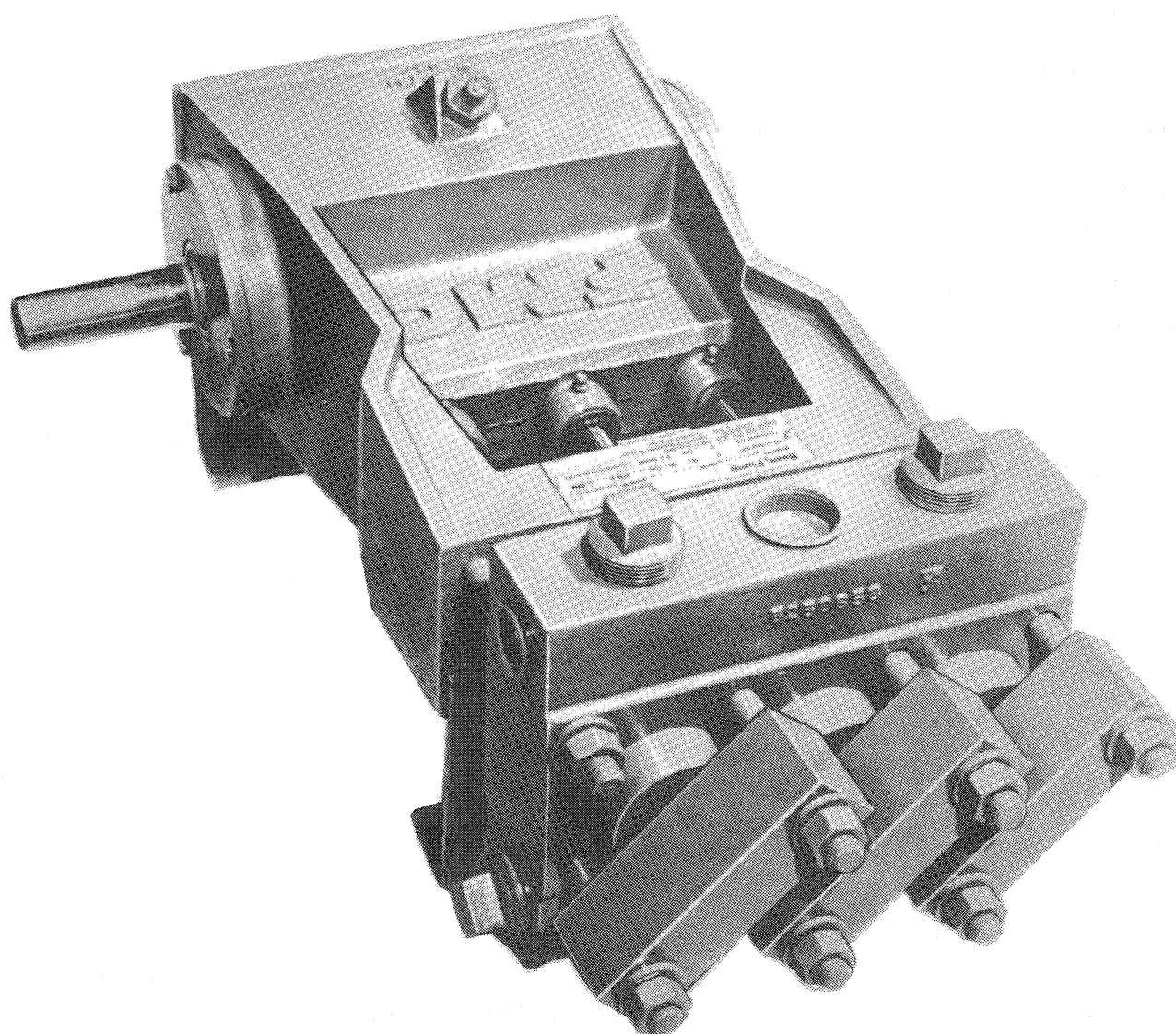


Owners Manual

Model M06 Industrial Pump



Warnings and Safety Instructions

FMC cannot anticipate all of the situations a user may encounter while installing and using FMC products. Therefore, the user of FMC products **MUST** know and follow all applicable industry specifications on the safe installation and use of these products. Refer to FMC product catalogues, product brochures and installation, operating and maintenance manuals for additional product safety information or contact FMC at 800/772-8582.



WARNING: FAILURE TO FOLLOW THESE WARNINGS COULD RESULT IN SERIOUS INJURY OR DEATH!

1. Do not mix or assemble components, parts or end connections with different pressure ratings. Mismatched parts may fail under pressure.
2. Do not use or substitute non FMC components or parts in FMC products and assemblies.
3. Do not strike, tighten or loosen pressurized components or connections.
4. Do not exceed the rated working pressure of the product.
5. Complete and proper make-up of components and connections is required to attain rated working pressure.
6. Do not use severely worn, eroded or corroded products. Contact FMC for more information on how to identify the limits of erosion and corrosion.
7. Follow safe practices when using products in overhead applications. Products not properly secured could fall.
8. Select only appropriate product and materials for the intended service:
 - Do not expose standard service products to sour gas fluids. (Refer to NACE MR0175). Do not interchange sour gas with standard service components.
 - Use appropriate safety precautions when working with ferrous products in below freezing temperatures. Freezing temperatures lower the impact strength of ferrous materials.
9. Follow manufacturers instructions and Material Safety Data Sheet directions when using solvents.
10. Make certain that personnel and facilities are protected from residual hazardous fluids before disassembly of any product.
11. If any leakage is detected from FMC products, remove them from service immediately to prevent potential damage and personal injury.

SAFETY INSTRUCTIONS: The applications of FMC products are in working environments where general personnel safety procedures and policies **MUST** be followed. Always use appropriate protective equipment in high pressure, extreme temperature or severe service applications.

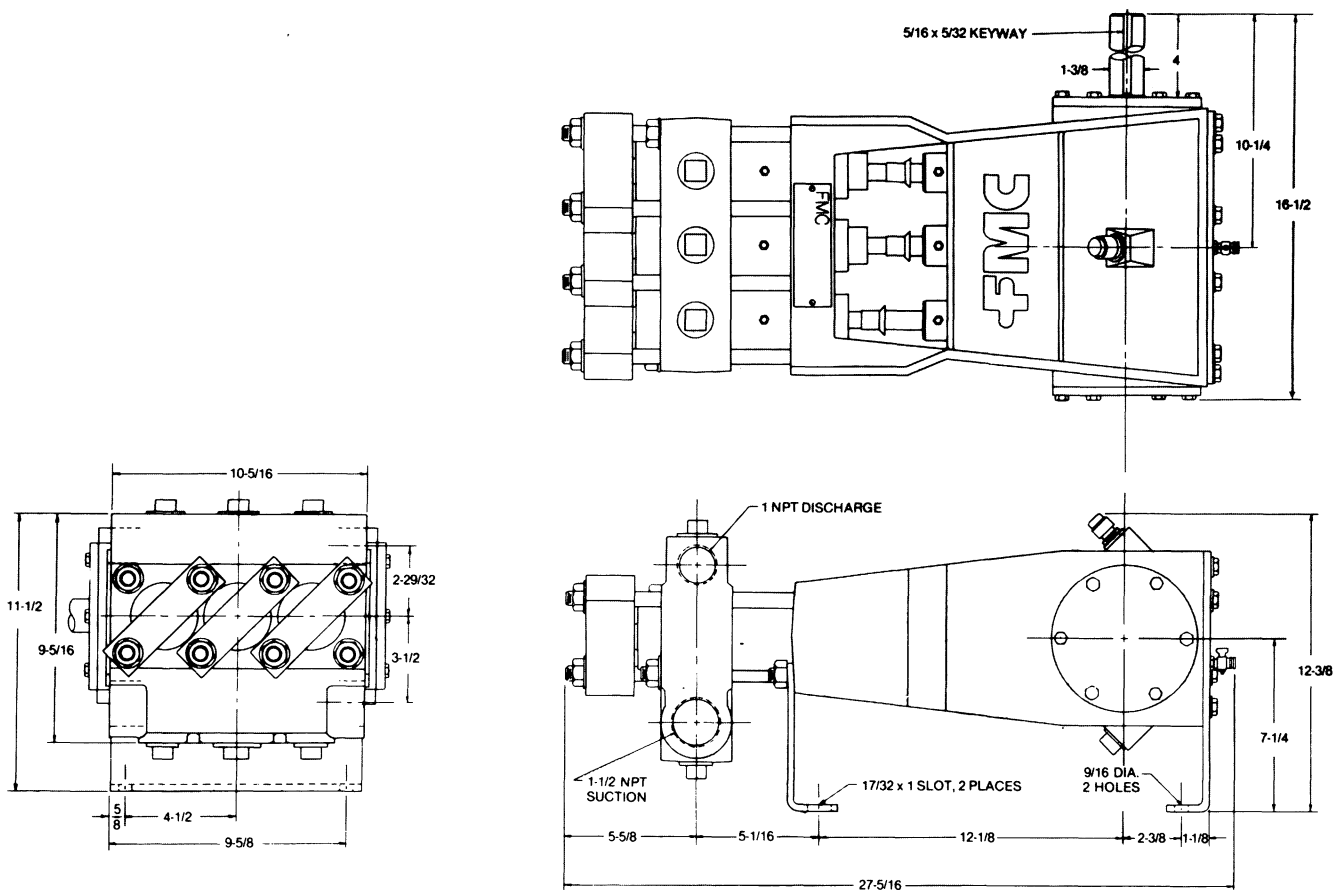
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To Our Customer

We at FMC would like to express our appreciation in your decision to use one of our industrial pumps. This pump was designed by experienced engineers and built by skilled workmen to provide you with quality equipment.

FMC stands behind all its products. The warranty on your pump is printed on the back of the Delivery Report. Be sure your dealer has you sign a Delivery Report and supplies you with a copy.



English

Metric

	M0606	M0608	M0610	M0612	M0615	M0606	M0608	M0610	M0612	M0615
No. of cyl.	3	3	3	3	3	3	3	3	3	3
Bore, cyl.	3/4"	1"	1 1/4"	1 1/2"	1 7/8"	19.1mm	25.4mm	31.8mm	38.1mm	
Stroke	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	38.1mm	38.1mm	38.1mm	38.1mm	38.1mm
Capacity	GPM	GPM	GPM	GPM	GPM	LPM	LPM	LPM	LPM	LPM
Min.	.8	1.5	2.4	3.4	5.4	3.0	5.7	9.1	12.9	20.4
Max.	5.1	9.2	14.3	20.6	32.2	19.3	34.8	54.1	78.1	121.9
Discharge pressure	PSI	PSI	PSI	PSI	PSI	KPA	KPA	KPA	KPA	KPA
Cont.	5000	3400	2200	1500		34500	23400	15000	10300	
Input Shaft										
RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM
Min.	100	100	100	100	100	100	100	100	100	100
Max.	600	600	600	600	600	600	600	600	600	600
Shaft diam.	1-3/8"	1-3/8"	1-3/8"	1-3/8"	1-3/8"	34.9mm	34.9mm	34.9mm	34.9mm	34.9mm
Crankcase cap	2 qt.	2 qt.	2 qt.	2 qt.	2 qt.	1.9L	1.9L	1.9L	1.9L	1.9L
Lubrication oil		S.	A.	E.		30				
Inlet opening diameter	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT	1 1/2 NPT
Outlet opening diameter	1 NPT	1 NPT	1 NPT	1 NPT	1 NPT	1 NPT	1 NPT	1 NPT	1 NPT	1 NPT
Max. fluid Temperature	*190°F	*190°F	*190°F	*190°F	*190°F	*88°C	*88°C	*88°C	*88°C	*88°C
Dimensions	inches	inches	inches	inches	inches	M.M.	M.M.	M.M.	M.M.	M.M.
Height	12-3/8	12-3/8	12-3/8	12-3/8	12-3/8	314.3	314.3	314.3	314.3	314.3
Width	16 1/2	16 1/2	16 1/2	16 1/2	16 1/2	419	419	419	419	419
Length	27-1/8	27-1/8	27-1/8	27-1/8	27-1/8	689	689	689	689	689
Weight	245 lbs.	245 lbs.	245 lbs.	245 lbs.	245 lbs.	111 kg	111 kg	111 kg	111 kg	111 kg

*Higher temperatures can be handled with the stainless steel plungers and packings.

Section B

Specifications

Description

The M06 is a horizontal plunger (or outside packed) style pump. This style pump pulls fluid into the pump when the plunger makes a return stroke and the intake valve is open. Then when the plunger moves forward, the discharge valve opens, and releases the fluid. The M06 is a triplex (three plunger) reciprocating pump designed to handle high pressures.

Standard Equipment

Fluid End - Ductile iron constructed valve chamber with hardened stainless steel valves. Duck and Nitrile "V" ring plunger packings in stainless steel stuffing boxes. Model M0608 and M0612 are available with aluminum bronze fluid end.

Drive End - Cast iron, oil bath crankcase, ductile iron connecting rods with split cap design and shell type bearing inserts, cylindrical design cast iron crossheads with stainless steel crosshead rods and alumina ceramic plungers, and ductile iron crankshaft.

Section C

Installation Procedures

Storing Before Installation

Your FMC pump will come to you prepared for any necessary storage periods before installation.

Selecting Pump Location

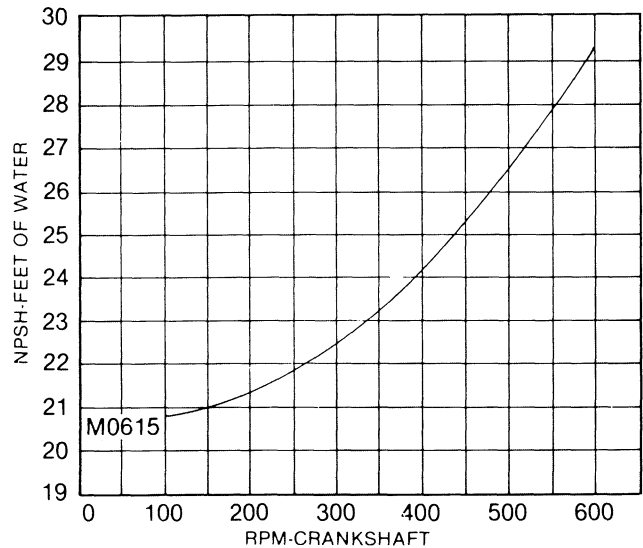
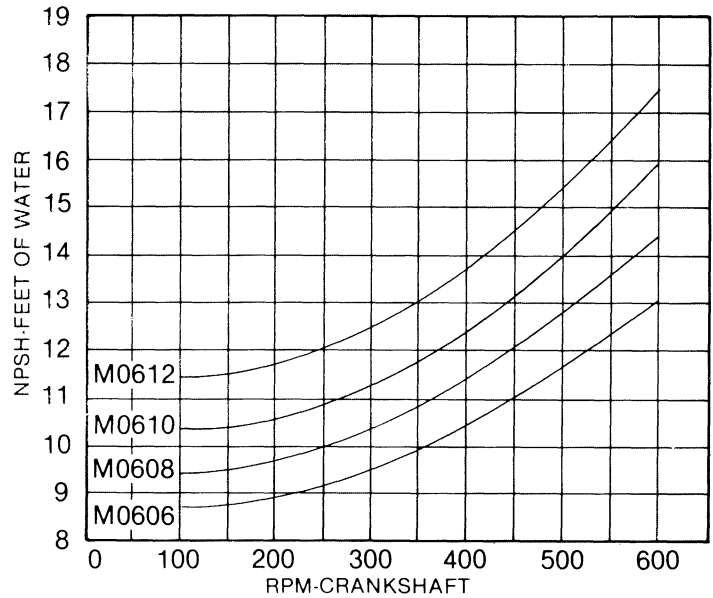
Always locate the pump as close to the source of supply as possible. The pump should also be located in a light, clean, dry space where adequate inspection and maintenance operations can be performed.

Securing Pump to Foundation

Step	Procedure
1	Locate the pump so the power will turn the top of the pump sheave toward the fluid end of the pump. NOTE: Fluid can be pumped satisfactorily regardless of the direction of rotation. However, friction and wear on internal components will be reduced by using the recommended rotation.
2	Align the power source drive sheave and pump sheave. To check the alignment, use a straight edge, square or rule. Place the straight edge against the sides of the sheaves to be sure they are in line and running exactly parallel to each other. NOTE: Proper alignment of the drive sheaves is very important to prevent excessive pump bearing and V-belt wear.
3	Mount the pump on either a concrete or rigid metal-base using the mounting supplied with the pump and 1/2" bolts. (Use shims, to level the pump if necessary, to prevent straining the pump case.)
4	Secure the pump to maintain alignment and to prevent vibration.

Installing the Pump Suction Line

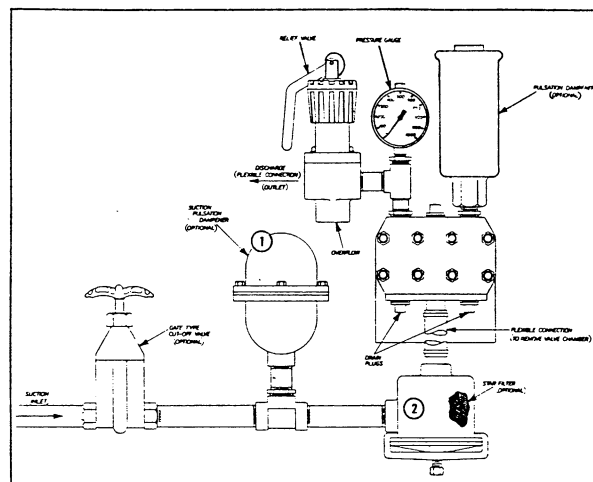
Step	Procedure
1	Determine the shortest most direct route possible for the suction hose.
2	Make a preliminary design of suction piping. Remember the line should be as large, direct, and short as possible.
<p>NOTE: Line must be laid out so there are no high spots to cause air pockets. Any air pockets in the line could make priming the pump difficult or impossible.</p>	
3	<p>Analyze the Net Positive Suction Head that would be available in your preliminary design. The NPSHA (Net Positive Suction Head Available) is a characteristic of your pumping system determined by:</p> <ol style="list-style-type: none"> The elevation of the suction supply in relation to the pump suction port (static head) <p>NOTE: Static head is (+) plus when liquid is above the pump's center line, and (-) minus when liquid is below (or suction lift).</p> <ol style="list-style-type: none"> Altitude of the installation above sea level (atmospheric head) Friction in suction line (friction loss) Liquid vapor pressure (p) Amount of suction head required to accelerate fluid in the suction pipe to prevent cavitation (acceleration head) <p>NOTE: $NPSHA = \pm \text{static head} + \text{atmos. head} - \text{friction loss} - \text{acceleration head} - VP$</p>
4	Compare available NPSH with required NPSH for your pump at your particular RPM requirements.
<p>NOTE: There must be at least two additional feet of NPSHA over the required NPSH to compensate for variations in atmospheric pressure and other similar variables.</p>	
5	After determining the correct suction line for your required needs install the line. The suction line should be supported independently of the pump. Install a union as close to the pump as possible, to allow for easy removal of the valve chamber during servicing.
<p>NOTE: It is advisable to use a flexible connection such as a hose between the hard pipe and pump suction opening to isolate vibrations.</p> <p>NOTE: Be sure all parts are free of dirt, scale, burrs, or other foreign material which might interfere with pump operation.</p>	



Installing the Pump Suction Line - Con't.

Step	Procedure
6	Install a foot valve when there is suction lift. The foot valve should be installed in the suction line near the fluid source. The foot valve will keep the lines to the pump filled and avoid the necessity of priming at each start.
7	If the supply of liquid is delivered from a pressurized line or through rigid pipe, it is advisable to install a suction line air chamber close to the pump inlet (1) to reduce the possibility of water hammer. On pressurized suction lines an accumulator should be used and pre-charged to 2/3 of the maximum anticipated suction pressure.
8	Install drain plugs or drain cocks in low points of suction lines.
NOTE: This is highly important where temperature conditions are below freezing.	
9	Install inline strainer (2) in the suction line to remove particles that could damage internal pump components.
NOTE: Use only full opening gate valves for minimizing flow restriction.	
10	Make sure all joints are air tight.
NOTE: Air leaks reduce pump capacity and cause cavitation.	

NOTE: Use a double suction arrangement when applying the M0615 Pump.



1 air chamber
2 inline strainer

Installing Pump Discharge Lines

Step	Procedure
1	Determine the shortest most direct route for the discharge line.
2	Determine the length of hose or pipe required and determine the size of the hose or pipe by considering pressure loss per foot of hose required.
3	Select weight of pipe required to meet pressure requirements from adjacent chart. Hose ratings are clearly marked on outer surface of hose.

NOTE: Working pressure of hose should not exceed 1/4 of bursting pressure.

Warning

Always use hose or pipe that is designed for your particular pressure requirements. Inadequate hose could burst resulting in possible personal injuries and equipment damage.

4 Install pipe or hose to pump.

NOTE: It is advisable to use a flexible connection between the pump and the rigid pipe (if used) and the discharge opening to isolate vibrations and to allow for easier service.

NOTE: Be sure all parts are free of dirt, scale, burns, or other foreign material which might interfere with pump operation.

5 Install the pressure gauge onto the discharge chamber. The pressure gauge will indicate the fluid pressure so that pressure can be adjusted to the proper level.(1)

6 Install the relief valve onto the discharge chamber.(2)

7 Install the relief valve by-pass. If the fluid is drawn from a tank, the relief valve by-pass should be returned to the tank. The flow may be returned to the suction line (when other means of return are not possible) if it is returned into the line as far as possible from the pump to reduce the possibility of turbulence and cavitation in the suction line.

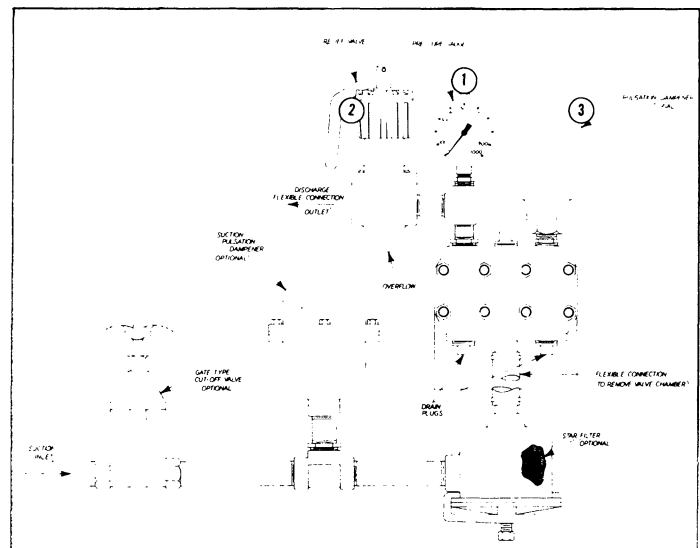
NOTE: The relief valve by-pass line must be as large as the pipe outlet in the relief valve. Never install valves in the bypass line or between the pump and relief valve.

Optional 8	A pop-off valve may be used in the discharge line to limit the pressure. However, provisions should be made to detect leakage past the valve.
Optional 9	A discharge pulsation dampener may be installed to absorb pulsations, pounding and prevent water hammer. It should be installed very near the pump. Bladder type pulsation dampners should be pre-charted to approximately 2/3 of the maximum anticipated pump pressure.

Pipe pressure chart

Pounds per square inch
For cold water, minor shock conditions
Working Pressures

Pipe Size	Seamless Steel Pipe ASTM A120				Butt Welded Pipe ASTM A120			
	Std. Wt. Sch 40	Extra Heavy Sch 160	Heavy	Double Extra Sch 40	Std. Wt. Sch 80	Extra Heavy Sch 160	Heavy	Double Extra
1/2	1650	3000	4500	8480	1000	1800	2700	5100
3/4	1370	2460	4300	6980	820	1480	2590	4200
1	1220	2190	3780	6340	730	1320	2280	3818
1-1/4	1040	1850	2850	5230	630	1120	1720	3148
1-1/2	900	1650	2830	4680	540	990	1700	2800
2	800	1480	2900	4030	480	890	1750	2430
2-1/2	800	1450	2380	4160	480	870	1430	2500



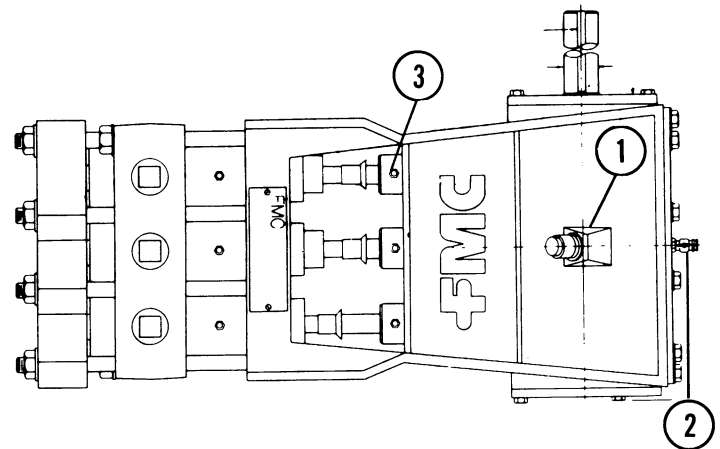
- 1 pressure gauge
- 2 relief valve
- 3 pulsation dampener

Section D

Operation

Check Points Before Starting - Always make the following checks before starting the pump.

Step	Procedure
1	Make sure the magnetic drain plug in the bottom of the pump case is tight.
2	Check the oil by means of the filler cap(1) if necessary add a good grade of SAE 30 non-detergent oil.
NOTE: The oil should come up to the petcock (2) on the back of the drive end.	
3	Inspect the entire pump installation to make sure all the joints are tight.
4	Apply grease to the 3 grease fittings (3) and regrease every 100 hours or once a week.
NOTE: Grease with a good grade of water resistant grease. (Refer to Lubrication Procedures.)	



- 1 filler cap
- 2 petcock
- 3 grease fittings

HORSEPOWER CURVES MODEL M06

Selecting Operating Speeds

The capacity (gallage) in a positive displacement pump, such as the M06 is determined by the RPM of the crankshaft.

To achieve the proper capacity desired, select the capacity on the chart then go up and find the RPM required to produce that gallage.

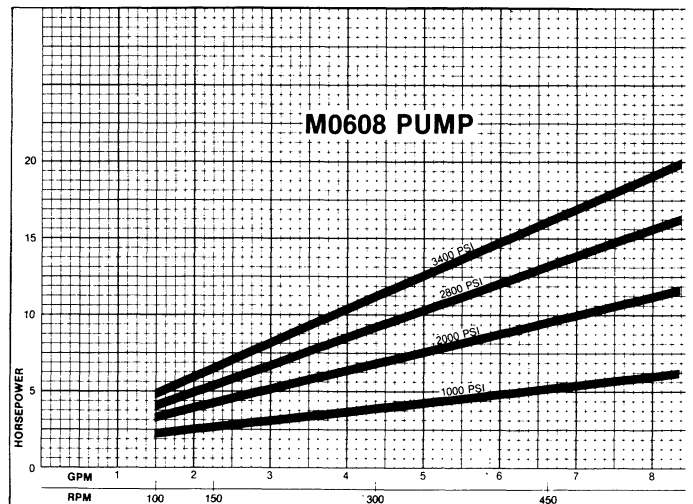
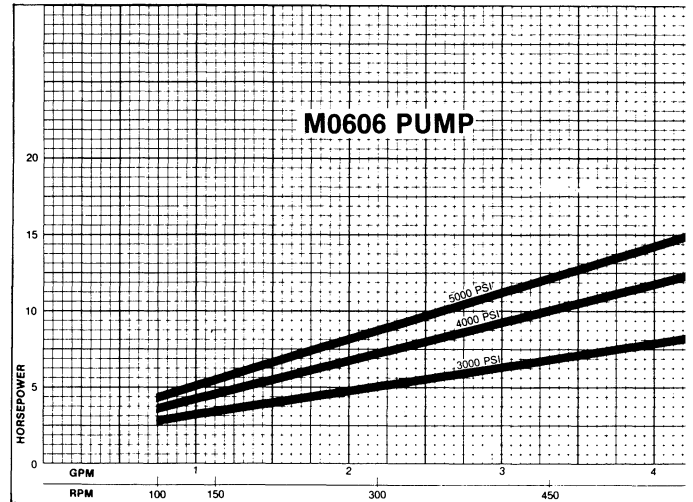
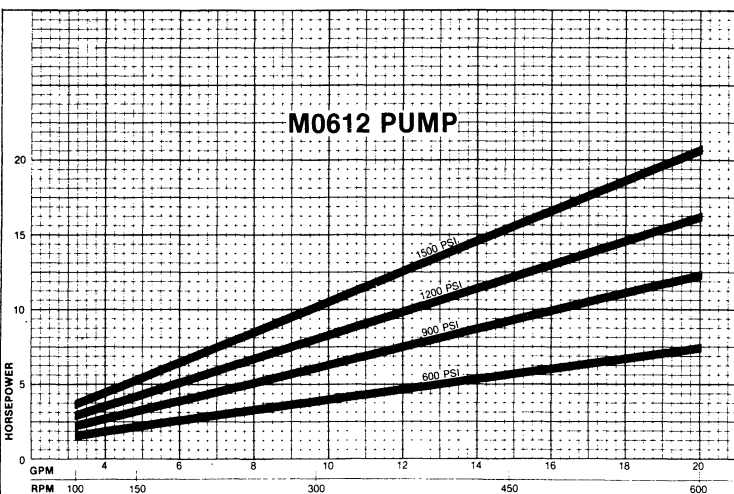
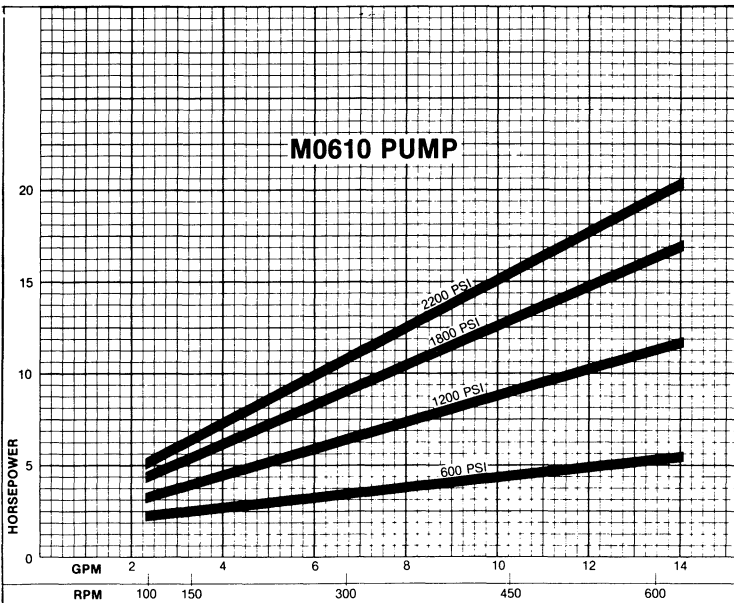
Selecting Operating Procedures

The pressure can be adjusted to the required value by adjusting the relief valve nut.

Caution

Do not run the pump beyond the rated pressure or the maximum rated RPM. Exceeding the pump ratings will result in reduced pump life and could cause damage to the motor and piping.

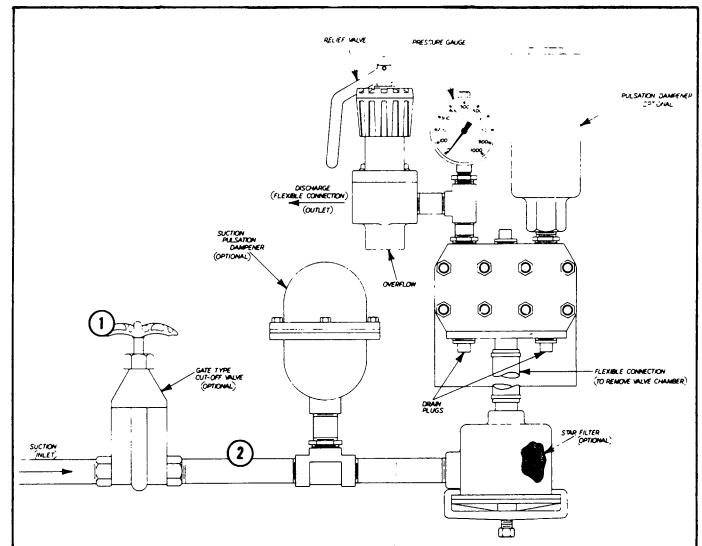
To determine the proper horsepower required to run at a specific pressure producing the required gallage refer to the chart.



Starting the Pump - The following procedures should be followed when starting the pump for operation.

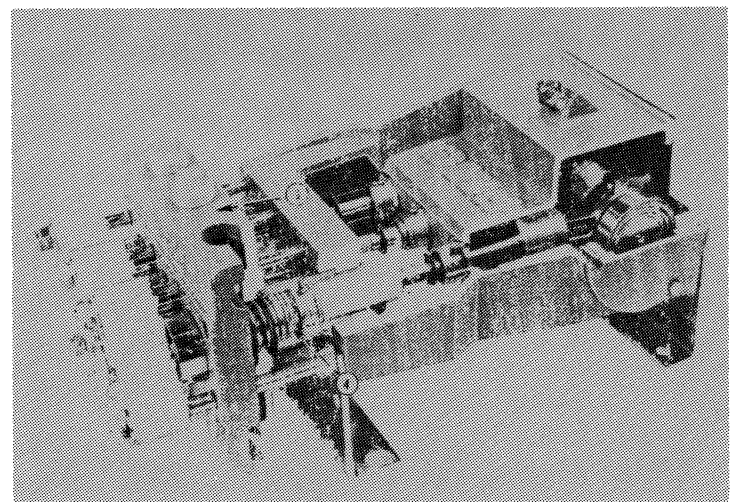
Step	Procedure
1	Open the gate valve in the suction line. (1) NOTE: The gate valve must remain fully open during operation of the pump.
2	Check to assure power is off.
3	Turn the pump over by hand to make sure the crankshaft is free.
WARNING Never try to turn the pump over when the power is on. Service personnel could be entangled in moving sheaves.	
4	Fill the suction line with fluid, if necessary to prime pump. (2)
5	Start the pump, and for a few seconds listen for erratic noise or for unsteady flow which indicates the pump is not primed. NOTE: Never run the pump over 30 seconds not primed. If flow is not continuous (pulsing) shut the pump off and prime.

Step	Procedure
7	If pump continues not to prime check the plunger packing (4) to see if there is excessive leakage through the packing. Should the packing be leaking 15 to 20 drops per minute shut the pump off and replace the packing. (Refer to Service, Section F)



Priming the Pump - The following procedures should be followed for priming the pump.

Step	Procedure
1	Fill the suction line and filter.
2	Remove the accumulator or the pressure gauge by unscrewing.
3	Fill the discharge portion of the valve chamber with fluid. (3)
4	Jog the pump until the fluid is pumped from the discharge ports in a steady, even flow.
5	Reinstall the accumulator or pressure gauge.
6	Start the pump and listen for unsteady flow or erratic noises. If unsteady flow persists repeat steps 1-6 until pump is properly primed.

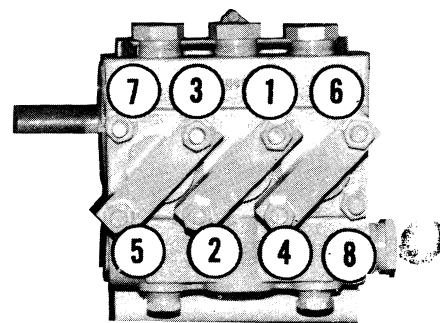
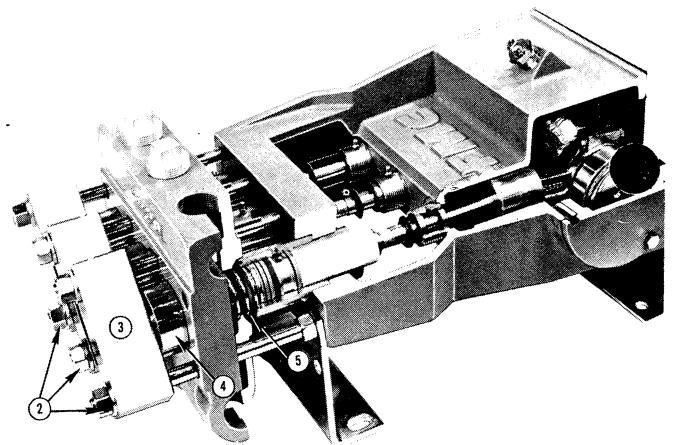
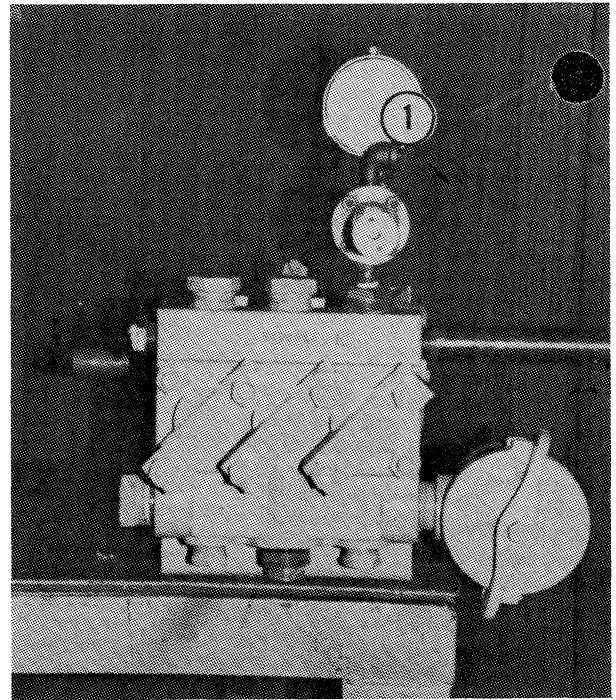


- 1 gate valve
- 2 suction line
- 3 discharge portion of valve chamber
- 4 plunger packings

Shutdown Procedures During Freezing Temperatures

The following procedures should be followed when stopping or storing the pump during freezing weather.

Step	Procedure
1	Let the pump pump air for a few seconds with the discharge outlet and suction line open. This will flush the valves and discharge lines.
2	Shut the pump off.
3	Relieve pressure on the relief valve by turning the nut on top of the valve counterclockwise.(1)
	Warning
	Failure to do this could cause fluid to shoot out when discharge manifold is removed and fluid could possibly splash in operator's eyes.
4	Remove the eight hex nuts (2) and three cover clamps (3).
5	Slide the valve covers (4) off and remove the packing springs.(5)
6	Slide the valve chamber away from the pump. Turn the chamber so any fluid inside will run out.
7	Drain all trapped fluid from inside the valve chamber by lifting the suction valves with the end of a pencil or screw driver.
8	Replace the valve chamber, valve covers, and cover clamps.
NOTE: FMC recommends lubricating bolts before replacing nuts.	
9	Replace the eight and torque in the sequence shown first to between 38 ft. lbs. to 40 ft. lbs. (52 to 54 N.M.) then to 77 ft. lbs. to 80 ft. lbs. (104 to 125 N.M) then repeat torquing sequence torquing bolts to between 115 to 120 ft. lbs. (156 to 163 N.M.)
10	If drain plug is used under relief valve remove plug.
11	Remove drain plugs in all low points of piping.
12	Leave all cut offs open.



- 1 relief valve
- 2 hex nuts
- 3 cover clamps
- 4 valve covers
- 5 packing springs

Section E Maintenance Procedures

Lubrication

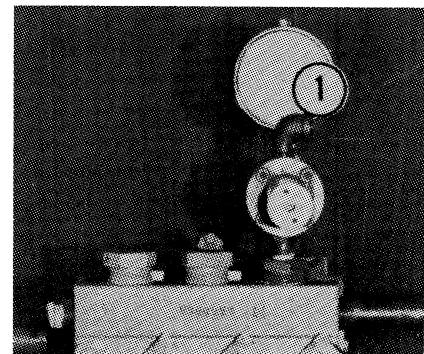
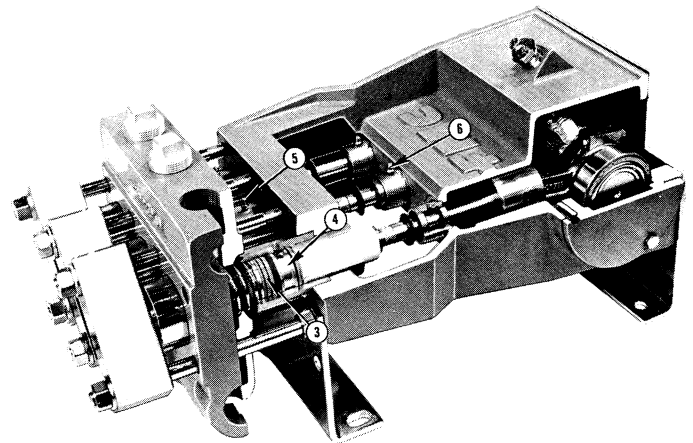
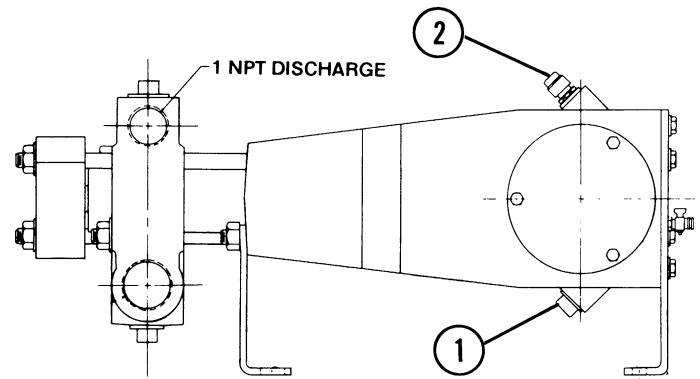
This triplex plunger (or outside packed) pump requires 2 quarts (2 liters) of Grade SAE 30 lubricant in the crankcase. After the first 50 hours of operation drain the oil from the crankcase and remove any metal adhering to the magnetic drain plug. Thereafter, at the end of each 750 hours of operation the oil must be drained and the drain plug(1) should be cleaned of any metal adhering to it. Should oil have a milky appearance, this indicates water is leaking past plunger rod seals into the pump. The plunger rod seals should be checked and replaced if necessary. After draining all oil replace the drain plug and add the oil through the oil fill opening.(2)

Another area of the pump requiring lubrication is the packings.(3) The packings are lubricated by means of a lantern gland(4) and grease fittings(5). The lantern gland allows for direct lubrication of the plunger packings. The lantern gland is kept filled with grease by means of the grease fittings. The grease fittings should be given a couple of shots of grease once a week to insure proper lubrication of the lantern glands. There are also three grease fittings on the plunger oil seal holders which require greasing once a week.(6)

Caution

Do not over grease fittings to the plunger oil seal holders or damage could occur to oil seals in holder.

A filter should be installed in the suction line to prevent contaminating material from entering the pump and reducing its life and efficiency. During the initial break-in period, the pump filter screen should be inspected frequently. The amount of material trapped in the filter during these inspections will indicate how often the filter screen should be checked and a regular inspection schedule should be developed from this information.



Periodic Maintenance Chart

Components	Description of Service	Remarks
------------	------------------------	---------

Break-in Period

Crankcase	Drain oil from crankcase by removing plug. Clean any metal adhering to plug before replacing. Refill pump case with new oil.	After the first 50 hours of operation.
Pump Filter Screen	Should be inspected frequently to determine a regular inspection schedule.	The amount of material collected in the filter with each check will indicate how often the filter should be inspected.

Components	Description of Service	Remarks
------------	------------------------	---------

Daily

Complete Pump	General inspection of pump in operation to determine if it is functioning properly.	This inspection should take place once each shift of operation.
Plunger Rod Oil Seals	Inspect plunger rod oil seals for leakage.	Leaking at the rate of one or two drops per minute indicates the need for replacing the oil seals (refer to Servicing Oil Seals, page F-9.)
Packing (Plunger)	Inspect packings for leakage.	Excessive dripping at this point indicates worn plunger packing. Adjust or replace as necessary. (Refer to Replacing Plunger Packings, page F-3.)
Pump System	Use water or a suitable solvent and flush the entire system.	For overnight shutdown when using materials that might harden or corrode the pump. Drain all water from pump chambers and piping when freezing temperatures are anticipated.

Periodic Maintenance Chart - Con't.

Components	Description of Service	Remarks
------------	------------------------	---------

Weekly

Crankcase NOTE: Do not over-fill, oil will run out oil fill opening when too full Grease fittings	Check oil level in crankcase by opening the petcock on the end of the pump. Add grease to fittings	With pump stopped oil level with petcock opening indicates proper oil level. Once a week using a good grade water resistant grease.
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Components	Description of Service	Remarks
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Every 750 Hours
(equals 1 month of continuous use)

Crankcase	Change oil and clean magnetic plug.	SAE 30 grade (non-detergent)
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Long Term Storage

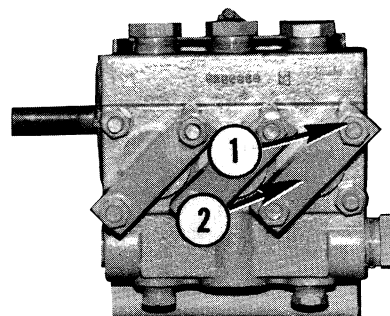
Pump System	Drain Pump (Refer to page D-3, Storing Pump During Freezing Weather.)	During freezing temperatures.
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Section F Service

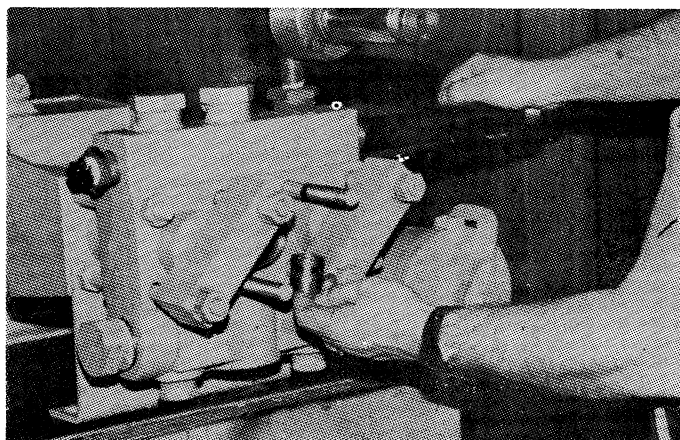
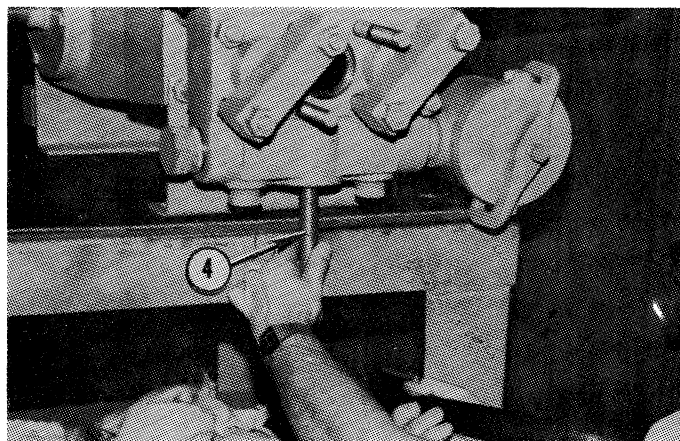
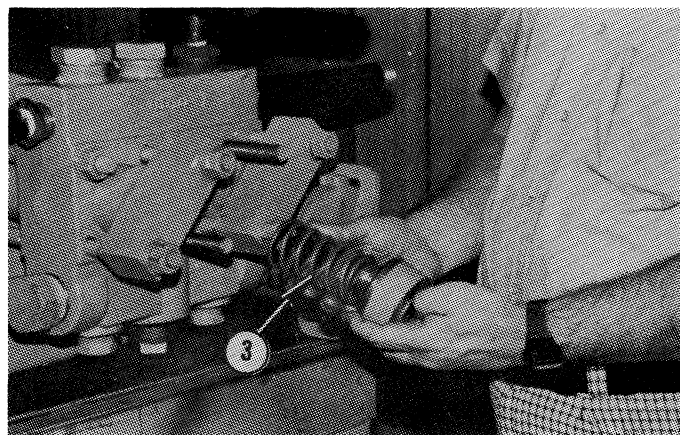
In this section we will cover how to service the pump. The first portion will cover step-by-step procedures for servicing the different areas of the pump. Then at the end of this section you will find a quick reference troubleshooting chart.

Servicing the Fluid End

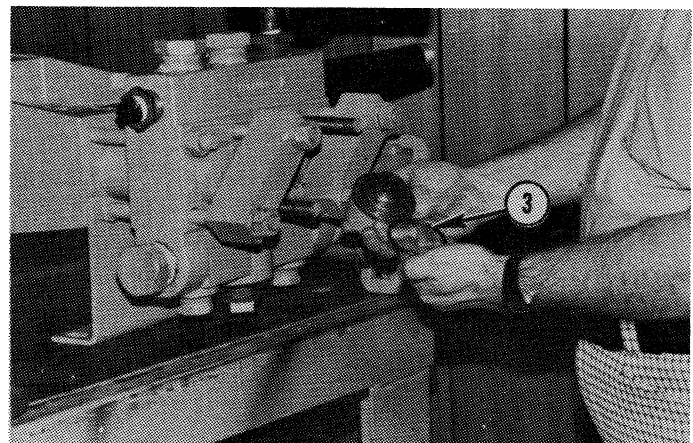
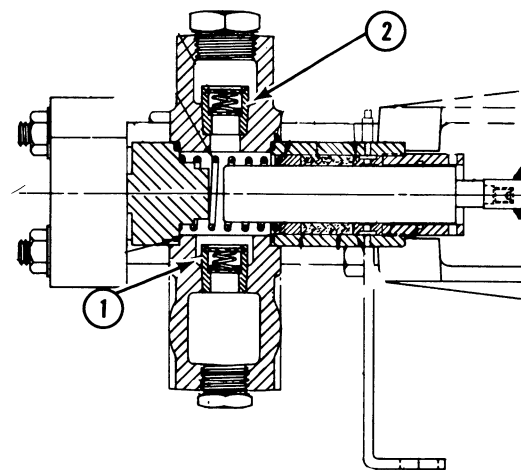
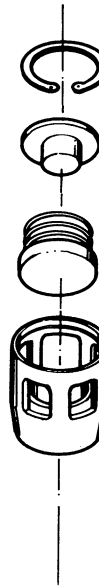
Servicing the Valves - Malfunctioning valves are identified by a uniform hammering or vibration and by reduced pump capacity (volumetric efficiency).



Steps	Procedures
<p>WARNING Always disconnect pump from power source before performing any service to the pump. Failure to do this could cause electrical shock or injury from moving pump parts.</p>	
1	Remove all plugs in discharge or suction inlets.
2	Remove the six nuts on the studs.(1)
3	Slide the three cover clamps off the studs.(2)
4	Slide the three valve covers from the valve chamber and the three packing springs. (3)
5	Rotate the shaft so one plunger is on the complete down stroke.
6	Place a blunt rod against the suction valve seat and by using a hammer, drive the suction valve seats loose.(4)
7	Remove the valve through valve cover opening.
8	Remove all three suction valves in the same manner.
9	Insert the blunt tool through the opening for the suction valves and position against the discharge valve seat.
10	Using the hammer, drive the discharge valve out the chamber discharge opening.
11	Repeat until all discharge valves are removed.



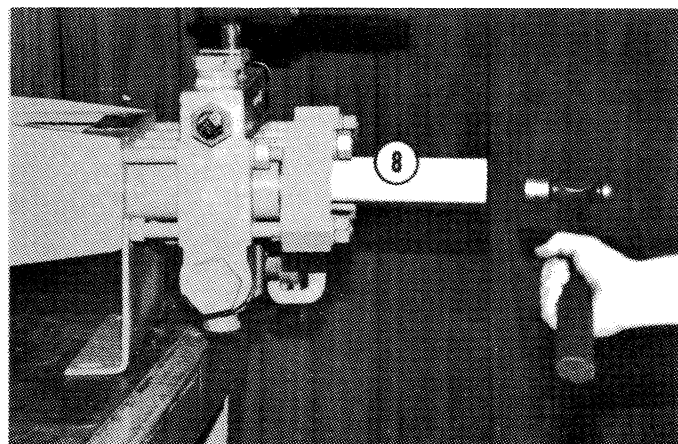
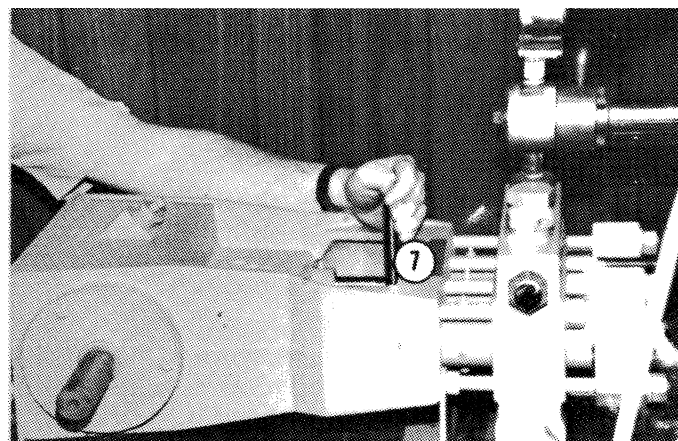
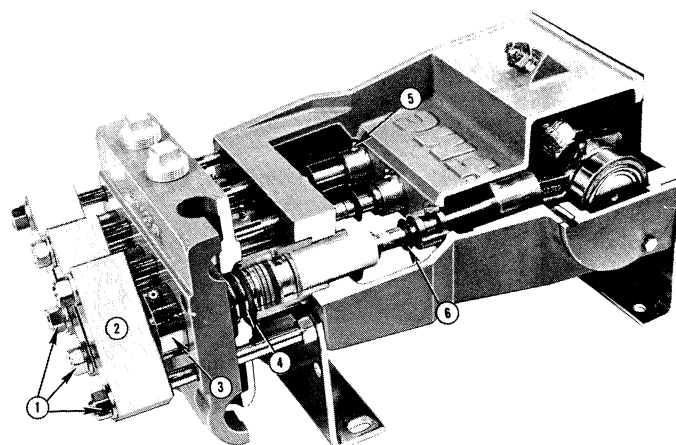
Steps	Procedure
<p>NOTE: The complete valve assembly is available for easy and quick servicing of the pump, or individual valve assembly parts are available. (Refer to parts list, page F-15.)</p>	
12	Complete valve assemblies can be replaced or just the individual damaged parts. To check the parts of the valve, remove the snap ring with a pair of snap ring pliers.
13	Once the snap ring has been removed the valve parts may be easily removed and inspected for damage.
14	Check that all surfaces on the valve are free from nicks, burrs and dirt and are dry. Replace any necessary parts.
<p>NOTE: If all valves show wear, replace all valve assemblies to prevent down time during critical periods.</p>	
15	Reassemble the valve parts in the order shown in the illustrations. Making sure the disc on the disc and spring assembly is positioned level in the seat.
16	Check that the spring and disc assembly work freely in valve, if not reassemble.
17	Insert suction valves squarely in the suction valve openings through the valve cover openings.(1)
<p style="text-align: center;">WARNING</p> <p>Incorrectly installed valves could result in severe damage to the pump and/or injury to personnel.</p>	
18	Use a dowel approximately the diameter of the valve and drive the valve firmly in the valve chamber.
19	Insert discharge valves through the discharge opening so the snap ring is toward the outside of inlet openings.(2)
20	Drive the discharge valves firmly in place as in step 18.
<p>NOTE: If O-rings are damaged replace.</p>	
21	Inspect the O-rings on the valve cover, if damaged replace. Carefully replace packing springs and valve covers taking care not to damage O-rings(3)
22	Replace valve cover clamps
23	Replace six nuts and torque in the sequence shown on page F-5 between 38 to 40 ft. lbs. (52 to 54 N.M) then retorque to between 77 ft. lbs. to 80 ft. lbs. (104 to 125 N.M) and repeat bring the torque to between 115 ft. lbs. to 120 ft. lbs. (163 N.M).



Servicing the Plunger Packings

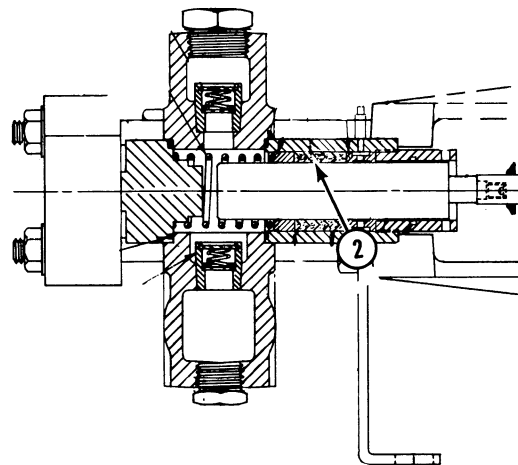
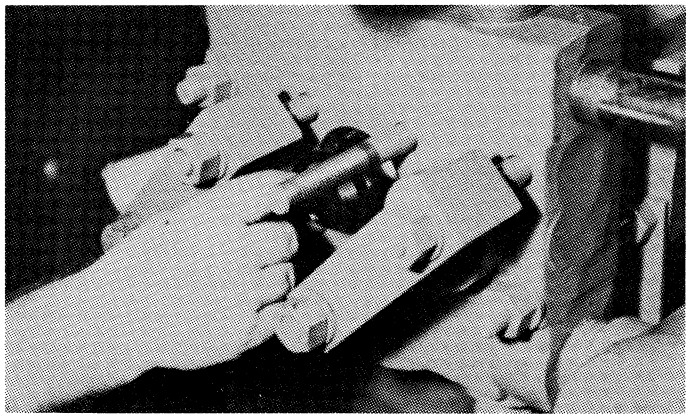
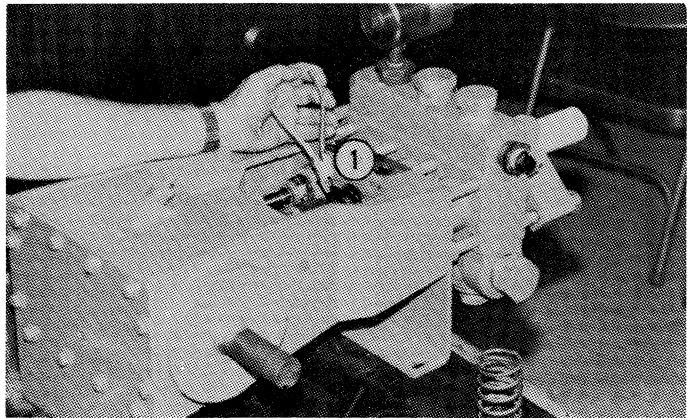
Plunger packings must be replaced whenever the leakage around the packings effects the pumps efficiency. A small amount of leakage past the packings (2-3 drops per minute) is normal and is actually desirable to help cool and lubricate the packings. Packing leakage is vented from the valve chambers through small openings in the stuffing boxes directly below the lantern glands.

Steps	Procedures
<p>WARNING Always disconnect pump from power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump parts or drive parts.</p>	
1	Remove six hex nuts on the front of the valve chamber.(1)
2	Slide the three valve chamber cover clamps from the valve chamber.(2)
3	Remove the three valve chamber covers(3). It may be necessary to tap on the sides of the covers to free them from the chamber.
4	Slide the three packing springs from the chamber(4).
5	Unscrew the three grease fittings(5) and remove from the three oil seal holders in the drive end. Slide the three barrier washers(6) back against the oil seal holders.
6	Rotate the plungers so one plunger is to the end of its stroke toward the valve chamber.
<p>CAUTION Take care not to score the crankshaft when manually rotating shaft. Careless abuse to the shaft will reduce its life and efficiency.</p>	
7	Using the special packing nut tool (FMC #5261438) loosen the packing nut to the plunger rotated to the end of its stroke.(7)
8	Once the packing nut is free from the valve chamber, slide it back over the oil seal holder. This will allow you room to get the packings.
9	Slide the special packing tool(8) through the front opening of the valve chamber and drive the packings from the stuffing boxes toward the drive end of the pump. (Packing tool FMC #M0606-5260965, M0608-5260966, M0610-5260967, M0612-5260968)



Servicing the Plunger Packings - Con't.

Steps	Procedures
<p>NOTE: Notice how the packings are arranged. The packing sets come in a set of six. Use all six packing rings together. Do not separate.</p>	
10	<p>With a sharp knife or scissors, cut each of the packing rings and remove from the plunger.(1)</p>
11	<p>Once all the old packings are removed, the throat ring and lantern gland must be removed out the front of the valve chamber. This is done by placing the two piece throat ring and lantern gland removal tool around the plunger. (FMC #M0606-5261847, M0608-5261984, M0610-5261985, M0612-5261986)</p>
12	<p>With the tool in place, tighten the packing nut back into the valve chamber driving the lantern gland and throat ring from the chamber.</p>
<p style="text-align: center;">CAUTION Take care not to damage the ceramic plungers while changing packings.</p>	
13	<p>Continue to tighten packing nut until it bottoms out.</p>
14	<p>Inspect the throat ring and lantern gland for wear or damage and replace with new parts if necessary. (Refer to parts list, page F-15)</p>
15	<p>Visually inspect the ceramic plunger for any roughness. (Excessive roughness can reduce packing life.) If necessary, change plungers. (Refer to Servicing Plungers, page F-5)</p>
16	<p>Visually inspect the stuffing boxes for wear or roughness. (Excessive roughness in the stuffing boxes can reduce the packing life.)</p>
<p>NOTE: It may be necessary to use a flashlight to inspect inside the stuffing box and plunger.</p>	
17	<p>Apply a light oil to the packings and insert the lantern gland, the packing rings, and the throat ring into the stuffing box. These parts should be driven into the stuffing box with the packing tool until the throat ring is just inside the stuffing box.</p>
<p>NOTE: Be sure parts are assembled in the correct direction and order shown in diagram.(2)</p>	



Servicing the Plunger Packings - Con't.

Steps	Procedures
18	Replace the packing spring.
19	Inspect the o-ring in the valve cover and replace if necessary. Apply a light oil to oil o-rings when replacing.
20	Replace valve cover and clamp.
21	Repeat steps 6-20 on remaining two plungers.
22	Replace grease fittings in oil seal holders. Slide the barrier washers back to their original place.
23	Replace six hex nuts and torque in the sequence shown to between 38 to 40 ft. lbs. (52 to 54 N.M.) then retorque to between 77 ft. lbs. and 80 ft. lbs. (104 to 125 N.M.) and repeat bringing the torque to between 115 ft. lbs. to 120 ft. lbs. (163 N.M.)

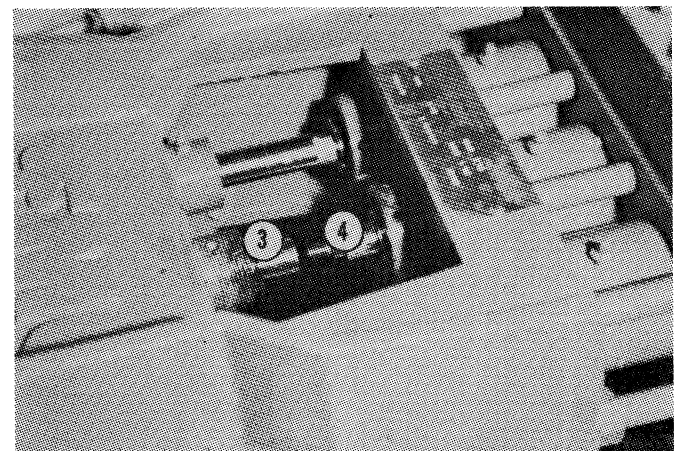
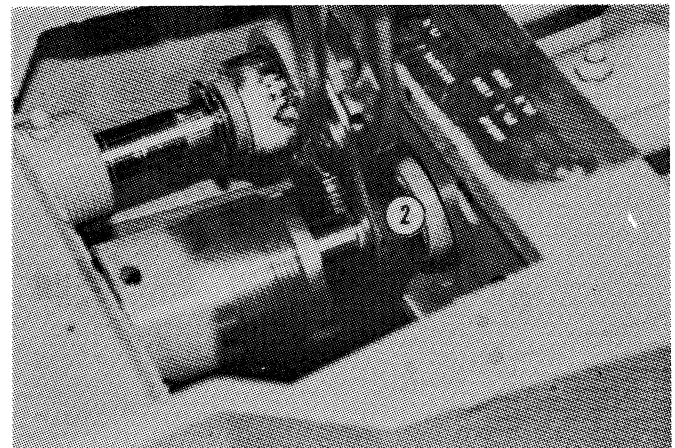
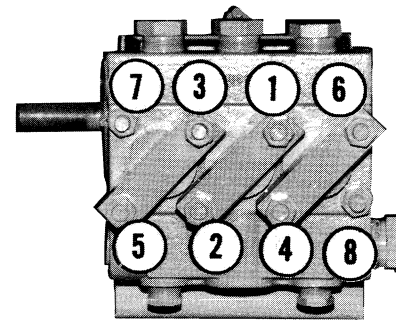
NOTE: Packings may be changed by unscrewing plungers if packing tool is not available.

Servicing the Plungers

It is virtually impossible to wear out a ceramic plunger under normal service conditions. However, they are quite brittle like all ceramic materials and can be cracked or chipped if subject to mechanical impacts or severe thermal shock. Hard objects such as tools and fittings should not be allowed to fall onto exposed plungers. Caution should also be used when changing from hot to very cold fluids via fast-acting solenoid valves.

In the event a plunger is cracked or broken, the plunger can be easily changed by following the steps below.

Steps	Procedures
	CAUTION Always take care not to strike ceramic plunger against anything. Ceramic is extremely brittle.
5	Make sure both end surfaces of the plunger(4) and the crosshead(3) are clean and dry.
	CAUTION The end of the plunger and the end of the crosshead must be flush against each other to assure proper alignment of plunger.
6	Tighten plunger into crosshead.
7	Follow steps 16-22 of changing plunger packings. (Refer to pages F-4 & F-5)



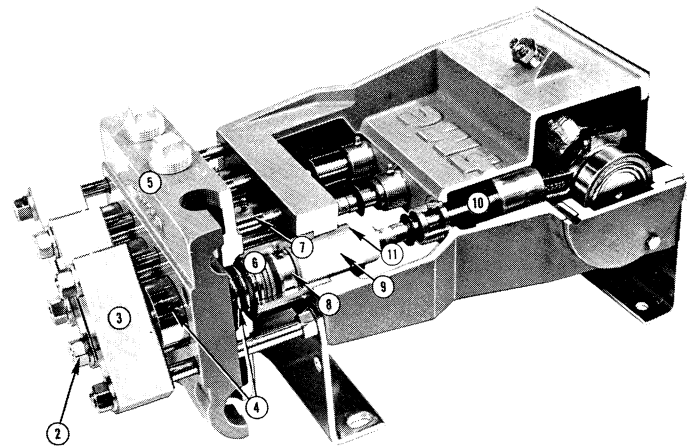
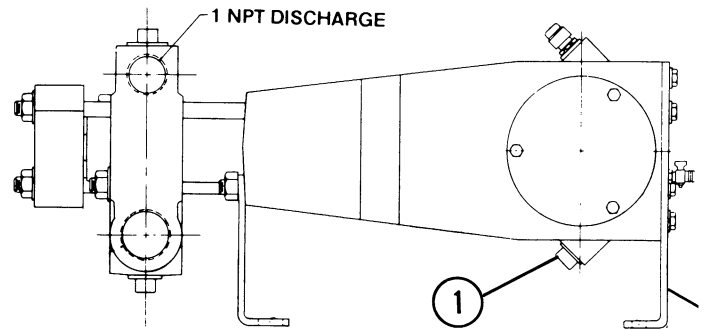
Steps	Procedures
	WARNING Always disconnect the pump from the power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump or drive parts.
1	Follow steps 1-15 for changing the plunger packings. (Refer to page F-4)

NOTE: When changing plungers, packings should be changed to avoid unnecessary down time.

2	Unscrew the plunger from the crosshead assembly.(2)
3	Slide the plunger out through the valve chamber opening.
4	Replace new plunger through valve chamber opening.

Servicing the Drive End

Servicing the eccentric shaft and connecting rods- These components seldom need servicing or replacing unless the pump has been run without oil or with severely contaminated oil. Problems with the shaft and rods will be indicated by a knocking noise or excessive pump case temperature.

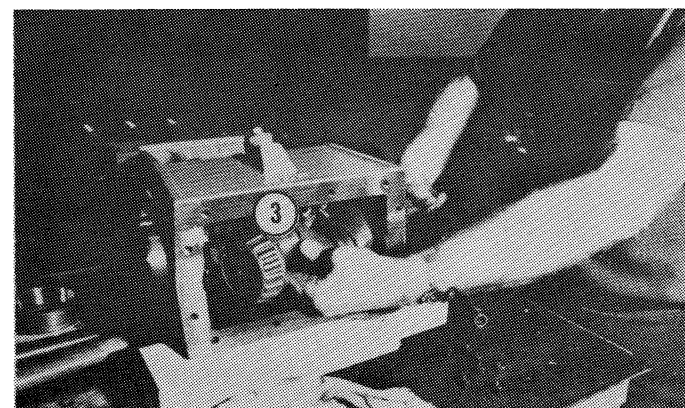
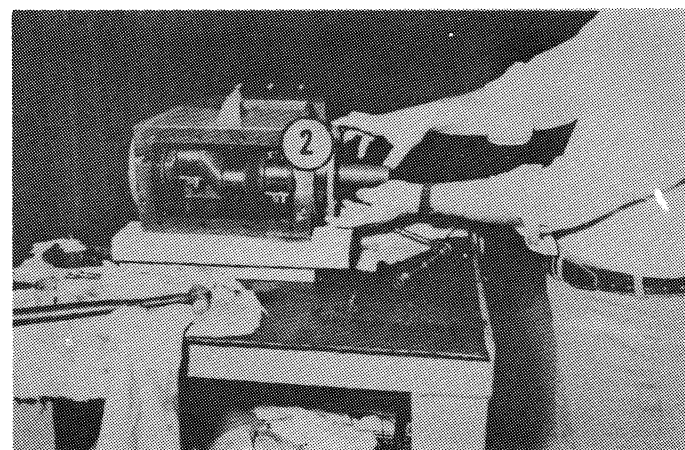
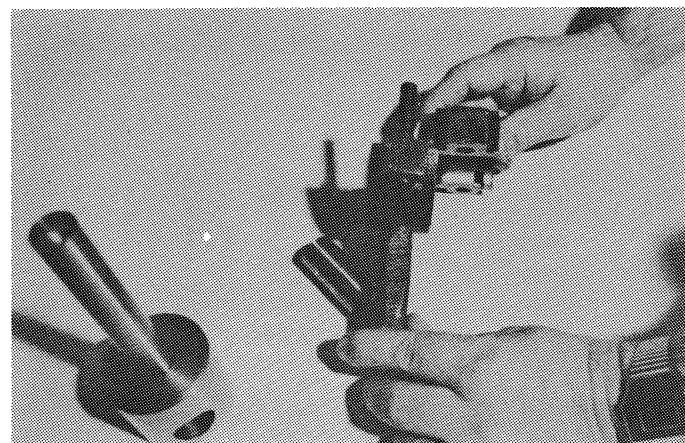
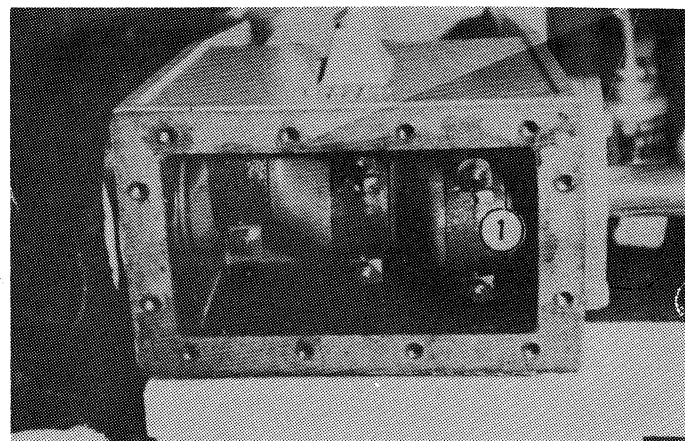


- 1 drain plug
- 2 8 nuts and studs
- 3 cover clamps
- 4 valve cover and packing springs
- 5 valve chamber
- 6 packings
- 7 stuffing boxes
- 8 lantern gland
- 9 plunger
- 10 crosshead
- 11 packing nut
- 12 cover

Steps	Procedures
	WARNING
	Always disconnect pump from power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump parts or drive parts.
1	Disconnect piping to valve chamber.
2	Remove the pump from its mounting and place on a bench or other convenient place for servicing the power end.
3	Place a container under the drain plug(1) in the drive end and remove the drain plug to drain all oil from the drive end. Also position a couple of 2 x 4's under the drive end of the pump.
4	Remove the eight nuts on the studs.(2)
5	Slide the three cover clamps off the studs.(3)
6	Slide the three valve covers from the valve chamber and the three packing springs.(4)
7	Remove the valve chamber from the pump.(5)
8	Follow steps 6-20 for changing the valves. (Refer to page F-1)
NOTE: To prevent unnecessary down time valves, packing, and other wear areas should be changed while breaking down the pump.	
9	The packings(6) must now be removed. Follow steps 5-11 (pages F3 & F4) for changing packings.
10	Pull the stuffing boxes.(7)
11	Drive the lantern gland(8) and throat ring from the stuffing box.
12	Unscrew the plunger(9) from crosshead(10) assemblies and remove the packing nuts(11)
13	Remove the three barrier washers.
14	Remove the capscrews, washers, cover and gasket from the power end of the pump.(12)

Servicing the Drive End - Con't.

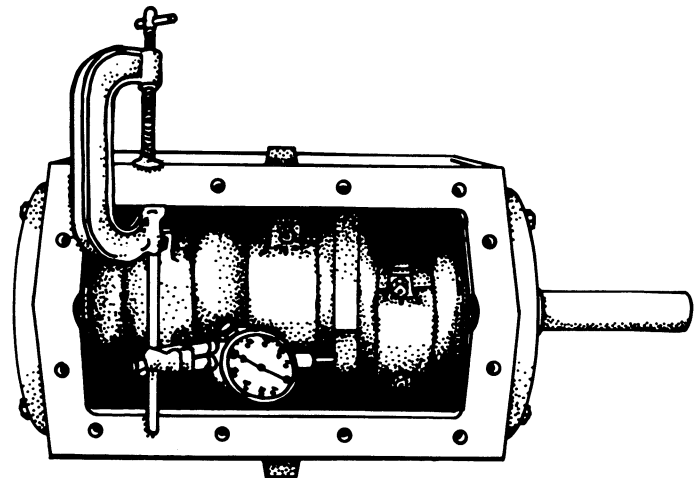
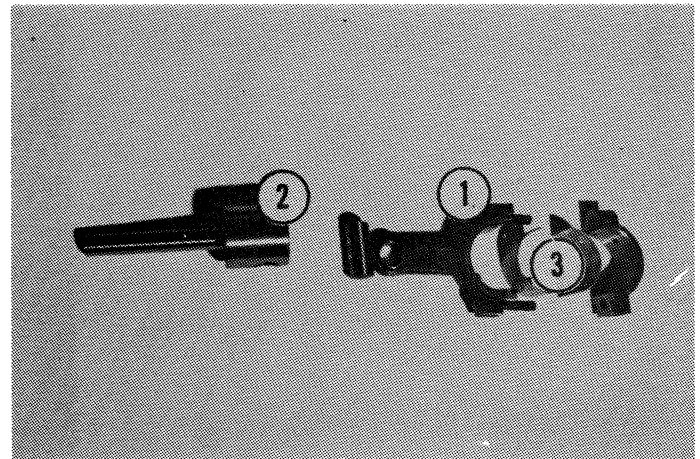
Steps	Procedures
15	Remove caps(1) from the connecting rod by unscrewing the nuts. CAUTION Caps and rods are coded and must always be assembled with their mate.
16	Remove sleeve bearings from the connecting rods if they do not come off with caps.
17	Remove bolts from bearing housings.
18	Remove bearings housings(2) It may be necessary to tap on housing with a rubber mallet to free housing from pump base.
19	Work crankshaft through bearing openings in the case.(3)
20	Pull connecting rods and crosshead assemblies from case taking care to place parts so they will be reassembled into same bore from which they were removed.
21	All oil seals should be replaced to avoid any unnecessary down time. A. To replace crosshead oil seals refer to Changing Plunger Rod Seals. B. To change eccentric shaft oil seals: (1) Pull oil seals from the bearing housing with a screwdriver or similar object and discard. CAUTION Take care not to damage housing bore. Scars on the housing could cause premature wear on bearings and oil seals.
22	(2) Fill the cavity between the inner and outer lips of the new seals (FMC #5257492) with silicon grease (FMC #1265784) (3) Press the new seals into the bearing housing so the seal lips are toward the inside of the case. Take care not to damage the seal lips or curl them when assembling.
22	Inspect the eccentric shaft bearings for: a. Cleanliness b. Rough spots when rotated c. Visible wear or damage d. Slack between the inner and outer races of the bearing.



Servicing Drive End

Steps	Procedures
<p>NOTE: All damaged bearings or bearings that have been removed from the shaft must be replaced with new bearings. If one bearing is faulty, it is a good practice to replace both bearings even though no damage is visible on the other bearing.</p>	
23	Inspect the eccentric shaft for damage, excessive scoring, or pitting on the eccentric shaft indicates the need for replacement (FMC #5253744)
24	Inspect the connecting rods(1) for damage. Excessive scoring or pitting on the connecting rods indicates the need for replacement (FMC #5253749)
25	Inspect the crosshead assemblies(2) and replace if any wear is visible. (FMC #5259573)
26	Clean all parts in a solvent and apply a thin coat of oil (Grade SAE 30) before installing.
27	Thoroughly clean case and cap in solvent and blow dry.
28	To replace bearings slide bearings over the end of the shaft and press into place with either an arbor press or an installation tool applying pressure only to the inner race.
<p>CAUTION Use extreme care when installing bearings. They can be easily damaged, shortening their life and efficiency.</p>	
29	Replace the crosshead assemblies and connecting rods, taking care not to damage the crosshead oil seals. Reassemble the rods in the same openings they were originally assembled.
<p>NOTE: Connecting rod oil pocket must be up.(4)</p>	
30	Replace bearing insert(3) in connecting rods (FMC #5254180).
31	Replace the eccentric shaft by carefully threading the shaft through the openings in the end of the case. Take care not to damage the bearings.
32	Replace shims (FMC #5254178) gasket (FMC #5254177) and bearing housings.
<p>NOTE: Always use gasket and shims.</p>	
33	Measure the crankshaft end play by: a) loosening the connecting rods b) placing a dial indicator on the pump

Steps	Procedures
	<p>case and against crankshaft as shown in diagram</p> <p>c) move the crankshaft fully to one end</p> <p>d) set the dial indicator to zero</p> <p>e) move the crankshaft to its maximum point</p> <p>f) read the end play on the dial indicator</p> <p>g) end play must be between .002 and .005 remove or add shims as necessary</p>
34	Replace cap screws and torque to between 30-35 foot pounds. (40 to 47 N.M.)

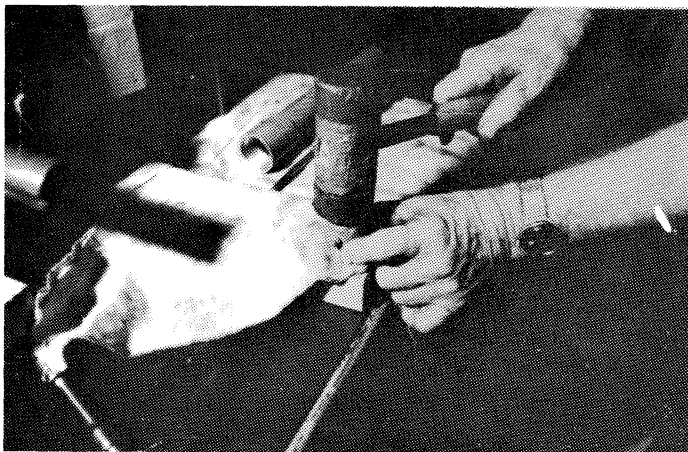
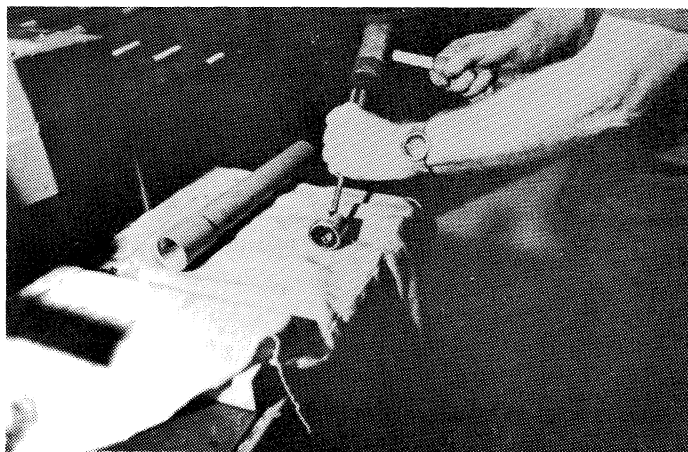
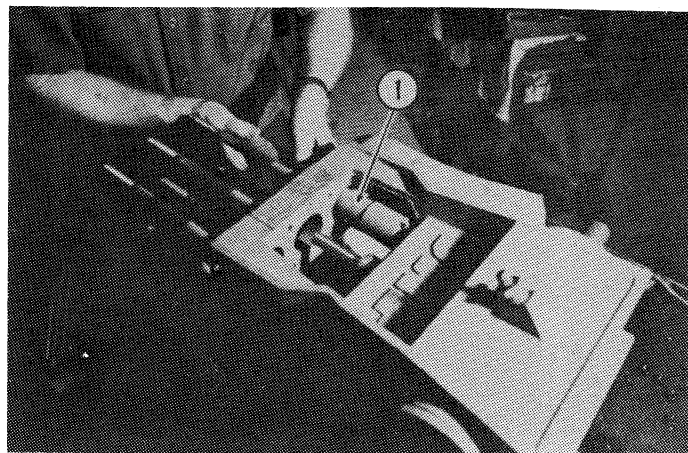


Servicing the Bearings - A knocking sound around the bearing or excessive heat coming from the pump case adjacent to the bearing are indications of faulty bearings. To replace or inspect bearings the crankshaft must be removed to allow access to the bearings. (Refer to Servicing the Drive End.)

Servicing the Eccentric Shaft Oil Seal - The oil seal also helps retain oil in the pump case and prevent dirt or fluid from entering the case. Oil leakage around the shaft, excessively dirty oil, or milky colored oil are indications of a worn or damaged seal. The eccentric shaft oil seal can be changed by removing the bearing housing. (Refer to step 21 servicing the drive end page F-7).

Servicing the Plunger Rod Oil Seals

These seals retain oil in the pump case and prevent dirt and fluids from entering the case by way of the plunger rods. Oil leakage around the plunger, dirt on the case, or milky colored oil are signs of worn or damaged crosshead seals. The seals may be replaced without disassembly of the drive end; however, the fluid end must be disassembled. To change the seals, follow the steps below.



Steps	Procedures
WARNING	
Always disconnect the pump from the power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump parts or drive parts.	
1	Follow steps 4-13 of Servicing the Eccentric Shaft and Drive End. (Refer to page F-6)
2	Remove the seal holders by threading the special puller (FMC#5259112)(1) over holder and prying them out.
3	Pull the oil seals by prying with a screwdriver or similar object.
4	Pack the area between the seals carefully with Dow-valve seal "A".
5	Press new seals into the housing.
NOTE: The lips of the inner seal faces the crankcase and the lips on the outer seal face the valve chamber.	
6	Apply a light coat of Permtate #2 (non-hardening) to outer edges and face of oil seal holder which contacts case.
7	Carefully thread the seals over the crosshead stems taking care not to fold or damage the seal lips.

Reading the Troubleshooting Chart

The following chart is designed to help you easily define and correct problem areas. As you can see the chart is divided into two columns. The first item is the Symptom, this is the signal that something is wrong. Once you have noticed the symptom you must determine the Cause because one symptom may be the signal for any one of various problems. The column titled Test and Result will be your aid for determining the Cause and Remedy.

Troubleshooting Chart

Symptom

Discharge Pressure too Low

Test/Result	Cause/Remedy
<p>Connect a hose to the overflow port in the relief valve and start the pump:</p> <p>1. Close all guns and/or nozzles and check overflow.</p> <p>RESULT: No overflow, see item 1, then recheck pressure.</p> <p>RESULT: Flow through overflow hose, see item 2, then recheck pressure.</p> <p>2. Open all of the discharge guns or nozzles.</p> <p>RESULT: No flow in the overflow hose, see items 3 and 4, recheck pressure.</p> <p>RESULT: Flow through the overflow hose, see items 5 and 6, or 7, recheck pressure.</p>	<p>1. Restriction in suction line.</p> <p>Checked for clogged strainers, closed valves, empty suction tank.</p> <p>2. Incorrect relief valve adjustment.</p> <p>To increase the relief pressure, tighten the nut on top of the valve by turning clockwise. (Refer pg. D-1.)</p> <p style="text-align: center;">Warning</p> <p>Do not exceed the rated pressure of the pump.</p> <p>3. Incorrect nozzle size.</p> <p>Worn nozzles or nozzles with capacity in excess of the pump capacity, will reduce the discharge pressure - replace where required. Refer nozzle manufacturer's literature.</p> <p>4. Pump speed too low.</p> <p>Change the sheave combination to obtain the desired speed.</p> <p style="text-align: center;">Caution</p> <p>Do not exceed the maximum rated speed.</p> <p>5. Worn seat or stem in the relief valve.</p> <p>Replace parts as required.</p> <p>6. Worn packing cup in the relief valve.</p> <p>Replace the packing if water is leaking through the openings in the relief valve body.</p> <p>7. Foreign material lodged in the relief valve.</p> <p>Relieve the spring tension and flush the interior of the valve to remove foreign material.</p>

Symptom

Discharge gallonage too low - low discharge gallonage will be caused by slow pump speed or low volumetric efficiency.

Test/Result	Cause/Remedy
<p>1. Calculate displacement gallonage of the pump as follows:</p> <ol style="list-style-type: none"> Measure crankshaft speed with a tachometer. Multiply speed x M0606-.0086, M0608-.01530, M0610-.02391, M0612-.03442 gal./rev. (Factors are figured assuming 100% volumetric efficiency.) <p>RESULT: Displacement gallonage lower than required, see item 1.</p> <p>RESULT: Displacement gallonage equal to or larger than required gallonage, see next test.</p> <p>2. Volumetric efficiency is a measure of how much the actual output is less than the displacement. To determine vol eff.:</p> <ol style="list-style-type: none"> Measure the actual gallonage from the pump. Close all guns and discharge valves and measure the number of gallons coming from the overflow hose for one minute. <p>NOTE: One gal. of water weighs 8.33 lbs. and fills .1337 cu. ft.</p> <p>NOTE: Measured flow is actual gallon per minute (GPM) output.</p> <ol style="list-style-type: none"> Divide the actual GPM found in Step a. by the displacement GPM found earlier then multiply by 100 to get the volumetric efficiency. $\text{Vol. Eff. } \% = \frac{\text{Actual GPM} \times 100}{\text{Displ. GPM}}$ <p>Normal Volumetric Efficiency — 85-90%</p> <p>RESULT: Normal volumetric efficiency but gallonage less than required, see item 1.</p> <p>RESULT: Volumetric efficiency less than normal, see items 2,3, and 4 or cavitation.</p>	<p>1. Pump speed too slow.</p> <p>Change the sheave combination to obtain desired speed.(Refer to Selecting Operating Speed, pg. D-1 and installation Procedures, page C-1.)</p> <p style="text-align: center;">Warning Do not exceed maximum Rated speed.</p> <p>2. Leakage from the pump plunger packings. Leakage exceeding 60 drops per minute indicates that the packing should be replaced. (Refer to pg. F-3)</p> <p>3. Suction or discharge valve seats worn, pitted, or broken.</p> <p>Inspect and replace where necessary. (Refer to page F-1.)</p> <p>4. Restriction in the suction line.</p> <p>Check for clogged strainers, closed valves, empty suction tank.</p>

Symptom

Noise coming from bearings and crankcase area

Test/Result	Cause/Remedy
See Item 1.	<p>1. Worn or damaged bearings</p> <p>Change bearings (Refer to Servicing, page 1.)</p>

Symptom

Cavitation - Cavitation in the pump occurs when the cylinders do not completely fill with water during the suction stroke. Resultant pressure pulsations can severely damage the pump and related piping if the condition is not recognized and corrected immediately.

Test/Result	Cause/Remedy
<p>Check the following to determine if cavitation exists:</p> <p>1. Volumetric Efficiency $\text{Vol. Eff.} = \frac{\text{Actual GPM}}{\text{Displ. GPM}} \times 100$</p> <p>(See Discharge Gallonage refer to preceding page) RESULT: Less than normal vol. eff. with good valves and plunger packings indicates cavitation.</p> <p>2. Discharge Pressure RESULT: Less than expected and fluctuating erratically indicates cavitation.</p> <p>3. Pulsations in suction or discharge line. RESULT: Erratic pulsations of abnormal magnitude indicate cavitation.</p> <p>4. Listen for sharp erratic hammering sounds in the valve chamber. Do not confuse the sharp regular sounds of the valves with the erratic sound that indicates cavitation.</p> <p>NOTE: There are several causes of cavitation. Once the problem has been determined as cavitation from the above test the following test must be performed to determine the cause.</p> <p>1. Reduce the temperature of the pump liquid to room temperature. RESULT: If cavitation stops, see item 1.</p> <p>2. If the relief valve overflow is piped into the pump suction line, disconnect the overflow line. RESULT: If cavitation stops, see item 2.</p> <p>3. Disconnect the suction inlet piping and replace it with a short hose connected to a barrel or tank. RESULT: If cavitation stops, see items 3, 4, and 5.</p> <p>4. Disconnect the discharge piping and connect a short hose to the pump outlet. RESULT: If cavitation stops, see item 6.</p> <p>5. Replace the pump plunger packing and inspect the valve assemblies. RESULT: If cavitation stops, see item 7.</p>	<ol style="list-style-type: none"> 1. Vapor pressure too high at pumping temperature. Reduce the temperature or increase the suction pressure by an amount sufficient to overcome the vapor pressure. Refer to Section C, Installations, page C-2. 2. Turbulence in the pump suction inlet. Relocate overflow lines further from the pump inlet. If necessary, provide a tank to supply undistributed suction flow conditions to the pump. 3. Suction or discharge valves' seats worn, pitted, or broken. Inspect and replace, where necessary. (Refer to page F-1.) 4. Excessive losses in the suction piping. Increase the suction pipe diameter, increase the suction pressure or reduce the length of the suction line. In some cases, an air chamber may be required to sufficiently reduce the suction losses. (Refer to Installations, page C-2.) 5. Air leaking into the suction system. Inspect and tighten all the hose and pipe connections. 6. Water hammer in the discharge line. Install an air chamber or an accumulator in the discharge piping. (Refer to Installations, page C-4.) 7. Weak and partially worn plunger packing. Partially worn plunger packing may draw air on suction stroke but not leak on the discharge stroke. This will cause the pump to operate as if cavitating. Adjust or replace the packing. (Refer to Servicing, page F-3.)