

**BETTIS**

**SERVICE INSTRUCTIONS**

**DISASSEMBLY AND REASSEMBLY**

**FOR MODELS**

**T3XX-MX AND T4XX-MX**

**DOUBLE ACTING SERIES**

**PNEUMATIC ACTUATORS**

**WITH A MANUAL HYDRAULIC**

**OVERRIDE PACKAGE**

PART NUMBER: 074891

REVISION: "A"

DATE: 28 September 2001

REPLACES: Service-001 (SE-001)

## CONTENTS

SECTION 1.0 – INTRODUCTION		PAGE
1.1	General Introduction .....	2
1.2	Definitions .....	2
1.3	Safety .....	2
1.4	Basic Service Information .....	2
1.5	Bettis Reference Materials .....	3
1.6	General Assembly & Disassembly Information	3
1.7	Lubrication & Fluid Requirements .....	4
SECTION 2.0 – ACTUATOR DISASSEMBLY		
2.1	General Actuator Disassembly .....	4
2.2	Pneumatic Cylinder Disassembly .....	5
2.3	Hydraulic Override Cylinder Disassembly .....	6
2.4	Housing Disassembly .....	8
SECTION 3.0 – ACTUATOR REASSEMBLY		
3.1	General Reassembly .....	9
3.2	Housing Reassembly .....	9
3.3	Pneumatic Cylinder Reassembly .....	13
3.4	Hydraulic Cylinder Reassembly .....	15
SECTION 4.0 – MX Manual Hydraulic Override Package		
4.1	MX Manual Override Package Configuration .....	17
4.2	M4 Manual Hydraulic Override Package Installation .....	18
4.3	M4 Manual Hydraulic Override Package Refilling Instructions	18
SECTION 5.0 – ACTUATOR TESTING		
5.1	Pneumatic Testing .....	19
5.2	Return To Service .....	21
SECTION 6.0 – ACTUATOR SUPPORT INFORMATION		
6.1	Tool Style And Wrench Sizes .....	21
6.2	Actuator Weights .....	22

## **SECTION 1.0 - INTRODUCTION**

### **1.1 GENERAL INTRODUCTION**

- 1.1.1 This service procedure is offered as a guide to enable general maintenance to be performed on Bettis models T3XX-M2, T3XX-M4, T3XX-M11-S, T3XX-M11, T4XX-M2, T4XX-M4, T4XX-M11-S, and T4XX-M11 double acting pneumatic series actuators equipped with a Manual Hydraulic Override Package (includes actuator models that have a -10 or -11 suffix at the end of the model number).
- 1.1.2 When the actuator model number has "-S" as a suffix then the actuator is special and may have some differences that are not included in this procedure.

### **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 provided to assist maintenance personnel to carry out maintenance procedures.
- MX:** Generically designates the Manual Hydraulic Override Package models M2, M4, M11-S or M11 as manufactured by Bettis Corporation.

### **1.3 SAFETY**

- 1.3.1 Products supplied by Bettis, 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 Bettis actuators, this procedure should be reviewed and implemented for safe disassembly and reassembly. Close attention should be noted to the **WARNINGS, CAUTIONS and NOTES** contained in 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 representative and a authorized Bettis representative.

### **1.4 BASIC SERVICE INFORMATION**

- 1.4.1 Complete actuator refurbishment will require the actuator to be dismantled from the valve or device it is operating.

- 1.4.2 The maximum recommended service interval for this actuator series is five years. Storage time is counted as part of the service interval.
- 1.4.3 This procedure does not include M2, M4, M11-S or M11 Disassembly and Reassembly Instruction. Bettis does not recommend periodic maintenance for the Manual Hydraulic Override Package itself. The Manual Hydraulic Override Package needs only to be serviced when it malfunctions.
- 1.4.4 Complete M4 or M11-S Manual Hydraulic Override Package refurbishment should be done by Bettis (contact Bettis Waller Service Coordinator for further information).
- 1.4.5 This procedure is applicable with the understanding that all electrical power and pneumatic pressure has been removed from the actuator.
- 1.4.6 Also, it is understood that the actuator has been removed from the valve as well as all piping and accessories that are mounted on the actuator have been removed.

## **1.5 BETTIS REFERENCE MATERIALS**

- 1.5.1 Actuator model T3XX-MX series Assembly drawing part number 036077.
- 1.5.2 Actuator model T4XX-MX series Assembly drawing part number 035967.
- 1.5.3 Actuator model T3XX-MX Exploded Detail drawing part number 063569.
- 1.5.4 Actuator model T4XX-MX Exploded Detail drawing part number 063572.

NOTE: Exploded Detail drawings are contained in Bettis standard Service Kit.

## **1.6 GENERAL ASSEMBLY AND DISASSEMBLY INFORMATION**

- 1.6.1 This procedure should only be implemented by a technically competent technician who should take care to observe good workmanship practices.
- 1.6.2 Numbers in parenthesis, ( ), indicate the bubble number (reference number) used on the Bettis Assembly Drawing, Exploded Detail Drawing, and actuator parts list.
- 1.6.3 This procedure is written using the following Actuator references:
  - 1.6.3.1 Stop screw side of housing (1-10) will be considered the front of the actuator.
  - 1.6.3.2 Housing cover (1-20) will be the top of the actuator.
- 1.6.4 Mating parts should be marked for ease of reassembly, i.e. left/right stop screws, pneumatic power cylinder to housing and hydraulic control package cylinder to housing.
- 1.6.5 When removing seals from seal groove, use a commercial seal removing tool or use a small standard screwdriver with the sharp edges rounded off.

1.6.6 Use a non-hardening thread sealant on all pipe threads.

**CAUTION: Apply thread sealant per the manufacture's instructions.**

1.6.7 Disassembly should be done in a clean area on a workbench.

## **1.7 LUBRICATION AND FLUID REQUIREMENTS**

1.7.1 LUBRICATION REQUIREMENTS: The actuator should be re-lubricated at the beginning of each service interval using the following recommended lubricants.

- NOTES:
1. Lubricants, other than those listed in steps 1.7.1.1 should not be used without prior written approval of Bettis Product Engineering. The lubricant item number on some assembly drawings is item (3-150) while the Bettis service kits lubricant item number is item number (500).
  2. The following lubricant is for use in all areas of actuator except in the Manual Hydraulic Override Package (8) and hydraulic cylinder (4-10).

1.7.1.1 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 Module Service Kit in tubes and the tube is marked ESL-4,5 & 10 lubricant.

1.7.2 FLUID REQUIREMENTS: For use in the M4 Hydraulic Control Package (8) and the hydraulic cylinder (4-10).

NOTE: Fluids, other than those listed in steps 17.2.1 and 17.2.2 should not be used in the Bettis M4 package without prior written approval of Bettis Product Engineering.

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

1.7.2.2 Low temperature service (-40°F to +150°F)/(-40°C to 65.6°C) use Exxon Unis J13 Hydraulic Fluid.

## **SECTION 2.0 - ACTUATOR DISASSEMBLY**

### **2.1 GENERAL ACTUATOR DISASSEMBLY**

**CAUTION:** Pressure applied to the actuator is not to exceed the maximum operating pressure rating listed on the actuator name tag.

- 2.1.1 Before starting the general disassembly of the actuator, it is a good practice to operate the actuator with the pressure used by the customer to operate the actuator during normal operation. Notate and record any abnormal symptoms such as jerky or erratic operation.

**WARNING:** It is possible, that the actuator may contain a dangerous gas (Sour gas/H<sub>2</sub>S, Oxygen, Nitrogen, etc.) or liquid (Chlorine, Condensates, etc.). Ensure that all proper measures have been taken to prevent dangerous exposure or release of these types of residues before commencing any work.

- 2.1.2 If not already removed disconnect all operating pressure from the actuator pneumatic cylinder (2-10).
- 2.1.3 Mark and record location of the pneumatic inlet ports on cylinder outer end cap (2-30) and inner end cap (2-40).
- 2.1.4 Mark the stop screws (1-60) left and right. The setting of the stop screws (1-60) should be checked and setting recorded before stop screws are loosened or removed.

NOTE: Stop screws will be removed later in this procedure.

## 2.2 PNEUMATIC CYLINDER DISASSEMBLY

NOTE: Review of Section 2.1 prior to the disassembly of the pneumatic cylinder.

- 2.2.1 Unscrew and remove socket head cap screw (2-120), lockwasher (2-110), and nut retainer (2-100) from the end of outer end cap (2-30).
- 2.2.2 Remove hex nuts (2-90) from tie bars (2-60).

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

- 2.2.3 Remove outer end cap (2-30). The fit between the cylinder (2-10) and the outer end cap is very tight. NOTE: Break the outer end cap free by tapping with a breaker bar on the lip provided on the end cap.
- 2.2.4 Pry inner end cap (2-40) away from the housing (1-10). Break the inner end cap free from the cylinder (2-10) by tapping with a breaker bar on the lip provided on the end cap.

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 (2-170).

- 2.2.5 Remove cylinder (2-10) from the actuator.

NOTE: Move the piston so that there is at least four to six inches of distance between inner end cap (2-40) and piston (2-20).

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

- 2.2.6 Unscrew the tie bars (2-60) from the housing (1-10).
- 2.2.7 Pull the tie bars out of inner end cap (2-40) far enough to expose o-rings (3-30). Remove o-rings (3-30) from inboard end of tie bars.
- 2.2.8 Remove tie bars (2-60) by pulling them out of piston (2-20).

**WARNING: Keep split ring halves (2-70) in matched sets.**

- 2.2.9 Remove split ring retainer (2-80) and split ring halves (2-70) from the outboard side of piston (2-20).
- 2.2.10 Remove piston (2-20) from piston rod (2-170).
- 2.2.11 Remove o-ring seal (3-40) from piston rod (2-170).

**WARNING: Keep split ring halves (2-70) in matched sets.**

- 2.2.12 Remove inboard split ring retainer (2-80) and split ring halves (2-70) from the inboard side of piston (2-20).
- 2.2.13 Remove inner end cap (2-40) from piston rod (2-170).

### **2.3 HYDRAULIC OVERRIDE CYLINDER DISASSEMBLY**

NOTE: Review Section 2.1 prior to the disassembly of the hydraulic override 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 (4-10). Use a bucket, tub, and large container, ECT.

- 2.3.1 Drain the hydraulic fluid from Hydraulic Cylinder (4-10) by opening the bleed valves (4-160) and then removing the cylinder drain plugs (4-150). One is located on outboard end of hydraulic cylinder and the other on the inboard end of hydraulic cylinder.

NOTE: Actuator models manufactured after 1995 will not be provided with cylinder bleed plugs. Instead of one bleed plug and one pipe plug on each end of the cylinder there will be two pipe plugs on each end of the cylinder.

**CAUTION: The bleed valves are 1/8 NPT and are made out of brass. Use only the correct size wrench. Refer to tool list at the end of this procedure for recommended wrench style and correct wrench size. Do not use pliers or other style adjustable wrench for bleed valve removal or adjustment.**

- 2.3.2 If the MX package is remote mounted then disregard the rest of this step. Remove the cylinder mounted MX Hydraulic Control package (8) from cylinder (4-10) by loosening the nuts/lockwashers on the mounting bracket u-bolts and then slid the MX/bracket assembly off of the end of cylinder (4-10).

**CAUTION: Plug all ports in the MX package as foreign material may enter the system and cause the MX package to malfunction.**





NOTE: Mark and record location of the hydraulic pressure ports on cylinder outer end cap (4-30) and inner end cap (4-40).

2.3.3 Unscrew and remove socket cap screw (4-120), lockwasher (4-110) and nut retainer (4-100) from the end of outer end cap (4-30).

2.3.4 Remove hex nuts (4-90) from tie bars (4-60).

**CAUTION: When separating cylinder (4-10) from inner end cap (4-40) and outer end cap (4-30) do not damage outer diameter seal groove.**

2.3.5 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.

2.3.6 Pry inner end cap (4-40) away from housing (1-10). NOTE: Break the inner end cap free from cylinder (4-10) by trapping with a breaker bar on lip provided on the end cap.

NOTE: When removing cylinder (4-10) off of piston (4-20), tilt cylinder (4-10) at an angle of approximately 15° to 30° degrees to the piston rod (4-170).

2.3.7 Remove cylinder (4-10) from the actuator.

2.3.8 Move the piston so that there is at least four to six inches of distance between inner end cap (4-40) and piston (4-20).

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

2.3.9 Unscrew the tie bars (4-60) from the housing (1-10).

2.3.10 Pull the tie bars out of inner end cap (4-40) far enough to expose o-rings (5-30). Remove o-rings (5-30) from inboard end of tie bars.

2.3.11 Remove tie bars (4-60) by pulling them out of piston (4-20).

**WARNING: Keep split ring halves (4-70) in matched sets.**

2.3.12 Remove split ring retainer (4-80) and split ring halves (4-70) from the outboard side of piston (4-20).

2.3.13 Remove piston (4-20) from piston rod (4-170).

2.3.14 Remove o-ring seal (5-40) from piston rod (4-170).

**WARNING: Keep split ring halves (4-70) in matched sets.**

2.3.15 Remove inboard split ring retainer (4-80) and split ring halves (4-70) from the inboard side of piston rod (4-170).

2.3.16 Remove inner end cap (4-40) from piston rod (4-170).

## 2.4 HOUSING DISASSEMBLY

NOTE: Review all of Section 2.1 prior to the disassembly of the housing.

2.4.1 Remove snubber valve (1-190) from the housing cover (1-20).

2.4.2 Remove socket cap screws (1-180) from position indicator (1-170) and yoke weather cover (3-130).

2.4.3 Remove position indicator (1-170) and yoke weather cover (3-130) from the top of yoke (1-160).

**CAUTION: Do not use a pipe wrench on the piston rods as it may mark the rod and cause seal leakage. Flats are provided on the outboard end of the piston rod for wrench placement.**

NOTE: Removal of piston rod may require extra amount of torque for break out due to the use of Loctite - 242 during assembly.

2.4.4 Unscrew piston rods (2-170) and (4-170) from yoke pin nut (1-30). Remove piston rods (2-170) and (4-170) with rod bushings (2-50) and (4-50) from housing (1-10).

2.4.5 Remove rod bushings (2-50) and (4-50) from the piston rods (2-170) and (4-170).

2.4.6 Remove cover screws (1-90) with gasket seals (3-100) from housing cover.

2.4.7 Remove housing cover (1-20) from top of housing (1-10). NOTE: The cover will have a very tight fit. It is not necessary to remove cover pins (1-130) from the cover.

2.4.8 Remove top two yoke rollers (1-50) from the top of yoke pin (1-40).

2.4.9 Remove yoke pin (1-40) from the yoke and yoke pin nut (1-30).

2.4.10 Remove yoke pin nut (1-30) from between the arms of yoke (1-160).

2.4.11 Remove lower two yoke rollers (1-50) from the housing.

2.4.12 Remove yoke (1-160) by lifting it from housing (1-10).

**CAUTION: The yoke to housing and yoke to housing cover bearing area must be lubricated and inspected to extend service life and prevent degradation of torque output. This can only be accomplished by removing the yoke from the housing which requires removing the actuator from the valve. Lubricating the yoke with grease fittings will not properly lubricate yoke to housing and yoke to cover on those actuators equipped with grease fittings.**

2.4.13 Remove the stop screws (1-60), jam nuts (1-120), and seal gaskets (3-110).

- 2.4.14 It is not necessary to remove pipe plug (1-80), cylinder bleed valves (4-160) or grease fittings (1-70) to service the actuator. NOTE: Grease fittings (1-70) are optional as of March, 1983.

## **SECTION 3.0 - ACTUATOR REASSEMBLY**

### **3.1 GENERAL REASSEMBLY**

**CAUTION:** Only new seals that are still within the seal's expectant shelf life should be installed into actuator being refurbished.

3.1.1 Remove and discard all used seals and gaskets.

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

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

3.1.3 Actuator Parts Inspection: Attention should be directed to threads, sealing surfaces and areas that will be subjected to sliding or rotating motion.

3.1.3.1 All parts should be thoroughly inspected for excessive wear, stress cracking, galling and pitting.

3.1.3.2 All sealing surfaces of the cylinder, tie bars and piston rod must be free of deep scratches, pitting, corrosion and blistering or flaking coating.

3.1.4 INSTALLATION LUBRICATION INSTRUCTIONS:

3.1.4.1 The parts and seals used in the actuator housing assembly and pneumatic cylinder (2-10) will be assembled using lubricant as identified in Section 1.7 step 1.7.1.

3.1.4.2 Parts and seals used in hydraulic cylinder (4-10) will be assembled using the hydraulic fluid identified in Section 1.7 step 1.7.2.

3.1.4.3 Before installation coat all moving parts with lubricant.

3.1.4.4 Coat all seals with lubricant, before installing into seal grooves.

### **3.2 HOUSING REASSEMBLY**

NOTE: Review Section 3.1 prior to the assembly of the housing.

3.2.1 If removed install drain plug (1-80) in actuator housing (1-10).

NOTE: Grease fittings are optional as of March, 1983.

3.2.2 If removed, install grease fitting (1-70) in actuator housing (1-10) and cover (1-20) as follows:

3.2.2.1 The fitting in the housing is located on the bottom of the housing, next to the lower yoke bearing area.

3.2.2.2 The fitting in the cover is located on top of the cover in the upper yoke bearing area.

3.2.3 Inside housing (1-10) apply lubricant to the tracks and yoke bore.

3.2.4 Coat one yoke oring seal (3-50) with lubricant and install into seal groove located in bottom area of housing (1-10).

3.2.5 Apply lubricant to the slots in the upper/lower yoke arms and the lower bearing surface of yoke (1-160).

3.2.6 Install yoke (1-160) into housing (1-10) as follows:

3.2.6.1 Rotate yoke arms to approximately a 45° degree position in either direction and lower the yoke (1-160) down into the housing (1-10).

NOTE: The hub of yoke (1-160) with tapped holes faces up.

3.2.6.2 Rotate the yoke arms back to approximately mid-stroke (center) position.

3.2.7 Apply lubricant to the surfaces of all four yoke pin rollers (1-50).

3.2.8 Place one yoke roller (1-50) in the track in the bottom of the housing and position it under the slot in the lower arm of yoke (1-160).

3.2.9 Place a second yoke roller (1-50) on top of the first yoke roller in the slot in the lower arm of yoke (1-160) and align the holes in both yoke rollers (1-50).

3.2.10 Coat the upper and lower surfaces of yoke pin nut (1-30) with lubricant and install into position between the two arms of yoke (1-160) and parallel to the track in the bottom area of housing (1-10).

NOTE: Align the yoke pin hole with the center holes of the two installed yoke rollers (1-50).

3.2.11 Lubricate the yoke pin (1-40) and insert through yoke pin nut (1-30) and the two yoke rollers (1-50).

3.2.12 Install the two remaining yoke pin rollers as follows:

3.2.12.1 Install the third yoke pin roller (1-50) over the yoke pin (1-40) and into the slot in the upper arm of yoke (1-160).

- 3.2.12.2 Install the fourth and last remaining yoke pin roller (1-50) on top of the yoke pin roller installed in step 3.2.12.1.

NOTE: The top roller will remain partially above the arm of yoke (1-160). When the housing cover (1-20) is install the top yoke pin roller will engage the track located in the housing cover (1-20).

NOTE: A new rod bushing (2-50) is provided in the standard Bettis Service Kit.

**CAUTION: If cycle speed of the actuator is two seconds or faster, apply Loctite 242 to external threads of piston rods (2-170) and (4-170). NOTE: Loctite cure time is 10 - 30 minutes.**

- 3.2.13 Apply lubricant to piston rod (2-170) and rod bushing (2-50). Install rod bushing (2-50) onto the piston rod (2-170).

- 3.2.14 Install piston rod (2-170) with rod bushing (2-50) as follows:

3.2.14.1 For standard construction actuators install piston rod (2-170) into right end of housing (1-10).

3.2.14.2 For inverse construction actuators install piston rod (2-170) into left end of housing (1-10).

3.2.14.3 After installing piston rod (2-170) in steps 3.2.14.1 or 3.2.14.2 slide rod bushing along the piston rod and into counter bore in the end of housing (1-10).

3.2.14.4 Screw piston rod into yoke pin nut (1-30). NOTE: Do not torque tighten piston rod until the housing cover is installed later in this procedure.

NOTE: A new rod bushing (4-50) is provided in the standard Bettis Service Kit.

- 3.2.15 Apply lubricant to piston rod (4-170) and rod bushing (4-50). Install rod bushing (4-50) onto the piston rod (4-170).

- 3.2.16 Install piston rod (4-170) with rod bushing (4-50) as follows:

3.2.16.1 For standard construction actuators install piston rod (4-170) into left end of housing (1-10).

3.2.16.2 For inverse construction actuators install piston rod (4-170) into right end of housing (1-10).

3.2.16.3 After installing piston rod (4-170) in steps 3.2.16.1 or 3.2.16.2 slide rod bushing along the piston rod and into counter bore in the end of housing (1-10).

3.2.16.4 Screw piston rod into yoke pin nut (1-30). NOTE: Do not torque tighten piston rod until the housing cover is installed later in this procedure.

- 3.2.17 Place jam nuts (1-120) and new gaskets (3-110) on stop screws (1-60).
- 3.2.18 Install the pre-assembled stop screws (1-60) into the front of housing (1-10).
- 3.2.19 Place cover gasket (3-20) onto the top of housing (1-10).
- 3.2.20 Coat remaining o-ring seal (3-50) with lubricant and install into the seal groove located in the yoke bore of housing cover (1-20).
- 3.2.21 Apply lubricant to the yoke bore and track in housing cover (1-20).
- 3.2.22 Apply lubricant to upper bearing surface of yoke (1-160).
- 3.2.23 Install housing cover (1-20), being careful not to damage gasket (3-20) or o-ring seal (3-50).
- 3.2.24 Install new seal gaskets (3-100) onto cover screws (1-90).
- 3.2.25 Install cover screws (1-90) with new seal gaskets (3-100). NOTE: Leave cover screws loose, do not tighten.
- 3.2.26 Do this step only if you have pulled cover pins (1-130) or if you are replacing the cover pins.

NOTE: The cover pins (1-130) are grooved at one end, tapering to a smooth diameter at the other end.

- 3.2.26.1 Install four cover pins smooth end first into housing cover (1-20).
- 3.2.26.2 Drive four cover pins (1-130) through cover (1-20) and into housing (1-10) until each pin is flush with the cover.
- 3.2.27 Tighten cover screws (1-90).

**CAUTION: Do not use a pipe wrench or similar tool to tighten piston rod. Flats are provided on the outboard end of piston rods (2-170) and (4-170) for wrenching purposes.**

- 3.2.28 Torque tighten piston rods (2-170) and (4-170) to a torque of 150 ±7 foot pounds (203 ±9 N-m) lubricated.
- 3.2.29 Replace software components of snubber (1-190) and then install snubber (1-190) in the housing cover port.
- 3.2.30 POSITION INDICATOR INSTALLATION:
  - 3.2.30.1 Rotate the yoke to full clockwise (CW) position (as shown on the assembly drawing).
  - 3.2.30.2 Position the yoke weather cover (3-130) and position indicator (1-170) on top of yoke (1-160). The pointer of position indicator (1-170) will be pointing or facing the front of the actuator and perpendicular to piston rods (2-170) / (4-170).



3.2.30.3 Install socket cap screws (1-180) through position indicator (1-170), yoke weather cover (3-130) and screw into the top of yoke (1-160).

3.2.31 Rotate yoke to a position that will leave a minimum of piston rod (2-170) protruding from actuator housing.

### **3.3 PNEUMATIC CYLINDER REASSEMBLY**

NOTE: Review Section 3.1 prior to the assembly of the pneumatic cylinder.

3.3.1 Apply lubricant to rod seal (3-70) and install, lip first, into the recess provided in inner end cap (2-40).

**CAUTION: Install rod seal (3-70) with the energizer ring facing outboard side (away from housing).**

3.3.2 Install end cap gasket (3-10) over piston rod (2-170) and rod bushing (2-50).

3.3.3 Install inner end cap (2-40) over piston rod (2-170) and rod bushing (2-50). NOTE: Install inner end cap with large raised boss toward the housing (flat side outward). End cap pressure inlet port should be toward the top of actuator.

3.3.4 Apply lubricant to o-ring seal (3-60) and install into outer diameter seal groove on inner end cap (2-40).

3.3.5 T-seal set (3-80) installation as follows:

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

3.3.5.1 Apply lubricant to two sets of piston tie bar T-seal components (3-80).

3.3.5.2 Install the T-seals into piston (2-20) internal seal grooves.

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

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

3.3.6 Apply lubricant to threads and outboard end of piston rod (2-170).

3.3.7 Apply lubricant to o-ring seal (3-40) and place into seal groove located in the out board end of piston rod (2-170).

3.3.8 Install matched set of split ring halves (2-70) into inner most groove on piston rod and retain with retaining ring (2-80).

3.3.9 Install piston (2-20) onto piston rod (2-170) and up against split ring set (2-70).

3.3.10 Install matched set of split ring halves (2-70) onto piston rod and retain with retaining ring (2-80).

3.3.11 Apply lubricant to threads and end of tie bars (2-60) end without wrench flat.





- 3.3.12 Install two tie bars (2-60) by carefully inserting through piston (2-20). NOTE: Install tie bars far enough through piston to expose inboard o-ring seal groove.
- 3.3.13 Apply lubricant to two o-ring seals (3-30) and install into exposed seal groove on inboard end of tie bars.
- 3.3.14 Insert the tie bars through the inner end cap (2-40) and screw into the end of housing (1-10).

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

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.

- 3.3.15 Coat D-ring seal (3-90) with lubricant and install into the piston external seal groove with the flat side of the D-ring installed down into the seal groove.
- 3.3.16 Apply a light coat of lubricant to the bore of the cylinder (2-10).

**CAUTION: If needed when installing cylinder (2-10), hammer on end of cylinder only with a non metallic object.**

- 3.3.17 Install end of cylinder (2-10) over piston (2-20) and onto inner end cap (2-40). When installing cylinder over the piston seal, tilt cylinder 15° to 30° degrees to piston rod (2-170).
- 3.3.18 Apply lubricant to two o-ring seals (3-30) and install into seal groove on outboard end of tie bars (2-60).
- 3.3.19 Apply lubricant to o-ring seal (3-60) and install into outer diameter seal groove on outer end cap (2-30).
- 3.3.20 Install outer end cap (2-30) onto tie bars and into end of cylinder (2-10). NOTE: Make certain that outer end cap inlet port(s) are toward top of actuator.
- 3.3.21 Install two hex nuts (2-90) onto tie bars (2-60), using them to draw all of the cylinder components into position.

**CAUTION: While the tie bar nuts are being tightened, do not allow the tie bars to turn.**

- 3.3.22 Torque tighten hex nuts (2-90) to 65 ± 7 foot pounds (88 ±9 N·m) lubricated. NOTE: It is necessary that the flats on the hex nuts (2-90) be aligned and parallel before nut retainer (2-100) can be installed.
- 3.3.23 Install lockwasher (2-120) onto socket cap screw (2-120).
- 3.3.24 Install nut retainer (2-100) between the flats of hex nuts (2-90).
- 3.3.25 Install and tighten socket cap screw (2-120) with lockwasher (2-110) through nut retainer (2-100).

### 3.4 HYDRAULIC CYLINDER REASSEMBLY

- NOTES:
1. Review Section 3.1 prior to the assembly of the pneumatic cylinder.
  2. Use hydraulic fluid, as listed in section 1.7 step 1.7.2 to lubricate parts being install into the hydraulic cylinder assembly.

3.4.1 Apply fluid to rod seal (5-70) and install, lip first, into the recess provided in inner end cap (4-40).

**CAUTION: Install rod seal (5-70) with the energizer ring facing outboard side (away from housing).**

3.4.2 Install end cap gasket (3-10) over piston rod (4-170) and rod bushing (4-50).

3.4.3 Install inner end cap (4-40) over piston rod (4-170) and rod bushing (4-50). NOTE: Install inner end cap with large raised boss toward the housing (flat side outward). End cap pressure inlet port should be toward the top of actuator.

3.4.4 Apply fluid to o-ring seal (5-60) and install into outer diameter seal groove on inner end cap (4-40).

3.4.5 T-seal set (5-80) installation as follows:

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

3.4.5.1 Apply fluid to two sets of piston tie bar T-seal components (5-80).

3.4.5.2 Install the T-seals into piston (4-20) internal seal grooves.

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

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

3.4.6 Apply fluid to threads and outboard end of piston rod (4-170).

3.4.7 Apply fluid to o-ring seal (5-40) and place into seal groove located in the out board end of piston rod (4-170).

3.4.8 Install matched set of split ring halves (4-70) into inner most groove on piston rod and retain with retaining ring (4-80).

3.4.9 Install piston (4-20) onto piston rod (4-170) and up against split ring set (4-70).

3.4.10 Install matched set of split ring halves (4-70) onto piston rod and retain with retaining ring (4-80).

3.4.11 Apply fluid to threads and end of tie bars (4-60) end without wrench flat.

3.4.12 Install two tie bars (4-60) by carefully inserting through piston (4-20). NOTE: Install tie bars far enough through piston to expose inboard o-ring seal groove.



3.4.13 Apply fluid to two o-ring seals (5-30) and install into exposed seal groove on inboard end of tie bars.

3.4.14 Insert tie bars (4-60) through the inner end cap (4-40) and screw into the end of housing (1-10).

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

3.4.15 Piston T-seal set (5-90) installation as follows:

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

3.4.15.1 Apply fluid to two sets of piston tie bar T-seal components (5-90).

3.4.15.2 Install the piston T-seals into piston (4-20) outer diameter seal groove.

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

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

3.4.16 Apply fluid to the bore of cylinder (4-10).

**CAUTION: If needed when installing cylinder (4-10), hammer on end of cylinder only with a non metallic object.**

**CAUTION: Make certain back-up rings, components of piston T-seal (5-90), are seated into piston external seal groove. Should back-up rings or seal member be pinched between the piston and cylinder, the component could be damaged, becoming a potential source of leakage.**

3.4.17 Install end of cylinder (4-10) over piston (4-20) and onto inner end cap (4-40). When installing cylinder over the piston seal, tilt cylinder 15° to 30° degrees to piston rod (4-170).

NOTE: Bleed valve holes (located in the outboard and inboard ends of the cylinder) should be arranged so the bleed valves will be at cylinder's highest point when actuator is mounted in its final operational position.

3.4.18 Apply fluid to two o-ring seals (5-30) and install into seal groove on outboard end of tie bars (4-60).

3.4.19 Apply fluid to o-ring seal (5-60) and install into outer diameter seal groove on outer end cap (4-30).

3.4.20 Install outer end cap (4-30) onto tie bars and into end of cylinder (4-10). NOTE: Make certain that outer end cap inlet port(s) are toward top of actuator.

- 3.4.21 Install two tie bar nuts (4-90) onto tie bars (4-60), using them to draw all of the cylinder components into position.

**CAUTION:** While tie bar nuts (4-90) are being tightened do not allow tie bars (4-60) to rotate.

- 3.4.22 Torque tighten tie bar nuts (4-90) to  $65 \pm 7$  foot pounds ( $88 \pm 9$  N-m) lubricated. NOTE: It is necessary that the flats on the hex nuts (4-90) be aligned and parallel before the nut retainer can be installed.
- 3.4.23 If bleed valves (4-160) and drain plugs (4-150) were removed then re-install them into cylinder (4-10).
- 3.4.24 Install lockwasher (4-120) onto socket cap screw (4-120).
- 3.4.25 Install nut retainer (4-100) between the flats of hex nuts (4-90).
- 3.4.26 Install and tighten socket cap screw (4-120) with lockwasher (4-110) through nut retainer (4-100).

## **SECTION 4.0 - MX MANUAL HYDRAULIC OVERRIDE PACKAGE**

### **4.1 MX MANUAL HYDRAULIC OVERRIDE PACKAGE CONFIGURATIONS**

- 4.1.1 Actuators manufactured prior to December 31, 1972 will not be an M4 and Section 4.0 will not be applicable (Contact Service Coordinator Bettis Corporation, Waller Texas for information concerning this Manual Hydraulic Override Package).
- 4.1.2 Actuators manufactured after December 31, 1972 will have a M4 Manual Hydraulic Override Package or one of its revisions and this procedure will be applicable to all M4 Manual Hydraulic Override Packages.
- 4.1.3 Actuators manufactured utilizing a Manual Hydraulic Override Package with a model designation of M11-S or M11 use the following part numbered procedures for Manual Hydraulic Override Package service.
- 4.1.3.1 M11-S use Bettis Service Procedure part number 121962 for Instructions or Operation and Installation.
- 4.1.3.2 M11 use Bettis Service Procedure part number 126858 for Instructions or Operation and Installation.

## **4.2 M4 MANUAL HYDRAULIC OVERRIDE PACKAGE INSTALLATION**

- 4.2.1 If the M4 Control Package is not remote mounted then re-install the M4 control package (8) on the hydraulic cylinder (4-10).

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

**CAUTION:** Do not use Teflon tape to seal hydraulic system threads. Bettis recommend that a non-hardening thread sealant, compatible with petroleum base hydraulic fluid be used in all MX Manual Hydraulic Control Systems.

- 4.2.2 Hook up piping from the M4 hydraulic manual override block to cylinder ports.

## **4.3 M4 MANUAL HYDRAULIC OVERRIDE PACKAGE REFILLING INSTRUCTIONS**

- 4.3.1 M4 Refilling Instructions Pressure Pump Method - Refilling of the M4 hydraulic control system and actuator cylinder is best accomplished using a pressure pump.

4.3.1.1 Put the actuator in the open position (CCW) and proceed using the following steps.

4.3.1.2 Remove the breather from the reservoir.

4.3.1.3 Attach the pump discharge line to reservoir breather port.

4.3.1.4 Open both speed control valves.

4.3.1.5 Open the two bleed valves (4-160), located at each end of the hydraulic cylinder.

4.3.1.6 Slowly pump hydraulic fluid into the reservoir. Approximately three to five PSIG will be required. As the hydraulic fluid passes through the M4 control block into the cylinder, air will be displaced.

4.3.1.7 Close each bleed valve (4-160) when the air has been displaced and hydraulic fluid appears.

4.3.1.8 Remove pump discharge line from reservoir breather port.

4.3.1.9 Adjust fluid level to 1-1/2" (40mm) from top of reservoir with actuator in open (CCW) position.

4.3.1.10 Re-install breather removed, in step 4.3.1.1.

- 4.3.2 M4 Refilling Instructions No Pressure Pump Method - Refilling the M4 hydraulic control system, during field service, often must be done without the use of a pressure pump. Proceed as follows:

4.3.2.1 Put the actuator in the open position (CCW).

4.3.2.2 Remove the breather from the reservoir.

- 4.3.2.3 Fill the reservoir approximately three-fourths (3/4) full.
- 4.3.2.4 Open both speed control valves.
- 4.3.2.5 Open the bleed valve (4-160) on the outboard end of the hydraulic cylinder only.
- 4.3.2.6 Rotate the handle slowly, clockwise, until all air has escaped from the system.
- 4.3.2.7 Close the bleed valve opened in step 4.3.2.5. During the fill procedure, it is important that the lowest level be not less than approximately one-fourth (1/4) of the reservoir volume at any time.
- 4.3.2.8 Open the bleed valve (4-160) on the inboard end of the hydraulic cylinder.
- 4.3.2.9 Rotate the handle slowly, counterclockwise, until all air has escaped from the system.
- 4.3.2.10 Close the bleed valve opened in step 4.3.2.8. During the fill procedure, the piston will not move. This may be determined by observing the position indicator (1-170) on the actuator.
- 4.3.2.11 Adjust fluid level to 1 1/2" (40mm) from top of reservoir with actuator in open (CCW) positions.
- 4.3.2.12 Re-install breather removed in step 4.3.2.2.
- 4.3.3 Additional M4 Instructions - These steps are to be performed to insure air is removed from the system (most likely air in pump) and to test the operation of M4 hydraulic control system.
  - 4.3.3.1 Turn M4 crank arm clockwise (CW). The actuator should move clockwise as well. Adjust outboard bleed valve (4-160) to remove air from system.
  - 4.3.3.2 Turn M4 crank arm counter clockwise (CCW). The actuator will move counterclockwise. Adjust inboard bleed valves to remove air from system.
  - 4.3.3.3 With bleed valves closed, stroke the actuator a full 90° degrees, clockwise (CW) and counter clockwise (CCW), using M4 Hydraulic Control System.

## **SECTION 5.0 - ACTUATOR TESTING**

### **5.1 PNEUMATIC TESTING**

- 5.1.1 General Leak Testing:



5.1.1.1 A small amount of leakage may be tolerated.

5.1.1.2 Generally, a small leak testing bubble, which breaks about three seconds after starting to form, is considered acceptable.

5.1.2 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 actuators name tag.**

5.1.3 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.**

5.1.4 Prior to testing for leaks, alternately apply and release pressure, as defined in step 5.1.3, 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.

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

5.1.6 Apply a leak testing solution to the following areas:

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

5.1.6.2 Around tie bar nuts (2-90) on the cylinder outer end cap (2-30). Checks tie bars to outer end cap o-ring seals.

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

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

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

5.1.8 Apply a leak testing solution to the following areas:

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

5.1.8.2 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 (3-10).

5.1.8.3 The snubber valve port hole in housing cover (1-20). Checks the rod seal and tie bars to end cap o-ring seals.

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

5.1.9 If an actuator was disassembled and repaired, the above leakage test must be performed again.



**5.2 RETURN ACTUATOR TO SERVICE**

- 5.2.1 Adjust both stop screws (1-60) back to settings recorded in section 5 under General Disassembly.
- 5.2.2 Tighten both jam nuts (1-120) securely, while holding stop screws (1-60).
- 5.2.3 After the actuator is installed on the valve all accessories should be hooked up and tested for proper operations and replaced, if found defective.

**SECTION 6.0 - ACTUATOR SUPPORT INFORMATION**

**6.1 TOOL STYLE AND WRENCH SIZES**

6.1.1 Tools - All tools are American Standard inch. Two each medium standard screwdriver, small standard screwdriver with corners rounded, putty knife, rubber or leather mallet and a torque wrench (up to 5,000 inch pounds / 565 Nm). For recommended tool list by item number refer to the following table.

<b>T3XX-MX AND T4XX-MX TOOL STYLE AND WRENCH SIZES</b>					
ITEM NO.	WRENCH SIZE	T3 QTY	T4 QTY	LOCATION	RECOMMENDED WRENCH STYLE
1-60	1/2"	2	2	Stop Screw	Open End or Adjustable
1-80	9/16"	1	1	Housing Pipe Plug	Open End or Adjustable
1-90	1/2"	8	-	T3 Cover Screws	Socket
1-90	9/16"	-	8	T4 Cover Screws	Socket
1-120	1-5/16"	2	2	Stop Screw Nut	Box End <b>(1)</b>
1-180	3/16"	4	4	Weather Cover Screws	Allen
1-190	7/8"	1	1	Snubber Valve	Deep Socket
2-60	1/2"	2	2	Tie Bar Flats	Open End or Adjustable
2-90	1-7/16"	2	2	Tie Bar Nuts	Deep Socket
2-120	3/16"	1	1	Nut Retainer	Allen <b>(1)</b>
2-170	1-1/4"	1	1	Piston Rod Flats	Crows Foot <b>(1)</b>
4-60	1/2"	2	2	Tie Bar Flats	Open End or Adjustable
4-90	1-7/16"	2	2	Tie Bar Nuts	Deep Socket
4-120	3/16"	1	1	Nut Retainer	Allen <b>(1)</b>
4-150	9/32" Sq	2	2	Pipe Plug (Drain Plugs)	Open End or Adjustable
4-160	13/32"	2	2	Bleed Valves	Open or Box End <b>(1)</b>
4-170	1-1/4"	1	1	Piston Rod Flats	Crows Foot <b>(1)</b>
8	9/16"	-	-	M4 Mounting Package	Open End or Adjustable
<b>(1) No alternate style tool recommended</b>					

## 6.2 ACTUATOR WEIGHTS

- 6.2.1 Some of the actuator models are very heavy and will require a means of assistance. For actuator approximate weight refer to following chart (includes actuator models that have a -10 or -11 suffix at the end of the model number).

ACTUATOR MODEL	APPROXIMATE WEIGHT		ACTUATOR MODEL	APPROXIMATE WEIGHT	
	POUNDS**	KG**		POUNDS**	KG**
T310-M4	313	141.9	T410-M4	364	165.1
T312-M4	338	153.3	T412-M4	396	179.6
T316-M4	386	175.1	T416-M4	444	201.4
			T420M4	517	234.5

\*\* Weights listed for each model are for a bare actuator without valve mounting bracket or mounted accessories.

ECN	REV		BY *	DATE
Released	A	COMPILED	Bill Cornelius	26 September 2001
		CHECKED	Bill Cornelius	26 September 2001
		APPROVED	Russell Smith	28 September 2001

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