

# 8 & 28PFR PLUNGER PUMP SERVICE MANUAL



**8 FRAME BLOCK-STYLE MANIFOLD: 781, 781K**  
**28 FRAME BLOCK-STYLE MANIFOLD: 2831, 2831K**

## 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 Sheet for complete specifications, parts list and exploded view.

**LUBRICATION:** Fill crankcase with special CAT PUMP oil per pump specifications [8PFR - 25 oz., 28PFR - 84 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).

**DRIVE 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 PLUMBING:** **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 that is 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.

If a large portion of the pumped liquid is by-passed (not used) when the high pressure system is running, this by-pass liquid should be routed to an adequately sized, baffled supply tank or to drain. If routed to the pump inlet, the **by-pass liquid can quickly develop excessive heat and result in damage to the pump.** A temperature control device to shut the system down within the pump limits or multiple THERMO VALVES must be installed in the by-pass line to protect the pump.

**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.

**SPECIAL "K" MODELS:** Standard pumps have internal weep holes between the V-Packings and Lo-Pressure Seals allowing the pumped liquid to cool the back side of the packings. The "K" models do not have the internal weep holes and do not connect to the inlet side. They have special ports on both sides of the inlet manifold that can be fitted to an external flushing system to provide cooling and flushing.

**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.

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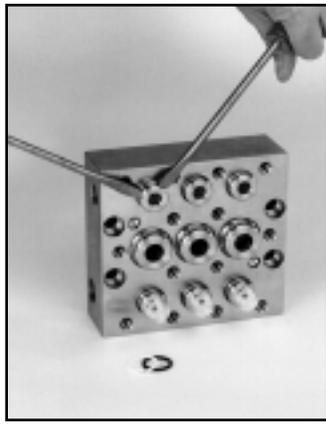
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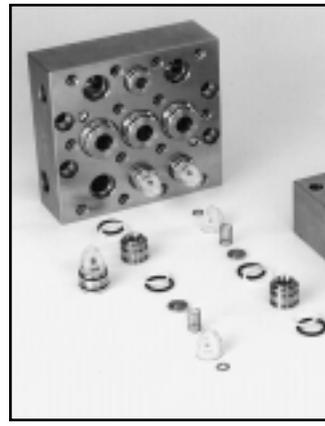
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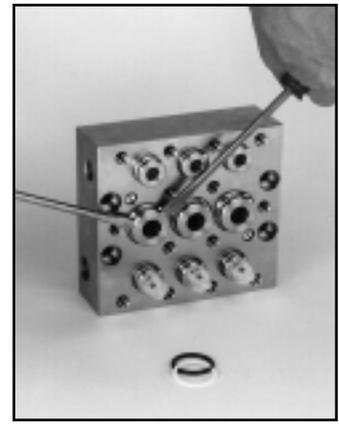
**781**  
Removal of Valve Block Manifold



**781**  
Removal of Valve Assembly from  
Inlet/Discharge Manifold



**781**  
Complete Inlet/Discharge Valve  
Assembly



**781**  
Removal of VP Cylinder from  
Inlet/Discharge Manifold

**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 - 781/781K and 2831/2831K (Discharge and Inlet Valves)

### Disassembly

**NOTE: Both the standard and the “K” versions are serviced in the same manner.**

1. To service the Discharge or Inlet Valve Assemblies, it is necessary to remove the Valve Block Manifold (VBM).
2. Using an allen wrench, remove the Hex Socket Head screws (HSH) from the VBM.
3. On the model 781, insert two M8 x 114 metric threaded bolts into the upper left and lower right intermediate holes on the VBM face. Thread in bolts until they make contact with Inlet Manifold/Discharge Manifold (IMDM) drilled holes. Continue threading until manifolds begin to separate. Support underside of VBM to avoid possible damage to ceramic plungers or plunger rods

**NOTE: The Valve Assemblies may stay with either the VBM or the IMDM.**

4. If the Inlet Valve Assemblies (lower chamber) stay in the IMDM or the Discharge Valve Assemblies (upper chamber) stay in the VBM, then grasp Spring Retainer tabs and pull assemblies from valve chambers.

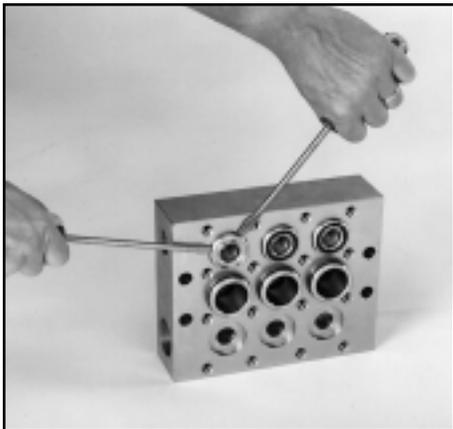
**NOTE: The model 2831 has Valve Adapters with O-Rings and Back-up-Rings that may remain with Inlet or Discharge Valve Assemblies when removed.**

5. If the Inlet Valve Assemblies (lower chamber) stay in the VBM or the Discharge Valve Assemblies (upper chamber) stay in the IMDM, then remove exposed O-Rings (781). Insert two screwdrivers into the groove on opposite sides of the Seat (781) or secondary groove on the Valve Adapter (2831) and pry from valve chamber.

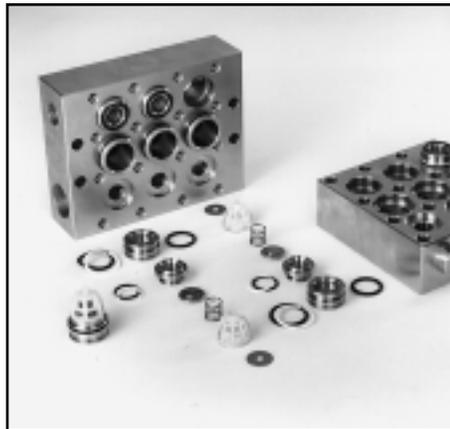
**CAUTION: Exercise caution as the screwdrivers may score o-ring sealing area.**

6. To separate Valve Assemblies, insert screwdriver into Spring Retainer and press the backside of Valve until Seat separates from the Spring Retainer. Each assembly consists of a Retainer Washer, Spring Retainer, Spring, Valve, Seat, O-Ring and Back-up-Ring.
7. On the model 2831, remove Seat from the Valve Adapter by inserting reverse pliers through Seat opening and gently pull out.

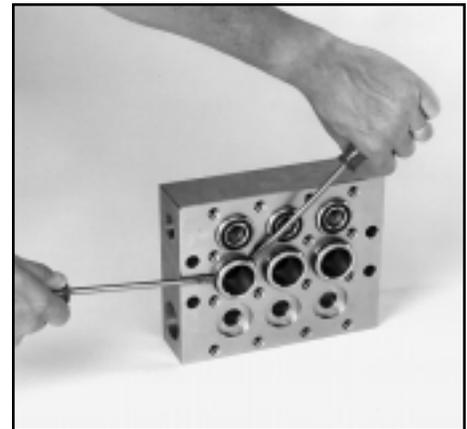
**CAUTION: Exercise caution as the reverse pliers may score sealing areas.**



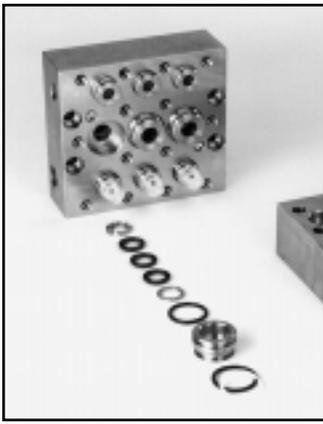
**2831**  
Removal of Valve Adapter from Inlet/Discharge  
Manifold



**2831**  
Complete Inlet/Discharge Valve Assembly



**2831**  
Removal of HPS Spacer from Inlet/Discharge Manifold



**781**  
V-Packing arrangement.



**781**  
Lo-Pressure Seal and Adapter

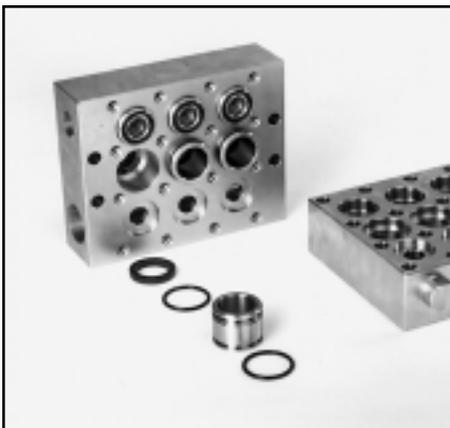


**781**  
Plunger arrangement

### Reassembly

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

1. Examine Retainer Washers for fatigue or wear and replace as needed.
2. Examine Spring Retainers for internal wear or breaks in the structure and replace as needed.
3. Examine Springs for fatigue or breaks and replace as needed.
4. Examine Valves and Seats for grooves, pitting or wear and replace as needed.
5. Examine Seat O-Rings and Back-up-Rings for cuts or wear and replace as needed.
6. On the model 2831, examine Valve Adapter for external surface scoring or wear and replace as needed. Examine Valve Adapter O-Rings for cuts or wear and replace as needed. Install Back-up-Ring, then O-Ring into large groove.
7. Place VBM on work surface with **IMDM side up**.
8. On the model 781, install Back-up-Rings and O-Rings onto both the front and rear of the seat **with the O-Rings to the outside**. On the model 2831, install Back-up-Ring and O-Ring on the Seat **with the O-Rings facing to the inside**.
9. On the model 781, place Seat with O-Rings and Back-up-Rings on work surface with **dish side up**. Then place the Valve onto the Seat **with dish side down/Spring tab up**. On the model 2831, place Valve Adapter on work surface with Back-up-Ring and O-Ring facing up. Press O-Ring side of Seat into Valve Adapter. Then place valve onto seat with dish side down.
10. Place Spring on Valve and snap Spring Retainer onto Seat.
11. On the model 781, insert Retainer Washer into valve chamber with **curved side down**. On the model 2831, place flat Retainer Washer into valve chamber. Press Valve Assembly into the valve chamber until completely seated.
12. On the model 2831, insert O-Rings into groove at bottom of Valve Adapters.
13. Support the VBM from the under side and align manifold with IMDM. Apply anti-seize to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.



**2831**  
Hi-Pressure Seal arrangement.



**2831**  
Lo-Pressure Seal



**2831**  
Plunger arrangement

## SERVICING THE SEALS - 781/781K and 2831/2831K

### Disassembly

**NOTE: Both the standard and the “K” versions are serviced in the same manner. All parts necessary for servicing are included in the Seat Kit.**

**CAUTION: Exercise caution as the reverse pliers may score sealing areas.**

1. To service the seals, it is necessary to remove both the VBM and IMDM. Follow the disassembly procedure found under **SERVICING THE VALVES**.

**NOTE: The V-Packing Cylinder (781) or Hi-Pressure Seal Spacers (HPS) (2831) may stay in the VBM or IMDM.**

2. Remove the exposed O-Rings and insert two screwdrivers into the grooves on opposite sides of the V-Packing Cylinder (781) or into the secondary groove on the HPS Spacer (2831) and pry from the chamber.

**CAUTION: Exercise caution as the screwdriver may score o-ring sealing area.**

3. On the model 781, remove Female Adapters from each chamber.
4. On the model 781, use reverse pliers to remove three V-Packings and one Male Adapter from each V-Packing Cylinder.
5. On the model 2831, use reverse pliers to remove one Hi-Pressure Seal from each IMDM chamber.
6. Invert IMDM and place on flat work surface with **crankcase side up**.
7. On the model 781, use reverse pliers to remove three Inlet Adapter Assemblies by grasping the Inlet Adapter.
8. Use reverse pliers to remove Lo-Pressure Seals from back-side of Inlet Adapter (781) or the IMDM chamber (2831).

### Reassembly

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

**NOTE: For standard installation, apply a small amount of oil to the outside edge of the LPS, HPS, VP, MA, FA for ease of installation and to avoid damage.**

#### **Models 781 and 781K**

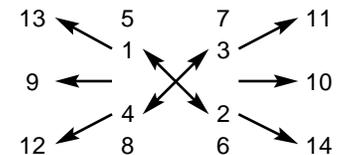
1. Examine Lo-Pressure Seals for wear to the internal ridges, outer surfaces or for broken springs and replace as needed.
2. Examine Inlet Adapters for scale build up or wear, and the Inlet Adapter O-Rings for cuts or deterioration and replace as needed.

**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.**

3. Press new Lo-Pressure Seals into the Inlet Adapters with the **garter spring up**.
4. Press Inlet Adapter Assembly into each chamber of the IMDM with the **garter spring down**.
5. Invert IMDM and place on flat work surface **with crankcase side down**.
6. Examine the V-Packing Cylinder for scale build-up, wear and replace as needed. Examine V-Packing Cylinder O-Rings and Back-up-Rings for cuts or deterioration and replace as needed.

7. Examine Male and Female Adapters for wear and replace as needed.
8. Examine V-Packings for frayed edges or wear and replace as needed.
9. Place the Male Adapters into the V-Packing Cylinder with **flat side down**.
10. Insert three new V-Packings into each V-Packing Cylinder with **“V” groove down**. The “V” will mate with “V side” of the Male Adapter.
11. Position Female Adapter into the IMDM with **“V” groove up**.
12. Press V-Packing Cylinder Assembly into IMDM center chambers with V-Packings facing **into the manifold chamber**.
13. Support the IMDM from the under side and align the manifold bolt holes with crankcase holes. Apply Loctite® 242® to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.
14. Support the VBM from the under side and align manifold with IMDM. Apply anti-seize to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.

#### **TORQUE SEQUENCE**



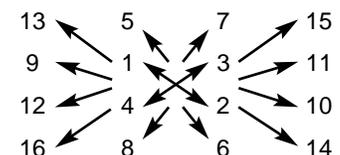
#### **Models 2831 and 2831K**

1. Examine Lo-Pressure Seals for wear to the internal ridges, outer surfaces or for broken springs and replace as needed.
2. Press new Lo-Pressure Seals into IMDM with the **garter spring down**.

**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.**

3. Invert IMDM and place on flat work surface with **crankcase side down**.
4. Examine HPS Spacer for scale build-up, wear and replace as needed. Examine HPS Spacer O-Rings for cuts or deterioration and replace as needed.
5. Examine Hi-Pressure Seals for frayed edges or wear and replace as needed.
6. Press Hi-Pressure Seal into each IMDM center chamber with metal backing **facing down into the manifold chamber**.
7. Press HPS Spacer into each center manifold chamber **with secondary groove facing out**.
8. Support the IMDM from the under side and align the manifold bolt holes with crankcase holes. Apply Loctite® 242® to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.
9. Support the VBM from the under side and align manifold with IMDM. Apply anti-seize to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.

#### **TORQUE SEQUENCE**



## SERVICING THE PLUNGERS - 781/781K and 2831/2831K

### Disassembly

**NOTE: Both the standard and the “K” versions are serviced in the same manner.**

1. To service the plungers, it is necessary to remove both the VBM and IMDM. Follow the disassembly procedure found under **SERVICING THE VALVES**.
2. Remove the one piece Seal Retainer from each Plunger Rod.
3. Using a Hex tool, loosen the Plunger Retainers about three to four turns.
4. Push the Ceramic Plungers back towards the crankcase to separate from the Plunger Retainers and proceed with unthreading the Plunger Retainers by hand.
5. Remove Plunger Retainers, O-Rings, Back-up-Rings and Gaskets.

**NOTE: Plunger Retainer Studs may stay on Plunger Rods or come off with Plunger Retainers.**

6. Remove Ceramic Plungers, Keyhole Washers and Barrier Slingers.

### Reassembly

1. Visually inspect Crankcase Oil Seals for deterioration or leaks and contact CAT PUMPS for assistance with replacement. See **SERVICING THE CRANKCASE** section.
2. Examine Plunger Retainers, Studs, Barrier Slingers and Keyhole Washers for wear and replace as needed.
3. Slide Barrier Slingers over Plunger Retainer Studs with **concave side away from crankcase**.
4. Slide Keyhole Washers over Plunger Retainer Studs with **split ends facing downward**.
5. Examine Ceramic Plungers for scoring, scale build-up, chips or cracks and replace as needed.
6. Slide Ceramic Plungers over Plunger Retainer Studs.

**NOTE: Plunger can only be installed in one direction. Do not force onto Plunger Rod.**

7. Examine Gaskets, O-Rings and Back-up-Rings for cuts or wear and replace as needed.
8. Install Gaskets first, then O-Rings and Back-up-Rings onto Plunger Retainers.

**NOTE: Lubricate O-Rings and Back-up-Rings for ease in installation and to reduce possible damage.**

9. Apply Loctite® 242® to exposed threaded end of Plunger Retainer Studs. Thread on Plunger Retainer and torque per chart.
10. On the model 781, install Seal Retainers with drain slots facing the crankcase with **openings to the top and bottom**. On the model 2831 the drain openings must **face the manifold**.
11. Support the IMDM from the under side and align manifold bolt holes with crankcase holes. Apply Loctite® 242® to HSH screws threads and thread in hand tight. Torque in sequence to specifications in torque chart.
12. Support the VBM from the under side and align manifold with IMDM. Apply anti-seize to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.

## SERVICING THE CRANKCASE SECTION - 781/781K and 2831/2831K

**NOTE: Both the standard and the “K” versions are serviced in the same manner.**

1. While manifolds, plungers and seal retainers are removed examine crankcase oil seals for leaking and wear.
2. Check for any signs of leaking at Rear Cover, Drain Plug, and Bubble Oil Gauge (781) or Rear Cover, Drain Plug, and Dipstick (2831).
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.

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## 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 multi-viscosity ISO68 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.

## 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 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 liquid 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 70 PSI (4.9 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.
- "K" versions are suitable for high inlet pressures. Consult CAT PUMPS.

**INLET ACCESSORIES** are designed to protect against over pressurization, 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 line.
- 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 cut off switch between the inlet filter and the pump to shut off pump when there is no positive inlet pressure.
- "K" versions are suitable for high temperatures and containment of harmful liquids. Consult CAT PUMPS for optional flushing and cooling accessory.

**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. When a pulsation dampener is used, 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 064 for additional information on the size and length of the by-pass line.
- Check the pressure in the by-pass line to avoid over pressurizing 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.

## TORQUE CHART

Pump Item			Torque		
Pump Model	Thread	Tool Size [P/N]	in. lbs.	ft. lbs.	Nm
<b>Plunger Retainer</b>					
781	M5	M11 Hex	55	4.4	6
2831	M7	M14 Hex	90	7.2	10
<b>Inlet/Discharge Manifold Screws</b>					
781	M10	M8 Allen [33046]	250	20.8	28
2831	M12	M10 Allen [33047]	355	29.6	40
<b>Valve Block Manifold Screws</b>					
781	M10	M8 Allen [33046]	250	20.8	28
2831	M12	M10 Allen [33047]	355	29.6	40
<b>Crankcase Cover/Bearing Cover Screws</b>					
781	M6	M10 Hex [25082]	115	9.4	13
2831	M8	M13 Hex [25324]	115	9.4	13
<b>Connecting Rod Screws</b>					
781, 2831	M8	M13 Hex [25324]	130	10.8	15
<b>Bubble Oil Gauge</b>					
781, 2831	M28	Oil Gauge Tool [44050]	45	3.6	5

## 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
035	Servicing Crankcase Section	7PFR - 60PFR
036	Cylinder and Plunger Reference Chart	All Models
043	LPS and HPS Servicing	All Plunger Models
053	Liquid Gasket	All Plunger NAB-S.S. Models
064	By-Pass Hose Sizing	All Unloaders/Regulators
074	Torque Chart	Piston and Plunger Pumps
077	Oil Drain Kit	All Models (except 2SF/4SF)
083	Winterizing a Pump	All Models
085	M8 Keyway	25FR, 25PFR, 28PFR

## 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							

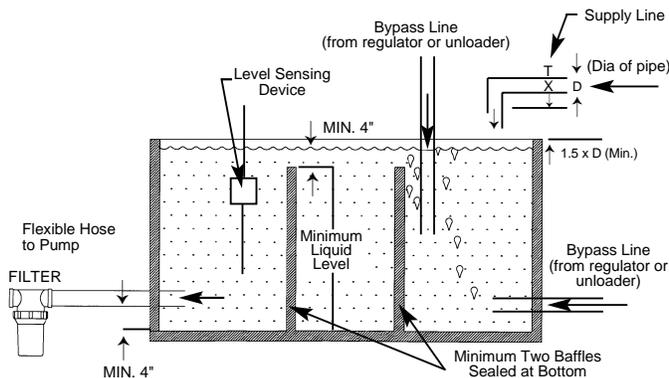
## RESISTANCE OF VALVES AND FITTINGS

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?

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

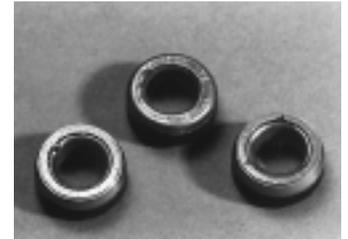
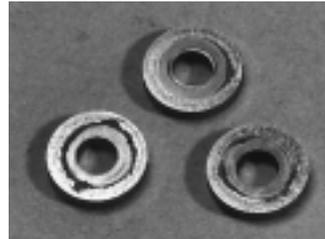
Q. What size motor pulley should I use?

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

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>• <b>Pressure feed high temperature liquids</b></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 V-Packings, Hi-Pressure or Lo-Pressure Seals.</li> <li>•Worn adapter/V/P cylinder 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 and V-Packings.</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 V-Packings, Hi-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>