

OPERATION, MAINTENANCE, & STORAGE PROCEDURE**M28 MANUAL**

Rev	ECN No.	Date	Reviewed By	Approved By	Status
A	5011457	30-Jan-04	Storey, Bryan T.	Herold, John R.	RELEASED

Summary:

This is an operations, storage and maintenance manual for an M28 pump. The M28 is a seven inch stroke triplex positive displacement pump.

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1.0 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.

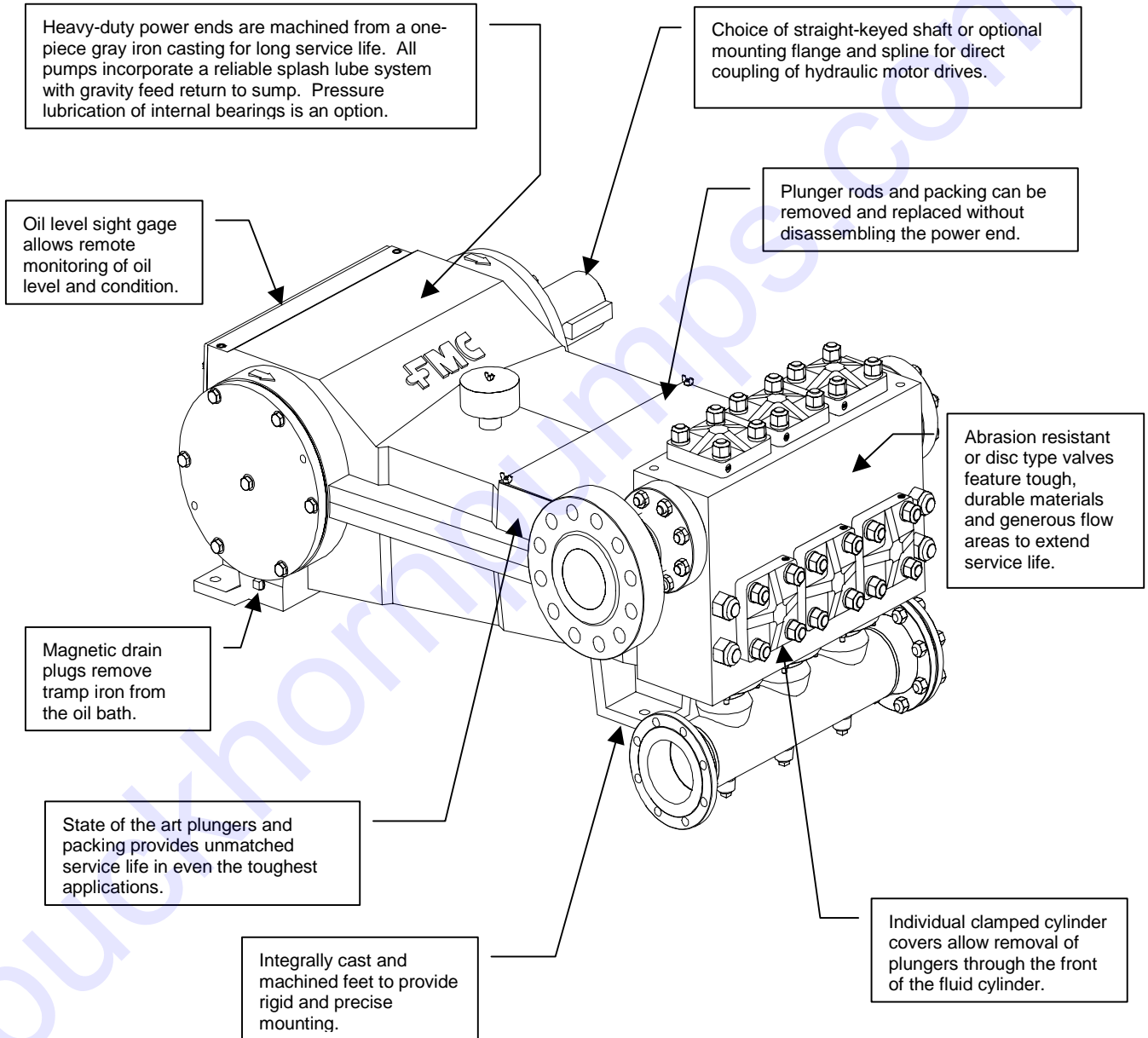
Always use guards on all belt drives and couplings. Guards can prevent personnel from becoming entangled and injured in rotating parts.

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.

2.0 M28 Pump Features

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



3.0 Storage Instructions

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

3.1 Short Term Storage

1. 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 for pumps in corrosive fluid applications, the fluid end should be drained, flushed with water or other non-corrosive cleanser and blown dry using compressed air whenever idle.

3.2 Short Term Storage for Severe Environments

1. Drain any fluid from pump, flush the fluid end with water to clean out any of the remaining pumpage and blow dry with compressed air. Spray a fog of preservative oil into the 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 (for example, the 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.

3.3 Long Term Storage

1. Long-term storage is defined as any period when the pump is in storage or idle in excess of six (6) months. 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.
2. Drain all remaining oil from the pump power end. Remove the rear 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 rear cover and add a concentrated internal rust inhibitor per recommendations (see Recommended Lubricant Chart, page 9).

3. Spray a rust preventative onto all exterior machined surfaces paying careful attention to any unpainted areas like the crankshaft extension and plunger rods. Remove the power end breather cap and store in a dry place. Cap the breather opening with a plug or other suitable means in order to keep the preservative atmosphere sealed inside the power frame.
4. 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.
5. Before operating the pump, drain the preservative and lubricating oil mixture from the power end. Reinstall the drain plug, breather/filler cap, 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. FMC can factory prepare units for extended storage for a nominal fee if specified at the time of order.

3.4 Precautions during Freezing Weather Conditions

1. 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.
2. 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.
3. As an alternative to the previous procedure, a compatible antifreeze solution can be circulated through the fluid end. RV antifreeze, propylene glycol, is recommended for this purpose.

4.0 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.

4.1 General Location

It is important to position the pump on a flat, level surface to assist the splash oil lubrication 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.

4.2 Mounting Pump to Foundation and Power Source

1. The M28 pump must be mounted in a horizontal position only. Secure the pump to the mounting surface using the four (4) holes provided in the pump base. Check motor or engine rotation direction to insure that the top of the pump drive shaft rotates towards the pump fluid end when in operation.
2. 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 the proper tension as recommended by the belt manufacturer. Verify that the sheaves are in line and running parallel to each other with a straight edge or other device. Never operate the pump without the belt guard securely in place.
3. For direct-coupled or spline driven units, insure that the shafts are centered and parallel when the driver is mounted to the pump. Never operate the pump without a shaft guard securely in place.

4.3 Suction Piping Recommendations

1. Poor suction piping practices are a very common source of pump problems. To insure proper operation it is very important to follow good design practice in the installation of the suction system before the pump is operated. A small amount of extra time and money invested in the piping 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 recommends that a gage always be installed in the suction line directly before it enters the pump.
2. The suction line from the fluid source to pump should be as short and direct as possible. Use rigid piping, non-collapsible hose or a combination of both as circumstances warrant in your installation. The suction pipe size should be at least equal to or 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 successfully.

3. 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.
4. 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. Make sure that all joints and connections are airtight. Air leaks reduce the capacity of the pump and can result in cavitation, rough operation, and/or loss of prime. To help isolate mechanical and hydraulic vibrations, FMC recommends the use of flexible hose connections between the pump and any rigid piping.
5. Always insure that calculated system net positive suction head available (NPSHa) exceeds pump net positive suction head required (NPSHr) by at least 5 feet (1.5 meters) of water for proper operation of the pump. NPSH requirements for each pump model are provided on the product data sheets available through FMC or you authorized FMC reseller. FMC does not recommend using the pump in static lift conditions without prior approval.

4.4 Discharge Piping Recommendations

1. 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 150 feet (50 meters), it is suggested to use the next larger size pipe to minimize friction losses

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

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.

2. 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.
3. 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 or the use of pulsation dampeners.
4. 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 deadhead 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.

4.5 Multiple Pump Systems

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

5.0 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 plugs on the bottom of the pump crankcase have been installed and are tight. Insure that the oil level sight glass 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 M28 pump requires 13 gallons (49.2 liters) of oil. Use the chart provided in Section 6 for assistance 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. Verify that all joints are pressure tight.
4. Open the suction line valve to allow fluid to enter pump.
5. Check to insure that power is locked out, and then turn the pump over by hand if possible 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 discharge pressure). Slowly close the bypass line to bring the pump into full load conditions. Shut down immediately if the flow becomes unsteady, pressure fluctuates or if unusual sounds or vibrations are noted.

6.0 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 Temperature	ISO Grade (cSt)	AGMA Number	SAE Weight	SSU Viscosity	Brand Names
General Service	0 - 95° F	100	3	30	550	Texaco Meropa 100 Shell Omala 100 Shell Rotella T SAE 30 Exxon XD-3 30 wt Mobil Trans HD-30
High Ambient Temperatures	95 - 120° F	220	5	50	1165	Texaco Meropa 220 Shell Omala 220 Shell Rotella T SAE 50 Exxon HD-3 50 wt Mobil Trans HD-50
Cold Ambient Temperatures	-30 - 60° F	68	2	20	350	Texaco Meropa 68 Shell Omala 68 Shell Rotella T SAE 20 Exxon HD-3 20 wt Mobil Trans HD-20
Frequent Start-Stop Cycles		150	4	40	775	Texaco Meropa 150
Specialty Items						
Internal Rust Inhibitor						Cortec VCI 329
External Rust Preventative						Texaco Metal Protective Oil L
Packing Lubrication		Rock Drill Oils			Exxon Arox 150 Shell Toreula 150 Mobil Almo 529	

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7.0 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 plugs are 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
	Packing Sets	Inspect	Check the stuffing box area of the pump for signs of leakage. Replace packing if leakage becomes excessive.
	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 plugs.

8.0 Component Parts List

A typical M28 pump configuration is shown below for general reference purposes for service procedures outlined in the following sections. Actual pumps supplied by FMC may use slightly different components or configurations. To order service parts or see exact component configurations for your particular pump, refer the cross section drawing in the literature kit supplied with the pump. Contact your OEM reseller or FMC if you do not have this information.

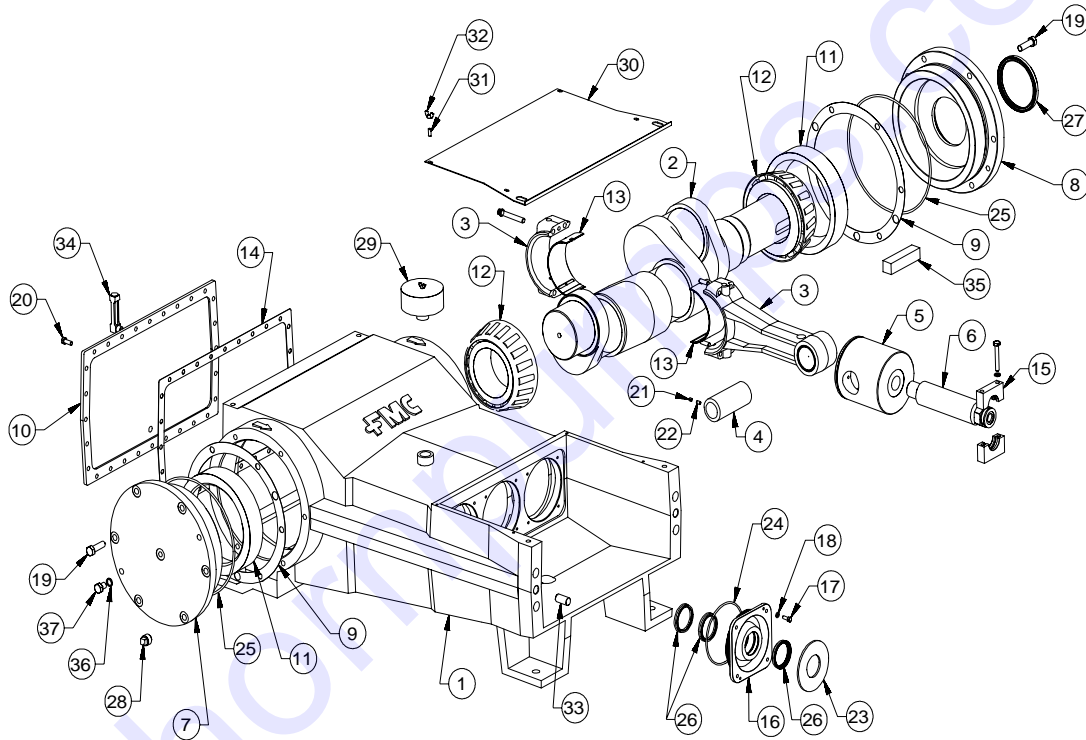


Figure 1: Power End Components

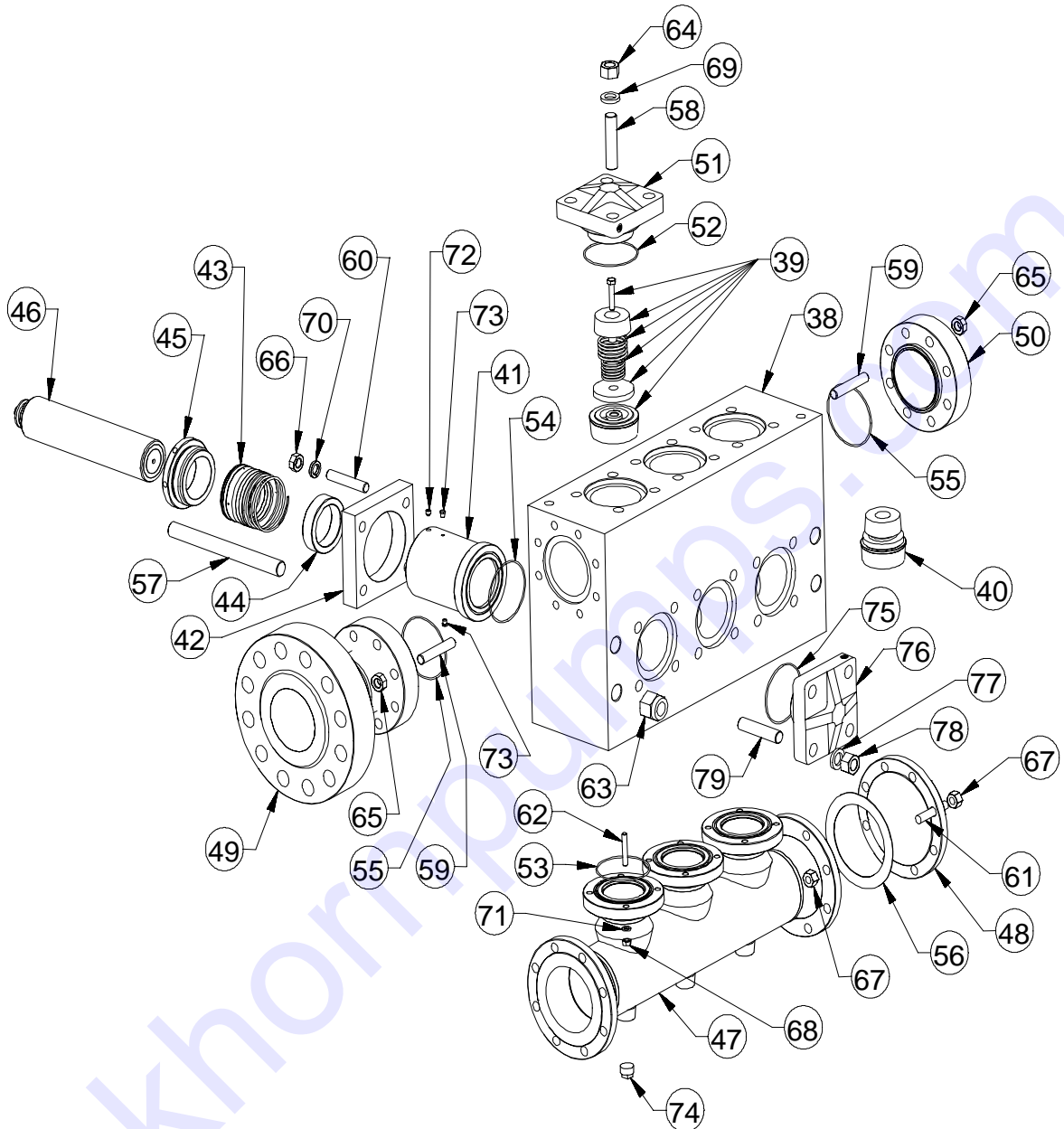


Figure 2: Fluid End Components

Item Number	Description	Quantity Required
1	Power Frame	1
2	Crankshaft	1
3	Connecting Rod Assembly	3
4	Wrist Pin	3
5	Crosshead	3
6	Plunger Rod	3
7	Blind Bearing Housing	1
8	Bearing Housing	1
9	Shim	As needed
10	Back Cover	1
11	Bearing Cup	2
12	Bearing Cone	2
13	Rod Bearing	6
14	Back Cover Gasket	1
15	Plunger Clamp Assembly	3
16	Seal Housing	3
17	Cap Screw(Seal Housing)	12
18	Lock Washer	12
19	Cap Screw(Bearing Housing)	12
20	Cap Screw(Back Cover)	28
21	Set Screw	3
22	Set Screw	3
23	Deflector Shield	3
24	O-ring(Seal Housing)	3
25	O-ring (Bearing Housing)	2
26	U Cup Seal	9
27	Oil Seal	1
28	Magnetic Pipe Plug	3
29	Oil Filler/Breather	1
30	Cradle Cover	1
31	Stud(Cradle Cover)	4
32	Wing Nut	4
33	Dowel Pin	2
34	Liquid Level Gage	1
35	Key	1
36	Nylon Washer	1
37	Hex Head Cap Screw	1
38	Fluid Cylinder	1
39	Discharge Valve Assembly	3
40	Suction Valve Assembly	3

Item Number	Description	Quantity Required
41	Stuffing Box	3
42	Stuffing Box Clamp	3
43	Plunger Packing	3
44	Throat Bushing	3
45	Adjusting Nut	3
46	Plunger	3
47	Suction Manifold	1
48	Blind Flange (Suction)	1
49	Discharge Spool	1
50	Blind Flange (Discharge)	1
51	Valve cover	3
52	O-ring(Valve Cover)	3
53	O-ring(Suction Manifold)	3
54	O-ring(Stuffing Box)	3
55	O-ring(Discharge Flange)	2
56	Gasket	1
57	Stud(Fluid Cylinder)	4
58	Stud(Valve Cover)	12
59	Stud(Discharge Flanges)	16
60	Stud(Stuffing Box Clamp)	12
61	Stud(Suction Flange)	8
62	Stud(Suction Manifold)	12
63	Lock Nut	4
64	Hex Nut(Valve Cover)	12
65	Hex Nut(Discharge Flanges)	16
66	Hex Nut(Stuffing Box Clamp)	12
67	Hex Nut(Suction Flange)	8
68	Hex Nut(Suction Manifold)	12
69	Lock Washer(Valve Cover)	12
70	Lock Washer(Stuffing Box Clamp)	12
71	Lock Washer(Suction Manifold)	12
72	Set Screw(Nylon Tipped)	3
73	Pipe Plug (Stuffing Box)	6
74	Pipe Plug (Suction Manifold)	3
75	O-ring(Cylinder Cover)	3
76	Cylinder Cover	3
77	Lock Washer(Cylinder Cover)	12
78	Hex Nut(Cylinder Cover)	12
79	Stud(Cylinder Cover)	12

9.0 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.

9.1 Replacing Plunger Packing

1. To make service easier, it is suggested that several gallons of clean water be pumped through the M28 before any service procedures that involve fluid end components are started. This action will remove a significant portion of contaminants left in the fluid cylinder by the normal pumpage and improve the ability to work with the parts or spot potential problem areas. Refer to the following page for the position of parts.
2. Bleed off all pressure inside pump fluid end before starting any service work. Shut the valve on the inlet piping if provided to prevent flow of liquid from the source into the pump during service. **CHECK TO INSURE THAT THE POWER IS LOCKED OUT.**
3. Unbolt the plunger clamps (15) and remove them from the plungers (46) and plunger rods (6). Remove the nuts (66) holding the stuffing box clamps (42) to the fluid cylinder (38) and remove the stuffing box clamps (42).
4. Rotate the crankshaft by hand until one of the plunger rods (6) is fully retracted from the plunger (46). Slide the plunger and stuffing box out of the cradle of the pump as a single unit. Repeat this procedure for the other two plunger stuffing box assemblies.
5. Loosen the set screw (72) locking the threads on the adjusting nut (45) and unscrew the adjusting nut. Use caution because the packing (43) is spring loaded. Pull the plunger (46) from the assembly and remove the packing (43).

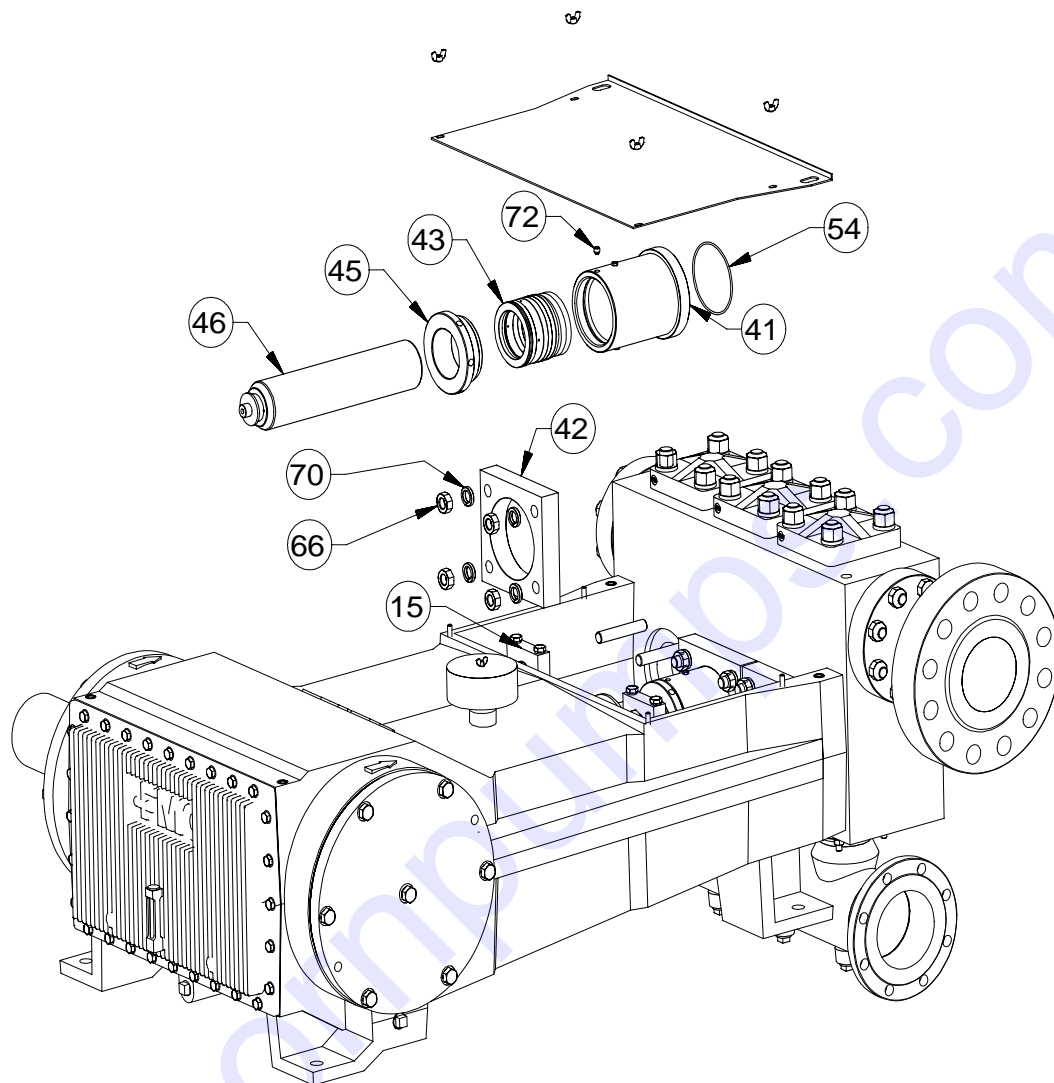


Figure 3: Plunger Packing Replacement

6. An alternate method for removing the stuffing box assemblies is to remove the nuts (78) that hold the cylinder covers (76) on the front of the fluid cylinder (38) and remove the cylinder covers (76). With the covers off, remove the plungers (46) by pulling them out through the front of the fluid cylinder (38). The stuffing box assemblies can then be removed through the cradle area of the pump. The advantage to this process is that the stuffing box assemblies are much lighter with the plungers removed.
7. Inspect all parts for damage or unusual wear patterns and replace any components that appear damaged. Insure that the plungers are smooth and free of cracks, scores and grooves. New packing will fail prematurely if used with plungers that have damaged or have rough surfaces. FMC recommends that all three packing sets be replaced, not just those that show signs of leakage, whenever this type of service is performed. This will help insure maximum operation time between service intervals.

8. Reverse the previous steps to rebuild the pump after worn or damaged components have been replaced. FMC recommends that all seals or gaskets that are disturbed during a service procedure be replaced. This includes the stuffing box face seal o-ring (54), cylinder cover o-rings (75), and valve cover o-rings (52). Insure that all fasteners are tightened to the values specified in the Fastener Torque Requirements section of this manual.

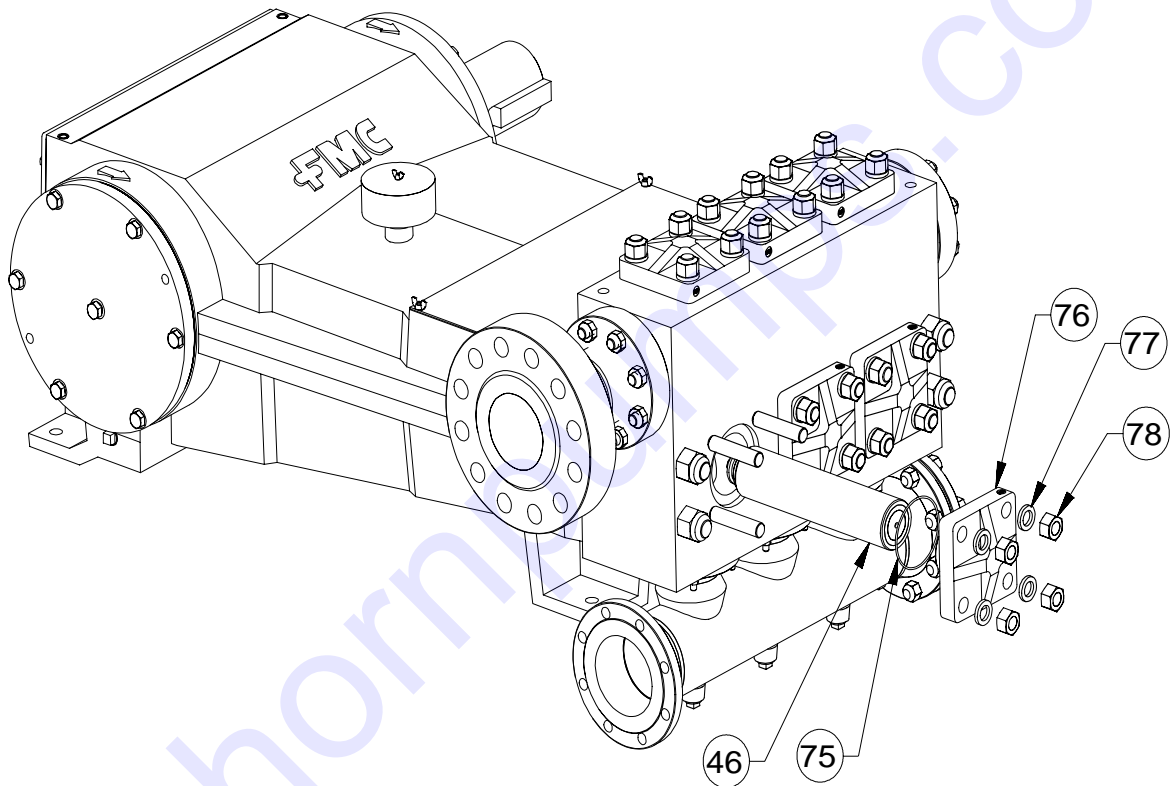


Figure 4: Cylinder Cover Removal

9.2 Removing the Fluid Cylinder

1. The fluid cylinder is removed to inspect for internal damage or to be refurbished.
2. To make service easier, it is suggested that several gallons of clean water be pumped through the M28 before any service procedures that involve fluid end components are started. This action will remove a significant portion of contaminants left in the fluid cylinder by the normal pumpage and improve the ability to work with the parts or spot potential problem areas.
3. Bleed off all pressure inside pump fluid end before starting any service work. Shut the valve on the inlet piping if provided to prevent flow of liquid from the source into the pump during service. **CHECK TO INSURE THAT THE POWER IS LOCKED OUT.**
4. Unbolt the plunger clamps (15) and remove them from the plungers (46) and plunger rods (6). Slide all of the plungers forward as far as possible.
5. Disconnect the suction and discharge piping.
6. Remove the lock nuts (63) holding the fluid cylinder assembly on to the power frame (1). Support the weight of the fluid cylinder assembly and slide the assembly away from the power frame (1).

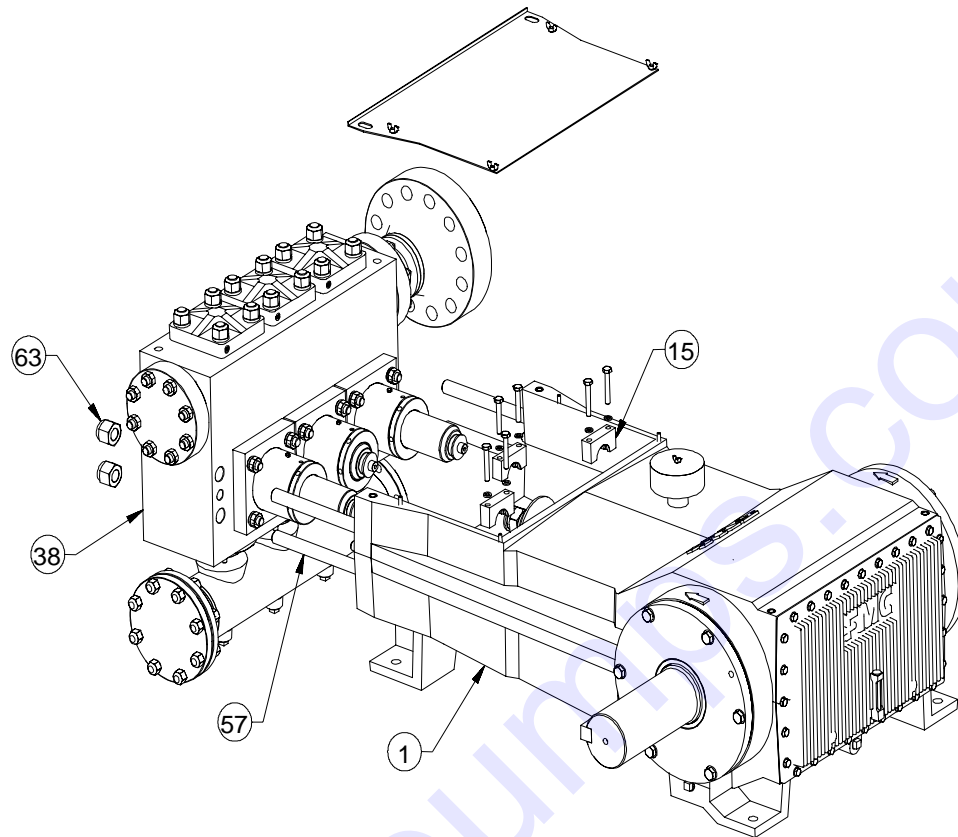


Figure 5: Removal of Fluid Cylinder

7. Installation will be the reverse of this procedure. Torque all fasteners as outlined in the Fastener Torque Requirements section of this manual. Please note that if the lock nuts (63) on the fluid cylinder studs (57) are not adequately torqued a failure is highly likely.

9.3 Replacing Plunger Rod Oil Seals

1. The plunger rod oil seals retain oil in the power frame (1) and prevent dirt, water, or other contaminants from entering the power frame (1) by way of the plunger rods. The fluid end need not be disturbed to perform this procedure.
2. Bleed off all pressure inside pump fluid end before starting any service work. **CHECK TO INSURE THAT THE POWER IS LOCKED OUT.**
3. Unbolt the plunger clamps (15) and remove them from the plungers (46) and plunger rods (6).
4. Rotate the crankshaft (2) by hand until one of the plungers (46) is moved fully forward, toward the fluid cylinder (38), and the plunger rod (6) is fully retracted.

5. Slide the deflector shield (23) off the end of the plunger rod (6).
6. Unbolt the four cap screws (17) holding the plunger rod seal housing (16) to the power frame (1). If needed the cap screws (17) can be used to jack the seal housing (16) away from the power frame (1) using the two tapped holes provided. Pull the seal housing over the end of the plunger rod and out of the cradle. Repeat these three steps for the other two seal housings.
7. Remove the cup seals (26) and the o-ring (24) from the seal housing (16). Note the orientation of each seal prior to removing it.
8. Inspect the plunger rod (6) at this time. If it is scored or damaged in any way it must be removed. To remove the plunger rod (6) unscrew it from the crosshead (5). A new plunger rod (6) is screwed into the cross head (5) and torqued per the Fastener Torque Requirements section of this manual.
9. Install a new o-ring (24) and new seals (26) in the seal housing (16) in the same orientation that they were originally.
10. Replace the seal housing (16) in the power frame cradle over the plunger rod and into position in the counterbore. Tap into position using a rubber mallet. The four cap screws (17) can be used to evenly draw the seal housing (16) into place. Take care to avoid folding the seal lips back when they are pushed over the plunger rod and cutting the o-ring (24) when the seal housing (16) is installed in the power frame (1). A small amount of motor oil on the plunger rod and the seal bore in the power frame (1) will aid this process and provide lubrication to the seals (26) during start-up.

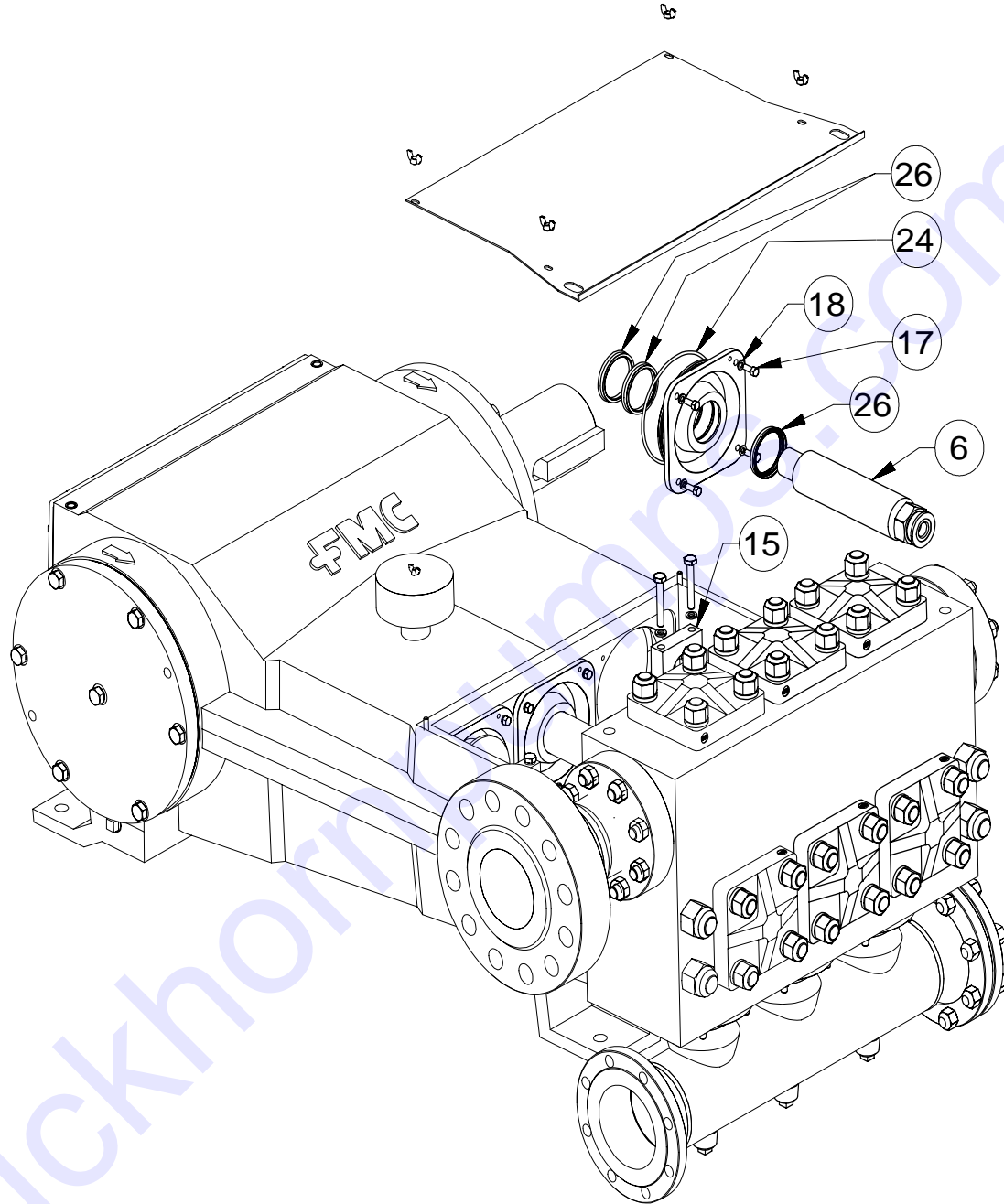


Figure 6: Oil Seal Replacement

9.4 Replacing Valves

1. Two types of valves may be supplied with an M28 pump. They are disc type valves and AR style valves. The next steps must be performed for either type of valve.
2. Adequate clearance is required above, below, and in front of the pump fluid cylinder to allow valve service without removal of the fluid end. If sufficient clearance is not available, the fluid end must be removed as outlined in other sections and taken to a work shop for valve service. The following procedure is written under the assumption that sufficient clearance exists.
3. Loosen the hex nuts (64) that retain the three valve covers (51) on the top of the fluid cylinder. Remove the covers (51).
4. For AR type valves refer to [MSP500000080](#). This document describes the methods for removing and installing the AR valves.
5. For disc type valves refer to [MSP500000081](#). This document describes the methods for removing and installing disc valves.
6. After the valves have been replaced, inspect the o-ring (52) on the valve cover (51). FMC recommends that the valve cover o-rings (52) be replaced at this service interval even if they do not appear damaged. Fit the valve cover (51) with the o-ring (52) in place over the studs (58). Replace valve cover lock washers (69) and the valve cover hex nuts (64). Torque the cover hex nuts (64) to the recommend values listed in the Fastener Torque Requirements section of this manual.

9.5 Servicing the Power End

1. Disconnect the driver from the pump and insure that suction and discharge lines are disconnected or blocked and have no pressure applied. Removal of the fluid cylinder simplifies most power end service procedures.
2. Remove magnetic pipe plugs (28) from bottom of pump and allow all oil to drain from crankcase.
3. Remove the 28 rear cover cap screws (20). Remove the back cover (10) and back cover gasket (14) from the pump case (1).

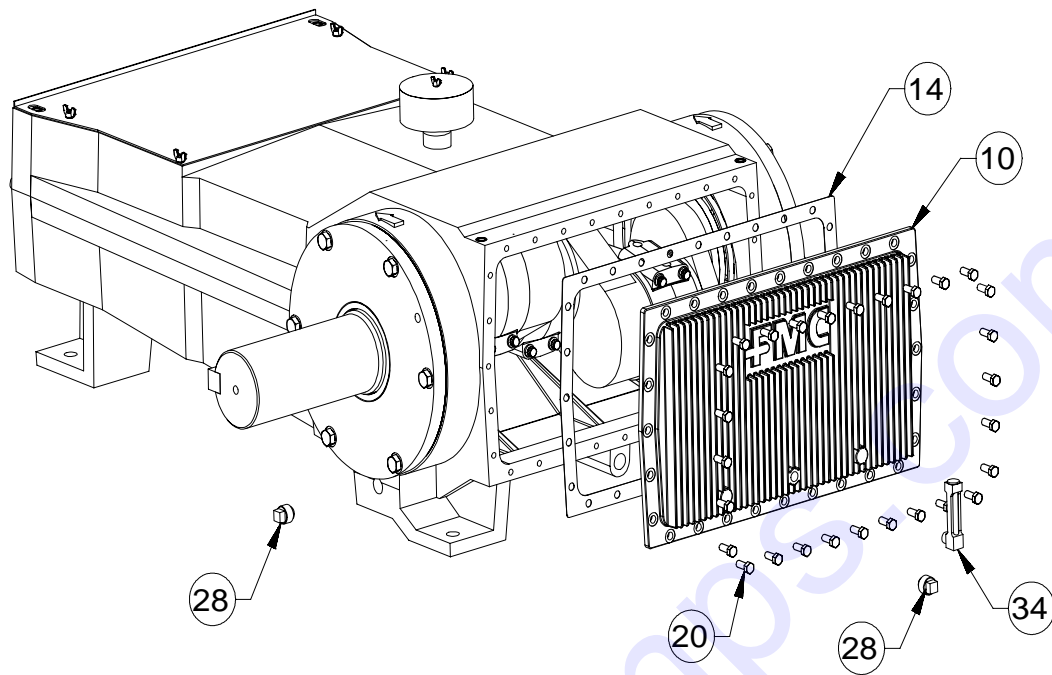


Figure 7: Back Cover Removal

4. Remove the end cap of the connecting rod (3) by unscrewing the four cap screws that hold each cap to the rod body. The connecting rod cap can be separated from the body by unscrewing the cap screws slightly and tapping on the heads.
5. Slide the six rod bearings (13) from the connecting rod (3) and rod cap (3). Note that these parts sometimes adhere to the crankshaft pin (2).
6. Connecting rods and caps are matched sets and must always be reassembled with their original mate and in the same orientation. Note the numbered codes stamped on each half of the connecting rod assemblies and make certain they are installed as matched set and in the same orientation when re-assembling the pump.
7. Unbolt the four cap screws (17) holding the plunger rod seal housing (16) to the power frame (1). If needed the cap screws (17) can be used to jack the seal housing (16) away from the power frame (1) using the two tapped holes provided. Pull the seal housing over the end of the plunger rod (6) and out of the cradle.
8. Push the connecting rods (3) and crosshead assemblies (5) as far forward into the power frame (1) as possible to provide clearance for the crankshaft (2). This will provide additional clearance when removing the crankshaft (2).

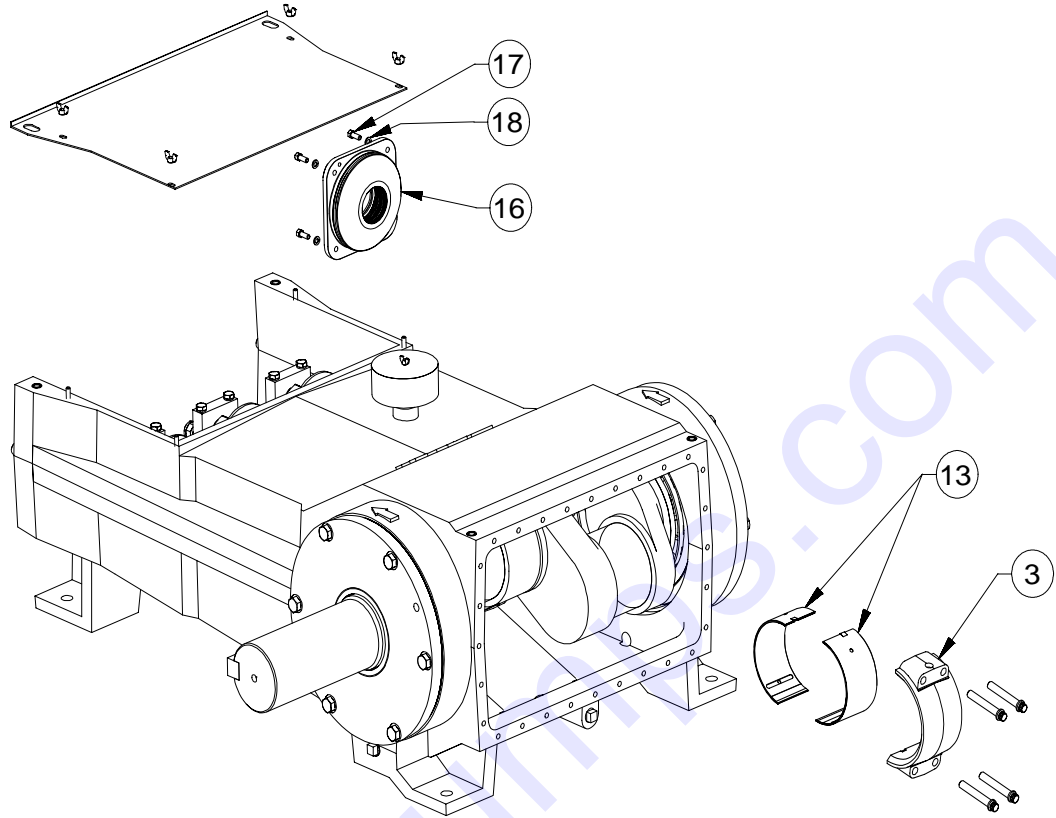


Figure 8: Power End Disassembly

9. Remove blind side bearing housing (7), hex head cap screws (19) and shims (9). Remove the drive side bearing housing (8), hex head cap screws (19) and shims (9). Note that the bearing cups (11) and crankshaft oil seal (27) will remain attached to the bearing housing (8). It may be necessary to tap on the housing with a rubber mallet to free it from the power frame (1) after the hex head cap screws (19) have been removed. If that is not adequate, tapped jack screw holes which are the same size as the cap screws (19) holding the housings in place have been provided in each bearing housing to help remove stuck housings.

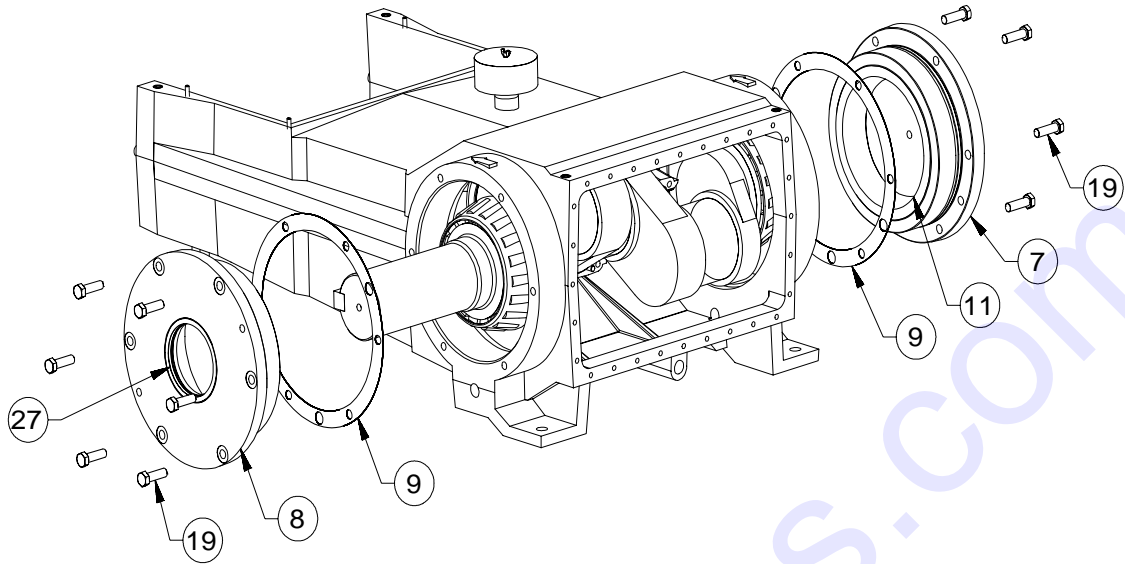


Figure 9: Crank Shaft Bearing Removal

10. To remove the crankshaft (2) work it through one side of the bearing housing opening in power frame (1) to remove. Tool P517959 (A) is extremely useful for this purpose, as the typical crankshaft weighs nearly 600 pounds. The throws may have to be rotated as the crank is removed to clear the connecting rods. The crankshaft should be handled very carefully to prevent the critical bearing surfaces from being scratched or damaged.
11. Bearings cones (12) can be removed from the crankshaft (2) using an automotive type bearing puller. Bearing cups (11) can be removed from the bearing housing using a puller if a sufficient lip is available for the puller arms to grab. An alternate procedure involves running a weld bead around the inside surface of the cup. When cool, this will reduce the interference between the cup and bearing housing enough to free the cup. Always replace with new bearing cups and cones.

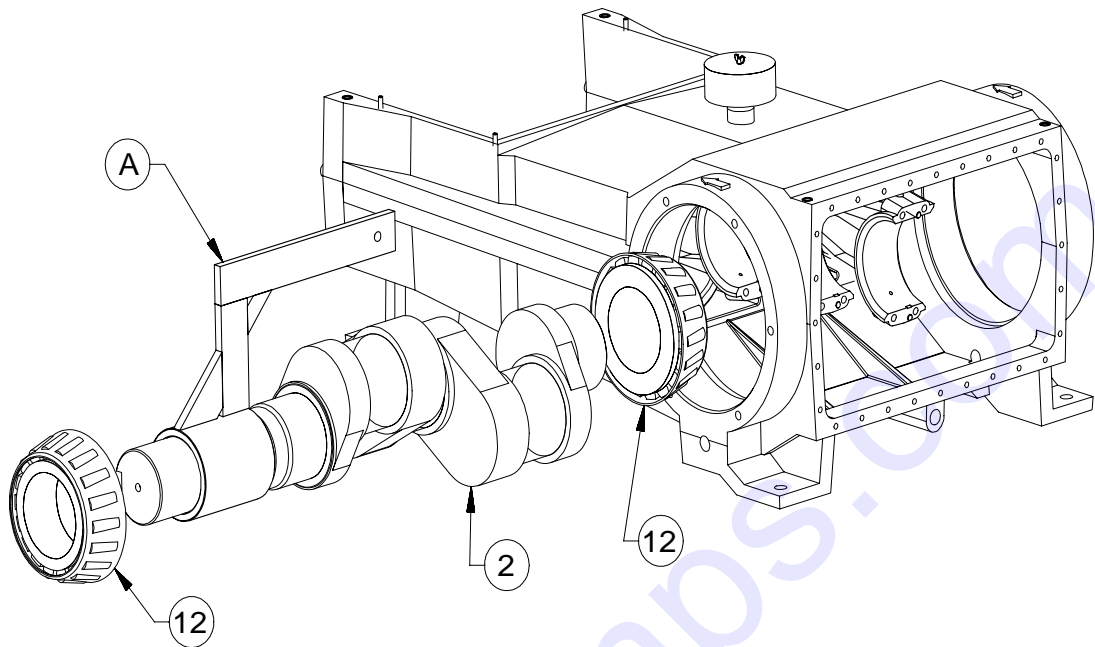


Figure 10: Crankshaft Removal

12. Pull connecting rod and crosshead assemblies from the power frame (1). Take care to insure they are reassembled into the same bore from which they were removed.
13. Inspect all components for signs of wear or damage and replace if required. Carefully check the crankshaft bearing surfaces for pits, scratches or other signs of wear. If any of the bearings are damaged and must be replaced, FMC recommends that all bearings be replaced even though some may not show visible signs of damage.

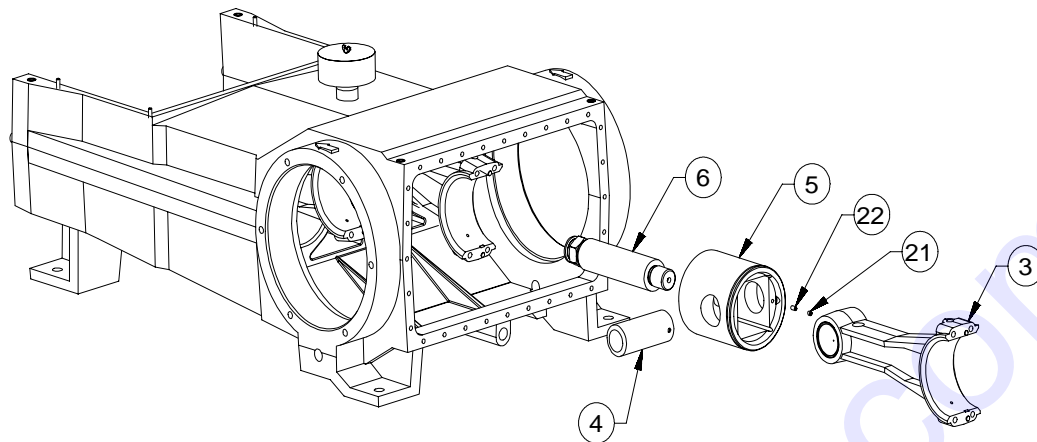


Figure 11: Cross Head and Con Rod Removal

14. Thoroughly clean all parts with solvent and apply a thin coat of oil before reassembly.
15. Tapered roller bearing cones must be heated to aid in assembly to the shaft. Always observe proper safety procedures and use heat resistant tools and gloves when handling hot parts. There are a number of recommended methods for heating bearings. Electric ovens or electrically heated oil baths may be used, but only when accompanied by proper thermostatic control.
16. To replace the crankshaft (2) tapered roller bearings, heat the cones to a maximum of 300° F and slide down the shaft until it is fully seated against shoulder. The hot cone (12) may pull away from the cold shoulder unless it is held in position until it cools enough to grab the shaft. Use a .001" thick feeler gauge to insure the cone (12) is fully seated against the shoulder after parts have cooled.
17. Use a press to seat the new cups (11) in the bearing housing (7 & 8). Never use new bearing cones (12) with old bearing cups (11).
18. Reassemble the crosshead assemblies (5) and connecting rods (3). Install new rod bearing inserts (13). Insure that the set screws (21 & 22) retaining the wrist pins (4) are in place if they were removed for repair or inspection of the wrist pin bushing.
19. Push the crosshead assemblies fully forward in power frame (1) to provide maximum clearance for the crankshaft (2). Insure crosshead assemblies (5) are replaced in same orientation and in the same cylinder bore they were originally. The oil cup pocket feeding lubricant to the wrist pin bushing is on the top of the connecting rod (3) and should be in the up position.
20. Install crankshaft (2) in the power frame (1). Take care not to scratch bearing surfaces of the crank (2). Again tool P517959 (A) is very helpful for this purpose due to the weight of the crankshaft (2).
21. Reinstall the shims (9) and bearing housings (7 & 8). As a starting point, install the same number of shims (9) that the pump originally had prior to service. Inspect the o-ring (24) that seals the bearing housing (7 & 8) and replace it if damaged.

22. Replace the rod bearings (13) in the connecting rod caps. Insure that rod caps are assembled with their mating connecting rod. Torque the cap screws holding the end caps to the mating rod per the values given in the Fastener Torque Requirements section of this manual. After the cap screws are torqued, striking the cap with a rubber hammer will help properly seat the rod bearings.
23. A dial indicator must be used to properly adjust the endplay of the crankshaft (2). Improper adjustment may result in excessive temperature, noise, and reduced bearing life. FMC recommends between .002”-.005” of internal axial clearance (end play) when properly assembled. The final adjustment must be verified using a dial indicator.
24. Turn the crankshaft (2) more than two revolutions to insure the connecting rods are loose, there is no binding in the rod bearings, the wrist pin joints are free and the crossheads move freely in the power frame (1).
25. Mount indicator base on back of power frame (1) with the indicator tip on a shoulder of the crankshaft (2) and the axis of the indicator parallel to the crankshaft (2).
26. Move the crankshaft (2) to one side of the power frame (1) using a light tap from a rubber mallet, a pry bar or with a jackscrew in the threaded hole in the blind bearing housing (7).
27. Set the dial indicator to zero.
28. Move the crankshaft (2) back over to the opposite side and read bearing endplay as total indicator movement. Remove or add shims as necessary to achieve proper endplay (.002” to .005”). Distribute shims equally on both bearing housings (7 & 8). Verify the endplay with the dial indicator per the procedure described before final assembly.
29. Install the oil seal (27) into the bearing housing (8). The oil seal (27) can be installed with light hammer blows. When properly seated it will be flush with the face of the bearing housing (8).
30. Install the plunger rod seal housing (16) in the power frame (1). The crankshaft should turn freely.
31. Complete reassembly of pump. Torque all fasteners as outlined in the Fastener Torque Requirements section of this manual.

10.0 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. Values are in FT-LBS and Newton meters. Typical sizes are shown; other sizes may be used depending on application.

Power End						
Item				Typical	Torque	
Number	Description	Size		Material	Ft-lbs	N-m
20	Back Cover Bolts	0.500 -13-UNC		GR-5	40	54
19	Bearing Housing Bolts	0.750 -10-UNC		GR-5	130	176
3	Connecting Rod Bolts	0.625 -18-UNF		A193-B7	150	203
21 & 22	Cross Head Set Screw	0.375 -16-UNC		Alloy	20	27
17	Seal Holder Cap Screw	0.375 -16-UNC		GR-5	25	34
32	Cradle Cover Wing Nuts	0.375 -16-UNC		GR-2	25	34
6	Pony Rod to X Head	2.000 -12-UN		17-4 PH	450	610
15	Pony Rod/Plunger Clamp	0.750 -10-UNC		18-8 SST	95	129
Fluid End						
Item				Typical	Torque	
Number	Description	Size		Material	Ft-lbs	N-m
63	Attachment to Power End	1.375 -8-UN		A193-B7	1250	1,695
64	Valve Cover					
	M2828-M2834	1.125 -8-UN		A193-B7	600	813
	M2836-M2840	1.125 -8-UN		A193-B7	600	813
78	Cylinder Cover					
	M2828-M2834	1.125 -8-UN		A193-B7	600	813
	M2836-M2840	1.125 -8-UN		A193-B7	600	813
66	Stuffing Box Clamp					
	M2816-M2818	1.000 -8-UNC		A193-B7	400	542
	M2820-M2826	1.000 -8-UNC		A193-B7	400	542
	M2828-M2834	0.875 -9-UNC		A193-B7	275	373
	M2836-M2840	0.750 -10-UNC		A193-B7	175	237
68	Suction Manifold Bolts					
	M2828-M2834	0.500 -13-UNC		A193-B7	50	68
	M2836-M2840	0.500 -13-UNC		A193-B7	50	68

Refer to figures on pages 11 and 12 for item numbers.

11.0 Special Service Tools

The items listed below are special tools available from FMC to help aid in key service procedures. They are referenced in several of the proceeding maintenance procedures.

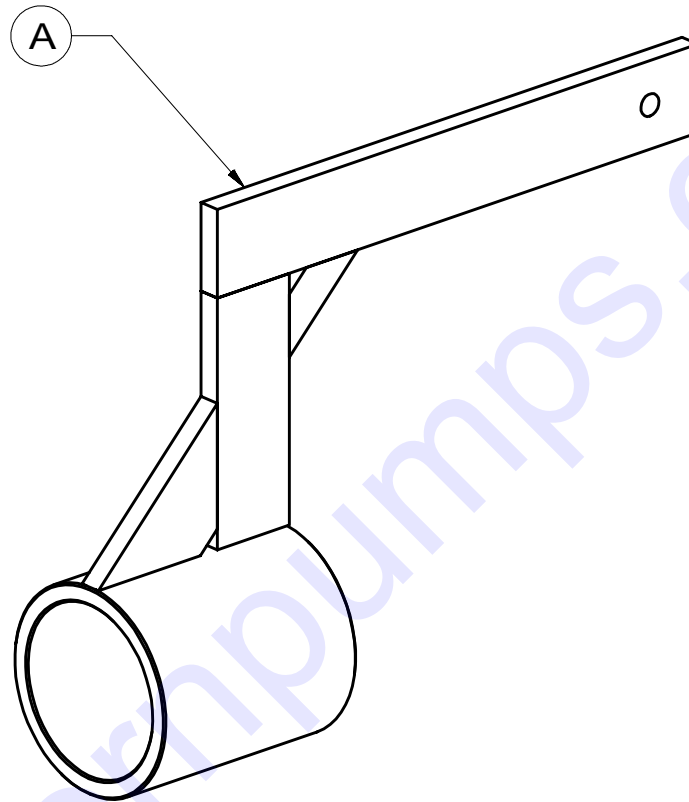


Figure 12: Crankshaft Lifting Tool

Valve removal kits

Pump Models	AR Style	Disc Style	Valve Series
M2816 – M2818	5276358		8
M2820 – M2826			9
M2830 – M2834		P511484	10, 11
M2836 – M2842		P511484	12
M2844 – M2850		P518342	20, 25

12.0 Trouble-Shooting 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.

No flow from pump

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

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

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

Insufficient flow OR pressure AND rough operation

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

Pump runs rough, knocks, or vibrates ONLY

- Loose piston assembly
- Valve assembly is damaged or has unseated
- Pump is cavitating due to:
 1. Insufficient NPSHa (tank head or charge pressure)
 2. Fluid viscosity is too high
 3. Inlet line is too long and/or too small diameter
- Worn or damaged power frame components
- Pump is sucking air across worn piston cups during suction stroke (usually only observed on pumps that do not have a booster pump)

Suction pressure fluctuates rapidly

- Pump is cavitating
- Air is entering into the suction piping

Fluid leaking from pump

- Piston cups are wearing and about to fail
- Fluid cylinder bolts are not properly tightened
- Fluid cylinder o-rings (or gaskets) are damaged
- Piston assembly o-rings are damaged

Short piston seal life

- High abrasive particle content in fluid
- Wrong style or type of piston for service
- Piston liner is damaged
- Pump is cavitating (cylinders may run hot)
- Piston assembly o-ring is damaged
- Poor quality water used (sources like lakes, streams, or fire hydrant that has not been purged)
- Pump is allowed to run dry for extended periods of time
- Liner wash system not properly maintained (if equipped)

Short valve life

- High abrasive particle content in fluid
- Valve assemblies only partially rebuilt during previous service
- Valve assemblies damaged do to improper installation techniques
- Poor quality water used (sources like lakes, streams, or fire hydrant that has not been purged)
- Pump is cavitating

Cracked fluid cylinder

- Discharge pressure too high
- Pump exposed to freezing conditions without properly draining
- Hydraulic shock resulting from cavitation or entrained air
- Discharge valve is stuck shut
- Material or manufacturing defect

Crankshaft jerks or starts and stops rotation

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

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

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

Broken Fluid End Bolts

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

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

13.0 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 and bill of materials 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 or bill of materials 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 name tag 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.

14.0 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 and 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 increased fluid pressure on the discharge stroke.
DAMPENER	A device that reduces pressure pulsations in the suction or discharge piping. This may 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 converts supplied rotary motion into linear motion used by the Fluid End to move the pumpage.
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 level of liquid in the suction vessel is above the centerline of the suction port of the pump.
FLUID END	The portion of the pump that converts the linear motion supplied by the power end into fluid flow at pressure. This may also be called a Liquid End.

N P S H A	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 feet of water.
N P S H R	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 design and speed and is determined by the pump manufacturer through a specific NPSH test.
P I S T O N	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.
P L U N G E R	A type of power pump that uses a cylindrical element or “plunger” to drive fluid through the valves. The plunger reciprocates through a stationary set of seals known as packing.
P O W E R P U M P	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.
P O W E R F R A M E	The major portion of a power pump that encloses and supports all other components of the power (or drive) end.
S T R O K E L E N G T H	The length of one complete, unidirectional motion of the piston or plunger. Stroke length is usually expressed in inches.
V A L V E	A component that allows unidirectional flow of liquid. FMC pumps have a series of two valves, one inlet or suction and one discharge, per pumping cylinder.

15.0 Reference Information

Use the following section to record key information about your specific pump model. Information such as part and serial numbers will be needed when ordering service parts. This data may be found stamped on the metal nameplate located on the pump power frame. This area may also be used to make notations about special parts, procedures, phone numbers, or other important information related to your pump.

Pump Model

Part Number

Serial Number

Rated Pressure

Rated Capacity

Rated Speed

Notes: