

# 15 & 25PFR PLUNGER PUMP SERVICE MANUAL



**15 FRAME SPLIT MANIFOLD:  
25 FRAME SPLIT MANIFOLD:**

**1530, 1531, 1540, 1540E, 1560  
2510, 2511**

## 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 (15PFR-42 oz., 25PFR-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**. Additional lubrication may be required with increased hours of operation and temperature.

**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 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 (Prrrr-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.

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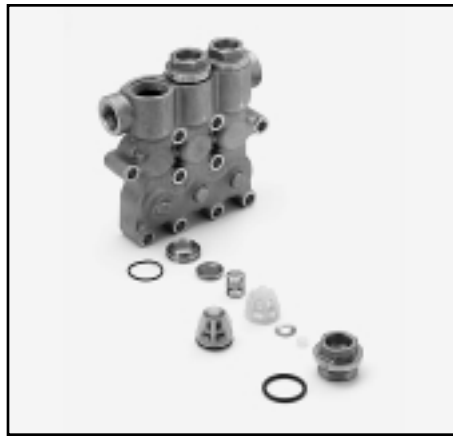
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**1530, 1531**  
Complete Inlet/Discharge Valve Assembly



**1540, 1540E**  
Complete Inlet/Discharge Valve Assembly



**2510, 2511**  
Complete Inlet/Discharge Valve Assembly

**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. Models 1530 1531, 1540, 1540E, 2510, 2511: Remove the hex valve plugs with o-ring.

Model 1560: Remove the eight (8) hex socket head (HSH) screws and valve cover. Remove valve plugs with o-ring and back-up-ring.

2. Models 1530 1531, 2510, 2511: Remove the exposed coil spring and washer from the top of the spring retainer.

Models 1540 and 1540E: Remove washer from the top of the spring retainer.

3. Models 1530, 1531, 1540, 1540E, 2510 and 2511: Using a pliers to grasp the spring retainer by the tab at the top and remove from valve chamber. Normally the valve assembly will remain together. If the assembly separates during removal, use a reverse pliers and lift the seats from the chamber.

Model 1560: Use a reverse pliers to grasp the spring retainer and remove the stacked valve assemblies.

4. 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 spring retainer, spring, valve, seat, o-ring and back-up-ring.

Models 1540, 1540E ONLY: The discharge manifold must be removed in order to remove the inlet valve assemblies. Follow disassembly procedure for REMOVING THE DISCHARGE MANIFOLD.

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

1. Examine spring retainers for internal wear or breaks in the structure and replace as needed.
2. Examine springs and coil springs for fatigue or breaks and replace as needed.
3. Examine valves and seats for grooves, pitting or wear and replace as needed.
4. Examine seat o-rings and back-up-rings for cuts or wear and replace as needed.
5. Models 1530, 1531, 2510, 2511: Install o-ring, then back-up-ring onto seat.

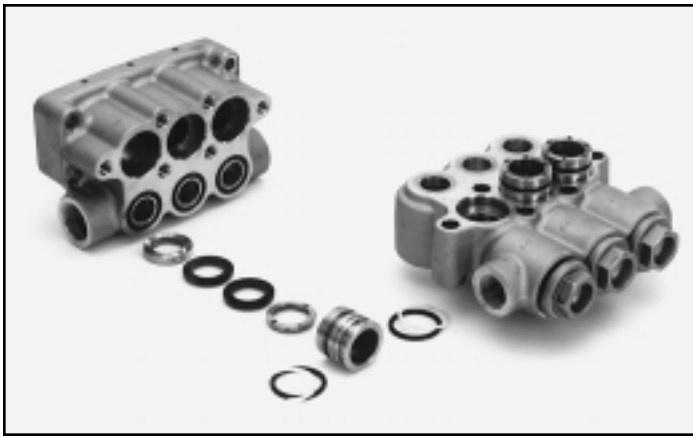
Models 1540, 1540E: Install o-ring onto seat.

6. Place the valve onto the seat with dish side down.

7. Place spring on valve and snap the spring retainer onto seat.
8. Model 1560: Install o-ring onto small diameter inlet seat.
9. Place the valve onto the seat with dish side down.
10. Place spring on valve and snap longer spring retainer with large opening onto seat.
11. Install o-ring, then back-up-ring onto discharge seat. Snap discharge seat onto inlet spring retainer.
12. Place valve onto seat with dish side down.
13. Place spring on valve and snap smaller spring retainer onto discharge seat.
14. Lubricate outer o-ring and back-up-ring surface and walls of valve chamber and press valve assembly squarely into valve chamber until completely seated.
15. Models 1530, 1531, 2510, 2511: Place washer, then coil spring on top of the spring retainer.
- Models 1540, 1540E: Place washer on top of the spring retainer.
16. Models 1540, 1540E (inlet valve assemblies): Place washer into valve chamber on back side of manifold. Lubricate outer o-ring and press valve assembly into valve chamber, retainer first, until completely seated.
17. Examine the o-ring on the valve plug and replace if cut or worn. Lubricate new o-ring before installing on valve plug to avoid damaging as they are worked over the plug threads.

**NOTE:** It is highly recommended that antiseize lubricant (PN6119) be applied to the threads on all stainless steel components to prevent galling.

18. Slowly thread the valve plug into chamber. Exercise caution to avoid extruding or cutting the o-ring. Torque to specifications in torque chart.
19. Model 1560: Place valve cover over valve plugs. Thread HSH screws in hand tight. Torque to specifications in torque chart.
20. Install new o-rings at bottom inlet ports of inlet manifold. Support the discharge manifold from the under side and press discharge manifold into inlet manifold. Thread HSH screws in hand tight. Torque in sequence to specifications in torque chart.



### 1530, 1531

V-Packing Arrangement

#### REMOVING THE DISCHARGE MANIFOLD

1. Remove the HSH screws.
2. Support the manifold from the underside and tap the backside of the discharge manifold with a soft mallet to gradually work manifold from pump.
3. Remove the o-rings from lower chambers of the face of the inlet manifold.

#### REMOVING THE INLET MANIFOLD

1. Remove the HSH Screws. Rotate the crankshaft to begin the separation of the inlet manifold from the crankcase.
2. Support the manifold from the underside and tap the rear of the inlet manifold with a soft mallet to gradually work from pump.

**NOTE:** Two screwdrivers on opposite sides of the manifold may be used to assist separation.

#### SERVICING THE SEALS

##### Disassembly

1. To service the seals and packings, it is necessary to remove both the discharge and inlet manifolds. Follow disassembly procedures for REMOVING THE DISCHARGE MANIFOLD and REMOVING THE INLET MANIFOLD.

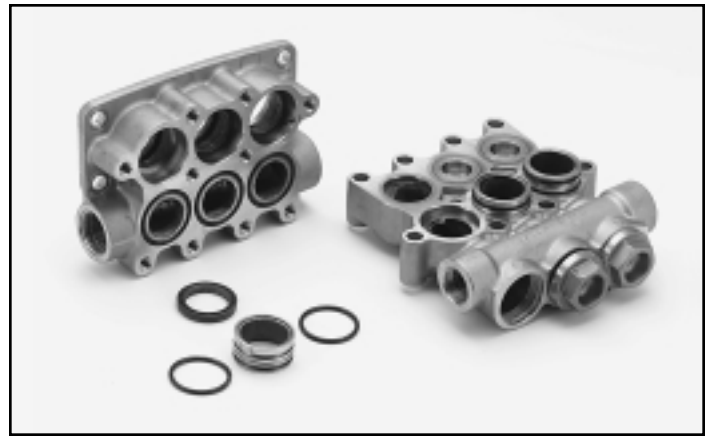
**NOTE:** On models 1530, 1531, 2510, 2511, the spacer with coil springs may stay in the discharge manifold or inlet manifold. On models 1540, 1540E, the HPS spacer will generally stay in the inlet manifold.

2. Models 1530, 1531, 2510, 2511: Remove the spacer with coil springs from either manifold and exposed o-rings and back-up-rings from the spacer.



### 2510, 2511

V-Packing Arrangement



### 1540, 1540E

Hi-Pressure Seal Arrangement

Models 1540, 1540E, 1560: Remove the exposed o-ring. Insert two screwdrivers into the grooves on opposite sides of the spacer and pry from the chamber.

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

3. Models 1530, 1531, 2510, 2511: Remove male adapter, two V-Packings and female adapter from each seal chamber.

Models 1540, 1540E: Remove Hi-Pressure seal (HPS) from each seal chamber.

Model 1560: Remove three V-Packings and female adapter from each seal chamber.

4. Place the inlet manifold on the work surface with crankcase side up.

5. Models 1530, 1531, 1540, 1540E, 1560: Use a screwdriver to remove Lo-Pressure seal (LPS) from backside of manifold.

Models 2510, 2511: Use a screwdriver to remove washer and Lo-Pressure seal from backside of manifold.

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

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

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

1. Examine Lo-Pressure seals for wear to the internal ridges, outer surfaces or for broken springs and replace as needed.
2. Press Lo-Pressure seal into each seal chamber of the Inlet Manifold with the garter spring down.

Models 2510, 2511: Install washers into each seal chamber.

**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. Models 1530, 1531, 2510, 2511: Examine the spacer with coil springs for scale build-up, wear, broken or fatigued coil springs and replace as needed. Examine both front and rear o-rings and back-up-rings for cuts or deterioration, replace as needed.

Models 1540, 1540E: Examine the HPS spacer for scale build-up or wear and replace as needed. Examine the front and rear o-rings for cuts or deterioration and replace as needed.

4. Models 1530, 1531, 2510, 2511: Examine male and female adapters for wear and replace as needed.

Model 1560: Examine female adapter and spacer and replace as needed.



**1530, 1531**  
Lo-Pressure Seal



**1540, 1540E**  
Lo-Pressure Seal



**2510, 2511**  
Lo-Pressure Seal

- Models 1530, 1531, 1560, 2510, 2511: Examine V-Packings for frayed edges or uneven wear and replace as needed.

Models 1540, 1540E: Examine Hi-Pressure seals for frayed edges or uneven wear and replace as needed.

- Place the inlet manifold on work surface with crankcase side down.
- Models 1530, 1531, 1560, 2510, 2511: Place the female adapter with flat side down, "V" side up into each seal chamber.
- Models 1530, 1531, 2510, 2511: Fit two new V-Packings together.  
Model 1560: Fit three new V-Packings together.

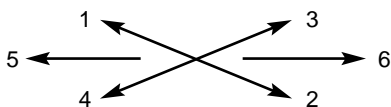
Lubricate the outer surface of the packings and insert into seal chamber with the "V" side down. The "V" will mate with "V" side of the female adapter.

- Models 1530, 1531, 2510, 2511: Place male adapter with "V" side down inside each seal chamber.
- Models 1530, 1531, 2510, 2511: Lubricate outer surface of spacer with coil springs and insert into seal chamber until completely seated.
- Models 1540, 1540E: Lubricate outer surfaces of Hi-Pressure seals and position into seal chamber with metal back down, grooved side up. Lubricate the outer o-rings on the HPS spacer and press into IM seal chamber.
- Model 1540E ONLY: Apply liquid gasket ThreeBond 1207D to the face of the crankcase and inlet manifold to maintain a moisture-free seal. Refer to Tech Bulletin 100.
- Support the inlet manifold from the under side and slide over plungers. Apply Loctite® 242® to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.
- Install new o-rings at bottom inlet ports of inlet manifold.
- Support the discharge manifold from the under side and press discharge manifold into inlet manifold. Thread HSH screws in hand tight. Torque in sequence to specifications in torque chart

**NOTE:** It is highly recommended that antiseize lubricant (PN6119) be applied to the threads on all stainless steel components to prevent galling.

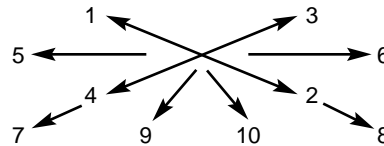
#### TORQUE SEQUENCE

**Models 1530, 1531, 1560, 2510, 2511**



#### TORQUE SEQUENCE

**Models 1540, 1540E**



#### SERVICING THE PLUNGERS

##### Disassembly

- To service the plungers, it is necessary to remove the discharge and inlet manifolds. Follow disassembly procedures for REMOVING THE DISCHARGE MANIFOLD and REMOVING THE INLET MANIFOLD.
- Models 1530, 1531, 1560: Remove the two-piece seal retainer and wick from each plunger rod.  
Models 2510, 2511: Remove the one-piece seal retainer and wick from each plunger rod.  
Model 1540, 1540E: Remove the one-piece seal retainer from each plunger rod.
- Using a wrench, loosen the plunger retainers about three to four turns.
- Push the ceramic plungers back towards the crankcase to separate from the plunger retainers and proceed with unthreading the plunger retainers by hand.
- Remove plunger retainers, o-rings, back-up-rings and gaskets.  
**NOTE:** On Models 1531, 2510, 2511, the plunger retainer studs may stay on plunger rods or come off with plunger retainers.
- Models 1530, 1531, 1540, 1540E: Remove ceramic plungers and barrier slingers.  
Models 1560, 2510, 2511: Remove ceramic plungers, keyhole washers and barrier slingers.

##### Reassembly

- Visually inspect crankcase oil seals for deterioration or leaks and contact CAT PUMPS for assistance with replacement.
- Examine plunger retainers, studs, barrier slingers and keyhole washers for wear and replace as needed.
- Models 1530, 1531, 1540, 1540E: Slide barrier slingers over plunger rods with concave side away from crankcase.  
Models 1560, 2510, 2511: Slide keyhole washer over plunger rods with split ends facing downward.



### 1530, 1531

#### Plunger Arrangement

4. Examine ceramic plungers for scoring, scale build-up, chips or cracks and replace as needed. Generally the ceramic plungers do not need to be replaced.
5. Slide ceramic plungers over plunger rods.

**NOTE:** Ceramic plunger can only be installed in one direction. Do not force onto plunger 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.

6. Examine gaskets, o-rings and back-up-rings for cuts or wear and replace as needed.
7. Models 1530, 1531, 1560, 2510, 2511: 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.

Models 1540, 1540E: Install gasket onto plunger retainers.

8. Apply Loctite® 242® to exposed threads on the plunger retainer and torque per chart.
9. Rotate the crankshaft so the two outside plungers are extended the same distance.
10. Models 1530, 1531, 1560, 2510, 2511: Install seal retainer onto the plunger rod with new wicks, long tab down.

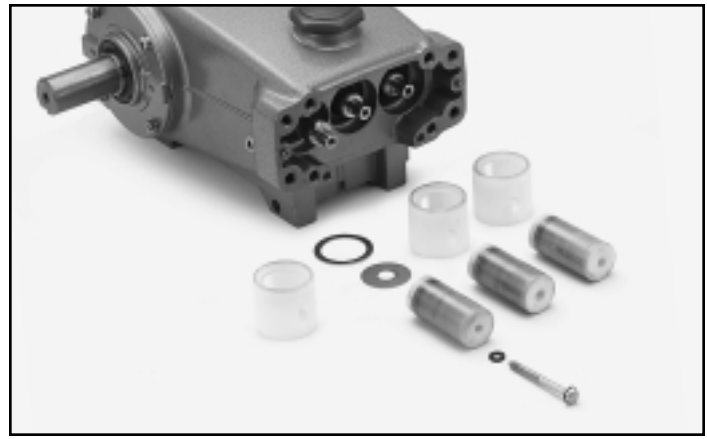
Models 1530, 1531, 1560: The drain slots should face the crankcase with openings to the top and bottom.

Models 1540, 1540E, 2510, 2511: The seal retainer openings should be at top and bottom. Press completely into crankcase.



### 2510, 2511

#### Plunger Arrangement



### 1540, 1540E

#### Plunger Arrangement

11. Lightly lubricate ceramic plungers to assist in installing into the manifold.
12. Support the inlet manifold from the under side and slide over plungers. Press completely into crankcase. Apply Loctite® 242® to HSH screw threads and thread in hand tight. Torque in sequence to specifications in torque chart.
13. Install new o-rings at bottom inlet ports of inlet manifold.
14. Support the discharge manifold from the under side and align with inlet manifold. Thread in hand tight. Torque in sequence to specifications in torque chart.

**NOTE:** It is highly recommended that antiseize lubricant (PN6119) be applied to the threads on all stainless steel components to prevent galling.

### SERVICING THE CRANKCASE SECTION

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, bubble gauge and dipstick (2510, 2511).  
Model 1540E ONLY: When servicing the crankshaft seal, bearing cover or rear cover, apply liquid gasket ThreeBond 1207D to the face of the crankcase, inlet manifold, bearing covers and rear cover o-ring groove to maintain a moisture-free seal. Refer to Tech Bulletin 100.
3. Check oil level and check 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 custom-blend multi-viscosity ISO68 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/relief valve at each seal servicing and check all system accessories and connections before resuming operation.

Refer to DVD for additional assistance.

## TORQUE CHART

Pump Item Pump Model	Thread	Tool Size [P/N]	in. lbs.	Torque ft. lbs.	Nm
<b>Plunger Retainer</b>					
15PFR	M6	M12 Hex	55	4.6	6.2
25PFR	M7	M14 Hex [25053]	108	9.0	12.2
<b>Inlet Manifold Screws</b>					
15PFR	M10	M8 Allen [33046]	222	18.5	25
25PFR	M12	M10 Allen [33047]	355	30.0	40
<b>Discharge Manifold Screws</b>					
1530, 1531, 1560, 2510, 2511	M12	M10 Allen [ 33047]	355	30.0	40
1540, 1540E	M10	M8 Allen [33046]	250	21.0	28
<b>Valve Plug/Valve Cover Screws</b>					
1560 ONLY	M12	M10 Allen [33047]	250	21.0	28
15PFR	M36	M32 Hex	1060	88	119
25PFR	M42	M36 Hex	1680	140	190
<b>Rear Cover/Bearing Cover Screws</b>					
15PFR	M6	M10 Hex [25082]	50	4.0	5.4
25PFR	M8	M13 Hex [25324]	115	9.58	13
<b>Connecting Rod Screws</b>					
15PFR, 25PFR	M8	M13 Hex [25324]	216	18	24
<b>Bubble Oil Gauge</b>					
15PFR Only	M28 Oil Gauge Tool	[44050]	45	3.8	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	7CP, 7PFR-68PFR
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
095	Galling Preventative	All Stainless Steel Pumps
100	Crankcase and Model Number Change	1540 to 1540E

## 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.

**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.

**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.

## 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						

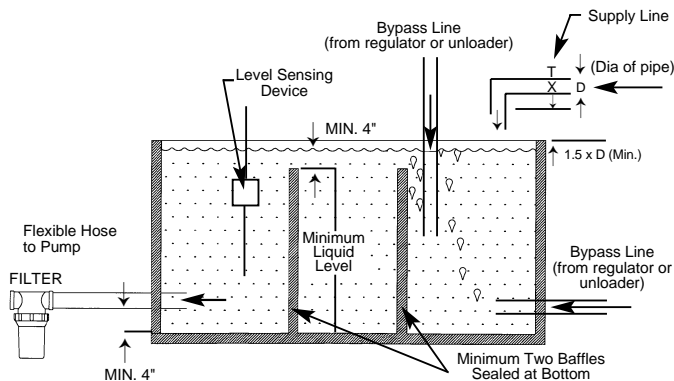
## RESISTANCE OF VALVES AND FITTINGS

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?

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

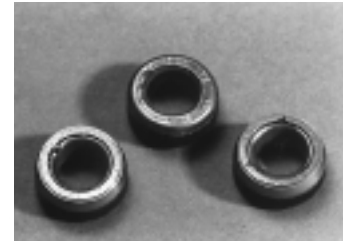
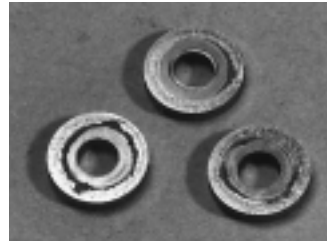
Q. What size motor pulley should I use?

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

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, 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 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, 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>