

BETTIS

SERVICE INSTRUCTIONS

DISASSEMBLY & REASSEMBLY

FOR MODELS

TR102XX-M4

DOUBLE ACTING SERIES

PNEUMATIC ACTUATORS WITH

HYDRAULIC CONTROL PACKAGE

PROCEDURE NUMBER: Service-020 (SE-020)

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1.0 **INTRODUCTION**

- 1.1 This service procedure is offered as a guide to enable general maintenance to be performed on Bettis TRI02XX-M4 "Scotch-Yoke type pneumatic actuators.
- 1.2 The maximum recommended service interval for this actuator series is five years. Storage time is counted as part of the service interval.
- 1.3 **BASIC SERVICE INFORMATION: Complete actuator refurbishment requires the actuator be dismantled from the valve or device it is operating.**
- 1.4 Normal recommended service interval for this actuator series is five years to maximum total life cycle.

NOTE: Storage time is counted as part of the service.

2.0 **BASIC TOOLS**

All tools 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 5,000 in. lbs./565 N-m), breaker bar, an socket set, putty knife, razor sharp cutting instrument, commercial non-corrosive leak testing solution, and non-hardening thread sealant.

3.0 **REFERENCE BETTIS MATERIALS**

- 3.1 Assembly Drawing Part Number 065105.
- 3.2 Exploded Detail Drawing Part Number 065347.
- 3.3 Rail Alignment Tool Drawing (Refer to back of this procedure).

4.0 **GENERAL INFORMATION**

- 4.1 Numbers in parentheses indicate the bubble number used on the assembly drawings, exploded detail drawings, and actuator parts lists.
- 4.2 Front view of actuator: Yoke bore nearest workman, side plate with accessory pads facing workman.
- 4.3 All components of this actuator are very heavy and will require a means of assistance.
- 4.4 Mating parts should be marked for ease of reassembly.
- 4.5 When removing seals from seal grooves, use a small screwdriver with the sharp edges rounded off or use a commercial seal removing tool.
- 4.6 Use a non-hardening thread sealant on all piping threads.
- 4.7 Disassembly of actuator should be done in a clean area on a work bench.

4.8 This procedure does not include M4 Disassembly and Reassembly Instructions. Bettis does not recommend periodic maintenance for the M4 itself. The M4 needs only to be serviced when it malfunctions. Complete M4 refurbishment should be done by Bettis or an authorized Bettis representative.

4.9 LUBRICATION REQUIREMENTS.

NOTE: Lubricants, other than listed in step 4.9.1 should not be used without prior written approval of Bettis Product Engineering. The lubricant item number on some assembly drawings is item (6-150) while the Bettis service kits lubricant item number is item number (500).

4.9.1. All temperature services (-50°F to +350°F)/(-45.5°C to +176.6°C) use Bettis ESL-5 lubricant. ESL-5 lubricant is contained in the Bettis Service Kit in tubes and the tubes are marked ESL-4,5 & 10 lubricant.

4.10 FLUID REQUIREMENTS.

NOTE: Fluids, other than listed in step 4.10.1 and 4.10.2 should not be used in the M4 override system without prior written approval of Bettis Product Engineering.

4.10.1 Standard and high temperature service (-20°F to +350°F)/(-28.9°C to +176.6°C) use Dexron Automatic Transmission Fluid.

4.10.2 Low temperature service (-50°F to +150°F))/(-45.5°C to +65.6°C) use Exxon Univis J13 Hydraulic Fluid.

5.0 GENERAL DISASSEMBLY

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

5.1 Rotate actuator to mid-stroke position.

5.2 Turn off air or power gas and depressurize air cylinder.

NOTE: Use a means of capturing the hydraulic fluid that will be lost during the removal or disassembly of the M4 and hydraulic cylinder (3-40). Use a bucket, tub, and large container, ECT.

5.3 If the M4 is mounted on the actuator then remove the M4 control package (8) from hydraulic cylinder (3-40). Remove the M4 package and bracket by loosening hex nuts on the U-bolts and sliding the M4/bracket assembly off the hydraulic cylinder (3-40).

NOTE: Plug M4 ports as foreign material may enter the system and cause the unit to malfunction.

5.4 Drain the hydraulic fluid from hydraulic cylinder (3-40) by removing the cylinder drain plugs (3-160). One is located on outboard end of hydraulic cylinder and the other on the inboard end of hydraulic cylinder.

6.0 PRESSURE CYLINDER DISASSEMBLY (RIGHT SIDE)

6.1 Remove stop screw nut (1-100) from outer end cap (2-30).

NOTE: Stop screw (1-90) may remain in outer end cap (2-30). If stop screw (1-90) is to be removed measure and record the exposed length of stop screw (1-90).

6.2 Remove tie bar nuts (2-100). Inspect Teflon insert - excessive damage may require the nuts to be replaced.

CAUTION: When separating cylinder (2-10) from outer end cap (2-30) and inner end cap (2-40) do not damage o-ring groove.

6.3 Remove outer end cap (2-30) from cylinder (2-10). The fit between the cylinder and the outer end cap is very tight. Break the end cap free by tapping with a breaker bar on lip provided on the end cap.

6.4 Pry inner end cap (2-40) away from housing (1-10).

6.5 Using breaker bar pry cylinder (2-10) from inner end cap (2-40).

NOTE: When removing cylinder (2-10) off of piston (2-20), tilt cylinder (2-10) at an angle of approximately 15° to 30° degrees to the piston rod (2-70).

6.6 Remove cylinder (2-10) from actuator.

CAUTION: Keep split ring halves (2-80) in matched sets.

6.7 Remove split ring halves (2-80) and split ring retainer (2-90) from outboard side of piston (2-20).

6.8 Remove piston (2-20) off piston rod (2-70) and tie bars (2-60)

CAUTION: Keep split ring halves (2-80) in matched sets.

6.9 Remove second set of split ring halves (2-80) and split ring retainer (2-90) from inboard side of piston (2-20).

6.10 Remove o-ring seal (4-20) from piston rod (2-70).

6.11 Remove inner end cap (2-40) off piston rod (2-70) and tie bars (2-60).

CAUTION: Do not use a pipe wrench on the tie bars (2-60) as it may mark the bars and cause seal leakage. Flats are provided on the outboard end of the tie bars for wrench placement.

6.12 Remove tie bars (2-60) from housing (1-10).

NOTE: Flats are provided on outboard end of piston rod (2-70) for wrench placement.

6.13 Remove piston rod (2-70) from yoke pin nut (1-30).

6.14 Remove rod bushing (2-50) and rod seal (4-60).

7.0 TANDEM CYLINDERS DISASSEMBLY (LEFT SIDE)

7.1 Remove stop screw nut (1-100) from outer end cap (3-70).

NOTE: Stop screw (1-90) may remain in outer end cap (3-70). If stop screw (1-90) is to be removed measure and record the exposed length of stop screw (1-90).

7.2 Remove tie bar nuts (3-140). Inspect Teflon insert - excessive damage may require the nuts to be replaced.

CAUTION: When separating cylinder (2-10) from outer end cap (3-70) and inner end cap (2-40) do not damage o-ring groove.

7.3 Remove outer end cap (3-70) from cylinder (3-40). The fit between the cylinder and the outer end cap is very tight. NOTE: Break the end cap free by tapping with a breaker bar on lip provided on the end cap.

7.4 Pry hydraulic cylinder inner end cap (3-60) away from the pneumatic cylinder outer end cap (3-30). Separate the cylinder (3-40) from the inner end cap (3-60). NOTE: Break the hydraulic cylinder inner end cap (3-60) free from the hydraulic cylinder (3-40) by tapping with a breaker bar on the lip provided on the end cap.

7.5 Remove the cylinder (3-40). NOTE: When sliding the cylinder off of the piston (3-50), tilt the cylinder 15° to 30° degrees to the piston rod (3-110).

CAUTION: Keep split ring halves (3-120) in matched sets.

7.6 Remove a set of split ring halves (3-120) and one split ring retainer (3-130) from the outboard side of piston (3-50).

7.7 Remove piston (3-50) from piston rod (3-110) and tie bars (3-100).

7.8 Remove a second set of split ring halves (3-120) and split ring retainer (3-130) from the piston rod (3-110).

7.9 Remove o-ring seal (5-10) from piston rod (3-110).

7.10 Remove inner end cap (3-60) from piston rod (3-110) and tie bars (3-100).

- 7.11 Remove rod bushing (3-90) and outboard rod seal (5-50) by carefully sliding both parts off of piston rod (3-110).
- 7.12 Remove outboard end cap (3-30) from cylinder (3-10). NOTE: The fit between the cylinder and the outer end cap is very tight. Break the end cap free by tapping with a breaker bar on lip provided on the end cap.
- 7.13 Pry inboard inner end cap (3-30) from housing, again using breaker bar. Pry cylinder (3-10) from inboard inner end cap (3-30).
- 7.14 Remove cylinder(3-10) from actuator. When removing cylinder off piston (3-20), tilt cylinder 15° to 30° degrees with respect to actuator centerline to help facilitate removal.

CAUTION: Keep split ring halves (3-120) in matched sets.

- 7.15 Remove a set of split ring halves (3-120) and split ring retainer (3-130) from the outboard side of piston (3-20).
- 7.16 Remove piston (3-20) off piston rod (3-110) and tie bars (3-100).

CAUTION: Keep split ring halves (3-120) in matched sets.

- 7.17 Remove a final set of split ring halves (3-120) and split ring retainer (3-130) from innermost inboard end of piston rod (3-110).
- 7.18 Remove o-ring seal (5-10) from piston rod (3-110) and slide inner end cap (3-30) off piston rod (3-110) and tie bars (3-100).

CAUTION: Do not use a pipe wrench on the tie bars (3-100) as it may mark the bars and cause seal leakage. Flats are provided on the outboard end of the tie bars for wrench placement.

- 7.19 Remove tie bars (3-100) from housing (1-10).

NOTE: Flats are provided on outboard end of piston rod (3-110) for wrench placement.

- 7.20 Remove piston rod (3-110) from yoke pin nut (1-30).
- 7.21 Remove rod bushing (3-80).

8.0 HOUSING DISASSEMBLY

- 8.1 Remove the four hex cap screws (1-170) and gasket seals (6-80) from the position indicator (1-410).
- 8.2 Remove position indicator (1-410) and yoke weather cover (6-110) from top of yoke (1-330).

8.3 Remove cover screws (1-170) and gasket seals (6-80) from the housing cover (1-20).

8.4 Remove housing cover (1-20). NOTE: the housing cover is a very tight fit.

NOTE: Cover pins (1-160) need not be removed.

8.5 Remove upper yoke bushing (1-110) from upper yoke trunion.

CAUTION: Hold or support rail (4-140) when removing cap screws to prevent rail falling or shifting in housing (1-10).

8.6 Remove outer "track-rail" (1-140) by unscrewing first set of shoulder bolts (1-420). Because tie bars with 'tipped' ends have been removed, the rails should lift out.

NOTE: There are three yoke rollers (1-40).

8.7 Remove upper yoke roller (1-40) from the top of the upper yoke arm of yoke (1-330).

8.8 Remove yoke pin (1-50) from the top of the upper yoke arm of yoke (1-330).

8.9 Remove the yoke pin nut (1-30) from between the upper and lower yoke arms of yoke (1-330).

8.10 Remove a second yoke roller (1-40) from inside yoke pin nut (1-30).

8.11 Remove lower yoke roller (1-40) from inside slot of the lower yoke arm of yoke (1-330).

8.12 Remove inside rail (1-140) by unscrewing second set of shoulder bolts (1-420).

8.13 Remove rail (1-140) from between yoke arms of yoke (1-330) and remove from housing (1-10).

8.14 Rotate yoke arms of yoke (1-330) clockwise (or counter clockwise) until they are in the approximately 45° degrees or mid-rotation position. Remove the yoke (1-330) by lifting from lower yoke bushing (1-120).

8.15 Remove lower yoke bushing (1-120) from lower area or bottom of housing (1-10).

9.0 GENERAL REASSEMBLY

CAUTION: Only new seals, that are still within the seals expectant shelf life, should be install into actuator being refurbished.

9.1 Taking care not to scratch or damage seal grooves, remove and discard all seals and gaskets.

9.2 All parts should be cleaned to remove all dirt and other foreign material prior to inspection.

- 9.3 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, and piston rod must be free of deep scratches, pitting, corrosion and blistering or flaking coating.

CAUTION: Actuator parts that reflect any of the previous listed characteristics must be replaced with new parts.

NOTE: The parts and seals used in the actuator housing and pneumatic cylinders will be assembled using lubricant as identified in step 4.9. Part and seal used in the actuator M4 overrided and override cylinder will be assembled using hydraulic fluid identified in step 4.10.

- 9.4 Before installation coat all moving parts with a complete film of lubricant.
- 9.5 Coat all seals with a complete film of lubricant, before installing into seal grooves.
- 9.6 The torque requirements for critical fasteners are specified at the appropriate step of the assembly procedure.

10.0 HOUSING REASSEMBLY

NOTE: The parts and seals used in the actuator housing (1-10) will be assembled using lubricant as identified in Section 4 step 4.9.

- 10.1 If removed, install elbow (1-260), breather (1-270) and pipe plugs (1-200).
- 10.2 Arrange the housing (1-10) with yoke bore toward front.
- 10.3 Apply lubricant to lower yoke bushing (1-120) and yoke bore in housing (1-10). Install lower yoke bushing (1-120).
- 10.4 Apply lubricant to lower yoke trunion and yoke arms of yoke (1-330).

NOTE: The hub of yoke (1-330) with the tapped holes faces "up" in the housing (1-10).

- 10.5 Install yoke (1-330) into lower yoke bushing (1-120), yoke arms positioned approximately 45° degrees in either direction.
- 10.6 Apply lubricant to both rails (1-140). Install inside rail (1-140) into housing between the arms of yoke (1-330).
- 10.7 Fasten inside rail (1-140) with shoulder bolts (1-420).

10.8 Torque shoulder bolts (1-420) to 150 foot pounds / 203 N-m lubricated.

NOTE: Tie bars with 'tipped' ends will be added later to support rail (1-140). Until that time, an adapter piece (see Drawing B-064899) may be used to support inside rail (1-140).

10.9 Rotate yoke (1-330) to mid-stroke position.

10.10 Apply lubricant to all surfaces of three yoke rollers and slots in the arms of yoke (1-330).

10.11 Install one lubricated short yoke roller (1-40) into slot of lower arm of yoke (1-330).

10.12 Lubricate the upper and lower surfaces of yoke pin nut (1-30) and install between the arms of yoke (1-330). NOTE: the yoke pin nut will be parallel to rail (1-140) inside housing (1-10).

12.13 Install a lubricated long yoke roller (1-130) into slot of yoke pin nut (1-30) .

NOTE: Align holes of both installed yoke rollers (1-40) and (1-130).

10.14 Apply lubricant to yoke pin (1-50) and install into the installed middle and lower yoke rollers (1-40).

10.15 Install final lubricated short yoke roller (1-40) on yoke pin (1-50).

10.16 Apply lubricant to surfaces of upper trunion area of yoke (1-330) and upper yoke bushing (1-110).

10.17 Install upper yoke bushing (1-110) over upper trunion of yoke (1-330).

10.18 Install outer rail (1-140) with shoulder bolts (1-420). Again, use adapter piece to support rail until tie bars are installed.

10.19 Torque shoulder bolts (1-420) to 150 foot pounds / 203 N-m lubricated.

10.20 Apply lubricant to rod bushings (2-50) and (3-80) and install into housing (1-10).

NOTE: Do not tighten the piston rods (2-70) and (3-110).

10.21 Install both piston rods (2-70) and (3-110) into yoke pin nut. Use wrench flats on outboard end.

10.22 If removed, install Bettiswitch cover (1-150) and hole cover gasket (6-40) onto housing cover (1-10).

10.23 Install socket cap screw (1-190) with lockwasher (1-220) through switch cover (1-150), cover gasket (6-40) and into housing cover (1-20).

10.24 Install the cover gasket (6-10) housing flange on top of housing (1-10).

10.25 Install cover (1-20) to housing (1-10).

10.26 Install gasket seals (6-80) on to hex cap screws (1-170).

NOTE: Do not tighten the cover hex cap screws (1-170).

10.27 Install hex cap screws (1-170) with gasket seal (6-80) through housing cover (1-20), cover gasket (6-10) and into housing (1-10).

10.28 If removed, install cover pins (1-160) into housing until the cover pins are flush with top of housing cover (1-20).

10.29 Tighten cover hex cap screws (1-170).

10.30 Torque tighten piston rods (2-70) and (3-110) to a torque of 166 ±8 foot pounds / 225 ±22 N-m lubricated.

10.31 Install position indicator (1-410) and yoke weather cover (6-110). NOTE: With yoke (1-330) at mid-stroke, position indicator (1-410) will point away at approximately 45° degrees to the right (about 2 o'clock position).

10.32 Install and tighten hex cap screws (1-170) with gasket seals (6-80) through position indicator (1-410), yoke weather cover (6-110) and into the top of yoke (1-330).

NOTE: Hex cap screws (1-170) will require rechecking for tightness after the actuator has been cycled a few times.

11.0 PNEUMATIC CYLINDER REASSEMBLY (RIGHT SIDE)

NOTE: The parts and seals used in the pneumatic cylinder (2-10) will be assembled using lubricant as identified in Section 4 step 4.9.

11.1 Rotate the yoke (1-330) to full counter-clockwise (CCW) position leaving a minimum of piston rod (2-70) protruding from housing (1-10).

11.2 Install end cap gasket (6-20) over piston rod (2-70), rod bushing (2-50) and against side of housing (1-10).

NOTE: Install rod seal (4-60) with the imbedded energizer ring facing outboard side of inner end cap (2-40) - away from housing (1-10).

11.3 Apply lubricant to rod seal (4-60) and install into recess (counterbore) provided in inner end cap (2-40).

NOTE: O-ring seals (4-10) may have seal grooves formed in the end caps by a "staked" in place washers. Check position and placement of washers before installing o-ring seals. If washers are loose then re-stake the washers.

11.4 Apply lubricant to o-ring seals (4-10). Install seals in both inner end cap (2-40) and outer end cap (2-30).

CAUTION: Exercise extreme care during inner end cap installation in order to prevent damage to the rod seal (4-60).

11.5 Install inner end cap (2-40) over piston rod (2-70), rod bushing (2-50) and against right hand side of housing (1-10).

11.6 Align inner end cap tie bar holes with the holes in the side of housing (1-10) and the holes in the rails (1-140). Rail alignment tool (see last page of this procedure) if used, will help with alignment.

NOTE: Pressure ports in the end caps should be above the actuator centerline.

11.7 Install a matched set of split ring halves (2-80) into the inner most groove in the piston rod and retain with one of the split ring retainers (2-90).

11.8 Coat the ends of the piston rod (2-70) with lubricant.

11.9 Apply lubricant to the o-ring seal (4-20) and place into the seal groove of piston rod (2-170).

11.10 Apply lubricant to o-ring seals (4-10) and install into tie bar bores in piston (2-20).

11.11 Apply lubricant to o-ring seal (4-30) and install into the outer diameter seal groove of inner end cap (2-40).

NOTE: Ribbed sections of piston (2-20) will face away from housing.

11.12 Install piston (2-20) onto piston rod (2-70).

11.13 Install a matched set of split ring halves (2-80) into the outer most groove in piston rod (2-70) and retain with one of the split ring retainers (2-90).

NOTE: The original seal used in the outer diameter seal groove of piston (2-20) was a piston T-seal with two back-up rings. The replacement seal for this location is a Bettis D-ring seal (no back-up rings are required). The D-ring seal is directly interchangeable with the T-seal.

11.14 Coat D-ring seal (4-50) with lubricant and install into the piston external seal groove with the flat side of the D-ring installed down into the seal groove.

NOTE: Remove rail alignment tool pieces one at a time as the tie bars (2-60) are installed.

11.15 Insert tie bars (2-60) through piston (2-20), inner end cap (2-40) and screw into the right hand side of housing (1-10).

NOTE: All tie bar surfaces, except threads, can be coated with lubricant.

CAUTION: Tighten the tie bars until the threads bottom out, then back out each tie bar one-half (1/2) turn.

- 11.16 If removed, install stop screw (1-90) into outer end cap. Adjust stop screw back to setting recorded in Section 6 after step 6.1.
- 11.17 Apply lubricant to the bore of cylinder (2-10).
- 11.18 Install the lubricated cylinder (2-10) over piston (2-20) and onto the inner end cap (2-40). When installing the cylinder over the piston seal tilt cylinder 15° to 30° degrees to the piston rod.

CAUTION: If needed, when installing the cylinder, hammer on the end of the cylinder only with a non metallic object.

- 11.19 Apply lubricant to o-ring seal (4-30) and install into the outer diameter seal groove of outer end cap (2-30).
- 11.20 Install outer end cap (2-30) onto tie bars (2-60) and inside cylinder (2-10).
- 11.21 Install tie bar nut assemblies (2-100) onto tie bars (2-60). Use the tie bar nuts to draw all cylinder components into position.

CAUTION: While tie bar nuts (2-100) are being tightened do not allow tie bars (2-60) to rotate.

- 11.22 Torque tighten tie bar nuts (2-100) to approximately 150 ±15 foot pounds / 203 ±20 N-m lubricated.
- 11.23 Apply lubricant to o-ring seal (6-60) and install in stop screw nut (1-100).

NOTE: It is necessary that the flats on the tie bar hex nuts (2-100) be aligned and parallel before the stop screw nut (1-100) can be installed.

- 11.24 Install and tighten stop screw nut (1-100) onto stop screw (1-90).

12.0 TANDEM POWER CYLINDER REASSEMBLY

NOTE: The parts and seals used in steps 12.1 through 12.21 will be assembled using lubricant as identified in Section 4 step 4.9.

- 12.1 Rotate the yoke (1-330) to full clockwise (CW) position leaving a minimum of piston rod (3-110) protruding from housing (1-10).
- 12.2 Install final end cap gasket (6-20) over piston rod (3-110), rod bushing (3-80) and against left hand side of housing (1-10).

NOTE: Install rod seal (5-40) with the imbedded energizer ring facing outboard side of inner end cap (3-30) - away from housing (1-10).

- 12.3 Apply lubricant to rod seal (5-40) and install into the recess (counterbore) provided in the inner end cap (3-30).

- 12.4 Coat two tie bar o-ring seals (5-60) with lubricant and install onto the inboard end of the inner end cap (3-30) in the o-ring grooves provided.

CAUTION: Exercise extreme care during inner end cap (3-30) installation in order to prevent damage to the rod seal (5-40).

NOTE: Install inner end cap (3-30) with the large raised boss toward the housing (large area flat side outward).

- 12.5 Install inner end cap (3-30) over piston rod (3-110), bushing (3-80) and against left hand side of housing (1-10).

- 12.6 Align inner end cap tie bar holes with the holes in the side of housing (1-10) and the holes in the rails (1-140). Rail alignment tool (see last page of this procedure) if used, will help with alignment.

NOTE: Pressure ports in the end caps should be above the actuator centerline.

- 12.7 Coat the (inboard) first section of three grooves on the piston rod (3-110) with lubricant.

- 12.8 Install a matched set of split ring halves (3-120) into the inner most groove in piston rod (3-110) and retain with one of the split ring retainers (3-130).

- 12.9 Apply lubricant to o-ring seal (5-90) and install into the outer diameter seal groove of outer end cap (3-30) installed in step 12.5.

- 12.10 Apply lubricant to o-ring seals (5-60) and install into tie bar bores in piston (3-20).

- 12.11 Apply lubricant to the o-ring seal (5-10) and place into the innermost seal groove of piston rod (3-110) groove next to the split ring halves (3-120) installed in step 12.8.

NOTE: Ribbed sections of piston (3-20) will face away from housing.

- 12.12 Install piston (3-20) onto piston rod (3-110) against split ring halves (3-120) installed in step 12.8.

- 12.13 Install a matched set of split ring halves (3-120) into the piston rod groove next to the piston installed in step 12.12 and retain with one of the split ring retainers (3-130).

NOTE: The original seal used in the outer diameter seal groove of piston (3-20) was a piston T-seal with two back-up rings. The replacement seal for this location is a Bettis D-ring seal (no back-up rings are required). The D-ring seal is directly interchangeable with the T-seal.

- 12.14 Coat D-ring seal (5-100) with lubricant and install into the external seal groove of piston (3-20) with the flat side of the D-ring installed down into the seal groove.

NOTE: Remove rail alignment tool pieces one at a time as the tie bars (3-100) are installed.

12.15 Insert tie bars (3-100) through the piston (3-20), inner end cap (3-30) and screw into the left hand side of housing (1-10).

CAUTION: Tighten tie bars (3-100) until the threads bottom out, then back out each tie bar one-half (1/2) turn.

NOTE: All tie bar surfaces, except threads, can be coated with lubricant.

12.16 Apply lubricant to the bore of cylinder (3-10).

CAUTION: If needed, when installing cylinder (3-10), hammer on the end of the cylinder only with a non metallic object.

12.17 Install the lubricated cylinder (3-10) over piston (3-20) and onto the inner end cap (3-30). When installing the cylinder over the piston seal tilt cylinder 15° to 30° degrees to the piston rod.

12.18 Apply lubricant to two end cap tie bar o-ring seals (5-60) and install into the end cap (3-30) in the internal o-ring seal grooves.

12.19 Apply lubricant to the end cap cylinder o-ring seal (5-90) and install into the outer diameter seal groove of end cap (3-30).

12.20 Install end cap (3-30) onto the tie bars, piston rod and into the outboard end of cylinder (3-10). NOTE: Rod seal cavity (counterbore) facing away from housing (1-10).

NOTE: Install rod seal (5-50) with the imbedded energizer ring facing into the counterbore of end cap (3-30) – toward housing (1-10).

12.21 Apply lubricant to rod seal (5-50) and install into end cap (3-30) installed in step 12.20.

12.22 Apply lubricant to rod bushing (3-90), install it over the piston rod (3-110) and slide it up into the recess in end cap (3-30) installed in step 12.20.

NOTE: The parts and seals used in steps 12.21 through 12.44 will be assembled using fluid as identified in Section 4 step 4.10.

NOTE: Slot in end cap gasket (101) will be install pointing to the actuator down position.

12.23 Install end cap gasket (101) over piston rod (3-110), rod bushing (3-90) and against end cap (3-30) installed in step 12.20.

NOTE: Install final rod seal (5-50) with the imbedded energizer ring facing into the counterbore of end cap (3-60) – when end cap is installed on the piston rod the imbedded energizer ring will face away from housing (1-10).

12.24 Coat final rod seal (5-50) with fluid and install into end cap (3-60). This inner end cap will be the smaller diameter end cap.

12.25 Coat two tie bar o-ring seals (3-60) with fluid and install onto the inner end cap (3-60) in the o-ring grooves provided.

NOTE: Inner end cap (3-60) to be installed with the pressure inlet port facing down.

12.26 Install inner end cap (3-60) over the piston rod (3-110), rod bushing (3-90) and against end cap (3-30).

12.27 Apply fluid to o-ring seal (5-20) and install onto the outer diameter seal groove of inner end cap (3-60).

12.28 Apply fluid to two o-rings (5-60) and install into the piston inner diameter seal grooves (3-50).

12.29 Coat the second section of three grooves (outboard end) in piston rod (3-110) with fluid.

12.30 Install a matched set of split ring halves (3-120) into the inner most exposed groove in piston rod (3-110) and retain with one of the split ring retainers (3-130).

12.31 Apply fluid to o-ring (5-10) and install into the piston rod (3-110).

NOTE: Ribbed sections of piston (3-50) will face away from housing.

12.32 Install piston (3-50) onto piston rod (3-110) against the split ring halves (3-120) install in step 12.30.

12.33 Install a matched set of split ring halves (3-120) into the piston rod groove next to the piston installed in step 12.32 and retain with one of the split ring retainers (3-130).

NOTE: The original seal used in the outer diameter seal groove of piston (3-20) was a piston T-seal with two back-up rings. The replacement seal for this location is a Bettis D-ring seal (no back-up rings are required). The D-ring seal is directly interchangeable with the T-seal.

12.34 Coat D-ring seal (5-30) with lubricant and install into the external seal groove of piston (3-50) with the flat side of the D-ring installed down into the seal groove.

12.35 Apply fluid to the bore of the cylinder (3-40).

CAUTION: If needed, when installing cylinder (3-40), hammer on the end of the cylinder only with a non metallic object.

12.36 Install the lubricated cylinder (3-40) over piston (3-50) and onto the inner end cap (3-60). When installing the cylinder over the piston seal tilt cylinder 15° to 30° degrees to the piston rod.

12.37 Apply fluid to the final two o-ring seals (5-60) and install into the outer end cap (3-70).

12.38 Apply fluid to o-ring seal (5-20) and install into the outer diameter seal groove of outer end cap (3-70).

12.39 Install outer end cap (3-70) onto tie bars (3-100) and into the end of cylinder (3-40).

NOTE: It is necessary that the flats on the tie bar hex nuts (3-140) be aligned and parallel before the stop screw nut (1-100) can be installed.

12.40 Install the two tie bar nuts (3-140) on the tie bars (3-100) using them to draw all of the cylinder components into position.

CAUTION: While tie bar nuts (3-140) are being tightened do not allow tie bars (3-100) to rotate.

12.41 Torque tighten tie bar nuts (3-140) to approximately 150 ±15 foot pounds / 203 ±20 N-m lubricated.

12.42 If removed, install stop screw (1-90) into outer end cap (3-70). Adjust stop screw back to setting recorded in Section 7 after step 7.1.

12.43 Coat o-ring (6-60) with lubricant and install into stop screw nut (1-100).

NOTE: It is necessary that the flats on the tie bar hex nuts (3-140) be aligned and parallel before the stop screw nut (1-100) can be installed.

12.44 Install stop screw nut (1-100) onto outer end cap (3-70) and over stop screws (1-90).

13.0 ACTUATOR TESTING

13.1 **Leak Test - General** - A small amount of leakage may be tolerated. Generally, a small bubble which breaks about three seconds after starting to form is considered acceptable.

13.2 All areas, where leakage to atmosphere may occur, are to be checked using a commercial leak testing solution.

WARNING: Pressure is not to exceed the maximum operating pressure rating listed on the name tag.

13.3 All leak testing will use 65 psig/4.48 bar pressure or the pressure used by the customer to operate actuator during normal operation.

CAUTION: Test the actuator using a properly adjusted self relieving regulator, with gauge.

13.4 Prior to testing for leaks, alternately apply and release pressure, as defined in step 13.3, to the each side of the piston to stroke the actuator fully. Repeat this cycle approximately five times. This will allow the new seals to seek their service condition.

NOTE: Steps 13.5 through 13.8 will be performed on the actuator right hand side pneumatic cylinder and steps 13.9 through 13.12 will be performed on the actuator left hand side pneumatic cylinder (tandem cylinder).

13.5 Apply 65 psig/4.48 bar pressure to the pressure port in the outer end cap (2-30).

13.6 Apply a leak testing solution to the following areas:

13.6.1 Joint between outer end cap (2-30) and cylinder (2-10). Checks cylinder to end cap o-ring seal.

13.6.2 Around tie bar nuts (2-100) on the cylinder outer end cap (2-30). Checks tie bars to outer end cap o-ring seals.

13.6.3 The pressure inlet port in inner end cap (2-40). Checks piston to cylinder, piston to tie bar, and piston to piston rod seals.

13.6.4 Remove pressure from pressure inlet port in the outer end cap.

13.7 Apply 65 psig/4.48 bar pressure to the pressure port in the inner end cap (2-40).

13.8 Apply a leak testing solution to the following areas:

13.8.1 Joint between inner end cap (2-40) and cylinder (2-10). Checks cylinder to inner end cap o-ring seal.

13.8.2 Around the joint of inner end cap (2-40) and housing (1-10). Checks tie bars to inner end cap o-ring seals and the inner end cap to housing gasket seal (6-20).

13.8.3 The breather (1-270) in the side of housing (1-10). Checks the rod seal and tie bars to end cap o-ring seals.

11.8.4 Remove pressure from pressure inlet port in the inner end cap.

13.9 Apply 65 psig/4.48 bar pressure to the pressure port in the inner end cap (3-30).

- 13.10 Apply a leak testing solution to the following areas:
- 13.10.1 Joint between inboard end cap (3-30) and cylinder (3-10). Checks cylinder to end cap o-ring seal.
 - 13.10.2 Around the joint of inboard end cap (3-30) and housing (1-10). Checks tie bars to inner end cap o-ring seals and the inner end cap to housing gasket seal (6-20)..
 - 13.10.3 The pressure inlet port in the outboard end cap (3-30). Checks piston to cylinder, piston to tie bar, and piston to piston rod seals.
 - 13.10.4 The breather (1-270) in the side of housing (1-10). Checks the rod seal and tie bars to end cap o-ring seals.
 - 13.10.5 Remove pressure from pressure inlet port in the outer end cap.
- 13.11 Apply 65 psig/4.48 bar pressure to the pressure port in the outboard end cap (3-30).
- 13.12 Apply a leak testing solution to the following areas:
- 13.12.1 Joint between outboard end cap (3-30) and cylinder (3-10). Checks cylinder to inner end cap o-ring seal.
 - 13.12.2 Around the joint of outboard end cap (3-30) and inner end cap (3-60). Checks tie bars to outboard end cap o-ring seals and the out board end cap (3-30) rod seal (5-50).
 - 13.12.3 Remove pressure from pressure inlet port in the inner end cap.
- 13.13 If an actuator was disassembled and repaired, the above leakage test must be performed again.
- 13.14 Hydraulic override and cylinder will be tested when the fluid is added to the M4 override (8).

14.0 M4 HYDRAULIC CONTROL INSTALLATION

- NOTES:
- 1. The M4 must be mounted with reservoir upright with the pump shaft horizontal.
 - 2. Recommend that a non hardening thread sealant, compatible with petroleum base hydraulic fluid be used in this system.
 - 3. For M4 disassembly and reassembly information refer to Section 4 step 4.8.

CAUTION: Do not use Teflon tape to seal hydraulic system threads.

- 14.1 If the M4 (8) was mounted on the actuator then reinstall it on the hydraulic control cylinder assembly -M4 (3-20).
- 14.2 Hook up piping from the M4 hydraulic control block to cylinder ports.

15.0 M4 REFILLING INSTRUCTIONS

- 15.1 Refilling of the M4 hydraulic control system and actuator cylinder is best accomplished using a pressure pump. Put the actuator in the closed position (CW) and proceed using the following steps.
- 15.2 Remove the breather from the reservoir. Be sure drain plugs (3-160) are installed in hydraulic cylinder.
- 15.3 Attach the pump discharge line to reservoir breather port.
- 15.4 Open both speed control valves.
- 15.5 Open the two bleed valves (3-170), located at each end of the hydraulic cylinder.
- 15.6 Slowly pump hydraulic fluid into the reservoir. Approximately three to five PSI will be required. As the hydraulic fluid passes through the M4 control block into the cylinder, air will be displaced.
- 15.7 Close each bleed valve (3-170) when the air has been displaced and hydraulic fluid appears.
- 15.8 Remove pump discharge line from reservoir breather port.
- 15.9 Adjust fluid level to 1-1/2" inches or 40mm from top of reservoir with actuator in open (CCW) position.
- 15.10 Re-install breather removed, in step 15.2.

16.0 ALTERNATE REFILLING INSTRUCTIONS

- 16.1 Refilling the M4 hydraulic control system, during field service, often must be done without the use of a pressure pump. Proceed as follows:
 - 16.2 Put the actuator in the closed position (CW).
 - 16.3 Remove the breather from the reservoir.
 - 16.4 Fill the reservoir approximately three-fourths full.
 - 16.5 Open both speed control valves.
 - 16.6 Open the bleed valve (3-170) on the outboard end of the hydraulic cylinder only.
 - 16.7 Rotate the handle slowly, clockwise, until all air has escaped from the system.
 - 16.8 Close the bleed valve opened in step 16.6.
- NOTE: During the fill procedure, it is important that the lowest fluid level be not less than approximately one-fourth of the reservoir volume at any time.
- 16.9 Open the bleed valve (3-170) on the inboard end of the hydraulic cylinder.

- 16.10 Rotate the handle slowly, counter-clockwise, until all air has escaped from the system.
- 16.11 Close the bleed valve opened in step 16.9. During the fill procedure, the piston will not move. This may be determined by observing the position indicator (1-410) on the actuator.
- 16.12 Adjust fluid level to 1-1/2" inches or 40mm from top of reservoir with actuator in open (CCW) position.
- 16.13 Re-install breather removed in step 16.3.

17.0 ADDITIONAL M4 INSTRUCTIONS

- 17.1 This is performed to insure air is removed from the system (most likely air in pump) and to test the operation of M4 override.
- 17.2 Turn M4 crank arm clockwise (CW). The actuator should move clockwise as well. Adjust outboard bleed valve (3-170) to remove air from system.
- 17.3 Turn M4 crank arm counter clockwise (CCW). The actuator will move counter-clockwise. Adjust inboard bleed valve to remove air from system.
- 17.4 With bleed valves closed, stroke actuator full 90°, clockwise (CW) and counter clockwise (CCW), using M4 override.

18.0 RETURN TO SERVICE

- 18.1 After actuator is reinstalled on the device it is to operate all accessories should be hooked up, leak tested, and then tested for proper operation and replaced if found defective.
- 18.2 The actuator should now be ready to return to service.

PRESSURE REQUIREMENTS & LIMITATIONS FOR TRI02XX-M4 ACTUATORS					
ACTUATOR MODEL	NOMINAL OPERATING PRESSURE (NOP)	MAXIMUM OPERATING PRESSURE (MOP)		SHELL TEST PRESSURE	
		PSIG	BAR	PSIG	BAR
TR10210-M4	Customer Spec. or N.A.	200	13.79	250	17.24
TR10212-M4	Customer Spec. or N.A.	200	13.79	250	17.24
TR10216-M4	Customer Spec. or N.A.	150	10.34	250	17.24
TR10220-M4	Customer Spec. or N.A.	100	6.89	162	11.17
TR10224-M4	Customer Spec. or N.A.	75	5.17	106	7.31

ACTUATOR DISPLACEMENT				
ACTUATOR MODEL	DISPLACEMENT			
	CLOCKWISE (CW)		COUNTER CLOCKWISE (CCW)	
	INCH ³	LITERS	INCH ³	LITERS
TR10212-M4	4611.6	76	4753.1	78
TR10216-M4	7592.6	124	7674.1	126
TR10220-M4	12121.4	199	12202.9	200

ACTUATOR APPROXIMATE WEIGHT		
ACTUATOR MODEL	WEIGHT	
	POUNDS	KILOGAMS
TR10210-M4	2278	1033
TR10212-M4	2396	1086
TR10216-M4	2470	1120
TR10220-M4	2714	1231

RAIL ALIGNMENT TOOL FOR TR/TRQ ACTUATORS

