

SERVICE INSTRUCTIONS

ASSEMBLY & DISASSEMBLY

T30X.X-M4 & T40X.X-M4 SERIES HYDRAULIC ACTUATORS

INTRODUCTION

This service procedure is offered as a guide to enable general maintenance to be performed on GH-Bettis T30X.X-M4 & T40X.X-M4 'Scotch-Yoke' type hydraulic actuators. NOTE: This does not include those actuators (5000 PSI) that use the Miller cylinder mod. as hydraulic cylinder.

BASIC TOOLS

Large Adjustable Wrench, Screwdriver, Pipe Wrench, (1/4") Drift Punch, 24 oz. Ball Peen Hammer, Allen Wrench Set, Pry Bar, 1/2" Drive Socket Set, and Torque Wrench (up to 3000 in. lbs.).

REFERENCE GH-BETTIS MATERIALS

T30X.X-M4 Assembly Drawing 60893 & Base I Dimensional Drawing 42387
T40X.X-M4 Assembly Drawing 38739 & Base I Dimensional Drawing 42389
Operating, Storage and Maintenance Instructions for GH-Bettis Hydraulic Rotary Valve Actuators (O/P Maint-002)
GH-Bettis M4B Hydraulic Control System Operating Instructions (OP/MAINT-005).

DISASSEMBLY - HYDRAULIC CYLINDER (M4)

NOTE: Numbers in parenthesis () indicate the bubble number (reference number) used on GH-Bettis Assembly Drawing and Actuator Bill of Material.

1. Remove all operating pressure from actuator power cylinder and cylinder adapter. Remove all piping and accessories mounted on actuator.
2. Remove M4 Hydraulic Control (8) NOTE: Plug 3/8" NPT ports as foreign material may enter the system and cause the unit to malfunction.
3. Drain the hydraulic fluid from hydraulic cylinder (4-10) by removing the cylinder drain plugs (4-150). They are located on outboard and inboard end of hydraulic cylinder bottom side.
4. Drain the hydraulic fluid from hydraulic cylinder (2-10) by removing the cylinder drain plugs (2-80). They are located on the outboard end and inboard end of hydraulic cylinder - bottom side.
5. Remove socket cap screws (4-120), lockwasher (4-110) and nut retainer (4-100).

6. Remove hex nuts (4-90) from tie bars (4-60).
7. Remove outer end cap (4-30). The fit between the cylinder (4-10) and the outer end cap is very tight. Break the outer end cap free by tapping with a breaker bar on the lip provided on the end cap. NOTE: DO NOT DAMAGE O-RING GROOVE ON END CAP.
8. Pry inner end cap (4-40) away from the housing (1-10). Break the inner end cap free from the cylinder (4-10) by tapping with a breaker bar on the lip provided on the end cap.
9. Remove the cylinder (4-10).
10. Remove the ring retainer (4-80) and the split ring (4-70) from the outboard side of the piston (4-20).
11. Remove the piston (4-20) from the piston rod (4-170). The piston will slide off of the piston rod.
12. Remove o-ring seal (5-40).
13. Remove the split ring retainer (4-80) and the split ring (4-70) from the inboard side of the piston.
14. Slide the inner end cap (4-40) off over the tie bars (4-60) and piston rod (4-170).
15. Remove rod bushing (4-50) and rod seal (5-70). The bushing and rod seal will slide off of the end of the piston rod.
16. Unscrew the tie bars (4-60) from the housing (1-10). Flats are provided on the outboard end of the tie bars for wrench placement. DO NOT use a pipe wrench on the tie bars as it will mark the bar and cause seal leakage.

DISASSEMBLY - HYDRAULIC CYLINDER (POWER)

1. Remove socket cap screws (2-140) and lockwashers (2-130) from cylinder assembly (2-10).
2. Apply downward pressure on end of cylinder assembly (2-10). By canting cylinder up and down, assembly should break free from adapter (2-40).
3. Remove hex nut (2-100) and lockwasher (2-110) from piston rod (2-170).
4. Piston seal retainers (2-70) and piston (2-20) will slide off the piston rod (2-170).
5. Remove piston seals (3-90) and piston head seal (3-40) from piston (2-20).
6. Remove o-ring seal (3-30) and back-up ring (3-120) from cylinder adapter (2-40).

GENERAL DISASSEMBLY

1. Remove four socket cap screws (1-180) from position indicator (1-170), yoke weather cover (3-130) and remove position indicator/yoke weather cover.
2. Unscrew piston rod (2-170) from yoke pin nut (1-30) and remove. Flats are provided for wrench placement. DO NOT use a pipe wrench on the piston rod as it will mark the rod and cause seal leakage.
3. Unscrew piston rod (4-170) from yoke pin nut and remove. Flats are provided on the outboard end of the piston rod for wrench placement. DO NOT use a pipe wrench on the piston rod as it will mark the rod and cause seal damage.
4. Remove cover screws (1-90) and gasket seals (3-100).
5. Remove housing cover (1-20). NOTE: This piece will have a very tight fit.
6. Remove the top two yoke rollers (1-50) from the top of the yoke pin (1-40). Remove yoke pin (1-40).
7. Remove yoke pin nut (1-30).
8. Remove bottom two yoke rollers (1-50) from the housing. You may have to swing yoke (1-160) to one side in order to install bottom rollers.
9. The yoke (1- 160) can now be removed by lifting it from the housing.
10. Remove socket cap screws (2-120) and lockwashers (2-130) from inside housing (1-10). NOTE: T3 units will have a quantity of three screws and T4's will have four.
11. Slide cylinder adapter (2-40) away from housing. Remove rod seal (3-70) from adapter.
12. Remove rod bushing (2-50) from housing.

NOTE: It is not necessary to remove the stop screws, drain plug or grease fittings to service the actuator.

GENERAL RE-ASSEMBLY

Remove all old seals and gaskets, taking care not to scratch or damage seal grooves.

Before starting the assembly of an actuator, all parts should be thoroughly cleaned, inspected and deburred. Particular attention should be directed to threads, sealing surfaces and areas that will be subjected to sliding motion. After inspection, the parts should be carefully cleaned to remove all dirt, gaskets and other foreign material.

LUBRICATION REQUIREMENTS

1. Standard and high temperature service (-200° F to 350° F) use Kronaplate 100. Reference GH-Bettis Engineering Standard ESL 5.
2. Low temperature service (-100° F to 300° F) use Aeroshell 17. Reference GH-Bettis Engineering Standard ESL-4.

FLUID REQUIREMENTS

1. Standard and high temperature service (-35° F to 350° F) use Exxon Dexron II Automatic Transmission Fluid. Identification #D-20106. Reference GH-Bettis Engineering Standard F-SF 1.
2. Low temperature service (-65° F to 180° F) use Exxon Univis J13 Hydraulic Fluid. Reference GH-Bettis Engineering Standard ESF 2.

CENTER HOUSING GROUP RE-ASSEMBLY

1. If removed install drain plug (1-80) in actuator housing (1-10).
2. If removed install grease fitting (1-70) in the actuator housing (not shown on assembly drawing). This fitting is located on the bottom of the housing next to the lower yoke bearing area. NOTE: Grease fittings optional as of 3/1/83.
3. Take all the yoke rollers (1-50) and check to see if they will run (move) freely thru the tracks in the bottom of the housing and the housing cover.
4. Coat the yoke o-ring seal (3-50) with grease and install into the housing (1-10). with the yoke bore nearest you and top of housing (gasket surface) facing up.
5. Inside the housing (1-10) apply grease to the tracks and yoke bore and orient the housing with the yoke nearest you and top of housing (gasket surface) facing up.
6. Apply grease to the yoke (1-160) lower bearing surface and install into the housing (1-10) as follows: Orient the yoke arm to approximately a 45° position in either direction and lower into the housing. The hub with tapped holes faces up. Rotate the yoke back to approximately the mid-stroke (center) position.
7. Apply grease to the slots in the upper and lower yoke arm.
8. Apply grease to all surfaces of all four yoke rollers (1-50). Place one yoke roller (1-50) in the bottom track of the housing and position it under the slot in the yoke arms. Place a second yoke roller on top of the first yoke roller in the slot in the lower yoke arm and align the holes in the yoke rollers.

9. Coat the upper and lower surfaces of the yoke pin nut (1-30) with grease and insert into position between the yoke arm, parallel to the track in the housing. Align the yoke pin hole with the yoke rollers.
10. Grease the yoke pin (1-40) and insert through the yoke pin nut (1-30) and the two yoke rollers (1-50).
11. Apply grease to all the surfaces of the two remaining yoke rollers (1-50).
12. Install the third yoke pin roller over the yoke pin in the slot in the upper yoke arm and now install the fourth and last remaining yoke roller on top of the yoke roller you just installed in the upper yoke arm slot.

NOTE: The top roller will remain above the yoke arm and will engage the cover track when cover is installed.

13. Install piston rod (2-170) into housing (1-10). Slide into the right side of housing and screw into the yoke pin nut (1-30). (DO NOT TIGHTEN) Flats are provided on the outboard end of the piston rod. These flats should be used to put a wrench on to tighten the piston rod. DO NOT use a pipe wrench on the piston rod, as it will cause seal leakage.
14. Install piston rod (4-170) in housing. Slide into the left side of housing and screw into the yoke pin nut. (DO NOT TIGHTENING). Flats are provided on the outboard end of the piston rod. These flats should be used to put a wrench on to tighten the piston rod. DO NOT use a pipe wrench on the piston rod, as it will cause seal leakage.
15. Apply grease to the rod bushing (2-50), install it over the piston rod and slide it up into the housing.
16. Coat end cap gasket (3-10) with grease on both sides and install over the piston rod end bushing.
17. Coat the rod seal (3-70) with fluid and install into the recess provided in the cylinder adapter. Be sure that the seal lips are installed first, with heel of seal facing housing.
18. Install cylinder adapter (2-40) over piston rod and slide adapter up against housing. As adapter is installed, be sure to align bolt holes in housing.
19. Fasten cylinder adapter (2-40) to housing (1-10) with socket cap screws (2-120) and lockwashers (2-130) from inside housing.

NOTE: Yoke (1-160) will have to be orientated to full counter-clockwise position, opposite cylinder adapter.

20. Do this step only if you have removed the housing stop screws (1-60). Place gasket (3-110) and jam nut (1-110) on the stop screw (1-60). Install stop screws in the housing. Screw the jam nut down against the actuator housing finger tight.

21. Apply a thin coating of grease to the housing cover gasket (3-20) surface.
22. Place the housing cover gasket (3-20) on the housing (1-10).
23. Coat the yoke o-ring seal (3-50) with grease and install in cover (1-20).
24. Apply grease to the cover yoke bore and the track in the housing cover (1-20). Apply a thin coat of grease to the gasket surface.
25. Apply grease to the yoke upper bearing surface.
26. Install the housing cover (1-20), being careful not to damage the gasket (3-20) or yoke o-ring (3-50).
27. Install the cover screws (1-90) and seal gasket (3-100). LEAVE FINGER TIGHT - DO NOT TIGHTEN.
28. Do this step only if you have pulled the cover pins (1-120) or if you are replacing the cover pins. Drive the four pins (1-120) thru the cover (1-20) and into the housing (1-10) until the pin is flush with the cover.

NOTE: The pins are deeply grooved at one end, tapering to a smooth diameter at the other end. The pin should be installed smooth end first.
29. Tighten the cover screws (1-90).
30. Tighten the piston rod (4-170) to a torque of approximately 150 ft. lbs. (1800 in. lbs.). Flats are provided on the outer end for wrenching purposes. DO NOT USE A PIPE WRENCH OR SIMILAR TOOL TO TIGHTEN PISTON ROD.
31. With the yoke rotated to the full clockwise (cw) position (as shown on the assembly drawing) position the yoke weather cover (3-130)/position indicator (1-170) on the yoke with the pointer facing the front and perpendicular to the piston rods (2-170 & 4-170), secure with socket head cap screws (1-180).
32. Rotate the yoke to the full counter-clockwise position, leaving a minimum of the piston rod (2-170) protruding from the actuator housing.

POWER HYDRAULIC CYLINDER RE-ASSEMBLY

1. Coat o-ring seal (3-30) and back-up ring (3-130) with hydraulic fluid and install in cylinder adapter (2-40). NOTE: Back-up ring will be installed in the groove between the o-ring and the 'housing-side' of the groove.
2. Coat o-ring seal (3-40) with hydraulic fluid and install in piston (2-20).

3. Coat piston seals (3-90) with hydraulic fluid and install on piston (2-20). They should simply slide onto the piston.
4. Install piston seal retainer (2-70) over piston rod (2-170).
5. Coat piston rod (2-170) with hydraulic fluid (threaded end) and slide piston (2-20) into place.
6. Install last piston seal retainer (2-70).
7. Install lockwasher (2-110) and heavy hex nut (2-100) onto piston rod. Torque to 200 foot pounds maximum (2400 in. lbs.). Piston rod will be tightened as well.
8. If removed, install drain plugs (2-80) into cylinder assembly (2-10).
9. Coat cylinder adapter (2-40) and cylinder assembly cylinder bore (2-10) with hydraulic fluid. Install cylinder assembly over adapter.
10. Fasten cylinder assembly (2-10) with socket cap screws (2-140) and lockwasher.
11. Fill hydraulic cylinder (both inboard and outboard) with fluid until 'full'; if removed, install bleed valves (2-90).

M4 HYDRAULIC CYLINDER RE-ASSEMBLY

1. Apply grease to the rod bushing (4-50), install it over the piston rod and slide it up into the housing.
2. Coat the rod seal (5-70) with fluid and install into the recess provided in the inner end cap.

NOTE: Rod seal is a bi-directional seal and will seal in both directions.
3. Coat the end cap gasket (3-10) with grease on both sides and install over the piston rod and rod bushing.
4. Slide the inner end cap (4-40) over the piston rod (4-170) and the rod bushing (4-50), protruding from the housing.

NOTE: Exercise extreme care during installation, in order to prevent damage to the rod seal (5-70).
5. Apply fluid to the end cap o-ring seal (5-60) and install on the inner end cap (4-40).
6. Apply fluid to two sets of piston tie bar T-seal components (5-80) and install into the piston (4-20).
7. Apply fluid to the piston o-ring (5-40) and place onto the piston rod (4-170).
8. Coat the ends of the piston rod (4-170) with fluid.

9. Install the two halves of the split ring (4-70) into the inner most groove in the piston rod and retain with one of the spiral retaining rings (4-80).
10. Slide the piston (4-20) onto the piston rod against the split ring (4-70).

NOTE: Piston seal groove side of piston will face housing.

11. Install the two halves of the remaining split ring (4-70) onto the piston rod and retain with the spiral retaining ring (4-80).
12. Coat the piston T seal components (5-90) with fluid and install on the inner end cap (4-40).
13. Begin installation of tie bars (4-60) into housing by carefully threading tie bars through the piston (4-20) - end without wrench flat first.
14. Coat two tie bar o-ring seals (5-30) with fluid and install into the o-ring groove on the tie bar (4-60).
15. Insert tie bars (4-60) through the inner end cap (4-40) and screw into the housing (1-10).
16. Apply fluid to the bore of the cylinder (4-10) for a distance of approximately four inches (100mm).
17. Slide the lubricated end of the cylinder (4-10) over the piston (4-20) and onto the inner end cap (4-40).

NOTE: When sliding the cylinder over the piston seal cant cylinder to piston rod, make certain the back-up rings (components of the piston seal) are seated into the seal groove. Should the back-up rings or seal member be pinched between the piston and cylinder, the components could be damaged, becoming a potential source of leakage. DO NOT hammer on ends of cylinder.

Bleed valve (4-160) and cylinder pipe plug (4-150) should be orientated so the bleed valve is at the cylinders' highest point when actuator is mounted in its' final operational position.

18. Apply fluid to two end cap tie bar o-ring seals (5-30) and install into the o-ring grooves on the outer end of the tie bars (4-60).
19. Apply fluid to the outer end cap cylinder o-ring seal (5-60) and install onto the outer end cap (4-30).
20. Install the outer end cap (4-30) onto the tie bars and into the end of the cylinder (4-10).
21. Install the two tie bar nuts (4-90) on the tie bars (4-60), using them to draw all of the cylinder components into position. Torque alternately, in 50 ft. lb. increments, until a final torque of 125 ft. lbs. (1500 in. lbs.) has been achieved.

22. Install the nut retainer (4-100), securing in place with the retainer screw (4-120) and lockwasher (4-110). It is necessary that the flats on the hex nuts (4-90) be aligned and parallel before the nut retainer can be installed.

LEAKAGE

For all but the most demanding applications, a small amount of leakage may be tolerated. Generally, a small bubble which breaks about three seconds after starting to form is considered acceptable.

POWER HYDRAULIC CYLINDER TESTING

Before testing for leaks, alternately apply air at 65 PSIG to each side of the piston allowing the actuator to stroke fully in each direction. Repeat this cycle approximately five times. This will allow the seals to seek a normal working attitude.

1. Apply ten PSIG air pressure to the cylinder adapter (2-40).
2. Apply a leak testing soap solution, using a soft Ill wide brush, to the following areas:
 - a. Joint between the cylinder adapter and the cylinder assembly (2-10). (Checks the end cap adapter to cylinder assembly seal).
 - b. The air inlet in the outer end of the cylinder. (Checks piston to cylinder assembly seals).
 - c. Around the joint between the cylinder adapter and the housing (1-10).
 - d. The hole in the cover into which the breather (1-190) is to be installed. (Checks cylinder adapter to rod seal).
 - e. Increase the air pressure to 65 PSIG and repeat steps a, b, c and d above.
3. Reduce the air pressure to ten PSIG and apply it to the outer end of the cylinder (2-10).
4. Apply a leak testing soap solution, using a soft Ill wide brush to the following areas:
 - a. The air inlet to the inner end of the cylinder (2-10). (Checks piston to cylinder assembly seal).
 - b. Increase air pressure to 65 PSIG and repeat steps a, b and c above.

M4B HYDRAULIC CYLINDER TESTING

Before testing for leaks, alternately apply air at 65 PSIG to each side of the piston allowing the actuator to stroke fully in each direction. Repeat this cycle approximately five times. This will allow the seals to seek a normal working attitude.

1. Apply ten PSIG air pressure to the inner end of the cylinder (4-10).
2. Apply a leak testing soap solution, using a soft Ill wide brush, to the following areas:
 - a. Joint between the outer end cap (4-40) and the cylinder (4-10). (Checks the end cap to cylinder seal).
 - b. The air inlet in the outer end of the cylinder. (Checks piston to cylinder, piston to tie bars and piston to push rod seals).
 - c. Around the joint between the inner end cap (4-40) and the housing (1-10).
 - d. The hole in the cover into which the breather (1-190) is to be installed. (Checks the following seals: inner end cap to tie bars and inner end cap to push rod seal).
 - e. Increase the air pressure to 65 PSIG and repeat steps a, b, c and d above.
3. Reduce the air pressure to ten PSIG and apply it to the outer end of the cylinder (4-10).
4. Apply a leak testing soap solution, using a soft Ill wide brush to the following areas:
 - a. Joint between the outer end cap (4-30) and the cylinder (4-10). (Checks cylinder to end cap seal).
 - b. Around the tie bar nuts (4-90) on the cylinder end. (Checks tie bar to end cap seals).
 - c. The air inlet to the inner end of the cylinder (4-10). (Checks piston to cylinder, piston to tie bar and piston to piston rod seals).
 - d. Increase air pressure to 65 PSIG and repeat steps a, b and c above.

M4 HYDRAULIC CONTROL INSTALLATION

1. Re-install the M4 control package (8) on the hydraulic cylinder (4-10).

NOTE: The unit must be mounted with reservoir upright with the pump shaft horizontal.

2. Hook up piping from the M4 hydraulic control block to cylinder ports.

NOTE: Recommend that a non-hardening thread sealant, compatible with petroleum base hydraulic fluid (example: Rector seal #5 be used in this system).NOTE: DO NOT USE TEFLON TAPE TO SEAL HYDRAULIC SYSTEM THREADS.

M4 REFILLING INSTRUCTIONS

(See "Fluid Requirements" for fluid specifications).

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.

1. Remove the breather from the reservoir.
2. Attach the pump discharge line to reservoir breather port.
3. Open both speed control valves.
4. Open the two bleed valves (4-160), located at each end of the hydraulic cylinder.
5. 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.
6. Close each bleed valve (4-160) when the air has been displaced and hydraulic fluid appears.
7. Remove pump discharge line from reservoir breather port.
8. Adjust fluid level to 1 1/2" (40mm) from top of reservoir with actuator in open (ccw) position.
9. Re-install breather removed, in step 1.

ALTERNATE REFILLING INSTRUCTIONS

Refilling the M4 hydraulic control system, during field service, often must be done without the use of a pressure pump. Proceed as follows:

1. Put the actuator in the closed position (cw).
2. Remove the breather from the reservoir.
3. Fill the reservoir approximately three-fourths (3/4) full (see "Fluid Requirements" for proper fluid specifications).
4. Open both speed control valves.
5. Open the bleed valve (4-160) on the outboard end of the hydraulic cylinder only.
6. Rotate the handle slowly, clockwise, until all air has escaped from the system.
7. Close the bleed valve opened in step 5.

NOTE: During the fill procedure, it is important that the lowest fluid level be not less than approximately one-fourth (1/4) of the reservoir volume at any time.

8. Open the bleed valve (4-160) on the inboard end of the hydraulic cylinder.
9. Rotate the handle slowly, counter-clockwise, until all air has escaped from the system.
10. Close the bleed valve opened in step 8.

NOTE: During the fill procedure, the piston will not move. This may be determined by observing the position indicator (1-170) on the actuator.

11. Adjust fluid level to 1-1/2" (40mm) from top of reservoir with actuator in open (ccw) position.
12. Re-install breather removed in step 2.

ADDITIONAL M4 INSTRUCTIONS

This is performed to insure air is removed from the system (most likely air in pump) and to test the operation of M4 override.

1. Turn M4 crank arm clockwise. The actuator should move clockwise as well. Adjust outboard bleed valve (4-160) to remove air from system.
2. Turn M4 crank arm counter-clockwise. The actuator will move counter-clockwise as well. Adjust inboard bleed valve to remove air from system.
3. With bleed valves closed, stroke actuator full 90°, clockwise and counter-clockwise using M4 override.

TESTING HYDRAULIC ACTUATORS

A. Leakage Test

NOTE: All sources of leakage to atmosphere and across the piston are to be checked using hydraulic pressure.

Procedure:

1. Cycle the actuator five (5) times at 100% of the normal operating pressure (NOP), as marked on actuator name tag. This allows the seals to seek their proper working attitude.
2. Apply 100% of the maximum operating pressure (MOP), as marked on actuator name tag, and allow the unit to stabilize.

3. If there is any notable leakage, the actuator must be disassembled and the cause of leakage must be determined and corrected.
4. Shell tests the actuator by applying 1.5 times the maximum test pressure, as marked on actuator name tag, to both sides of the piston simultaneously for a period of two (2) minutes. If any leakage occurs, the unit must be disassembled and the cause of leakage must be determined and corrected.
5. If an actuator was disassembled and repaired, the above leakage test must be performed again.

B. Operational (Functional) Test

NOTE: This test is used to verify proper function of the actuator and its' related system (accessories).

Procedure:

1. Cycle the actuator at 10% the maximum operating pressure (MOP) per actuator name tag. Any jumpy or jerky operation, not attributed to seal drag or limited flow capacity, must be corrected.
2. All accessories, including solenoid valves, positioners, pressure switches, etc., must be hooked up and tested for proper operations, and replaced if found defective.

RETURN TO SERVICE

1. Pneumatic rotary valve actuators - Refer to "Operating, Storage & Maintenance Instructions for GH-Bettis Pneumatic Rotary Valve Actuators" (OP/MAINT-001) for actuator start-up procedures.
2. Hydraulic rotary valve actuators - refer to "Operating, Storage and Maintenance Instructions for GH-Bettis Hydraulic Rotary Valve Actuators" (OP/MAINT-002) for actuator start-up procedures.

FINAL QUALITY TESTING OF ACTUATORS

	NOMINAL OPERATING PRESSURE (<u>NOP</u>)	MAXIMUM OPERATING PRESSURE (<u>MOP</u>)	MAXIMUM ALLOWABLE WORKING PRESSURE (<u>MAWP</u>)
<u>MODEL</u>			

T302.7-M4	Customer Spec.	2775	2775
T303.5-M4	or N.A.	1615	1750
T402.7-M4	"	3750	3750
T403.5-M4	"	2200	2600
T404.0-M4	"	1620	2000