

# 3PFR PLUNGER PUMP SERVICE MANUAL



## 3 FRAME SPLIT MANIFOLD:

230, 240, 270, 231, 241, 271,  
237, 247, 277, 279

## INSTALLATION AND START-UP INFORMATION

Optimum performance of the pump is dependent upon the entire liquid system and will be obtained only with the proper selection, installation of plumbing, and operation of the pump and accessories.

**SPECIFICATIONS:** Maximum specifications refer to individual attributes. It is **not** implied that **all maximums** can be performed **simultaneously**. If more than one maximum is considered, check with your CAT PUMPS supplier to confirm the proper performance and pump selection. Refer to individual pump Data Sheets for complete specifications, parts list and exploded view.

**LUBRICATION:** Fill crankcase with special CAT PUMP oil per pump specifications [3PFR-10 oz.]. **DO NOT RUN PUMP WITHOUT OIL IN CRANKCASE.** Change initial fill after 50 hours running period. Thereafter, change oil every **3 months or 500 hour intervals**.

**PUMP ROTATION:** Pump was designed for forward rotation to allow optimum lubrication of the crosshead area. Reverse rotation is acceptable if the crankcase oil level is increased slightly above center dot to assure adequate lubrication.

**PULLEY SELECTION:** Select size of motor pulley required to deliver the desired flow from Horsepower Requirement and Pulley Selection Chart (refer to Tech Bulletin 003 or individual Data Sheet).

**MOTOR SELECTION:** The motor or engine driving the pump must be of adequate horsepower to maintain full RPM when the pump is under load. Select the electric motor from the Horsepower Requirement Chart according to required pump discharge flow, maximum **pressure at the pump** and drive losses of approximately 3-5%. Consult the manufacturer of gas or diesel engine for selection of the proper engine size.

**MOUNTING:** Mount the pump on a rigid, horizontal surface in a manner to permit drainage of crankcase oil. An uneven mounting surface will cause extensive damage to the pump base. To minimize piping stress, **use appropriate flexible hose to inlet and discharge ports**. Use the correct belt; make sure pulleys are aligned. Excessive belt tension may be harmful to the bearings. Hand rotate pump before starting to be certain shaft and bearings are free moving.

**LOCATION:** If the pump is used in extremely dirty or humid conditions, it is recommended pump be enclosed. Do not store or operate in excessively high temperature areas or enclosed without proper ventilation.

**INLET CONDITIONS:** Refer to complete **Inlet Condition Check-List** in this manual before starting system. **DO NOT STARVE THE PUMP OR RUN DRY.** Temperatures above 130°F are permissible. Add 1/2 PSI inlet pressure per each degree F over 130°F. Elastomer or RPM changes may be required. See Tech Bulletin 002 or call CAT PUMPS for recommendations.

**C.A.T.:** Installation of a C.A.T. (Captive Acceleration Tube) is recommended in applications with stressful inlet conditions such as high temperatures, booster pump feed, long inlet lines or quick closing valves.

**DISCHARGE CONDITIONS:** **OPEN ALL VALVES BEFORE STARTING SYSTEM** to avoid deadhead overpressure condition and severe damage to the pump or system.

Install a **Pulsation Dampening** device on the discharge head or in the discharge line as close to the head as possible. Be certain the pulsation dampener (Prrrrr-o-lator) is properly precharged for the system pressure (refer to individual Data Sheet).

A **reliable Pressure Gauge** should be installed near the discharge outlet of the high pressure manifold. This is extremely important for adjusting pressure regulating devices and also for proper sizing of the nozzle or restricting orifice. The pump is rated for a maximum pressure; this is the **pressure** which would be **read at the discharge manifold of the pump, NOT AT THE GUN OR NOZZLE**.

Use PTFE thread tape or pipe thread sealant (sparingly) to connect accessories or plumbing. Exercise caution not to wrap tape beyond the last thread to avoid tape from becoming lodged in the pump or accessories. This condition will cause a malfunction of the pump or system.

**PRESSURE REGULATION:** All systems require both a primary pressure regulating device (i.e., regulator, unloader) and a secondary pressure safety relief device (i.e., pop-off valve, safety valve). The primary pressure device must be installed on the discharge side of the pump. The function of the primary pressure regulating device is to protect the pump from over pressurization, which can be caused by a plugged or closed off discharge line. Over pressurization can severely damage the pump, other system components and can cause bodily harm. The secondary safety relief device must be installed **in-line** between the primary device and the pump **or on the opposite side of the manifold head**. This will ensure pressure relief of the system if the primary regulating device fails. Failure to install such a safety device will void the warranty on the pump.

When the high pressure system is left running with the trigger gun off, the by-pass liquid can be routed to drain or to the pump inlet. If routed to the pump inlet, the **by-pass liquid can quickly develop excessive heat and result in damage to the pump**. A THERMO VALVE installed in the by-pass line is recommended to protect the pump. An AUTO SHUT-OFF ASSEMBLY may also be used.

**NOZZLES:** A worn nozzle will result in loss of pressure. Do not adjust pressure regulating device to compensate. Replace nozzle and reset regulating device to system pressure.

**PUMPED LIQUIDS:** Some liquids may require a **flush between operations or before storing**. For pumping liquids other than water, contact your CAT PUMPS supplier.

**STORING:** For extended storing or between use in cold climates, drain all pumped liquids from pump and **flush with antifreeze solution to prevent freezing and damage to the pump**. **DO NOT RUN PUMP WITH FROZEN LIQUID** (refer to Tech Bulletin 083).

### WARNING

All systems require both a primary pressure regulating device (i.e., regulator, unloader) and a secondary pressure safety relief device (i.e., pop-off valve, safety valve). Failure to install such relief devices could result in personal injury or damage to the pump or to system components. CAT PUMPS does not assume any liability or responsibility for the operation of a customer's high pressure system.

Products described hereon are covered by one or more of the following U.S. patents 3558244, 3652188, 3809508, 3920356, 3930756 and 5035580

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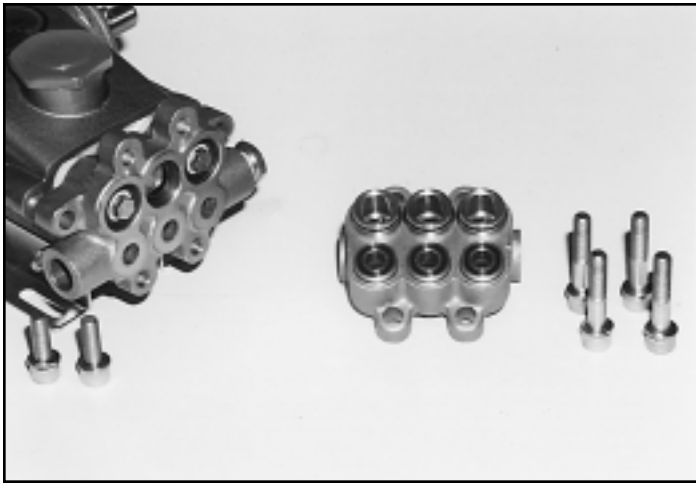
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Removal of Discharge Manifold and socket head screws

**CAUTION:** Before commencing with service, shut off drive (electric motor, gas or diesel engine) and turn off water supply to pump. Relieve all discharge line pressure by triggering gun or opening valve in discharge line.

After servicing is completed, turn on water supply to pump, start drive, reset pressure regulating device and secondary valve, read system pressure on the gauge at the pump head. Check for any leaks, vibration or pressure fluctuations and resume operation.

Inspect and service all system accessories on the same schedule as your pump.

## SERVICING THE VALVES

### Disassembly

1. Remove the four (4) Socket Head Screws and Spring Washers from end of Manifold.
2. Support the Discharge Manifold from the underside and tap with a soft mallet to separate from the Inlet Manifold.
3. Carefully place Discharge Manifold on work surface with crankcase side up.
4. From the three (3) **lower and shallow inlet chambers** remove the Inlet Valve Adapters with front and rear O-Rings. These adapters are not held securely in position and may fall out as the Discharge Manifold is removed.
5. Remove the Seats, Valves, Springs and Retainers from the inlet chambers.
6. From the three (3) **upper and deeper discharge chambers** remove the Discharge Valve Adapters with front and rear O-Rings. These Adapters generally remain with the Discharge Manifold as it is removed. Insert two screwdrivers under the lip of the Adapter and pry the Adapter from the manifold chamber.
7. Remove the Seats, Valves, Springs and Retainers from the discharge chambers.

**NOTE:** The inlet and discharge use the same Retainers, Springs, Seats and Valves. The O-Rings and valve adapters are different. Keep parts in order as they are removed.

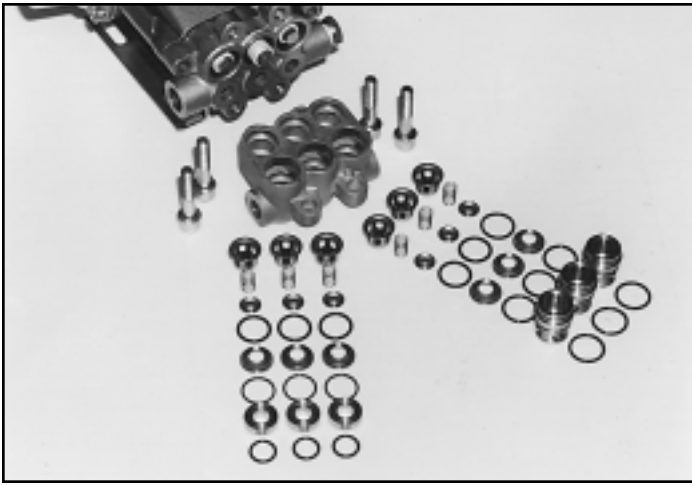
### Reassembly (Discharge)

**NOTE:** For certain applications, apply liquid gasket to O-Ring crevices and seal surfaces. Refer to Tech Bulletin 053 for model identification.

**NOTE:** EPDM elastomers require silicone-base lubricant.

**NOTE:** Inlet and discharge valve parts are interchangeable. One Valve Kit is needed for complete valve change.

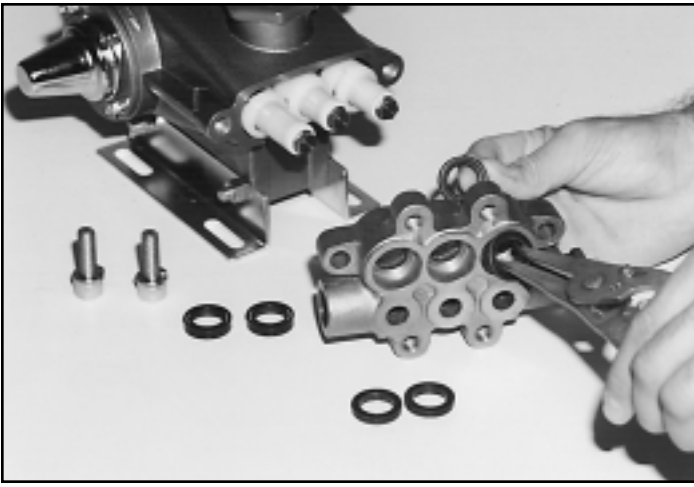
1. Examine Spring Retainers for internal wear or breaks in the structure and replace as needed.
2. Examine the Spring for fatigue or breaks and place the new Spring into the Retainer over the plastic center guide. Place the Spring Retainers in the upper **deeper valve chambers**. They will rest on the machined ridge in each chamber.
3. Examine the Valves for wear or pitting and replace if necessary. Install Valves over Springs with **concave side down**.
4. Examine Seat O-Rings for wear and replace. **Place O-Rings on lip of retainers**. Carefully square O-Rings in the upper discharge valve chamber to avoid cutting O-Ring when Seat is installed.
5. Examine Seats for pitting, scale or ridges and replace if necessary. Install Seat with **concave side down**, so O-Ring fits snugly into groove on Seat.
6. Examine both front and rear O-Rings on the Discharge Valve Adapter and replace if necessary. Lubricate O-Rings and fit **into grooves on outside of spacer**.
7. Apply liquid gasket to the O-Ring crevices on the O.D. of Discharge Valve Adapter and carefully press into upper valve chambers in the discharge manifold with **small diameter side down** until Adapter snaps tightly into position.



Discharge and Inlet Valve Assemblies

### Reassembly (Inlet)

1. Examine Spring Retainers for internal wear or breaks in the structure and replace as needed.
2. Insert Springs into Retainers over plastic center guide and place Spring Retainers into the lower **shallow valve chambers**. They will rest on the machined ridge in each chamber.
3. Inspect the Valves for wear, ridges or pitting and replace if necessary. Insert Valves over the Springs with **concave side down**.
4. Examine Seat O-Rings for wear and replace. **Lubricate and place O-Rings on lip of retainers.** Carefully square O-Rings in lower inlet valve chamber to avoid cutting O-Ring when Seat is installed.
5. Examine Seats for pitting, scale or ridges and replace if necessary. Install Seat with **concave side down**, so O-Ring fits snugly into groove on Seat.
6. Examine both the **front and the rear** O-Rings on the Inlet Valve Adapter and replace if worn. Lubricate O-Rings and **fit into grooves on outside of adapters**.
7. Apply liquid gasket to the O-Ring crevice of the O.D. of Inlet Valve Adapter and press into lower valve chambers in the discharge manifold. Carefully square Inlet Valve Adapter into chamber to avoid cutting or extruding O-Rings.
8. Rotate Crankshaft by hand so the two outside plungers are extended equally.
9. Carefully replace Discharge Manifold over Plunger ends **aligning Discharge Valve Adapters with Inlet Manifold Chambers** and press into position. Tap with a soft mallet until Inlet and Discharge Manifolds make contact.
10. Replace all four (4) Washers and Socket Head Screws. Hand tighten each. Then torque per chart.



Removal of Hi and Lo-Pressure Seals

## SERVICING THE SEALS

**NOTE: All parts necessary for servicing are included in the Seal Kit.**

### Disassembly

1. With Discharge Manifold removed from the pump remove the two (2) Socket Head Screws and spring washers from end of Inlet Manifold.
2. Rotate Crankshaft forward to separate Inlet Manifold from crankcase.
3. Support Inlet Manifold from underside and tap with a soft mallet to separate I.M. from Crankcase.
4. With **crankcase side of Inlet Manifold down** remove Hi-Pressure Seals using a reverse pliers.
5. Invert Inlet Manifold so **crankcase side is up** and with reverse pliers remove Lo-Pressure Seals.

### Reassembly

**NOTE: For certain applications, apply liquid gasket to O-Ring crevices and seal surfaces. Refer to Tech Bulletin 053 for model identification.**

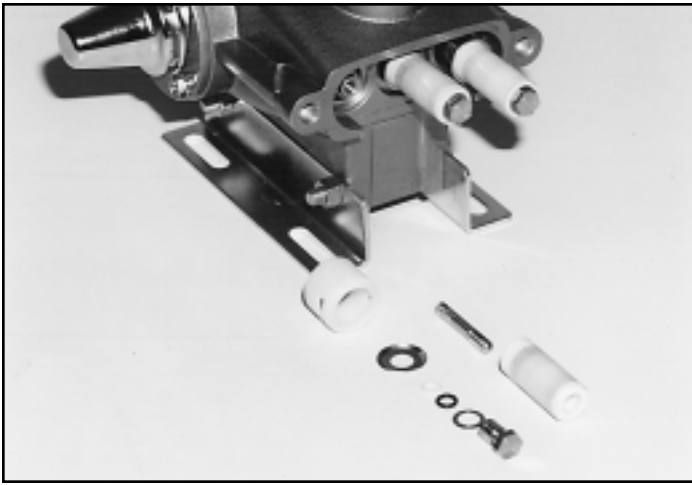
**NOTE: EPDM elastomers require silicone-base lubricant.**

1. Examine Lo-Pressure Seal for wear or spring failure and replace if necessary. With **crankcase side of inlet manifold up**, press the new Lo-Pressure Seal into the valve chamber with **Garter Spring down**. Carefully square seal into position.

**NOTE: When using alternate materials, the fit of the special materials may be snug and require gently driving the LPS into position with a cylinder of the same diameter to assure a square seating and no damage to the LPS.**

2. Examine Hi-Pressure Seal for wear and replace if necessary. Invert Inlet Manifold with **crankcase side down** and press the new seal into the manifold chamber with **v-side up** (metal side down) until completely seated.

3. Rotate Crankshaft by hand so the two outside plungers are extended equally.
4. Lubricate Plungers and carefully slide the Inlet Manifold over the Plungers and press into the Crankcase.
5. Replace two (2) M10 Inlet Manifold Socket Head Screws, and Washers, hand tighten and then torque per chart.
6. If the valves have not been serviced, examine O-Rings on both the Discharge Adapter and Inlet Valve Adapter for cuts or wear and replace as needed. Lubricate O-Rings and fit into grooves on outside of adapters.
7. Carefully slip the Discharge Manifold onto Plungers and press the exposed Discharge Valve Adapters into the Inlet Manifold chambers. Tap with a soft mallet until seated.
8. Replace the four (4) M10 Discharge Manifold Socket Head Screws and Washers and hand tighten. Then torque per chart.



Ceramic Plunger Arrangement

## SERVICING THE PLUNGERS

### Disassembly

1. Remove Discharge and Inlet Manifold as described.
2. Using a wrench; loosen Plunger Retainers approximately three (3) to four (4) turns.
3. Grasp Ceramic Plunger and **push towards Crankcase** until Plunger Retainer with stud pops out.
4. Remove Plunger Retainer with O-Ring, Back-up-Ring and Gasket.
5. Slip Ceramic Plungers, Keyhole Washer and Barrier Slings from each Plunger Rod.
6. Examine Crankcase Seal for deterioration and replace if needed. Contact CAT PUMPS supplier for crankcase servicing.

### Reassembly

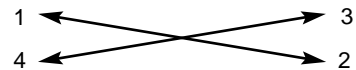
1. Replace Barrier Slinger if damaged when removing and position onto Plunger Rod with **concave facing out**. Then examine the Keyhole Washer and place on the Plunger Rod with the slot down.
2. Carefully examine Ceramic Plunger for scoring or cracks and replace if worn. Slip onto Rod. **Ceramic Plunger can only be installed one direction (front to back)**. Do not force onto Rod.

**NOTE: Do not lubricate wicks at initial start-up. Operate for 10 to 15 minutes to allow grease from LPS to penetrate the plunger surface, then lubricate as needed.**

3. Examine O-Ring and Back-up-Ring on Plunger Retainer and replace if worn or cut. Lubricate O-Ring for ease of installation and to avoid damage to O-Ring. **First install NEW Gasket on Plunger Retainer, then O-Ring, then Back-up-Ring.**
4. Apply Loctite® 242® to threads and install **short threaded end of Stud into Plunger Retainer**.
5. Apply Loctite® 242® to threads and thread Plunger Retainer and Stud assembly **with long threaded end of Stud into plunger rod**. Torque per chart.

**Exercise caution not to over torque the Plunger Retainer.**

6. Re-install the Seal Retainers with the **slots to the top and bottom**.
7. Rotate Crankshaft by hand so the two outside plungers are extended equally. Lubricate O.D. of plungers.
8. Carefully slip Inlet and Discharge Manifold assembly onto Plungers and tap with soft mallet until flush with Crankcase.
9. Replace the two (2) Inlet Manifold Socket Head Screws and Washers and hand tighten. Then torque per chart.
10. Torque the four (4) Discharge Manifold Socket Head Screws in sequence per chart.



## SERVICING CRANKCASE SECTION

1. While Manifold, Plungers and Seal Retainers are removed, examine Crankcase Oil Seals for leaking and wear.
2. Check for any signs of leaking at Bearing Covers, Rear Cover, Drain Plug or Bubble Oil Gauge.
3. Check oil level and for evidence of water in oil. Change crankcase oil on a regular schedule. See Preventative Maintenance Check-List.
4. Rotate Crankshaft by hand to feel for smooth bearing movement.
5. Examine Crankshaft Oil Seals externally for drying, cracking or leaking.
6. Contact CAT PUMPS or your local distributor if crankcase service is required. Refer to Tech Bulletin 035.

**See Plunger Pump Service DVD for additional information.**

## PREVENTATIVE MAINTENANCE CHECK-LIST

Check	Daily	Weekly	50 hrs.	500 hrs.*	1500 hrs.**	3000 hrs.**
Clean Filters	x					
Oil Level/Quality	x					
Oil Leaks	x					
Water Leaks	x					
Belts, Pulley		x				
Plumbing		x				
Initial Oil Change			x			
Oil Change				x		
Seal Change					x	
Valve Change						x
Accessories					x	

- \* If other than CAT PUMPS special custom-blend, multi-viscosity, ISO-68 hydraulic oil is used, change cycle should be every 300 hours.
- \*\* Each system's maintenance cycle will be exclusive. If system performance decreases, check immediately. If no wear at 1500 hours, check again at 2000 hours and each 500 hours until wear is observed. Valves typically require changing every other seal change.
- Duty cycle, temperature, quality of pumped liquid and inlet feed conditions all effect the life of pump wear parts and service cycle.
- \*\* Remember to service the regulator/unloader at each seal servicing and check all system accessories and connections before resuming operation. Refer to DVD for additional assistance.

## TORQUE CHART

Pump Item	Thread	Tool Size [Part No.]	Torque		
			in.lbs.	ft.lbs.	Nm
<b>Plunger Retainer 303 S.S./Brass</b>					
	M6	M11 Hex [44044]	55	4.6	6.2
<b>Plunger Retainer 316 S.S.</b>					
	M6	M12 Hex	55	4.6	6.2
<b>Inlet Manifold Screws</b>					
	M10	M8 Allen [33046]	220	18.0	24
<b>Discharge Manifold Screws</b>					
	M10	M8 Allen [33046]	220	18.0	24
<b>Rear Cover/Bearing Cover Screws</b>					
	M6	M10 Hex/Phil. [25082]	50	4.0	5.4
<b>Connecting Rod Screws</b>					
	M7	M10 Hex [25082]	95	8.0	11
<b>Bubble Oil Gauge</b>					
	M28	Oil Gauge Tool [44050]	45	3.8	5
<b>Mounting Bolts</b>					
	M8	M13 Hex [25324]	115	9.58	13

## TECHNICAL BULLETIN REFERENCE CHART

No.	Subject	Models
002	Inlet Pressure VS Liquid Temperature	All Models
003	Power Unit Drive Packages	3PFR - 68PFR, 10FR - 60FR
024	Lubrication of Lo-Pressure Seals	All Models
033	Crankcase and Rear Cover	270, 279, 280, 290
034	Servicing Crankcase Section	3FR, 4FR, 10FR, 25FR
035	Servicing Crankcase Section	7CP, 7PFR - 68PFR
036	Cylinder and Plunger Reference Chart	All Models
043	LPS and HPS Servicing	All Plunger Models
047	Blind Bearing Shaft Cover	Gearbox Plunger Pumps
049	Stainless Steel Hardware	3PFR7, 5PFR7, 15PFR7
053	Liquid Gasket	All Plunger NAB-S.S. Models
064	By-Pass Hose Sizing	All Unloaders/Regulators
067	S.S. Plunger Retainer	3PFR, 5PFR, 7PFR
073	Hi-Temp HPS	2SF, 3PFR, 5PFR, 5CP, 7PFR
074	Torque Chart	Piston and Plunger Pumps
077	Oil Drain Kit	All Models (except 2SF/4SF)
083	Winterizing a Pump	All Models
095	Galling Prevention	Stainless Steel Models

## INLET CONDITION CHECK-LIST

### Review Before Start-Up

Inadequate inlet conditions can cause serious malfunctions in the best designed pump. Surprisingly, the simplest of things can cause the most severe problems or go unnoticed to the unfamiliar or untrained eye. REVIEW THIS CHECK-LIST BEFORE OPERATION OF ANY SYSTEM. Remember, no two systems are alike, so there can be no **ONE** best way to set-up a system. All factors must be carefully considered.

**INLET SUPPLY** should exceed the maximum flow being delivered by the pump to assure proper performance.

- Open inlet shut-off valve and turn on water supply to avoid starving the pump. **DO NOT RUN PUMP DRY.**
- Temperatures above 130°F are permissible. Add 1/2 PSI inlet pressure per each degree F over 130°F. Elastomer or RPM changes may be required. See Tech Bulletin 002 or call CAT PUMPS for recommendations.
- Avoid closed loop systems especially with high temperature, ultra-high pressure or large volumes. Conditions vary with regulating/unloader valve.
- Low vapor pressure liquids, such as solvents, require a booster pump and C.A.T. to maintain adequate inlet supply.
- Higher viscosity liquids require a positive head and a C.A.T. to assure adequate inlet supply.
- Higher temperature liquids tend to vaporize and require positive heads and C.A.T. to assure adequate inlet supply.
- When using an inlet supply reservoir, size it to provide adequate liquids to accommodate the maximum output of the pump, generally a minimum of 6-10 times the GPM (however, a combination of system factors can change this requirement); provide adequate baffling in the tank to eliminate air bubbles and turbulence; install diffusers on all return lines to the tank.

**INLET LINE SIZE** should be adequate to avoid starving the pump.

- Line size must be a minimum of one size larger than the pump inlet fitting. Avoid tees, 90 degree elbows or valves in the inlet line of the pump to reduce the risk of flow restriction and cavitation.
- The line **MUST** be a FLEXIBLE hose, NOT a rigid pipe, and reinforced on SUCTION systems to avoid collapsing.
- The simpler the inlet plumbing the less the potential for problems. Keep the length to a minimum, the number of elbows and joints to a minimum (ideally no elbows) and the inlet accessories to a minimum.
- Use pipe sealant to assure air-tight, positive sealing pipe joints.

**INLET PRESSURE** should fall within the specifications of the pump.

- Acceleration loss of liquids may be increased by high RPM, high temperatures, low vapor pressures or high viscosity and may require pressurized inlet and C.A.T. to maintain adequate inlet supply. DO NOT USE C.A.T. WITH SUCTION INLET.
- Optimum pump performance is obtained with +20 PSI (1.4 BAR) inlet pressure and a C.A.T. for certain applications. With adequate inlet plumbing, most pumps will perform with flooded suction. Maximum inlet pressure is 60 PSI (4 BAR).
- After prolonged storage, pump should be rotated by hand and purged of air to facilitate priming. Disconnect the discharge port and allow liquid to pass through pump and measure flow.

**INLET ACCESSORIES** are designed to protect against overpressurization, control inlet flow, contamination or temperature and provide ease of servicing.

- A shut-off valve is recommended to facilitate maintenance.
- Installation of a C.A.T. is essential in applications with stressful conditions such as high temperatures, booster pump feed or long inlet lines. **Do not use C.A.T. with negative inlet pressure.**
- A stand pipe can be used in some applications to help maintain a positive head at the pump inlet.
- Inspect and clean inlet filters on a regular schedule to avoid flow restriction.
- A pressure transducer is necessary to accurately read inlet pressure. (**Short term, intermittent cavitation will not register on a standard gauge.**)
- All accessories should be sized to avoid restricting the inlet flow.
- All accessories should be compatible with the solution being pumped to prevent premature failure or malfunction.
- Optional inlet protection can be achieved by installing a pressure cutoff switch between the inlet filter and the pump to shut off pump when there is no positive inlet pressure.

**BY-PASS TO INLET** Care should be exercised when deciding the method of by-pass from control valves.

- It is recommended the by-pass be directed to a baffled reservoir tank, with at least one baffle between the by-pass line and the inlet line to the pump.
- Although not recommended, by-pass liquid may be returned to the inlet line of the pump if the system is properly designed to protect your pump. A PRESSURE REDUCING VALVE must be installed on the inlet line (**BETWEEN THE BY-PASS CONNECTION AND THE INLET TO THE PUMP**) to avoid excessive pressure to the inlet of the pump. It is also recommended that a THERMO VALVE be used in the by-pass line to monitor the temperature build-up in the by-pass loop to avoid premature seal failure.
- A reinforced, flexible, low pressure hose rated up to 300 PSI should be used for routing by-pass back to the pump inlet.
- Caution should be exercised not to undersize the by-pass hose diameter and length. Refer to Technical Bulletin 64 for additional information on the size and length of the by-pass line.
- Check the pressure in the by-pass line to avoid overpressurizing the inlet.
- The by-pass line should be connected to the pump inlet line at a gentle angle of 45° or less and no closer than 10 times the pump inlet port diameter e.g. 1-1/2" port size = 15" distance from pump inlet port.

## HOSE FRICTION LOSS

Water* Flow Gal/Min	PRESSURE DROP IN PSI PER 100 FT OF HOSE WITH TYPICAL WATER FLOW RATES Hose Inside Diameters, Inches						
	1/4	5/16	3/8	1/2	5/8	3/4	1"
0.5	16	5	2				
1	54	20	7	2			
2	180	60	25	6	2		
3	380	120	50	13	4	2	
4		220	90	24	7	3	
5		320	130	34	10	4	
6			220	52	16	7	1
8			300	80	25	10	2
10			450	120	38	14	3
15			900	250	80	30	7
20			1600	400	121	50	12
25				650	200	76	19
30					250	96	24
40					410	162	42
50					600	235	62
60						370	93

\*At a fixed flow rate with a given size hose, the pressure drop across a given hose length will be directly proportional. A 50 ft. hose will exhibit one-half the pressure drop of a 100 ft. hose. Above values shown are valid at all pressure levels.

## WATER LINE PRESSURE LOSS PRESSURE DROP IN PSI PER 100 FEET

Water GPM	Steel Pipe—Nominal Dia.						Brass Pipe—Nominal Dia.						Copper Tubing O.D. Type L					
	1/4	3/8	1/2	3/4	1	1 1/4	1/4	3/8	1/2	3/4	1	1 1/4	1/4	3/8	1/2	5/8	3/4	7/8
1	8.5	1.9					6.0	1.6					120	13	2.9	1.0		
2	30	7.0	2.1				20	5.6	1.8				400	45	10	3.4	1.3	
3	60	14	4.5	1.1			40	11	3.6				94	20	6.7	2.6		
5	150	36	12	2.8			100	28	9.0	2.2			230	50	17	6.1	3.0	
8	330	86	28	6.7	1.9		220	62	21	5.2	1.6		500	120	40	15	6.5	
10	520	130	43	10	3.0		320	90	30	7.8	2.4		180	56	22	10		
15	270	90	21	6.2	1.6		190	62	16	5.0	1.5		120	44	20			
25	670	240	56	16	4.2	2.0	470	150	40	12	3.8	1.7	330	110	50			
40		66	17	8.0				39	11	5.0			550	200	88			
60			37	17						23	11							
80				52	29						40	19						
100				210	107	48					61	28						

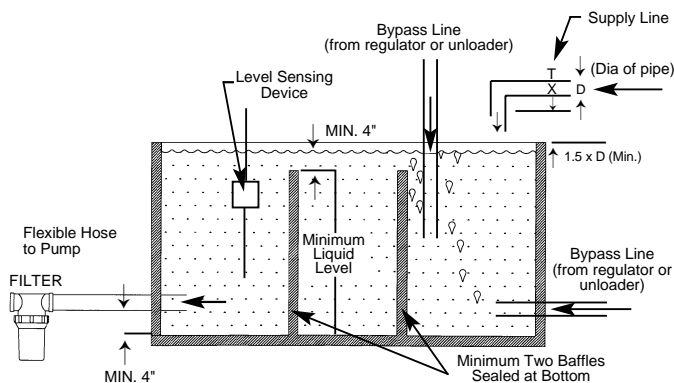
## RESISTANCE OF VALVES AND FITTINGS

Nominal Pipe Size Inches	Inside Diameter Inches	Equivalent Length of Standard Pipe in Feet								
		Gate Valve	Globe Valve	Angle Valve	45° Elbow	90° Elbow	180° Close Ret	Tee Thru Run	Tee Thru Branch	
1/2	0.622	0.41	18.5	9.3	0.78	1.67	3.71	0.93	3.33	
3/4	0.824	0.54	24.5	12.3	1.03	2.21	4.90	1.23	4.41	
1	1.049	0.69	31.2	15.6	1.31	2.81	6.25	1.56	5.62	
1 1/4	1.380	0.90	41.0	20.5	1.73	3.70	8.22	2.06	7.40	
1 1/2	1.610	1.05	48.0	24.0	2.15	4.31	9.59	2.40	8.63	
2	2.067	1.35	61.5	30.8	2.59	5.55	12.30	3.08	11.60	
2 1/2	2.469	1.62	73.5	36.8	3.09	6.61	14.70	3.68	13.20	
3	3.068	2.01	91.5	45.8	3.84	8.23	18.20	4.57	16.40	
4	4.026	2.64	120.0	60.0	5.03	10.80	23.90	6.00	21.60	

Arriving at a total line pressure loss, consideration should then be given to pressure loss created by valves, fittings and elevation of lines.

If a sufficient number of valves and fittings are incorporated in the system to materially affect the total line loss, add to the total line length, the equivalent length of line of each valve or fitting.

## TYPICAL RESERVOIR TANK RECOMMENDED 6 TO 10 TIMES SYSTEM CAPACITY



## Handy Formulas to Help You

Q. How can I find the RPM needed to get specific GPM (Gallons Per Minute) I want?

$$A. \text{Desired RPM} = \text{Desired GPM} \times \frac{\text{Rated RPM}}{\text{Rated GPM}}$$

Q. I have to run my pump at a certain RPM. How do I figure the GPM I'll get?

$$A. \text{Desired GPM} = \text{Desired RPM} \times \frac{\text{Rated GPM}}{\text{Rated RPM}}$$

Q. Is there a simple way to find the approximate horsepower I'll need to run the pump?

$$A. \text{Electric Brake Horsepower Required} = \frac{\text{GPM} \times \text{PSI}}{1460} \quad (\text{Standard } 85\% \text{ Mech. Efficiency})$$

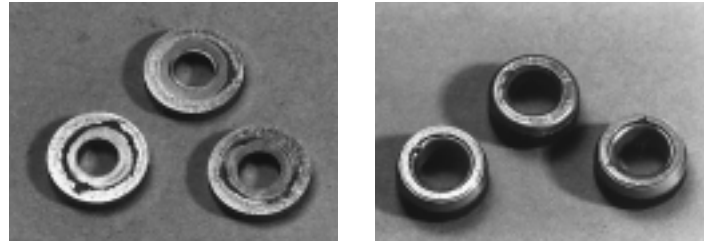
Q. What size motor pulley should I use?

$$A. \text{Pump Pulley (Outer Diameter)} \times \frac{\text{Pump RPM}}{\text{Motor/Engine RPM}} \quad (\text{Consult Engine Mfr.})$$

Q. How do I calculate the torque for my hydraulic drive system?

$$A. \text{Torque (ft. lbs.)} = 3.6 \left( \frac{\text{GPM} \times \text{PSI}}{\text{RPM}} \right)$$

## Avoid Cavitation Damage



One or several of the conditions shown in the chart below may contribute to cavitation in a system resulting in premature wear, system downtime and unnecessary operating costs.

CONDITION	SOLUTION
Inadequate inlet line size	<ul style="list-style-type: none"> <li>• Increase line size to the inlet port or one size larger</li> </ul>
Water hammering liquid acceleration/deacceleration	<ul style="list-style-type: none"> <li>• Install C.A.T. Tube</li> <li>• Move pump closer to liquid supply</li> </ul>
Rigid Inlet Plumbing	<ul style="list-style-type: none"> <li>• Use flexible wire reinforced hose to absorb pulsation and pressure spikes</li> </ul>
Excessive Elbows in Inlet Plumbing	<ul style="list-style-type: none"> <li>• Keep elbows to a minimum and less than 90°</li> </ul>
Excessive Liquid Temperature	<ul style="list-style-type: none"> <li>• Use Thermo Valve in bypass line</li> <li>• Do not exceed pump temperature specifications</li> <li>• Substitute closed loop with baffled holding tank</li> <li>• Adequately size tank for frequent or high volume bypass</li> <li>• Pressure feed high temperature liquids</li> <li>• Properly ventilate cabinets and rooms</li> </ul>
Air Leaks in Plumbing	<ul style="list-style-type: none"> <li>• Check all connections</li> <li>• Use PTFE thread tape or pipe thread sealant</li> </ul>
Agitation in Supply Tank	<ul style="list-style-type: none"> <li>• Size tank according to pump output — <b>Minimum 6-10 times system GPM</b></li> <li>• Baffle tank to purge air from liquid and separate inlet from discharge</li> </ul>
High Viscosity Liquids	<ul style="list-style-type: none"> <li>• Verify viscosity against pump specifications before operation</li> <li>• Elevate liquid temperature enough to reduce viscosity</li> <li>• Lower RPM of pump</li> <li>• Pressure feed pump</li> <li>• Increase inlet line size</li> </ul>
Clogged Filters	<ul style="list-style-type: none"> <li>• Perform regular maintenance or use clean filters to monitor build up</li> <li>• Use adequate mesh size for liquid and pump specifications</li> </ul>

## DIAGNOSIS AND MAINTENANCE

One of the most important steps in a high pressure system is to establish a regular maintenance program. This will vary slightly with each system and is determined by various elements such as the duty cycle, the liquid being pumped, the actual specifications vs rated specifications of the pump, the ambient conditions, the inlet conditions and the accessories in the system. A careful review of the necessary inlet conditions and protection devices required before the system is installed will eliminate many potential problems.

CAT PUMPS are very easy pumps to service and require far less frequent service than most pumps. Typically, only common tools are required, making in-field service convenient, however, there are a few custom tools, special to certain models, that do simplify the process. This service manual is designed to assist you with the disassembly and reassembly of your pump. The following guide will assist in determining the cause and remedy to various operating conditions. You can also review our **FAQ** or **SERVICE** sections on our **WEB SITE** for more facts or contact CAT PUMPS directly.

PROBLEM	PROBABLE CAUSE	SOLUTION
<b>Low pressure</b>	<ul style="list-style-type: none"> <li>•Worn nozzle.</li> <li>•Belt slippage.</li> <li>•Air leak in inlet plumbing.</li> <li>•Pressure gauge inoperative or not registering accurately.</li> <li>•Relief valve stuck, partially plugged or improperly adjusted.</li> <li>•Inlet suction strainer (filter) clogged or improperly sized.</li> <li>•Abrasives in pumped liquid.</li> <li>•Leaky discharge hose.</li> <li>•Inadequate liquid supply.</li> <li>•Severe cavitation.</li> <li>•Worn seals.</li> <li>•Worn or dirty inlet/discharge valves.</li> </ul>	<ul style="list-style-type: none"> <li>•Replace with properly sized nozzle.</li> <li>•Tighten belt(s) or install new belt(s).</li> <li>•Tighten fittings and hoses. Use PTFE liquid or tape.</li> <li>•Check with new gauge. Replace worn or damaged gauge.</li> <li>•Clean/adjust relief valve. Replace worn seats/valves and o-rings.</li> <li>•Clean filter. Use adequate size filter. Check more frequently.</li> <li>•Install proper filter.</li> <li>•Replace discharge hose with proper rating for system.</li> <li>•Pressurize inlet and install C.A.T.</li> <li>•Check inlet conditions.</li> <li>•Install new seal kit. Increase frequency of service.</li> <li>•Clean inlet/discharge valves or install new valve kit.</li> </ul>
<b>Pulsation</b>	<ul style="list-style-type: none"> <li>•Faulty Pulsation Dampener.</li> <li>•Foreign material trapped in inlet/discharge valves.</li> </ul>	<ul style="list-style-type: none"> <li>•Check precharge. If low, recharge, or install a new dampener.</li> <li>•Clean inlet/discharge valves or install new valve kit.</li> </ul>
<b>Water leak</b>		
•Under the manifold	<ul style="list-style-type: none"> <li>•Worn High Pressure or Lo-Pressure Seals.</li> <li>•Worn adapter o-rings.</li> </ul>	<ul style="list-style-type: none"> <li>•Install new seal kit. Increase frequency of service.</li> <li>•Install new o-rings.</li> </ul>
•Into the crankcase	<ul style="list-style-type: none"> <li>•Humid air condensing into water inside the crankcase.</li> <li>•Excessive wear to seals.</li> </ul>	<ul style="list-style-type: none"> <li>•Install oil cap protector. Change oil every 3 months or 500 hours.</li> <li>•Install new seal kit. Increase frequency of service.</li> </ul>
<b>Knocking noise</b>		
•Inlet supply	<ul style="list-style-type: none"> <li>•Inadequate inlet liquid supply.</li> </ul>	<ul style="list-style-type: none"> <li>•Check liquid supply. Increase line size, pressurize or install C.A.T.</li> </ul>
•Bearing	<ul style="list-style-type: none"> <li>•Broken or worn bearing.</li> </ul>	<ul style="list-style-type: none"> <li>•Replace bearing.</li> </ul>
•Pulley	<ul style="list-style-type: none"> <li>•Loose pulley on crankshaft</li> </ul>	<ul style="list-style-type: none"> <li>•Check key and tighten set screw.</li> </ul>
<b>Oil leak</b>		
•Crankcase oil seals.	<ul style="list-style-type: none"> <li>•Worn crankcase oil seals.</li> </ul>	<ul style="list-style-type: none"> <li>•Replace crankcase oil seals.</li> </ul>
•Crankshaft oil seals and o-rings.	<ul style="list-style-type: none"> <li>•Worn crankshaft oil seals or o-rings on bearing cover.</li> </ul>	<ul style="list-style-type: none"> <li>•Remove bearing cover and replace o-rings and/or oil seals.</li> </ul>
•Drain plug	<ul style="list-style-type: none"> <li>•Loose drain plug or worn drain plug o-ring.</li> </ul>	<ul style="list-style-type: none"> <li>•Tighten drain plug or replace o-ring.</li> </ul>
•Bubble gauge	<ul style="list-style-type: none"> <li>•Loose bubble gauge or worn bubble gauge gasket.</li> </ul>	<ul style="list-style-type: none"> <li>•Tighten bubble gauge or replace gasket.</li> </ul>
•Rear cover	<ul style="list-style-type: none"> <li>•Loose rear cover or worn rear cover o-ring.</li> </ul>	<ul style="list-style-type: none"> <li>•Tighten rear cover or replace o-ring.</li> </ul>
•Filler cap	<ul style="list-style-type: none"> <li>•Loose filler cap or excessive oil in crankcase.</li> </ul>	<ul style="list-style-type: none"> <li>•Tighten filler cap. Fill crankcase to specified capacity.</li> </ul>
<b>Pump runs extremely rough</b>		
•Inlet conditions	<ul style="list-style-type: none"> <li>•Restricted inlet or air entering the inlet plumbing</li> </ul>	<ul style="list-style-type: none"> <li>•Correct inlet size plumbing. Check for air tight seal.</li> </ul>
•Pump valves	<ul style="list-style-type: none"> <li>•Stuck inlet/discharge valves.</li> </ul>	<ul style="list-style-type: none"> <li>•Clean out foreign material or install new valve kit.</li> </ul>
•Pump seals	<ul style="list-style-type: none"> <li>•Leaking High Pressure or Lo-Pressure seals.</li> </ul>	<ul style="list-style-type: none"> <li>•Install new seal kit. Increase frequency of service.</li> </ul>
<b>Premature seal failure</b>		
	<ul style="list-style-type: none"> <li>•Scored plungers.</li> <li>•Over pressure to inlet manifold.</li> <li>•Abrasive material in the liquid being pumped.</li> <li>•Excessive pressure and/or temperature of pumped liquid.</li> <li>•Running pump dry.</li> <li>•Starving pump of adequate liquid.</li> </ul>	<ul style="list-style-type: none"> <li>•Replace plungers.</li> <li>•Reduce inlet pressure per specifications.</li> <li>•Install proper filtration at pump inlet and clean regularly.</li> <li>•Check pressure and inlet liquid temperature.</li> <li>•DO NOT RUN PUMP WITHOUT LIQUID.</li> <li>•Increase hose one size larger than inlet port size. Pressurize and install C.A.T.</li> </ul>
	<ul style="list-style-type: none"> <li>•Eroded manifold.</li> </ul>	<ul style="list-style-type: none"> <li>•Replace manifold. Check liquid compatibility.</li> </ul>