). Remove the pump cylinder (20-10-20).
- 2.6.20** Remove seal O-ring (20-20-40) and backup ring (20-20-50) from the pin, cylinder (20-10-60).
- 2.6.21** Remove seal O-ring (20-20-60) and backup ring (20-20-70) from the pump cylinder (20-10-20).

2.7 M18 Reservoir Disassembly

- 2.7.1** Remove acorn nut (10-50), countersink washer (10-60) and thread seal (10-70) from the end cap, upper (10-10).
- 2.7.2** Remove end cap, bottom (10-40) by tapping from the open end of center bar (10-30).
- 2.7.3** Remove seal O-ring (10-100) from the end cap, bottom (10-40).
- 2.7.4** Remove end cap, upper (10-10) from the reservoir cylinder (10-20).
- 2.7.5** Remove seal O-ring (10-100) from the end cap, upper (10-10).

Section 3: Actuator Reassembly

3.1 General Reassembly

⚠ CAUTION

Only new seals, which are still within the seal's expectant shelf life, should be installed into the actuator being refurbished.

- 3.1.1** Remove and discard all old seals.
- 3.1.2** All parts should be cleaned to remove all dirt and other foreign material prior to inspection.
- 3.1.3** All parts should be thoroughly inspected for excessive wear, stress cracking, galling and pitting. Attention should be directed to threads, sealing surfaces and areas that will be subjected to sliding or rotating motion. Sealing surfaces of the cylinder, tie bars and piston rod must be free of deep scratches, pitting, corrosion and blistering or flaking coating.

⚠ CAUTION

Actuator parts that reflect any of the above listed characteristics should be replaced with new parts.

- 3.1.4** Before installation, coat all moving parts with a complete film of lubricant. Coat all seals with a complete film of lubricant before installing into seal grooves.

NOTE:

The parts and seals used in the actuator will be assembled using lubricant as identified in Section 1, step 1.7.1.

- 3.1.5** For spring module installation, refer to Section 5, step 5.4.

3.2 Drive Module Reassembly

NOTE:

Review Section 3.1, General Reassembly before proceeding with Drive Module Reassembly.

NOTE:

Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "B" in Appendix B for section drawing of guide block.

- 3.2.1** If guide bar bearings are being replaced, install new bearings into guide block (1-30).
-

NOTE:

The guide bar bearing must be pressed fit into guide block guide bar bore with the seam located $45^\circ \pm 5^\circ$ of the top or bottom centerline as shown in Assembly Drawing Part Number 121410 sheet 2 of 2 Section A-A in Appendix B.

NOTE:

FG01 model actuators skip steps 3.2.2 through 3.2.13 and continue reassembly at step 3.2.14.

- 3.2.2** Lubricate guide block (1-30), two spherical washers (1-40) and one extension rod assembly (1-50).

- 3.2.3** Install one spherical washer (1-40) into the side of guide block (1-30).3
-

NOTE:

The spherical side of washer (1-40) will be facing to the outside of guide block (1-30).

- 3.2.4** Install second spherical washer (1-40) over threaded end of extension rod assembly (1-50).
-

NOTE:

The spherical side of the washer will go on the extension rod assembly facing the head of the extension rod assembly.

-
- 3.2.5** Install extension rod assembly (1-50) into guide block (1-30) and up against the first spherical washer (1-40).
 - 3.2.6** Install extension retainer nut (1-60) over extension rod assembly (1-50) and screw into guide block (1-30).
 - 3.2.7** Tighten extension retainer nut assembly (1-60) until extension rod assembly (1-50) cannot move. Back off the extension retainer nut assembly (1-60) just enough to allow for extension rod assembly (1-50) to move freely.

NOTE:

Steps 3.2.8 through 3.2.13 are to be completed when the actuator is equipped with a spring module. If the actuator is double-acting, then skip steps 3.2.8 through 3.2.13 and continue actuator reassembly starting with step 3.2.14.

- 3.2.8** Lubricate guide block (1-30), two spherical washers (9-40) and one extension rod assembly (9-50).
- 3.2.9** Install one spherical washer (9-40) into the side of guide block (1-30).

NOTE:

The spherical side of washer (9-40) will be facing to the outside of guide block (1-30).

- 3.2.10** Install second spherical washer (9-40) over threaded end of extension rod assembly (9-50).

NOTE:

The spherical side of the washer will go on the extension rod assembly facing the head of the extension rod assembly.

- 3.2.11** Install extension rod assembly (9-50) into guide block (1-30) and up against the first spherical washer (9-40).
- 3.2.12** Install extension retainer nut (9-60) over extension rod assembly (9-50) and screw into guide block (1-30).
- 3.2.13** Tighten extension retainer nut assembly (9-60) until extension rod assembly (9-50) cannot move. Back off the extension retainer nut assembly (9-60) just enough to allow for extension rod assembly (9-50) to move freely.

NOTE:

Consult your local Biffi service center for yoke bearing, yoke pin bearing or yoke/guide block bushing installation information.

- 3.2.14** If the two yoke bearings (2-40) are being replaced, install new bearing into housing cover (1-20) and housing (1-10).
-

NOTE:

The yoke bearing (2-40) must be pressed fit into housing (1-10) and housing cover (1-20). Install the yoke bearings with the bearing seam located $45^\circ \pm 5^\circ$ from the yoke arm slot when yoke (1-70) is rotated to its full clockwise position.

- 3.2.15** If the two yoke pin thrust bearings (2-10) are being replaced install new bearing into housing cover (1-20) and housing (1-10).
- 3.2.16** Lubricate two yoke/guide block bushings (2-30) and install onto top and bottom sides of guide block (1-30).
-

NOTE:

The guide block (1-30) should be already preassembled with extension rod assembly and associated parts assembled in the guide block.

- 3.2.17** Install guide block (1-30) with yoke/guide block bushings (2-30) between arms of yoke (1-70).
- 3.2.18** Install O-ring seal (2-50) into inner diameter O-ring groove in the bottom of housing (1-10).
- 3.2.19** Coat the bearing surfaces of the yoke (1-70) with lubricant and install into housing (1-10).
- 3.2.20** Align hole in guide block (1-30) with the matching holes in the two yoke/guide block bushings (2-30) and the slots in the arms of yoke (1-70).
-

NOTE:

The yoke pin can be held in place by installing a screw into the 0.375-16 UNC tapped hole in the upper end of yoke pin (1-80).

- 3.2.21** Install yoke pin (1-80) by inserting into the upper yoke arm, upper yoke/guide block bushing, guide block, lower yoke/guide block bushing, lower yoke arm and resting on lower yoke pin thrust bearing (2-10).
- 3.2.22** Install guide bar (1-90) into either side of housing (1-10) by inserting through the housing, through guide block and then insert the guide bar into the other side of housing (1-10).

3.2.23 Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Section A-A in Appendix B. Install spring pin (1-100) into the top of yoke (1-70).

3.2.24 Install position indicator assembly (1-140) onto the top of yoke (1-70) and over spring pin (1-100).

NOTE:

Refer to Section 2, step 2.3.7 for correct installation position.

3.2.25 Install O-ring (2-50) into housing cover (1-20).

3.2.26 Install housing cover O-ring (2-60) into housing cover (1-20).

3.2.27 Install the housing cover (1-20) being careful not to damage O-ring seals (2-50) and (2-60).

3.2.28 Place lock washers (1-115) onto hex cap screws (1-110).

NOTE:

On FG7 through FG10 model actuators, apply thread adhesive LOCTITE® 242 to threads of hex cap screws (1-110). Refer to Assembly Drawing Part Number 121411 Sheet 1 of 2 Note Number 9 in Appendix B.

3.2.29 Install hex cap screws (1-110) with lock washers (1-115) through housing cover (1-20) and into housing (1-10).

NOTE:

Leave hex cap screws (1-110) finger tight - do not tighten.

NOTE:

Do this step only if groove pins (1-130) have been pulled or if the pins are being replaced. Drive groove pins (1-130) through housing cover (1-20) and into housing (1-10). The groove pins should be flush with the cover.

3.2.30 Torque tighten hex cap screws (1-110) until a final lubricated torque, as listed in Table 2 has been achieved.

Table 2. Housing Cover Screw Quantity and Torque

Model	Quantity	Torque (±5%)		Model	Quantity	Torque (±5%)	
		lb-ft	Nm			lb-ft	Nm
FG01	4	40	54	FG5	8	100	136
FG2	6	40	54	FG7	8	100	136
FG3	8	40	54	FG8	12	100	136
FG4	8	40	54	FG10	16	100	136

NOTE:

Complete step 3.2.31 on FG5 through FG10 model actuators. For FG01 through FG4 model actuators, skip step 3.2.31 and proceed to step 3.2.32.

3.2.31 On FG5 through FG10 models:

3.2.31.1 Place lock washers (1-115) onto hex cap screws (1-120).

NOTE:

Hex cap screws (1-120) are only used as “hole” fillers and to protect threads from environment.

3.2.31.2 Install and tighten hex cap screws (1-120) with lock washers (1-115).

3.2.32 Install thrust bearing (2-110) onto position indicator (1-140).

3.2.33 Install O-ring seal (2-100) onto position indicator (1-140).

3.2.34 Install upper bearing (2-120) into yoke cover (1-150).

3.2.35 Install rod wiper (2-80) into yoke cover (1-150).

3.2.36 Install O-ring seal (2-70) into yoke cover (1-150).

3.2.37 Install yoke cover (1-150) onto housing cover (1-20) and over position indicator assembly (1-140).

NOTE:

During yoke cover installation, be careful not to damage O-ring seal (2-70) and rod wiper (2-80).

3.2.38 Place lock washers (1-170) onto hex cap screws (1-160).

3.2.39 Install and tighten hex cap screws (1-160) with lock washers through yoke cover (1-150) and into housing cover (1-20).

3.2.40 Vent check assembly installation as follows:

3.2.40.1 FG01, FG2 and FG3 housing (1-10) using pipe sealant, install one vent check assembly (13) into the front of housing (1-10).

3.2.40.2 FG01, FG2 and FG3 housing (1-10) using pipe sealant, install one vent check assembly (13) into the top area of housing cover (1-20).

3.2.40.3 FG4 through FG10 housing (1-10) using pipe sealant, install two vent check assemblies (13) into the front of housing (1-10).

NOTE:

Refer to Section 2, step 2.3.3 for correct position indicator placement.

- 3.2.41** Install position indicator (1-220) over the exposed shaft of position indicator assembly (1-140).
- 3.2.42** Install stop screw nuts (1-190) onto stop screws (1-180).
- 3.2.43** Install O-ring (2-90) onto stop screws (1-180).
- 3.2.44** Install two stop screws (1-180) into two stop screw holes on the front of housing (1-10).
- 3.2.45** Adjust both stop screws (1-180) back to settings recorded earlier in Section 2 at step 2.3.2.
- 3.2.46** Tighten both stop screw nuts (1-190) securely.

3.3 Pneumatic Power Module Reassembly

NOTES:

1. For early model FG2 and FG3 actuators with double nuts on the power module, use Section 3.4 for reassembly.
2. Refer to Section 2, step 2.1.4 for the correct installation location for piston rod (3-40).
3. The actuator must be in the appropriate overtravel position. Confirm overtravel position by observing the guide block (1-30) is against the inner wall of housing (1-10).

- 3.3.1** Lubricate piston rod (3-40) and insert through the side of housing (1-10).
 - 3.3.1.1** FG2 thru FG10 screw piston rod (3-40) onto extension rod assembly (1-50).
 - 3.3.1.2** FG01 only screw piston rod (3-40) into guide block (1-30).
- 3.3.2** Torque tighten piston rod (3-40) to the lubricated torque as listed in Table 3.

Table 3. Piston Rod Torque Information

Housing Model	Torque (±5%)		Housing Model	Torque (±5%)	
	lb-ft	Nm		lb-ft	Nm
FG01	90	122	FG5	240	325
FG2	90	122	FG7	240	325
FG3	90	122	FG8	240	325
FG4	240	325	FG10	240	325

CAUTION

PolyPak seal facing piston side. Install the PolyPak seal with energizer ring facing piston side of inner end cap (3-10).

- 3.3.3** Install one O-ring seal (4-90) into seal groove located on the inboard face of inner end cap (3-10).
- 3.3.4** Install inner end cap (3-10) on to housing (1-10).

NOTE:

The pressure inlet port should be positioned in the same position as recorded in Section 2.2, step 2.2.1.

- 3.3.5** Place lock washers (3-110) onto hex cap screws (3-100).
- 3.3.6** Install hex cap screws (3-100) with lock washers through housing (1-10) and into inner end cap (3-10).
- 3.3.7** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "D" in Appendix B. Install one O-ring seal (4-70) into the seal groove in piston rod (3-40).
- 3.3.8** Apply lubricant to two sets of rod T-seal components (4-50).

NOTE:

The T-seal is composed of one rubber seal and two split skive-cut back-up rings.

- 3.3.8.1** Install two sets of rod T-seals (4-50) into the internal diameter seal grooves of piston (3-30).
- 3.3.8.2** Install a back-up ring on each side of the T-seal.
- 3.3.8.3** When installing the back-up rings, do not align the skive-cuts.
- 3.3.8.4** If the back-up rings are too long and the rings overlap beyond the skive-cuts, then the rings must be trimmed with a razor-sharp instrument.
- 3.3.9** Install two split ring halves (3-50) into the inner most groove in piston rod (3-40) and retain by installing the recessed area of piston (3-30) onto the piston rod and over the two split ring halves (3-50).
- 3.3.10** Install two split ring halves (3-50) into the piston rod, in front of the piston installed in the previous step and retain with retainer ring (3-60).

- 3.3.11** Install one O-ring seal (4-40) onto the outer diameter seal groove of inner end cap (3-10).
- 3.3.12** Coat one D-ring seal (4-60) with lubricant and install into the piston external seal groove.

NOTE:

The flat side of the D-ring seal goes down into the seal groove.

- 3.3.13** Coat two tie bars (3-20) with lubricant and install by carefully pushing tie bars through piston (3-30) and rod T-seal (4-50).
- 3.3.14** Screw tie bars (3-20) into inner end cap (3-10) and tighten until the threads bottom out.
- 3.3.15** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "E" in Appendix B. Coat two O-ring seals (4-80) with lubricant and install into outer end cap (3-80).
- 3.3.16** Apply lubricant to one O-ring seal (4-40) and install into the outer diameter O-ring groove of outer end cap (3-80).
- 3.3.17** Apply lubricant to the bore of cylinder (3-70).
- 3.3.18** Install lubricated cylinder (3-70) over piston (3-30) and onto inner end cap (3-10). When installing the cylinder over the piston seal, tilt cylinder 15 to 30° to piston rod.

⚠ CAUTION

Carefully install cylinder. If needed, when installing the cylinder, hammer on the end of the cylinder only with a non-metallic object.

- 3.3.19** Install outer end cap (3-80) over tie bars (3-20) and into cylinder (3-70).

NOTE:

The pressure inlet port should be positioned in the same position as recorded in Section 2.2, step 2.2.1.

- 3.3.20** Install tie bar nuts (3-90) onto tie bars (3-20). Torque tighten tie bar nuts, alternately in 100 lb-ft / 136 Nm increments, until a final lubricated torque, as listed in Table 4, has been achieved.

Table 4. Tie Bar Nuts

Housing Model	Torque (±5%)		Housing Model	Torque (±5%)	
	lb-ft	Nm		lb-ft	Nm
FG01	120	163	FG5	400	542
FG2	120	163	FG7	500	678
FG3	150	203	FG8	500	678
FG4	150	203	FG10	1,200	1,627

- 3.3.21** Install lock washers (3-140) onto socket cap screws (3-130).
- 3.3.22** Install and tighten socket cap screws (3-130) with lock washers (3-140) into outer end cap (3-80).
- 3.3.23** If removed using pipe dope, install pipe plug (3-120) into outer end cap (3-80).
- 3.3.24** Apply sufficient pneumatic pressure to outer end cap (3-80) pressure inlet port to move the piston to its full inboard position (next to inner end cap).
- 3.3.25** Remove pneumatic pressure from outer end cap (3-80).
- 3.3.26** Install breather assembly (12) in outer end cap (3-80).

NOTE:

Individual actuators may not have reducer bushing (14) depending on port and breather size.

3.4 FG2 and FG3 Early Model Pneumatic Power Module Reassembly

NOTE:

1. Early FG2 and FG3 pneumatic power modules were equipped with tie bars that had nuts on both ends of the tie bars (3-20) – double nuts.
2. Refer to Section 2, step 2.1.4 for the correct installation location for piston rod (3-40).
3. The actuator must be in the appropriate overtravel position. Confirm overtravel position by observing the guide block (1-30) is against the inner wall of housing (1-10).
4. Refer to Assembly Drawing Part Number 121410 in Appendix B for details.

- 3.4.1** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "C" in Appendix B. Install one rod wiper (4-10) into inner end cap (3-10).
- 3.4.2** Install one rod bushing (4-20) into inner end cap (3-10).
- 3.4.3** Coat one PolyPak seal (4-30) with lubricant and install lip first into inner end cap (3-10).

⚠ CAUTION

Install PolyPak seal correctly. Install the PolyPak seal with energizer ring facing outboard side of inner end cap (3-10).

3.4.4 Install piston rod (3-40) through inner end cap (3-10).

NOTE:

The piston rod end with retainer grooves to be on the outboard side of inner end cap (3-10).

3.4.5 Apply lubricant to two sets of rod T-seal components (4-50).

NOTE:

The T-seal is composed of one rubber seal and two split skive-cut back-up rings.

3.4.5.1 Install two sets of rod T-seals (4-50) into the internal diameter seal grooves of piston (3-30).

3.4.5.2 Install a back-up ring on each side of the T-seal.

3.4.5.3 When installing the back-up rings, do not align the skive-cuts.

3.4.5.4 If the back-up rings are too long and the rings overlap beyond the skive-cuts, then the rings must be trimmed with a razor-sharp instrument.

3.4.6 Coat one D-ring seal (4-60) with lubricant and install into the piston external seal groove.

NOTE:

The flat side of the D-ring seal goes down into the seal groove.

3.4.7 Install piston (3-30) onto piston rod (3-40).

NOTE:

The cast rib side of the piston is to be facing away from the outboard side of inner end cap (3-10) or position piston (3-30) on the piston rod so that the retainer grooves are on the outboard side of the piston.

3.4.8 Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "D" in Appendix B. Install O-ring seal (4-70) into the seal groove in the outboard end of piston rod (3-40).

3.4.9 Install two split ring halves (3-50) into the outer most groove in piston rod (3-40) and retain by installing the recessed area of piston (3-30) over the two split halves (3-50).

- 3.4.10** Install two split ring halves (3-50) into the piston rod, behind the piston and retain with retainer ring (3-60).
- 3.4.11** Coat two tie bars (3-20) with lubricant and install by carefully pushing tie bars through piston (3-30) and rod T-seal (4-50).
- 3.4.12** Install two tie bar O-ring seals (4-80) onto the inboard end of tie bars (3-20) and into the O-ring grooves provided.
- 3.4.13** Insert the tie bars through inner end cap (3-10) and screw hex nuts (3-90) onto inboard end of the tie bars.

NOTE:

Screw the tie bars through the hex nuts (3-90) until one complete thread is exposed.

- 3.4.14** Refer to Assembly Drawing Part Number 121410 sheet 2 of 2 Detail "E" in Appendix B. Install two tie bar O-ring seals (4-80) onto the outboard end of tie bars (3-20) and into the O-ring grooves provided.
- 3.4.15** Apply lubricant to one O-ring seal (4-40) and install into the outer diameter O-ring groove of outer end cap (3-80).
- 3.4.16** Apply lubricant to the bore of cylinder (3-70).
- 3.4.17** Install lubricated cylinder (3-70) over piston (3-30) and onto inner end cap (3-10). When installing the cylinder over the piston seal, tilt cylinder 15 to 30° to piston rod.

CAUTION

Carefully install cylinder. If needed, when installing the cylinder, hammer on the end of the cylinder only with a non-metallic object.

- 3.4.18** Install outer end cap (3-80) over tie bars (3-20) and into cylinder (3-70).

NOTE:

The pressure inlet port should be positioned in the same position as recorded in Section 2.2, step 2.2.1.

- 3.4.19** Install tie bar nuts (3-90) onto tie bars (3-20). Torque tighten tie bar nuts, alternately in 100 lb-ft increments, until a final lubricated torque, as listed in the following table, has been achieved.

Table 5. FG2 Tie Bar Nuts

Housing Model	Torque (±5%)		Housing Model	Torque (±5%)	
	lb-ft	Nm		lb-ft	Nm
FG2	120	163	FG3	150	203

- 3.4.20** Install lock washers (3-140) onto socket cap screws (3-130).
- 3.4.21** Install and tighten socket cap screws (3-130) with lock washers (3-140) into outer end cap (3-80).
- 3.4.22** Install pneumatic power module per Section 5, step 5.4.

3.5 FG01 Through FG5 M18 Hydraulic Override Cylinder Reassembly

NOTE:

Review Section 3.1, General Reassembly before proceeding with FG01 through FG5 M18 Hydraulic Override Cylinder Reassembly.

- 3.5.1** Install ram bushing (8-20) into hydraulic ram cover (7-10).
 - 3.5.2** Install PolyPak seal (8-30) into hydraulic ram cover (7-10).
-

NOTE:

The lip of PolyPak seal (8-30) are to face toward the hydraulic override end cap when installed in the hydraulic ram cover.

- 3.5.3** Install rod wiper (8-10) into hydraulic ram cover (7-10).
 - 3.5.4** Install hydraulic ram (7-20) into hydraulic ram cover (7-10).
-

NOTE:

When installing the hydraulic ram (7-20), push it through the hydraulic ram cover until the ram is at least flush with the outboard ram cover.

- 3.5.5** Install O-ring seal (8-35) into inner diameter seal groove located at the outboard end of the threads in the hydraulic override end cap (7-70).
 - 3.5.6** Install hydraulic ram cover (7-10) into the hydraulic override end cap (7-70) by screwing the ram cover into the end cap until the ram cover bottoms out into the end cap.
-

NOTE:

For M18 Hydraulic Override Cylinder installations, refer to Section 5, step 5.2.

3.6 FG7 Through FG10 M18 Hydraulic Override Cylinder Reassembly

NOTE:

Review Section 3 step 3.1, General Reassembly before proceeding with FG7 through FG10 M18 Hydraulic Override Cylinder Reassembly.

3.6.1 Install PolyPak seal (8-30) into hydraulic cylinder assembly (7-10).

NOTE:

The lip of PolyPak seal (8-30) will face toward the hydraulic override end cap when installed in the hydraulic cylinder assembly.

- 3.6.2** Install rod bushing (8-20) into hydraulic cylinder assembly (7-10).
 - 3.6.3** Install rod wiper (8-10) into hydraulic cylinder assembly (7-10).
 - 3.6.4** Install two split ring halves (7-30) into the inner most groove in piston rod (7-20) and retain by installing retainer ring (7-40) onto the split ring halves.
 - 3.6.5** Apply hydraulic fluid to O-ring seal (8-50) and install it into the seal groove located between the two split ring grooves on the piston rod (7-20).
 - 3.6.6** Install the piston (7-50) onto the piston rod (7-20) and up against the split rings installed in step 3.6.4.
 - 3.6.7** Install two split ring halves (7-30) into the outboard groove in piston rod (7-20) and retain by installing retainer ring (7-40) onto the split ring halves.
 - 3.6.8** Install PolyPak seal (8-60) into outer diameter seal groove of piston (7-50).
-

NOTE:

The lip of PolyPak seal (8-60) will face toward the hydraulic override outer end cap (7-70) when installed in the hydraulic cylinder assembly.

- 3.6.9** Install piston bearing (8-40) into outer diameter bearing groove of piston (7-50).
- 3.6.10** Install O-ring seal (8-80) into inner diameter seal groove located in the piston (7-50).
- 3.6.11** Use pipe dope on the threads install pipe plug (7-110) into the vent tube hole in the inboard end of the hydraulic cylinder assembly (7-10).
- 3.6.12** Install vent tube (7-60) into the hydraulic cylinder assembly inboard end.

- 3.6.13** Install the assembled piston rod (7-20) with piston (7-50) into the open end of the hydraulic cylinder assembly and install the piston over the vent tube (7-60).
- 3.6.14** Install O-ring seal (8-90) into the vent tube port located in the outer end cap (7-70).
- 3.6.15** Install O-ring seal (8-70) into the O-ring groove located on the inner diameter of the hydraulic cylinder assembly flange opening.
- 3.6.16** Install the outer end cap (7-70), assemble piston rod (7-20) with piston (7-50) onto the open end of the hydraulic cylinder assembly and over the vent tube (7-60).
- 3.6.17** Install lock washers (7-90) onto hex cap screws (7-80).
- 3.6.18** Install and tighten hex cap screws (7-80) with lock washers (7-90) through outer end cap (7-70) and into hydraulic cylinder assembly.

NOTE:

For M18 Hydraulic Override Cylinder installations, refer to Section 5, step 5.2.

3.7 Actuator Testing

- 3.7.1** Leakage Test: All areas where leakage to atmosphere may occur are to be checked, using a commercial leak testing solution.

CAUTION

Pressure applied to the actuator is not to exceed the maximum operating pressure rating listed on the actuator name tag. Test the actuator using a properly adjusted self-relieving regulator, with gauge.

- 3.7.2** Cycle the actuator five times at the Maximum Operating Pressure (MOP) as listed on the actuator's name tag or the customer's normal actuator supply pressure. If excessive leakage across the piston is noted, generally a bubble which breaks three seconds or less after starting to form, cycle the actuator five times as this will allow the seals to seek their proper service condition.

NOTE:

If excessive leakage across the piston remains, the actuator must be disassembled and the cause of leakage must be determined and corrected.

- 3.7.3** Apply MOP pressure to the pressure port in inner end cap (3-10) and allow the actuator to stabilize.

- 3.7.4** Apply a commercial leak testing solution to the following areas:
- 3.7.4.1** Joint between inner end cap (3-10) and cylinder (3-70). This checks cylinder to inner end cap O-ring seal.
 - 3.7.4.2** The port hole in the outer end cap (3-80). This checks the piston D-seal to cylinder (3-70), O-ring seal (4-70) and rod T-seal (4-50).
 - 3.7.4.3** The vent check port hole in housing. This checks Polypak seal (4-30) that seals piston rod (3-40) to inner end cap (3-10).
 - 3.7.4.4** Remove pressure from the pressure inlet port.
- 3.7.5** If an actuator was disassembled and repaired, the above leakage test must be performed again.
- 3.7.6** Shell Pressure Test – Optional pressure test could be performed on a Pressure Equipment Directive (PED) certified actuator by applying pressure to both sides of the piston simultaneously for a period of two (2) minutes. If any leakage occurs across a static seal, the unit must be disassembled and the cause of leakage must be determined and corrected.

WARNING

The actuator's main pressure bearing parts will be tested in controlled conditions in accordance with the requirement of PED by pressuring both sides of the piston to avoid damage and over torquing of the actuator components. If further future testing in the field is necessary, Biffi should be contacted for guidance.

Section 4: Field Conversions

4.1 Fail Mode Reversal (CW to CCW or CCW to CW)

- 4.1.1 Remove spring module per Section 5.3.
- 4.1.2 Remove pneumatic power module per Section 5.5.
- 4.1.3 Reinstall the spring module onto the opposite end of housing (1-10) as it was previously located per Section 5.4.
- 4.1.4 Reinstall the override cylinder assembly into spring module per Section 5.2.

4.2 Converting Double-Acting Actuator to Spring-Return With Override Cylinder Assembly

- 4.2.1 Remove Blind End Cap per steps 4.2.1.1 and 4.2.1.2.
 - 4.2.1.1 Remove hex cap screws (5-20) with spring lock washers (5-30) from blind end cap (5-10).
 - 4.2.1.2 Remove blind end cap (5-10) from end of housing (1-10).
- 4.2.2 If pneumatic power module needs to be relocated due to fail mode requirements (fail counterclockwise), use Section 5.5 for removal and Section 5.6 for installation.
- 4.2.3 Install Powr-Swivl module per Section 5.8.
- 4.2.4 Install the spring module onto the end of housing (1-10) per Section 5.4.
- 4.2.5 Install the override cylinder assembly into spring module per Section 5.2.

Section 5: Module Removal and Installation

5.1 M18 Override Cylinder Removal

- 5.1.1 Shut off and exhaust the operating media from both sides of the actuator's power cylinder.
- 5.1.2 Place the M18 pump control knob (25-200) in the auto position.

NOTE:

Control knob (25-200) is in front and at the bottom of the M18 pump manifold (20-10-10).

NOTE:

Use a means of capturing the hydraulic fluid that will be lost during the following steps. Use a bucket, tub and large container, etc.

- 5.1.3 Remove all the piping from the M18 override cylinder end cap (7-70).
- 5.1.4 M18 Hydraulic Override Cylinder removal: For models FG01 through FG5, use step 5.1.5 and for FG7 through FG10, use step 5.1.6.

WARNING

Confirm that the M18 pump control knob is in the auto position prior to completing step 5.1.5. Do not stand directly in front of the M18 Override Cylinder when completing step 5.1.5 - Stand to one side or the other.

- 5.1.5 FG01 through FG5 M18 override cylinder removal.
 - 5.1.5.1 Unscrew and remove hex cap screws (7-80) with lock washers (7-90) from override cylinder end cap (7-70).
 - 5.1.5.2 Remove override cylinder assembly from spring cartridge assembly (5-10).
- 5.1.6 FG7 through FG10 M18 override cylinder removal.

CAUTION

Do not remove hex cap screws (7-80) from M18 Override Cylinder at this time. If hex cap screws (7-80) are removed at this time, it is possible that hydraulic fluid will be dumped inside the spring cartridge.

- 5.1.6.1 Unscrew and remove hex cap screws (7-100) with lock washers (7-90) from override cylinder end cap (7-70).

NOTE:

To identify hex cap screws (7-100) from hex cap screws (7-80), hex cap screws (7-100) will be located to the left and right of SR cartridge top dead center and will then be counted as every other hex cap screw. To verify correct hex cap screws, check the following table for screw length.

Table 6. Hex Cap Screw Length

Actuator Model	Item 7-80 Length *		Item 7-100 Length *	
	in.	mm	in.	mm
FG7	2	50.8	2.75	69.85
FG8	3	76.2	4.5	114.3
FG10	3.5	88.9	5.0	127

Note:

* Refer to Assembly Drawing Part Number 121410 in Appendix B for details.

5.1.6.2 Remove override cylinder assembly from spring cartridge assembly (5-10).

5.2 M18 Override Cylinder Installation

- 5.2.1** Install O-ring seal (6-10) into the O-ring groove in the outboard end of spring cartridge assembly (5-10).
- 5.2.2** M18 Hydraulic Override Cylinder installation: For models FG01 through FG5, use step 5.2.3 and for FG7 through FG10, use step 5.2.4.
- 5.2.3** FG01 through FG5 M18 Override Cylinder installation:
 - 5.2.3.1** Insert M18 Hydraulic Override Cylinder assembly through spring cartridge outer end.
 - 5.2.3.2** Install lock washers (7-90) on to hex cap screws (7-80).
 - 5.2.3.3** Install hex cap screws (7-80) with lock washers (7-90) through hydraulic override end cap (7-70) and into outer end of spring cartridge (5-10).
- 5.2.4** FG7 through FG10 M18 Override Cylinder installation:
 - 5.2.4.1** Insert M18 Hydraulic Override Cylinder assembly into spring cartridge outer end.
 - 5.2.4.2** Install lock washers (7-90) on to eight hex cap screws (7-100).
 - 5.2.4.3** Install hex cap screws (7-100) with lock washers (7-90) through hydraulic override end cap (7-70) and into outer end of spring cartridge (5-10).

5.2.5 Torque tighten hex cap screws (7-100) and (7-80) alternately until a final lubricated torque, as listed in the following table, has been achieved.

Table 7. M18 Override Cylinder End Cap to SR Cartridge Screw Torque

Housing Model	Torque (±5%)		Housing Model	Torque (±5%)	
	lb-ft	Nm		lb-ft	Nm
FG01	16	21.68	FG5	40	54.2
FG2	16	21.68	FG7	80	108.4
FG3	16	21.68	FG8	130	176.15
FG4	40	54.2	FG10	190	257.45

5.2.6 Using pipe dope on threads, reinstall all piping between hydraulic override cylinder assembly and the M18 pump.

5.2.7 Fluid filling instructions for M18 and M18-S Hydraulic Override Systems:

5.2.7.1 To fluid fill M18 Manual Hydraulic Override System, refer to Installation, Operation and Maintenance Manual (IOM) with document number VA-DC-000-1879.

5.3 Spring Module Removal

WARNING

Check spring cartridge positioning. The spring cartridge must be checked to verify that the spring(s) are in their extended position before the spring cartridge is removed from the actuator.

NOTE:

1. When the spring module is to be removed, it should be removed from the drive module prior to the pneumatic power module removal or disassembly.
2. Review Section 2.1, General Disassembly before proceeding with spring module disassembly.
3. The setting of stop screws (1-180) should be checked and setting recorded before stop screws are loosened or removed.

- 5.3.1** Shut off and exhaust the operating media from both sides of the actuator's power cylinder.
- 5.3.2** The M18 Override Cylinder must be removed prior to spring module removal: Proceed to Section 5.1 and complete all steps 5.1.1 through 5.1.6 and then continue with step 5.3.3.
- 5.3.3** Apply pneumatic pressure to inner end cap (2-40) port "A" to compress the spring enough to move the yoke off the stop screw on the spring module side of the drive module.
- 5.3.4** Loosen the stop screw nut (1-190) located on the stop screw that is closest to or next to spring module.
- 5.3.5** Unscrew stop screw (1-180) that is closest to or next to spring module (unscrew or back out until the load is removed from the stop screw).
- 5.3.6** Remove pneumatic pressure from pressure inlet port of inner end cap (3-10).

CAUTION

Due to the weight and size of spring cartridge assembly (5-10), heavy duty support equipment will be required when removing spring cartridge assembly from the actuator housing. Refer to Section 6 for spring cartridge module weights.

- 5.3.7** The spring cartridge “pre-load” must be removed before spring cartridge assembly (5-10) is removed from housing (1-10). Refer to steps 5.3.4 through 5.3.6 for spring cartridge “pre-load” removal.
- 5.3.8** Remove breather assembly (12) from outer end cap (3-80) port “B”.

⚠ CAUTION

The maximum pressure to be applied in step 5.3.9 is 25 psig / 1.72 bar.

- 5.3.9** Apply pneumatic pressure, not to exceed the maximum as indicated in the above “CAUTION”, to the pressure inlet port “B” of outer end cap (3-80) to move the spring cartridge tension rod hex nut out of its cast hex seat.

NOTE:

If pneumatic pressure is not available to apply to the pressure inlet port “B” located in outer end cap (3-80), then remove pipe plug (3-120) or if equipped with an extended stop (ES) remove the ES. Using a long rod, go through the outer end cap pipe plug or ES vacant port hole and push on the piston rod to move the spring cartridge tension rod hex nut out of its cast hex seat.

- 5.3.10** Unscrew the spring cartridge tension rod from the drive module. The tension rod can be rotated for removal by going through the open end of spring cartridge assembly with a square male drive extension.
- 5.3.11** Remove hex cap screws (5-20) with lock washers (5-30) from housing (1-10).
- 5.3.12** Remove spring cartridge assembly (5-10) from actuator housing (1-10).

⚠ WARNING

Do not cut spring cartridge assembly. Under no circumstances should the spring cartridge assembly (5-10) be cut apart, as the spring is pre-loaded and the spring cartridge is a weld assembly.

5.4 Spring Module Installation

CAUTION

Use heavy duty support equipment. Due to the weight and size of spring module, heavy duty support equipment will be required when installing spring cartridge module to the actuator housing. For the approximate weight of the spring cartridge, refer to Section 6.

WARNING

Actuator must be in the appropriate overtravel position (see detail "A" on warning tag attached to spring module access hole cover). Confirm overtravel position by observing the guide block (1-30) is against the inner wall of housing (1-10).

NOTE:

The setting of stop screws (1-180) should be checked and setting recorded before stop screws are loosened or removed.

- 5.4.1** On stop screw (1-180) that is located on the same side of the housing as spring cartridge (5-10), loosen stop screw nut (1-190).
- 5.4.2** Unscrew or back out stop screw (1-180) to achieve overtravel as illustrated in detail "A" on the warning tag attached to the spring module cover plate.
- 5.4.3** Install O-ring seal (6-20) into the O-ring groove in the inboard end of spring cartridge assembly (5-10).
- 5.4.4** Using lifting equipment, move spring module up to housing (1-10) and align spring cartridge tension rod with extension rod assembly (9-50).

WARNING

Complete step 5.4.5 to avoid severe injury to personnel or incur major damage to the actuator.

- 5.4.5** Spring cartridge tension rod to rod extension installation as follows:
 - 5.4.5.1** Using a male square drive extension, go through the open end of spring module (5-10) and rotate the tension rod nut until initial thread engagement is achieved.

NOTE:

Confirm initial thread engagement of rod extension (9-50) to tension rod.

5.4.5.2 After confirming initial thread engagement, rotate tension rod into extension rod assembly (9-50) per the following table.

⚠ WARNING

After initial thread engagement, the tension rod must be rotated clockwise the minimum number of turns listed in Table 8.

Table 8. Minimum Turns

Actuator Model	Torque Units	FG01	FG2	FG3	FG4	FG5	FG7	FG8	FG10
Minimum number of turns	N/A	N/A	10	10	10	13	14	20	25

⚠ WARNING

When screwing piston rod into extension rod assembly (9-50), make certain that the tension rod and extension rod assembly threads do not cross-thread.

5.4.6 Torque tighten the spring cartridge tension rod as listed in the following table.

Table 9. Spring Cartridge Tension Rod Torque

Housing Model	Torque (±5%)		Housing Model	Torque (±5%)	
	lb-ft	Nm		lb-ft	Nm
FG01	50	68	FG5	240	325
FG2	90	122	FG7	240	325
FG3	90	122	FG8	240	325
FG4	240	325	FG10	240	325

- 5.4.7** Install lock washers (5-30) onto hex cap screws (5-20).
- 5.4.8** Install hex cap screws (5-20) with lock washers (5-30) through housing (1-10) and into spring cartridge assembly (5-10) and tighten.
- 5.4.9** Install O-ring seal (6-10) into the O-ring groove in the outboard end of spring cartridge assembly (5-10).
- 5.4.10** M18 Hydraulic Override Cylinder installation: For models FG2 through FG5, use step 5.4.11 and for FG7 through FG10, use step 5.4.12.
- 5.4.11** FG2 through FG5 M18 Override Cylinder installation:
 - 5.4.11.1** Insert M18 Hydraulic Override Cylinder assembly into spring cartridge outer end.
 - 5.4.11.2** Install lock washers (7-90) on to eight hex cap screws (7-80).
 - 5.4.11.3** Install eight hex cap screws (7-80) with lock washers (7-90) through end cap (7-70) and into outer end of spring cartridge (5-10).

- 5.4.12** FG7 through FG10 M18 Override Cylinder installation.
 - 5.4.12.1** Insert M18 Hydraulic Override Cylinder assembly into spring cartridge outer end.
 - 5.4.12.2** Install lock washers (7-80) on to eight hex cap screws (7-100).
 - 5.4.12.3** Install eight hex cap screws (7-100) with lock washers (7-90) through end cap (7-70) and into outer end of spring cartridge (5-10).
- 5.4.13** Torque tighten hex cap screws (7-100) and (7-80) alternately until a final lubricated torque, as listed in the following table, has been achieved.

Table 10. M18 Override Cylinder End Cap to SR Cartridge Screw Torque

Housing Model	Torque (±5%)		Housing Model	Torque (±5%)	
	lb-ft	Nm		lb-ft	Nm
FG01	16	21.68	FG5	40	54.2
FG2	16	21.68	FG7	80	108.4
FG3	16	21.68	FG8	130	176.15
FG4	40	54.2	FG10	190	257.45

- 5.4.14** Using pipe dope on threads reinstall all piping between hydraulic override cylinder assembly and the M18 pump.
- 5.4.15** Fluid filling instructions for M18 and M18-S Hydraulic Override Systems:
 - 5.4.15.1** To fill fluid in M18 Manual Hydraulic Override System, refer to instructions Part Number 126858 (Request through your local Biffi representative).
 - 5.4.15.2** To fill fluid in M18-S Manual Hydraulic Override System, refer to instructions Part Number 121960 (Request through your local Biffi representative).
- 5.4.16** If removed, install stop screw nuts (1-190) onto stop screws (1-180).
- 5.4.17** If removed, install O-ring (2-90) onto stop screws (1-180).
- 5.4.18** If removed, install two stop screws (1-180) into two stop screw holes on the front of housing (1-10).
- 5.4.19** Adjust both stop screws (1-180) back to settings recorded earlier in Section 5.
- 5.4.20** Tighten both stop screw nuts (1-190) securely.

5.5 Pneumatic Power Module Removal

CAUTION

Due to the weight and size of power module, heavy duty support equipment will be required when removing power module from the actuator housing. Refer to Section 6 for Pneumatic Power Module Weights.

- 5.5.1** Remove pipe plug (3-120) from outer end cap (3-80).
- 5.5.2** Remove hex cap screws (3-100) with lock washers (3-110) from housing (1-10).

- 5.5.3** Using a male square drive extension, go through outer end cap (3-80) and unscrew piston rod (3-40) from extension rod assembly (1-50).

NOTE:

When removing power module from housing (1-10), be careful not to lose O-ring seal (4-90).

- 5.5.4** Remove power module from actuator housing (1-10).

5.6 Pneumatic Power Module Installation

NOTE:

Reinstall the power module onto the opposite side of housing (1-10) as it was previously located.

- 5.6.1** Check to verify that O-ring seal (4-90) is properly seated in its seal groove located on the housing side of inner end cap (3-10).

NOTE:

FG2 and FG3 models confirm that the two inboard hex nuts (3-90) flats are aligned to fit into the slot located in the end of housing (1-10).

- 5.6.2** Using lifting equipment, move the power module up to housing (1-10) and align piston rod (3-40) with extension rod assembly (1-50).
- 5.6.3** Using a male square drive extension, go through outer end cap (3-80) and screw piston rod (3-40) into extension rod assembly (1-50).

CAUTION

Do not cross-thread piston rods. When screwing piston rod into extension rod assembly (1-50), make certain that the piston rod and extension rod assembly threads do not cross-thread.

- 5.6.4** Torque tighten piston rod (3-40) as follows:
- 5.6.4.1** FG2 and FG3 torque to 90 lb-ft lubricated.
 - 5.6.4.2** FG4 and FG10 torque to 240 lb-ft lubricated.
- 5.6.5** Install lock washers (3-110) onto hex cap screws (3-100).
- 5.6.6** Install and tighten hex cap screws (3-100) with lock washers (3-110) through housing (1-10) and screw into inner end cap (3-10).
- 5.6.7** Using pipe dope, install pipe plug (3-120) into outer end cap (3-80).

5.7 Powr-Swivl Removal

- 5.7.1** Push the guide block to the side of housing (1-10) that will expose the extension rod assembly (1-50).

NOTE:

The guide block can be moved by inserting a long non-metallic rod through the hole where the blind end cap was removed and pushing on the guide block.

- 5.7.2** Refer to Assembly Drawing Part Number 121411 sheet 2 of 2 Detail "B" in Appendix B. Use Biffi tool part number as listed in table in Section 1, step 1.5.2 to remove retainer nut assembly (1-60) from the guide block (1-30).

⚠ CAUTION

Carefully handle spherical washers. When removing rod extension assembly from guide block, be careful not to drop one of the spherical washers inside the housing.

- 5.7.3** Remove rod extension assembly (1-50) from guide block (1-30).

NOTE:

One spherical washer (1-40) will be removed from guide block (1-30) when extension rod assembly is removed.

- 5.7.4** Remove the remaining spherical washer (1-40) from guide block (1-30).

5.8 Powr-Swivl Module Installation

⚠ WARNING

The actuator must be in the appropriate overtravel position. Confirm overtravel position by observing the guide block (1-30) is against the inner wall of housing (1-10).

- 5.8.1** Push the guide block to the required side of the housing (1-10).

NOTE:

The guide block can be moved by inserting a long rod through either end of the housing and pushing on the guide block.

5.8.2 Lubricate two spherical washers (1-40) and one extension rod assembly (1-50).

5.8.3 Install one spherical washer (1-40) into the side of guide block (1-30).

NOTE:

The spherical side of washer (1-40) will be facing to the outside of guide block (1-30).

5.8.4 Install second spherical washer (1-40) over threaded end of extension rod assembly (1-50).

NOTE:

The spherical side of the washer will go on the extension rod assembly facing the head of the extension rod assembly.

5.8.5 Install extension rod assembly (1-50) into right of guide block (1-30) and up against the first spherical washer (1-40).

5.8.6 Install extension retainer nut assembly (1-60) over extension rod assembly (1-50) and screw into guide block (1-30).

5.8.7 Tighten extension retainer nut assembly (1-60) until extension rod assembly (1-50) cannot move. Back off the extension retainer nut assembly (1-60) just enough to allow for extension rod assembly (1-50) to move freely.

Section 6: Actuator Support Information

6.1 M18 Hydraulic Override System Fluid Volume

Table 11. M18 Hydraulic Override System Fluid Volume

Actuator Size		FG01	FG2	FG3	FG4	FG5	FG7	FG8	FG10
Approximate Volume Fluid for M18	Quarts	1.6	1.8	2.0	3.6	10.2	9.7	15.9	27.0
	Liters	1.8	1.7	1.9	3.4	9.6	9.1	15.1	25.6

6.2 Module Weights by Item Number and Actuator Housing Size

Table 12. Module Weight by Item Number and Actuator Housing Size (1)

Item Number		FG01 Weight	FG2 Weight	FG3 Weight	FG4 Weight	FG5 Weight	FG7 Weight	FG8 Weight	FG10 Weight	Module Description
1	lb	83	110	162	280	545	1025	1495	2550	Drive module
	kg	38	50	73	127	247	465	678	1157	
3	lb	69	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8 in. diameter power
	kg	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
3	lb	68	80	N/A	N/A	N/A	N/A	N/A	N/A	9 in. diameter power
	kg	30.5	36	N/A	N/A	N/A	N/A	N/A	N/A	
3	lb	75	73.5	88	N/A	N/A	N/A	N/A	N/A	10 in. diameter power
	kg	34	33	40	N/A	N/A	N/A	N/A	N/A	
3	lb	86	86	104	130	N/A	N/A	N/A	N/A	12 in. diameter power
	kg	39	39	47	59	N/A	N/A	N/A	N/A	
3	lb	96	96	114	145	N/A	N/A	N/A	N/A	14 in. diameter power
	kg	44	44	51	66	N/A	N/A	N/A	N/A	
3	lb	N/A	135	145	168	295	N/A	N/A	N/A	16 in. diameter power
	kg	N/A	61	66	76	134	N/A	N/A	N/A	
3	lb	N/A	N/A	235	260	305	585	N/A	N/A	20 in. diameter power
	kg	N/A	N/A	107	118	138	265	N/A	N/A	
3	lb	N/A	N/A	N/A	340	410	735	911	N/A	24 in. diameter power
	kg	N/A	N/A	N/A	154	186	334	413	N/A	
3	lb	N/A	N/A	N/A	505	590	810	1225	1120	28 in. diameter power
	kg	N/A	N/A	N/A	229	268	367	556	508	
3	lb	N/A	N/A	N/A	N/A	977	1100	1260	1440	32 in. diameter power
	kg	N/A	N/A	N/A	N/A	443	499	572	653	

Table 13. Module Weight by Item Number and Actuator Housing Size (2)

Item Number		FG01 Weight	FG2 Weight	FG3 Weight	FG4 Weight	FG5 Weight	FG7 Weight	FG8 Weight	FG10 Weight	Module Description
3	lb	N/A	N/A	N/A	N/A	1243	1400	1525	1755	36 in. diameter power
	kg	N/A	N/A	N/A	N/A	564	653	692	796	
3	lb	N/A	N/A	N/A	N/A	N/A	N/A	1975	2205	40 in. diameter power
	kg	N/A	N/A	N/A	N/A	N/A	N/A	896	1000	
3	lb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	44 in. diameter power
	kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
3	lb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	48 in. diameter power
	kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
3	lb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52 in. diameter power
	kg	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
5	lb	160	225	320	564	975	2740	3545	4975	SR1 spring
	kg	73	102	145	256	442	1243	1608	2257	
5	lb	158	215	310	549	980	2630	2345	4515	SR2 spring
	kg	72	98	141	249	445	1193	1064	2048	
5	lb	153	215	295	534	925	2410	3085	4095	SR3 spring
	kg	153	98	295	534	925	2410	3085	4095	
5	lb	144	200	280	474	860	2210	N/A	3735	SR4 spring
	kg	65	91	127	215	390	1002	N/A	1694	
5	lb	N/A	200	N/A	N/A	N/A	N/A	N/A	N/A	SRA5 spring
	kg	N/A	91	N/A	N/A	N/A	N/A	N/A	N/A	
5	lb	N/A	180	N/A	N/A	N/A	N/A	N/A	N/A	SRA6 spring
	kg	N/A	82	N/A	N/A	N/A	N/A	N/A	N/A	
7	lb	18	34	47	82	100	181	270	530	M18 SR override cylinder
	kg	8.2	15.3	21.2	36.9	45	81.45	1275	239	
2	lb	35	35	35	45	50	35	45	50	M18 SR pump/reservoir
	kg	14.5	14.5	14.5	20.4	22.7	14.5	20.4	22.7	

6.3 FG01 Tool Style and Wrench Size

Table 14. FG01 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	9/16 in.	4	Hex Cap Screws	Socket
1-160	1/2 in.	4	Hex Cap Screws	Socket
1-180	3/8 in. (square)	2	Stop Screws	Open End or Adjustable
1-190	1-15/16 in.	2	Hex Jam Nuts	Open End or Adjustable
3-20	3/8 in.	2	Tie Bar (flats)	Open End or Adjustable
3-40	3/8 in. (square)	1	Piston Rod	Male Drive
3-90	1-1/8 in.	2	Standard Hex Nuts	Socket
3-100	9/16 in.	4	Hex Cap Screws	Socket
3-120	5/8 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	9/16 in.	4	Hex Cap Screws	Socket
7-80	9/16 in.	4	Hex Cap Screws	Socket
7-110	1/8 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
7-120	9/16 in. (square)	1	Square Head Pipe Plug	Square Head Pipe Plug
12	1 in.	1	Breather Assembly	Socket
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/8 in. (square)	1	Tension rod	Male Drive

6.4 FG2 Tool Style and Wrench Size

Table 15. FG2 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	9/16 in.	6	Hex Cap Screws	Socket
1-160	9/16 in.	4	Hex Cap Screws	Socket
1-180	3/8 in. (square)	2	Stop Screws	Open End or Adjustable
1-190	1-1/8 in.	2	Hex Jam Nuts	Open End or Adjustable
3-20	3/8 in.	2	Tie Bar (flats)	Open End or Adjustable
3-40	3/8 in. (square)	1	Piston Rod	Male Drive
3-90	1-1/8 in.	4	Standard Hex Nuts	Socket
3-100	9/16 in.	4	Hex Cap Screws	Socket
3-120	5/8 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	9/16 in.	6	Hex Cap Screws	Socket
7-80	9/16 in.	4	Hex Cap Screws	Socket
7-110	1/8 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
7-120	1/2 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/8 in. (square)	1	Tension rod	Male Drive

6.5 FG3 Tool Style and Wrench Size

Table 16. FG3 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	9/16 in.	8	Hex Cap Screws	Socket
1-160	9/16 in.	4	Hex Cap Screws	Socket
1-180	1/2 in. (square)	2	Stop Screws	Open End or Adjustable
1-190	1-5/16 in.	2	Hex Jam Nuts	Open End or Adjustable
3-20	1/2 in.	2	Tie Bar (flats)	Open End or Adjustable
3-40	3/8 in. (square)	1	Piston Rod	Male Drive
3-90	1-5/16 in.	4	Standard Hex Nuts	Socket
3-100	9/16 in.	6	Hex Cap Screws	Socket
3-120	5/8 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	9/16 in.	6	Hex Cap Screws	Socket
7-80	9/16 in.	6	Hex Cap Screws	Socket
7-110	1/8 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
7-120	1/2 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/8 in. (square)	1	Tension rod	Male Drive

6.6 FG4 Tool Style and Wrench Size

Table 17. FG4 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	9/16 in.	8	Hex Cap Screws	Socket
1-160	9/16 in.	4	Hex Cap Screws	Socket
1-180	3/4 in. (square)	2	Stop Screws	Open End or Adjustable
1-190	1-13/16 in.	2	Hex Jam Nuts	Open End or Adjustable
3-20	5/8 in.	2	Tie Bar (flats)	Open End or Adjustable
3-40	1/2 in. (square)	1	Piston Rod	Male Drive
3-90	1-5/8 in.	2	Standard Hex Nuts	Socket
3-100	3/4 in.	6	Hex Cap Screws	Socket
3-120	5/8 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	3/4 in.	6	Hex Cap Screws	Socket
7-80	3/4 in.	6	Hex Cap Screws	Socket
7-110	1/8 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
7-120	1/2 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/4 in.	1	Tension rod	Male Drive

6.7 FG5 Tool Style and Wrench Size

Table 18. FG5 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	3/4 in.	8	Hex Cap Screws	Socket
1-120	3/4 in.	4	Hex Cap Screws	Socket
1-160	9/16 in.	6	Hex Cap Screws	Socket
1-180	7/8 in. (square)	2	Stop Screws	Open End or Adjustable
1-190	2-3/8 in.	2	Heavy Hex Jam Nuts	Open End or Adjustable
3-20	1/2 in. (square)	2	Tie Bar (flats)	Open End or Adjustable
3-40	1/2 in. (square)	1	Piston Rod	Male Drive
3-90	2 in.	2	Standard Hex Nuts	Socket
3-100	3/4 in.	8	Hex Cap Screws	Socket
3-120	1-1/8 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	3/4 in.	8	Hex Cap Screws	Socket
7-80	3/4 in.	8	Hex Cap Screws	Socket
7-110	1/8 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
7-120	1/2 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/4 in.	1	Tension rod	Male Drive

6.8 FG7 Tool Style and Wrench Size

Table 19. FG7 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	3/4 in.	8	Hex Cap Screws	Socket
1-120	3/4 in.	4	Hex Cap Screws	Socket
1-160	9/16 in.	8	Hex Cap Screws	Socket
1-180	1 in.	2	Stop Screws	Open End or Adjustable
3-20	3/4 in. (square)	2	Tie Bar (female square)	Open End or Adjustable
3-40	3/4 in. (square)	1	Piston Rod	Male Drive
3-90	2-3/8 in.	2	Standard Hex Nuts	Socket
3-100	15/16 in.	8	Hex Cap Screws	Socket
3-120	1-1/8 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	15/16 in.	8	Hex Cap Screws	Socket
7-80	15/16 in.	8	Hex Cap Screws	Socket
7-100	15/16 in.	8	Hex Cap Screws	Socket
7-110	9/16 in.	1	Flush Socket Head Pipe Plug	Allen
7-130	9/32 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/4 in.	2	Tension rod	Male Drive

6.9 FG8 Tool Style and Wrench Size

Table 20. FG8 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	3/4 in.	12	Hex Cap Screws	Socket
1-120	3/4 in.	4	Hex Cap Screws	Socket
1-160	9/16 in.	8	Hex Cap Screws	Socket
1-180	1-1/4 in.	2	Stop Screws	Open End or Adjustable
3-20	3/4 in. (square)	2	Tie Bar (female square)	Open End or Adjustable
3-40	3/4 in. (square)	1	Piston Rod	Male Drive
3-90	2-3/4 in.	2	Heavy Hex Nuts	Socket
3-100	1-1/8 in.	8	Hex Cap Screws	Socket
3-120	1-5/16 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	1-1/8 in.	8	Hex Cap Screws	Socket
7-80	1-1/8 in.	8	Hex Cap Screws	Socket
7-100	1-1/8 in.	8	Hex Cap Screws	Socket
7-110	9/16 in.	1	Flush Socket Head Pipe Plug	Allen
7-130	9/32 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/4 in.	1	Tension rod	Male Drive

6.10 FG10 Tool Style and Wrench Size

Table 21. FG10 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
1-110	3/4 in.	16	Hex Cap Screws	Socket
1-120	3/4 in.	4	Hex Cap Screws	Socket
1-160	9/16 in.	8	Hex Cap Screws	Socket
1-180	1-1/2 in.	2	Stop Screws	Open End or Adjustable
3-20	3/4 in. (square)	2	Tie Bar (female square)	Open End or Adjustable
3-40	3/4 in. (square)	1	Piston Rod	Male Drive
3-90	3-1/2 in.	2	Heavy Hex Nuts	Socket
3-100	1-5/16 in.	8	Hex Cap Screws	Socket
3-120	1-5/16 in. (square)	1	Pipe Plug	Open End or Adjustable
3-130	3/16 in.	2	Socket Cap Screws	Allen
5-20	1-1/8 in.	8	Hex Cap Screws	Socket
7-80	1-5/16 in.	8	Hex Cap Screws	Socket
7-100	1-5/16 in.	8	Hex Cap Screws	Socket
7-110	9/16 in.	1	Flush Socket Head Pipe Plug	Allen
7-130	9/32 in. (square)	1	Square Head Pipe Plug	Open End or Adjustable
12	1 in.	1	Breather Assembly	Open End
13	3/4 in.	2	Vent Check Assembly	Open End
-	3/4 in.	1	Tension rod	Male Drive

6.11 M18 Tool Style and Wrench Size

Table 22. M18 Tool Style and Wrench Size

Item Number	Wrench Size	Item Quantity	Location or Description	Recommended Tool Style
10-50	3/4 in.	1	Acorn Nut	Socket
10-80	3/8 in.	2	Pipe Plug	Socket
10-90	3/4 in.	1	Breather	Socket
10-110	3/4 in.	1	Pipe Plug	Socket
20-10-27	11/16 in.	1	Check Valve	Socket
20-10-30	13/16 in.	1	Relief Valve	Open End or Adjustable
20-10-40	11/16 in.	2	Check Valve	Socket
20-10-180	1/2 in.	3	Socket Cap Screws	Allen
20-10-190	5/16 in.	6	Socket Cap Screws	Allen
20-10-210	3/16 in.	17	Socket Cap Screws	Allen
20-10-240	3/16 in.	1	Socket Cap Screws	Allen
20-10-260	7/8 in.	2	Orifice Check Valve	Socket
20-10-400	1/2 in.	1	Square Head Pipe Plug	Open End or Adjustable
25-240	3/16	4	Socket Cap Screws	Allen
25-410	5/32 in.	2	Socket Cap Screws	Allen
25-430	3/32 in.	1	Socket Cap Screws	Allen
30-20	7/16 in.	4	Hex Cap Screws	Socket
30-40	3/16 in.	2	Socket Cap Screws	Allen
30-100	7/32 in.	4	Socket Cap Screws	Allen
30-110	3/8 in.	4	Socket Cap Screws	Allen
40	11/16 in. or 5/8 in. (square)	1	Male Elbow	Open End or Adjustable
60	11/16 in. or 5/8 in. (square)	1	Male Connector	Open End or Adjustable
80-10	3/16 in.	2	Socket Cap Screws	Allen
80-20	1/2 in.	1	Elbow	Open End or Adjustable
80-60	5/8 in.	1	Bulkhead Adapter	Open End or Adjustable
80-70	1/2 in.	1	Hex Cap Nut	Open End or Adjustable
80-120	3/8 in.	1	Pivot Pin	Open End or Adjustable
90-30	11/16 in.	1	Check Valve	Socket
90-40	11/16 in.	1	Male Tube Adapter	Open End or Adjustable
90-50	11/16 in.	1	Male Connector	Open End or Adjustable
90-60	11/16 in.	1	Check Valve	Socket

Section 7: Troubleshooting

7.1 Fault Insertion

In the unlikely event of a fault developing, the following Fault Location Table is provided to assist the service engineer to perform troubleshooting. This table is designed to cover as wide a range of Biffi actuators as possible. Reference to equipment not supplied should be ignored.

Table 23. Fault Location Table

Symptom	Potential Causes	Remedy
Erratic movement	Irregular supply of operating medium	Check operating medium for consistent supply pressure and correct as necessary.
	Inadequate lubrication	Dismantle, relubricate and reassemble.
	Worn parts	Dismantle, visually inspect for significant wear. Actuator replacement may be required.
	Defective valve	Consult the valve OEM's documentation.
Short stroke	Incorrectly set stops (valve and/or actuator)	Check the position of the travel stops and readjust as necessary.
	Hardened grease	Dismantle, remove any hard grease, relubricate and reassemble.
	Debris left in the cylinder or housing during maintenance	Disassemble cylinder assembly to remove debris. Reassemble cylinder assembly as necessary.
	Defective valve	Consult the valve manufacturer's documentation.
Apparent lack of torque	Inadequate supply pressure	Ensure supply pressure is above the minimum operating pressure of the actuator and that output torque produced at supply pressure exceeds valve torque demand.
	Incorrect speed control settings	Adjust speed controls to increase flow.
	Exhaust port blocked	Remove and clean the exhaust port silencers and replace.
	Pipe work blocked, crushed or leaking	Examine the pipe work for blockages, crushed pipe or leakage. Clear or replace as necessary.
	Defective controls	Examine the controls, refurbish or renew as necessary. Refer to component manufacturer's documentation.
	Defective piston seal	Dismantle the cylinder assembly, remove the defective piston seal. Fit new seal and reassemble.
	Defective rod seal	Dismantle the cylinder assembly, remove the defective rod seal. Fit new seal and reassemble.
	Defective housing seal	Dismantle the housing assembly, remove the defective seal. Fit new seal and reassemble.
High valve torque or valve seized	Consult the valve OEM documentation.	

7.2 Operational Test

7.2.1 Full Stroke Test

The "Full Stroke Test" ("On-line") must be performed to satisfy the PFD_{AVG} (average probability of failure on demand) value. The full stroke test frequencies will be defined by the final installer to achieve the defined SIL level.

7.2.1.1 Procedure

7.2.1.1.1 Stroke the actuator/valve assembly two complete open/close cycles with complete closing of the valve.

7.2.1.1.2 Verify the open/close cycles functioned correctly (e.g., check locally, or automatically via Logic solver, the correct movement of the actuator/valve).

Upon successful completion of the above described Full Stroke Test procedure, the "Test Coverage" can be considered 99%.

7.2.2 Partial Stroke Test (when requested)

The "Partial Stroke Test" ("On-line") can be performed to improve the PFD_{AVG} value and to satisfy PFD_{AVG} value. A typical partial stroke value is 15% of the stroke and the recommended test interval is about everyone to three months.

7.2.2.1 Procedure

7.2.2.1.1 Operate the actuator/valve assembly for No° 1 open/close cycles 15% of the stroke.

7.2.2.1.2 Verify the partial stroke test functioned correctly (e.g., check locally, or automatically via Logic solver, or via the PST system the correct movement of the actuator/valve was 15% of the stroke).

NOTE:

The above test is only applicable on systems equipped with a partial stroke feature.

Section 8: Removal and Decommissioning

WARNING

Always follow safe work practices to remove and disassemble an FG-Series actuator.

The below basic procedure should not supersede or replace any customer's plant safety or work procedures. If a conflict arises between this procedure and the customer's procedures, the differences should be resolved in writing between an authorized customer's representative and an authorized Biffi representative.

CAUTION

Make sure actuator is isolated before removing from valve. Turn OFF the power medium and bleed off all pressure first, including storage tank (if present). Next, bleed off pilot pressure, disconnect pneumatic pressure supply, pilot tubing and electrical wiring (if equipped).

Before starting the disassembly, a large area should be created around the actuator so to allow any kind of movement.

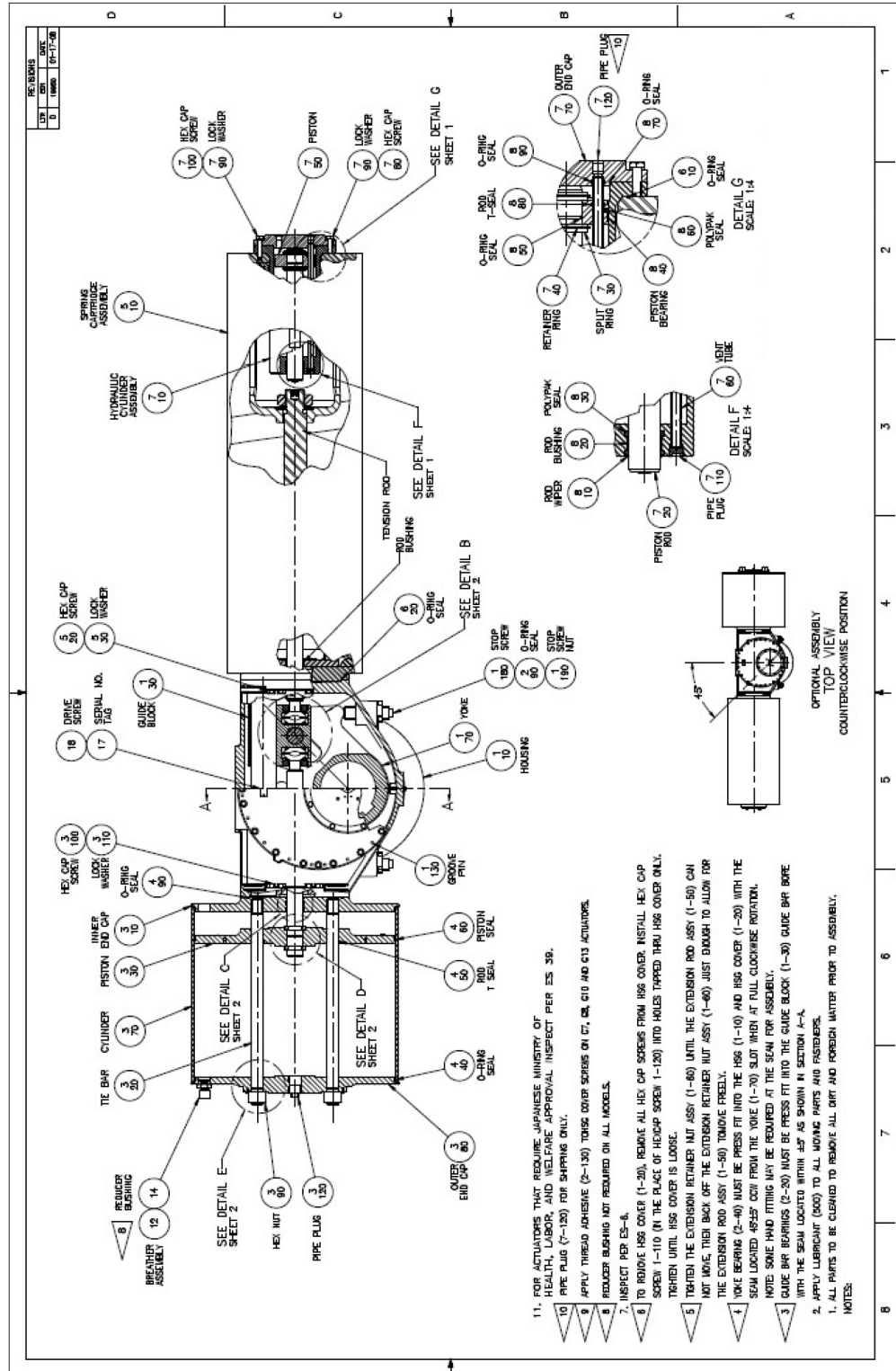
Separate the parts composing the actuator according to their nature (e.g., metallic and plastic materials, fluids, etc.) and send them to differentiated waste collection sites, as provided for by the laws and provisions in force.

1. Drain tanks and remove tubing from actuator. Remove accessories (if equipped) and controls from actuator.
2. Remove all equipment mounted on top of actuator (limit switches, end of stroke valve and relevant pneumatic/electric connection, etc.).
3. Remove mounting bolts and actuator is ready to be removed from valve. For complete actuator tear down, refer to Section 2 of the manual.

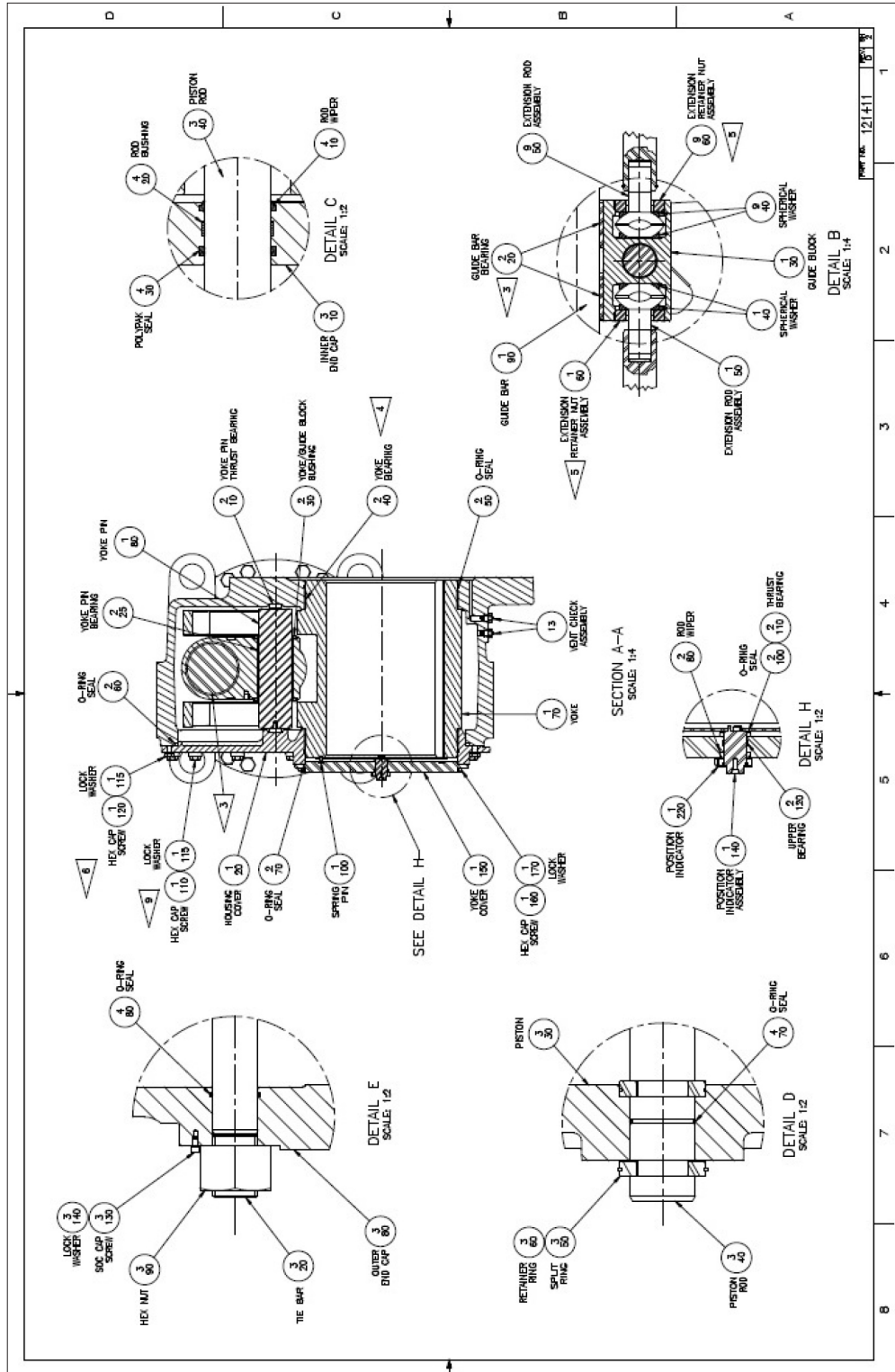
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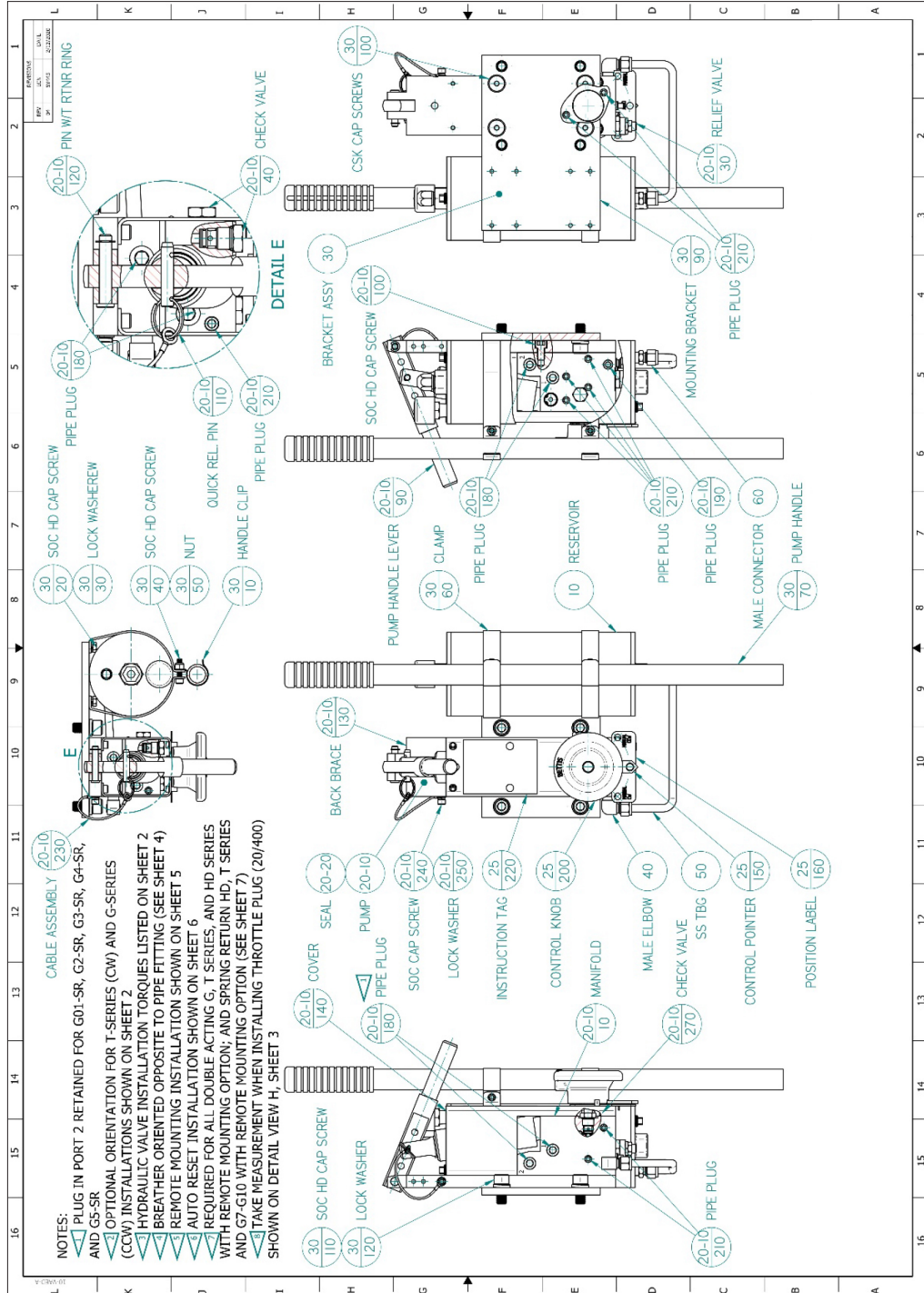
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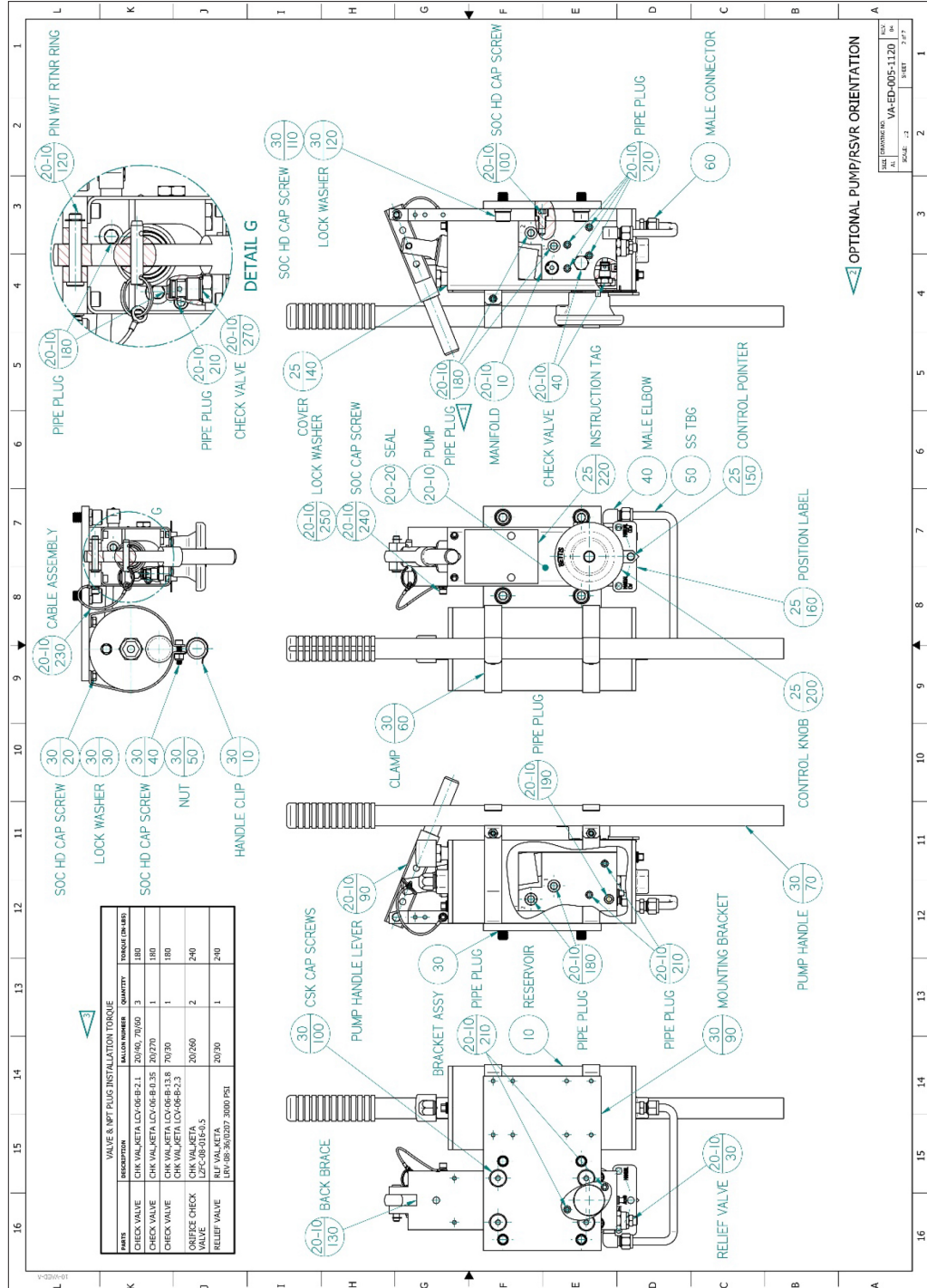
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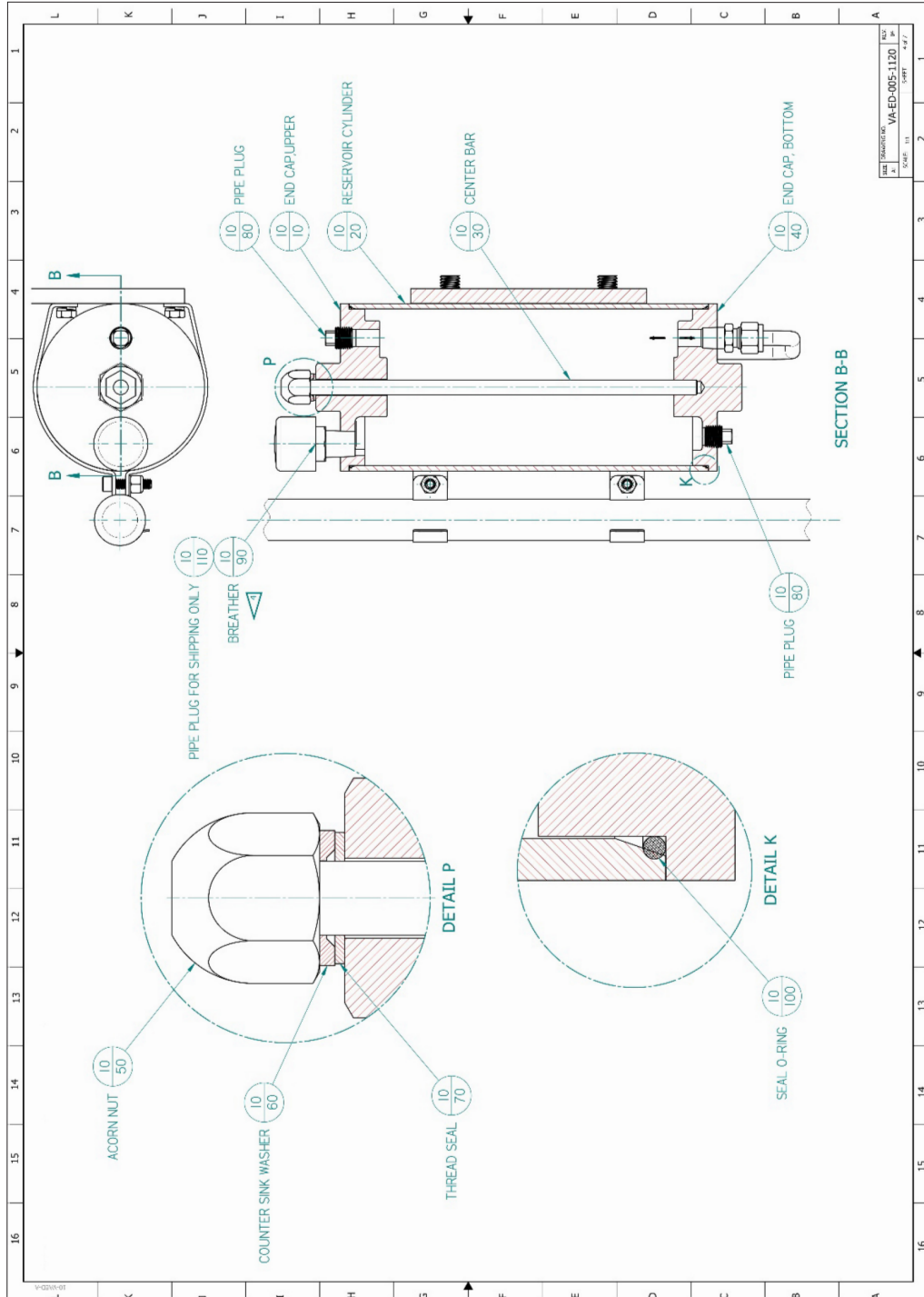
B.5 Part Number VA-ED-005-1120, M18 Assembly Drawing, Sheet 1 of 7



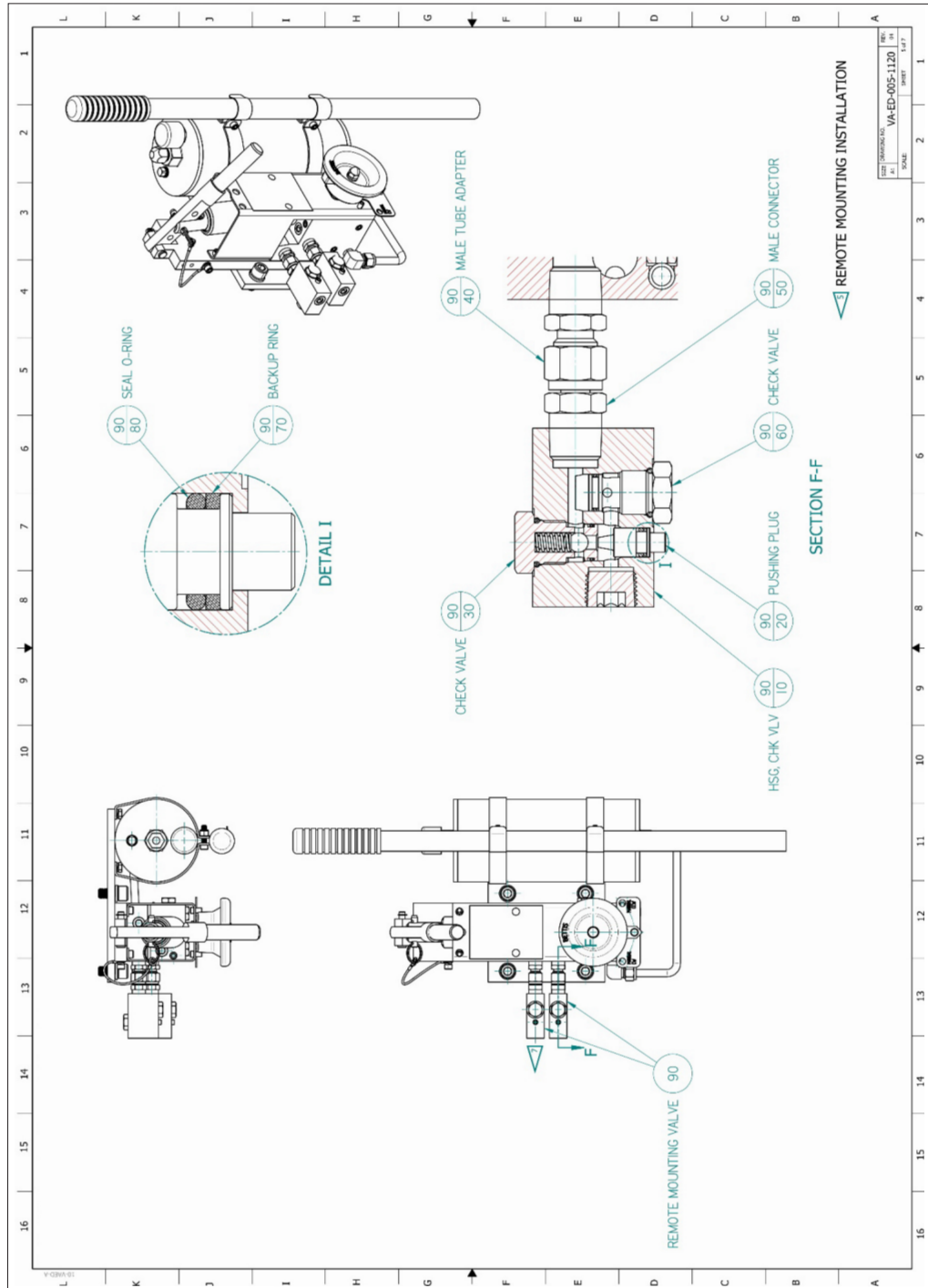
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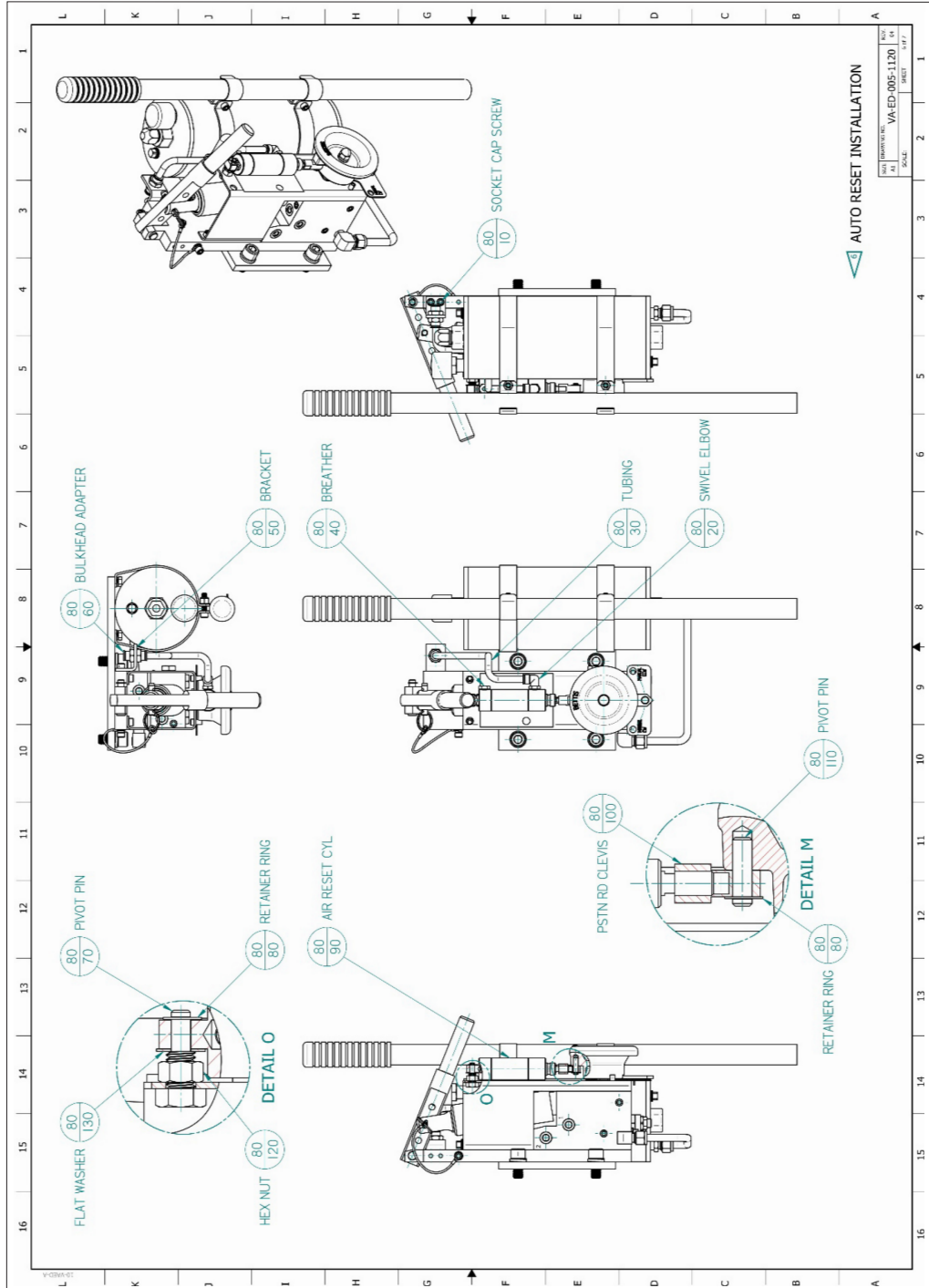
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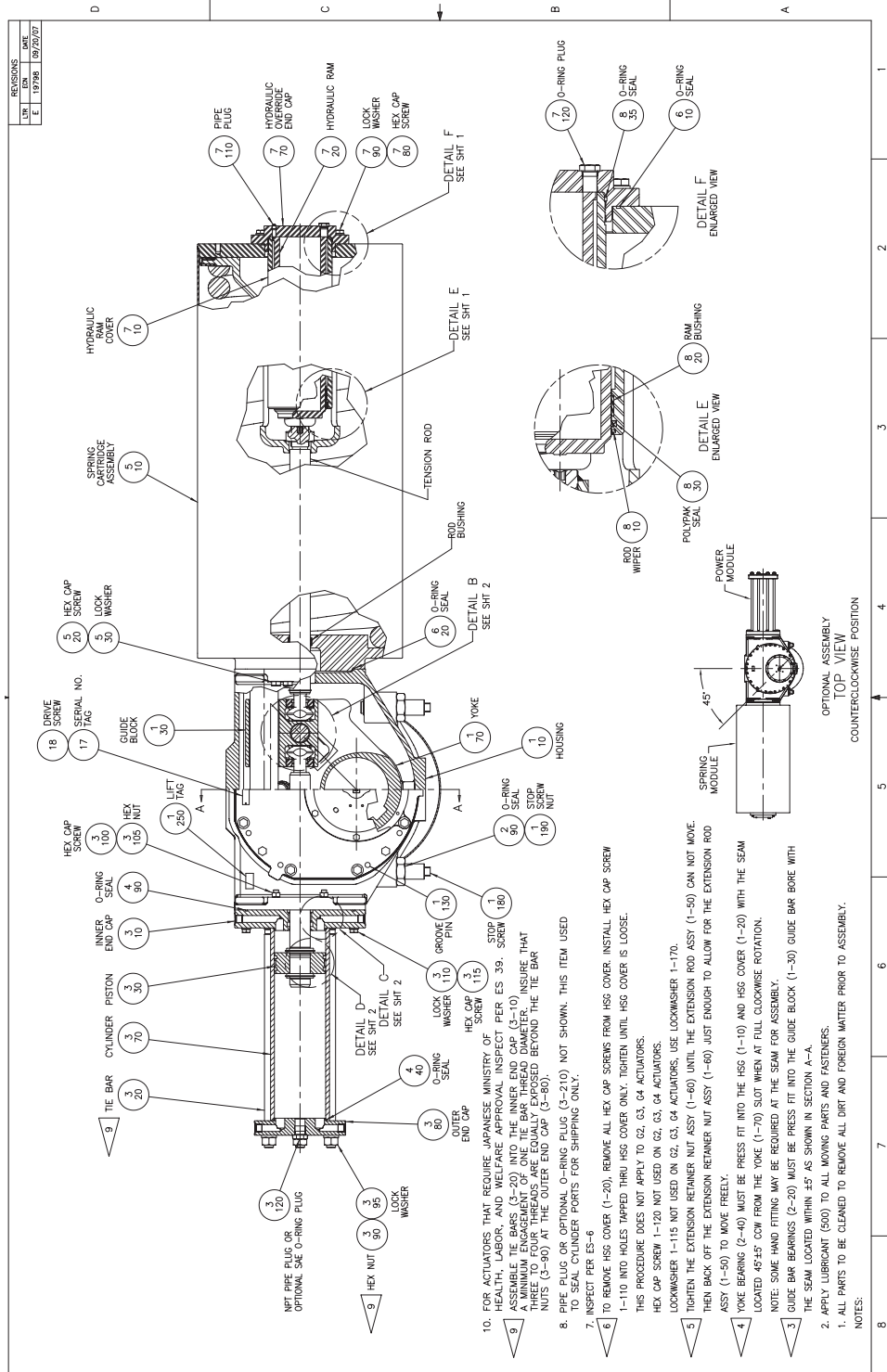
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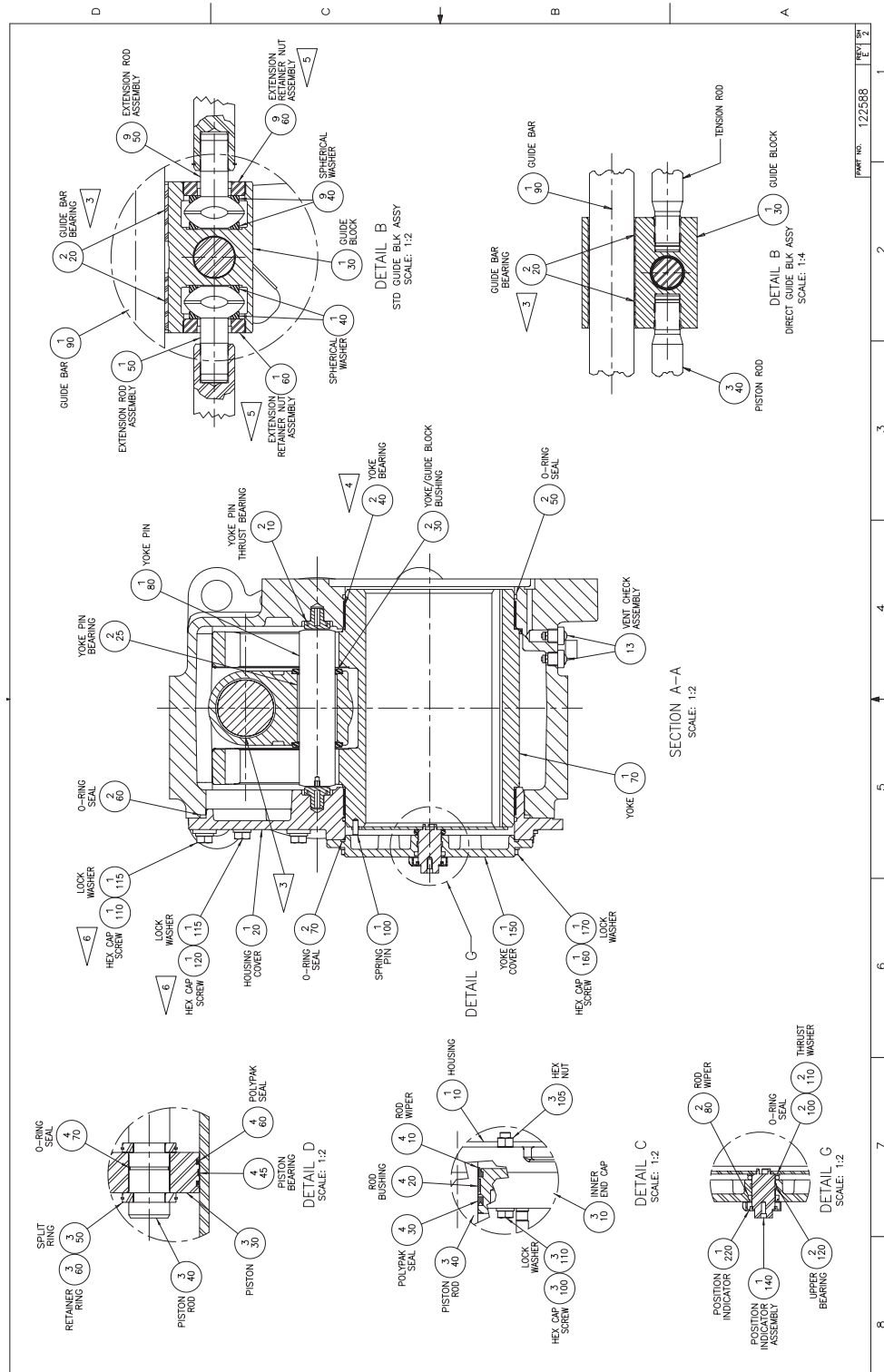
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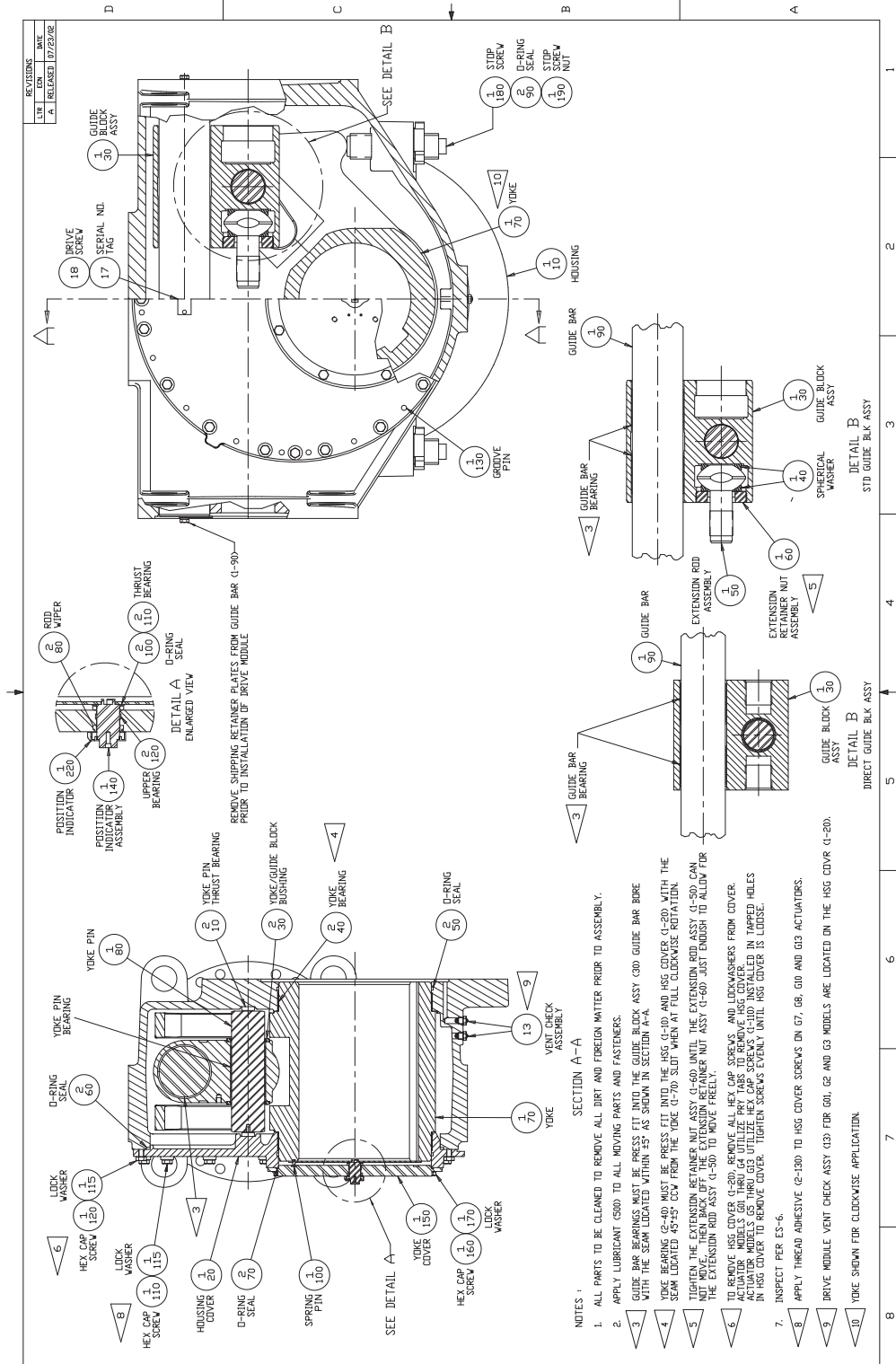
B.12 Part Number VA122588, FG1/2/3/4/5-SRX-H Hydraulic Assembly Drawing, Sheet 1 of 2



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Appendix C: Safety Instructions for Use in (Potential) Explosive Atmosphere



C.1 Intended Use

The actuator series have been designed to comply with the explosion safety requirements in the Ex-standards EN IEC 60079-0:2018, EN ISO 80079-36, EN ISO 80079-37:2016 and EN 1127-1:2019. These standards contain the requirements for non-electrical equipment in potentially explosive atmospheres.

The actuators comply with the constructional safety type "c" requirements. The actuators are designed for gas group IIB or IIC and dust group IIIC applications and are applicable in temperature classes T6 to T3 depending on model. The Equipment Protection Level is Gb for gas and Db for dust, so the actuators can be used in Ex classified hazardous zones 1/21.

C.2 ATEX Marking

Complete ATEX Marking:

  II 2 G Ex h IIB or IIC T6 to T3 Gb
II 2 D Ex h IIIC T85 °C to T200 °C Db

Ambient Temperature Ranges (T_{amb}):

- Standard Temperature: -20 to 200 °F / -29 to 93 °C
- Low Temperature: -40 to 150 °F / -40 to 65 °C
- High Temperature: 0 to 350 °F / -18 to 176 °C

NOTES:

1. The minimum and maximum temperatures can vary according to the project design (gaskets, O-rings and grease used) as well as other certifications within the given range. Please refer to the special conditions for safe use.
 2. Hazardous area is likely to occur in normal operation occasionally in greater than 10 and less than 1000 hours/year.
-

C.3 Safety Instructions

1. Before the installation, please carefully read the service instructions. Biffi is not responsible for damages caused by operations not complying with the instructions contained in such manuals.
2. All the operations shall be done by a trained and qualified operator. All maintenance operations must be performed in accordance with the instructions detailed in the maintenance manual.
3. The assembly cannot be installed and used in classified areas as zone 0 to 20, mines (group I).
4. The equipment shall be installed in a place where the risk of lightning is covered by the relevant industrial code of practice.
5. Assembly, disassembly and maintenance is only allowed at the actuator, when at the time of the activity, there are no explosive mixtures.
6. During maintenance operations, the user must take all appropriate measures to prevent risks related to the toxicity of substances, using appropriate protective equipment (e.g., gloves, goggles, face mask), according to the extent provided the technical and organizational point of use and the recommendations provided in the specifications of the used substances.
7. All the mechanical components do not have ignition sources during the normal working process. The user shall check periodically the vibration presences and/or abnormal noises and it must stop the unit immediately, check the causes and contact the manufacturer.
8. Actuators do not have an inherent ignition source due to electrostatic discharge, but explosion hazards may be present due to the discharge of static electricity from other valve assembly components.
 - a. To avoid personal injury or property damage, make sure that the valve is grounded to the pipeline before placing the valve assembly into service.
 - b. Use and maintain alternate shaft-to-valve body bonding, such as a shaft-to-body bonding strap assembly.
 - c. The equipment must be earthed through an anti-loosening and anti-rotation device. The user must regularly check the effectiveness of the ground connection.
 - d. A warning is present into the label: "Potential Electrostatic Charging Hazard".
9. When equipment is installed in a hazardous area location (potentially explosive atmosphere), prevent sparks by proper tool selection and avoiding other types of impact energy.
10. It is under end user responsibility to avoid the explosive mixture inside the actuator.
11. To avoid increasing dust explosion risk, periodically clean dust deposits from all equipment.
12. Proper care must be taken to avoid generation of static electricity on the non-conductive external surfaces of the equipment (e.g., rubbing of surfaces, etc.).

13. The paint protection must not exceed 200 µm if the actuator is used in a group IIC atmosphere. For group IIA or IIB atmospheres, the paint protection must not exceed a thickness of 0.08 in. / 2 mm.
14. For single acting actuators, it is necessary to use safe air and to convey by a piping inlet/exhaust of the cylinder outside of the Ex-zone (Safe Area).
15. After maintenance operations are carried out, perform a few actuator operations to check that its movement is regular and that there is no air/oil leakage through the seals/gaskets.
16. It is under end user responsibility to make sure the electrical equipment installed on the actuators have a separated ATEX evaluation and they are designed according to the ATEX Directive and they are suitable for the installation zone, group of gas, temperature class, maximum surface temperature, EPL and range of temperature.
17. It is forbidden to use this equipment in a different way if it is not included in the instruction manual. Biffi is not responsible for damages caused by an improper and/or dangerous use.

C.4 Maximum Temperatures

WARNING

The actuator's surface temperature is dependent upon process operating conditions. Personal injury or property damage caused by fire or explosion, can result if the actuator's surface temperature exceeds the acceptable temperature for the hazardous area classification. To avoid an increase of instrumentation and/or accessory surface temperature due to process operating conditions, ensure adequate ventilation, shielding or insulation of these actuator components installed in a potentially hazardous or explosive atmosphere.

Table C-1. Ambient and ATEX Temperatures

Temperature			Valid Actuator Trim
Ambient Range	ATEX Class	TX (ATEX Surface Temperature)	
-20 to 167 °F / -29 to 75 °C	T6	T185 °F / T85 °C	Standard Temperature Trim
-20 to 194 °F / -29 to 90 °C	T5	T212 °F / T100 °C	
-20 to 200 °F / -29 to 93 °C	T4	T217 °F / T103 °C	
-40 to 150 °F / -40 to 65 °C	T6	T167 °F / T75 °C	Low Temperature Trim
0 to 257 °F / -18 to 125 °C	T4	T275 °F / T135 °C	High Temperature Trim
0 to 350 °F / -18 to 176 °C	T3	T367 °F / T186 °C	

Note:

The specified values are valid with condition: Maximum cycle frequency of the actuator is less than 1 Hz at a maximum of 50 cycles per hour and at maximum load.

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