35FR PLUNGER PUMP SERVICE MANUAL

SPLIT MANIFOLD PLUNGER PUMP
35 FRAME [3520, 3521 and 3527]
35 FRAME [3535, 3531 and 3537]
35 FRAME [3545, 3541]

CAUTION: CAT PUMPS are positive displacement pumps. Therefore, a properly designed pressure RELIEF OR SAFETY VALVE MUST BE INSTALLED in the discharge piping. Failure to install such a relief mechanism could result in personal injury or damage to the pump or system. CAT PUMPS does not assume any liability or responsibility for the operation of a customer's high pressure system.

INSTALLATION AND START-UP INFORMATION

Optimum performance of the pump is dependent upon the entire fluid 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.

LUBRICATION: Fill crankcase with special CAT PUMP oil per pump specifications [4.2 Qts. - 4.0 L]. 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. Oiler adjustment** is vertical to start feed, horizontal to stop feed, dial to adjust flow rate. 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 volume from Horsepower Requirement and Pulley Selection Chart.

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 volume, 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.

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.

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 mounted directly to the discharge line. Be certain the pulsation dampener (Prrrrr-o-lator) is properly precharged for the system pressure (see individual Prrrrr-o-lator 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.

A Pressure Regulator or Unloader Valve must be installed to prevent over pressurizing the pump in the event the discharge or downstream plumbing becomes plugged or is turned off. Severe damage to the pump will result if this condition occurs without a relief valve in the line. **CAUTION: Failure to install such a safety valve will void the warranty on the pump. Discharge regulating devices should be at minimum pressure setting at start-up.** On systems over 2000 PSI SECONDARY PROTECTION is recommended by installing a pop-off valve, safety valve or rupture disc. START SYSTEM WITH ALL VALVES OPEN OR IN THE LOW PRESSURE SETTING.

Use PTFE liquid (sparingly) or tape 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.

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

STORING: For extended storing or between use in cold climates, drain all pumped fluids from pump and **flush with antifreeze solution to prevent freezing and damage** to the pump. DO NOT RUN PUMP WITH FROZEN FLUID.

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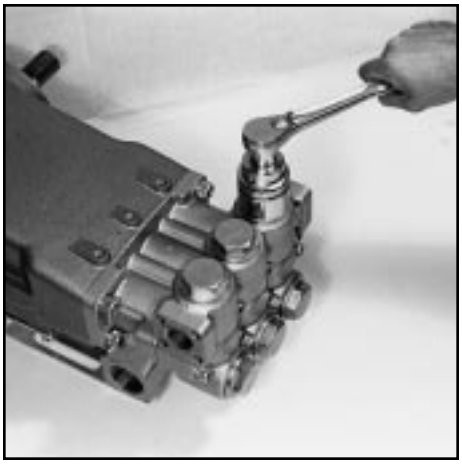
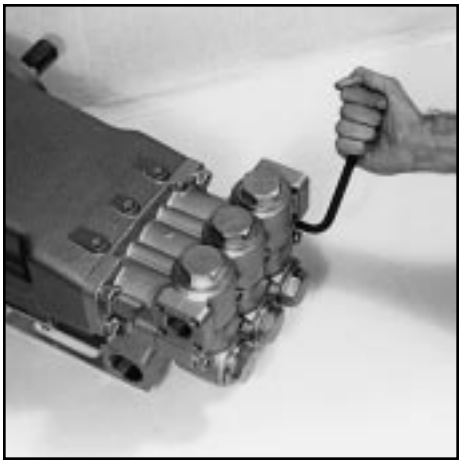




SERVICING THE VALVES

DISASSEMBLY

1. Remove the six (6) M41 Hex Valve Plugs.
2. Remove the exposed Coil Spring from the top of the Spring Retainer. Thread an M8 bolt into the top of the Spring Retainer. The assembly will usually remain together. To separate, continue threading the bolt into the back side of the Valve Seat until it separates from the Spring Retainer. In all models if the assembly separates during removal, use a valve seat removal tool and lift the Seats from the chamber.

REASSEMBLY

NOTE: For certain applications apply liquid gasket to the o-ring crevices and seal surfaces. See Tech Bulletin #53 for model identification.

1. Examine the O-Rings and Back-up-Rings on the Seat and replace if cut or worn. Lubricate the O-Ring before installing.
2. Examine the surface of the Valve and Seat for pitting, grooves or wear and replace if necessary.
3. Next assemble Valve Retainer, Spring, Valve and Seat by snapping together securely. Thread the M8 bolt into spring retainer for installation.
4. Lubricate outer O-Ring and Back-up-Ring surface and walls of valve chamber and press Valve Assembly squarely into chamber. Remove M8 bolt. Place the washer over the top of the Spring Retainer and then the Coil Spring on top of the Washer.
5. Examine the O-Ring and Back-up-Ring on the Valve Plug and replace if cut or worn. Lubricate new O-Ring and Back-up-Ring before installing on Valve Plug to avoid damaging as they are worked over the plug threads. NOTE: The Back-up-Ring must go on first, then the O-Ring.
6. **Slowly** thread the Valve Plug into chamber. Exercise caution to avoid extruding or cutting the Back-up-Ring or O-Ring. Then torque to specifications.
   NOTE: Apply Loctite 242 to the threads of the Valve Plug before threading into the manifold chamber.

REMOVING THE DISCHARGE MANIFOLD

1. Remove the eight (8) hex socket head screws.
2. Tap the back side of the Discharge Manifold with a soft mallet and gradually work head from pump.
3. Remove the O-Rings from lower chambers of the face of the Inlet Manifold.

REMOVING THE INLET MANIFOLD

1. Using a hex allen wrench, remove the four (4) hex socket head screws. Rotate the Crankshaft to begin the separation of the Inlet Manifold from the Crankcase.
2. Tap the rear of the Inlet Manifold with a soft mallet and gradually work from pump. NOTE: Support from the underside and exercise caution to keep manifold aligned with Plungers to avoid damage to the Plungers as the manifold is removed. NOTE: Two screwdrivers on opposite sides of the manifold may be used to assist separation.

SERVICING THE PACKINGS

DISASSEMBLY OF THE V-PACKINGS

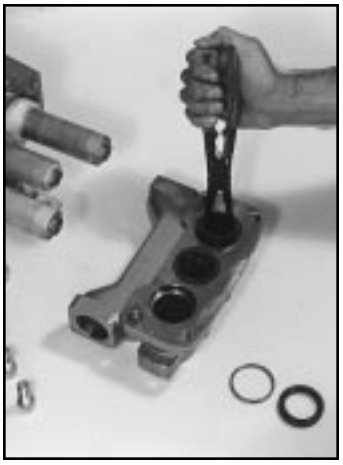
1. Place the **crankcase side** of the Inlet Manifold **down** on the work surface.
2. First remove the V-Packing Spacer. These may stay in either the Inlet or Discharge Manifold ports when the Discharge Manifold is removed. If they are extremely dirty or dry, remove the exposed O-Ring and Back-up-Ring and insert two screwdrivers on opposite sides to pry out of chamber.
3. Examine both front and rear O-Rings and Back-up-Rings on the V-Packing Spacer for cuts or wear and replace as needed. NOTE: The 3545, 3541 do not have Back-up-Rings.
4. To remove the V-Packing Cylinder (3520, 3521, 3527), insert two screwdrivers on opposite sides of the V-Packing Cylinder and pry out. Examine the O-Ring for wear and replace as needed.
5. Next remove Spacer with coil springs. Examine for broken or fatigued springs or scale build up or pitting and replace as needed.
6. Then with reverse pliers remove the Male Adapter, V-Packings and Female Adapter. NOTE: Using the reverse pliers may damage the V-Packings or Female Adapter.
7. Examine Female Adapter for worn I.D. and replace as needed.

REASSEMBLY OF THE V-PACKINGS

NOTE: For certain applications apply liquid gasket to the o-ring crevices and seal surfaces. See Tech Bulletin #53 for model identification.

1. Lubricate outer surface of V-Packing Cylinder and install new O-Ring in groove (3520, 3521, 3527). Press V-Packing Cylinder with **O-Ring end down** into the manifold chamber until completely seated.
2. Insert the Female Adapter into the V-Packing Cylinder (3520, 3521, 3527) or manifold chamber (3535, 3531, 3537, 3545, 3541) with the **"V" groove up**.
3. Next fit the new V-Packings together, lubricate the outer surface of the packings and insert into V-Packing Cylinder (3520, 3521, 3527) or manifold chamber (3535, 3531, 3537, 3545, 3541) with the **"V" groove up.**
4. Then install the Male Adapter into V-Packing Cylinder (3520, 3521, 3527) or manifold chamber (3535, 3531, 3537, 3545, 3541) with the **"V" groove down** (notches up).
5. Lubricate outer surface of Spacer with coil springs and insert into V-Packing Cylinder (3520, 3521, 3527) or manifold chamber (3535, 3531, 3537, 3545, 3541) with **springs facing down**. See Tech Bulletin #50 when servicing old style pumps; both the spacer with coil springs and Inlet Manifold must be updated.
6. Lubricate outer surface of V-Packing Spacer, install new O-Rings and Back-up-Rings in both front and rear groove and press into V-Packing Cylinder (3520, 3521, 3527) or manifold chamber (3535, 3531, 3537) with **small diameter down** until completely seated. NOTE: The 3545, 3541 do not have Back-up-Rings.


Model 3531, 3537



DISASSEMBLY OF THE LO-PRESSURE SEAL

1. With the Inlet Manifold on blocks and with the **crankcase side down,** insert screwdriver into seal chamber and tap opposite sides of the Washer Spacer to drive out seal assembly.
   NOTE: Models 3535, 3531, 3537, 3545, 3541 include Spacer and Lo-Pressure Seal. Models 3520, 3521, 3527 include Washer, Lo-Pressure Seal, Inlet Adapter and O-Ring.
2. Elevate Inlet Adapter with **Lo-Pressure Seal down** and tap with screwdriver on opposite sides of seal to drive seal out of Inlet Adapter (Models 3520, 3521, 3527 only). Replace the Lo-Pressure Seal and examine O-Ring for wear and replace as needed.

REASSEMBLY OF THE LO-PRESSURE SEAL

NOTE: For certain applications apply liquid gasket to the o-ring crevices and seal surfaces. See Tech Bulletin #53 for model identification.

MODELS 3535, 3531, 3537

1. With the **crankcase side of Inlet Manifold up** insert the Spacer into the seal chamber.
2. Install Lo-Pressure Seal into seal chamber with **garter spring facing down** and press squarely into position.

MODELS 3520, 3521, 3527

1. With the **crankcase side of Inlet Manifold up** insert the Washer into the seal chamber.
2. Install Lo-Pressure Seal into larger diameter of Inlet Adapter **with spring up**.
3. Next lubricate outer surface of Adapter and install O-Ring into the groove of the Adapter.
4. Press **Inlet Adapter with seal** into seal chamber with **garter spring facing down**.

MODEL 3545, 3541

1. With the **crankcase side of the Inlet Manifold up** install Lo-Pressure Seal into the manifold chamber with **garter spring facing down** and press squarely into position.
   NOTE: Spacer is installed after the Seal Retainer on model 3545, 3541. See Servicing The Plungers.

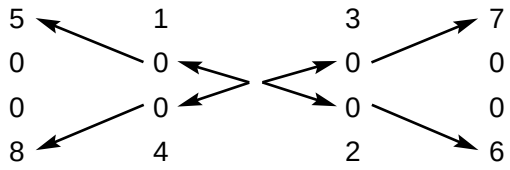
SERVICING THE PLUNGERS

DISASSEMBLY

1. Remove the Seal Retainers from the Ceramic Plungers.
2. Remove the inner collar from the front of the seal retainer.
3. Remove the used Wick and install new Wick. Lubrication: Oiler setting for Wicks is three drops per hole, twice per month for normal operation. Oiler adjustment is vertical to start feed, horizontal to stop feed, 45° to flush bearing. Additional lubrication may be required with increased hours of operation and temperature.
   NOTE: Model 3545, 3541 do not have Wicks or front Collar of Seal Retainer.
4. Replace Inner Collar on Seal Retainer.
5. Loosen Plunger Retainer 4 to 5 turns. Push Plunger towards Crankcase until Plunger Retainer pops out.
6. Unscrew and remove Plunger Retainer, Gasket, O-Ring, Back-up-Ring and Ceramic Plunger, Keyhole Washer and Barrier Slinger from the Plunger Rod.

REASSEMBLY

1. With these plunger items removed, examine the Crankcase Oil Seal for wear or deterioration and replace as needed.
2. Replace Keyhole Washer on Plunger Rod.
3. Carefully examine each Plunger for scoring or cracks and replace if worn.
   NOTE: Ceramic Plunger can only be installed one direction **(front to back)**. Do not force onto rod.
4. Examine Gasket, O-Ring and Back-up-Ring on Plunger Retainer and replace if cut or worn. Lubricate O-Ring for ease of installation and to avoid damaging O-Rings. NOTE: First install Gasket, then O-Ring and Back-up-Ring.
5. Apply loctite 242 to the threads of the Plunger Retainer and thread Plunger Retainer onto Plunger Rod. Torque per specifications.
6. Slip Seal Retainers over Plungers. NOTE: On Model 3545, 3541 install Spacer over end of Seal Retainer. Insert smaller diameter first. Line up Wicks with the oil holes in the Crankcase and tabs in the Oil Pan (3520, 3521, 3527, 3535, 3531, 3537).
7. Rotate shaft and line up two outside Plungers.
8. Lubricate the Plungers.
9. Carefully replace Inlet Manifold onto Plungers and press into Crankcase. Keep manifold aligned to avoid damaging Plungers.
10. Replace four (4) hex socket head screws and torque per chart.
11. Examine inlet port o-rings at bottom of manifold and replace if cut or worn.
12. Lubricate outer surface of V-Packing Spacer, O-Rings and valve chamber walls and carefully slip Discharge Manifold over V-Packing Spacer.
13. Hand tighten the two (2) hex socket head screws first. Then hand tighten the remaining six (6) hex socket head screws. Torque per chart and in this sequence.



SERVICING THE CRANKCASE SECTION

1. While manifold, Plungers and Seal Retainers are removed, examine Crankcase Seals for wear.
2. Check oil level and for evidence of water in oil.
3. Rotate Crankshaft by hand to feel for smooth bearing movement.
4. Examine Crankshaft Oil Seal externally for drying, cracking or leaking.
5. Consult factory or your local distributor if crankcase service is evidenced.

See section III of the Plunger Pump Service Video for additional information.

PREVENTATIVE MAINTENANCE CHECK-LIST

Check	Daily	Weekly	50 hrs.	500 hrs.*	1500 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.
**Remember to service the regulator/unloader at each seal servicing and check all system accessories and connections before resuming operation.

TORQUE CHART

Pump Item	Thread	Tool Size [Part No.]	Torque in.lbs.	ft.lbs.	Nm
Plunger Retainer	M10	M21 Hex	220	18.1	25
Inlet Manifold Screws	M14	M12 Allen [33048]	480	39.8	55
Discharge Manifold Screws	M12	M10 Allen [33047]	350	28.9	40
Valve Plugs	M45	M41 Hex	1305	108.5	148
Crankcase Cover/ Bearing Cover Screws	M8	M13 Hex [25324]	115	9.4	13
Connecting Rod Screws	M10	M17 Hex [25083]	395	32.5	45
Bubble Oil Gauge	M28	Oil Gauge Tool [44050]	45	3.6	5
Mounting Bolts	M14	M22	600	47.4	68

TECHNICAL BULLETIN REFERENCE CHART

No.	Subject	Models
002	Inlet Temperature vs. Inlet Pressure	All Models
003	5FR - 68FR Drive Packages	5FR - 68FR Plunger Models
024	Lubrication of Lo-Pressure Seals	All Models
040	Manifold and Valve Part Changes	3527, 3537
041	Crankcase Changes	35FR
043	Plunger Pump LPS and HPS Servicing	All Plunger Models
050	Spacer with Coil Springs	3520, 3527, 3535, 3537
052	Plunger Rod and Stud Change - CR Pumps	3FR, 5FR, 15FR, 35FR, 60FR
053	Liquid Gasket	5FR, 7FR, 15FR, 35FR, 60FR
056	Sealed and Rechargable Prrrrr-O-Lators	All Models
064	By-Pass Hose Length	All Unloaders/Regulators
069	35 Frame Forged Extended Manifolds	3520, 3521, 3527, 3535, 3531, 3537, 3507, 3517
074	Piston and Plunger Pump Torque Chart	All Models
077	Oil Drain Kit	All 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 be adequate to accommodate the maximum flow being delivered by the pump.

- ❏ Open inlet shut-off valve and turn on water supply to avoid cavitating pump. **DO NOT RUN PUMP DRY.**
- ❏ Avoid closed loop systems especially with high temperature, ultra-high pressure or large volumes. Conditions vary with regulating/unloader valve.
- ❏ Low vapor pressure fluids, such as solvents, require a booster pump and C.A.T. (Captive Acceleration Tube) to maintain adequate inlet supply.
- ❏ Higher viscosity fluids require a positive head and a C.A.T. (Captive Acceleration Tube) to assure adequate inlet supply.
- ❏ Higher temperature fluids tend to vaporize and require positive heads and C.A.T. (Captive Acceleration Tube) to assure adequate inlet supply.
- ❏ When using an inlet supply reservoir, size it to provide adequate fluid to accommodate the maximum output of the pump, generally a minimum of 6 to 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 thick walled fittings, 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 fluids may be increased by high RPM, high temperatures, low vapor pressures or high viscosity and may require pressurized inlet and C.A.T. (Captive Acceleration Tube) to maintain adequate inlet supply. DO NOT USE C.A.T (Captive Acceleration Tube) 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 (5 BAR).
- ❏ After prolonged storage, pump should be purged of air to facilitate priming. Disconnect any discharge port and allow fluid to pass through pump.

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. (Captive Acceleration Tube) 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 in the inlet line.
- ❏ Inspect and clean inlet filters on a regular schedule.
- ❏ A pressure gauge is recommended to monitor the inlet pressure and should be mounted AS CLOSE TO THE PUMP INLET as possible. **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.

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 fluid may be returned to the inlet line of the pump if the system is properly designed to protect your pump. When using this method a PRESSURE REDUCING VALVE should 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 when a flow sensitive regulating device is used. 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 low-pressure, flexible cloth braid (not metal braid) hose should be used from the by-pass connection to the inlet of the pump.
- ❏ 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. 1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	Brass Pipe—Nominal Dia. 1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	Copper Tubing O.D. Type L 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

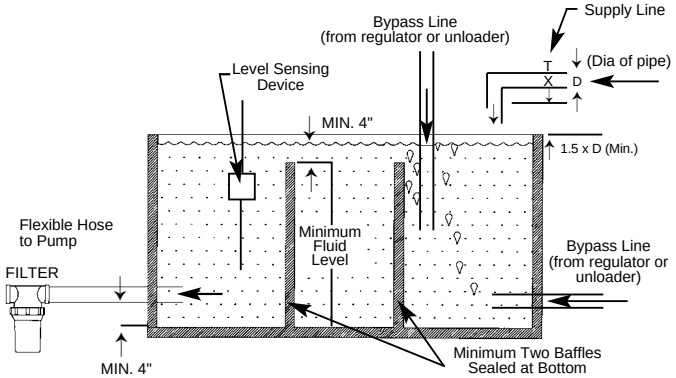
Nominal Pipe Size Inches	Inside Diameter Inches	Equivalent Length of Standard Pipe in Feet: Gate Valve	Globe Valve	Angle Valve	45° Elbow	90° Elbow	180° Close Ret	Tee Thru Run	Tee Thru Branch
1/2	0.622	0.41	18.5	9.3	0.78	1.67	3.71	0.93	3.33
3/4	0.824	0.54	24.5	12.3	1.03	2.21	4.90	1.23	4.41
1	1.049	0.69	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 values, fittings and elevation of lines.

If a sufficient number of values 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 value 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. Desired RPM = Desired GPM x $\frac{\text{Rated RPM}}{\text{Rated GPM}}$

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

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

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

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

Q. **What size motor pulley should I use?**

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

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

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

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	• Increase line size to the inlet port or one size larger
Water hammering fluid acceleration/ deacceleration	• Install C.A.T. Tube • Move pump closer to fluid supply
Rigid Inlet Plumbing	• Use flexible wire reinforced hose to absorb pulsation and pressure spikes
Excessive Elbows in Inlet Plumbing	• Keep elbows to a minimum and less than 90°
Excessive Fluid Temperature	• Use Thermo Valve in bypass line • Do not exceed pump temperature specifications • Substitute closed loop with baffled holding tank • Adequately size tank for frequent or high volume bypass • **Pressure feed high temperature fluids** • Properly ventilate cabinets and rooms
Air Leaks in Plumbing	• Check all connections • Use Teflon tape
Agitation in Supply Tank	• Size tank according to pump output — **Minimum 6-10 times system GPM** • Baffle tank to purge air from fluid and separate inlet from discharge
High Viscosity Fluids	• Verify viscosity against pump specifications before operation • Elevate fluid temperature enough to reduce viscosity • Lower RPM of pump • Pressure feed pump • Increase inlet line size
Clogged Filters	• Perform regular maintenance or use clean filters to monitor build up • Use adequate mesh size for fluid and pump specifications

DIAGNOSIS AND MAINTENANCE

PROBLEM	PROBABLE CAUSE	SOLUTION
• Pulsation	• Faulty Pulsation Dampener • Poor inlet and discharge plumbing	• Check precharge. If low, recharge it or install a new one. • Install flexible hose inlet, and discharge of pump. If long feed lines use C.A.T. on booster pump.
• Low Pressure	• Worn nozzle • Belt slippage • Air leak in inlet plumbing • Pressure gauge inoperative or not registering accurately • Relief valve stuck, partially plugged or improperly adjusted; valve seat worn • Inlet suction strainer clogged or improper size • Worn Packing. Abrasives in pumped fluid or severe cavitation. Inadequate water supply • Fouled or dirty inlet or discharge valves • Worn inlet or discharge valves • Leaky discharge hose	• Replace nozzle of proper size. • Tighten or replace. Use correct belt type and length. • Disassemble, reseal, and reassemble. • Check with new gauge; replace worn or damaged gauge. • Clean and adjust relief valve; check for worn or dirty valve seats. Repair with Valve Kit. • Clean. Use adequate size. Check more frequently. • Install proper filter. Check flow available to pump. • Clean inlet and discharge valve assemblies. • Replace worn valves, valve seats and/or discharge hose.
• Pump runs extremely rough, pressure low	• Restricted inlet or air entering the inlet plumbing • Stuck or worn inlet or discharge valves • Leaking Hi-Pressure seals	• Proper size inlet plumbing; check for air tight seal. • Clean out foreign material, replace worn valves. • Repair with Seal Kit.
• Water leakage from under the manifold	• Worn or damaged Lo-Pressure seals • Worn male and female adapter	• Repair with Seal Kit. • Install new male and female adapter. • Lubricate and replace o-rings in seal area.
• Oil leak between crankcase and pumping section	• Worn crankcase oil seals	• Replace crankcase oil seals and change oil in crankcase.
• Oil leaking in the area of crankshaft	• Worn or improperly installed crankshaft or cut or worn O-ring on bearing case • Bad bearing	• Replace damaged O-ring and/or oil seals. • Replace bearing.
• Excessive play in the end of the crankshaft pulley	• Worn main bearing from excessive tension on drive belt	• Replace bearing. Properly tension belt. Use correct type and length.
• Water in crankcase	• May be caused by humid air condensing into water inside the crankcase • Worn and leaking Lo-Pressure Seals and V-Packing. Operating beyond normal service cycle.	• Change oil every 3 months or 500 hour intervals using special CAT PUMP Premium Grade Oil, PN 06100 (Case) 6107 (Bottle), (other approved oil every month or 200 hours). • Repair with seal kit. Initiate more frequent service cycle.
• Oil leaking from under-side of crankcase	• Worn crankcase oil seals	• Replace seals.
• Oil leakage from drain plug	• Loose drain plug or worn drain plug O-ring	• Tighten drain plug or replace O-ring.
• Loud knocking noise in pump	• Pulley loose on crankshaft • Broken or worn bearing • Stressful inlet conditions	• Check key and tighten set screw. • Replace bearing. • Install C.A.T. and/or booster pump.
• Frequent or premature failure of the packing	• Scored plungers • Excessive inlet pressure • Abrasive material in the fluid being pumped • Excessive temperature of pumped fluid • Running pump dry	• Replace plungers. • Reduce inlet pressure to specifications. • Install proper filtration on pump inlet plumbing. • Reduce fluid temperature to specifications. Use adequate sized holding tank for proper feed and by-pass. • DO NOT RUN PUMP WITHOUT WATER.
• Strong surging at the inlet and low pressure on the discharge side	• Foreign particles in the inlet or discharge valve or worn inlet and/or discharge valves • Stressful inlet conditions	• Check for smooth lap surfaces on inlet and discharge valve seats. Discharge valve seats and inlet valve seats may be lapped on a very fine oil stone. • Install and maintain good inlet filter. • Install C.A.T. and/or booster pump.