

BETTIS

SERVICE INSTRUCTIONS

DISASSEMBLY & REASSEMBLY

FOR MODELS

ST8XX-SR2-M7, ST8XX-SR3-M7,

ST8XX-SR4-M7 AND ST8XX-SR5-M7

SPRING RETURN SERIES

PNEUMATIC ACTUATORS WITH

HYDRAULIC CONTROL PACKAGE

PART NUMBER: 111584

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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 Models ST8XX-SR2-M7, ST8XX-SR3-M7, ST8XX-SR4-M7 and ST8XX-SR5-M7 "Scotch-Yoke" pneumatic type actuators. When the model number has a "S" as a suffix then the actuator is special and may have some differences that are not included in this procedure.
- 1.2 **SAFETY STATEMENT:** 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 a trained, equipped, prepared and competent technician.

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.

1.3 **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.

SR: Spring Cartridge

- 1.4 **BASIC SERVICE INFORMATION:** Complete actuator refurbishment requires the actuator be dismantled from the valve or device it is operating.
- 1.5 The maximum recommended service interval for this actuator series is five years. Storage time is counted as part of the service interval.
- 1.6 This procedure does not include M7 Disassembly and Reassembly Instruction. Bettis does not recommend periodic maintenance for the M7 itself. The M7 needs only to be serviced when it malfunctions. Complete M7 refurbishment should be done by Bettis.
- 1.7 This procedure is applicable with the understanding that all electrical power and pneumatic pressure has been removed from the actuator, allowing the spring to stroke and rotate the actuator to its fail position. 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. **NOTE:** Do not remove the M7 hydraulic control package and it's piping until Section 6 has been completed.

2.0 **SUPPORT ITEMS AND TOOLS**

- 2.1 Support Items - Service Kit, razor sharp cutting instrument, Seal removal tool, commercial leak testing solution, two each 1-8 UNC hex nuts, Loctite 242 and non-hardening thread sealant.
- 2.2 Tools - All tools are American Standard inch. Large adjustable wrench, two large screwdrivers, Allen wrench set, set of open/box-end wrenches, rubber or leather mallet, torque wrench (up to 5,000 in. lbs.), breaker bar, 1/4" drift punch and a 1/2" drive socket set. For recommended tool list refer to the last page of this procedure.

3.0 **BETTIS REFERENCE MATERIALS**

- 3.1 Assembly Drawing part number 105459 for ST8XX-SR2 thru -SR5(CW)-M7 fail close actuators.
- 3.2 Assembly Drawing part number 109706 for ST8XX-SR2 thru -5(CCW)-M7 fail open actuators.

4.0 **GENERAL DETAILS**

WARNING: This procedure is only to be used to disassemble the ST8XX-SR2, -SR3, -SR4 and -SR5-M7 series actuators. DO NOT USE THIS PROCEDURE FOR DISASSEMBLY OF ST8XX-SR1-M7 ACTUATORS. Refer to procedure part number 112666 for ST8XX-SR1-M7 actuators.

- 4.1 This procedure should only be implemented by a technically competent technician who should take care to observe good workmanship practices.
- 4.2 Numbers in parentheses, () indicate the bubble number (reference number used on the Bettis Assembly Drawing and actuator Part Lists).
- 4.3 This procedure is written using the stop screw side of the housing (1-10) as a reference and this side will be considered the front of the actuator. The housing cover (1-20) will be the top of the actuator.
- 4.4 Mating parts should be marked for ease of reassembly, i.e. spring cartridge to housing and cylinder to housing.
- 4.5 When removing seals from seal grooves, use a commercial seal removing tool or a small screwdriver with sharp corners rounded off.
- 4.6 Use a non-hardening thread sealant on all pipe threads.

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

- 4.7 Disassembly of actuator should be done in a clean area on a workbench.
- 4.8 Refer to Chart 1, of this instruction, for actuator weights. NOTE: Some components of this actuator are very heavy and will require a means of assistance.
- 4.9 **LUBRICATION REQUIREMENTS:** For use in all areas of the actuator except in the M7 Hydraulic Control Package (8) and the hydraulic cylinder (2-40).
 - 4.9.1 Standard and high temperature service (-20⁰F to 350⁰F) use Bettis ESL-5 (Kronaplate 100). ESL-5 is contained in the Bettis Service Kit.
 - 4.9.2 Low temperature service (50⁰F to 150⁰F) use Kronaplate 50. This lubricant is not in the Service Kit.
- 4.10 **FLUID REQUIREMENTS:** For use in the M7 Hydraulic Control Package (8) and the hydraulic cylinder (2-40).
 - 4.10.1 Standard and high temperature service (35⁰F to 350⁰F) use Dexron II Automatic Transmission Fluid.

4.10.2 Low temperature service (-65°F to 180°F) use Exxon Univis J13 Hydraulic Fluid.

- 4.11 It is a good practice to operate the actuator with the nominal operating pressure (NOP), as listed on the actuator nametag or the pressure used by the customer to operate the actuator during normal operation, before starting the general disassembly of the actuator. Notate and record any abnormal symptoms such as jerky or erratic operation. NOTE: Pressure is not to exceed the maximum operating pressure rating listed on the nametag.

5.0 GENERAL DISASSEMBLY

- 5.1 Make sure that the M7 block/by-pass valve, located on the right hand side of the control package block, is fully open. If not already removed, disconnect all operating pressure from actuator power cylinder (2-10), allowing the spring to stroke. The spring will rotate the yoke to the fail position.
- 5.2 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.
- 5.4 Remove the snubber valves (1-190) from the housing cover (1-20) and the housing (1-10).
- 5.5 Mark and record location of the hydraulic inlet ports on the hydraulic cylinder outer end cap (2-70) and inner end cap (2-60).

6.0 SPRING CARTRIDGE REMOVAL

WARNING: Under no circumstances should the spring cartridge be cut open as the spring is pre-loaded with the end caps and cylinder welded around the loaded spring.

- 6.1 When the spring cartridge is installed on the actuator the spring is under compression, "pre-load".

WARNING: Do not remove the spring cartridge (4-10) until the actuator has the spring "pre-load" removed.

- 6.2 SPRING CARTRIDGE "PRE-LOAD " REMOVAL - Use Method #1 if the M7 control package is operational. Use Method #2 if the M7 control package is not operational.
- 6.3 METHOD #1 - Close the block/by-pass valve located on the M7 block. Insert the pump handle into the pump handle holder and hand jack the pump until the actuator has moved a few degrees off of the stop screw (1-60).
- 6.4 Locate the stop screw (1-60), that is on the opposite side of the housing spring cartridge (4-10), and loosen its stop screw nut (1-120).
- 6.5 Unscrew the stop screw (1-60) until it has all of the "pre-load" removed.
- 6.6 Open the block/bypass valve on the M7 block and allow the spring to return the actuator to the spring extended position (fail position). Continue actuator disassembly at step 6.10.
- 6.7 METHOD #2 - Apply sufficient pneumatic pressure to the pressure inlet port, located in the outboard end cap of cylinder (2-10), to move the actuator yoke (1-160) off of the stop screw (1-60).
- 6.8 Unscrew the stop screw (1-60) until it has all of the "pre-load" removed.

- 6.9 Remove the pressure from the pressure inlet port and allow the spring to return the actuator to the spring extended position (fail position).
- 6.10 Remove socket cap screw (4-60), lockwasher (4-50), and nut retainer (4-40) between large hex nuts on outboard end of the spring cartridge (4-10).
- 6.11 SPRING CARTRIDGE REMOVAL

CAUTION: Due to the weight and size of the spring cartridge, heavy duty support equipment will be required when removing the spring cartridge from the actuator housing. For the approximate weight of the spring cartridge only refer to the following list:

SR2 = 772 lbs. SR3 = 667 lbs. SR4 = 686 lbs. SR4 = 686 lbs.

- 6.11.1 Remove the hex cap screws (4-100) from the spring cartridge adapter plate (4-80).
- 6.11.2 Loosen the two large hex nuts on the outboard end of the spring cartridge (4-10). Unscrew the tie bars until the spring cartridge is free from the spring cartridge adapter plate (4-80). Flats are provided on the outboard end of the tie bars for wrench placement. NOTE: Care should be taken so that the tie bars are not pulled back into the spring cartridge.
- 6.11.3 Remove the Spring Cartridge Assembly (4-10) clear of the housing (1-10). To keep from inadvertently pulling the tie bars back into the spring cartridge use two each one inch -8 UNC hex nuts and install them on to the spring cartridge tie bars. Place the spring cartridge (4-10) to one side.

7.0 TANDEM PRESSURE/HYDRAULIC CYLINDER DISASSEMBLY

- 7.1 Drain the hydraulic fluid from Hydraulic Cylinder (2-40) by opening the bleed valves (2-240) and then removing the cylinder drain pipe plugs (2-230). One is located on outboard end of hydraulic cylinder and the other on the inboard end of hydraulic cylinder.
- 7.2 If the M7 is mounted on the actuator then remove the M7 control package (8) from hydraulic cylinder (2-40). Remove the M7 package and bracket by loosening hex nuts on the U-bolts and sliding the M7/bracket assembly off the hydraulic cylinder (2-40).

CAUTION: Plug the inlet ports in the M7 as foreign material may enter the system and cause the package to malfunction.

- 7.3 Remove breather (11) from the inboard inner end cap (2-30).
- 7.4 Locate the hydraulic cylinder outer end cap (2-70) and remove socket cap screw (2-160), lockwasher (2-150) and nut retainer (2-140).
- 7.5 Remove hex nuts (2-130) from tie bars (2-100).

CAUTION: Do not damage o-ring groove on the outer end cap (2-70).

- 7.6 Remove the outer end cap (2-70). The fit between the cylinder (2-40) and the outer end cap (2-70) is very tight. NOTE: Break the outer end cap free by tapping with a beaker bar on the lip provided on the end cap.

- 7.7 Pry hydraulic cylinder inner end cap (2-60) away from the pneumatic cylinder outer end cap (2-30). Separate the cylinder (2-40) from the inner end cap (2-60). NOTE: Break the hydraulic cylinder inner end cap (2-60) free from the hydraulic cylinder (2-40) by tapping with a breaker bar on the lip provided on the end cap.
- 7.8 Remove the cylinder (2-40). NOTE: When sliding the cylinder off of the piston, tilt the cylinder 15° to 30° degrees to the piston rod (2-170).
- 7.9 Remove a set of split rings (2-110) and a split ring retainer (2-120) from outboard end of piston rod (2-170). NOTE: Keep the split rings in matched sets.
- 7.10 Remove hydraulic piston (2-50) from piston rod (2-170) and tie bars (2-100).
- 7.11 Remove second set of hydraulic piston split rings (2-110) and a split ring retainer (2-120). NOTE: Keep the split rings in matched sets.
- 7.12 Remove o-ring seal (5-40) from the outboard end of the tandem piston rod (2-170).
- 7.13 Remove the inner end cap (2-60) off of the tie bars (2-100) and piston rod (2-170).
- 7.14 Remove the rod bushing (2-90) from the pneumatic end cap (2-30).
- 7.15 Remove outboard 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 beaker bar on the lip provided on the end cap.
- 7.16 Pry inner end cap (2-30) away from the housing (1-10). Separate the cylinder (2-10) from the inner end cap (2-30). NOTE: Break the inner end cap free from the cylinder (2-10) by tapping with a beaker bar on the lip provided on the end cap.
- 7.17 Remove the cylinder (2-10). NOTE: When sliding the cylinder off of the piston, tilt the cylinder 15° to 30° degrees to the piston rod.
- 7.18 Unscrew and remove the tie bars (2-100) from spring cartridge adapter plate (4-80). Flats are provided on the outboard end of the tie bars for wrench placement.
- 7.19 Pull the tie bars out through the housing (1-10), remaining end cap (2-30) and piston (2-20).
- 7.20 Remove the split ring retainer (2-120) and the split rings (2-110) from the outboard side of the piston (2-20). NOTE: Keep the split rings in matched sets.
- 7.21 Remove the piston (2-20) from the piston rod (2-170). Refer to step 7.27 for disassembly of 24" and larger pistons with tie bar bushings (2-220).
- 7.22 Remove piston rod o-ring seal (3-40) from piston rod (2-170).
- 7.23 Remove the split ring retainer (2-120) and the split ring (2-110) from the inboard side of the piston rod (2-170). NOTE: Keep the split rings in matched sets.
- 7.24 Slide the inner end cap (2-30) off of the piston rod (2-170).

7.25 Unscrew piston rod (2-170) from yoke pin nut (1-30) and remove. Flats are provided on the outboard end of the piston rod for wrench placement.

CAUTION: Do not use a pipe wrench on the piston rod as it may mark the rod and cause seal leakage.

7.26 Remove the rod bushing (2-80).

7.27 Fabricated piston disassembly, 24" inch cylinders and larger. Refer to assembly drawing detail "B".

7.27.1 Remove the retaining rings (2-120) from piston (2-20).

7.27.2 Remove the piston tie bar bushings (2-180) from the piston.

8.0 HOUSING DISASSEMBLY

8.1 Remove socket cap screws (4-90) from the spring cartridge adapter plate (4-80).

8.2 Remove the spring cartridge adapter plate (4-80).

8.3 Unscrew push rod (4-20) from yoke pin nut (1-30) and remove from the housing (1-10).

8.4 Remove position indicator pin (1-170).

8.5 Unscrew and remove hex cap screws (1-240) with gasket seals (3-100) from position indicator cover (1-210).

8.6 NOTE: Mark and record the orientation of the position indicator drive (1-230) relative to the top of the yoke (1-160). Remove position indicator cover (1-210).

8.7 NOTE: Mark the hole that the set screw (1-180) is removed from. Unscrew and remove set screw (1-180) from position indicator drive (1-230).

8.8 Remove position indicator drive (1-230) from the top of the yoke (1-160).

8.9 Remove cover hex cap screws (1-90) and gasket seals (3-100).

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

8.11 Remove the yoke rollers (1-50) and roller spacers (1-110) from the top of the yoke pin (1-40).

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

8.13 Remove yoke pin nut (1-30) from between the yoke arms.

8.14 Remove the lower two yoke rollers (1-50) and roller spacers (1-110) from the bottom of the yoke and housing.

8.15 The yoke (1-160) can now be removed by lifting it out from the housing cavity.

- 8.16 NOTE: Be sure to mark or identify stop screws (1-60) as left and right. Remove the stop screws (1-60), stop screw nuts (1-120), thread seals (3-110) and countersunk washers (3-120).
- 8.17 It is not necessary to remove the yoke bushings (1-200) from the housing cover (1-20) or the housing (1-10) unless these items are being replaced due damage or wear. It is not necessary to remove pipe plugs (1-80) to service the actuator.

9.0 GENERAL RE-ASSEMBLY

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

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

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

- 9.4 Before installation coat all moving parts with a complete film of lubricant. Coat all seals with a complete film of lubricant, before installing into seal grooves. NOTE: The parts and seals used in the actuator housing assembly, power cylinder and spring cartridge will be assembled using lubricant as identified in step 4.9. The parts and seals used in the hydraulic cylinder assembly will be assembled using the hydraulic fluid identified in step 4.10.
- 9.5 T-seal set installation - The T-seal is composed of one rubber seal and two split skive-cut back-up rings.
- 9.5.1 Install the T-seal into the seal grooves.
- 9.5.2 Install a back-up ring on each side of the T-seal.
- 9.5.3 When installing the back-up rings, do not align the skive-cuts.
- 9.5.4 If the back-up rings are too long and the rings overlap beyond the skive-cuts, then the rings must be trimmed with a razor sharp instrument.
- 9.6 Prime and apply master gasket (510) to all surfaces as indicated on the assembly drawing (reference note 5 on the assembly drawing).

10.0 HOUSING REASSEMBLY

- 10.1 If removed install pipe plugs (1-80).
- 10.2 Coat one of the yoke o-ring seal (3-50) with lubricant and install into the housing (1-10).
- 10.3 If the yoke bushings (1-200) were removed then install one in the housing yoke bore and one in the housing cover yoke bore.

- 10.4 Inside the housing (1-10) apply lubricant to the tracks and yoke bore and arrange the housing with the yoke bore nearest you.
- 10.5 Apply lubricant to the slots in the upper/lower yoke arms and the lower yoke bearing surface.
- 10.6 Install the yoke (1-160) into the housing (1-10) as follows: NOTE: The yoke hub with tapped holes faces up. Arrange the yoke arms to approximately a 45° degree position in either direction and lower into the housing. Rotate the yoke back to approximately the mid-stroke (center) position.
- 10.7 Apply lubricant to all surfaces of two of the yoke rollers (1-50) and two roller spacers (1-110). Place one yoke roller in the track in the bottom of the housing and position it under the slot in the yoke arms. Place a roller spacer (1-110) on top of the bottom yoke roller (1-50). Place a second yoke roller on top of the roller spacer in the slot in the lower yoke arm. Place another roller spacer (1-110) on top of the second yoke roller (1-50) and align the holes in the roller spacer and the yoke rollers.
- 10.8 Coat the upper and lower surfaces of the yoke pin nut (1-30) with lubricant and insert into position between the yoke arms, parallel to the track in the housing. Align the yoke pin hole with the yoke rollers (1-50) and roller spacers (1-110).
- 10.9 Lubricate the yoke pin (1-40) and insert through the yoke pin nut (1-30), the two yoke rollers (1-50) and the two roller spacers (1-110).
- 10.10 Apply lubricant to all the surfaces of the two remaining yoke rollers (1-50) and two remaining roller spacers (1-110). Place one roller spacer (1-110) on top of the yoke pin nut (1-30) then install the third yoke roller (1-50). Place the last roller spacer (1-110) on top of the third yoke roller (1-50). Place the fourth and final yoke roller (1-50) on top of the yoke pin. The top roller will remain above the yoke arm and will engage the cover track when the cover is installed.
- 10.11 Apply lubricant to the rod bushing (2-50), install it up into the right side of the housing for fail close (CW) actuators or into the left side of the housing for fail open (CCW) actuators.
- 10.12 Apply Loctite - 242 to external threads on the piston rod (2-170). NOTE: Loctite cure time is 10 - 30 minutes. Lubricate the piston rod (2-170) and insert it into and through the rod bushing installed in step 11.10. Screw the piston rod into the yoke pin nut (1-30).

CAUTION: Do not tighten the piston rod until the housing cover is installed later in the procedure.

- 10.13 Prepare the mounting surface of the SR adapter plate (4-80) and spring cartridge side of the housing (1-10) per master gasket instructions (reference note 5 on assembly drawing).
- 10.14 Install the end cap o-ring seal (3-10) into the spring cartridge adapter plate (4-80).
- 10.15 Install the spring cartridge adapter plate (4-80) up against the housing (1-10).
- 10.16 Retain the spring cartridge adapter plate with socket cap screws (4-90). Torque to 90 ft. lbs (±5%).
- 10.17 Lubricate the push rod (4-20) and slide into the opposite side of housing from the piston rod and screw into the yoke pin nut (1-30).

CAUTION: Do not tighten the push rod until the housing cover is installed later in the procedure.

- 10.18 Install the position indicator drive (1-230) onto the top of yoke (1-160) with the slot positioned over the hole that was marked in section 8. Secure with the set screw (1-180).
- 10.19 Install the o-ring seal (3-150) over the position indicator drive shaft and down against the flat cover plate.
- 10.20 Coat the remaining yoke o-ring seal (3-50) with lubricant and install into the housing cover (1-20).
- 10.21 Apply lubricant to the yoke bore and the track in the housing cover (1-20).
- 10.22 Apply lubricant to the yoke upper bearing surface.
- 10.23 Prepare the mounting surfaces of the housing cover (1-20) and the housing (1-10) per master gasket instructions (reference note 5 on the assembly drawing).
- 10.24 Place the housing cover gasket (3-20) on the housing (1-10).
- 10.25 Install the housing cover (1-20) being careful not to damage the cover gasket (3-20) or yoke o-ring seal (3-50). NOTE: If the housing cover does not want to go down against the housing then the cover may be hanging on the top yoke roller.
- 10.26 Lubricate and install cover screws (1-90) and seal gaskets (3-100). NOTE: Leave finger tight - do not tighten.
- 10.27 Do this step only if you have pulled the cover pins (1-130) or if you are replacing the cover pins. Drive the pins (1-130) through 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.
- 10.28 Tighten the cover screws (1-90) and torque to 16 ft. lbs. ($\pm 5\%$).
- 10.29 Tighten the piston rod (2-170) to a torque of 150 ft. lbs. ($\pm 5\%$). Flats are provided on the outer end for wrenching purposes.

CAUTION: Do not use a pipe wrench or similar tool to tighten piston rod or the push rod.

- 10.30 Tighten the push rod (4-20) with a strap wrench.
- 10.31 Place thread seals (3-110), countersunk washers (3-120) and jam nuts (1-120) on the stop screws (1-60). Install the stop screws into the housing, making sure the stop screws marked in step 8.16 are installed into the same stop screw holes as they were removed from.
- 10.32 Prepare the mounting surface of the position indicator cover (1-210) and the housing cover (1-20) per master gasket instructions (reference note 5 on assembly drawing).
- 10.33 Install the o-ring seal (3-140) into the bottom seal groove inside the position indicator cover (1-210).
- 10.34 Install the wiper ring (3-160) into the top groove inside the position indicator cover (1-210).
- 10.35 Install the o-ring seal (3-170) into the bottom seal groove on the bottom of the position indicator cover (1-210).

- 10.36 Install the position indicator cover (1-210), being careful not to damage the o-ring seals (3-140), (3-170) and wiper ring (3-160).
- 10.37 Install new gasket seals (3-100) on to hex cap screws (1-240).
- 10.38 Install and tighten the position indicator cover hex screws (1-240).
- 10.39 Install the position indicator pointer (1-170) into the taped hole in the position indicator drive assembly (1-230).
- 10.40 Rotate the yoke to a position that will leave a minimum of the piston rod (2-170) protruding from the actuator housing.

11.0 TANDEM PRESSURE/HYDRAULIC CYLINDER RE-ASSEMBLY

- 11.1 Coat the rod seal (3-70) with lubricant and install, lip first, into the recess provided in the inboard end cap (2-30).

CAUTION: Install the rod seal with energizer ring facing into the seal cavity.

- 11.2 Prepare the mounting surfaces of the inboard end cap (2-30) and end cap side of the housing (1-10) per master gasket instructions (reference note 5 on assembly drawing).
- 11.3 Install a end cap o-ring seal (3-10) into the inboard end cap (2-30).
- 11.4 Coat two tie bar o-ring seals (3-30) with lubricant and install into the inboard end cap (2-30).
- 11.5 Install the inboard end cap (2-30) over the piston rod (2-170) and the rod bushing (2-80). Install with the large raised boss toward the housing (flat side outward). NOTE: The pressure inlet port should be toward the top of the actuator.
- 11.6 Apply lubricant to the end cap o-ring seal (3-60) and install on the inboard end cap (2-30).
- 11.7 Skip this step if your piston is 20" inch diameter or less. Fabricated Piston Reassembly , 24" inch diameter and larger. Refer to assembly drawing detail "B".
 - 11.7.1 Install the o-ring seals (3-35) into the O.D. groove on piston tie bar bushings (2-180).
 - 11.7.2 Install the rod T-seals (3-80) into the I.D. groove in the piston bushing (2-180).
 - 11.7.3 Install the piston bushings (2-180) into the piston.

CAUTION: The piston tie bar bushings should be replaced each time the actuator has its five year refurbishment. NOTE: The Bettis Service Kit should contain new piston tie bar bushings.

- 11.7.4 Install the retaining rings (2-190) into the piston.
- 11.8 Apply lubricant to two sets of piston tie bar T-seal components (3-80) and install into the piston internal seal groove. Refer to section 9 for proper T-seal installation instructions.
- 11.9 Coat the ends of the piston rod (2-170) with lubricant.

- 11.10 Apply lubricant to the o-ring seal (3-40) and place into the innermost seal groove of piston rod (2-170).
- 11.11 Install a matched set of split rings (2-110) into the inner most groove in the piston rod and retain with one of the split ring retainers (2-120). NOTE: The retaining ring groove will face away from the piston.
- 11.12 Install the piston (2-20) onto the piston rod against the split ring (2-110). NOTE: When installing cast pistons install with ribbed section of piston is facing away from the housing (1-10). When installing fabricated pistons, 24" inch diameter and larger, make certain that the smaller diameter piston plate is facing away from housing (1-10).
- 11.13 Install a matched set of split rings (2-110) into the groove out board of the piston (2-20) and retain with the split ring retainer (2-120). NOTE: The split ring retainer groove will face away from the piston.
- 11.14 Coat the piston T seal components (3-90) with lubricant and install into the piston external seal groove. Refer to section 9 for proper "T" seal installation instructions.
- 11.15 Take "housing-end" of tie bars (2-100), end without wrench flat, and install by carefully inserting tie bars into the piston (2-20) and through the rod T-seal (3-80), inner end cap (2-30), housing (1-10) and screwing into the SR adapter plate (4-80).

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

- 11.16 Apply lubricant to the bore of the cylinder (2-10).
- 11.17 Slide the lubricated end of the cylinder (2-10) over the piston (2-20) and onto the inboard end cap (2-30). When sliding 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.

CAUTION: 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.

- 11.18 Apply lubricant to two end cap tie bar o-ring seals (3-30) and install into the outboard end cap (2-30).
- 11.19 Apply lubricant to the outer end cap cylinder o-ring seal (3-60) and install onto the end cap (2-30).
- 11.20 Install the end cap (2-30) onto the tie bars and into the end of the cylinder (2-10).
- 11.21 Prepare the Interfacing surfaces of the pneumatic cylinder outboard end cap (2-30) and hydraulic cylinder inner end cap (2-60) per master gasket instructions (reference note 5 on assembly drawing).

CAUTION: The energizer ring of rod seal (5-70) must facing into the end cap recess.

- 11.22 Coat rod seal (5-70) with lubricant and install into inner end cap (2-30).
- 11.23 Apply lubricant to the rod bushing (2-90), install it over the piston rod and slide it into the inner end cap (2-30) .
- 11.24 Apply lubricant to end cap o-ring seal (5-10) and install into the seal groove on the outboard face of end cap (2-30).

CAUTION: When the following steps indicate to "coat the item with fluid" then use the hydraulic fluid specified in step 4.10.

- 11.25 Coat two tie bar o-ring seal (5-30) with fluid and install into the hydraulic inner end cap (2-60).
- 11.26 Apply fluid to the end cap o-ring seal (5-60) and install on the inner end cap (2-60).
- 11.27 Coat the second rod seal (5-70) with hydraulic fluid and install it, lip first, into the recess provided in the hydraulic cylinder inner end cap (2-60).

CAUTION: The energizer ring of the rod seal (5-70) must be facing into the end cap recess.

- 11.28 Install the hydraulic inner end cap (2-60) over the tie bars (2-100), piston rod (2-170) and the rod bushing (2-90). NOTE: The pressure inlet port should be installed in the position recorded in Section 5.
- 11.29 Install a matched set of split rings (2-110) into inner-most groove in the piston rod (2-170) and retain with one of the split ring retainers (2-120).
- 11.30 Apply fluid to the piston o-ring (5-40) and place onto the piston rod (2-170).
- 11.31 Apply fluid to two sets of hydraulic cylinder T-seal components (5-80) and install into the inner diameter of piston (2-50).
- 11.32 Install the piston (2-50) onto the piston rod against the split rings (2-110).
- 11.33 Install the remaining matched set of split rings (2-110) onto the piston rod (2-170) and retain with the split ring retainer (2-120).
- 11.34 Coat the hydraulic cylinder T-seal components (5-90) with fluid and install into the external seal groove of the piston (2-50). Refer to step 9.5 for T-seal installation instructions.
- 11.35 Apply hydraulic fluid to the exposed areas of the tie bars (2-100) and to the bore of the hydraulic cylinder (2-40).
- 11.36 Install the lubricated cylinder (2-40) over the piston (2-50) and onto the inner end cap (2-60). When installing the cylinder over the piston seal tilt the cylinder 15° to 30° degrees to the piston rod.

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

CAUTION: Make certain the back-up rings (components of the piston T-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.

- 11.37 Apply fluid to two end cap tie bar o-ring seals (5-30) and install into the outer end cap (2-70).
- 11.38 Apply fluid to the outer end cap cylinder o-ring (5-60) and install onto the outer end cap (2-70).
- 11.39 Install the outer end cap (2-70) onto the tie bars and into the end of the cylinder (2-40). NOTE: The pressure inlet port should be installed in the position recorded in step 5.5.
- 11.40 Install the two tie bar nuts (2-130) on the tie bars (2-100), using them to draw all of the cylinder components into position. Torque alternately, in 50 ft. lb. increments, until a final torque of 110 ± 11 ft. lbs. has been achieved.

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

- 11.41 Install the nut retainer (2-140), securing in place with the retainer screw (2-160) and lockwasher (2-150). It is necessary that the flats on the hex nuts (2-130) be aligned and parallel before the nut retainer can be installed.
- 11.42 Install the Bleed valves (2-240) and pipe plugs (2-230) into the hydraulic control cylinder (2-40).
- 11.43 Apply sufficient pneumatic pressure to the breather port in the pneumatic cylinder inboard end cap (2-30) to stroke the actuator. Remove the pneumatic pressure from the breather port. If air pressure is not available then by pushing on the exposed spring return push rod (4-20) or tapping it with a soft mallet, stroke the actuator until the yoke touches the housing or the stop screw at the end of its stroke.

12.0 SPRING CARTRIDGE INSTALLATION

NOTE: Make sure that the stop screws (1-60) have not been screwed into the point that "pre-load" will be created on the spring cartridge.

- 12.1 Remove the tie bar nuts on outboard end of the spring cartridge (4-10) and install new thread seals (3-180) and countersunk washers (3-190).
- 12.2 Re-install the tie bar nuts onto the outboard end of the SR tie bars.
- 12.3 Prepare the Interfacing surfaces of the spring cartridge inboard end and the outboard side of the spring cartridge adapter plate (4-80) per master gasket instructions (reference note 5 on assembly drawing).
- 12.4 On the outboard side of the spring cartridge adapter plate (4-80) install o-ring seal (3-200) into the seal groove.
- 12.5 Remove the two nuts, installed in section 6, from the inboard end of the spring cartridge tie bars.

- 12.6 Place the spring cartridge (4-10) onto the push rod (4-20) and align the spring cartridge tie bars with the holes in the spring cartridge adapter plate (4-80).

CAUTION: When installing the SR do not allow the spring cartridge tie bars to be pushed back into the cartridge.

- 12.10 Insert and screw the SR tie bars into the mating holes in the SR adapter plate (4-80). Tighten each tie bar until the threads bottom out, then back out one quarter-turn.

- 12.11 Use the spring cartridge tie bar nuts to draw the spring cartridge firmly against the adapter plate (4-80). Torque alternately, in 50 ft. lb. increments, until a final torque of 110 ± 11 ft. lbs. has been achieved.

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

- 12.12 Install the nut retainer (4-40), securing in place with the retainer screw (4-60) and lockwasher (4-50).
NOTE: It is necessary that the flats on the SR tie bar hex nuts be aligned and parallel before the nut retainer can be installed.

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 leak testing will use the nominal operating pressure (NOP) as listed on the actuator name tag.

- 13.3 Before testing for leaks, alternately apply and release actuator name tag NOP pressure, to the pressure side of the pneumatic cylinder piston to stroke the actuator fully. Repeat this cycle approximately five times. This will allow the new seals to seek their proper service condition.

- 13.4 Using a pressure regulator apply the name tag NOP pressure to the pressure inlet port in the pneumatic cylinder outboard end cap (2-30).

- 13.5 Apply a leak testing solution to the following areas:

13.5.1 The breather port in the pneumatic cylinder inboard end cap (2-30).

13.5.2 Joint between the outboard pneumatic cylinder end cap (2-30) and the cylinder (2-10).

13.5.3 Joint between the outboard pneumatic cylinder end cap (2-30) and the hydraulic cylinder inner end cap (2-60).

13.5.4 The pressure port in hydraulic cylinder inner end cap (2-60).

- 13.6 Remove the pressure from the inlet port in the outboard pneumatic cylinder end cap (2-30).

- 13.7 Adjust the pressure regulator to 40 psig and apply to the pressure inlet port in the hydraulic cylinder inner end cap (2-60).

- 13.8 Apply a leak testing solution to the following areas:
 - 13.8.1 Joint between the inner end cap (2-60) and the cylinder (2-40).
 - 13.8.2 Joint between the outboard pneumatic cylinder end cap (2-30) and the hydraulic cylinder inner end cap (2-60).
 - 13.8.3 The pressure inlet port in the pneumatic cylinder outboard end cap (2-30).
 - 13.8.4 The pressure inlet port in the hydraulic cylinder outer end cap (2-70).
- 13.9 Remove the pressure from the inlet port in the hydraulic cylinder inner end cap (2-60).
- 13.10 If an actuator was disassembled and repaired, the above leakage test must be performed again.
- 13.11 Operation test the actuator to verify proper function of the actuator. This test is to be done off of the valve.
- 13.12 Adjust the pressure regulator to the name tag NOP pressure.
- 13.13 Apply the above pressure to the actuator power cylinder pressure inlet port and allow the actuator to stabilize. The actuator should stroke a full 90° travel.
- 13.14 Any jumpy or jerky operation, not attributed to seal drag or limited flow capacity, must be corrected and the above test performed again.
- 13.15 Remove NOP pressure from the pressure inlet port.

14.0 M7 HYDRAULIC CONTROL PACKAGE INSTALLATION AND SYSTEM SERVICE

- 14.1 If M7 Hydraulic Control Package (8) was originally mounted on the hydraulic cylinder (2-40) then mount the M7 package and bracket to hydraulic cylinder (2-40).
- 14.2 Reconnect all tubing between the M7 Hydraulic Control Package (8) and both inboard and outboard of the hydraulic cylinder.
- 14.3 Refilling of the M7 Hydraulic Control System and actuator cylinder is best accomplished using a pressure pump. If a pressure pump is not available go to step 14.14 for the manual field service refilling procedure.
- 14.4 Remove all pressure from the pneumatic cylinder (2-10) make sure the actuator has fully stroke to its fail position.
- 14.5 Remove the breather from the M7 package (8) reservoir.
- 14.6 Attach the pump discharge line to reservoir breather port.
- 14.7 Open the two bleed valves located at each end of the hydraulic cylinders.
- 14.8 Open the M7 block/by-pass valve.
- 14.9 Slowly pump hydraulic fluid into the reservoir. Approximately 3 to 5 psi will be required. As the fluid passes through the M7 control module into the cylinder, air will be displaced.

- 14.10 Close each bleed valve when the air has been displaced and hydraulic fluid appears.
- 14.11 Remove the pressure pump.
- 14.12 With the actuator in its "fail" position; add fluid to the reservoir so that its level is within approximately 1-1½ inches of full.
- 14.13 Install the breather into the M7 package reservoir.
- 14.14 Refilling the M7 control system during field service often must be done without the use of a pressure pump. Proceed as follows:
- 14.15 On hydraulic cylinder on which M7 override is mounted, the piston must be stroked toward outboard side of the actuator.
- 14.16 Fill hydraulic cylinder(s) with fluid by removing bleed valves at the top of cylinder.
- 14.17 Fill the reservoir. Maintain at least 1-1/2 inches of fluid within the reservoir at all times.
- 14.18 Close the by-pass valve.
- 14.19 Close both speed control valves.
- 14.20 Open outboard end cylinder bleed valve.
- 14.21 Operate hand pump slowly. Keep handle up for about 4 to 5 seconds before each pressure stroke. This allows time for the pump cylinder to fill in order that full displacement of the pump is utilized. NOTE: If the pump fails to deliver fluid, open the by-pass valve, rapidly operate the pump 15 to 20 times, close the by-pass valve and continue filling sequence.
- 14.22 Close the outboard end cylinder bleed valve when fluid appears.
- 14.23 Open the inboard end cylinder bleed valve.
- 14.24 Operate the hand pump to fully stroke the actuator. Refill reservoir as required.
- 14.25 Open by-pass valve.
- 14.26 Slightly open the outboard cylinder (right hand) speed control. As the actuator strokes, fluid will be displaced from the greater volume of the outboard cylinder into the lesser volume of the inboard cylinder. Fluid will begin flowing from the inboard end cylinder bleed valve.
- 14.27 Close the inboard end cylinder bleed valve when fluid appears. NOTE: If the actuator completes its stroke and fluid does not appear at the inboard end cylinder bleed valve, omit procedure step 14.26 and proceed as follows:
- 14.28 Close the outboard cylinder (right hand) speed control valve.
- 14.29 close the by-pass valve.
- 14.30 Open inboard end cylinder bleed.

- 14.31 Operate hand pump as described to cycle actuator.
- 14.32 Close inboard end cylinder bleed valve when fluid appears. Stop operation of pump. NOTE: If fluid does not appear, repeat steps 14.22 through 14.26.
- 14.33 Open by-pass valve. Fully open inboard cylinder speed control.
- 14.34 Slowly open outboard speed control.
- 14.35 Allow the actuator to complete its stroke to "fail" position. Add fluid to reservoir so that level is within approximately 1-1/2 inches of full. Install breather. Connect power supply lines and cycle the actuator using available power media. Adjust and lock speed controls. Actuator is in normal service.
- 14.36 POWER OPERATION CHECK.
 - 14.36.1 Fully open the M7 block/by-pass valve, located on the right hand side of the M7 block.
 - 14.36.2 Apply NOP pressure to the power cylinder and cycle the actuator. The fail close (clockwise) actuator should be able to complete a full closed to open stroke in power operation and the fail open (counter clockwise) actuator should be able to complete a full open to closed stroke in power operation.
 - 14.36.3 Remove the NOP pressure from the power cylinder. The fail close (clockwise) actuator should be able to complete a open to full closed position and the fail open (counter-clockwise) actuator should be able to complete a closed to full open position.
- 14.37 MANUAL OPERATION CHECK.
 - 14.37.1 Manual operation requires that the block/by-pass valve be fully closed.
 - 14.37.2 Operate the hand pump until the actuator strokes from full closed to open. When the actuator is fully stroked against the travel stops, an increased resistance in pumping effort will be noted. Continued operation of the pump simply circulates fluid through a high pressure relief.
 - 14.37.3 Fully open the block/by-pass valve to reverse the actuator rotation or to return to the full closed position or normal power operation position.

15.0 RETURN TO SERVICE

- 15.1 Install breather (11) in the inboard inner end cap (2-30).
- 15.2 Replace the software components of the snubber valves (1-190). Install one snubber valve in the housing cover (1-20) and one in the housing (1-10).
- 15.3 Adjust both stop screws (1-60) back to settings recorded in section five under General Disassembly.
- 15.4 Tighten both stop nuts (1-120) securely, while holding stop screw (1-60).
- 15.5 Actuator is ready to be returned to service.

- 15.6 After the actuator is installed on the valve all accessories should be hooked up and tested for proper operation and replaced if found defective.

CHART NO. 1 - ACTUATOR WEIGHTS

ACTUATOR MODEL	APPROXIMATE WEIGHT (POUNDS)**			
	SR2	SR2	SR2	SR5
ST812-SRX-M7	N/A	1435	1454	1245
ST816-SRX-M7	1547	1492	1511	1303
ST820-SRX-M7	1664	1608	1628	1419
ST824-SRX-M7	1992	1937	1956	1747
ST828-SRX-M7	2323	2268	2287	2078

** Weights listed for each model are for bare actuators without valve mounting and accessories.

CHART NO. 2 - TOOL STYLE AND WRENCH SIZES

ITEM NO.	WRENCH SIZE	QTY	LOCATION	RECOMMENDED WRENCH STYLE
1-60	15/16"	2	Stop Screw	Open end or adjustable
1-90	9/16"	14	Cover Screws	Socket
1-120	1-7/8"	2	Stop Screw nut	Box end (1)
1-180	3/16"	4	Weather cover screws	Allen
1-190	7/8"	1	Snubber	Deep socket
1-240	9/16"	6	Pos. Ind. cover screws	Socket
2-60	5/8"	2	Tie bars flats	Open end or adjustable
2-90	1-5/8"	2	Tie bar nuts	Crows foot (1)
2-120	3/16"	1	Nut retainer screw	Allen
2-170	1-3/8"	1	Piston rod flat	Crows foot (1)
2-230	9/32"	2	1/8" NPT drain plug	Open end or adjustable
2-240	13/32"	2	Bleed valves	Open end or box
None	1-5/8"	2	SR Tie bar nut	Deep socket
4-20	(1)	1	Push rod	Strap wrench
4-60	3/16"	1	Nut retainer screw	Allen
4-90	1/2"	4	SR adapter screws	Allen
4-100	15/16"	4	SR adapter screws	Socket

(1) No alternate style recommended or wrench placement not provided.

ECN	DATE	REV	BY *	DATE
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* Signatures on file Bettis Actuator & Controls, Waller, Texas