Auxiliary Machines II

Lab Book

Fall 2014

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Introduction

Auxiliary Machine II Lab uses cutaway equipment, operational trainers, and simulators. The goal of the lab is for students to be able to follow directions to do maintenance on both positive and non-positive displacement pumps. The goal of the lab is to understand the operation of control valves and hydraulics.

The objective of the first four labs is to disassemble and reassemble the machinery as per the STCW requirements.

Requirements for Lab:

Steel toed shoes, Eye protection, and a Boiler suit. All students need to bring their lab book, calculator, and pen/pencil.

Labs are mandatory. This is a STCW lab. If you miss a lab, this will result in a failing grade for the semester until the lab has been made up at the instructor's convenience or within the timeframe of the Fall of 2015.

LOCKOUT TAGOUT FORM

System	Device #	De-Energized	Initials / Date	Re-Energized	Initials / Date	Lock #
Air Compressor	1-AC-1					
Electrical Disc.	1-ED-1					
Motor Contoller	1-MC-1					
Electrical Plug	1-EP-1					
Comp. Discharge	1-CDV-1					
System Air Valve	1-SAV-1					
Recip. Pump	2-RP-1					
Air Inlet Valve	2-AIV-1					
Water Suction Valve	2-WSV-1					
Water Disch. Valve	2-WDV-1					
System Air Valve	2-SAV-1					
End Suction	3-CP-1					
Electrical Disc.	3-ED-1					
Motor Contoller	3-MC-1					
Electrical Plug	3-EP-1					
Water Suction Valve	3-WSV-1					
Water Disch. Valve	3-WDV-1					
Split Case	4-CP-1					
Electrical Disc.	4-ED-1					
Motor Contoller	4-MC-1					
Electrical Plug	4-EP-1					
Water Suction Valve	4-WSV-1					
Water Disch. Valve	4-WDV-1					

Split Case Centrifugal Pump

Learning Objectives:

- OICEW - A4.3 Preparation, operation, fault detection and measures to prevent damage for auxiliary prime movers and associated systems
- OICEW - C2.3 Dismantling, adjustment and reassembling of machinery and equipment
- OICEW - C2.4 The use of appropriate specialized tools
- OICEW - 8.2A Demonstrate proficiency in centrifugal pump maintenance
- Read and follow written instructions
- Read and understand a blueprint
- Disassemble and reassemble a centrifugal pump
- Operate a pump, monitoring suction, discharge pressures, and power requirements

USCG STCW Standards:

- Plan reflects proper sequence of actions, is complete, and conforms to the requirements of manufacturer's instructions and ship's procedures
- Dismantling, examination and measurements, assessment of wear or deterioration, re-fitting and clearance checks, and replacement/adjustment of seals is successful and conducted according to plan
- Actions taken are correctly and completely described
- Required steps taken are verified by assessor, utilizing sample checklist as a guide
- No safety violations are observed

Student's Name: _____ Date:_____

Instructor's Name: _____ Date:_____

Maintenance Data:

Model:	Serial Number:
Size:	Type of Seal:
Impeller Type:	Impeller Size:
Motor RPM:	Motor HP:

Preliminary:

1. Read complete lab handout
2. Complete lock-out, tag-out procedures to electrical power, pump suction, and discharge valves. (Ensure lock-out, tag-out sheet is filled out, signed, and dated!!)
3. **Stop** until instructor has approved the lock-out, tag-out Instructor_____
4. Visually inspect the pump, then open casing drains and vent
5. Fill in the Maintenance Data log
6. Make room on the workbench for parts

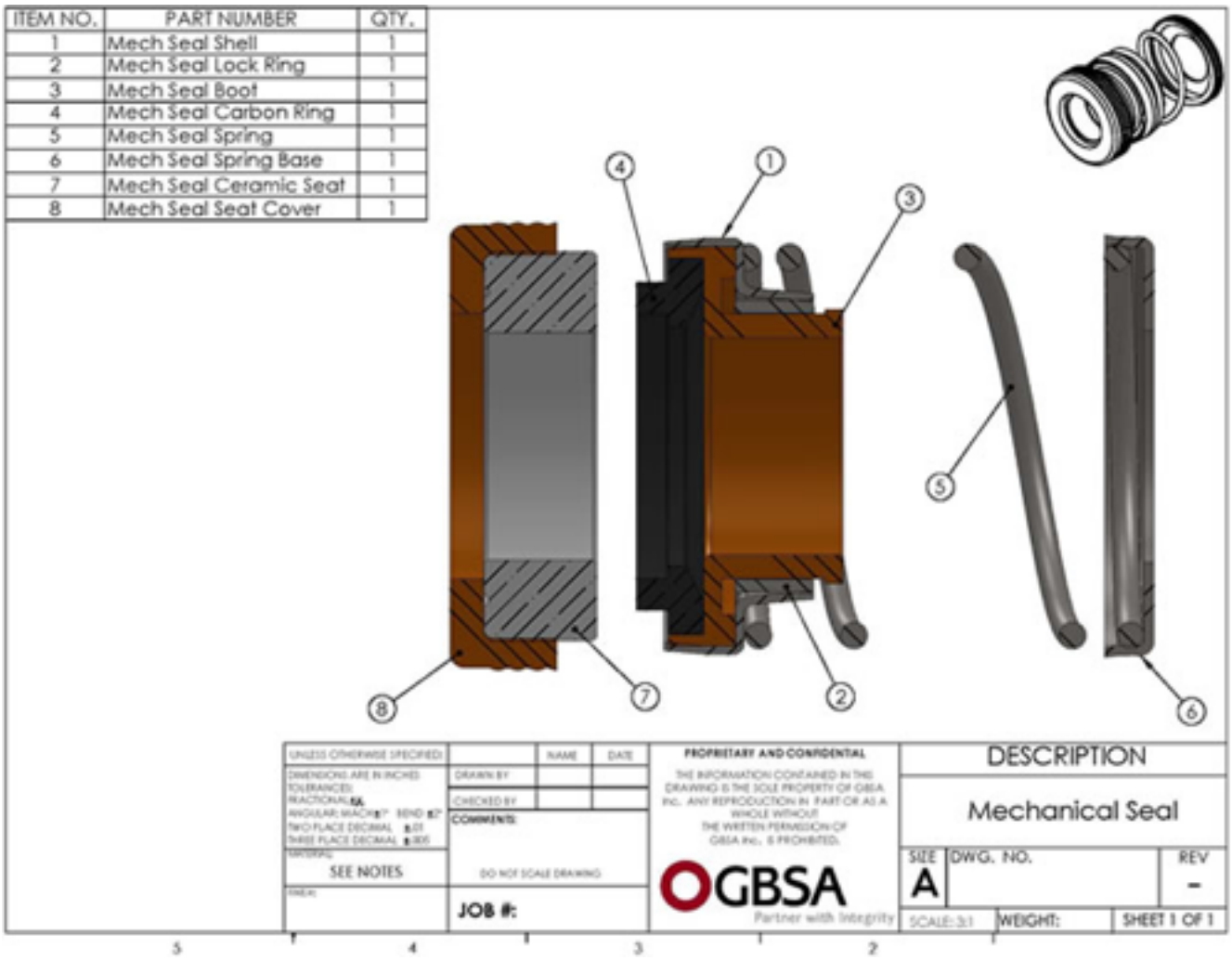
Disassembly:

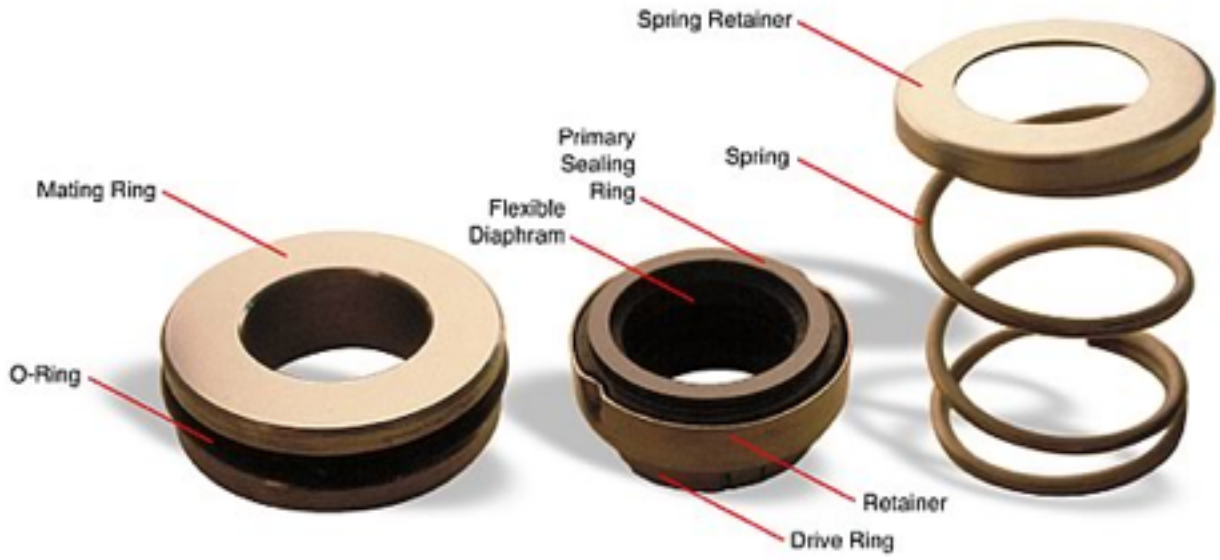
1. Remove the coupling guard (1/2" wrench)
2. Loosen the coupling set screws on the motor and pump end. (allen key 6/32"). Separate the motor from the pump by sliding the coupling apart
3. Remove the rubber Spider coupling
4. Remove the vent tubing (9/16" tubing wrench)
5. Loosen and unscrew the mechanical seal gland bolts on both glands (3/4 wrench)
6. Loosen and remove the 4 casing nuts (ref# 425, 1- 1/4" socket) and the 9 casing bolts (ref# 426, 1- 1/8" socket) **Do this in a cross pattern**
7. Remove the casing tapered dowel pins (ref# 469G) by screwing down the 9/16" nut on top of the pins
8. Inset a pry bar into the machined slots in the lower casing and pry up against the upper casing half. Do this **SLOWLY** as you only want to separate the two halves
9. Place a pipe in the eye bolt on the upper half of the casing. Lift the upper casing and place it on the bench on its **side**. DO THIS WITH TWO PEOPLE!!!!
10. Carefully remove the casing gasket
11. Loosen and remove the bearing housing hold down bolts from both ends of the pump (ref# 372U and 134, 15/16" socket)
12. With two people lift the impeller assembly out and place it on the wooden stand
13. Loosen the bearing housing cover bolts on both sides (ref# 371C, 9/16" socket)
14. Remove the bolts holding the bearing housing (ref# 371C) and slide the bearing housing off the shaft. If tight, use a soft-head hammer to remove the housing

15. On the THRUST BEARING end, remove the bearing retaining ring (ref# 361). This is done using the retaining ring/snap ring pliers
16. Using the bearing pullers, remove the THRUST BEARING, JOURNAL BEARING, and bearing end covers (ref# 109)
17. Remove the deflector (ref# 123) from the shaft
18. Remove the gland bolts and then the mechanical seal gland and gasket

NOTE: BE CAREFUL HANDLING THE MECHANICAL SEAL

As you remove the gland, be careful to tip the unit so the carbon (rotary seal) does not fall out. Sometimes it sticks to the stationary seal which is ceramic and is located in the housing. If the carbon seal is stuck to the ceramic seal, remove it and place it on the bench on a sheet of paper or cardboard. Be careful not to place it on the sealing side. If the seal is still in the seal housing on the shaft, remove it and place it on the bench taking care as noted above.





19. Remove the casing wear rings (ref# 103). Use an outside micrometer to measure the OD of the impeller eye. Use a dial caliper to measure the ID of the casing wear ring. This measurement is to determine the amount of wear and clearance of the wear ring and impeller. You will subtract the impeller OD from the wear ring ID and divide by two. The manufacture recommends 0.005" to 0.007" running clearance between the impeller and ring.

Impeller OD	Ring ID	Clearance

20. Place the seal gland on the bench on a sheet of paper or cardboard with the seal facing down. Using your thumbs, press out the seal.
21. **The instructor will review the mechanical seal construction, operation, and the parts of the shaft seal.**

Assembly:

1. Reinstall the casing wear rings. Make sure the beveled edge goes toward the impeller.
2. Reassemble the mechanical seal:
    1. Check both seals for cracks or breaks
    2. Inspect the o-ring for any wear or damage

3. Place the ceramic seal in the gland housing, ensuring the sealing side is facing up. Using a clean or piece of white paper to protect the seal face, press the seal into the housing using your hands.
4. Install the carbon seal (rotary seal) onto the shaft. Ensure that the notches on the seal fit properly into the stainless steel ring that holds and drives the rotating carbon seal. Use a clean rag or paper to ensure the seal is on fully.

AVOID TOUCHING THE FACES OF THE SEALS AS MUCH AS POSSIBLE AS THIS WILL LEAD TO THEM FAILING!!!!!

3. Reinstall the seal gland and gasket on to the shaft, taking care not to damage the stationary ceramic seal face. Reinstall the gland bolts.
4. Reinstall the deflector. Check to see if you can notice the deflector is touching the machined part of the shaft. If not, you need to compress the rotary seal spring some more by pushing on the deflector and rotary seal assembly until the deflector touches the machined surface. If this is not done, the rest of the assembly will not fit properly.
5. Reinstall the inner bearing cover. Ensure the gasket is in place. If necessary, put some anti-seize on the gasket.
6. Reinstall the bearings:
    1. Make sure the bearing heater is powered on
    2. Place the bearing on the heater
    3. After a few minutes using a thermo melt pencil marked for 250 degrees F, touch the bearing. If the bearing is hot enough the pencil mark will melt showing that the bearing has heated to a high enough temperature to cause it to expand and allow you to slide it back on the shaft.

Note: You must be quick on getting the bearing all the way back to the bearing stop on the shaft. As you are pushing the bearing back, it is cooling off and can bind up before it is fully back on. If the bearing is not completely back to the bearing stop, you have to start over!!!

    4. For the THRUST BEARING, you must reinstall the retaining ring. It is best done while you are holding the bearing in place.
    5. After the bearing has cooled, reinstall the bearing housing
    6. Reinstall the bearing housing bolts and tighten them until they are **SNUG**
7. Inspect the pump casing for damage and gasket material. You may need to wipe down sections to properly inspect the inside of the pump
8. Ensure that the coupling is on the end of the shaft
9. Reinstall the pump assembly back into the pump casing. Ensure the wear rings anti rotation pins are on top. Make sure the assembly fits flush into the casing. As the assembly

is being set, slip the wear rings around until the pins are in the slots on the casing. Ensure the gasket for the seal gland is not being set into the casing.

10. Reinstall the bearing housing to the lower casing bolts and torque to **60 ft-lbs**
11. Torque the bearing housing bolts to **12 ft-lbs**
12. Check the casing gasket. If needed, put a light coating of anti-seize on them. Place them on the lower casing ensuring they are set properly.
13. Reinstall the alignment pins into the upper casing, and with two students reinstall the upper casing onto the lower casing

Note: While doing this another student should make sure the alignment pins line up to their appropriate holes and that the gasket does not move while placing the units together. DO NOT move the upper housing once in place as you may also be moving the gasket.

14. Install the casing nuts and bolts, tightening them in a cross pattern until they are **SNUG**. Then torque them to **40 ft-lbs**. DO NOT force the bolts into place, you should be able to hand screw them in, if the housing are set properly.
15. Ensure that the pipe plug on the seal gland is **UP** and the gland gasket is in place. Tighten the mechanical seal gland bolts until the gasket seals against the pump casking. **DO NOT** over tighten as this is a rubber gasket.

Note: Before tightening the bolts, ensure that the rotary mechanical seal is properly set. If you miss this, you stand a good chance that the seal will not fit properly and crack. You will not notice any problems until you turn the water on and the pump leaks around the seal.

16. Reinstall the flexible coupling
17. Turn the pump shaft by hand to make sure it turns freely
18. Reinstall the coupling guard
19. Reinstall the vent line

Ready the Pump for Operation:

1. Remove the lock-out, tag-out equipment from the suction and discharge valves
2. Close the drain valves and the vent valve
3. Roll over the portable water supply tank and attach the hoses. Open the valves on the hoses.
4. Open the pump suction valve checking for leaks. If leaks are observed, take appropriate action to secure them.
5. Open the casing vent valve and leave open until a steady flow of water comes from the vent line. The pump is full of water and is primed. Re-check for leaks.
6. Remove the lock-out, tag-out equipment from the power circuit breakers and close both breakers. (Ensure all lock-out, tag-out paperwork is complete)

7. Log the suction side pressure gauge reading
8. Start the motor. The discharge valve is closed. This will give you the maximum discharge pressure and minimum current drawn on the motor.

Note: The discharge pressure gauge and power meter ampere readings. Log these values in the table.

9. After the motor is up to speed and you have your readings, open the discharge valve slowly.

Note: The amperage reading goes up and the discharge pressure goes down. After the discharge valve is fully open, log in the table the amperage and pressure gauge readings.

10. Stop the pump. Open the motor controller and the circuit breakers
11. Close the suction and discharge valves on the pump and water supply lines
12. At this point, the instructor will instruct you on how the system should be left for the next class
13. Empty the drain bucket under the pump and ensure all the tools are placed in the tool box properly
14. **ENSURE THE TOQURE WRENCH IS ZEROED!!!**

Split Case Pump Operation Log

Valve Position	Pump Power	Amperage	Suction PSI	Discharge PSI
Suct. Open Disch. Closed	Off			
Suct. Open Disch. Closed	On			
Suct. Open Disch. Open	On			

Calculations:

Using the information collected, calculate how much head the pump can generate. Show your math and units. Also calculate the GPM of the pump.

Questions:

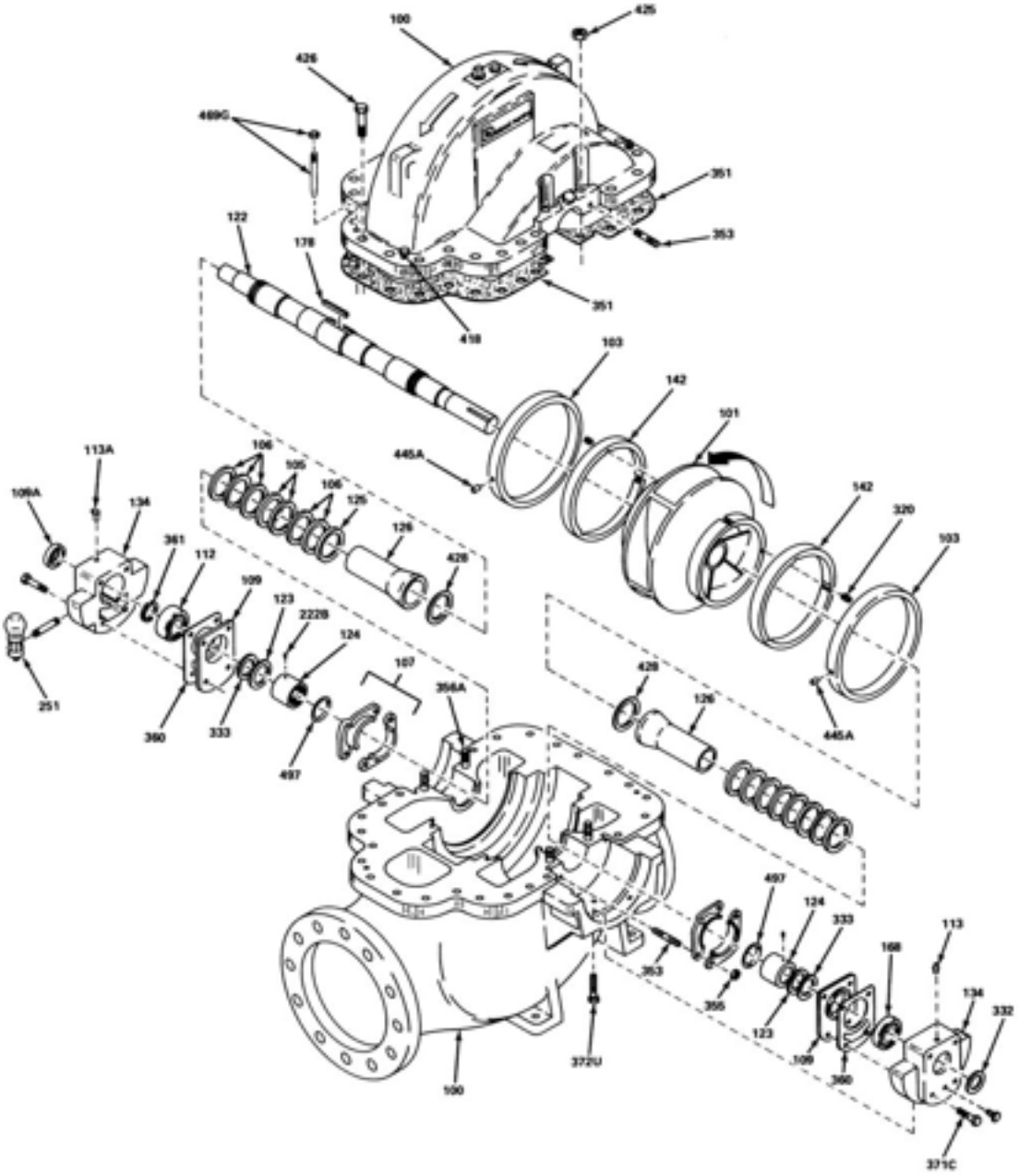
1. Why did the pump prime itself without having to start the pump?

2. Explain how the mechanical seal works.

3. What type of impeller is in the split case?

4. Why do we have wearing rings?

5. How do you properly remove and install a bearing?


100
425
426
469G
351
353
122
178
418
103
142
101
445A
113A
106A
134
106
105
125
126
428
361
112
109
123
222B
124
107
356A
251
360
333
497
372U
355
168
332
371C

Illustrated Parts List and Materials of Construction"

Item No.	No. Req"d Per Pump.	Part Name	Material			
			Bronze-Pitted	All Iron	AU Iron! 316 Rot. EL	AU 316SS
100	1 Upper 1 Lower	Casing	1003	1.003	1003	316
101	1	Impeller	1102	1000	316	316
102	2	Seal Tubing (Optional)	Brass	Steel		316
103	2	Wear Ring, Casing	1104	1000	316	
105	2	Lantern Ring	Glass-Filled Teflon			
106	1 set	Stuffing Box Packing	Square Non-Asbestos (Die-Formed S&M Groups)			
107	2	Stuffing Box "Gland	AISI 316.			
109	2	Bearing End Cover	1000			
109A	1	Bearing End Cover, Thrust	Steel			
112	1	Ball Bearing, Thrust	Steel			
113	2	Grease Fitting	Steel			
113A	2	Breather, (Oil Lubrication Only)	Steel			
122	1	Shaft	AISI 4140*			
123	2	Deflector	Laminated Plastic			
124	2	Sleeve Nut (M, L and XL only)	1104	1000	316	
125	2	Stuffing Box Bushing	316			
126	2	Shaft Sleeve (Optional on S Group)	1104	1000	316	
134	2	Bearmg Housing	1000			
142	2	Wear Ring. Impeller (Optional)	1104	1000	316	
168	1	Ball Bearing, Coupling	Steel			
178	1	Impeller Key	AIS! 1018**.			
222B	2	Set Screw, Sleeve Nut	Steel			
250	2	Gland, Mech Seal *** (Flush STD)	1102	1003	1102	316
	2	Gland, Mech Seal, . *** FL-VT-DR (Optional)	Steel			
251	2	Sight Oiler (Optional Oil Lubrication)	White Metal and Glass			
317	2	Magnetic Seal, *** Thurst (Optional)	Steel			
317A	1	Magnetic Seal Radial *** (Optional)	Steel			
320	6	Retaining Set Screw, Impeller Wear Ring (Optional)	303 SS			
332	1	Grease - Oil Seal, Outboard	Buna Rubber			
"332A	1	Labyrinth Seal, *** Outboard (Optional)	Steel			

Item No.	No. Req'd Per Pump	Part Name	Material			
			. Bronze-Fitted	All Iron	All Iron! 316 Rot. EL	All 316SS
333	2.	Grease - Oil Seal, Inboard	Buna Rubber			
333A	2	Labyrinth Seal, *** Inboard (Optional)	Steel			
351	- 1	Casing Gasket, Parting	1/32" Non-Asbestos			
353	4	Studs, Gland-	316			
353B	2	HC Screw (W/C.I. Mech Seal Gld)	Steel.			
	4	HC Screw (W/Stl. Mech Seal Gld)	Steel			
355	4	Hex Nuts, Gland	304			
356A	4	Studs, Parting	Steel			
360	2	Gasket, End Cover to Bearing Housing	Kraft Paper			
360Q	2	Gasket, Gland to Case	Non-Asbestos			
361	1	Retaining Ring, Thrust Bearing	Steel			
361H	2	Retaming Rmg, Impeller (8 Group Only) .	Steel		Stainless Steel	
371C	8	Hex Cap Screw	Steel			
372U	4	Hex Cap Screw	. Steel			
418	2	Jacking Bolt	Steel			
425	4	Hex Nuts, Parting	Steel			
426	Variable	Hex Cap Screw, Parting"	Steel			
428	2	Gasket, Sleeve to Impeller (M,L and XL only)	1/32" Non-Asbestos			
445A	2	. Anti-Rotation Pm, Casing "Wear Ring	AISI420		AISI316	
469G	2	Tapered Pin W/Hex Nut	Steel			
494	2	Cooling Assembly (Optional)	Copper Tube, Fitting			
497	2	O-ring, Sleeve Nut (M,L lind XL only)	Buna Rubber .			

*S Group AISI 420 (All Iron & Bronze-Fitted Construction).

AISI 316 (All 316 & 316 Trim Construction).

**S Group AISI 303.

***Contact your GOULDS Representative for information on seal options.

Illustrated Parts List and Materials of Construction - CONT

End Suction Centrifugal Pump

Learning Objectives:

- OICEW- A4.3 Preparation, operation, fault detection, and measures to prevent damage for auxiliary prime movers and associated systems
- OICEW- C2.3 Dismantling, adjustment, and reassembling of machinery and equipment
- OICEW- C2.4 The use of appropriate specialized tools
- OICEW- 8.2A Demonstrate proficiency in centrifugal pump maintenance
- Read and follow written instructions
- Read and understand a blueprint
- Properly handle basic hand tools
- Disassemble and reassemble centrifugal pumps
- Operate a pump, monitoring suction, discharge pressures, and power requirements

USCG STCW Standards:

- Plan reflects proper sequence of actions, is complete, and conforms to the requirements of manufacturer's instructions and ship's procedures
- Dismantling, examination and measurement, assessment of wear or deterioration, re-fitting and clearance checks, and replacement/adjustment of seals is successful and conducted according to plan
- Actions taken are correctly and completely described
- Required steps taken are verified by assessor, utilizing sample checklist as a guide
- No safety violations are observed

Student's Name: _____ Date: _____

Instructor's Name: _____ Date: _____

Maintenance Data:

Model:	Serial Number:	
Size:	Packing Type:	Size:
Sleeve Diameter:	Impeller Type:	Size:
Motor RPM:	Motor HP:	

Preliminary:

1. Read complete lab handout
2. Complete lock-out, tag-out procedures to electrical power, suction, and discharge valves. (Ensure all paperwork is filled out, signed, and dated!!)
3. **Stop** until instructor has approved the lock-out, tag-out Instructor_____
4. Visually inspect the pump, then open casing drains and vent
5. Fill in the above data log with information from the nameplate. (The rest of the log will be filled in later)
6. Make room on the workbench for parts

Disassembly:

1. Remove the packing gland (ref# 107) by unscrewing both 9/16" gland stud nuts (ref# 355). Then slide the packing gland back off the gland studs.

Note: The packing gland is split and comes off in two pieces

2. Using the packing removal tool, remove two sections of packing
3. Remove the coupling guard between the pump and motor
4. Separate the motor from the pump by removing the coupling
    1. Using a 5/16" wrench, remove the 4 coupling bolts that hold the motor end coupling pieces together
    2. Loosen both coupling set screws with a 5/32" hex (Allen) wrench, then slide both the motor and pump coupling halves away from each other
    3. Remove the rubber flexible coupling piece and motor side coupling hub
5. Disconnect the 1/4" tubing line from the vent valve and the 1/4" brass pipe, screwed into the stuffing box
6. Using a small pipe wrench, remove the brass pipe from the stuffing box
7. Remove the 4 adapter to case bolts, size 15/16" (ref# 370)
8. Loosen the 3/4" bearing frame foot bolt (ref# 241)

Note: It may be necessary to tighten the 2 adapters to case jacking bolts (ref# 418) to loosen the frame adapter (ref# 108) from the pump (ref# 100)

Note: The following is a two person job! Do not drop the bearing frame!!

9. Slide the bearing frame (ref# 228) back from the pump casing until the impeller clears the casing
10. Turn the bearing frame **90 degrees** and tighten the bearing frame hold down bolt
11. Remove the jacking bolts
12. Carefully remove and inspect the casing gasket (ref# 351)
13. Remove the impeller (ref# 101). Use an adjustable wrench to hold the shaft in place with the pump coupling, and a strap wrench on the impeller. The impeller has **right hand threads**, thus unscrew in counter-clockwise direction.
14. Measure the size of the impeller and note it in the maintenance data section
15. Remove the seal chamber/stuffing box cover (ref# 184) from the frame adapter by removing the 1/2" stuffing box cover-to-adapter nuts and sliding the stuffing box cover out
16. Using a machinist's rule determine the correct packing size by measuring the distance from the shaft sleeve to the edge of the packing box

Note: The size of the packing in the maintenance data suction

17. Remove the shaft sleeve and lantern ring
18. Using dial calipers, measure the diameter of the shaft sleeve
19. Measure the wooden mandrel to be used in cutting the packing to ensure that it is the correct one
20. Using the correct mandrel and packing knife, cut two packing strips and set them aside for later use

STOP: The instructor will review the assembly and operation of this unit

21. **Check shaft/sleeve run out:** Put on the shaft and thread on impeller, ***hand tight***. Using the magnetic base indicator, mount the dial indicator so the dial indicator is in the center of the shaft and perpendicular to it. Rotate the shaft 360 degrees. Log the reading, if total indicator reading is greater than 0.002", disassemble and determine cause. Remove impeller and shaft sleeve.
22. **Check frame face run out:** Using the screw base, mount the dial indicator on the shaft and place the indicator so it is touching the frame face. Rotate the shaft so the indicator rides along the face for 360 degrees. If the total indicator is greater than 0.001" disassemble and determine cause. Log readings.
23. **Check shaft end play:** Using the magnetic base indicator, mount the dial indicator on the drive end so the dial is touching the end of the shaft. Move the shaft forward then

backward by hand. Log reading. If the reading is greater than listed, disassemble and determine cause.

	Shaft/Sleeve Run Out	Frame Face Run Out	Shaft End Play
Tolerance	0.002″	0.001″	0.0011″/0.0019″
Reading			

Reassembly:

1. Carefully reinstall the sleeve into the seal chamber/stuffing box cover. Inset the lantern ring and both packing strips that were previously cut

Note: Make sure each piece is staggered **90 degrees** from the last piece. Use the packing gland to push each ring of packing into place and tighten the bolts **finger tight**.

2. Put a light coating of anti-seize on the inside of the sleeve, if necessary
3. Carefully install the seal camber/stuffing box cover and sleeve over the pump shaft. Make sure the 1/4″ pipe hole is facing up. Press the cover firmly into its groove.
4. Install the cover nuts and tighten to **20 ft-lbs**
5. Put anti-seize on the casing gasket (ref# 351) and carefully install the gasket
6. Put a light coating of anti-seize on the impeller threads and install the impeller by turning clockwise
7. Tighten the impeller until it is **snug** (use the strap wrench and the adjustable wrench on the shaft coupling)
8. Loosen the frame foot bolt and reinstall the bearing frame back into the pump casing

Note: This is a two person job. Be careful while moving the pump assembly

9. Install and tighten the 4 casing bolts, in a cross pattern, to **30 ft-lbs**
10. Tighten the frame foot bolt **snug** using a 3/4″ wrench
11. Set the impeller to case clearance @ 0.010″
    1. Loosen the jam nuts (ref# 423) on the jacking bolts (ref# 370D) and back the jacking bolts out about two turns
    2. Tighten each locking bolt (ref# 370C) evenly, drawing the bearing housing towards the bearing frame. Rotate the shaft as you do this so you know when the impeller contacts the casing
    3. Mount the magnetic base dial indicator assembly so the indicator is against the coupling end of the shaft
    4. Push the dial indicator towards the shaft until the contact pointer causes the pointer to turn about a half of a revolution. This is done to load the indicator

5. Tighten the linkage so the indicator cannot move from this position. Now, zero the indicator

Note: BE SURE NOT TO TOUCH THE INDICATOR FROM THIS POINT ON OR YOUR READINGS WILL BE OFF AND YOU WILL NEED TO START OVER!!!

6. Thread the jacking bolts evenly in until they contact the bearing frame
7. Loosen the locking bolts about one turn. This will allow you to back out the impeller from the casing.
8. Tighten the jacking bolts slowly and evenly until the indicator reads 0.010"
9. Tighten the locking bolts snug and jacking bolt jam nuts maintaining the 0.010" reading
10. Check the shaft for free turning
12. Screw in and tighten the 1/4" brass seal line into the threaded hole in the stuffing box
13. Reattach the 1/4" tubing to the seal line and valve
14. Reinstall the coupling, tighten the coupling screws, and check the shaft for free turning

Ready the Pump for Operation:

1. Remove the lock-out, tag-out from the suction and discharge valves
2. Connect the hoses from the water supply tank and open the shut off valves
3. Close the pump casing drains, vent valve, and seal line valve
4. Check that the discharge valve is closed
5. Open the pump suction valve and the vent valve
6. Close the vent valve once water flows out the vent line
7. Check for leaks
8. Open the seal line valve to supply water to the lantern ring
9. Check the packing area for water flowing from the packing
10. Take the suction side pressure reading and note it in the table below
11. Remove the lock-out, tag-out from the power cord and plug it in (make sure the paperwork is filled out)
12. Close both circuit breakers
13. Check the power meter to ensure power is available
14. Start the pump

Note: With the discharge valve closed and the pump running you have the least amount of work out of the motor, minimum current reading and maximum pressure the pump can produce

15. Log the current reading and pressure reading in the table below
16. Check that a small amount of water is flowing from the packing area

Note: You can control the flow by adjusting the seal supply valve, or tighten down on the packing

17. Check the temperature of the water

Note: If the water is getting hot, the packing is too tight or you are not getting enough water to the lantern ring

18. Open the discharge valve and check the flow back to the supply tank
19. Take the motor current reading and discharge pressure reading and log it in the table below

Discharge Valve Position	Suction Pressure (PSI)	Discharge Pressure (PSI)	Motor Current (Amps)
Closed			
Open			

20. Stop the pump
21. Close the suction and discharge valves on the pump and feed lines from the water supply tank
22. **ENSURE THE TOQURE WRENCH IS ZEROED!!!**

Calculations:

Using the information collected, calculate how much head the pump can generate. Show your math and units. Also calculate the GPM of the pump.

Questions:

1. Explain why there is a lantern ring

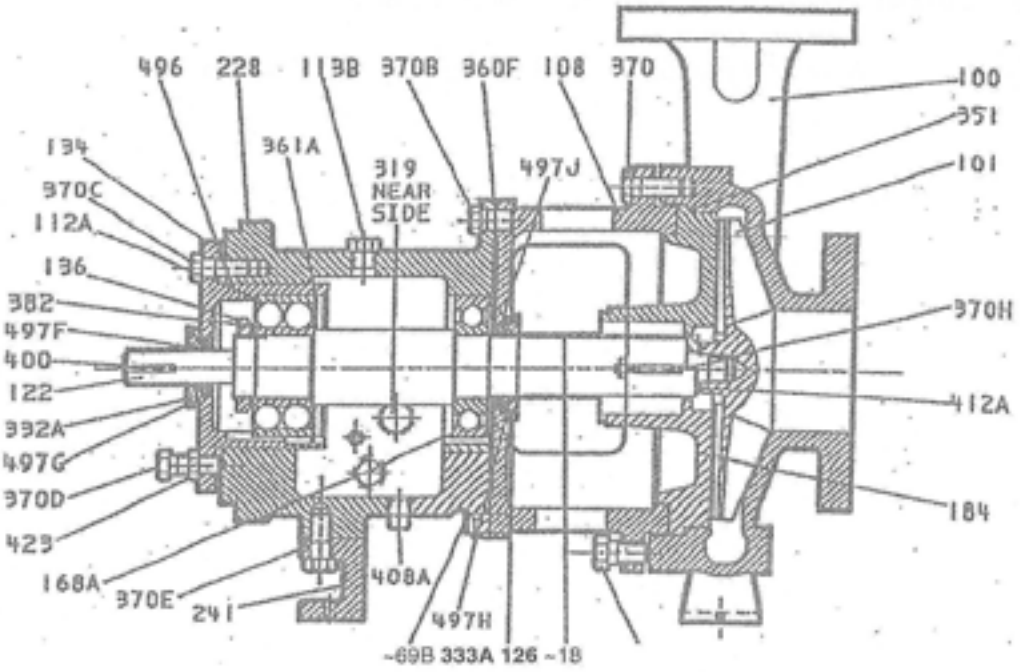
2. What type of impeller is in the end suction

3. How do you cut new packing

4. How do you determine if the packing gland is tight enough

5. Explain the steps used to start the end suction centrifugal pump

Goulds Model 3196 CrossSectional



Parts List Model 3196 STX .

Ref #	Part Name
100	Casing
101	Impeller
107	Gland - Packed Box
108	Frame Adapter
1I3B	Plug - Oil Fill
122	Shaft - Less Sleeve
126	Shaft Sleeve .
134 -	Bearing Housing
136	Bearing Locknut
168A	Radial Bearing
184	Seal Chamber/Stuffing Box Cover
228	Bearing Frame
241	Frame Foot
248	Oil Thrower
351	Casing Gasket
353	Gland Stud
355	Gland Stud Nut
358	Plug - Casing Drain
360C	Gasket - Thrust End Cover
360F	Gasket Frame-to-Adapter
370	Bolt - Adapter to Case
370B	Bolt - Frame-to-adapter
370C	Clamp Bolt - Bearing Housing
370D	Jack Bolt - Bearing Housing
370E	Bolt - Frame Foot to Frame
418	Jack Bolt- Adapter to Case
423	Jam Nut - Bearing Housing Jack Bolt
423B	Hex Nut - Stuffing Box Cover to Adapter
529	. Lockwasher - Frame Foot-to-Bearing Frame

11. Coat outside of bearing housing (134) with oil.

12. Coat all internal surfaces of bearing frame (228AJ with oil.

13. Install shaft assembly into frame (228A). Check shaft for free turning (Fig. 138).

14. Install clamping bolts (370C) into bearing housing (134). Hand tighten.

15. Install jacking bolts (3700) with locking nuts (423) into housing (134). Hand tighten.

16. Attach bearing frame foot (241) with bolts (370F). Hand tighten.

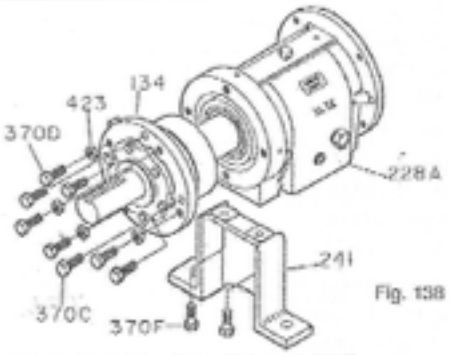


Fig. 138

ALL MODELS

1. Support frame assembly in horizontal position.

2. Check shaft end play. Move shaft forward then backward by hand, noting indicator movement. If total indicator reading is greater than *Table 10* values, disassemble and determine cause (Fig. 139).

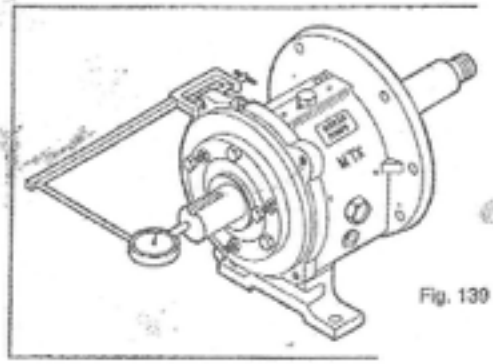


Fig. 139

3. Check shaft/sleeve runout. Put on shaft sleeve (126) if used, and thread on impeller, hand tight. Rotate shaft 360 degrees. If total indicator reading is greater than .002 in., disassemble and determine cause. Remove impeller and shaft sleeve (Fig. 140).

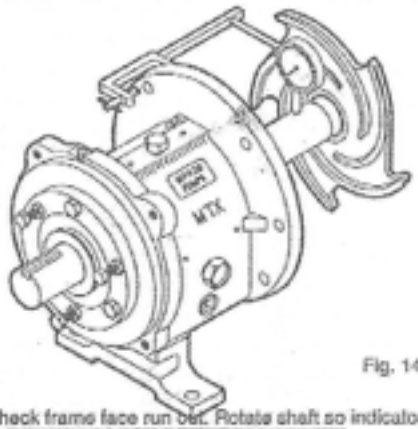


Fig. 140

4. Check frame face run out. Rotate shaft so indicator rides along the fit for 360 degrees. If total indicator reading is greater than 0.00lin, (.. 025 mm) disassemble and determine cause (Fig. 141).

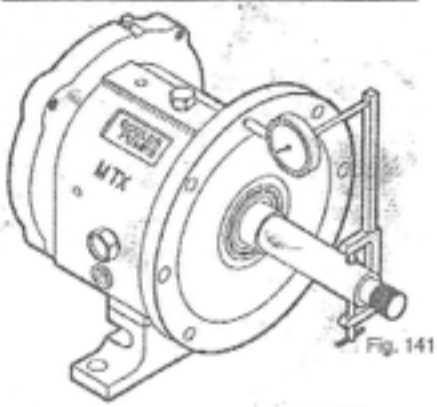


Fig. 141

Duplex Double Acting Reciprocating Pump

Learning Objectives:

- OICEW- A4.3 Preparation, operation, fault detection, and measures to prevent damage for auxiliary prime movers and associated systems
- OICEW- C2.3 Dismantling, adjustment, and reassembling of machinery and equipment
- OICEW- C2.4 The use of appropriate specialized tools
- OICEW- 8.2B Demonstrate proficiency in reciprocating pump maintenance
- Read and follow written instructions
- Read and understand a blueprint
- Properly handle basic hand tools
- Operate a pump, monitoring suction, discharge pressures, and power requirements
- Disassemble and reassemble a duplex, double acting reciprocating pump, set the steam admission valves properly, prove the correct settings by actual operation in a closed circuit system

USCG STCW Standards:

- Plan reflects proper sequence of actions, is complete, and conforms to the requirements of manufacturer's instructions and ship's procedures
- Dismantling, examination and measurement, assessment of wear or deterioration, re-fitting and clearance checks, and replacement/adjustment of seals is successful and conducted according to plan
- Actions taken are correctly and completely described
- Required steps taken are verified by assessor utilizing sample checklist as a guide
- No safety violations are observed

Student's Name: _____ Date:_____

Instructor's Name: _____ Date:_____

Preliminary:

1. Read the complete lab handout
2. Close the steam chest inlet (in our case compressed air) and air supply valve (at bulkhead)
3. Complete lock-out, tag-out procedures to the steam chest inlet, air supply valve, the water suction and discharge valves. (Ensure all paperwork is filled out, signed, and dated!!)
4. **Stop** until instructor has approved the lock-out, tag-out Instructor_____
5. Visually inspect the pump and drain the steam end and the water end (use the 1/2" drain valves attached underneath the pump end)
6. Make room on the workbench for parts

Disassembly:

1. Remove the steam cylinder head (ref# 2, 15/16" box end wrench), and carefully remove the steam head gasket
2. Remove the water cylinder head (ref# 59, 15/16" box end wrench), and carefully remove the pump head gasket

Note: You will have water leakage here. Try to contain the water in the drip pan

3. Remove the four 1 - 7/16" nuts that hold the force chamber in place (ref#65, 1 - 7/16" socket). Then remove the force chamber and the force chamber rubber gasket

Note: You will have water leakage here. Try to contain the water in the drip pan

4. Remove the discharge valve plate (ref# 62) and the discharge valve plate gasket

Note: DO NOT REMOVE THE SUCTION VALVES

Stop: At this point the students will disassemble all four discharge valves:

- Unscrewing counter-clockwise (CCW) the valve guard (ref# 85)
- Remove the discharge valve spring (ref# 87)
- Remove the valve rotator (ref# 84a)
- Remove the valve disc (ref# 84)
- Instructor will now explain the operation

5. Reassemble all four discharge valves and tighten them **hand** tight
6. Remove the steam chest cover (ref# 19, 1 - 1/4" box end wrench) and gasket

STOP: The instructor will go over the operation of the Duplex Double Acting Reciprocating Pump

7. Remove the two valve rod head pins (ref# 571)
8. Lift and remove the steam chest (ref# 18)

STOP: Notice that the "D" slide valves are NOT symmetrical. The longer end must face the steam cylinder head. If these are reinstalled incorrectly, you will not be able to set the "D" slide valves!!!!!

9. Remove the "D" slide valves

Notice how the underside is cutaway to allow the flow of the exhaust steam. Due to the machined face, the "D" slide valves must be set on their side.

Note: There is no need to remove the "D" slide valve plate (seat)

10. Loosen the piston rod spool jam nuts (ref# 3411, (2) 1 - 3/8" open end wrenches on each side of the spool piece)

Note: If the shafts don't separate, use a 3/4" combination wrench on the steam side and a 13/16" wrench on the water side

11. Loosen the water end and steam end packing nuts (13/16" wrench)
12. Unscrew the water end rod (ref# 332) from the crosshead (ref# 34), then unscrew the crosshead from the steam piston rod (ref# 33)
13. Remove the two locknuts (ref# 332) from the piston rods
14. Thread the piston removal tool (threaded rod) into the tapped hole in the steam piston (ref# 7)
15. Remove the steam piston and rod assembly and then set the assembly aside
16. Thread the piston removal tool (threaded rod) into the tapped hole in the water piston (ref# 69)
17. Remove the water piston and rod assembly and then set the assembly aside
18. Measure the diameter of the water and steam piston cylinder and record the readings

Water Piston Diameter:
Steam Piston Diameter:

Note: We will not be pulling the packing out of this pump

Reassembly:

1. Using a lint free rag, wipe out the cylinder liners (steam end and water end) with a rag. Spray a little WD 40 into the steam end.

2. Start the steam piston in the liner. Attach the ring compressor around the steam piston and using a wooden handle **lightly tap** on the piston head until the rings are completely in the cylinder.

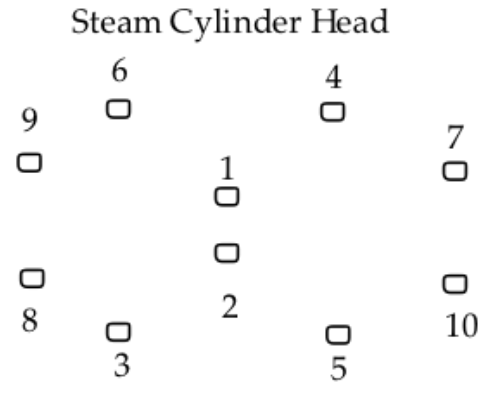
BE EXTREMELY CAREFUL HANDLING THE RING COMPRESSOR AS THE EDGES ARE VERY SHARP!

DO NOT STRIKE THE PISTON HEAD WITH A HAMMER AS THIS WILL BREAK THE RINGS!

3. Rethread the locknut (ref# 34211) and the crosshead (ref# 34) back onto the steam rod. Screw the threads until it reaches the middle of the crosshead.
4. **DO NOT** lubricate the water end
5. Reinstall the water piston by pushing and twisting **lightly,** then using a 1" socket and a speed wrench, thread the water rod into the crosshead until it touches the steam rod in the middle of the crosshead.
6. Tighten the locknuts agains the crosshead (Two 1 - 3/8" open end wrenches)

Note: Do not over tighten

7. **FINGER TIGHTEN** the steam packing gland nuts
8. Install the steam chest gasket
9. Reinstall both "D" slide valves with the long end pointing toward the steam cylinder head
10. Reinstall the steam chest with the short end of the lost motion nut (ref# 56) pointing down into the ears of the "D" slide valves
11. Reinstall the steam cylinder head and tighten the bolts to **50 ft-lbs** in the following crossing pattern



Tighten in a crossing pattern to 50 ft-lbs

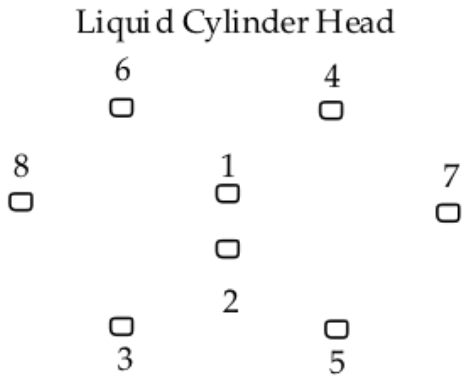
12. Center the pistons and “D” slide valves
13. Remove the water side packing nuts
14. Move the packing gland towards the spool piece
15. Push the water piston up against the water cylinder head

Notice the mark on the rod at the packing gland

16. Push the water piston through its complete stroke towards the steam end
17. Measure from the mark to the stuffing box face, record this reading

Stroke:

18. Take your number and divide it by 2 to find the center of the stroke and mark it
19. Move the piston to this location
20. Repeat the same procedure for the other piston
21. Center the steam chest and make it **snug** by tightening two nuts with pipe spacers and flat washers (ref page#)
22. Center the “D” slide valves over the steam ports and adjust for lost motion
23. Reinstall the valve rod head pins (ref# 571)
24. Carefully remove the two nuts and pipe spacers that were holding the steam chest in place
25. Reinstall the steam chest cover gasket and steam chest cover
26. Tighten the four cover nuts in a crossing pattern to **50 ft-lbs**
27. Reinstall the water cylinder head and tighten the eight bolts in a crossing pattern to **50 ft-lbs**



Tighten in a crossing pattern to 50 ft-lbs

28. Reinstall the discharge valve plate gasket and the discharge valve plate (ref# 62)
29. Reinstall the force chamber (ref# 65) and tighten the bolts in a crossing pattern to **50 ft-lbs**

30. Offset one piston

To Simplify the Timing Procedure:

- Close the steam valve and the water side valves
- Lock-out, Tag-out at this time
- Center the piston (this will give you the stroke, which is (L))
- Plumb the rocker arm
- Square the "D" slide valves over the ports
- Equalize for Lost Motion
- Move one piston off center

NOTE: If there is not enough Lost Motion, the pistons will "short stroke". If there is too much Lost Motion, the pistons will "long stroke" and strike the heads

REMEMBER: A Duplex double acting pump has five ports:

- Two admission ports
- Two exhaust ports
- One main exhaust port

Ready the Pump for Operation:

1. Remove the lock-out, tag-out (Ensure the paperwork is signed and dated)
2. Connect the water tank to the suction and discharge lines
3. Connect the compressed air from the wall
4. Close and open the cushioning chamber valve (notice the difference in discharge pressure)
5. **ENSURE THE TOQURE WRENCH IS ZEROED!!!**

Calculation:

Solve the following problem for GPM as determine by the Instructor:

Remember the following for a Reciprocating Pump:

GPM = LANE/231

GPM = Gallons per minute
L = Length of stroke
A = Area of the water piston in square inches: (0.7854 X D^2)
N = Number of (working) strokes per minute
E = Efficiency of the pump: (For lab purpose use 92%)

To ensure that the "N" is the proper number, remember the following:

If it is a:	
Simplex Single Acting: N/2	Duplex Single Acting: N
Simplex Double Acting: N	Duplex Double Acting: N X 2

Questions:

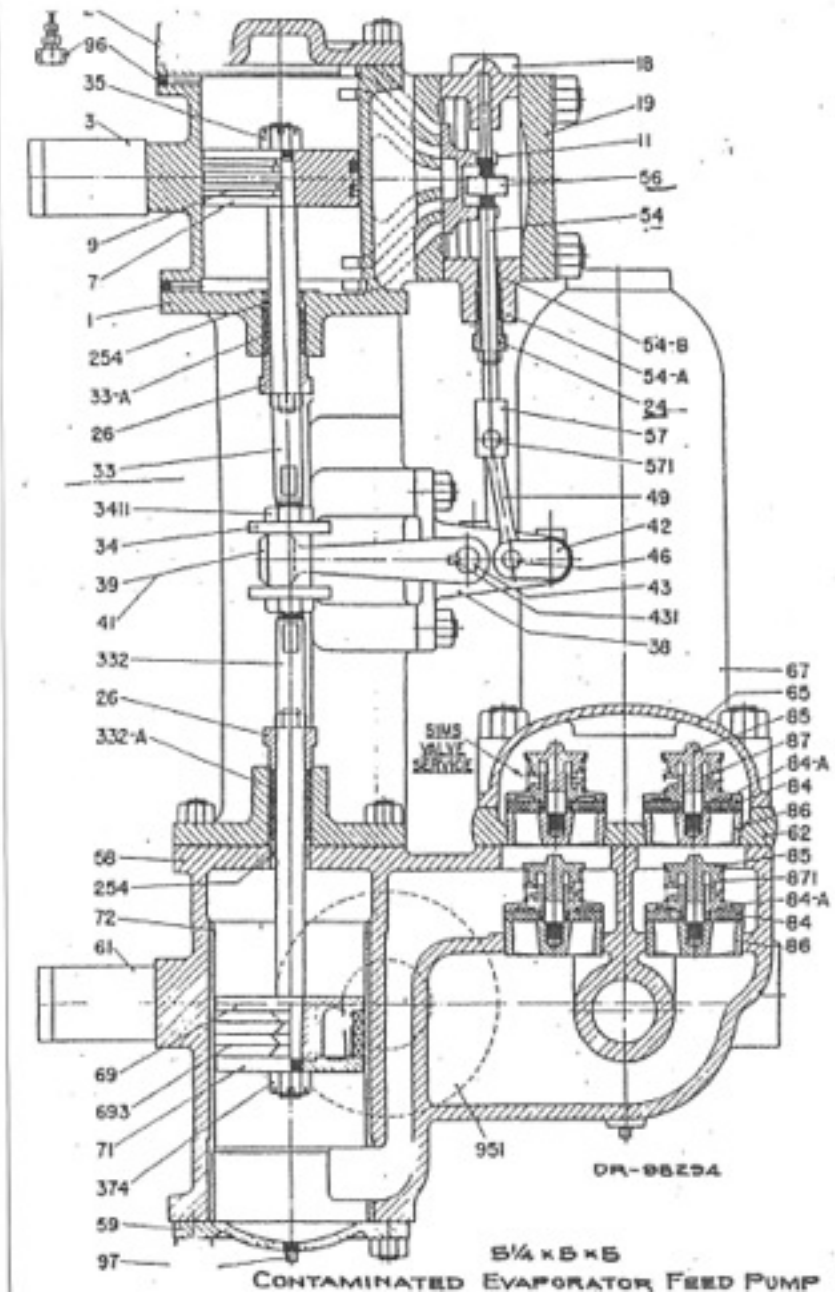
1. Describe a simplex pump

2. What are "D" slide valves as used on a reciprocating duplex pump?

3. What do the numbers 8 X 4 X 10 mean in relation to a reciprocating pump?

4. How do you equalize for lost motion?

5. List several reasons why a simplex or duplex reciprocating pump may fail to provide a normal amount of water.



PIECE #	NAME OF PART
1	Steam cylinder
2	Stem cylinder head
3	Steam cylinder foot
7	Steam piston
9	Steam cylinder rings
11	D slide valve
18	Steam chest
19	Steam chest cover
24	Valve rod stuffing box gland
26	Piston rod stuffing box gland
33	Steam piston rod
33A	Steam piston rod packing
34	Piston rod spool (crosshead)
35	Steam piston rod nut
38	Cross stand
39	Long lever
41	Short lever
42	Upper rock shaft, long crank
43	Lower rock shaft, short crank
46	Crank pin
49	Valve rod link
54	Valve rod
54A	Valve rod packing
54B	Valve rod stuffing box bushing
56	Valve rod nut
57	Valve rod head
58	Liquid cylinder
59	Liquid cylinder head
61	Liquid cylinder foot
62	Valve plate
65	Force chamber
67	Discharge air chamber
69	Liquid piston body
71	Liquid piston follower
72	Liquid cylinder liner
84	Valve disk
84A	Valve rotator
85	Valve guard
86	Valve seat
87	Discharge valve spring
96	Steam cylinder drains
97	Liquid cylinder drain plug
254	Piston rod stuffing box bushing
332	Liquid piston rod
332A	Liquid piston rod packing
374	Liquid piston rod nut
431	Lever key
571	Valve rod head pin
693	Liquid piston packing ring
871	Suction valve spring
951	Suction blank flange
3411	Piston rod spool jam nut

Two Stage Reciprocating Quincy Air Compressor

Learning Objectives:

- OICEW - A4.1 Basic construction and operation principles of an air compressor
- OICEW - A4.3 Preparation, operation, fault detection and measures to prevent damage for auxiliary prime movers and associated systems
- OICEW - C2.3 Dismantling, adjustment, and reassembling of machinery and equipment
- OICEW - C2.4 The use of appropriate specialized tools
- OICEW - 5-1D Demonstrate proficiency in starting an air compressor
- OICEW - 5-1E Demonstrate proficiency in shutting down an air compressor
- Read and follow written instructions
- Read and understand a blueprint
- Properly handle basic hand tools
- Operate a pump, monitoring suction, discharge pressures, and power requirements
- Disassemble and reassemble a two stage reciprocating air compressor. Run the air compressor to demonstrate correct operation.

USCG STCW Standards:

- Plan reflects proper sequence of actions, is complete, and conforms to the requirements of manufacturer's instructions and ship's procedures
- Dismantling, examination and measurement, assessment of wear or deterioration, re-fitting and clearance checks, and replacement/adjustment of seals is successful and conducted according to plan
- Actions taken are correctly and completely described
- Required steps taken are verified by assessor utilizing sample checklist as a guide
- No safety violations are observed

Student's Name: _____ Date:_____

Instructor's Name: _____ Date:_____

Preliminary:

1. Read the complete lab handout
2. Isolate the electrical power, simulation air, and discharge valve
3. Complete lock-out, tag-out procedures to the electrical power, simulation air, and discharge valve. (Ensure all paperwork is filled out, signed, and dated!!)
4. **Stop** until instructor has approved the lock-out, tag-out Instructor_____
5. Remove the belt guard from the flywheel
6. Visually inspect the compressor
7. Make room on the cart for parts

YOU WILL BE REMOVING THE L.P. AND H.P. VALVE ASSEMBLIES!!

Disassembly:

1. Remove and set aside the air intake manifold (ref# 9, 5/8" box end wrench), with the air intake filter (ref# 11), and the air intake flange gasket (ref# 7) as a complete assembly
2. Remove the discharge pipe flange (ref# 10, 5/8" box end wrench)
3. Remove and set aside the unloader and crankcase vent tubing lines

If necessary, use the correct wrench (flare nut), but the lines should be hand tight!

4. Remove the High Pressure (H.P.) suction valve unloader assembly (ref# 24, 18" angle pipe wrench)
5. Then remove the H.P. unloader piston assembly (ref# 15) and the unloader pin (ref# 6)
6. Remove the H.P. suction valve hold down screw (ref# 14, manufacturer's special wrench)
7. Take out the valve plate (ref# 23) completely
8. Remove the valve plate cover (ref# 23), bolts (ref# 17, 5/8" wrench), and the valve plate cover gasket (ref# 21)
9. Remove the valve retainer (ref# 7), the valve platform (ref# 5), the H.P. suction valve assembly (ref# 2), and the copper gasket (ref# 25)
10. **Completely** remove the hold down bolt from the valve plate cover (ref# 22) on the H.P. discharge valve assembly
11. Remove the H.P. discharge valve plate cover (ref# 22) and gasket (ref# 21)
12. Remove the H.P. discharge valve retainer (ref# 8, using a magnet)
13. Remove the discharge valve assembly (ref# 19) and the copper gasket (ref# 25)
14. Repeat the above steps for the front Low Pressure (L.P.) suction valves

Do not remove the L.P. discharge plate with the lifting eye!!!

15. Loosen and remove all the head bolts (using a 1/2" box end wrench, 3/4" box end wrench, and a 1/2" 12 point socket with 1/2" drive)

NOTE: There are 18 head bolts total. The intercooler bolts are longer than the head bolts. Use the cardboard cutout to place the bolts in.

16. Remove the compressor head (ref# 1, using the chain hoist)
17. Carefully remove the cylinder head gasket (ref# 2) and the intercooler gasket (ref# 5)

STOP: At this point the Instructor will show the unloader assembly operation, by using the cutaway model. The Instructor will also go over the flow of air through the compressor head from intake through discharge:

A. Suction into the L.P. cylinder
B. Discharge from the L.P. cylinder to intercooler inlet
C. Intercooler discharge to the suction of the H.P. cylinder
D. Discharge of the H.P. cylinder to air receiver

Reassembly:

1. Install the three (threaded rod) alignment studs (one in the intercooler and two in the head)
2. Reinstall the head gasket (ref# 2) and the intercooler gasket (ref# 5)
3. Reinstall the cylinder head (ref# 1, using the chain hoist)
4. Thread in all head bolts and intercooler bolts
5. Remove the alignment studs and install the final three bolts
6. **Hand tighten** all head bolts
7. Torque the head bolts in the correct pattern to **40 ft-lbs** then to **65 ft-lbs**

NOTE: On the bolts that cannot be reached by the conventional torque wrench, use the "special torque wrench" and set the torque wrench for **40 ft-lbs** then **65 ft-lbs**

8. Install H.P. suction and discharge valve copper gaskets (ref# 13)
9. Install the discharge valve assembly (ref# 3) and the discharge valve retainer (ref# 4)
10. Install the suction valve assembly (ref# 2), the valve platform (ref# 5), and the valve retainer (ref# 7)

DO NOT INSTALL UNLOADER PIN YET!!!

11. Reinstall the suction and discharge valve cover gaskets
12. Tighten valve cover hold down bolts (ref# 17) to **15 ft-lbs** then **30 ft-lbs** (using a crossing pattern)
13. Install the suction valve hold down screw (ref# 14) and the discharge valve hold down screw (ref# 11)

14. Tighten suction valve hold down screw to **50 ft-lbs** (using special manufacturers tool)
15. Tighten the discharge valve hold down screw to **50 ft-lbs**
16. Tighten the locknut until it is **snug**
17. Install the unloader pin (ref# 6)
18. Install unloader assembly gasket (ref# 13)
19. Install unloader piston assembly (ref# 15)
20. Install the unloader assembly (ref# 24)
21. **Snug** up the unloader assembly (18" angle pipe wrench). **DO NOT OVER TIGHTEN!**
22. Repeat the above steps for the L.P. suction and discharge valves
23. Reconnect the crankcase breather and the unloader tubing lines
24. Reinstall the air filter manifold assembly (ref# 9)
25. Torque the bolts in a crossing pattern to **40 ft-lbs**
26. Reinstall the discharge pipe flange
27. Torque the bolts in a crossing pattern to **40 ft-lbs**

Ready the Compressor for Operation:

1. Remove the lock-out, tag-out (ensure the paperwork is signed and dated)
2. Reinstall the belt guard
3. Check the oil level
4. **ENSURE THE TORQUE WRENCHES ARE ZEROED!!!**

When running, observe the load (amps) with the compressor unloaded and then loaded.

Unloaded (amps):	Loaded (amps):

Questions:

1. To obtain maximum efficiency, two stage air compressors are usually_____.

2. Explain the air flow through the heads from suction to discharge?

3. For what is the intercooler used?

4. How does the H.P. and L.P. valves operate?

5. How does the unloader work?

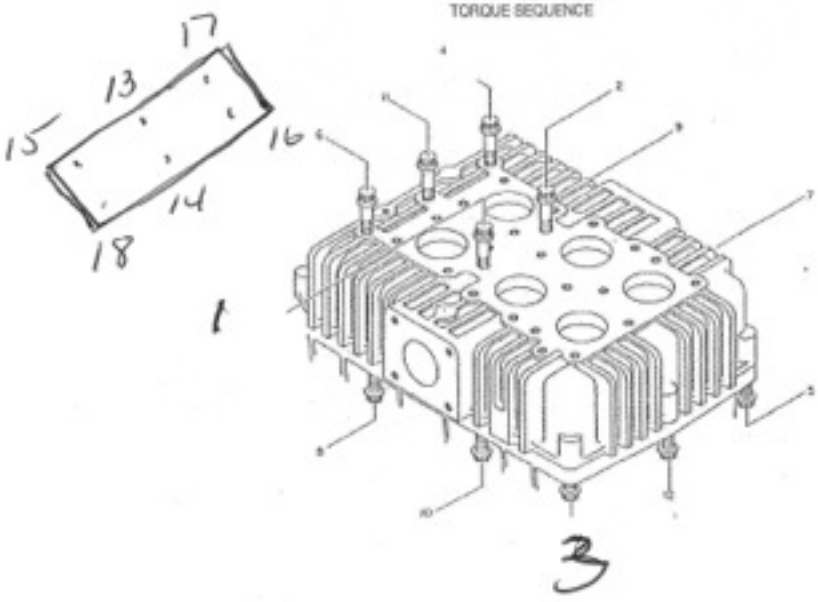
CYLINDER AND HEAD GROUP NO. 110634
(FOR LOADLESS AND PILOT CONTROLLED COMPRESSOR)

INDEX NUMBER	QTY	PART NUMBER	DESCRIPTION
1	1	7362LU-003	HEAD ASSEMBLY (SEE PAGE 26 FOR PARTS BREAKDOWN)
2	1	7403	GASKET - CYLINDER TO HEAD
3	1	6262-1	CYLINDER - COMPRESSOR
4	1	6807	GASKET - CYLINDER TO CRANKCASE
5	1	6860	GASKET - INTERCOOLER TO HEAD
6	1	6857-001	INTERCOOLER
7	2	6828	GASKET - VALVE
8	1	6801	VALVE - DISCHARGE
9	1	6858	VALVE - INTAKE
10	8	123476-M15	SCREW - HEX, M 7/16-14UNR 1.00,GRADE 5 (FT-LBS.)
11	1	1100772S0	FILTER - AIR
12	20	122115-Gac	LOCKWASHER - 1/2
13	13	123479-M15	SCREW - HEX., 1/2- 13 UNC X 1.50, GRADE 5 (CYL TO C"CASE" 75FT. - LBS.) (INTRCR. TO HEAD-75ft/T. -LBS.)
14	6	1476	WASHER - FLAT, 1/2" (COPPER)
15	6	5003	SCREW - COUNTERBORE, 7/12-(7/Ua X 4.25, GRADE 8 (FT-LBS.)
16	8	123476-N14	SCREW - HEX" 1/2- 13 UNC X 1.25, GRADE 5 (75FT. - LBS.)
17	1	002368-H14	SCREw - COUNTERBORE, 1/2- 13 Una X 1.25, GRADE 8(75FT.,- LBS.)
18	1	122115-001	LOCKWASHER - 3/8
19	1	110426M036	FLATWASHER - 3/8
20	1	123479-L1	SCREW - HEX" 3/8-16 Una X .69, GRADE 5 (F30FT.-LBS.)
21	2	2729	ANGLE - ELBOW, 3/8 TUBE X 3/8 PIPE
22	2FT.	1100/15-038	TUBE - COPPER, 3/8
			* 1 NoICAHS TORQUE VALUE IN IOOT POUNDS (DRY THREADS)
			REPLACEMENT PARTS
23	1	1103775200	ELEMENT - AIR FILTER
	1	7362LU-XL	HEAD ASSEMBLY (OCLUDES: (1) 7362LU- 003 HEAD ASSEMBLY (1) 7403 HEAD GASKH (1) 6860 INTERCOOLER GASKET

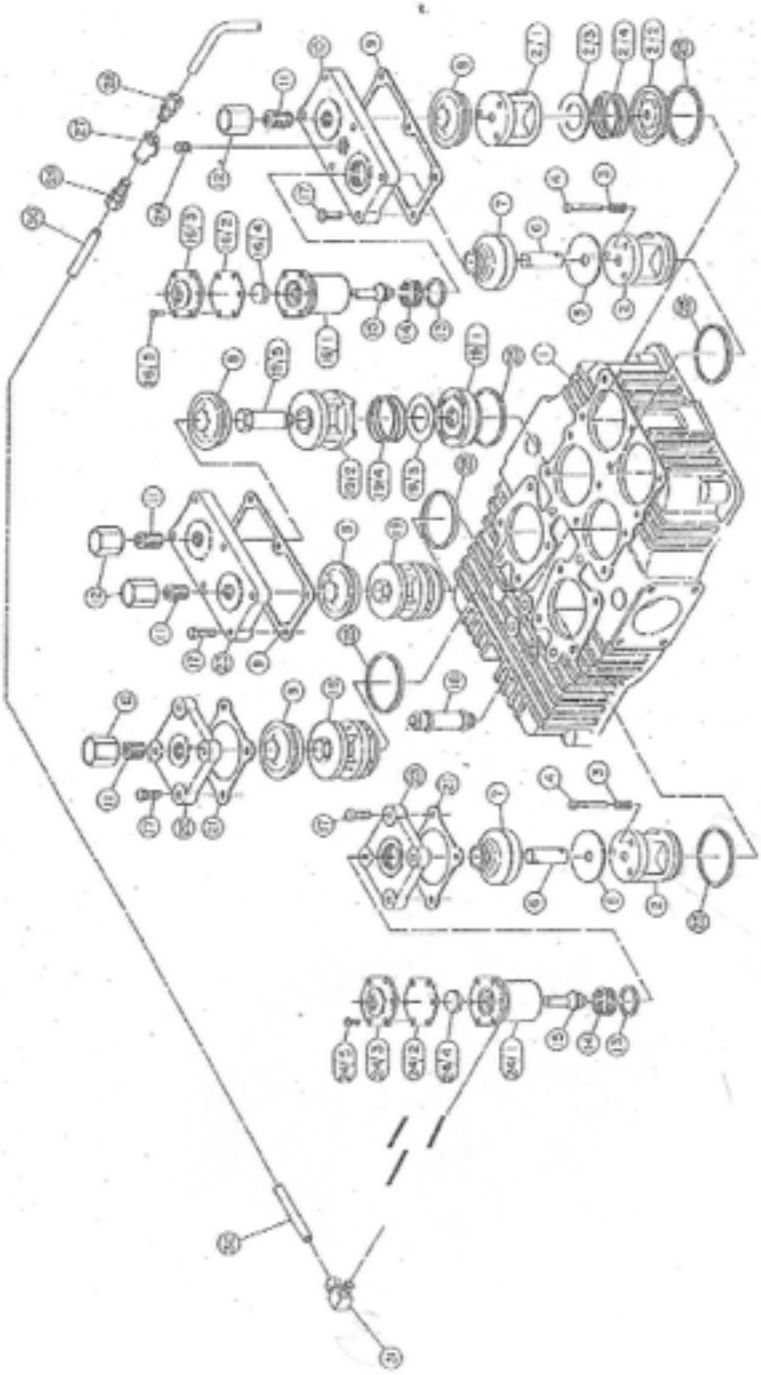
IOTES: TIGHTEN All SOL TS AND CAPSCREWS IN ANY BOLT PATTERN EVENLY BRIQING EACH BOLT TO TORQUE

CONNECTRE; RCO -HD HEAD BOLTS.,

PROPER HEAD BOLT .
TORQUE SEQUENCE



HEAD ASSEMBLY NO. 7382UU-003
(FOR LOADLESS COMPRESSOR)



HEAD ASSEMBLY NO. 7382UU-003
(FOR LOADLESS COMPRESSOR)

INDEX NUMBER	QTY	PART NUMBER	DESCRIPTION
1	1	7382	HEAD - COMPRESSOR
2	3	774001	VALVE ASSEMBLY - SUCTION
211	1	7749	SEAT - SUCTION
212	1	7751	BUMPER - VALVE
213	1	7753	DISC - VALVE
214	1	6909	SPRING - VALVE
3	6	6910	SPRING - VALVE *
4	6	1857	PIN - VALVE
5	2	6799	PLATFORM - VALVE
6	2	6912	PIN - UNLOADER
7	2	6911	RETAINER - VALVE
8	4	6908	RETAINER - SUCTION VALVE
9	2	7398 *	GASKET - COVER PLATE
10	1	7385	PLATE - COVER
11	4	5919	SCREW - SET, 3/4-16 UNF X 1.00, GRADE 5 (+90FT. LBS)
12	4	2623	NUT - SPECIAL, 3/4-16 UNF (+75FT. LBS.)
13	3	1556	GASKET - VALVE
14	2	3008	SCREW [illegible] (+40FT. LBS.)
15	2	113500-001	UNLOADER PISTON ASSEMBLY
16	1	40132	UNLOADER ASSEMBLY
1611	1	8372	* BODY - UNLOADER
162 *	1	1855	DIAPHRAGM - UNLOADER
163	1	14138	PLATE - COVER
164	1	5910	DISC - DIAPHRAGM
165	6	7499	SCREW - HEX [illegible] X .75, GRADE 5 (+8FT. LBS.)
17	20	7480	SCREW - HEX [illegible] X 1.38, GRADE 5 (+40FT. LBS.)
18*	1	2961-100	VALVE - SAFETY
19	3	775001	VALVE ASSEMBLY - DISCHARGE
1911	1	7750	SEAT - DISCHARGE
192	1	7752	BUMPER - DISCHARGE
193	1	7753	DISC - VALVE
194	1	6909	SPRING - VALVE
195	1	5748	POST - VALVE
20	1	7384	PLATE - COVER
21	2	2525	GASKET - VALVE PLATE
22	1	6888	PLATE - COVER
23	1	6868	PLATE - COVER
24	1	-005	* UNLOADER ASSEMBLY
2411	1	7483	BODY - UNLOADER
242	1	1855	DIAPHRAGM - UNLOADER
243	1	10169	PLATE - COVER
244	1	5910	DISC - DIAPHRAGM
245	6	7499	SCREW - HEX 1/4-20 [illegible] X .75, GRADE 5 (+8FT. LBS.)
25	6	2024	GASKET - VALVE
26	1	125933-001	NIPPLE - PIPE, 1/4 NPT X CLOSE
27	1	4574	TEE - PIPE, 1/4 NPT X 1/4 NPT X 1/4 NPT
28	1	2616	FITTING - STRAIGHT, 3/8 TUBE X 1/4 NPT
29	1	110394-005	FITTING - STRAIGHT, 1/4 TUBE X 1/4 NPT
30	1	110315-005	TUBE - COPPER, 1/4
31	1	1942	FITTING - ELBOW, 1/4 TUBE X 1/8 NPT
			INDICATES TORQUE VALUE IN FOOT POUNDS (DRY THREADS)
			REPLACEMENT PARTS
162	1	18005	DIAPHRAGM - UNLOADER (FOR SYNTHETIC LUBRICATED WITH PHOSPHATE ESTER [illegible])
		7749K	* VALVE ASSEMBLY - SUCTION INCLUDES: (1) 774000 VALVE ASSEMBLY (1) 2024 VALVE GASKET
		774002	VALVE ASSEMBLY - SUCTION INCLUDES: ALL ITEMS IN 7749K & (3) 6910 PIN SPRING (3) 1857 VALVE PIN
		7750K	VALVE ASSEMBLY - DISCHARGE INCLUDES: (1) 775000 VALVE ASSEMBLY (1) 2024 VALVE GASKET
		7483K	UNLOADER ASSEMBLY INCLUDES: (1) 40005 UNLOADER BODY ASSEMBLY (1) 1556 VALVE GASKET (1) 110580-001 UNLOADER PISTON

NOTE: TIGHTEN ALL BOLTS AND CAPSCREWS IN ANY BOLT PATTERN EVENLY BRING EACH BOLT TO TORQUE [illegible]

[illegible] CONNECT[illegible] ROD AND HEAD BOLTS.

TIGHTEN AND TORQUE VALVE COVER PLATE SCREWS (ITEM 17) BEFORE TIGHTENING VALVE CLAMP SCREWS (ITEM 11 AND ITEM 14)

10

Pneumatic Control Lab

Learning Objectives:

- OICEW - C2.7 The interpretation of piping, hydraulic, and pneumatic diagrams
- Construct pneumatic systems on a pneumatic simulator
- Operate pneumatic systems and demonstrate proper operation

Student's Name: _____ Date:_____

Instructor's Name: _____ Date:_____

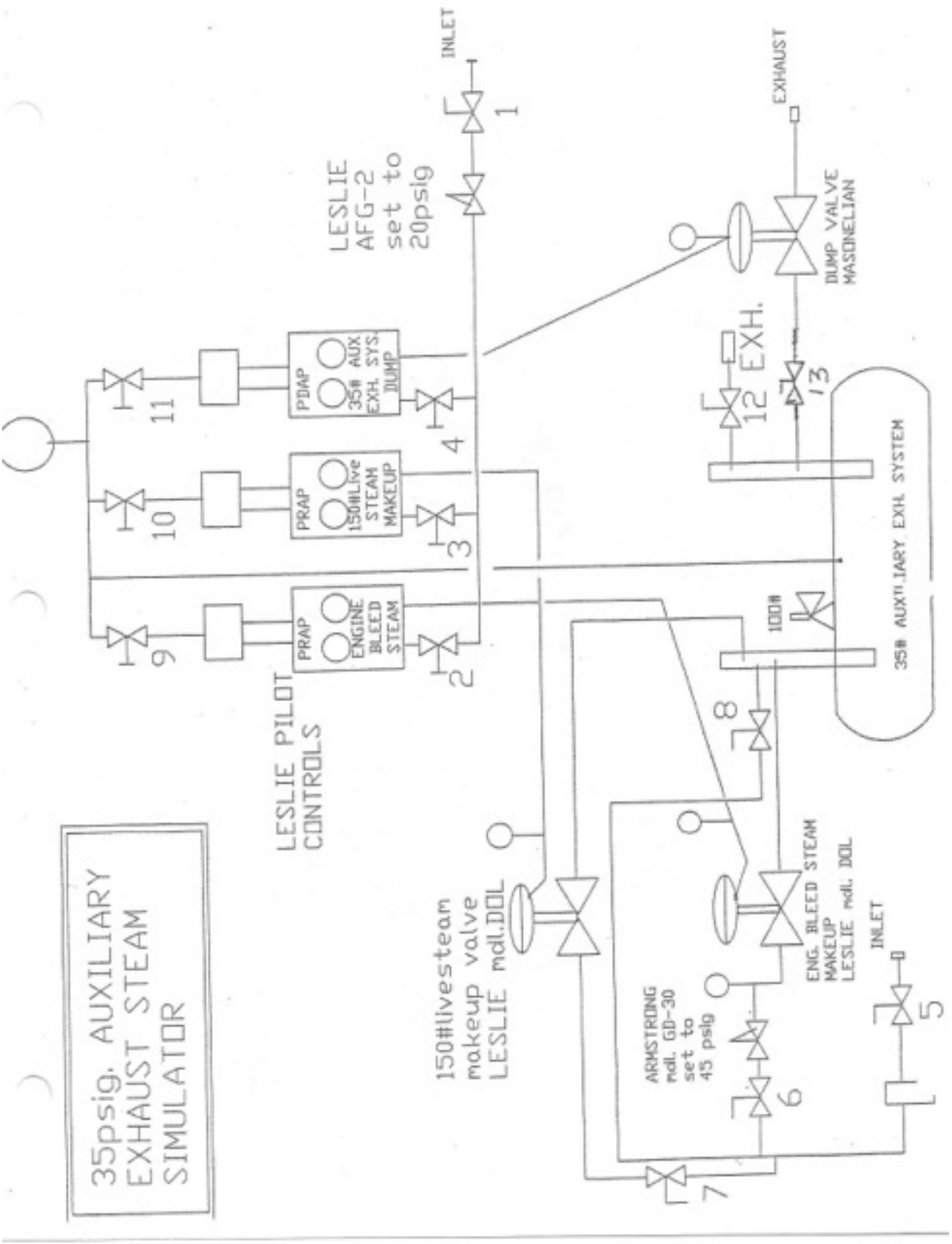
Introduction:
The lab will consist of drawing a circuit or circuits on a computer simulator. The student will then transfer the circuit to a drawing, consisting of the systems symbols and then assembling the circuits on the pneumatic test stand. The instructor will review each circuit symbol as it is applied to the circuit on the simulator, the circuit drawing and pneumatic units will be reviewed before the circuit is connected on the test stand.

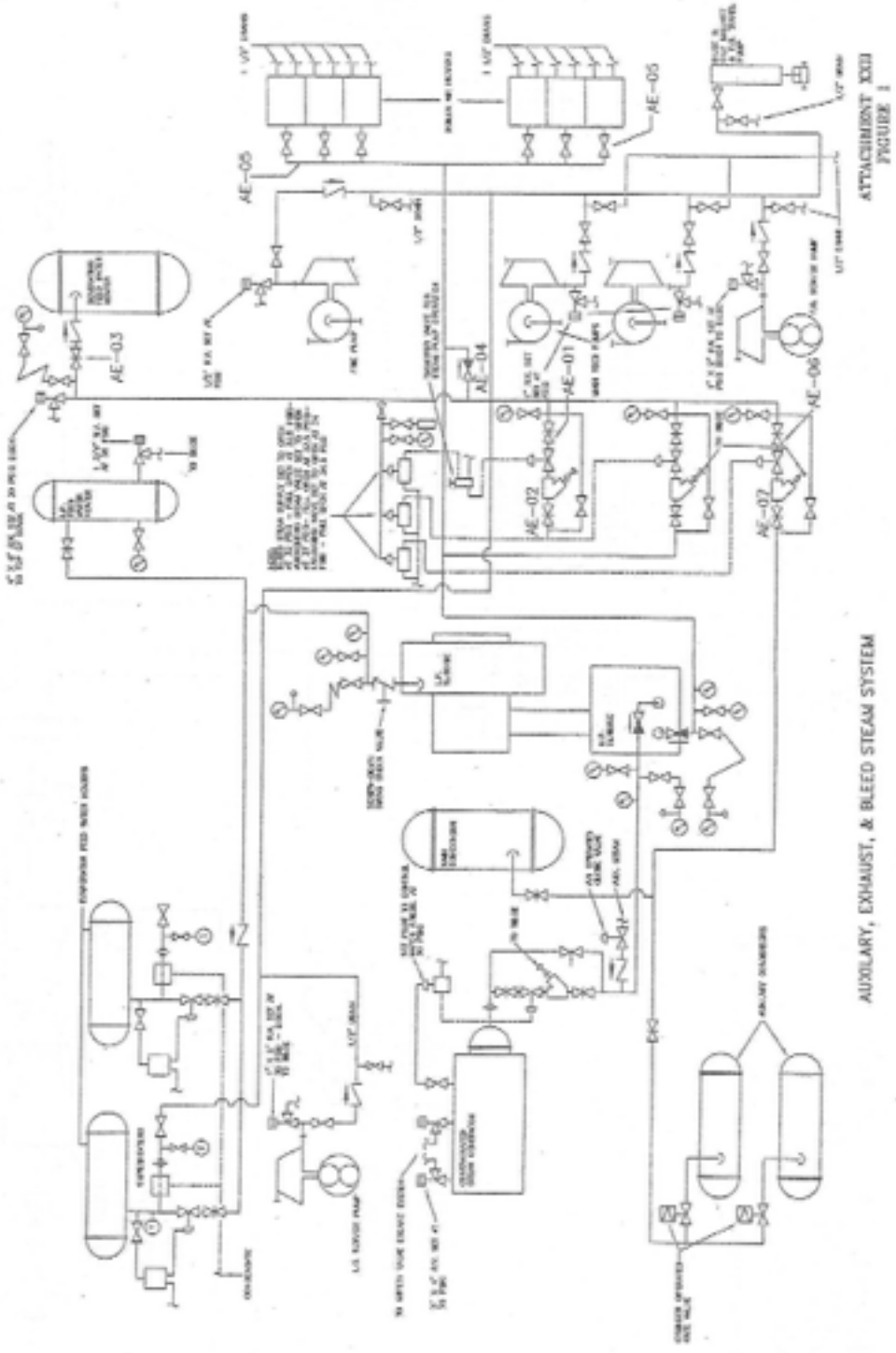
Care must be taken when installing and removing the tubing from the fitting. You need to push down on the plastic ring on the fitting and pull up on the tubing to remove it. You only need to push tubing into the fitting to have it connect.

Some common rules or agreement is made for the symbols of valves:
- Every switched position is represented by one square
- The number of squares indicates the number of possible positions it can be switched in
- The pressure and return lines are drawn to the square that represents its normal (non-operated) position
- By shifting the corresponding square, we get different possible positions
- Lines in the square indicate the ways of flow within the valve
- Arrows represent the direction of flow
- The way of operation is drawn using symbols as well

Automation Studio:
- Turn on computer
- Open desk top icon
- Open the pneumatic library on the left-hand side
- Open the + and the manual for the components will appear
- Click on the + next to the listed component's name
- Example: +Compressor and Power Units
  - Pressure sources
  - Universal fixed displacement
- Enlarge the work area to 150%
- Grab the correct component and drop in to the work area
- When the component has a dotted line around it, you can rotate the component using the rotate buttons with the quick bar at the top. Put all the components on the page and position them.
- Connect lines to the components as directed on the lab page by placing the mouse over the red dot, then left click and drag to the component you are connecting to
- To delete a component - Highlight then right click then select delete
- Under directional valves, you can either make your own or select one that is already there

- To make your own - Select a valve place in the work area, then double click on the valve….The valve properties will appear; then select what is needed
- Once the system is together and operating-Go to simulation-select normal. Now the simulation will run
- To exit-Go to simulation and select stop


35psig. AUXILIARY
EXHAUST STEAM
SIMULATOR
LESLIE PILOT
CONTROLS
LESLIE
AFG-2
set to
20psig
INLET
EXHAUST
DUMP VALVE
MASONELIAN
PDAP
35# AUX
EXH. SYS.
DUMP
PRAP
150#Live
STEAM
MAKEUP
PRAP
ENGINE
BLEED
STEAM
12 EXH.
13
35# AUXILIARY EXH. SYSTEM
100#
150#livesteam
makeup valve
LESLIE mdl.DOL
ARMSTRONG
mdl. GD-30
set to
45 psig
ENG. BLEED STEAM
MAKEUP
LESLIE mdl. DOL
INLET
1
2
3
4
5
6
7
8
9
10
11


ATTACHMENT XXII
FIGURE 1
AUXILARY, EXHAUST, & BLEED STEAM SYSTEM
AE-01
AE-02
AE-03
AE-04
AE-05
AE-06
AE-07

LESLIE CONTROLS, INC.	INSTALLATION, OPERATING, AND MAINTENANCE INSTRUCTIONS	20/1.5.2.1

STEM LENGTH ADJUSTMENT AND PROPORTIONAL BAND
PILOT CONTROLLERS

PDAP ADJUSTABLE PROPORTIONAL BAND TYPE

ADJUSTMENT PROCEDURE

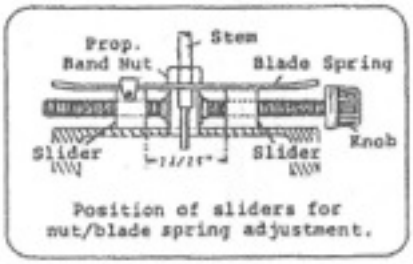
Supply 20-22 psig operating pressure to the pilot controller. Turn adjusting nut to compress adjusting spring to set upper diaphragm against its top limit stop. If possible, remove fluid pressure from top of diaphragm. If not compress spring sufficiently to overcome fluid pressure and move diaphragm to stop.

Adjust sliders 13/16" apart as shown in sketch below. Move proportional band nut upward on adjusting pin thread sufficiently to keep nut from touching blade spring during stem length adjustment. Loosen adjusting pin set screw and turn adjusting pin either up or down until pilot air output is 0 psig then turn adjusting pin downward toward pilot body until pilot air output increases from 0 to 21 psig. Lock set screw. Turn proportional band nut down against blade spring until air output pressure decreases from 21 to 18 psig.

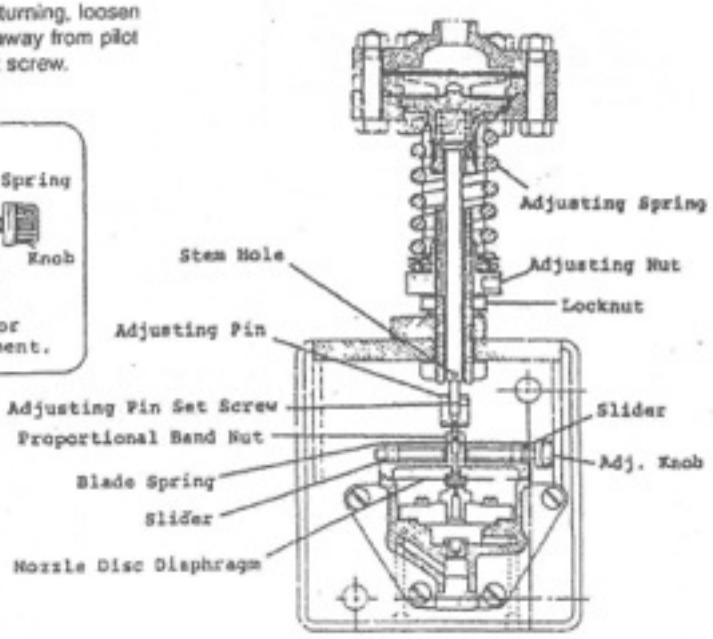
With pin in stem hole to keep stem from turning, loosen set screw and turn adjusting pin upward away from pilot body approximately 1-1/4 turns. Lock set screw.

When adjustments have been properly made, the proportional bands noted in Table will be obtained when the sliders are set the approximate distances apart as shown.

Pilot Range	Conv. Press. PSIG	Max. Prop. Band PSIG	Min. Prop. Band PSIG	Approx. Distance Between Sliders
50-800	50 800	17-20 25-28	4-6 6-8	1-1/32" - 2-3/4" 1-1/2" - 2-3/4"
5-70	5 70	3-5 4-6	.3-.5 .6-.9	1-3/32" - 2-3/4" 1-3/32" - 2-3/4"



Position of sliders for nut/blade spring adjustment.



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LESLIE CONTROLS, INC. 12501 Telecom Drive, Tampa Florida 33637	INSTALLATION, OPERATING, AND MAINTENANCE INSTRUCTIONS	20/1.5.2.2

STEM LENGTH ADJUSTMENT AND PROPORTIONAL BAND

PILOT CONTROLLERS

PRAP ADJUSTABLE PROPORTIONAL BANK TYPE

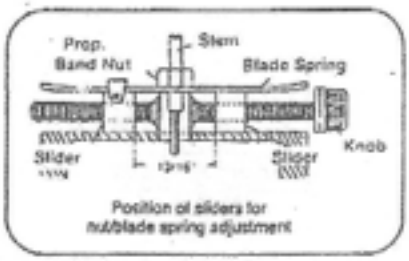
ADJUSTMENT PROCEDURE

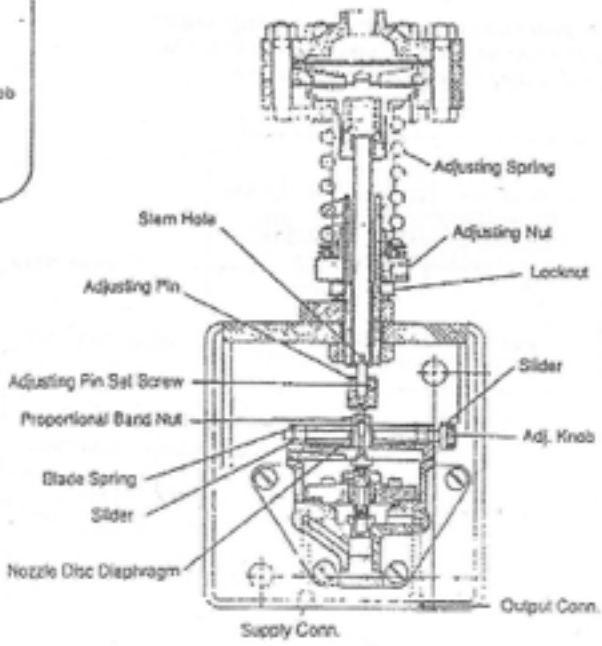
Supply 20-22 psig operating pressure to the pilot controller. With output connection plugged, turn adjusting nut to compress adjusting spring to set upper diaphragm against its top limit stop. If possible remove fluid pressure from top of diaphragm, if not, compress spring sufficiently to overcome fluid pressure and move diaphragm to stop.

Adjust sliders 13/16" apart as shown in sketch below. Move proportional bank nut upward on adjust in pin thread sufficiently to keep nut from touching blade spring during stem length adjustment. Loosen adjusting pin set screw and turn adjusting pin either up or down until pilot air output is 21 psig. Then turn adjusting pin downward toward pilot body until pilot air output decreases from 21 to 0 psig. Lock set screw. Turn proportional bank nut down against blade spring until air output pressure increases from 0 to 3 psig. With pin in stem hole to keep stem from turning, loosen set screw and turn adjusting pin upward away from pilot body approximately 1-1/4 turns. Lock set screw.

When adjustments have been properly made, the proportional bands noted in table will be obtained when the sliders are set the approximate distances apart as shown.

Pilot Range	Contr. Press PSIG	Max. Prop. Band PSIG	Min. Prop. Band PSIG	Approx. Distance Between Sliders
50-800	50 800	17-20 25-28	4-6 6-8	1-1/32" - 2-3/4" 1-1/2" - 2-3/4"
5-70	5 70	3-5 4-6	.3-.5 .6-.9	1-3/32" - 2-3/4" 1-3/32" - 2-3/4"





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2.24

TYPE PDAP/PRAP CONSTANT PRESSURE CONTROL PILOT WITH ADJUSTABLE PROPORTIONAL BAND

Types PDAP and PRAP

Type PDAP and PRAP Pressure Pilots have been developed to meet the need for adjustable proportional bands in pressure control systems requiring a rugged controller that is not susceptible to wear, shock and minor system disturbances.

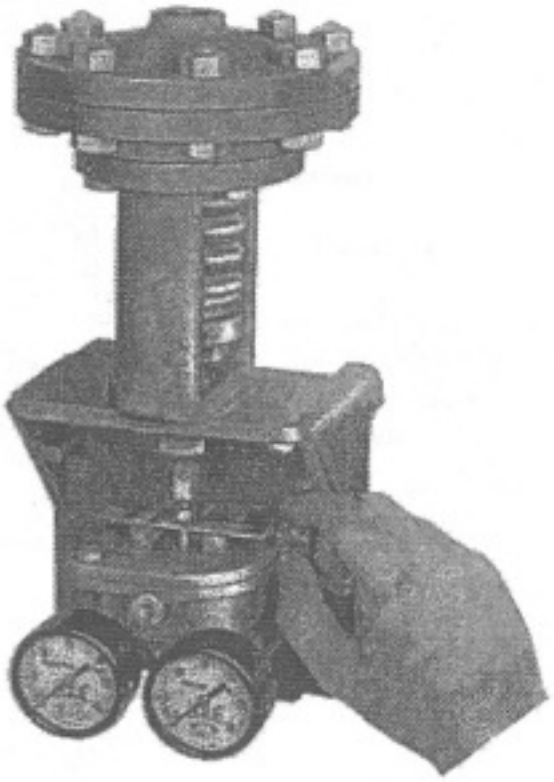
HOW IT OPERATES

Controlled pressure is applied to the top side of a spring opposed diaphragm. Variations in controlled pressure produce stem motion and nozzle disc positions which are proportionate to the pressure change. The nozzle disc position controls the bleed rate of operating air to atmosphere. Since a fixed metering orifice is used in the air supply and in series with the variable bleed orifice, the intermediate or output pressure is a function of the nozzle disc position. The pneumatic portion of the PRAP Pilot operates with a reverse acting nozzle valve to produce reverse action.

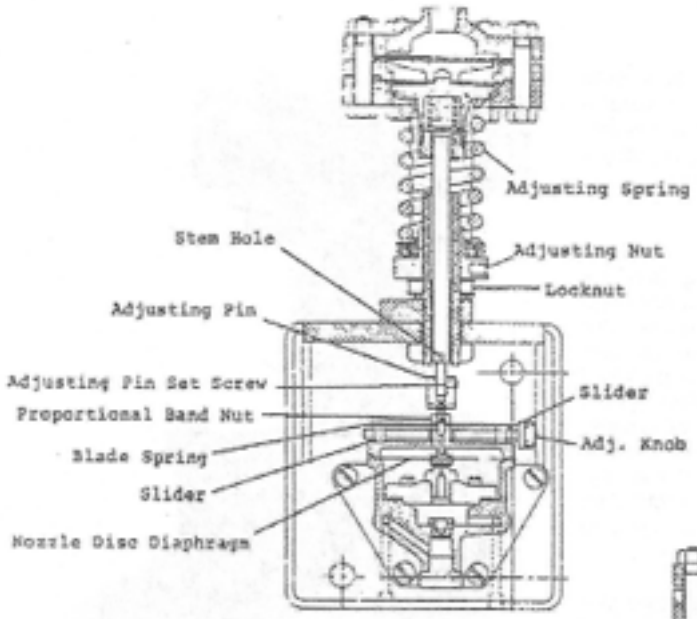
The amount of stem movement per psi of controlled pressure change (adjusting spring and blade spring) and upper diaphragm area. The diaphragm area and adjusting spring rate are fixed. The stem assembly is fitted with a blade spring which has an adjustable spring rate. The adjustment of the blade spring rate provides the means of manually setting the proportional band.

Pressure controlling stations having time lags in response to load changes because of system inertia, long distances between elements in the control loop, long impulse lines or other reasons, tend to cycle or are unstable.

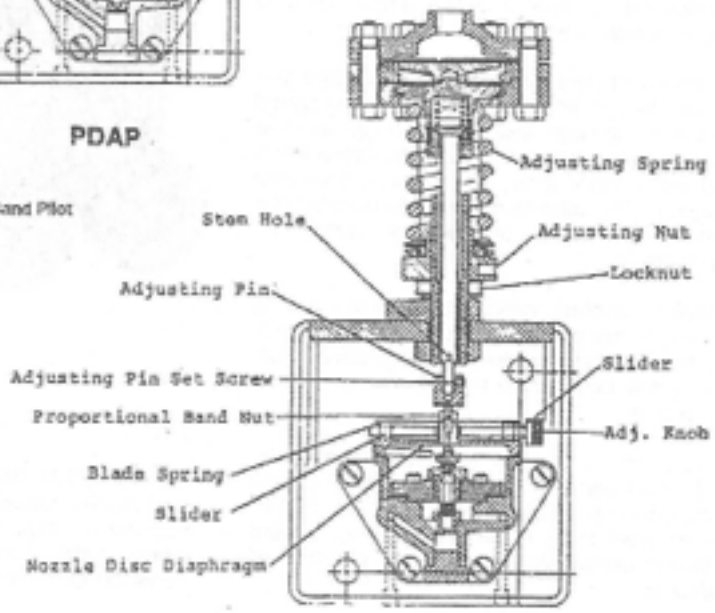
Stable control is obtained in these installations by using a controller with proportional band which can be adjusted until stability is achieved. Types PDA or PRA Pressure Pilots or narrow proportional band controllers usually are unsuitable for this type of application.



PDAP and PRAP Pressure Pilots are also available for applications requiring valve positioners, volume boosting or other relays or receiver controllers with various modes of control. Both types may be used as controllers or transmitters.

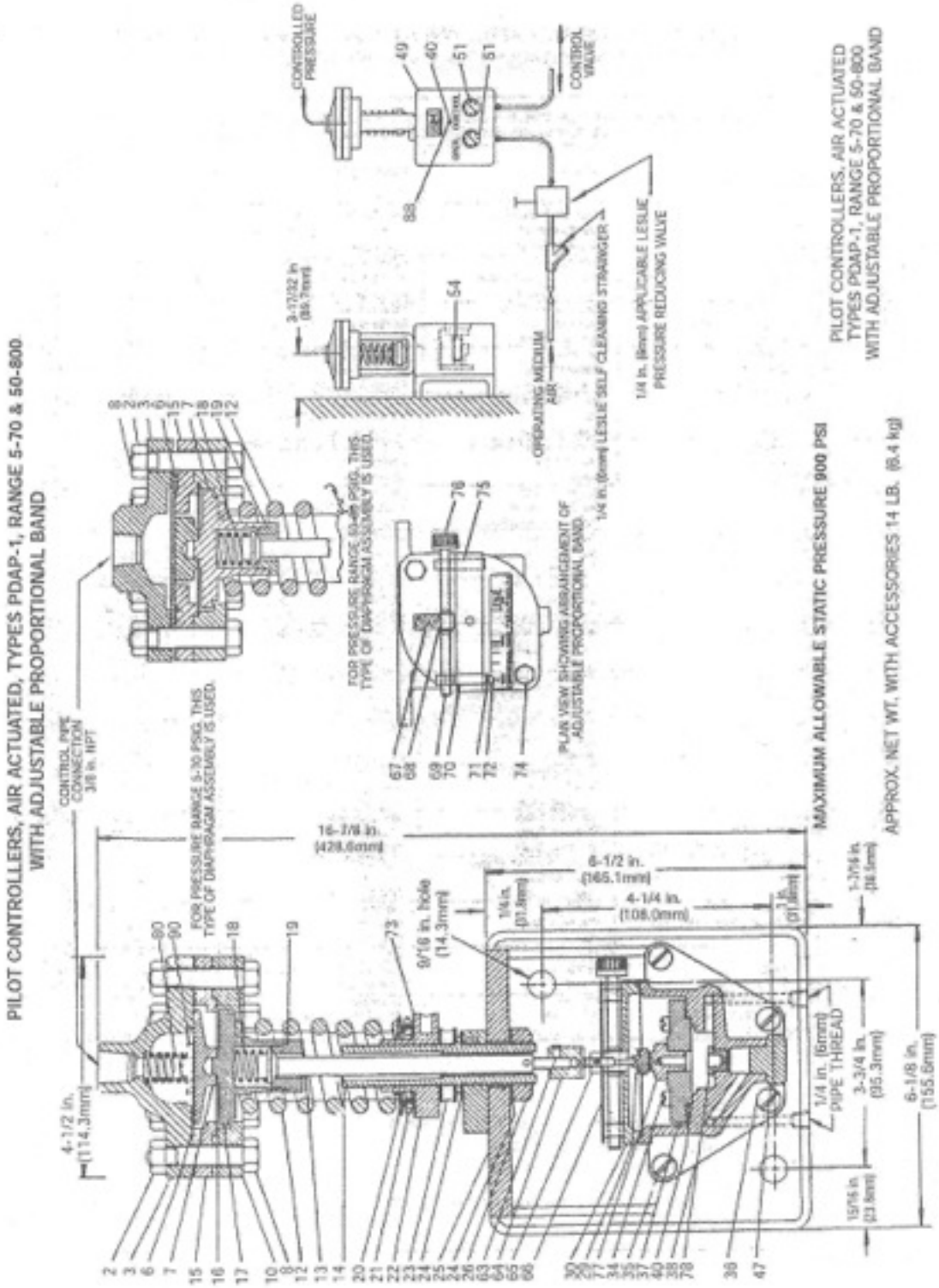


PDAP



PRAP

Figure 10. Adjustable Proportional Band Pilot Controllers


PILOT CONTROLLERS, AIR ACTUATED, TYPES PDAP-1, RANGE 5-70 & 50-800
WITH ADJUSTABLE PROPORTIONAL BAND
PILOT CONTROLLERS, AIR ACTUATED
TYPES PDAP-1, RANGE 5-70 & 50-800
WITH ADJUSTABLE PROPORTIONAL BAND
MAXIMUM ALLOWABLE STATIC PRESSURE 900 PSI
APPROX. NET WT. WITH ACCESSORIES 14 LB. (6.4 kg)
CONTROLLED PRESSURE
CONTROL VALVE
OPERATING MEDIUM
AIR
1/4 in. (6mm) LESLIE SELF CLEANING STRAINER
1/4 in. (6mm) APPLICABLE LESLIE PRESSURE REDUCING VALVE
CONTROL PIPE CONNECTION 3/8 in. NPT
FOR PRESSURE RANGE 5-70 PSIG, THIS TYPE OF DIAPHRAGM ASSEMBLY IS USED.
FOR PRESSURE RANGE 50-800 PSIG, THIS TYPE OF DIAPHRAGM ASSEMBLY IS USED.
PLAN VIEW SHOWING ARRANGEMENT OF ADJUSTABLE PROPORTIONAL BAND
16-3/8 in. (428.6mm)
6-1/2 in. (165.1mm)
4-1/4 in. (108.0mm)
9/16 in. hole (14.3mm)
1/4 in. (31.8mm)
1-3/16 in. (30.5mm)
4-1/2 in. (114.3mm)
1/4 in. (6mm) PIPE THREAD
3-3/4 in. (95.3mm)
6-1/8 in. (155.6mm)
15/16 in. (23.8mm)

Page 18

PILOT CONTROLLERS, AIR ACTUATED, TYPES PDAP-1, RANGE 5-70 & 50-800 WITH ADJUSTABLE PROPORTIONAL BAND

WHEN ORDERING PARTS, PLEASE GIVE TYPE, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW.
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NO.	PART NAME	MATERIAL	MATERIAL SPEC.	QTY PER UNIT	REF. NO. - EACH RANGE	
					5-70	50-800
2	Nut	Steel, Cadmium Plated	ASTM A-194 Gr. 2H	6	42643	42643
3	Diaphragm Cover	Cast Aluminum	ASME B-26 Alloy 356. OT6	1	33027	33028
* 6	Diaphragm	Synthetic Rubber	Neoprene	1	13226	13226
7	Diaphragm Disc	Aluminum	ASTM B-211 2017/2024	1	33942	33943
8	Bolt	Steel, Cadmium Plated	ASTM A-193 Gr. B7	6	45749	45749
10	Yoke	Cast Aluminum	ASTM B-26 Alloy B443.0	1	33971	33971
12	Adjusting Spring	Spring Steel, Plated	Commercial	1	51483	13218
13	Stem, Compl. (Note 2)	Aluminum	ASTM B-211 2017/2024	1	45085	45085
14	Adjusting Sleeve	Stainless Steel	AISI Type 410	1	33086	33086
15	Diaphragm Spacer	Aluminum	ASTM B-211 2017/2024	1	33937	33939
16	Diaphragm Guide	Stainless Steel	AISI Type 302	1	33933	33933
17	Tape Spring Seat	Cast Aluminum	ASTM B-26 Alloy B443.0	1	33944	33944
* 18	Yielding Spring	Steel, Nickel Plated	Commercial	1	12471	12471
19	Stem Nut	Aluminum	ASTM B-211 2017/2024	1	31830	31830
20	Bottom Spring Seat	Stainless Steel	AISI Type 410	1	11683	11683
21	Thrust Bearing	Stainless Steel & Brass	AISI Type 336 & ASTM B16	1	11684	11684
22	Adjusting Nut	Cast Bronze	ASTM B-61	1	12396	12396
23	Lock Nut	Brass	ASTM B-16	1	12833	12833
24	Washer	Stainless Steel	AISI Type 410	1	30673	30673
25	Base	Die Cast Aluminum	ASTM B-85 Alloy A360	1	43320	43320
26	Nut For Frame	Steel, Cadmium Plated	Commercial	1	13744	13744
* 29	Diaph. Nozz. Disc, Compl. (Note 1)	Stainless Steel	AISI Type 303	1	16086	16086
30	Diaph. Plate	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	38030	38030
34	Screw	Aluminum	ASTM B-211 2017/2024	4	33078	33078
* 35	O-Ring	Synthetic Rubber	Neoprene	2	42213	42213
36	Screw	Aluminum	ASTM B-211 2017/2024	4	33950	33950
37	Flange Ring	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	47910	47910
38	Body	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	40445	40445
* 40	Gasket	Synthetic Rubber	Neoprene	1	47916	47916
47	Bottom Plug	Aluminum	ASTM B-211 2017/2024	1	33991	33991
48	Cover	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	40447	40447
50	Cover Screw	Steel, Cadmium Plated	Commercial	1	33960	33960
* 51	Gage	Steel Case, Clear Lok Crystal	Commercial	2	52354	52354
54	Connector Piece	Cold Rolled Steel	AISI 1117	2	41037	47934
63	Allen Set Screw	Steel, Cadmium Plated	Commercial	1	12300	12300
* 64	Adjusting Pin	Aluminum	ASTM B-211 2017/2024	1	38032	38032
65	Nut	Steel, Cadmium Plated	ASTM A-194 Gr. 2H	1	38060	38060
* 66	Blade Spring	Stainless Steel	AISI Type 301-2B	1	38036	38036
67	Screw	Stainless Steel	Commercial	2	38173	38173
68	Bearing	Stainless Steel	AISI Type 302	1	38034	38034
69	Adjusting Screw	Stainless Steel	AISI Type 302	1	38033	38033
70	Proportioning Slider, Rt. Hand	Stainless Steel	AISI Type 302	1	38029	38029
71	Drive Screw	Steel, Cadmium Plated	ASTM A-228	1	58376	58376
72	Indicator	Stainless Steel	AISI Type 302	1	38027	38027
73	Washer	Stainless Steel	AISI Type 302	1	11685	11685
74	Cap Screw	Aluminum	Commercial	2	33079	33079
75	Proportioning Slider, Left Hand	Stainless Steel	AISI Type 302	1	38028	38028
76	Knob	Plastic	Commercial	1	38126	38126
* 77	Nozzle	Aluminum	AISI Type 316	1	22339	22339
78	Orifice Plug	Aluminum	ASTM B-211 2017/2024	1	33990	33990
* 88	Cover Screw Washer	Rubber	Commercial	2	57685	57685
89	Diaphragm Spring	Inconel	Commercial	1	10080	- -
90	Diaphragm Spring Seat	Aluminum	ASTM B-211 2017/2024	1	56129	- -
	Adjusting Rod	Cold Rolled Steel	Commercial	1	11808	11808

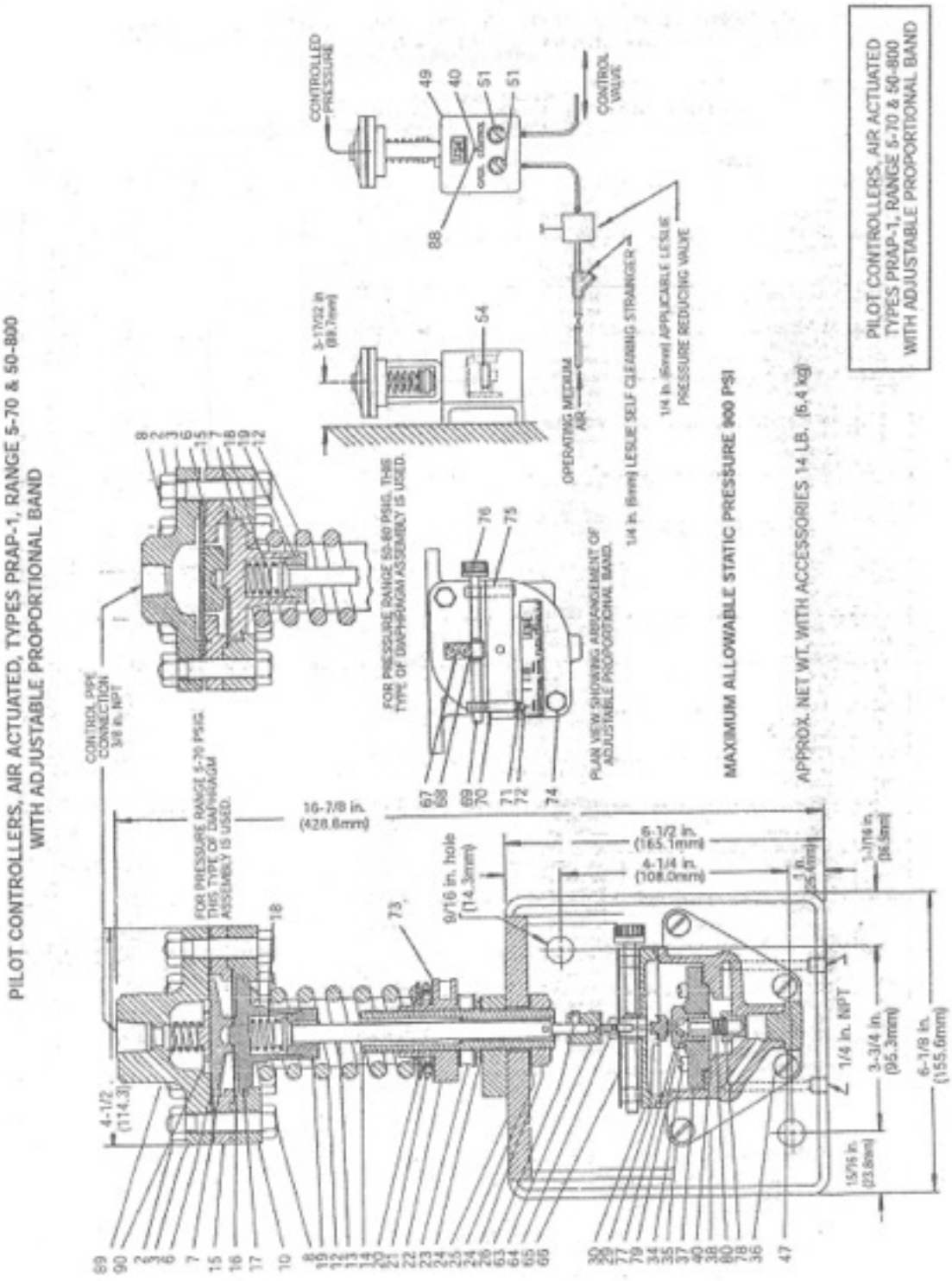
☆ RECOMMENDED SPARE PARTS.

* THESE PARTS SHOULD BE ON HAND, PLUS RECOMMENDED SPARE PARTS, WHEN OVERHAULING THIS EQUIPMENT.

NOTE 1 - CONSISTS OF NOZZLE DISC, RETAINING RING, AND DIAPHRAGM

NOTE 2 - CONSISTS OF STEM AND STEM HEAD

FOR ALL TYPES NOT LISTED, PLEASE ORDER PARTS BY NAME AND INCLUDE RANGE, TYPE, AND SERIAL NUMBER


PILOT CONTROLLERS, AIR ACTUATED, TYPES PRAP-1, RANGE 5-70 & 50-800
WITH ADJUSTABLE PROPORTIONAL BAND
PILOT CONTROLLERS, AIR ACTUATED
TYPES PRAP-1, RANGE 5-70 & 50-800
WITH ADJUSTABLE PROPORTIONAL BAND
MAXIMUM ALLOWABLE STATIC PRESSURE 800 PSI
APPROX. NET WT. WITH ACCESSORIES 14 LB. (6.4 kg)
CONTROLLED PRESSURE
CONTROL VALVE
OPERATING MEDIUM AIR
1/4 in. (6mm) LESLIE SELF CLEANING STRAINER
1/4 in. (6mm) APPLICABLE LESLIE PRESSURE REDUCING VALVE
CONTROL PIPE CONNECTION 3/8 in. NPT
FOR PRESSURE RANGE 5-70 PSIG THIS TYPE OF DIAPHRAGM ASSEMBLY IS USED.
FOR PRESSURE RANGE 50-80 PSIG THIS TYPE OF DIAPHRAGM ASSEMBLY IS USED.
PLAN VIEW SHOWING ARRANGEMENT OF ADJUSTABLE PROPORTIONAL BAND.
16-7/8 in. (428.6mm)
6-1/2 in. (165.1mm)
4-1/4 in. (108.0mm)
1 in. (25.4mm)
3-1/16 in. (96.9mm)
9/16 in. hole (14.3mm)
4-1/2 (114.3)
1/4 in. NPT
3-3/4 in. (95.3mm)
6-1/8 in. (155.6mm)
15/16 in. (23.8mm)
3-17/32 in. (89.7mm)

Page 20

PILOT CONTROLLERS, AIR ACTUATED, TYPES PRAP-1, RANGE 5-70 & 50-800 WITH ADJUSTABLE PROPORTIONAL BAND

TYPE PRAP-1, RANGE 5-70 AND 50-800

WHEN ORDERING PARTS, PLEASE GIVE TYPE, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW. USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NO.	PART NAME	MATERIAL	MATERIAL SPEC.	QTY PER UNIT	REF. NO. - EACH RANGE	
					5-70	50-800
2	Nut	Steel, Cadmium Plated	ASTM A 194 Gr. 2H	6	42843	42843
3	Diaphragm Cover	Aluminum Alloy	ASME SB-211 Alloy 6061-T6	1	33927	33927
★ 6	Diaphragm	Synthetic Rubber	Neoprene	1	13226-04	13226-04
7	Diaphragm Disc	Aluminum	ASTM B-211 2017/2024	1	33942	33943
8	Bolt	Steel, Cadmium Plated	ASTM A-193 Gr. B7	6	65749	65749
10	Yoke	Cast Aluminum	ASTM B 26 Alloy B443.0	1	33971	33971
12	Adjusting Spring	Spring Steel, Plated	Commercial	1	51403	19218
13	Stem, Compl. (Note 2)	Aluminum	ASTM B-211 2017/2024	1	45005	45005
14	Adjusting Sleeve	Stainless Steel	AISI Type 410	1	32686	32686
15	Diaphragm Spacer	Aluminum	ASTM B-211 2017/2024	1	33937	33938
16	Diaphragm Guide	Stainless Steel	AISI Type 302	1	33933	33933
17	Yoke Spring Seat	Cast Aluminum	ASTM B-26 Alloy B443.0	1	33944	33944
▲ 18	Yielding Spring	Steel, Nickel Plated	Commercial	1	12471	12471
19	Stem Nut	Aluminum	ASTM B-211 2017/2024	1	31836	31839
20	Bottom Spring Seat	Stainless Steel	AISI Type 410	1	11681	11681
21	Thrust Bearing	Stainless Steel & Brass	AISI Type 302 & ASTM B16	1	11684	11684
22	Adjusting Nut	Cast Bronze	ASTM B 61	1	12395	12395
23	Lock Nut	Brass	ASTM B 16	1	12833	12833
24	Washer	Stainless Steel	AISI Type 410	1	30673	30673
25	Base	Die Cast Aluminum	ASTM B-85 Alloy #300	1	43320	43320
26	Nut For Frame	Steel, Cadmium Plated	Commercial	1	13744	13744
★ 29	Diaph. Nozz. Disc, Compl. (Note 1)	Stainless Steel	AISI Type 302	1	15086	15086
30	Diaph. Plate	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	38030	38030
34	Screw	Aluminum	ASTM B-211 2017/2024	4	33678	33678
★ 35	O-Ring	Synthetic Rubber	Neoprene	2	43213-04	43213-04
36	Screw	Aluminum	ASTM B-211 2017/2024	4	33950	33950
37	Flange Ring	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	47510	47510
38	Body	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	40445	40445
★ 40	Gasket	Synthetic Rubber	Neoprene	1	47016-05	47016-05
47	Bottom Plug	Aluminum	ASTM B-211 2017/2024	1	33959	33959
49	Cover	Die Cast Aluminum	ASTM B-85 Alloy A360.0	1	40447	40447
50	Cover Screw	Steel, Cadmium Plated	Commercial	1	33960	33960
▼ 51	Glass	Steel Case, Chemical Crystal	Commercial	2	52354	52354
54	Connector Plate	Cold Rolled Steel	AISI 1117	2	41837	41837
83	Allen Set Screw	Steel, Cadmium Plated	Commercial	1	12395	12395
▲ 84	Adjusting Pin	Aluminum	ASTM B-211 2017/2024	1	38032	38032
65	Nut	Steel, Cadmium Plated	ASTM A-194 Gr. 2H	1	30060	30060
★ 66	Blade Spring	Stainless Steel	AISI Type 301-2B	1	30036	30036
67	Screw	Stainless Steel	Commercial	2	30123	30123
68	Bearing	Stainless Steel	AISI Type 302	1	38034	38034
69	Adjusting Screw	Stainless Steel	AISI Type 302	1	38033	38033
70	Proportioning Slider, Rt. Hand	Stainless Steel	AISI Type 302	1	38028	38028
71	Drive Screw	Steel, Cadmium Plated	ASTM A-738	1	58378	58378
72	Indicator	Stainless Steel	AISI Type 302	1	38027	38027
73	Washer	Stainless Steel	AISI Type 302	1	11685	11685
74	Cap Screw	Aluminum	Commercial	2	38679	38679
75	Proportioning Slider, Left Hand	Stainless Steel	AISI Type 302	1	38029	38029
76	Knob	Plastic	Commercial	1	38126	38126
▲ 77	Nozzle	Stainless Steel	AISI Type 316	1	47909	47909
78	Orifice Plug	Aluminum	ASTM B-211 2017/2024	1	33990	33990
★ 79	Nozzle Valve	Stainless Steel	AISI Type 303/304	1	47900	47900
80	Spring	Stainless Steel	AISI Type 302	1	23022	23022
★ 88	Cover Screw Washer	Rubber	Commercial	2	57685	57685
★ 89	Diaphragm Spring	Inconel	Commercial	1	10940	--
90	Diaphragm Spring Seat Adjusting Rod	Aluminum Cold Rolled Steel	ASTM B 211 2017/2024 Commercial	1 1	58728 11608	11608

★ RECOMMENDED SPARE PARTS.

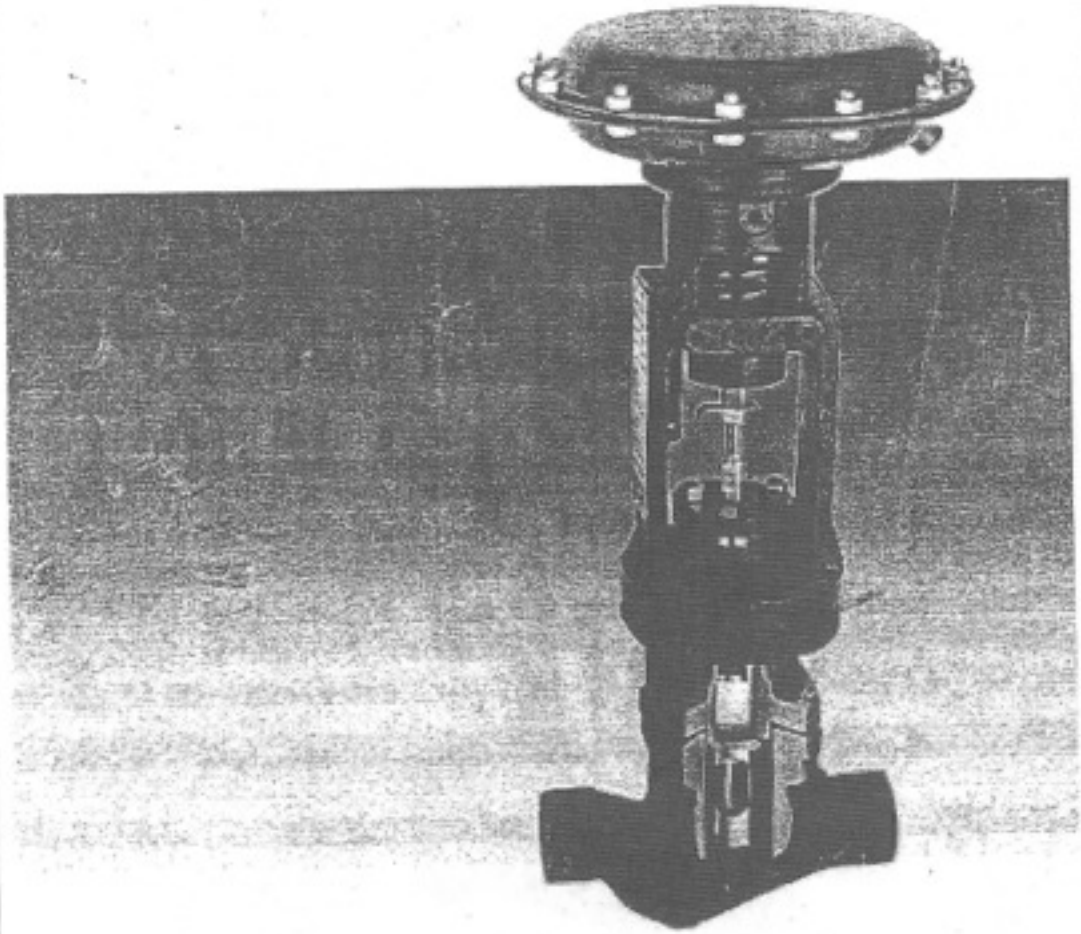
▲ THESE PARTS SHOULD BE ON HAD, PLUS RECOMMENDED SPARE PARTS, WHEN OVERHAULING THIS EQUIPMENT.

NOTE 1 - CONSISTS OF NOZZLE DISC, RETAINING RING AND DIAPHRAGM

NOTE 2 - CONSISTS OF STEM AND STEM HEAD

FOR ALL TYPES NOT LISTED, PLEASE ORDER PARTS BY NAME AND INCLUDE RANGE, TYPE AND SERIAL NUMBER

LESLIE CLASS DLO(S)-2 CAGE-RETAINED TRIM CONTROL VALVES ANSI 125-300 CLASS



Page B1

CLASS DLO(S)-2 CAGE-RETAINED TRIM CONTROL VALVES

DESIGN FEATURES

Leslie's Class DLO(S)-2 cage-retained control valves are designed for general purpose control of clean, dirty, viscous or corrosive liquids, as well as low to medium pressure, clean or dirty steam and gas service.

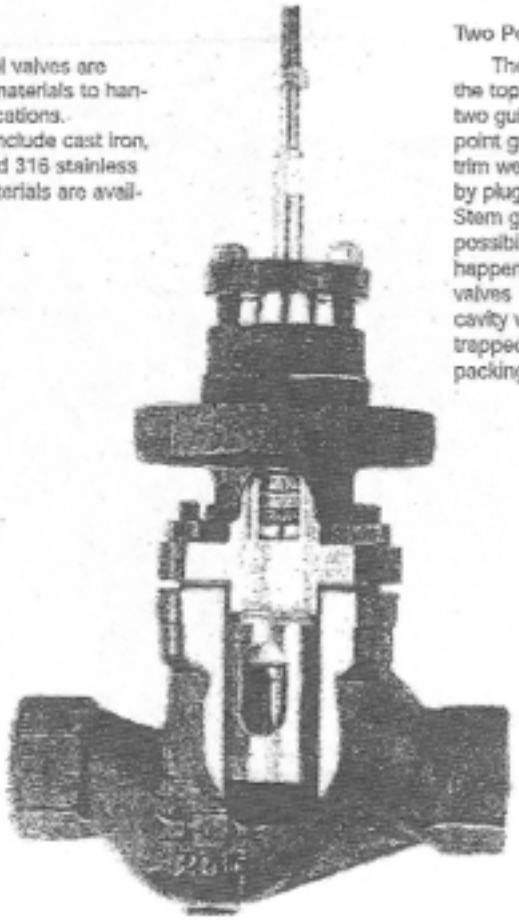
The cage-retained seat design eliminates the need or use of any threaded internal parts insuring ease of maintenance and parts replacement even after years in corrosive service. Top entry design also permits easy access to all internal parts for inspection or maintenance without removal of the valve from the pipeline. The DLO-2 class also features the highest Cv capacity of any comparable single seated valve in the industry providing maximum flows and minimum pressure losses.

Two point stem guiding provides rigid plug guiding and makes these valves especially suited for controlling dirty liquids or steam.

Through-bolted bonnet on cast steel and stainless steel valves, in lieu of bonnet studs, makes valve servicing easy, even after many years of service in corrosive environments.

Body Materials

Class DLO(S)-2 control valves are available in several body materials to handle a wide variety of applications. Standard body materials include cast iron, carbon steel (DLOS-2), and 316 stainless steel (DLOS-2). Other materials are available on request.



Two Point Stem Guiding

The heavy duty stem is guided at the top and bottom of the bonnet by two guide bushings. Unlike single point guiding, this method minimizes trim wear and seat leakage caused by plug deflection and vibration. Stem guiding also eliminates any possibility of pumping of fluid as can happen with post guided globe valves by eliminating the bushing cavity where media can become trapped then pumped through the packing.

Tight Shut-Off

Seat material choices include 316 stainless steel seats with Stellite* alloy hard-facing providing ANSI Class IV or V shut-off, 316 stainless steel optional. An optional 316 stainless steel seat with a PTFE insert provides ANSI Class VI bubble-tight shut-off and Class IV metal-to-metal back-up.

End Connections

DLO-2 Series valves are available in ANSI 125# 250#, and (DLOS-2) series in 150# and 300# class body ratings. Choice of standard end connections include threaded, socket weld, butt weld and raised face flanged. DIN flange end connections optional.

STELLITE is a registered trademark of Stoody Deloro Stellite, Inc.

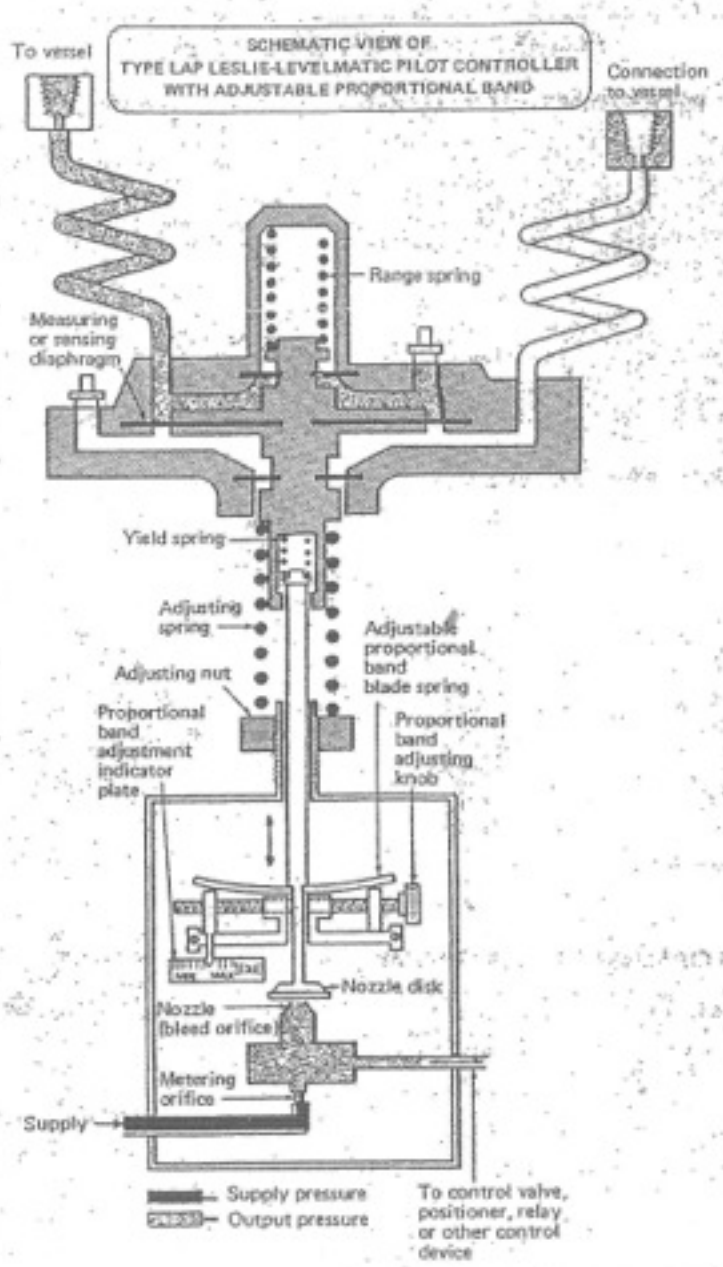


Figure 2-22A. Proportional Response by Differential Spring Action

(Courtesy Leslie Co.)

Instrument Control Lab

The objective of this lab is to set up and operate a three loop Leslie pilot control pressure control system. This system utilizes the simulation of the Kennedy's auxiliary exhaust system.

Learning Objectives:

- Function and setting of regulating valves
- Function, operation, and adjustment of diaphragm operated process control valves
- Function, operation, and setup of direct and reverse acting pilot control valves
- Function of direct and reverse controller action in a process loop
- Comparison of ON/OFF control and an automatic process control utilizing proportional band in a process system

Student's Name: _____ Date:_____

Instructor's Name: _____ Date:_____

Introduction:

This lab involves the set up operation of a pressure controlled process loop, utilizing the Leslie pilot control valves and diaphragm operated valves. The unit we will be using is a simulation of the Kennedy's auxiliary exhaust system, which is made up of three separate loops controlling one system. They consist of one Leslie pressure direct adjustable proportional (PDAP) control valve, two Leslie reverse adjustable proportional (PRAP) pilot control valves, two Leslie class DLO, and one Masonelian diaphragm control valve. Each system will be set up separately and then combined to operate as one.

To better understand the construction of the Leslie pilot control valve, we will dismantle and put back together several Leslie pilot control units.

As you look through this lab, you will find pages from Leslie controls installation, operating, and maintenance instruction manuals. This is done to assist you in better understanding the operation and functions of this equipment.

Terminology and Definition:

On/Off Control: The simple action of operating a switch or valve to turn a source off and on. A simple example is boiler water. Turn the heat on and when the water boils, turn the heat off.

Automatic Process Control: As a system becomes more complex and demanding, controls were designed to control the system around a particular parameter. This control action that governs loop controllers includes three modes: proportional, integral, and derivative better known as PID. Because we are only dealing with proportional band in this lab, we will only review its function.

Proportional Control Mode: The most basic control mode, which produces an output signal from a controller, the value which is proportional to the amount of deviation or difference between the measured variable and the set-point.

Proportional control action responds to the size and sign of the deviation. For each value of deviation, there is a specific valve opening. If the process is below the set-point the valve will open, as the process goes above the set-point the valve will close. The actual relationship between a given deviation value and its corresponding valve opening depends on what valve opening can supply the right amount of control media to maintain process set-point, and the proportional band setting of the controller. The control action is governed by the amount of proportional and setting we have. If we have a narrow proportional setting, a small process change causes a large valve movement. If there is a wide setting, it will take a large process change to have a small valve movement.

Rule of thumb is that the wider the proportional band, the smaller the change in valve position for any given change in process variable

Proportional action continues to operate the valves until the process reaches the desired value, or set-point. If the proportional band is adjusted narrower than the setting, which gives a steady performance, it could cause an unstable control operation.

Proportional Band: The range of change or range of deviation, in percent of scale, that corresponds to the full range of valve opening.

Off Set: Condition found in proportional only controller. It is the difference or "off set" between desired set point and the actual process value.

A disadvantage of a proportional mode system is that there is a fixed relationship between the value of the process variable and the position of the valve. That is there is only one position of the valve for any given value of the controlled variable, regardless of the process load. So whenever there is a load change, the system will respond and proportional action will work to try to bring the process to a set point. However, as proportional action works to reduce the deviation, it cannot eliminate it completely. (Off Set) - The size of the off set can be reduced by making the proportional band narrow, but this may result in an unstable control operation. A proportional band of zero produces a two-position or on-off control.

Control Valve Action: Direct and Reverse: The control valve acts directly with a change in the process, that is if the process is too high, the dump valve opens and the supply closes; and if the process is low the supply valve opens, and dump valve closes. As in most cases all of the valves fail closed for this reason. The controller is designed to operate the process valve as required by the use of the controller action.

Example: If the pressure gets too high, we want the dump valve to open. This is **direct acting. As the process increases, we want the controller output to increase.** In the opposite, if the process pressure drops, we want the make-up valves to open. This is **reverse acting. As the process decreases, we want the controller output to increase.**

Diaphragm Operated Control Valve: This is a cage-retained trim control valve with a diaphragm operated mounted on top. Reference the later pages showing the valve assembly and the valve and trim assembly.

Leslie Pilot Control Valve and Proportional Control: We will be using two types of controller, a pressure direct acting adjustable proportional, "PDAP," and a pressure reverse acting adjustable proportional, "PRAP".

The movement of the measuring diaphragm is governed by a range spring and an adjusting spring, whose forces are in opposition. The adjusting spring serves as the set point adjustment. Motion of the measuring diaphragm is transmitted to the stem and blade spring through a yield spring, which allows for over travel of the diaphragm unit after the stem is in contact with the blade spring.

Proportional response adjustment is provided by the blade spring whose effective length can be changed by positioning the two spring support blocks. By adjusting the proportional blade spring, more or less movement of the diaphragm is required for a given change in output pressure.

ADJUSTMENT OF THE PILOT CONTROLS

Utilizing the schematic drawing:

1. Ensure all valves are closed
2. Connect the air supply lines to both stand inlet. Open the supply pressure valve to the pilot controls, valve #1

Adjust the regulator to 20 psig

3. Open the air supply valves to the pilot controls, valves #2, 3, & 4
4. Check the supply gauges on the controls read 20 psig
5. Set the stem length and the proportional band on all three pilot controls
6. Open the sensing line for the engine bleed steam and 150 psi steam makeup valves #9 & #10
7. Check the position of the process control valves, the makeup and steam valves should be open and the dump valve closed
8. Notice the control output; they should read 20 psig and 0 psig accordingly

We will now set each of the Control Systems, one at a time. This is done to ensure each system functions properly by itself.

SETTING OF THE BLEED CONTROL SYSTEM

1. Open the system air supply valve #5 and inlet to the bleed steam makeup valve #6
2. Adjust the supply air regulator to 45 psig
3. Check to ensure the exhaust valve #13 is closed

Note: The pressure in the main tank will increase and steady out at a pressure equal to the setting of the bleed pilot control

4. Check the reading on the main system pressure tank (we want this system to operate between 30 to 40 psig

Note: Adjusting the set-point adjusting nut will allow increasing or decreasing of the system pressure. Check that the bleed valve opens when the pressure drops below 30 psig and closes above 40 psig.

5. Adjust the proportional band nut, checking the output pressure gauge changes as you make an adjustment

Note: To check the operation of the system, you can open valve #8 to supply air to the system and valve #12 to exhaust the system. These valves allow you to simulate a system change without the system operating.

SETTING OF THE DUMP CONTROL SYSTEM

1. Shut the bleed control valve #6
2. Open the exhaust valve #13
3. Set the operation of the dump valve controls by opening the pilot sensing valve #11

Note: The system pressure, by adjusting valve #8 we can increase system pressure

4. Adjust the valve so pressure is above 35 psig (the control valve should open)
5. Close valve #8

Note: As pressure drops notice the valve closes as it drops below 35 psig

6. Adjust the control set point to operate the valve at 35 psig
7. Check setting by operation of valve #8
8. Adjusting the set-point adjusting nut will allow the setting of the system pressure
9. Check that the dump valve opens when the pressure increases above 35 psig and closes below 35 psig
10. Adjust the proportional band nut checking the output pressure gauge changes as you make an adjustment
11. Open the bleed control valve #6 and check the operation with both systems operating
12. Adjust the proportional band on each or either system as needed
13. Close valves #6, 8, & 12

SETTING OF THE 150 LB CONTROL SYSTEM

As you were setting up and testing the bleed make up and dump systems, you may have noticed the movement of the makeup valve. This valve is set to open when the system pressure drops below the makeup capabilities of the bleed valve. We will set this system to operate if system pressure drops to 30 psig.

1. Open valve #7 and close valve #13
2. Check system pressure
3. Open valve #12 to drop the pressure below 30 psig as you observe the control valve open
4. Adjust the set-point so the valve opens at 30 psig
5. Operate valves #8 and #12 to simulate the system pressure change
6. Adjust the proportional band nuts checking the output pressure gauge changes as you make an adjustment

Check the operation of the complete system by opening valves #6 & 13. By using valve #8 & #12, system pressure changes and valve operation can be observed.

Pneumatics Problem #4

Application:

Parts are accumulating on a conveyor belt and waiting to be released and transferred to the next phase of assembly. Technicians at multiple stations need to control the gate release mechanism to have parts sent to their assembly station.

Objective:

To be able to design and assemble an "OR" logic circuit.

Circuit Problem:

Using the given components and layout, design a schematic circuit which will operate one spring return cylinder from any one of three identical valves.

Design and draw schematic diagram. Approved: _____

Connect components to match schematic diagram.

Operate and explain circuit to instructor. Approved: _____

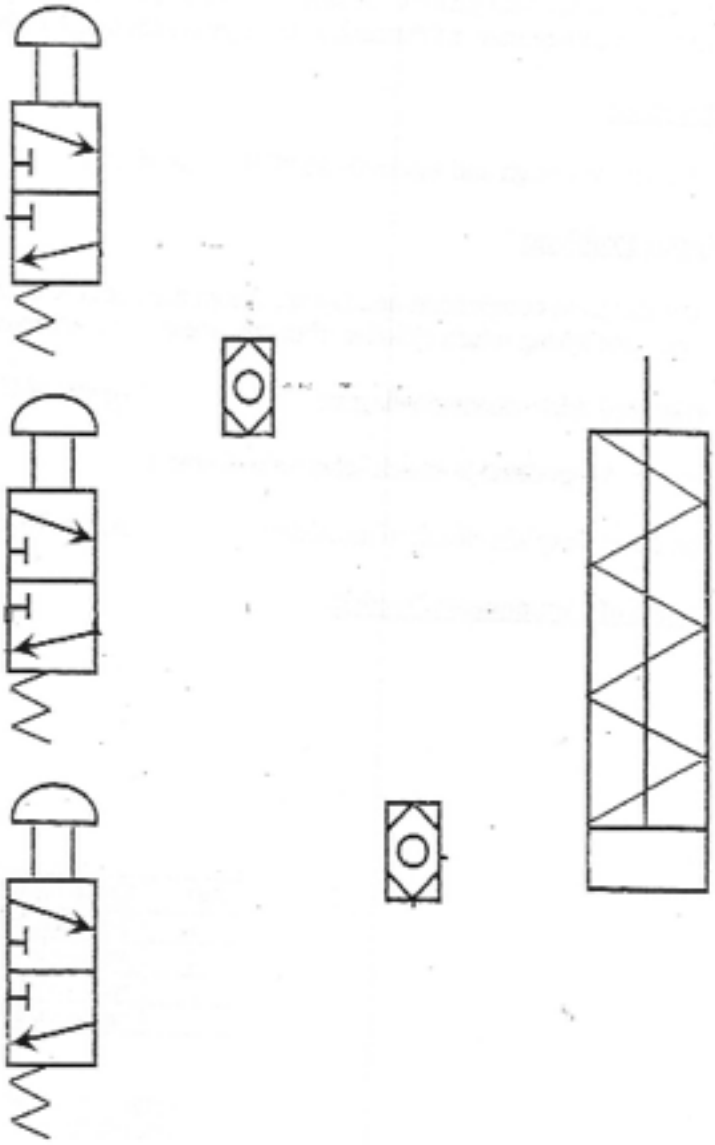
Layout of Components Needed:

Part #	Component Description	Qty
1	2-position, spring offset, 3-way valve	3
2	shuttle valve	2
3	push button actuator	3
4	Single acting, spring return cylinder	1

N
NOTE: ACTUATORS MAY ALREADY BE ASSEMBLED ON A VALVE.

Solution for Pneumatics Problem #4

Schematic Diagram for Circuit Problem



Pneumatics Problem #6

Application:

A gravel yard has a single conveyor that can transport gravel to two different loading docks. In order to shift the out feed of the conveyor to the alternate loading dock the operator must push a button. As a safety precaution, the conveyor will always be held in the last shifted position.

Objective:

To be able to design and assemble an "FULL MEMORY" circuit.

Circuit Problem:

Using the given components and layout, design a schematic circuit that requires the operator to push one of two buttons that in turn shifts a detented, two position, four-way valve. The valve is air-piloted in both directions and operates a double acting cylinder.

Design and draw schematic diagram. Approved: _____

Connect components to match schematic diagram.

Operate and explain circuit to instructor. Approved: _____

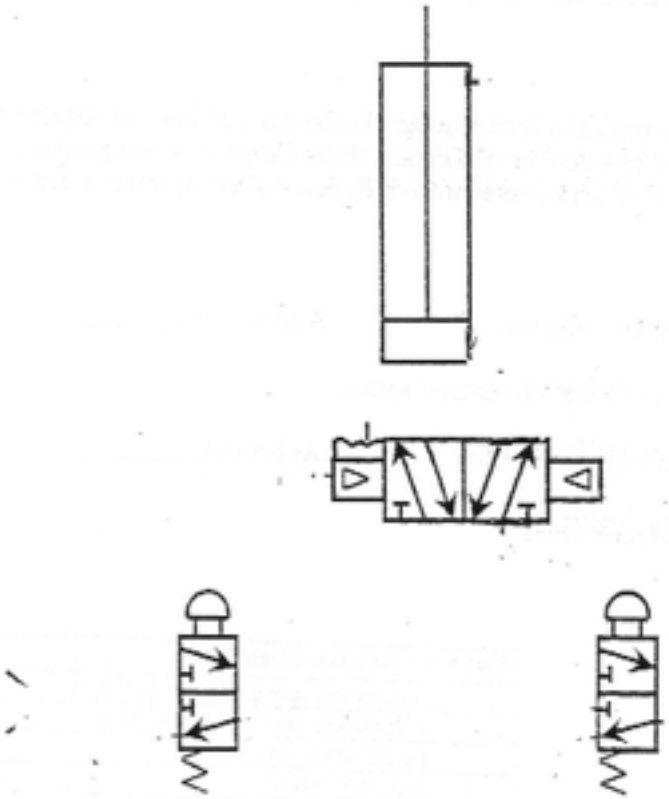
Layout of Components Needed:

Part #	Component Description	Qty
1	2-position, spring offset, 3-way valve	2
2	2-position, detented, 4-way valve	1
3	push button actuator	2
4	air pilot actuator	2
5	double acting cylinder	1

NOTE: ACTUATORS MAY ALREADY BE ASSEMBLED ON A VALVE.

Solution for Pneumatics Problem #6

Schematic Diagram for Circuit Problem



Pneumatics Problem #8

Application:

The machine head of a precision grinder needs to continuously reciprocate over a cylinder head surface being finished. The speed of the stroke must be controlled in both directions.

Objective:

To be able to design and assemble an "AUTOMATIC CAM CYCLING" circuit.

Circuit Problem:

Using the given components and layout, design a schematic circuit that automatically cycles the continuous reciprocation of a cylinder. Limit valves located at the full extension and retraction of the cylinder are mechanically (cam) operated. Flow control valves are located so that they control the exhaust flow leaving the cylinder, thereby governing the speed of the operation. The cycle is started and stopped by shifting a manually operated valve.

Design and draw schematic diagram. Approved: _____

Connect components to match schematic diagram.

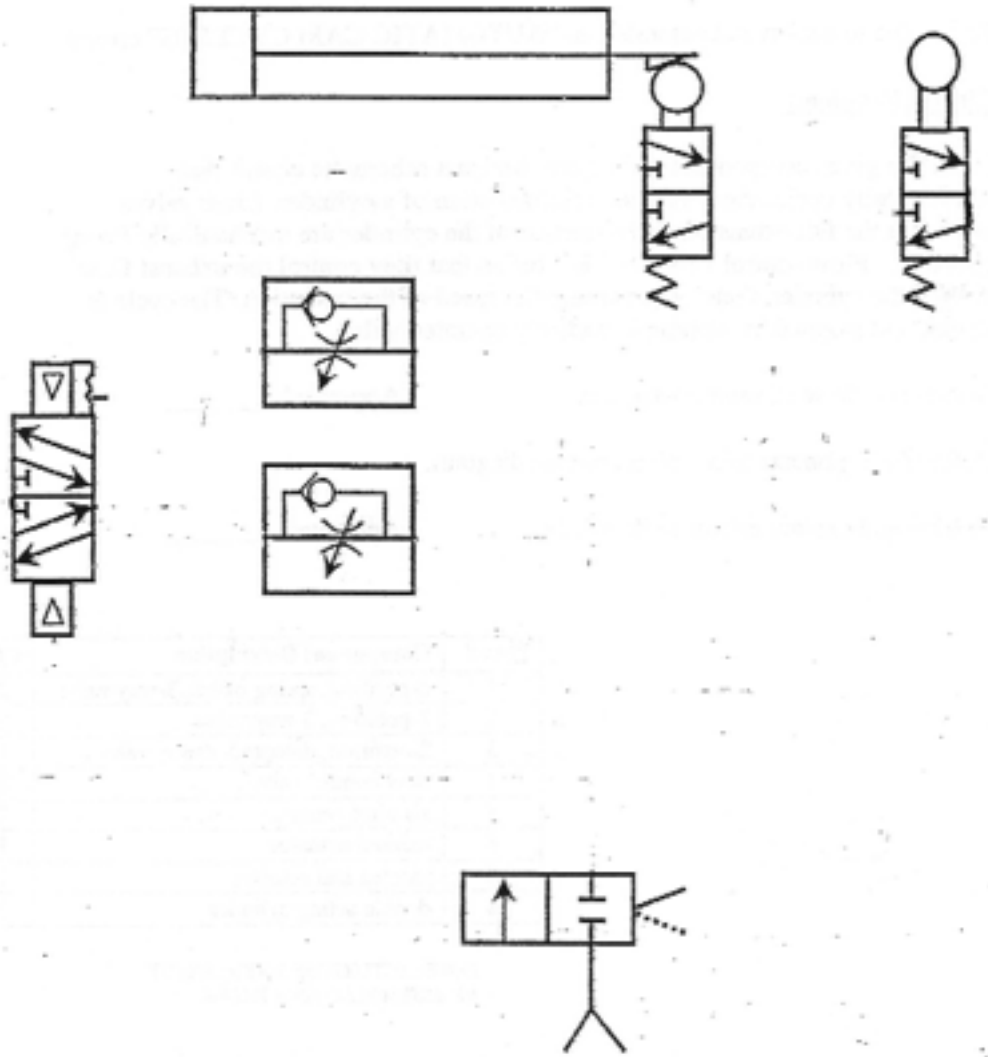
Operate and explain circuit to instructor. Approved: _____

Part #	Component Description	Qty
1	2-position, spring offset, 3-way valve	2
2	2-position, 3-way valve	1
3	2-position, detented, 4-way valve	1
4	flow control valve	2
5	air pilot actuator	2
6	manual actuator	1
7	mechanical actuator	2
8	double acting cylinder	1

NOTE: ACTUATORS MAY ALREADY BE ASSEMBLED ON A VALVE.

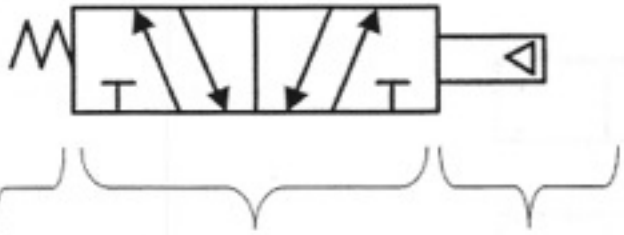
Pneumatics Problem #8

Schematic Diagram for Circuit Problem



Schematic Symbols for Directional Valves

A directional valve is a valve that directs the flow of air in one with or another. It doesn't throttle or meter the airflow, and it doesn't change the pressure of the air. It just changes the direction of the airflow in some way. The ANSI symbol for directional valves are the most complicated of all the fluid power symbols, but some of the most important, so let us start with directional valves, see how the symbol system works. A typical directional valve symbol is made up of three parts:

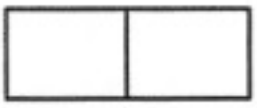


Left Actuator Valve Action Right Actuator

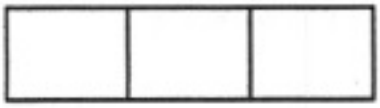
The actuators are the devices or methods that cause the valve to shift from one position to another. The valve action refers to the combinations of positions and flow paths which the valve offers.

Position Boxes

Every valve provides two or more usable positions, each position providing one or more flow paths. For example, the familiar single solenoid spring return valve provides two usable positions, one position occurring when the solenoid is in command of the valve, the other position occurring when the spring is in command of the valve. The ANSI symbol for a directional valve is built around a series of boxes or rectangles, one box for each usable position of the valve.



A 2-Position valve is shown by two boxes.

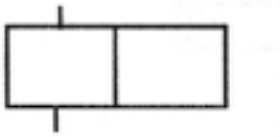


A 3-Position valve is shown by three boxes.

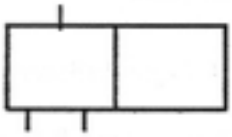
Most air moves are either 2-position or 3-position valves, but it would be possible to have an unusual valve with four or five or even six positions. In any case, there would be a box to represent each position of the valve.

Valve Ports

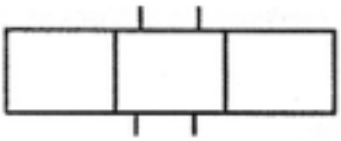
Every valve port, which appears on the outside of the valve, is supposed to be shown on the symbol. But the ports are shown on only one of the boxes, the box that represents the flow paths that exist at the start of the machine cycle. Some examples are:



A 2-position 2-port valve



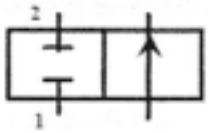
A 2-position 3-port valve



A 3-position 4-port valve

Flow Paths

Each box contains a group of lines that represent the flow paths the valve provides when it is in that position. If a port is blocked, we show that by the symbol ⊤. If two ports are connected and air can flow, this is shown by a line drawn between the two ports.



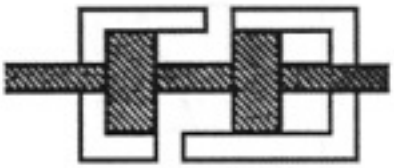
In the example above, the left box shows the conditions that exist at the start of the cycle. Port 1 is blocked, and port 2 is blocked. When the valve is shifted, the flow condition shown in the right hand box exists. Port 1 is open to port 2.

Functional Types of Directional Control Valves

One method of classifying a directional control valve is by the flow paths that are set up in its various operating conditions. Important factors to be considered are the number of individual ports, the number of flow paths the valve is designed for and internal connection of ports with the movable part.

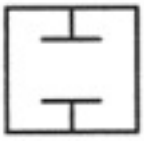
Two-Way Directional Valve

A two-way directional valve consists of two ports connected to each other with passages, which are connected and disconnected. In one extreme spool position, port A is open to port B; the flow path through the valve is open. In the other extreme, the large diameter of the spool closes the path between A and B; the flow path is blocked. A two-way directional valve gives an on-off function.



Flow Path Open

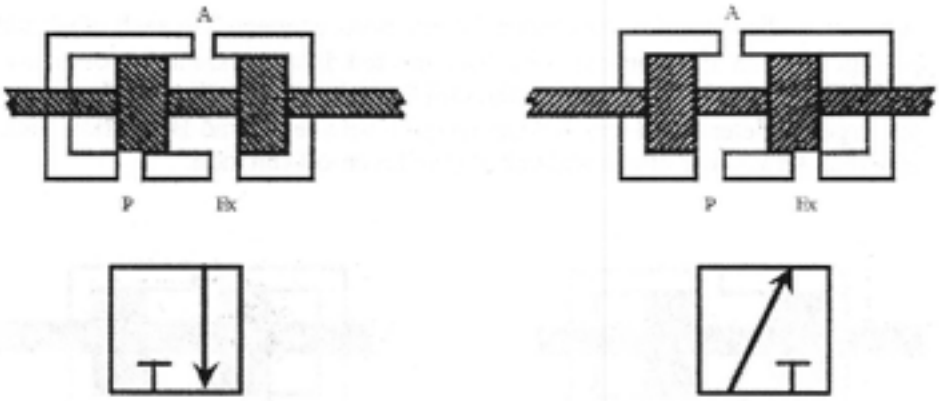
Flow Path Closed



Three-Way Directional Valve

A three-way directional valve consists of three ports connected through passages within a valve body that are shown here as port A, port P and port Ex. If port A is connected to an actuator, port P to a source of pressure and port Ex is open to exhaust, the valve will control the flow of air to (and exhaust from) Port A.

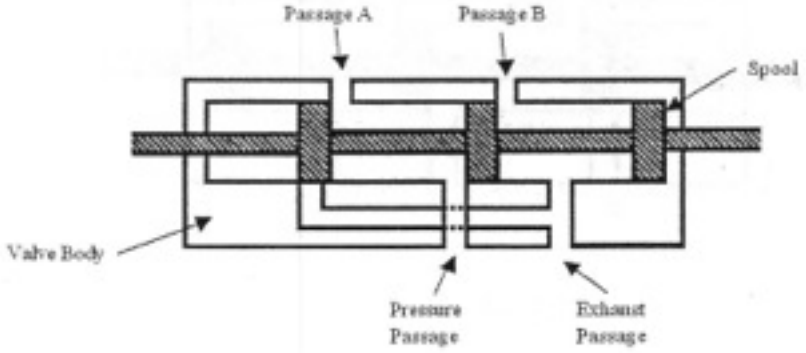
The function of this valve is to pressurize and exhaust one actuator port. When the spool of a three-way valve is in one extreme position, the pressure passage is connected with the actuator passage. When in the other extreme position, the spool connects the actuator passage with the exhaust passage.

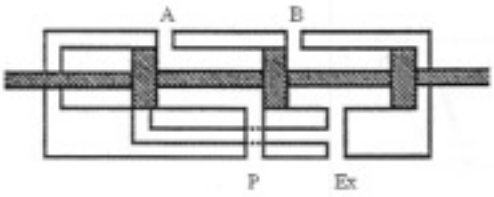


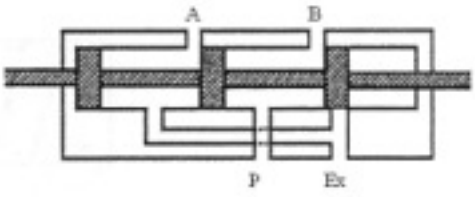
Four-Way Directional Valve

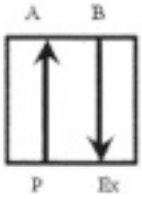
Perhaps the most common directional valve in simple pneumatic systems consists of pressure port, two actuator ports and one or more exhaust ports. These valves are known as four-way valves since they have four distinct flow paths or "ways" within the valve body.

A common application of four-ported four-way directional valve is to cause reversible motion of a cylinder or motor. To perform this function, spool connects the pressure port with one actuator port. At the same time, the spool connects the other actuator port with the exhaust port. This is a four-ported four-way valve.



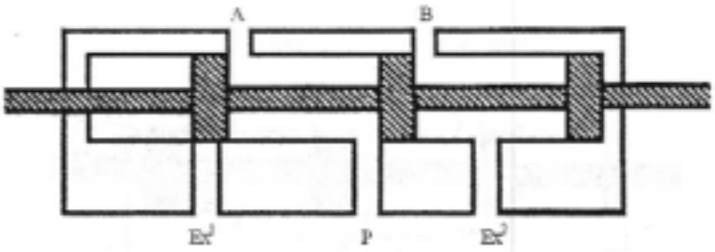




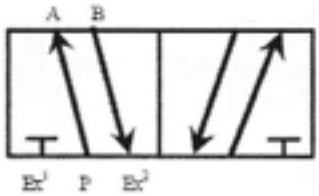


Five-Port / Four-Way Directional Valve

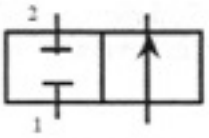
Four-way valves are also available with five external ports, one pressure port, two actuator ports, and two exhaust ports. Such valves provide the same basic control of flow paths as the four-ported version, but have individual exhaust ports. In the fluid power field this is referred to as a "five-ported, four-way valve." This type of valve brings all flow paths to individual external ports. The pressure port is connected to system pressure after a regulator. Actuator ports are connected to inlet and outlet ports of a cylinder or motor. Each exhaust port serves an actuator port.



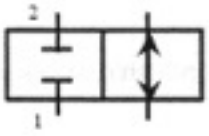
5-Ported, 4-Way Valve



The direction in which air flows *during a normal operating cycle* is shown by putting arrowheads at the ends of the flow paths next to the ports where the air will come out.



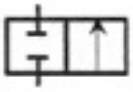
Example #1 - At the start of the cycle, the flow path from port 1 to port 2 is blocked. When the valve shifts, flow is from port 1 to port 2.



Example #2 - At the start of the cycle, the flow path from port 1 to port 2 is blocked. When the valve shifts, port 1 is opened to port 2, but during some part of the cycle air flows from port 1 to port 2, and during another part of the cycle air flows from port 2 to port 1.

Typical Symbols for Valve Actions

Two- Position Valves

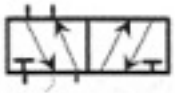


2-Way, Blocked at start of cycle

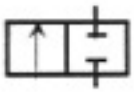
3-Way, Blocked at start of cycle

2-Inlet Selector

4-Way, 4-port Single Inlet

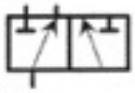


4-Way, 5-port Dual Pressure Common Exhaust



2-Way, Open at start of cycle

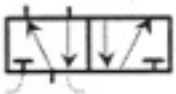
3-Way, Open at start of cycle



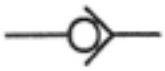
Distributor (Diverter)

4-Way, 5-Port Single Inlet Dual Exhausts

or



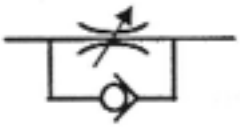
Miscellaneous Valve Symbols



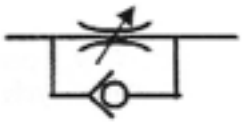
Check Valve - Allows flow in one direction, but blocks flow in the other direction. In this example flow can go from right to left, but now flow left to right is blocked.

Fixed Restriction or orifice - Restricts flow in both directions.

Adjustable Restriction - Restricts flow in both directions.

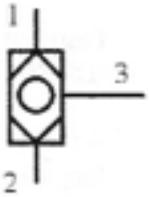


Flow Control Valve - (also called speed control valve) allows free flow in one direction but restricts flow in the other direction. In this example free flow is from right to left, restricted flow from left to right.



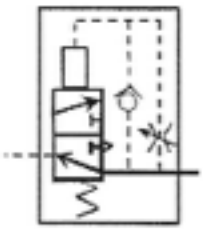
In this example, free flow is from left to right. Restricted flow is from right to left.

Shuttle Valve - A three-port valve with two inlets and one outlet. In this example ports 1 and 2 are inlets, port 3 the outlet. If pressure is applied to port 1, it will appear out port 3, but will not back-flow out port 2.



If pressure is applied to port 2, it will appear out port 3 but will not back-flow out port 1.

When the pressures are removed from ports 1 and 2, port 3 will exhaust back out one of the two inlet ports, but it may exhaust out either of them.



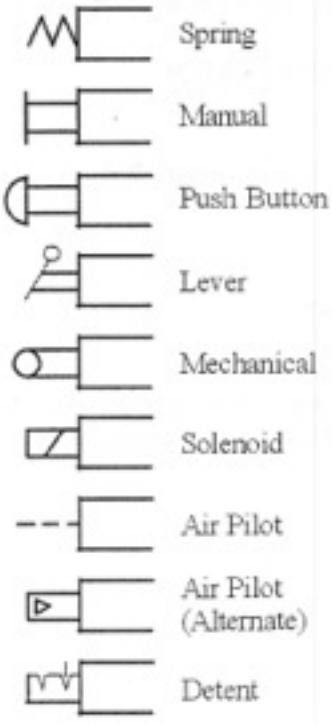
Pulse Valve A valve that allows the initial supply of air it receives to pass through it just for a few milliseconds (pulse), then remains closed until the supply pressure is exhausted.

Symbols for Valve Actuators

The symbols for the valve actuators are drawn next to the end of the valve boxes.

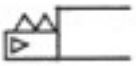
The rule is that each actuator is drawn next to the box that exists when that actuator is in command. In the drawing above, when the spring has control of the valve, the flow paths in the left hand box. When the solenoid (the right hand actuator) is in command, the flow paths in the right hand box exist.

There are a series of standard symbols for actuators. These symbols may be drawn on either end of the valve without altering their meaning.



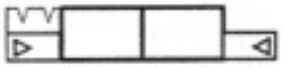
Composite Actuators

If two actuator symbols are drawn side by side, this means that either one can cause the valve to actuate.



Either the air pilot OR the spring can cause the valve to move.

Typical Actuator Combinations



2-Position, Double pilot, detented

3-Position, Double pilot, spring centered

Summary Explanation of Valve Terminology

TWO Way Valve, Normally Closed:
Flow is from inlet to outlet when the valve is actuated.
Fluid in outlet line is trapped when the valve is deactivated.

THREE Way Valve, Normally Closed:
Flow is from inlet to outlet when the valve is actuated.
On deactivation of valve, outlet line is vented to atmosphere.

THREE Way Valve, Normally Open:
Flow is from inlet to outlet in the deactivated valve condition.
Actuation of the valve stops flow from inlet to outlet, the outlet is then exhausted.

FOUR Way Valve:
From inlet, flow is diverted to one of the outlets; outlet port that is not active is vented to atmosphere.
Valve can be either spring return or two-position type.

FLOW Control Valve:
Allows free flow in one direction and controlled adjustable flow rate in the other direction.

SHUTTLE Valve:
Allows flow from either input to the output.

PULSE Valve:
A unitized valve that converts a continuous supply of air into an outlet pulse of air and then remains closed until the supply pressure is exhausted.

Section

8000

How to Read Symbols in a Hydraulic Schematic

CASE CORPORATION
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Racine, WI 53404 U S A

CASE CANADA CORPORATION
450 Sherman Ave
Hamilton, ON CANADA L8N 4C4

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TABLE OF CONTENTS

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HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC

Introduction

Accurate diagrams of hydraulic circuits are essential to the man who must repair them The diagram shows how the components will interact It shows the field technician how it works, what each component should be doing and where the oil should be going so that he can diagnose and repair the system

The purpose of this section is to show you how to find your way around schematic circuit diagrams

Circuit Diagrams

There are two types of circuit diagrams

1 Cutaway Circuit Diagrams show the internal construction of the components as well as the flow paths By using colors, shades or various patterns in the lines and passages, they are able to show many different conditions of flow and pressure Cutaway diagrams take considerably longer to produce because of their complexity

2 Schematic Circuit Diagrams the "shorthand" system of the industry, are usually preferred for troubleshooting A schematic diagram is made up of simple geometric symbols for the components and their controls and connections

Symbol Systems

There are several systems of symbols used when making schematic diagrams They are as follows

I S O = International Standards Organization

A N S I = American National Standards Institute

A S A = American Standards Association

J I C = Joint Industry Conference

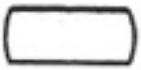
A combination of these symbols are shown in this section There are differences between the symbols but there is enough similarity so that if you understand the symbols in this section you will be able to interpret other symbols as well

Using Schematic Symbols

Reservoirs

VENTED RESERVOIR

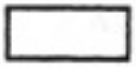
710L8B



PRESSURIZED RESERVOIR

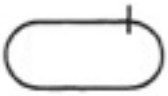
710L8D

A rectangle with the top removed represents a vented reservoir A rectangle with the top in place represents a pressurized reservoir



PRESSURIZED RESERVOIR

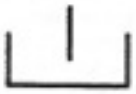
710L8C



PRESSURIZED RESERVOIR

710L8A

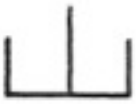
There are other schematic diagrams that show a slightly different version of a pressurized reservoir, but the symbols are similar and easily recognized An oval with a short line on top or a rectangle with curved sides represents a reservoir that is pressurized



RETURN LINE ABOVE THE OIL LEVEL

710L8E

Lines connected to the reservoir usually are drawn from the top, regardless of where the actual connection is



SUCTION LINE OR RETURN LINE BELOW THE OIL LEVEL

710L8F

If the hydraulic line terminates below the fluid level, it is drawn all the way to the bottom of the symbol

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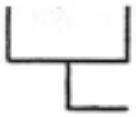
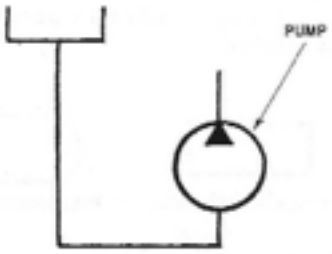
8000-4



RESERVOIR WITH SUCTION LINE ATTACHED AT THE BOTTOM

710BG

A hydraulic line connected to the bottom of the reservoir may be drawn from the bottom of the symbol if the bottom connection is essential to the systems operation



749L8B

If the pump inlet must be charged or flooded with a positive head of oil above the inlet port, we would position the reservoir symbol above the pump symbol, and draw the suction line out of the bottom of the reservoir symbol

Every vehicle or system reservoir has at least two hydraulic lines connected to it, and some may have many more Often the components that are connected to the reservoir are spread all over the schematic Rather than having a lot of confusing lines all over the schematic, it is customary to draw individual reservoir symbols close to the components The reservoir is usually the only component symbol pictured more than once

Lines, Tubes and Hoses

A hydraulic line, tube, hose or any conductor that carries the fluid between components is shown as a line

710L8H

A working line, such as an inlet pressure or return, is shown as a solid line

OIL FLOWS ONE WAY ONLY

710L8J

OIL CAN FLOW EITHER WAY

710L8K

Working lines with arrows show direction of flow

710L8K

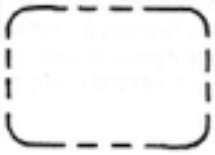
Pilot or control lines are broken into long dashes

710L8B

Drain lines for leakage oil are broken into short dashes

710L8C

A flexible line is shown as an arc between two dots and is always represented by a solid line



710L8D

Quite often you will see an enclosure outline that indicates that there are several symbols that make up a component assembly such as a valve or a valve stack The enclosure outline appears like a box and is broken with dashes on all sides

Rac 8-94372

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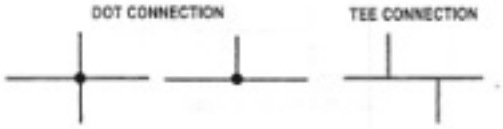
Crossing or Joining Lines

LINES THAT ARE NOT CONNECTED

711L8E 710L8L 710L8M

The shortest distance between two components that are connect is a straight line There are lines that cross other lines but are not connected There are several ways to show crossing lines

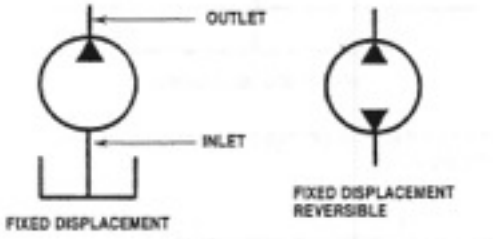


LINES THAT ARE CONNECTED

710L8N 710L8P 711L8H

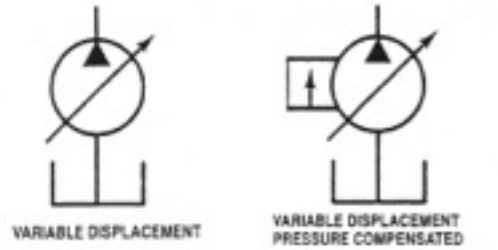
Lines that are connected are shown with a dot that represents the connection or shown as a tee connection The dot connection is the most commonly used when drawing schematic diagrams

Pump Symbols



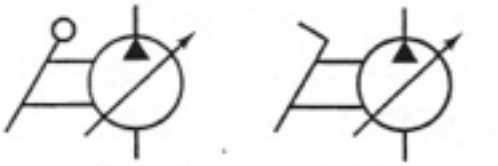
711L8J 711L8K

There are many basic pump designs A simple fixed displacement pump is shown as a circle with a black triangle that is pointing outwards The black triangle is like an arrow head and points in the direction that the oil will flow If the pump is reversible or designed to pump in either direction, it will have two black triangles in it and they will be opposite each other



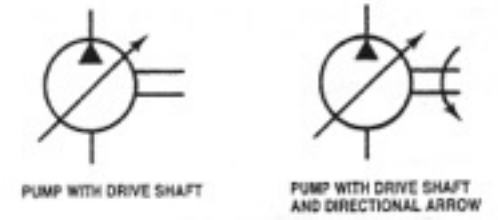
710L8S 710L8T

A variable displacement pump is designated by drawing an arrow through the pump symbol at 45 degrees To indicate a variable displacement pressure compensated pump, a small box with an arrow in it will be added to the side of the pump symbol



710L8V 710L8U

If the pump is controlled by a lever or a pedal, it will be shown on the side of the pump



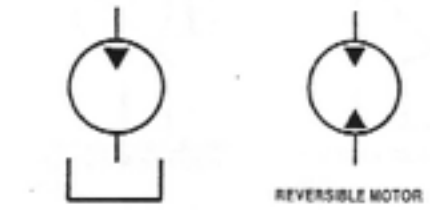
710L8W 711L8L

A drive shaft is shown as two short parallel lines extending from the side of the pump If a curved arrow is shown on the drive shaft, it will indicate the direction of rotation

Rac 8-94372 Revised 11-96 Printed in U S A

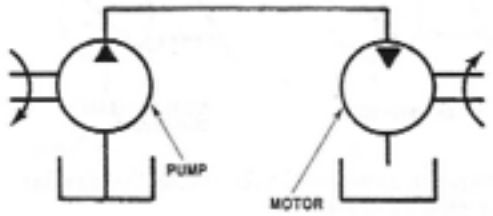
8000-6

Hydraulic Motor Symbols



711L8M 711L8N

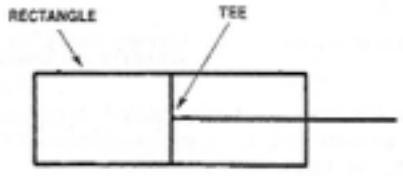
Hydraulic motor symbols are circles with black triangles, but opposite a pump the triangles point inward to show the motor is a receiver of oil One triangle is used in a nonreversible motor and two triangles are used for a reversible motor



711L8P

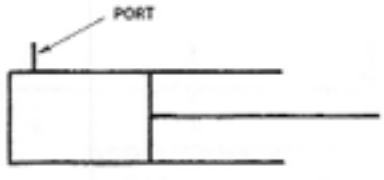
A simple schematic diagram is shown with a hydraulic motor connected to a hydraulic pump

Cylinder Symbols

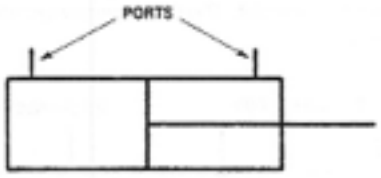


711L8Q

A cylinder symbol is a simple rectangle representing the barrel The piston and rod are represented by a tee that is inserted into the rectangle The symbol can be drawn in any position

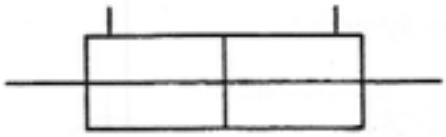


711L8P



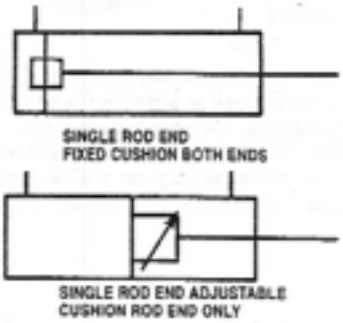
711L8Q

If the cylinder is single acting there is only one port shown on the symbol The port is shown on the end of the cylinder that receives pressurized fluid and the opposite end of the cylinder is left open A double acting cylinder symbol has both ends closed and has two ports on the symbol



712L8A

A double rod end cylinder has a rod extending from each end of the rectangle



749L8E 750L8E

Some cylinders have cushions built into them The cushion slows down the movement of the piston as it nears the end of its stroke Cylinder cushions are shown as a smaller rectangle on the piston If the cushion has an adjustable orifice, a slanted arrow is drawn at 45 degrees across the symbol

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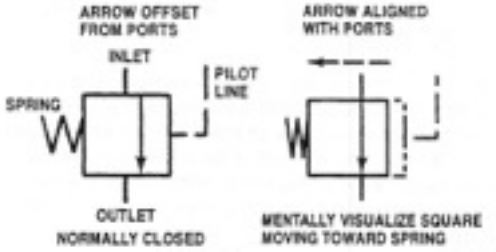
Pressure Control Symbols

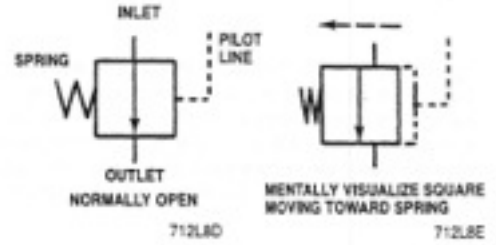
The basic symbol is a square (which is called an envelope) with external port connections and an arrow inside to show the oil passage and direction of flow. Usually this type of valve operates by balancing the oil pressure against a spring, so a spring is shown on one side of the symbol and a pilot pressure line on the other side.

Normally Closed



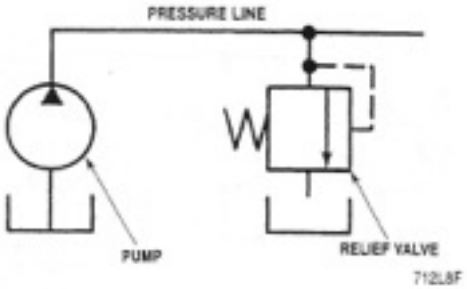
A normally closed valve, such as a relief or sequence valve, is shown with the arrow offset from the ports and toward the pilot pressure line side of the square. The spring holds the valve closed until the pilot line oil pressure is greater than the spring pressure. Mentally visualize a build up of pressure in the pilot line and the square moving over, compressing the spring. The oil can now flow through the valve.

Normally Open



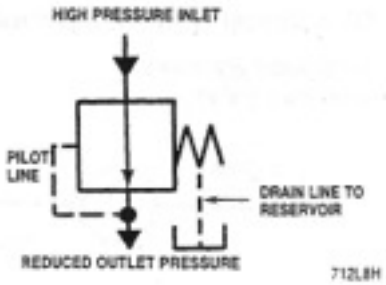
A normally open valve is shown with the arrow connecting the two ports. It closes when pressure overcomes spring force. Mentally visualize a build up of pressure in the pilot line and the square moving over, compressing the spring. The oil flow through the valve is now blocked.

Relief Valve



A relief valve is shown as a normally closed symbol connected between the pressure line and the reservoir. The flow direction arrow points away from the pressure line port and toward the reservoir. This shows very graphically how a relief valve operates. When pressure in the system overcomes the valve spring, flow is from the pressure line through the relief valve to the reservoir.

Pressure Reducing Valve



A pressure reducing valve is shown as a normally open symbol in a pressure line. This valve works opposite of a relief valve, since it senses outlet pressure versus inlet pressure. As the outlet pressure builds, it works against a predetermined spring force. As the spring force is overcome, flow through the valve is modulated or shut off.

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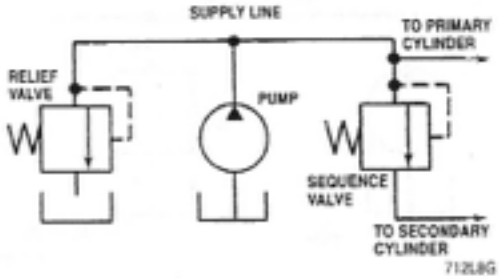
Sequence Valve

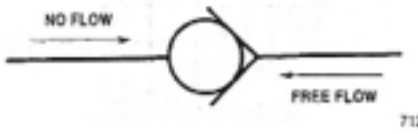


The normally closed symbol is also used for a sequence valve The inlet port is connected to a primary cylinder and the outlet port to the secondary cylinder line When the piston in the primary cylinder reaches the end of its stroke, the pressure in the supply line increases The sequence valve is also connected to the supply line and also feels the increase in pressure As pressure increases, the square and directional flow arrow moves over, connecting the inlet and outlet ports allowing fluid to flow to the secondary cylinder

Directional Control Symbols

Simplified Symbols

One Way Valve



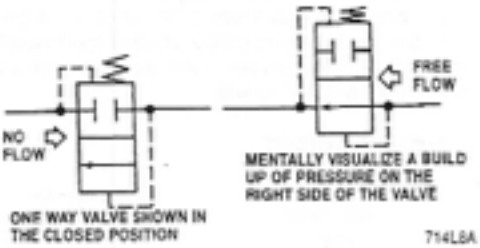
A simple ball check valve is shown When oil pressure is exerted on the left side of the ball, the ball is forced into the V and no oil can flow past it When oil pressure is applied to the right side of the ball, the ball moves away from the V and oil can flow past it

By Pass Valve

A by pass valve is shown as a one way valve with a spring on the ball end of the symbol This shows that a pressurized flow will be necessary to overcome the spring force and allow flow around the ball

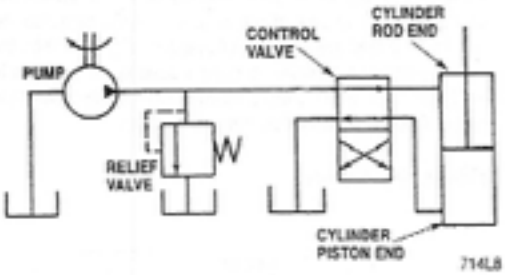
Composite Symbols

One Way Valves

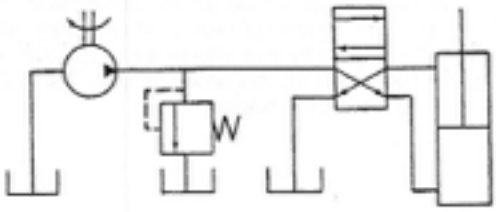


A more complex one way valve is now shown This directional control symbol uses a multiple envelope (square) system that has a separate square for each position Remember all of the port connections are made to the envelope that shows the neutral condition of the valve Within each envelope are arrows showing the flow paths when the valve is shifted to that position

Two Position Valves



A simple control valve has two envelopes (representing the spool) if it is a two position valve The envelopes show the flow conditions when they are in one position The above schematic is showing that oil is being supplied to the rod end of the cylinder If we mentally visualize the directional control valve moved to the other position, it would be as shown below



Here, pressurized oil is being supplied to the piston end of the cylinder and oil from the rod end of the cylinder is allowed to flow to the reservoir

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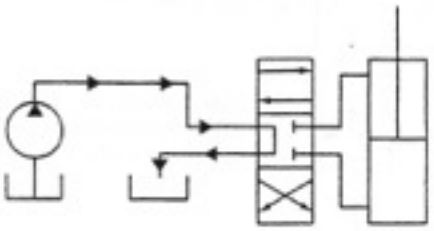
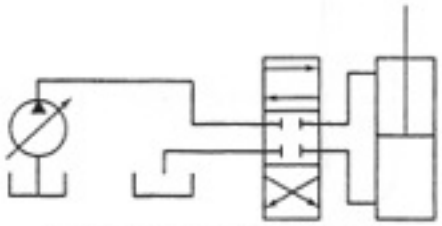
Three Position Valves



OPEN CENTER THREE POSITION VALVE

713L8A



CLOSED CENTER THREE POSITION VALVE

713L8B

Three position valves will have a centered (neutral) position The centered position can be either open or closed to flow The open center is usually used with a fixed displacement pump and the closed center is usually used with a variable displacement pump

Actuating Controls

LEVER

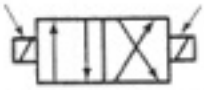
713L8G

PEDAL

713L8F

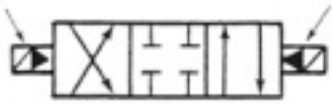
TWO POSITION, CONTROLLED BY EXTERNAL PILOT PRESSURE

713L8D



TWO POSITION, CONTROLLED BY SOLENOIDS

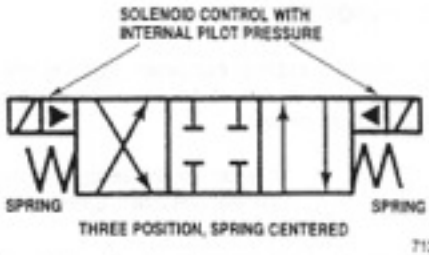
713L8E



THREE POSITION, SOLENOID CONTROLLED WITH INTERNAL PILOT ASSIST PRESSURE

713L8D

Valve spools are controlled by levers, pedals, pilot oil, electric solenoids, etc , which are called actuating controls These actuating controls are shown by symbols placed on the ends of the envelopes



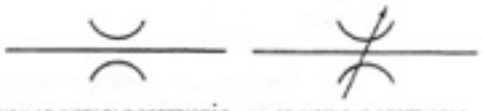
THREE POSITION, SPRING CENTERED

713L8C

To show that a valve is spring centered, a spring symbol is placed at each end of the envelope The above schematic shows that an electrical solenoid and pilot pressure assist are required to overcome spring force to move the valve spool

Flow Control Symbols

Restrictors



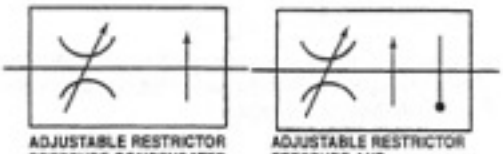
NON ADJUSTABLE RESTRICTOR

716L8A

ADJUSTABLE RESTRICTOR

716L8E

The basic flow control symbol is a representation of a restrictor If the restrictor is adjustable, a slanted arrow is drawn across the symbol The restrictor could be a special fitting with a small hole in it or a small drilled passageway within a valve If it is an adjustable restriction, it could be thought of as a water faucet that can be controlled by turning the handle to regulate the flow Restrictors can be applied to meter out, meter in and bleed off circuits



ADJUSTABLE RESTRICTOR PRESSURE COMPENSATED

716L8C

ADJUSTABLE RESTRICTOR PRESSURE AND TEMPERATURE COMPENSATED

716L8D

There are adjustable restrictors that are pressure compensated That means that the size of the opening in the restrictor will change with increases and decreases in pressure A perpendicular arrow indicates pressure compensation If the restrictor has both pressure and temperature compensation, the symbol for a thermometer will also be shown

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8000-10

Accessories

Filters, strainers and heat exchangers are represented as squares that are turned 45 degrees and have the port connection at the corners

A dotted line perpendicular to the flow line indicates a filter or strainer

FILTER OR STRAINER

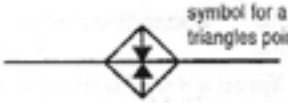
716L8E

A solid line perpendicular to the flow with black triangles pointing out indicates a cooler

COOLER

716L8F

The symbol for a heater is like the symbol for a cooler, except the black triangles point in



HEATER

731L8G

Two sets of triangles pointing in and out indicates a temperature control unit

TEMPERATURE CONTROL UNIT

731L8H

As you can see, the black triangles point in the direction that the heat is dissipated Or in the case of the control unit, they show that the heat can be regulated

An oval with details inside indicate an accumulator The details inside will tell you what type of accumulator it is, spring loaded, gas charged, or other features

The divider line indicates there is a separator between the charge and the oil A hollow triangle indicates gas

GAS CHARGED

716L8G

A spring shows that the accumulator is spring loaded

SPRING LOADED

716L8H

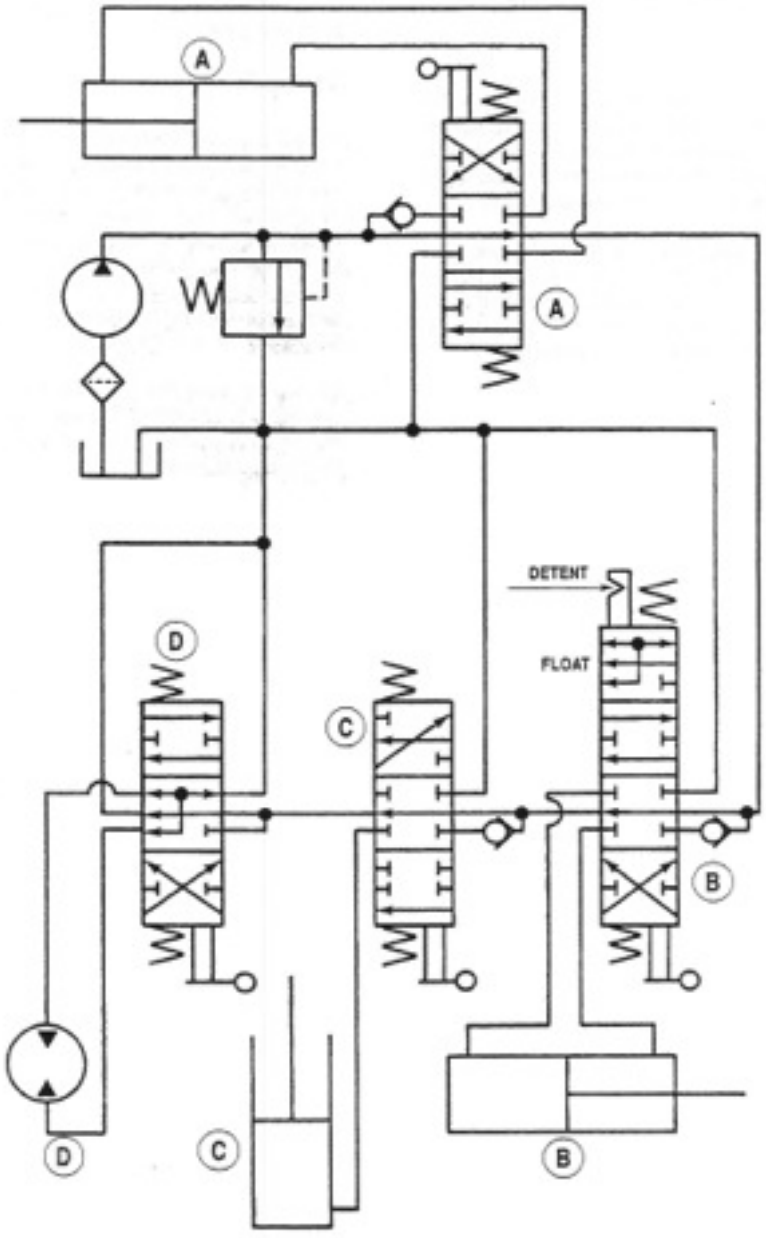
Rec 8-94372

Revised 11-96 Printed in U S A

8000-12

SIMPLE SCHEMATIC

Now that you have completed hydraulic symbols, we have put some of the symbols together to form a simple hydraulic schematic See if you can find your way around the schematic without reading the text for each valve The text explains the function of each valve in the hydraulic system



715L8

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Valve A

This valve is a three position valve The spool is lever operated and spring centered It is an open center valve Visually place the envelopes into the center position and you will see that the valve will direct oil into one end or the other of cylinder A When the spool in valve A is moved out of the centered position, the valves downstream will receive no oil

Valve B

Valve B is similar to valve A but it is a four position valve The fourth position is a float position and is held into that position with a detent With this valve the cylinder B can be extend, retracted, or placed in the float position Visualizes the envelope for the float position in the inlet passageway

You will see that oil can continue to flow to the next valve downstream and that the rod in cylinder B could be pushed back and forth The oil could move from one end of the cylinder to the other via the valve Both ends of the cylinder are also connected to the return line to the reservoir

Valve C

This valve is also similar to valve A but is designed to control a single acting cylinder When you visualize placing the upper envelope in the center position you will see that oil can drain back to the reservoir from cylinder C

At the same time, oil from the pump can flow through valve C to the next valve

Valve D

Valve D is a lever operated, spring centered valve and is designed to control a hydraulic motor If a hydraulic motor was turning a flywheel and the oil supply and return were shut off abruptly, this would cause damage to the hydraulic lines, the motor, or whatever it was powering Therefore when the valve supplying the motor is shut off, the motor should be able to slow down gradually The center (neutral) position of valve D will allow that to happen by letting oil from the outlet of the motor return to the inlet side

As you have seen, this brief information is all you need to read hydraulic schematics The more you use it, the more you will be comfortable using hydraulic schematics as a troubleshooting guide

Rac 8-94372 Revised 11-96 Printed in U S A

8000-14

COMMON SYMBOLS

Lines and Line Functions


710L8H

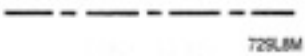
SOLID LINE
MAIN LINE

711L8A

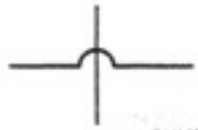
DASHED LINE
PILOT LINE


711L8B

DOTTED LINE
EXHAUST OR DRAIN


729L8M

ENCLOSURE OUTLINE

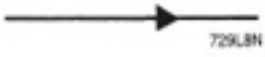

711L8E

LINES CROSSING

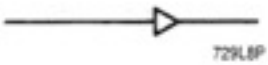

710L8M


710L8P

LINES JOINING


729L8N

LIQUID DIRECTION
OF FLOW


729L8P

GASEOUS DIRECTION
OF FLOW


711L8C

FLEXIBLE LINE

Mechanical Devices


730L8G

MECHANICAL CONNECTIONS
TWO PARALLEL LINES
(SHAFTS, LEVERS, ECT)


730L8H

VARIABLE COMPONENT (RUN ARROW
THROUGH SYMBOL AT 45 DEGREES


730L8J

SPRING

Pumps and Motors


729L8D

HYDRAULIC PUMP
FIXED DISPLACEMENT


729L8E

HYDRAULIC PUMP
VARIABLE DISPLACEMENT


729L8F

PRESSURE COMPENSATED
VARIABLE DISPLACEMENT PUMP


711L8K

FIXED DISPLACEMENT
HYDRAULIC PUMP
(TWO DIRECTIONAL FLOW)

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HYDRAULIC MOTOR
FIXED DISPLACEMENT

HYDRAULIC MOTOR
VARIABLE DISPLACEMENT

HYDRAULIC OSCILLATOR

Reservoirs

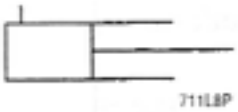
RESERVOIR
OPEN TO ATMOSPERER

PRESSURIZED RESERVOIR

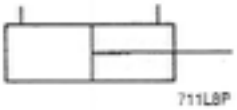
LINE TO RESERVOIR
BELOW FLUID LEVEL

LINE TO RESERVOIR
ABOVE FLUID LEVEL

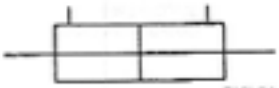
Cylinders



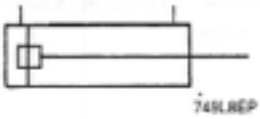
SINGLE ACTING



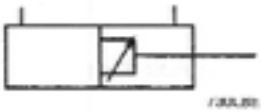
DOUBLE ACTING
SINGLE ROD END



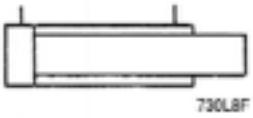
DOUBLE ACTING
DOUBLE ROD END



SINGLE ROD END
FIXED CUSHION BOTH ENDS

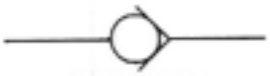


SINGLE ROD END
ADJUSTABLE CUSHION
ROD END ONLY

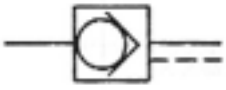


DIFFERENTIAL CYLINDER

Valves



CHECK VALVE



PILOT OPERATED CHECK

ON - OFF
MANUAL SHUT OFF

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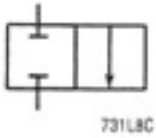
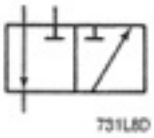
8000-16

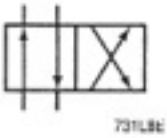
REGULATING OR SELECTOR VALVES



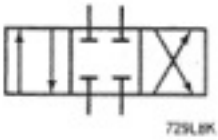
2 POSITION - 2 WAY VALVE



2 POSITION - 3 WAY VALVE



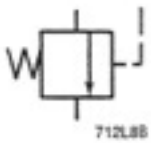
2 POSITION - 4 WAY VALVE



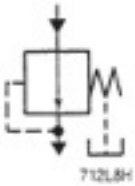
3 POSITION - 4 WAY VALVE

2 POSITION - 4 WAY OPEN CENTER CROSS OVER

VALVE CAPABLE OF INFINITE POSITIONING (INDICATED BY HORIZONTAL LINES DRAWN PARALLEL TO THE ENVELOPE)

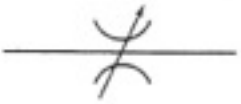


PRESSURE RELIEF VALVE

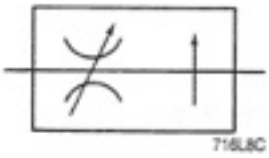


PRESSURE REDUCING VALVE

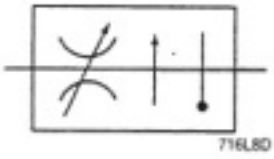
NON - ADJUSTABLE RESTRICTOR



ADJUSTABLE RESTRICTOR



ADJUSTABLE RESTRICTOR PRESSURE COMPENSATED



ADJUSTABLE RESTRICTOR (TEMPERATURE AND PRESSURE COMPENSATED)

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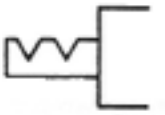
Valve Actuators


G731L8L

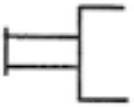
SOLENOID


729L8

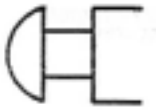
DETENT


730L8J

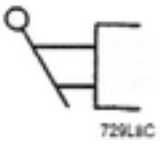
SPRING


729L8A

MANUAL



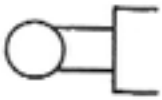
PUSH BUTTON


729L8C

PUSH PULL LEVER


713L8F

PEDAL


729L8G

MECHANICAL


729L8H

PRESSURE COMPENSATED


731L8F

PILOT PRESSURE
REMOTE SUPPLY


731L8M

LIQUID SUPPLY

Accessories


716L8E

FILTER


716L8F

COOLER


731L8G

HEATER


731L8H

TEMPERATURE
CONTROLLER


716L8G

ACCUMULATOR
HYDRO - PNEUMATIC

Rac 8-94372

Revised 11-96 Printed in U S A

8000-18

730L8K

REVERSING MOTOR

730L8L

STATION OR TEST POINT

730L8M

PRESSURE INDICATOR

730L8N

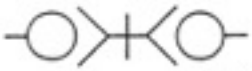
TEMPERATURE INDICATOR

730L8P

PRESSURE SWITCH

731L8J

QUICK DISCONNECTS (DISCONNECTED)



731L8K

QUICK DISCONNECTS (CONNECTED)

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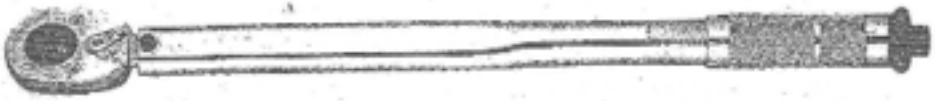
ADJUSTMENT OF TORQUE SETTING



HOW TO USE YOUR NEW TORQUE WRENCH.

A. Balancing wrench in left hand with graduations visible unlock knurled handle by turning lock nut counter-clockwise See Fig 1

B. Set amount of torque required by turning knurled handle to read exact amount on case graduations:

Example 86 ft. lbs.

1. Turn knurled handle until the zero graduation on the beveled edge of the knurled handle is lined up with the vertical mark on the case, and is even with the 80 ft.lbs graduation.
2. Turn knurled handle clockwise. until the 6 ft.lbs graduation on the beveled edge of the handle is in line with the vertical line on the case.
3. Lock handle securely by turning lock nut clock-wise. wrench is now set at 86 ft.lbs torque and is ready to use See fig. 2.

C. When setting for metric (KpM), use same procedures as setting for ft.-lb.

D. Install the proper socket or attachment to the square drive and apply to nut or bolt and pull handle until you feel and/or hear wrench click. Release pull and wrench automatically resets for next operation.

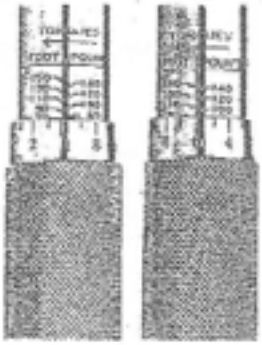
DO NOT CONTINUE TO PULL AFTER WRENCH RELEASES. USE SPECIAL CARE AT LOW TORQUE SETTINGS THAT PULL STOPS WHEN WRENCH CLICKS.

CAUTION:

1. If wrench has not been used or has been in storage for some time, operate it several times at a low torque setting which permits special internal lubricant to recoat internal working parts.
2. When wrench is not in use, keep adjustment at lowest torque setting.
3. Do not turn handle below lowest torque setting.
4. Do not continue pulling on the wrench after pre-set torque has been reached and the wrench has released. Pressure must be taken off the handle and the wrench allowed to automatically reset itself, continuing to apply pressure after the wrench has released, will result in damage to the part being torqued by applying more than the specified amount of torque.
5. Tool is rugged and designed for shop use, but is also a precision measuring instrument and should be treated as such.
6. Clean wrench by wiping: Do not immerse in any type of cleaner which may affect special high pressure lube with which the wrench is packed at the factory.
7. This torque wrench was calibrated and tested before leaving the factory and is accurate to ± 4%. THIS IS A PRECISION MEASURING INSTRUMENT CALIBRATION AND SERVICING MUST BE DONE REGULARLY AND IS THE OWNERS RESPONSIBILITY.

Fig. 1

Fig. 2



STURTEVANT RICHMONT
TORQUE MEASUREMENT SYSTEMS
DIVISION OF RYESON CORPORATION

OPERATING INSTRUCTIONS

Micrometer Adjustable Torque Wrench Series
SDR, SD, & CCM Series

Sturtevant Richmont torque wrenches are designed & manufactured to meet or exceed ASME B107.14, GGG-W-686 & ISO 6789. This series of wrenches are accurate to + or - 4% of indicated reading in the 20 to 100% range.

This tool operates and indicates torque in one direction only as indicated by the arrow on the case (Figure 1) . The wrench can be used in the reverse direction to loosen bolts provided you do not exceed the rated capacity of the wrench.

The case (Figure 1) is engraved with graduations (main scale) and the aluminum grip with increments (minor scale). The sum of these two numbers equals the desired torque value. One complete revolution of the rubber grip is equal to one graduation on the case (main scale).

To set desired torque, rotate the grip lock in the unlock direction until resistance is felt (Figure 2), grasp the head of the wrench with one hand and with the other, **rotate** rubber grip **CW** to increase torque & **CCW** to decrease torque. Lock the grip lock and recheck to confirm proper setting.

Affix the appropriate attachment and place on fastener. Grip the center of the handle and with a steady slow force pull in the direction of the arrow on the case. Wrench must be kept level and perpendicular to the work. Continue to pull the wrench until the operator hears or feels a click. **Stop pulling immediately** to prevent over torquing the application.

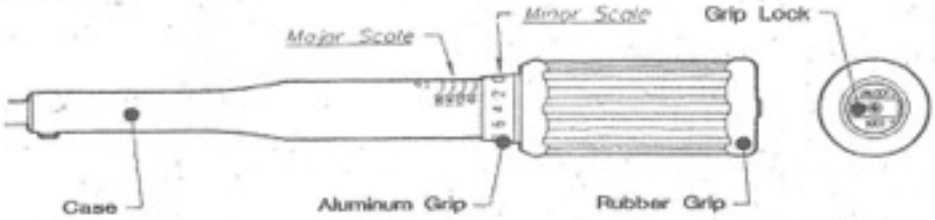


Figure 1

Figure 2

CARE & CLEANING

When the wrench is not used for any length of time it should be stored with settings set at the lowest value and in a clean dry environment. **Do Not** immerse wrench in any type cleaning fluids.

REPAIR PARTS, SERVICE & CERTIFICATION

Repair parts can be ordered from your local distributor. For the name of a distributor in your area contact the factory. See information on reverse side.

Repair and Certification, traceable to N.I.S.T., of **Sturtevant Richmont** product is available at the factory by sending to the address on the reverse side.

USE OF EXTENSIONS & ADAPTERS

When using an extension or adapter (increasing the effective length of the torque wrench) the output torque value will change. To calculate the new output of the wrench use the following formula:

$$Ta = \frac{Tw \times (L + A)}{L}$$

Ta = Torque exserted @ end of adapter
L = Lever length of wrench
Tw = Wrench scale reading
A = Length of adapter or extension

A number of variables including the length of the adapter or extension, length of the wrench and variations in hand position on the wrench will affect the accuracy of the above calculation.

CAUTION

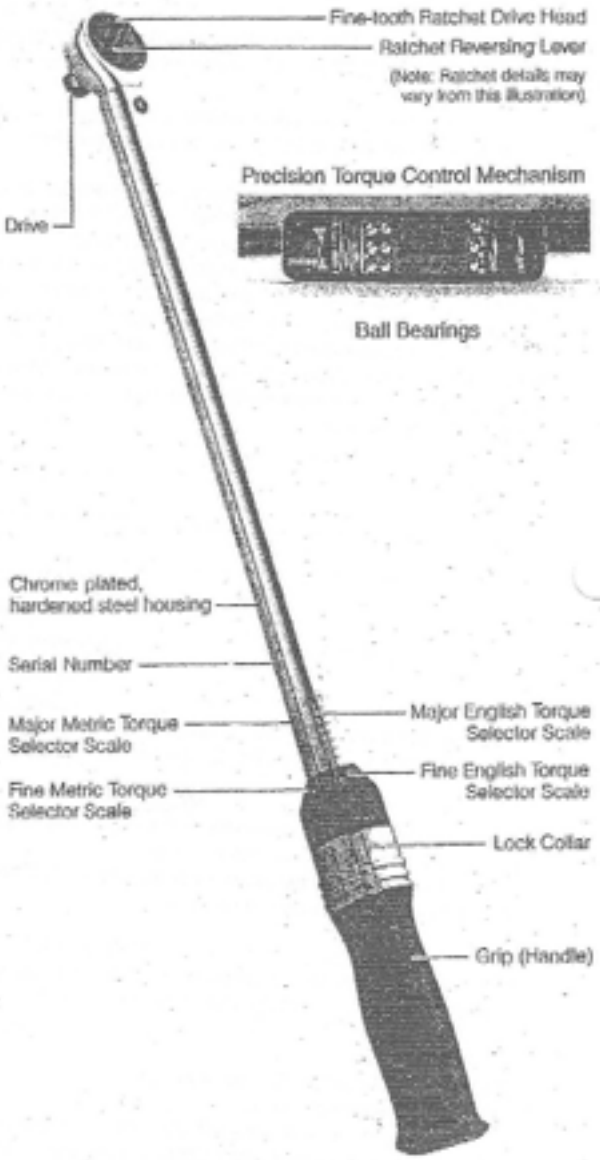
-Safety glasses should be worn when using any hand tool.
-Be sure attachment end is properly engaged and seated on the fastener.
-Cheater bars should never be used to increase the leverage.
-**Do Not** exceed the rated torque.
-**Do Not** use torque wrench as a hammer.
-Wrench should be re-calibrated periodically to maintain its accuracy.

MICRO-ADJUSTING TORQUE WRENCH

OPERATING INSTRUCTIONS

1. STUDY THIS BOOKLET CAREFULLY BEFORE ATTEMPTING TO OPERATE THIS WRENCH.
2. NEVER APPLY MORE TORQUE THAN THE MAXIMUM SCALE READING.
3. This Torque Wrench is designed for manual tightening of threaded fasteners only. DO NOT USE IT AS A NUT-BREAKER OR FOR ANY OTHER PURPOSE.
4. Overtorqued or defective fasteners and sockets may suddenly break. Ratchets or plain drives that are improperly engaged, worn out, damaged, or overtorqued may slip or break. TO PREVENT INJURY, KEEP PROPER FOOTING AND BALANCE AT ALL TIMES. DO NOT USE THE WRENCH IN PLACES FROM WHICH YOU MAY FALL OR SLIP, OR AROUND ROTATING MACHINERY.
5. This wrench will not prevent you from applying more torque than set — it is not a torque limiting tool. Learn how different amounts of torque "feel," so you will reduce the possibility of damage and/or injury due to accidental overtorquing.
6. APPLY FORCE TO THE GRIP ONLY. DO NOT USE "CHEATER BARS" (A piece of pipe placed over the hand grip).
7. There are no user-serviceable components inside the wrench. Disassembling the wrench or making any adjustments will result in the loss of accuracy, and will void the warranty.

SK Hand Tool Corporation
Chicago, Illinois 60632-9969



Note: Above illustration applies to all models except ¾" drive and plain (non-ratchet) drive.

GENERAL DESCRIPTION

The Micrometer Adjusting Torque Wrench indicates when the preset torque value has been reached by releasing the handle for a few degrees of free travel. This release or "give" is usually accompanied by an audible "click" signal and tells the operator to stop applying pressure.

On all models except ¾" drive, the torque is adjusted by unlocking and turning the grip. The amount of torque is shown on two separate micrometer scales — one in English units, and the other in Metric units.

On ¾" drive models, the torque is adjusted by pulling back, and turning the adjusting knob. The amount of torque is shown directly in one of the two viewing windows — one for English settings, the other for Metric.

The wrench is equipped with a reversible ratchet head or a plain (non-ratcheting) head and may be used in both right and left hand directions. The drive head accommodates sockets, extensions, crowfoot adapters, and other attachments to fit a multitude of fasteners in automotive, aircraft, marine, industrial, and other applications, both English and Metric.

The internal torque control mechanism is mounted on ball bearings and represents an improvement over the slide-cam arrangement employed in other makes of torque wrenches. Because of inconsistency and unreliability of lubrication of the slide-cam, other makes are often plagued by excessive accuracy variations between slow and fast loading, by short calibration life, and by the necessity of "breaking" the wrench in after storage to assure proper accuracy. The ball bearings help to reduce these problems thus giving you a torque wrench which is more accurate, more consistent, and which stays in calibration longer than other torque wrenches.

The wrench housing is made from precision drawn steel which is heat treated for hardness and strength, polished, and chrome plated for corrosion protection and superior appearance. On ½" and smaller drive size models molded plastic grip is contoured to fit comfortably and securely into the hand.

TO SET TORQUE — ALL MODELS EXCEPT ¾" DRIVE

1. Pull the lock collar back to unlock the mechanism.
2. While holding the lock collar in an unlocked position, turn the grip clockwise to increase the torque, and counterclockwise to decrease the torque. Keep turning until the desired torque reading is indicated on the micrometer scale.
3. Lock the setting by releasing the lock collar.

EXAMPLES OF TORQUE SETTINGS*

English Scales

40 In.-Lbs.
(250 In.-Lbs. Wrench)

231 Ft.-Lbs.
(250 Ft.-Lbs. Wrench)

126 Ft.-Lbs.
(150 Ft.-Lbs. Wrench)

31.5 Ft.-Lbs.
(100 Ft.-Lbs. Wrench)

Metric Scales**

20.95 N-m
(250 In.-Lbs. Wrench)

78.7 N-m
(250 Ft.-Lbs. Wrench)

*Various models and capacities of wrenches are illustrated. Though they might be different from your particular wrench, the principle of obtaining scale reading is the same.

**By necessity, metric scales are not calibrated in even numbers. Consequently, when using Metric scales, set the wrench at a reading closest to the desired torque.

TO APPLY TORQUE

1. Attach the proper socket or other attachment to the drive. Set the reversing lever for the proper direction of operation.

2. Insert the socket or attachment onto the fastener to be torc
3. Utilizing the ratcheting head, you may "spindown" the faste until resistance is felt (ratchet head models only).
4. Holding the wrench BY THE GRIP ONLY,* apply SLOW, AND STEADY pull until a momentary release impulse is felt. Release tightening pressure right at this moment.

*When using long sockets or concentric extensions, the wrench may be supported at the head (only at the head!) with only negligible effects on accuracy.

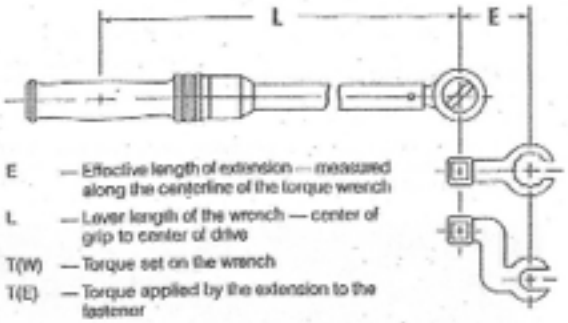
5. The wrench resets automatically and is ready for the next operation.

IMPORTANT SUGGESTIONS

1. Threads on bolts, nuts and other mating components should be clean and smooth. A lubricant applied to the threads and under the head of bolts will produce more accurate and consistent results.
2. Never torque a fastener that is already tightened. Loosen it first, then re-torque to the desired value. The same applies to fasteners that were accidentally overtorqued.
3. When tightening many fasteners holding one component (er head, pipe flanges, etc.) follow manufacturer's recommend procedures. If such procedures are not available, torque in a criss-cross manner first 60-70% of the desired torque, then to the final torque.
4. DO NOT apply more torque than the rated capacity of the torque wrench. Do not use it as a nut-breaker!!

ATTACHMENTS

At times, it is impossible or impractical to use regular sockets, (a good example being the tightening of threaded tubing connectors), and a special attachment must be utilized. Such attachments change the calibration of the torque wrench, and it is necessary to calculate the correct torque settings using the following formulas.



E — Effective length of extension — measured along the centerline of the torque wrench

L — Lever length of the wrench — center of grip to center of drive

T(W) — Torque set on the wrench

T(E) — Torque applied by the extension to the fastener

$$T(W) = T(E)\frac{L}{L+E} \qquad T(E) = T(W)\frac{L+E}{L}$$

NOTE:

1. Regular (concentric) socket extensions which extend directly under the drive head along the axis of the drive do not affect the calibration of the Torque Wrench.
2. Handle extensions (a piece of pipe put onto the wrench in order to make torqueing easier) SHOULD NOT BE USED under any circumstances. Their use will result in erroneous torque readings, and may damage the grip or the adjusting mechanism. While applying torque, the wrench should be held ONLY BY THE GRIP. At high torque readings, if both hands are necessary to apply enough pressure to operate the wrench, hold the grip in one hand, and put the other hand on the top of the first hand, never on the wrench body (on ¾" drive models there is enough grip area to accommodate both hands).

CARE AND MAINTENANCE

1. A Torque Wrench is a precision instrument and should be handled and stored with care. Do not throw it around, hammer with it, or use it as a prybar.
2. The wrench is lubricated for life and should not be oiled. The only exception is the ratchet head which may be lubricated as needed for smooth operation.
3. The plastic grip is not affected by petroleum products, but may be damaged by certain industrial solvents. It may be cleaned with a clean cloth wetted in mineral spirits or denatured alcohol. *NEVER IMMERSE THE WRENCH OR ANY PORTION OF IT IN ANY LIQUID!*
4. All torque wrenches should be periodically checked for accuracy. This should always be done after the wrench is subjected to abnormal handling or storage.

GENERAL TORQUE SPECIFICATION CHART FOR ENGLISH FASTENERS (in Foot Pounds)*

MATERIAL OR GRADE / BOLT SIZE	SAE 2 (Mild Steel)	SAE 5	SAE 8	SOCKET HEAD CAP SCREWS	BRASS	Stainless AISI TYPE 303
1/4-28	7	13	15	16	6	7
5/16-24	14	23	30	33	9	10
3/8-24	20	40	00	60	16	18
7/16-20	41	60	95	95	25	28
1/2-20	64	95	140	145	34	40
9/16-18	91	140	195	210	48	54
5/8-18	128	210	270	290	73	80
3/4-16	200	330	460	445	115	125
7/8-14	300	490	700	615	170	185
1"-14	435	715	1050	880	250	270

GENERAL TORQUE SPECIFICATION CHART FOR METRIC FASTENERS (in Newton Meters)*

MATERIAL CLASS / BOLT DIAM MM	BOLT DIAM INCH	4.6	4.8	5.8	8.8	9.8	10.9	12.9
6	.236	5	6	8	12.5	14	17	20
8	.315	12	16	20	30	34	44	50
12	.472	40	56	70	103	120	150	180
16	.630	100	140	170	270	290	380	440
20	.787	200	—	330	520	—	740	860

TORQUE UNITS CONVERSIONS

TO OBTAIN / MULTIPLY NUMBER OF	Inch Ounces	Inch Pounds	Foot Pounds	Meter Kilo-grams	Newton Meters
Inch Pounds	.0625[1]	1	12	86.80	8.851
Meter Kilogram[3]	.0007201	.01152	.1383	1	.1020

[1]or divide by 16
[2]or divide by 12
[3]Meter Kilogram (mkg) is also known as Meter Kilopond (mkp)