FMC Technologies

FMC E04

Pump Operation and Maintenance Manual

E04

Installation
General Operation
Trouble-Shooting Guide
Service Procedures

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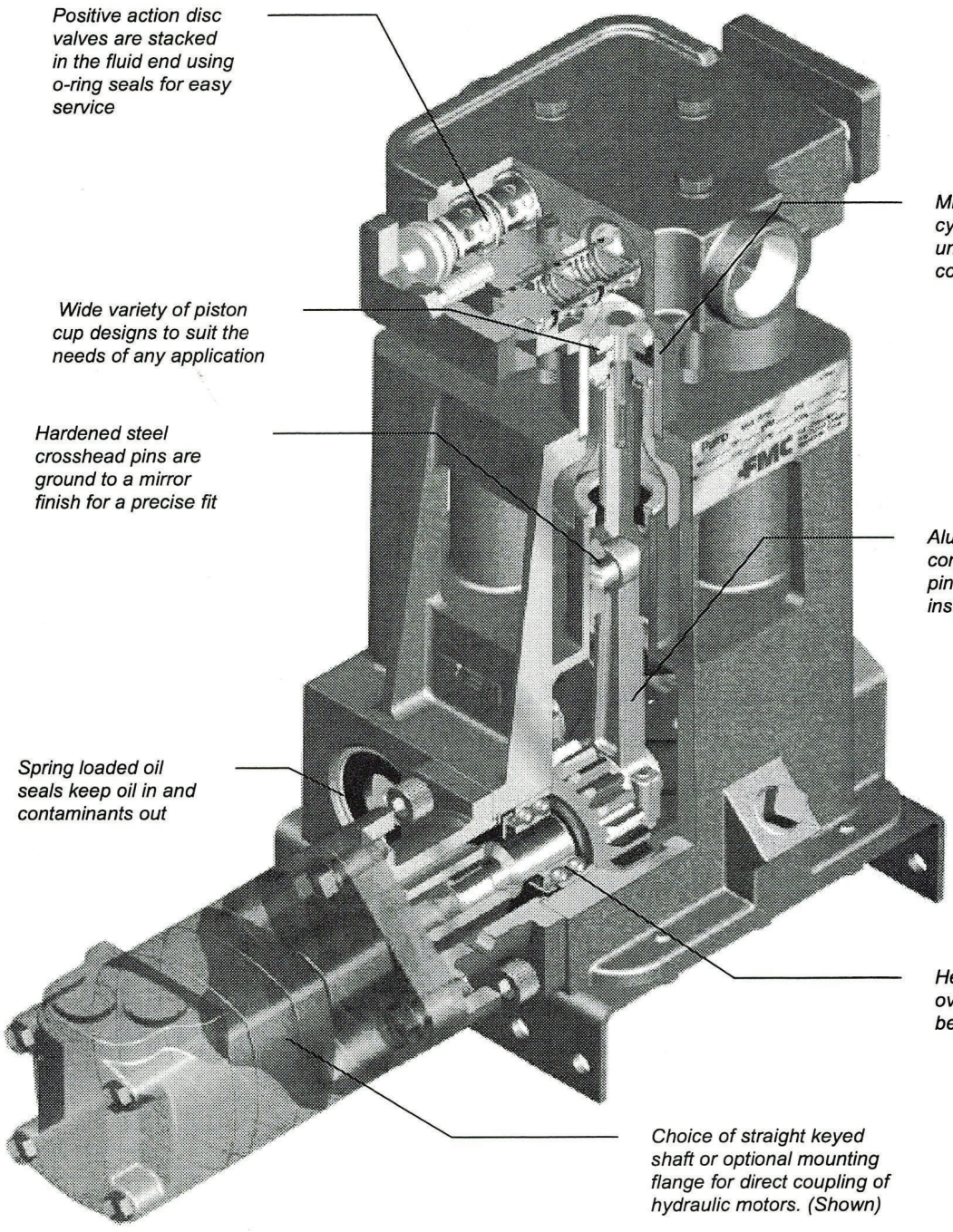
Important Safety Instructions

⚠ *Many accidents occur every year through careless use of mechanical equipment. You can avoid hazards associated with high-pressure equipment by always following the safety precautions listed below.*

- SHUT DOWN OR DISENGAGE the pump and all accessory equipment before attempting any type of service. Failure to do this could cause electrical shock or injury from moving pump parts or components under high pressure.
- BLEED OFF ALL PRESSURE to the pump and piping before attempting any maintenance to the pump. Failure to do so may spray water or chemicals at high pressure onto service personnel.
- NEVER OPERATE THE PUMP WITHOUT A PRESSURE RELIEF VALVE, burst disc, or other type of properly sized overpressure safety device installed.
- ALWAYS USE A PRESSURE GAGE when operating the pump. The pressure must never exceed the maximum pressure rating of the pump or damage may occur. This damage can cause leakage or structural damage resulting in injury to personnel.
- INSURE THAT NO VALVES ARE PLACED BETWEEN THE PUMP AND PRESSURE RELIEF VALVE. If the pump is started with a closed or restricted valve in line before the pressure relief valve, the pump may build up pressure in excess of its rated limits and burst causing injury to personnel.
- USE SHIELDS OR COVERS AROUND PUMPS when pumping hot water, chemicals, or other hazardous liquids. This precaution can prevent the exposure of service personnel to these fluids should leakage occur.
- ALWAYS USE GUARDS on all belt drives and couplings. Guards can prevent personnel from becoming entangled and injured in rotating parts.
- USE EXTREME CAUTION WITH SOLVENTS used to clean or degrease equipment. Most solvents are highly flammable. Observe all safety instructions on packaging.
- NEVER MODIFY THE PUMP TO PERFORM BEYOND ITS RATED SPECIFICATIONS.

E04 Pump Features

Exceptional design, workmanship, materials, and over 100 years experience building piston pumps are features you'll find built into every FMC pump.



Storage Requirements

Proper storage of your FMC pump will insure that it is ready for service when needed. Follow the guidelines below that fit the requirements of your application

FMC pumps come from the factory prepared for storage periods of up to six (6) months in proper environmental conditions. Indoor storage in a dry, temperature-controlled location is always recommended. If pumps are to be stored short term (less than six (6) months) in a severe environment, they should be prepared using the procedures outlined in the "Short Term Storage For Severe Environments" section below. If the pump is to be stored, or is inactive, for periods in excess of six (6) months, it is necessary to prepare the pump as outlined in the "Long Term Storage" section

Short Term Storage

If the pump is stored in an indoor, temperature controlled environment for less than six (6) months, no special steps are required to prepare it for storage. As a general rule, pumps in corrosive fluid applications should drain fluid end, flush with water or other suitable rust preventative, and blow dry using compressed air whenever idle for periods in excess of one (1) month.

Short Term Storage for Severe Environments

Drain any fluid from pump and blow dry with compressed air. Spray a fog of preservative oil into suction and discharge ports of fluid end, then install pipe plugs in openings. Remove the oil fill cap (or plug) and the power end breather vent. Spray a heavy fog of preservative oil into the oil fill hole until it can be seen coming out of the breather opening. Coat all exposed, unpainted metal surfaces (ex. Driveshaft) with a preservative oil. Replace the oil fill cap and breather vent, then cover the entire pump with a weather resistant covering such as a canvas or plastic tarp.

Long Term Storage

Long-term storage is defined as any period when the pump is in storage or idle for periods in excess of six (6) months. Remove the piston cup seals as described in the "Replacing Piston Cup Seals" section of this manual and store them in a separate location with a controlled environment where they are protected from UV exposure. If the pump has been in service, flush the fluid end with water to clean out any of the remaining pumpage, then blow the fluid end dry using compressed air.

Drain any remaining oil from the pump power end, then remove the power end cover to expose the drive components. Spray all internal parts with a rust preservative that is soluble in lubricating oil while rotating the driveshaft several turns by hand to insure complete coverage. Replace the power end cover and add a concentrated internal rust inhibitor per manufacturers recommendations (see Recommended Lubricant Chart, page 9).

Spray a rust preventative onto all exterior machined surfaces paying careful attention to any unpainted areas like the crankshaft extension. Remove the power end breather cap and store with the piston cup

seals. Cap the breather opening with a plug or other suitable means in order to keep the preservative atmosphere sealed inside the power frame.

Never store the pump on the floor or ground. Always place it on a shelf or pallet that is several inches above ground level. Cover the entire pump with a canvas or plastic tarp. Periodically inspect the unit and rotate the crankshaft by hand several turns during each inspection. Drain and replace the rust inhibitor after every six (6) months of storage.

Before operating the pump, drain the preservative and lubricating oil mixture from the power end. Reinstall the drain plug, breather/filler cap, piston cup seals, and any other components that were removed for storage. Once these steps have been completed, follow the normal pump start up procedures outlined in this manual. Note that FMC can factory prepare units for extended storage for a nominal fee if specified at the time of order.

Precautions during Freezing Weather Conditions

Freezing weather can cause problems for equipment when pumping water based fluids that expand in volume when changing from a liquid to a frozen solid state. For example, when water is left in a pump fluid end and exposed to freezing temperatures, the expansion of the water as it freezes can rupture the fluid cylinder of the pump and cause permanent equipment damage or personal injury.

Whenever the pump is stored or idle in conditions that are near or below freezing, any water based fluids should be removed from the pump. The best way to do this is to run the pump for a few seconds with the suction and discharge lines disconnected or open to atmosphere. This will clear the majority of the fluid from the pumping chamber as well as the suction and discharge manifolds. After the run, blow compressed air through the fluid end to remove all traces of fluid. If possible, lift up the suction valve seats to insure that all fluid is drained from the pumping chamber between the suction and discharge valves.

As an alternative to the previous procedure, a compatible antifreeze solution can be recirculated through the fluid end. RV antifreeze, propylene glycol, is often used for this purpose.

Installation Guidelines

A proper installation is the key to optimum performance, longer service life, and reduced maintenance requirements. Take time to thoroughly plan all aspects of your installation..

General Location

It is important to position the pump on a flat, level surface to assist the gravity splash oil system. Whenever possible, the pump should be mounted in a clean, dry location with sufficient lighting and adequate space for easy inspection and maintenance. Locate the pump as close to the suction source as possible to allow for the shortest and most direct routing of the inlet piping.

Mounting Pump to Foundation and Power Source

The E04 pump must be mounted in a vertical position only. Secure the pump to the mounting surface using at least four (4) the eight (8) 13/32" holes provided in the pump base. The design of the E04 pump allows for the driveshaft to be rotated in either direction.

For units that are V-belt driven, check the alignment of the sheaves after the unit is installed on its permanent mounting. Tighten belts to proper tension. Place a straight edge against the sides of the sheaves to be sure they are in line and running parallel to each other. Never operate the pump without the belt guard securely in place.

For direct-coupled units or spline driven units, insure that the shafts are centered and parallel when the driver is mounted to the pump. Never operate the unit without a shaft guard securely in place.

Suction Piping Recommendations

Poor suction piping practices are a very common source of pump problems. To insure proper operation it is very important to pay careful attention to the design of the suction system before the pump is installed. A small amount of extra time and money invested in the pump system usually provides for better pump performance and longer periods between service requirements. It is difficult to diagnose many pump problems without the aid of a suction pressure gage. For this reason, FMC always recommends that a gage be installed in the suction line directly before it enters the pump.

The suction line from the fluid source to pump should be as short and direct as possible. Use either rigid piping, non-collapsible hose or a combination of both as circumstances warrant in your installation. The suction pipe size should be at least one size larger than the pump inlet. Long piping runs, low suction heads, or indirect pipe routing may require even greater oversizing of the suction line for proper operation of the pump. In some cases it may be necessary to install a booster pump in the suction line of the pump to obtain sufficient pressure for the pump to operate.

The suction line must be laid out so that there are no high spots in the line where gas or air pockets could collect. These pockets can make the pump difficult to prime and cause rough, erratic operation. A drain valve or plug should be installed at the low point of the suction line to allow for drainage during freezing conditions or for maintenance.

FMC recommends that all piping be supported independently of the pump. By supporting the piping this way, vibrations are reduced and stress on the pump is kept to a minimum. The use of elbows, nipples, unions, or other fittings should be minimized. To help isolate mechanical and hydraulic vibrations, FMC recommends the use of flexible hose connections between the pump and any rigid piping. Make sure that all joint and connections are airtight. Air leaks reduce the capacity of the pump and can result in cavitation, rough operation, and/or loss of prime.

Always insure that calculated system NPSHa exceeds pump NPSHr by at least 5 ft-H2O for proper operation of the pump. NPSH requirements for each pump model are provided on the product data sheets available through FMC or your authorized FMC reseller. FMC does not recommend using the pump in static lift conditions without prior approval.

Discharge Piping Recommendations

Route the discharge piping in as short and direct a route as possible. Use the same pipe size as the outlet of the pump. In installations where the discharge piping is in excess of 50 feet, use the next larger size pipe to minimize friction losses downstream of the pump. Always use pipe or hose that is designed for your particular pressure requirements. Inadequate pressure ratings can allow hose or pipe to fail resulting in personal injuries or equipment damage. Normal hose pressure ratings are clearly marked on the outer surface of the hose. Working pressure ratings for steel pipe can be obtained from the manufacturer or from the adjacent chart.

Allowable Working Pressure For Steel Pipe (PSI @ 100F)

Pipe Size (inches)	Pipe Schedule Number				
	40	80	120	160	XX
1/2	2,300	4,100		7,300	12,300
3/4	2,000	3,500		8,500	10,000
1	2,100	3,500		5,700	9,500
1 1/4	1,800	3,000		4,400	7,900
1 1/2	1,700	2,800		4,500	7,200
2	1,500	2,500		4,600	6,300
2 1/2	1,900	2,800		4,200	6,900
3	1,600	2,600		4,100	6,100
3 1/2	1,500	2,400			5,600
4	1,400	2,300	3,350	4,000	5,300
5	1,300	2,090	2,950	3,850	4,780
6	1,210	2,070	2,850	3,760	4,660
8	1,100	1,870	2,840	3,700	3,560

Always use a pressure gage in the pump discharge line. A properly functioning gage mounted at the pump (and before any valves) is required to accurately determine the operating pressure of a pump.

Insure that all piping is supported independently of the pump to reduce vibrations and strain on the pump itself. The use of elbows, nipples, unions, or other fittings should be kept to an absolute minimum. Avoid short radius 90° elbows; use two long radius 45° elbows instead. To help isolate mechanical and hydraulic vibrations, FMC recommends the use of flexible hose connections between the pump and any rigid piping.

A properly adjusted pressure relief valve or rupture disc must be installed directly downstream of the pump to prevent damage or injuries resulting from over pressure or dead-head conditions. The relief valve by-pass line must be as large as the pipe outlet of the relief valve. Never install valves in the by-pass line or between the pump and relief valve. FMC recommends that the by-pass be returned to the suction tank or drain, not back into the pump suction line.

Multiple Pump Systems

Special care must be taken to avoid problems when operating multiple reciprocating pumps using common suction and discharge piping headers. It is recommended that the user contact FMC or other suitable industry consultants for assistance with the design of the system and installation of pump in these situations.

How to Start A Pump

Always take special precautions when starting a pump for the first time or after any extended shutdown. Never assume that someone else has properly prepared the pump and system for operation. Always check each component of the system prior to every start-up.

The checklist that follows is intended to be a general guide for starting a pump in a typical installation. Every installation is different, and each will have different requirements to insure safe and successful operation. It is the responsibility of the operator to determine the correct start-up procedure for each installation.

1. Insure that the drain plug on the bottom of the pump crankcase has been installed and is tight. If the pump is equipped with a sight-glass to monitor the crankcase oil level, insure that it has been properly installed.

2. Check the oil level to insure that the pump is properly filled and that the oil has not been contaminated with water or other liquids. FMC pumps are not shipped with oil in the power frame and must be filled with the proper grade of oil prior to start-up. The E04 pump requires 1 quart (.95 liters) of oil. Use the chart provided on page 9 for help in selecting the correct type of oil for your service.

3. Insure that the pressure relief valve and all accessory equipment have been installed and properly adjusted and that all joints are tight.

4. Open suction line valve to allow fluid to enter pump.

5. Check to insure that power is off. Turn the pump over by hand to insure free, unobstructed operation.

6. Make sure that all guards are in place and secure. Verify that all personnel are in safe positions and that system conditions are acceptable for operation.

7. Start the pump. Whenever possible, use a bypass line for the flow to allow the pump to start in an unloaded condition (no back pressure). Slowly close the bypass line to bring the pump into full load conditions. Shut down immediately if flow becomes unsteady, pressure fluctuates, or if unusual sounds or vibrations are noted.

Recommended Lubricants

Few factors can influence the life of a pump more than the power end lubricant. Careful selection of the right type of oil for your particular application will help insure optimal performance from your pump.

The intent of this section is to state the general lubrication requirements for FMC pumps. Several manufacturers products are listed by name in the table below in order to aid the customer in locating suitable products. The following listing is not exclusive, nor an endorsement of any particular product or manufacturer. Consult FMC for lubrication recommendations for applications that fall outside of the conditions listed below.

Recommended Lubricant Chart

Type of Service	Ambient Temperaure	ISO Grade (cSt)	AGMA Number	SAE Weight	SSU Viscosity
General Serivce	0 - 95°F	100	3	30	550
			Texaco Meropa 100		
			Shell Omala 100		
High Ambient Temperatures	95 - 120°F	220	5	50	1165
			Texaco Meropa 220		
			Shell Omala 220		
Cold Ambient Temperatures	-30 - 60°F	68	2	20	350
			Texaco Meropa 68		
			Shell Omala 68		
Frequent Start-Stop Cycles	0 - 95°F	150	4	40	775
			Texaco Meropa FM 150		
Specialty Items					
Internal Rust Inhibitor			*Cortec VCI 329*		
External Rust Preventative			*Texaco Metal Protective Oil L*		

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Preventative Maintenance Chart

Routine maintenance is an essential part of any successful pump installation. Properly maintained FMC pumps are designed to offer years of trouble-free service.

Regular maintenance and inspection will keep your pump operating at peak performance. FMC pumps have been carefully engineered to minimize maintenance requirements and simplify these tasks when they are required. Regular inspections allow operators to become familiar with normal pump operation so they can recognize the signals of potential problems and schedule maintenance. The chart shown below should be used as a guideline only. Many applications will require adjustment of the intervals shown in this chart for severe or unusual operating conditions.

Interval	Component	Service	Remarks
Break In Period	Crankcase Oil	Change	Drain and refill with new oil after first 50 hours of operation. Insure that magnetic drain plug is cleaned of debris
	Inlet Strainer	Inspect	Clean if required. The amount of material in the strainer will determine the interval of cleaning
Daily	Complete Pump	Inspect	General inspection of pump and system to check for proper operation of equipment
	Piston Seals	Inspect	Observe top of pump case under plastic umbrella for signs of excessive leakage. Replace if necessary.
	Pump System	Flush	Required for shutdown when pumping fluids that may harden or corrode pump if left inside once stopped.
	Crankcase Oil	Inspect	Insure that oil is at proper level and has not been contaminated by pumpage or condensation.
3 Months/2,000 Hours	Crankcase Oil	Change	Drain and refill with new oil. Clean magnetic drain plug.

Service Procedures

FMC pumps are designed to simplify all required maintenance. The following sections illustrate a step by step procedure for performing most common service needs of a pump. Read and understand each section completely before attempting to service the pump.

Replacing Piston Cup Seals

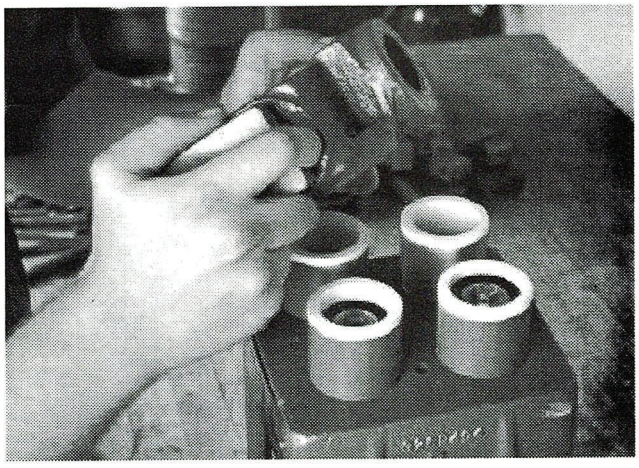
1. The fluid chamber must be removed to provide access the piston cups. To remove the fluid chamber, first remove the four (4) hex bolts holding it to the power frame, then lift it off the top of the ceramic cylinders.

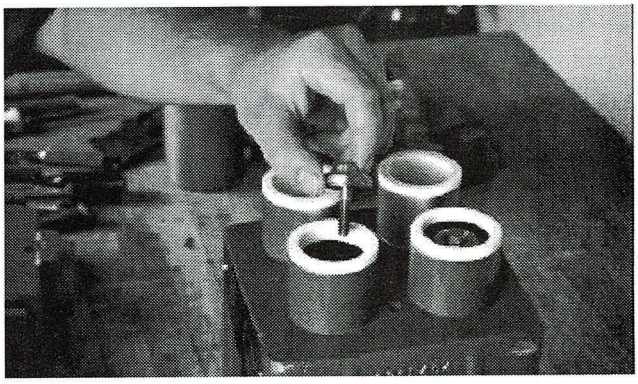
2. Each piston cup is held in place with a cap screw and piston retainer. Remove the cap screw and piston retainer from each of the four cylinders.

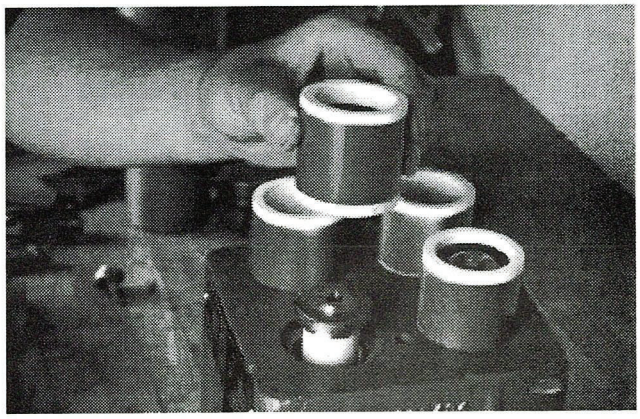
3. Lift each ceramic cylinder off from the top of the power frame. Friction will usually keep the piston inside the cylinder as it is removed. Once the cylinder and pistons are removed for each of the four cylinders, take them to a bench and push them out of the cylinder.

4. Inspect all o-rings, gaskets, seals, and other components for signs of damage or wear. Any damaged components should be replaced at this time. Inspect cylinder liners for cracks or grooves by running thumbnail around the bore of the cylinder and replace if any wear or damage is detected. New cups will wear quickly if operated in cylinders with rough or grooved bores. Note: to provide maximum operational time between service, FMC recommends that all four piston cups, not just the one that shows signs of leakage, be replaced whenever piston service is required.

5. The plastic umbrella shields keep any fluid that leaks past the piston cups from entering the power frame and contaminating the oil reservoir. Insure that the umbrella fluid shield is not damaged. If the umbrella requires replacement, the best way to remove it from the pump is to cut it free with a sharp knife.







6. To install new umbrella shields, fold the plastic as shown and insert through the opening and over the ends of the plunger rod. For easier installation of the umbrella, immerse in hot water for 2-3 minutes to soften. Press tops of umbrellas to place pilot washers over ends of plunger rods with groove in up position.

7. To rebuild, first place o-rings and packing holders in position on ends of plunger rod.

8. Place gasket and ceramic cylinder in counterbore of power frame.

9. Apply light oil or glycerin around the OD of the piston cups, then place them in the open (top) end of the cylinders. Use the thumb to press the cups down firmly into the holder of each cylinder.

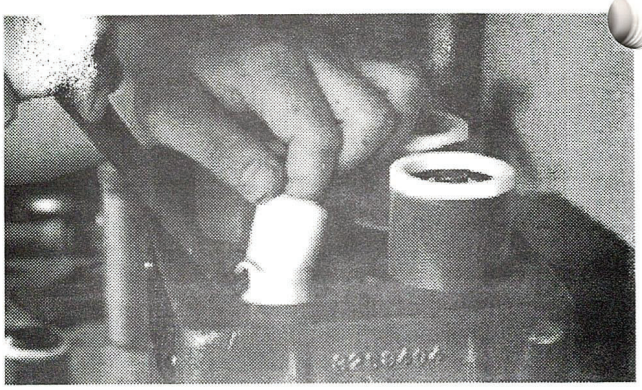
10. Insert the cup retainers into the cylinders with the ribbed side facing the piston cup.

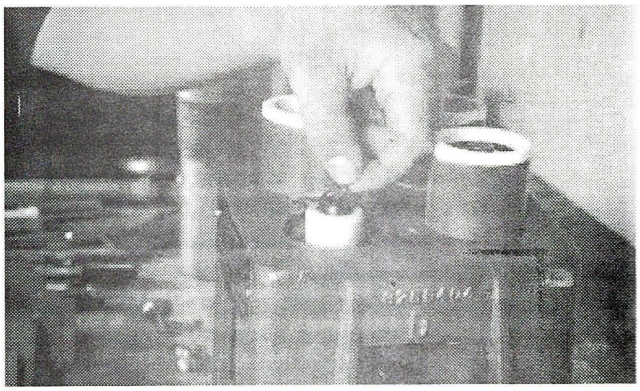
11. Secure piston assembly using cap screws. Torque as indicated in Fastener Torque Requirements section, page 19.

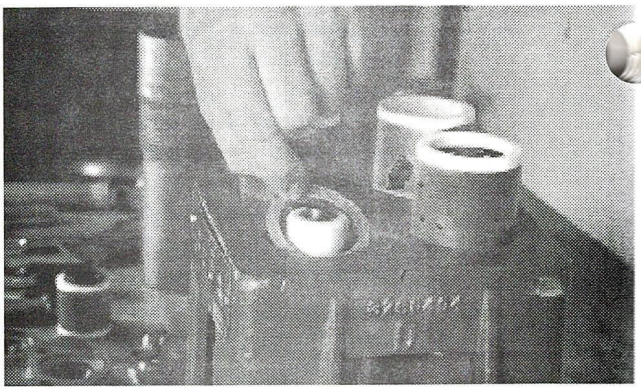
12. Insert top gasket (or o-ring and ring seal in some pump models) in fluid chamber counterbore using heavy oil or grease to hold in place.

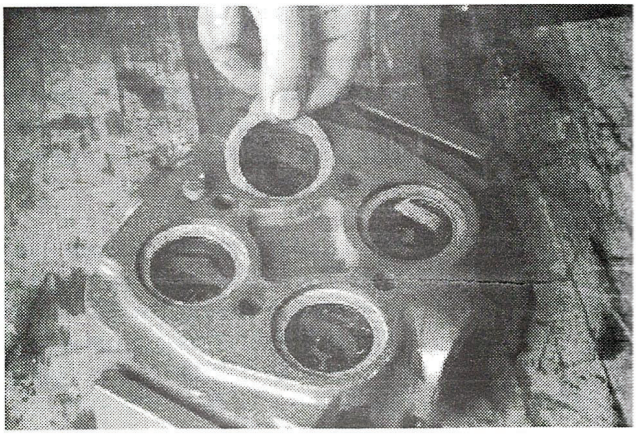
13. Return fluid chamber to position over cylinders and insure that all seals are in place. Use a slight twisting motion on the fluid end to insure all cylinders are fully seated in fluid end counterbores.

14. Replace fluid end cap screws. Torque cap screws in 3 stages to values shown in the Fastener Torque Requirements section, page 19.





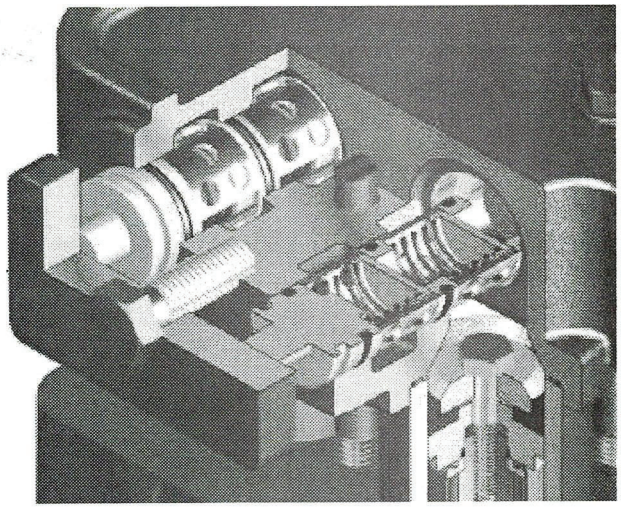


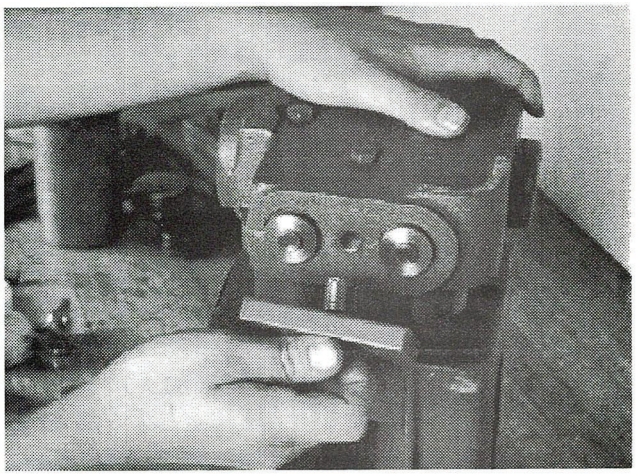


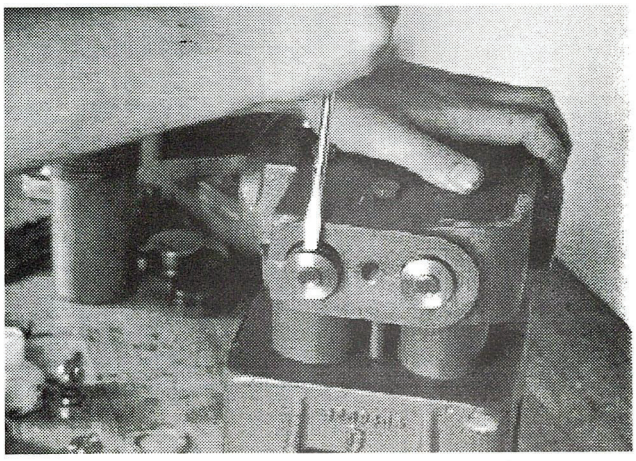
Replacing Suction and Discharge Valves

1. To access the suction and discharge valves, the valve cover clamps must be removed from each side of the fluid chamber. Remove cap screw and valve cover clamp from the each side of the fluid chamber.

2. Insert the end of a standard screwdriver into the valve cover groove and pry each of the four the valve covers away from the fluid chamber and remove.







3. Remove the discharge valve disc-spring assembly and the perforated valve cage from each of the four (4) pump cylinders.

4. Use a finger to reach through the opening at the center of the seat and work the seat loose from the chamber. Note, the optional valve seat removal tool (FMC part number 1250638) may be used to simplify this procedure. Insert the round end of the tool into the seat and rock from side to side to loosen the seat, then use the other end of the tool to hook under the valve seat and remove.

5. Use the same procedure to remove the suction valve cage and valve seat, which are located directly under the discharge valve seat. Turning the valve seat on edge will help it go through the discharge valve seating area easier. Repeat for the remaining three (3) pump cylinders.

6. Inspect all valve components and replace as necessary. Note that even small damage or erosion to the sealing area of the valve or the o-ring can adversely affect the performance of the pump.

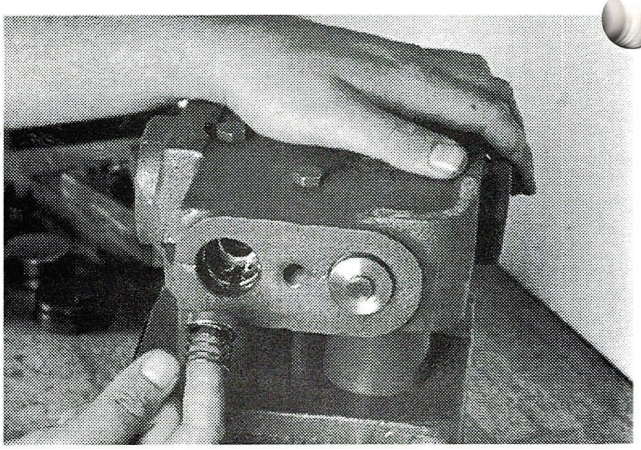
7. With the new o-ring in place on each valve seat, place a few drops of light oil around the o-ring to aid in installation. Place each valve seat SQUARELY in the counterbore in the bottom of the fluid chamber. Turn the valve seat on edge to help pass through the narrow areas of the pump. Use the round end of the FMC valve tool to aid in installation of the valve seats.

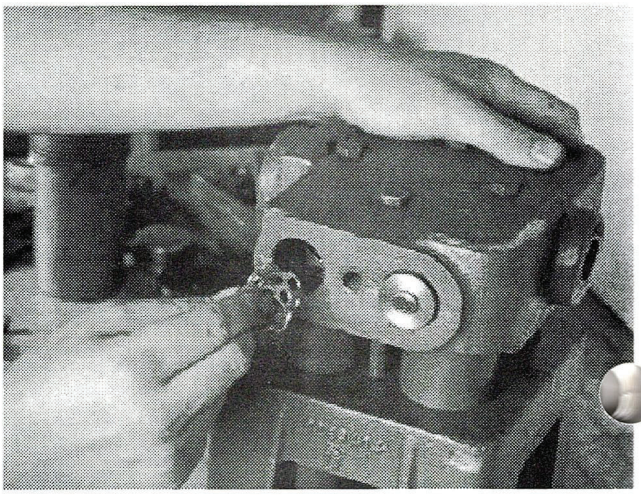
8. Place the valve cage on the valve seat and insert the disc/spring assembly inside of the cage on the valve seat. Note that the bottom of the valve disk should be installed facing the top of the valve seat.

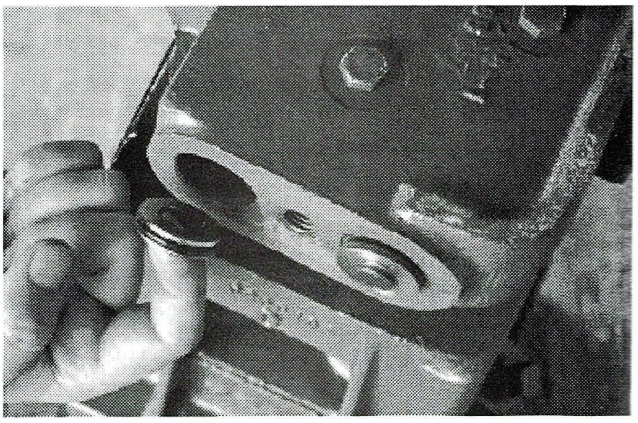
9. Repeat the previous two (2) steps to install the discharge valve seat and the discharge valve cage.

10. Place the valve covers (with o-rings on BOTTOM groove) in place over the valve assembly.

11. Replace valve cover clamp and cap screw and tighten as shown in the Fastener Torque Requirements section, page 19. Note: Over-tightening the cap screw can damage the valve components.







Servicing the Power End

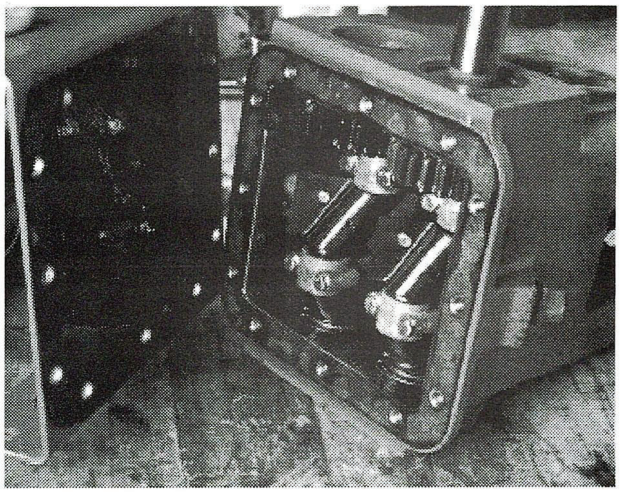
1. Remove bottom drain plug and allow all oil to drain from the power frame.

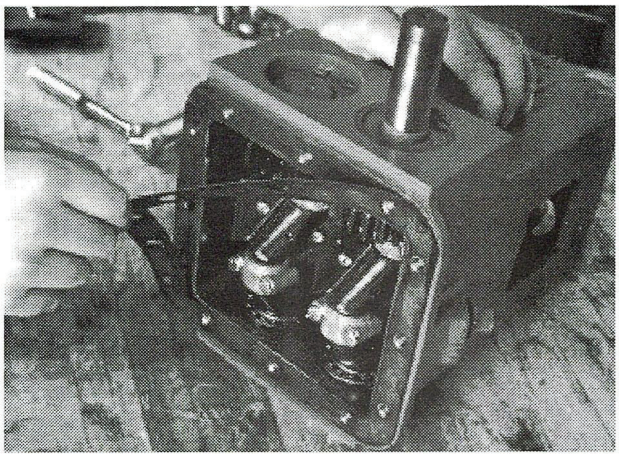
2. Disconnect suction and discharge piping, power source, and remove pump from mounting base.

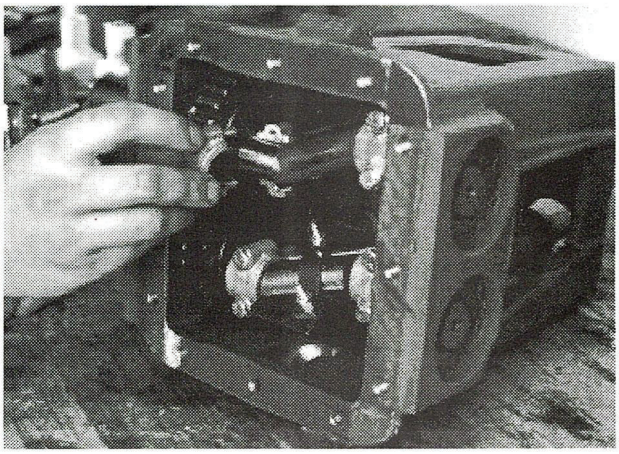
3. Although it is not required, it is easier to remove the crankshaft if the fluid end and pistons have been removed first. To remove the fluid end, follow steps 1-3 of the section titled Replacing Piston Cup Seals.

4. Remove the 12 (12) hex head cap screws, washers, and mounting base from rear of pump. After the mounting base is removed, the rear cover gasket can be removed.

5. Remove cap screws from the connecting rod assemblies and take out the back half of the four (4) the connecting rods. Note the orientation of the machine markings on the connecting rod and cap. Connecting rod halves are not interchangeable and must be reassembled in their original orientation and in the same cylinder.







6. Remove the oil slinger from the crankshaft.

7. Push the connecting rods and crosshead assemblies as far forward into the power frame as possible to provide clearance for the crankshaft.

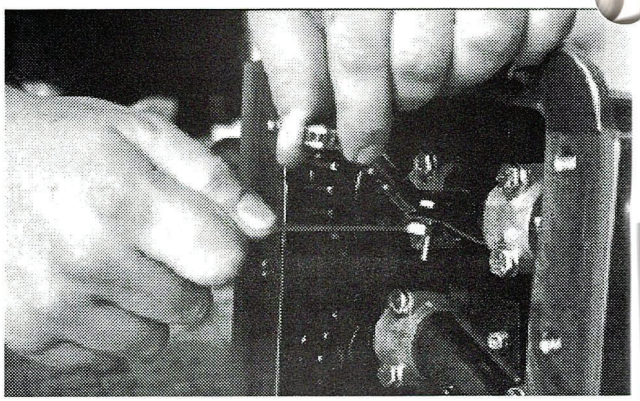
8. Use snap ring pliers to remove the four (4) crankshaft retainer snap rings from each side of the pump.

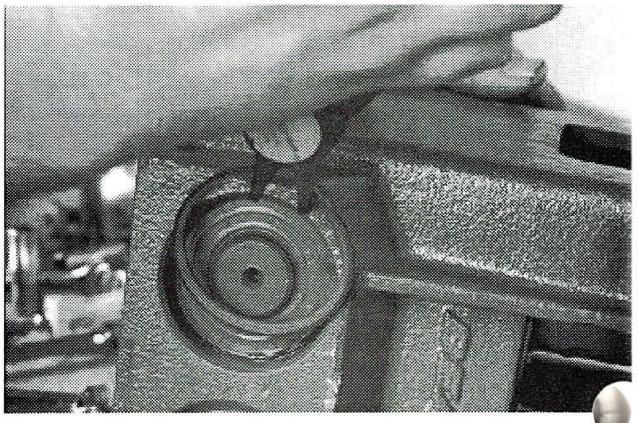
9. Using a hammer and wood block (or rubber mallet on the end of the crankshaft), drive each crankshaft until one bearing on each shaft clears the power frame. Drive from the gear side of the shafts.

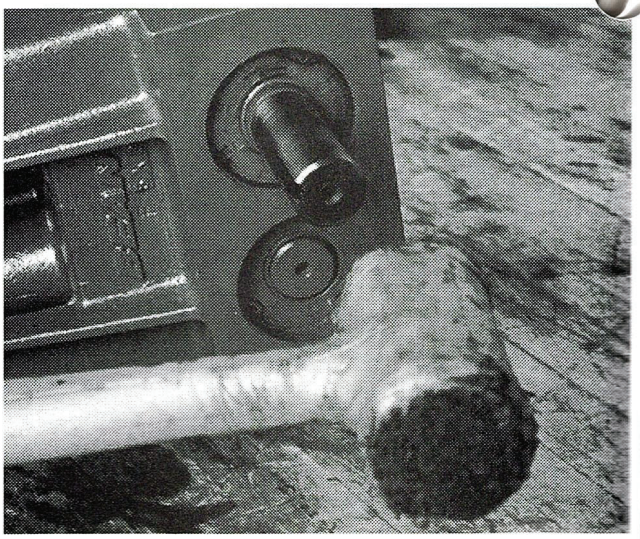
10. Remove the exposed bearings from the crankshaft using a press. Be sure to provide suitable support for the back side of the bearings during this step. Note: Never pound directly on the bearings or they may be damaged. Crankshafts with single bearing on each end may now be removed through bottom of power frame.

11. Carefully clean and inspect all parts. Replace worn or damaged components as necessary.

12. Place a single bearing on the gear side of each crankshaft and install in pump. Once the crankshaft has been placed in the proper position in the power frame the remaining bearings can be installed on the opposite end of the shaft.







13. Insure that timing marks on gears are aligned as shown for proper piston motion. Arrow (or dot) on one gear must be centered between two arrows (or dots) on other gear. Note area highlighted by circle in photo to right.

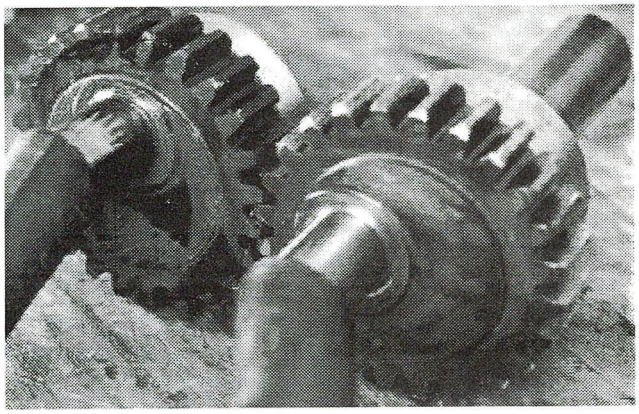
14. Place the oil seals over the ends of the crankshaft with the lip of the seals facing the inside of the power frame.

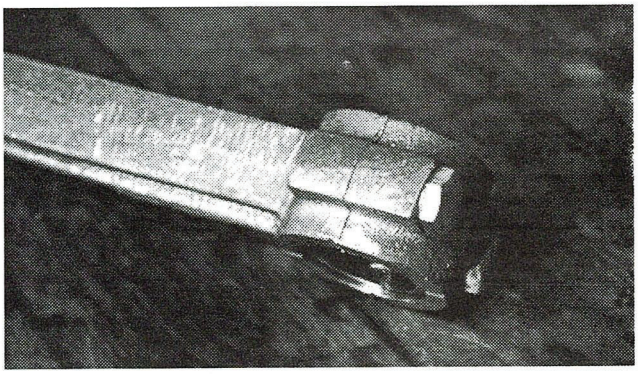
15. Seat the snap rings in the grooves in the bearing housing against the oil seals and tap the crankshaft to allow a SLIGHT endplay in the crankshaft.

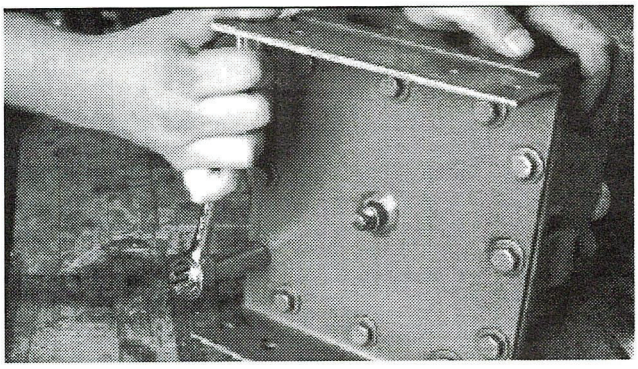
16. Reassemble the connecting rods and shell bearings around the crankshaft. The connecting rod and cap are a matched set. Be sure to properly match the connecting rods and caps back into their original position, orientation, and cylinder. Torque connecting rod bolts as shown in the Fastener Torque Requirements section, page 19.

17. Complete the reassembly by reversing steps 1-8. Torque mounting base cap screws as shown in the Fastener Torque Requirements section, page 19. Be sure to replace the drain plug in the mounting base.

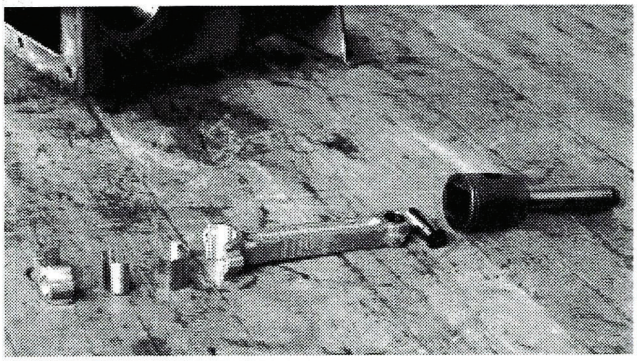
18. Refill the power frame with oil and turn the shaft over several revolutions by hand. When piston cups are not installed the pump shaft should rotate freely.







Servicing the Connecting Rod Bearings



1. Remove fluid chamber, cylinders, and piston cups using steps 1-3 from the Replacing Piston Cup Seals section, and the crankshaft as described in steps 1-10 of the section entitled Servicing the Power End.

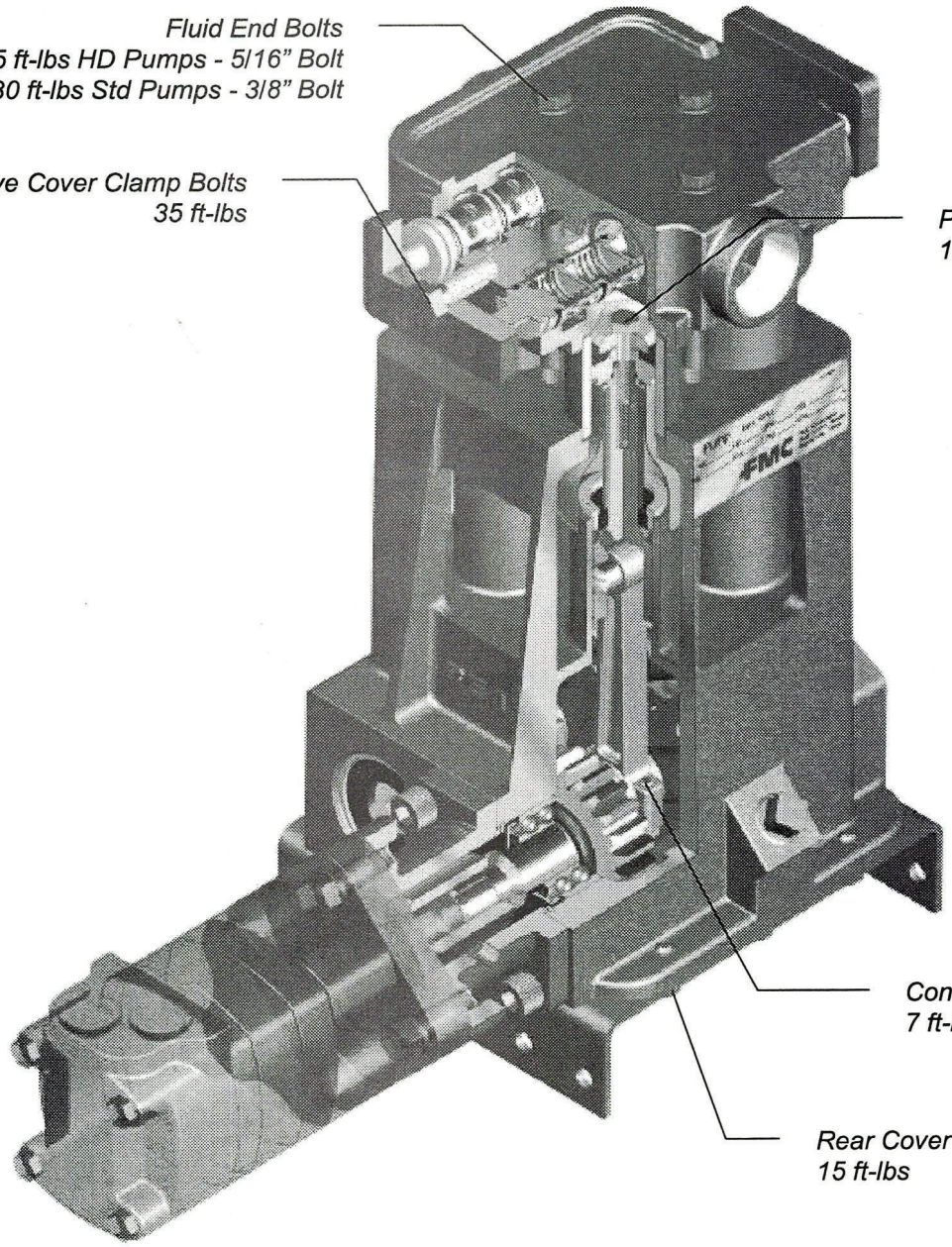
2. Once the crankshaft has been removed the connecting rod and crosshead assembly can be pulled from the back of the power frame opening.

3. The wrist pin is a slip fit through the connecting rod and crosshead. Check for signs of wear on the pin and connecting rod bushing. Replace the pin if noticeable wear is found. The complete connecting rod assembly must be replaced if the bushing is worn, as the wrist pin bushing is not field replaceable.

4. Reverse the sequence from steps 1-3 when reassembling the crosshead rod and cap. Insure that these parts are reassembled in their exact former orientation and position.

Fastener Torque Requirements

No pump service procedure is complete without insuring that the fasteners have been properly torqued. Failure to properly tighten the pump bolting could cause the pump to leak or even allow the bolts to fail. Always use a calibrated torque wrench during the installation of all critical fasteners listed below



Trouble-Shooting Piston Pumps

This chart is designed to aid in the solution of pump and pump system problems. Once the problem has been identified, work through the possible causes and solutions until the problem has been corrected.

1. No flow from pump

- Tank is empty
- Inlet valve is closed
- Inlet strainer is clogged with debris
- Crankshaft is not turning

2. Insufficient pressure from pump ONLY

- Pump speed is too slow
- Relief valve improperly adjusted and by-passing fluid
- Oversize or worn nozzle on equipment
- Worn pump valves
- Excessive leakage from pump seals

3. Insufficient flow from pump ONLY

- Pump speed is too slow
- Relief valve improperly adjusted and by-passing fluid
- Worn pump valves
- Excessive leakage from pump seals

4. Insufficient flow OR pressure AND rough operation

- Valve problem:
  a. Pump valve stuck in open or closed position
  b. Valve assembly is damaged or unseated
  c. Valve seat is washed out
- All pump cylinders not primed
- Inlet strainer is clogged with debris
- Excessive gas in liquid due to:
  a. Air leaks in suction line or fittings
  b. High spots in suction line that allow formation of gas pockets
  c. Vortex in tank near inlet pipe opening
- Pump is cavitating due to:
  a. Insufficient NPSHa (tank head or charge pressure)
  b. Fluid viscosity is too high
  c. Inlet line is too long and/or too small diameter

Ordering Parts

Service parts are available through FMC's worldwide network of distributors, or from the original supplier for the equipment that the pump is used on. If unsure where to purchase parts, contact FMC customer service for the location of an authorized parts retailer in your area. Always insist on genuine FMC replacement parts.

Use the assembly drawing included with this manual to determine the components and corresponding part numbers required to service the pump. Make sure that the part number on the drawing matches the part number of the pump requiring parts. When ordering parts, always reference the part number and serial number of the pump with the order. These numbers can be found stamped on the metal nametag affixed to the power end of every pump. By referencing these numbers you can insure that the components you receive work as intended with your pump.

Be sure to inquire about any special service tools or complete maintenance kits.

11. Crankshaft jerks or starts and stops rotation

- V-belts are loose and slipping (if equipped)
- Hydraulic system relief valve is chattering (if equipped):
  a. Attempting to operate pump at excessively high discharge pressure
  b. Discharge line is blocked or partially obstructed

12. Power end overheats (in excess of 180° F)

- Discharge pressure too high
- Low oil level
- Improper oil viscosity
- Contaminated power end oil
- Pump speed is too fast
- Pump is running backwards
- Couplings are misaligned
- V-belt drive tension is too tight
- Pump located too close to heat source
- Worn or damaged power frame bearings

13. Broken crankshaft or connecting rod

- Pump exposed to freezing conditions without proper draining
- Discharge pressure too high
- Suction pressure too high
- Hydraulic shock due to cavitation
- Material or manufacturing defect

14. Broken Fluid End Bolts

- Bolt or nut not properly torqued
- Discharge pressure too high
- Excessive piping loads on fluid end

15. Power end oil is contaminated

- Pump has been operated with failed piston cup for extended periods of time
- Use of high-pressure wash wand to clean near breather or oil seal areas
- Deflector shields are missing or damaged
- Crosshead extension oil seals are damaged or improperly installed
- Excessive capacity in liner wash system
- Improperly adjusted liner wash nozzle

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Glossary of Commonly Used Terms

CAPACITY	The total volume throughput per unit of time at suction conditions. It includes both liquid and any dissolved or entrained gases. For all practical purposes this can be considered the volume flow rate in the suction pipe. The standard unit of pump capacity is U.S. gallons per minute (GPM).
CAVITATION	The state where fluid pressure drops below vapor pressure, causing the liquid to begin to change from a liquid to a gas, "boil". Usually occurs in the chamber between the suction and discharge valves during the suction stroke, and often sounds like a mechanical knock. Cavitation results in the formation of gas bubbles, or cavities, in the fluid that cause vibration and damage when they are collapsed by the fluid pressure on the discharge stroke.
DAMPENER	A device which reduces liquid pulsations in the suction or discharge piping. May also be referred to as a suction stabilizer, accumulator, or surge suppressor.
DISPLACEMENT	The volume swept by all pistons or plungers per unit time. This term is typically expressed as gallons per revolution.
POWER END	The portion of the pump that provides power, or motion, to the liquid end. For power pumps it is often referred to as the Power End.
EFFICIENCY	Mechanical efficiency is the ratio, expressed as a percentage, of pump power output to the pump power input. The mechanical efficiency of reciprocating pumps is very high, typically in excess of 90%. Volumetric efficiency is the ratio of actual pump capacity to theoretical displacement
FLOODED SUCTION	Implies that the liquid will flow from an atmospheric source to the pump without the average pressure at the intake port of the pump dropping below atmospheric pressure with the pump operating at a specified capacity.
FLUID END	The portion of the pump which surrounds, and is in contact with, the pumpage. May also be called Liquid End.

NPSHA	An abbreviation that stands for Net Positive Suction Head Available. NPSHa is the total suction pressure, including allowance for acceleration head, available from the system at the pump suction connection, minus the vapor pressure of the liquid at actual pumping temperature. NPSHa for a reciprocating pump is normally expressed in units of ft-H2O.
NPSHR	An abbreviation that stands for Net Positive Suction Head Required. This is the minimum total inlet pressure required by the pump for proper operation. This value is a function of pump speed and is determined by the pump manufacturer through a specific NPSH test.
PISTON	A type of power pump that uses a cylindrical seal (piston) mounted on a holder to drive fluid through the valves. The piston seal reciprocates within a stationary cylinder.
PLUNGER	A type of power pump that uses a cylindrical plunger to drive fluid through the valves. The plunger reciprocates through a stationary set of seals known as packing.
POWER PUMP	A reciprocating pump that drives the pumping element(s) using a slider crank mechanism. Power pumps are piston, plunger, or diaphragm type. All require a driver with a rotating shaft, such as a motor or engine, as a power source.
POWER FRAME	The major portion of a power pump that encloses and supports all other components of the power (or drive) end.
STROKE LENGTH	One complete, unidirectional motion of the piston or plunger. Stroke length is usually expressed in inches.
VALVE	Reciprocating pumps use a series of check valves operated by differential pressure to trap and push fluid through the pump.