

High-Pressure System Design Guide



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System Design Basics

Achieving Maximum Pumping System Performance

High-pressure pumping systems typically involve positive displacement pumping technology, where flow directly correlates with the revolution of a pump crankshaft. The total output of the pump is not only determined by RPM but also cylinder bore and piston/plunger stroke. Since most liquids are not significantly compressible, pressure is created by restriction on the discharge line downstream of the pump.

Optimum performance of the pump is dependent upon the entire liquid system and can only be obtained with the proper design, component selection, installation and maintenance of the pump and system accessories.

This guide contains helpful system design information to assist in all phases of design, from component selection and installation to establishing a maintenance program and preparing for extended storage. There is also a collection of reference materials to assist with the system design process. This document is to be used as a guide only. Cat Pumps does not assume any liability or responsibility for the design or operation of a customer's high-pressure system.

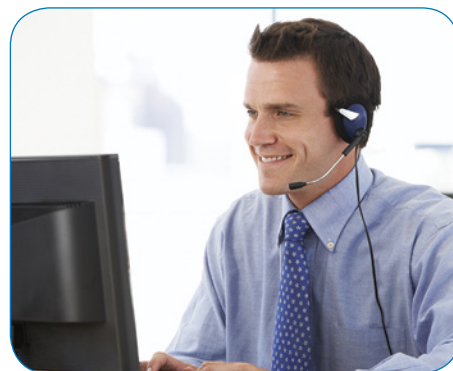
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Industry Leading Customer Service

Cat Pumps knowledgeable and experienced customer service team provides assistance with order information, as well as technical support in product selection, installation, maintenance, pump repair and general system troubleshooting.

Support is available M – F, 8:00 a.m. to 5:00 p.m. CST at (763) 780-5440.
Email: techsupport@catpumps.com



Selecting a Pump

Be careful not to fall into the price trap and buy an undersized pump with an oversized rating designed for intermittent duty. Investigate the longevity of the pump and the typical length of intervals between required servicing. Immediate availability of parts is also important to consider.

It is important to operate your pump within its rated performance. This not only includes flow and pressure but also includes inlet conditions, temperature, duty cycle and liquid compatibility. Beyond our standard product offering, we have a variety of different manifold and elastomer materials available to meet the most demanding application needs.

Selecting Accessories

Your pumping system is only as strong as your weakest component so it is critical that each component is carefully selected based on the same criteria as the pump. Each system requires carefully sized matching accessories to set and maintain system pressure, monitor system performance and protect system from over-pressurization. Not all systems require the same accessories. Minimally, we recommend a primary pressure regulating valve, secondary pressure relief valve and a pressure gauge. Other accessories can be determined by application and installation.

It is also critical to install and maintain a good inlet filter in your high pressure system. Even city water can contain abrasive particles that shorten pump life as well as other system accessories.

Selecting a Power Source

Positive displacement pumps can utilize a variety of different power sources including electric motors, gas or diesel engines, hydraulic and pneumatic motors. Be sure you have sized your system power source with adequate horsepower to handle the maximum system flow and pressure required.

Handy Formulas

$$\text{Required Electric Brake HP}^* = \frac{\text{GPM} \times \text{PSI}}{1460}$$

*Standard 85% Overall Efficiency

$$\text{Hydraulic Torque (ft. lbs.) Required} = 3.6 \times \frac{\text{GPM} \times \text{PSI}}{\text{RPM}}$$

Selecting a Drive

Cat Pumps are offered with a variety of different drive options. Most systems are belt driven by a pulley or clutch, but there are also direct drive options such as direct coupled, gearbox or hollow shaft direct drive.

Handy Formulas

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

$$\text{Pump Pulley}^* \times \frac{\text{Pump RPM}}{\text{Motor/Engine RPM}} = \text{Motor Pulley}^*$$

*Pitch Diameter

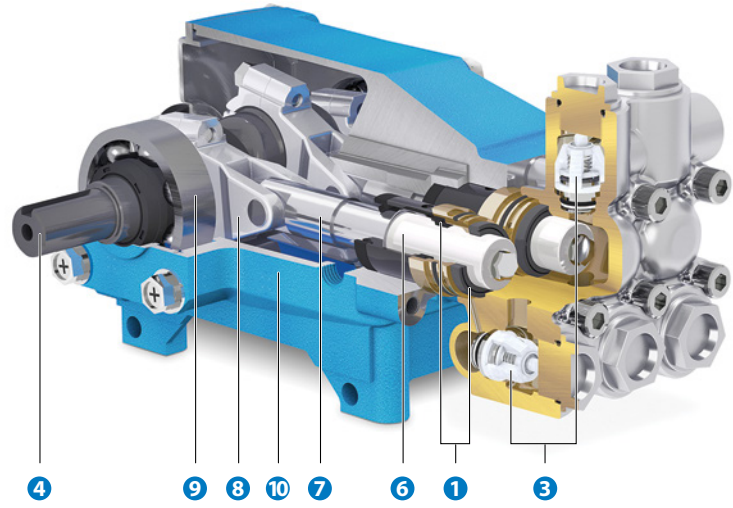
System Location

Your pumping system should be mounted in areas away from direct spray, standing water or freezing temperatures. Pump should be mounted on a rigid, horizontal surface for optimum lubrication and to minimize vibration. If the pump is used in extremely dry or humid conditions, it is recommended that the pump be enclosed. Do not store or operate in excessively high temperature areas without proper ventilation.

Selecting Your Pump

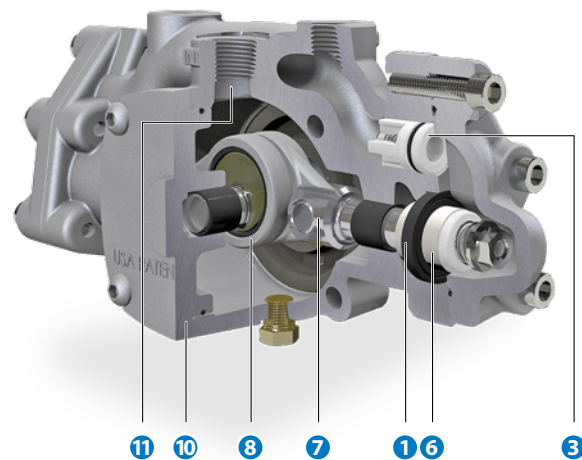
Plunger Pumps (0.13 – 240 gpm, 100 – 10,000 psi)

Plunger pumps utilize spring-loaded closed and hydraulically opened inlet and discharge valves to direct flow through the pump manifold. At the beginning of the stroke, the plunger displaces the liquid in the manifold chamber, forcing the discharge valve open. When the plunger reaches the end of the stroke, the discharge valve closes. As the plunger rod begins its backward stroke, the inlet valve opens to allow more liquid into the manifold chamber, thereby keeping a smooth forward flow of liquid.



XP Series Pumps (0.5 – 2 gpm, 100 – 800 psi)

In XP series pumps, fluid enters the inlet port and flows through the drive-end, lubricating the connecting rods and plunger rods as it passes to the inlet valves. Both inlet and discharge valves are spring-loaded closed and hydraulically opened, similar to plunger pumps, however, they utilize a flow-through ceramic plunger design. The continuous forward flow characteristics in conjunction with the packing design of plunger pumps result in improved suction capabilities as well as extended seal life.

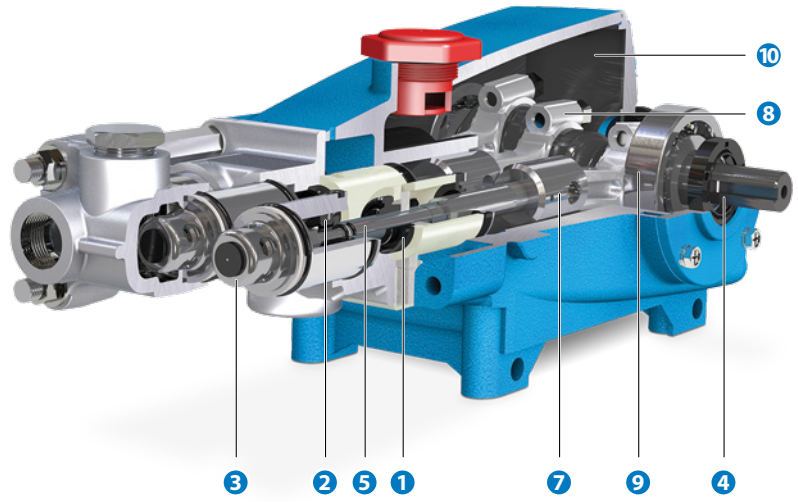


Features

- 1 Specially formulated, Cat Pumps exclusive high pressure seals/cups offer unmatched performance and seal life.
- 2 100% wet cup/seal design adds to service life by allowing pumped fluids to cool and lubricate the elastomers on both sides.
- 3 Stainless steel valves, seats, and springs provide corrosion-resistance, positive seating, and long life.
- 4 Chrome-moly crankshaft provides unmatched strength and surface hardness for long life.
- 5 The patented stepped piston rod with hard chrome-plated sleeve provides a durable wear surface and easy wet end servicing.
- 6 Precision-polished, solid ceramic plungers provide maximum resistance to corrosion and abrasion, extending seal life.

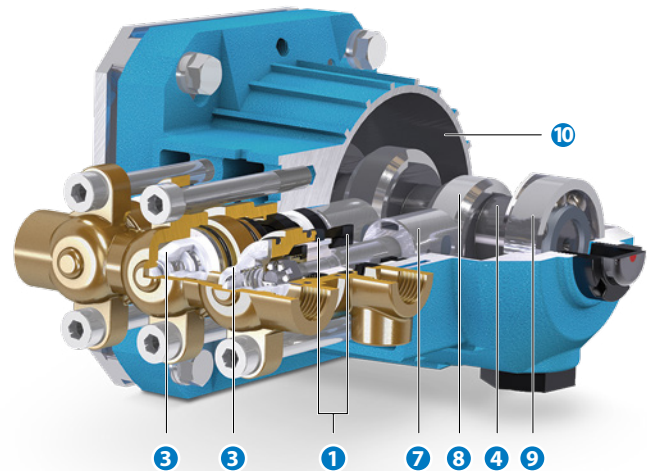
Piston Pumps (3.0 – 60 gpm, 100 – 1,500 psi)

The design of the piston pump is for the fluid to move continually in one, smooth forward direction. This design allows greater suction capabilities and reduces the risk of cavitation provided the pump is properly primed. At the beginning of the stroke, the mechanically actuated inlet valve (and piston) will close. As the piston rod moves forward, the liquid is forced out through the discharge valves. Simultaneously, the liquid enters the pump inlet and flows in behind the inlet valve. As the piston rod begins the backward stroke, the inlet valve mechanically opens, permitting the liquid to continue its flow forward through the piston into the discharge chamber.



SF Series Pumps (0.5 – 5 gpm, 100 – 3,500 psi)

In SF series pumps, both the inlet and discharge valves are spring-loaded closed and hydraulically opened, similar to plunger pumps, however, they have a flow-through ceramic plunger design. The continuous forward flow characteristic of piston pumps is utilized in conjunction with the packing design of the plunger pumps. These features give SF pumps both strong suction capabilities and higher pressure performances.

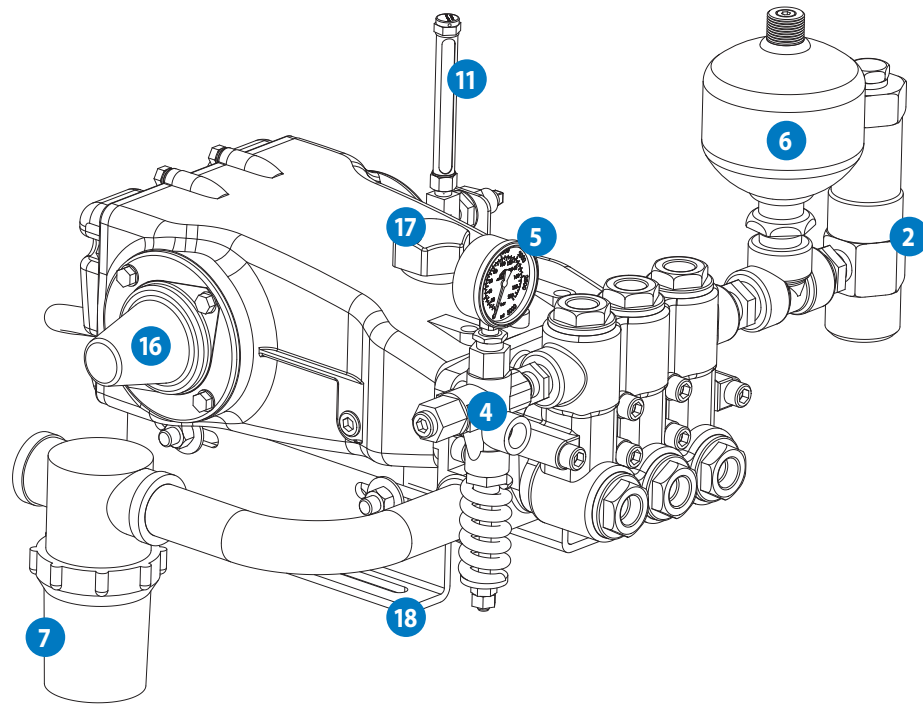


- 7 The high strength stainless steel plunger rods have a 360° supported crosshead providing uncompromising plunger rod alignment.
- 8 Matched oversized connecting rods are made of high strength material with exceptional bearing quality.
- 9 Oversized ball bearings or tapered roller bearings provide extended bearing life.

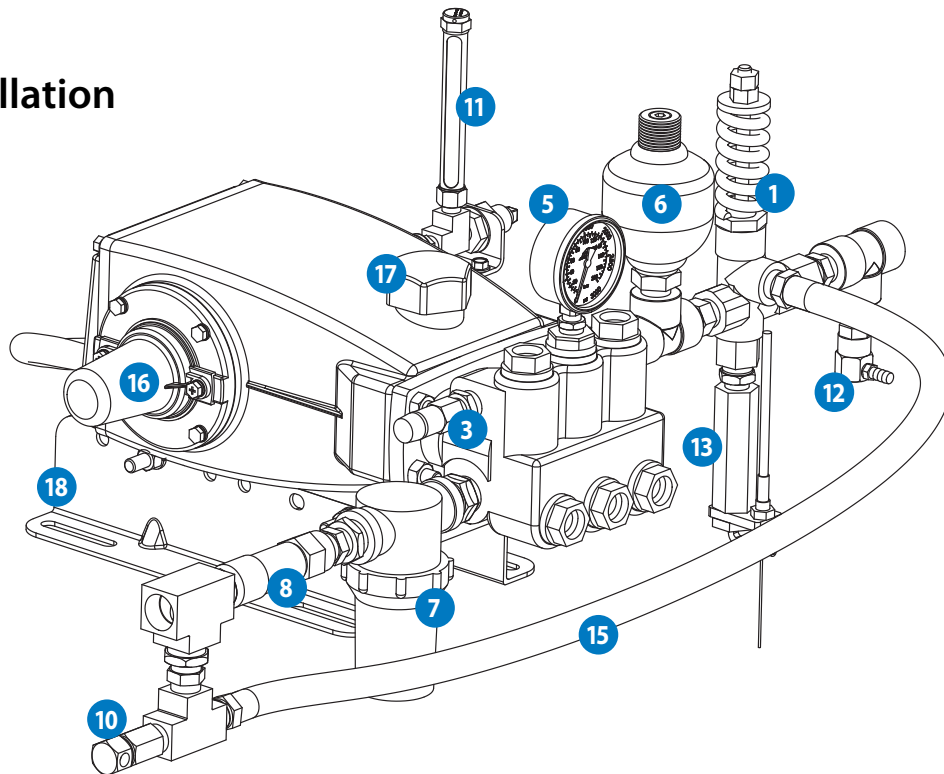
- 10 High Strength, light weight die cast aluminum crankcase with splash oil design allows operation at speeds as low as 100 RPM.
- 11 Patented greaseless design uses water from inlet as lubrication, eliminating the maintenance and mess of grease or oil.

Typical Installation

Basic Installation



Trigger Gun Installation



IMPORTANT NOTICE: These illustrations show the basic elements for a typical installation of a high pressure piston or plunger pump. Not all components shown are required for all applications or systems. Each component may present a potential problem that could interfere with the operation of your system such as: a clogged strainer, faulty gauge, or a malfunctioning regulator/unloader. Proper system installation, monitoring and maintenance of components are necessary for optimum pump performance. Cat Pumps does not assume any liability or responsibility for the design or operation of a customer's high pressure system.

Typical Accessories

Item	Part	Function	Installation Notes
1	Unloader	Used to accurately set and maintain system pressure as well as reduce load on the pump and motor when the system is in by-pass.	Plumbed to the high pressure side of the pump manifold, preferably on a discharge port. Must be in line with the discharge hose.
2	Regulator	Used to accurately set and maintain consistent system pressure.	Plumbed to the high pressure side of the pump manifold, preferably on a discharge port.
3	Pop-Off Valve	Provide your system with an accurate and reliable secondary pressure relief to protect your pump and system from damage caused by over-pressurization.	Plumbed to the high pressure side of pump manifold before primary regulating device or on an open discharge port. Set 200-300 psi above system operating pressure.
4	Relief Valve	Provides your system with an accurate and reliable secondary pressure relief to protect your pump and system from damage caused by over-pressurization.	Plumbed to the high pressure side of pump manifold before primary regulating device or on an open discharge port. Set 200-300 psi above system operating pressure.
5	Pressure Gauge	Used to accurately monitor pump pressure.	Plumbed to high pressure discharge side of pump. Note: If mounted before an unloader and there is a shut off valve downstream the pressure will be near zero. If located after the unloader the pressure will be at the set pressure.
6	Pulsation Dampener	Used to help provide smooth and consistent flow as well as increase overall system life. Reduces pulsation to 1-3%.	Plumbed on the high pressure side of the pump and as close to the pump as possible for optimum dampening. If system uses an unloader where bypass flow is diverted back to pump inlet with a check valve or inlet regulator, the pulsation dampener must be plumbed after the unloader.
7	Inlet Filter	Used to catch particles and debris from reaching and causing damage to your pump.	Plumbed on the inlet side of a pump near the supply tank or before the any other inlet accessories.
8	Inlet Pressure Regulator	Used to accurately set and maintain consistent system pressure at pump inlet.	Plumbed on the inlet side of a pump after a filter or by-pass hose but before a flexible hose or inlet pressure stabilizer.
9	Captive Acceleration Tube*	Used to stabilize and maintain consistent inlet pressure when dealing with high temperatures, booster pump feed, long inlet lines or pressure spikes caused by regulating valves.	Plumbed directly to the inlet port of a pump.
10	Thermal Valve	Used to relieve heat build-up in closed loop by-pass systems.	Plumbed in the bypass line near the inlet port for optimum performance.
11	Oil Gauge/Drain Kit	Used to provide convenient monitoring of crankcase oil as well as fast and convenient oil changes.	Plumbed to the rear cover of the crankcase.
12	Quick Start Valve	Relieves discharge line pressure during system start-up when using pressure lock style unloader with gas/diesel engines.	Plumbed in the high pressure side of the pump. When being used with an unloader, valve must be plumbed to discharge after unloader.
13	Throttle Controller	Reduces engine wear and fuel consumption by reducing engine RPM while in system bypass.	Plumbed to the high pressure side of the pump before an unloader or directly to a discharge port. Cannot be used with a regulator.
14	LPS Monitor*	Alerts you when the low pressure seals are worn and need replacement with indication light or can be integrated via PLC.	Replaces oil pan behind pump manifold. See product data sheet for selection and installation guide.
15	Bypass Hose	Used to route pump flow from unloader back to pump inlet when system is running in bypass.	Plumbed from the bypass port of a regulator or unloader back to the pump inlet or supply tank. If plumbed back to the inlet of a pump it should be before an inlet regulator. Always use a thermal valve to protect from heat buildup when system is running in bypass.
16	Shaft Protector	Eliminates exposure of rotating pump shaft.	Mounted on pump crankcase side cover.
17	Oil Cap Protector	Helps minimize water leakage into crankcase.	Mounted on crankcase oil fill cap.
18	Rails	Used to mount pump assembly to base.	Mounted to crankcase feet. Ensure that base is on an even, level surface.

* Not Shown

Inlet Design

Liquid Properties

Before selecting a high-pressure pump for any new pumping system, it is important to start with your desired performance and to evaluate the fluid you desire to pump. Viscosity, temperature and the chemical make-up of the desired fluid can have great impact your pumps performance.

Viscosity

Viscosity refers to “thickness” or resistance of a fluid. Due to the tight tolerances and motion of flow through a pump, the positive displacement, reciprocating design operates best with non-viscous fluids. Cat Pumps recommends operating with liquids up to 500 cPs or 2500 SSU. It is also important to consider that the viscosity of a fluid can change due to heat, velocity, exposure to atmosphere or mixing with other liquids. For applications above 500 cPs, contact Cat Pumps for more information.

Temperature

Standard pumps are rated to operate with a maximum fluid temperature between 140°F – 180°F depending on the model. However for some fluids special elastomers are available to allow temperatures to 240°F. As the temperature of water increases, the vapor pressure (pressure required to remain liquid) also increases. By increasing the inlet pressure to the pump, you can minimize the increased risk of cavitation. Several aspects of the system should be considered with elevated temperatures to achieve optimum performance.

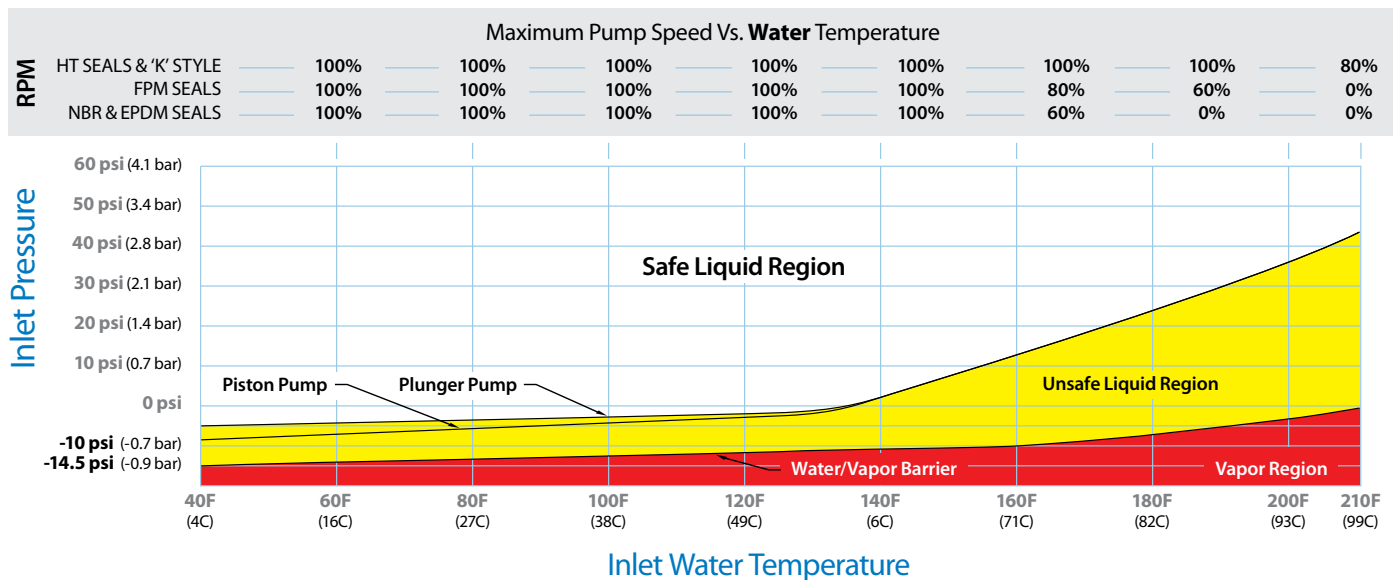
- Pressurize inlet above 130°F
- Reduce pump RPM
- Install Captive Acceleration Tube (C.A.T.) in inlet line
- Increase inlet line size to the pump

Pressurized inlet

To achieve the recommended inlet pressures with elevated temperatures, it is often necessary to install a booster pump. The booster pump flow rate should be approximately twice the system capacity to assure adequate flow into the pump. See chart below.

Reduction in RPM

Reducing pump RPM will also offer added protection from cavitation when elevated temperatures exist. Reducing pump RPM also reduces the acceleration and vaporization of the water and its damaging effects. See chart below.



Captive Acceleration Tube (C.A.T.)

C.A.T. tubes absorb energy from a positive head to increase the liquid acceleration which significantly reduces cavitation and dampens system spikes. If water tank is more than 5-6 feet from the pump, long feed lines, or high temperature are present, the C.A.T. should be installed to stabilize inlet pressure.

Note: The C.A.T. will not function with a negative suction inlet.

Increased Inlet Size

It is always important to have the inlet supply line sized to match or be one size larger than the pump inlet port for optimum performance, but it is most critical when the pumped liquid is at elevated temperatures. Undersizing the line will only compound the problems of high temperature vaporization. See individual pump data sheet.

Chemical Compatibility

If you are working with a fluid other than water, you must check the compatibility of the desired fluid with the seal and manifold material of your pump. Cat Pumps offer a variety of different elastomers and manifold materials to meet a wide variety of application needs. Cat Pumps work best with fluids with a pH level between 5 and 9. If you are working outside that range, please contact our technical support team for proper selection. A chemical compatibility chart can be found at catpumps.com in the reference literature section to assist with selecting proper elastomers and manifold materials for your desired fluid or you can contact Cat Pumps technical support team.

Inlet Feed

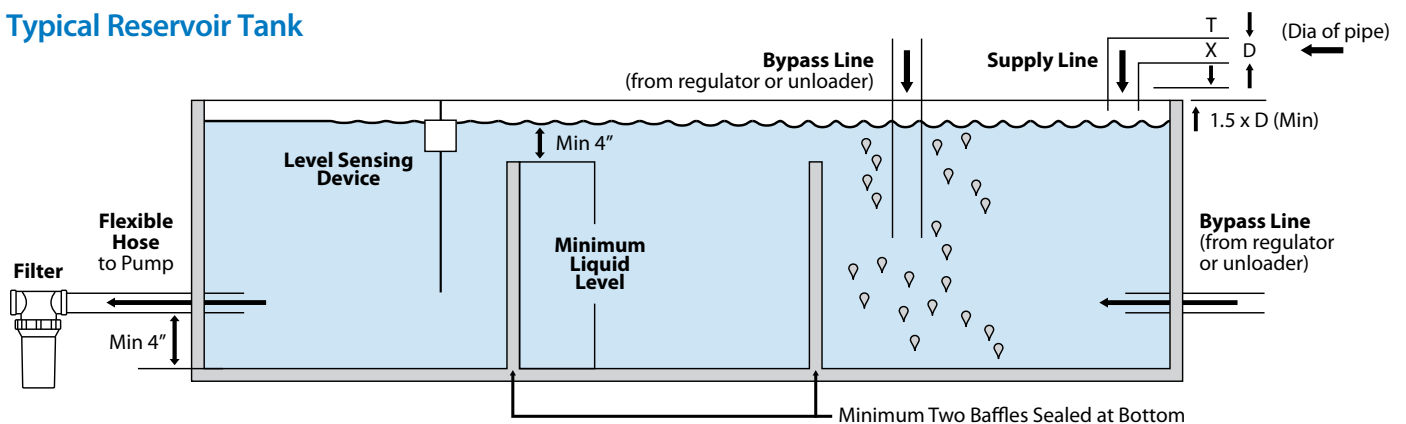
Inlet pressure specifications for proper pump priming vary by the pump design. Ideally, all piston and plunger pumps would have an inlet pressure of 20 to 30 psi, but inlet pressure can range based on models. Refer to individual pump data sheet for proper inlet pressure conditions. Gravity fed installations are also acceptable but need to be set up to maintain a positive head pressure to avoid pump cavitation.

Gravity Feed

When a gravity fed tank is used, Cat Pumps recommends the following precautions be taken:

- The reservoir should be 6-10 times the rated flow of the pump.
- The reservoir should be baffled so turbulent flow is not created causing air bubbles which lead to cavitation.
- The supply line should be on the opposite side of the baffles and return line.
- The tank should be covered to prevent contamination.
- The tank should be mounted as high as possible above the pump. Ideally the liquid level (even when the tank is nearly empty) should be at least 6.5 feet (2 meters) higher than the pump. Applications closer to the liquid vapor pressure (i.e., hot water) require a higher static head.
- A low-level switch or inlet pressure sensor should be installed to stop the pump should the tank levels fall too low.

Typical Reservoir Tank



Inlet Design

Suction Feed

Piston pumps have more suction lift because of their flow — through design, continuous forward flow design, and mechanically actuated inlet valves. For this reason, piston pumps are the preferred choice for suction lifting applications.

In most cases the inlet will lose prime when the pump is not in operation. Consider fitting a non-return foot valve at the bottom of the inlet feed pipe and manually prime the pump before initial start-up. Exceeding suction limits of pumps will “starve” the pump for liquid and cause cavitation.

- **Piston pumps:** Do not exceed - 8.5 psi gauge suction.
- **Plunger pumps:** Do not exceed - 5 psi gauge suction on some models and flooded inlet on other models (consult data sheet for the pump model selected).

IMPORTANT NOTICE: Be sure to consider all pressure losses that contribute to reduced inlet pressure when designing a system. This can include vertical distance, line, fitting and other frictional losses.

Pressure Feed

When a liquid is close to its vapor pressure or it is not possible to provide adequate head pressure, the pump can be pressure fed with a booster pump, typically a centrifugal pump.

For most pressure fed applications, an inlet feed pressure of 20 psi is adequate. The maximum inlet pressure allowable for plunger pumps is 60-70 psi and 40 psi for piston pumps. If your application requires inlet pressure above these ratings, utilize an inlet pressure regulator or contact Cat Pumps for more information on our specialty pumps designed for inlet conditions up to 800 psi.

Inlet Plumbing Recommendations

Recommendation	Description
Avoid Hard Plumbing	Do not hard plumb the supply to the pump inlet. The pump will vibrate during normal operation and vibrations can be transmitted through piping, occasionally causing leaks of hard plumbed fittings. A flexible inlet hose is recommended.
Plunger Pump Inlet Ports	A plunger pump can be fed from either side of the pump inlet manifold or both. Feeding the pump from both inlet ports is recommended when the supply conditions are poor, resulting in a higher risk of pump cavitation.
Piston Pump Inlet Port	A piston pump is typically fed at the bottom port of the pump manifold. If a top feed is desired, the manifold can be inverted without causing issues.
Sizing Plumbing	Size the inlet plumbing to allow unrestricted flow into the pump as a safeguard against cavitation. The plumbing should be a minimum of one pipe size larger than the pump inlet fitting size.
Avoid Unnecessary Fittings	Use as few fittings and changes of flow direction as possible.
Use Oversized Elbows	Use large radius swept elbows or reinforced inlet hose.
Direct Flow Straight into Inlet	When possible, install a straight pipe immediately before the pump inlet connection.
Multiple Pumps	If more than one pump will be supplied from the same supply tank, provide separate inlet lines from the tank to the pump. If this is not possible, use a Y fitting or swept tee to branch off a single supply line to multiple pumps. Ensure the main feed line is of an adequate diameter to feed all pumps simultaneously.



Need more detail?

Find Product Data Sheets online at catpumps.com

Cavitation

Proper design of the pump inlet supply is critical to avoid cavitation and operate an effective pumping system. Cavitation occurs when a lack of liquid to the inlet causes vaporization in the low pressure chamber of the pump. When a vapor bubble is re-pressurized, it quickly collapses supersonically and the shock wave causes surface erosion. This release of energy is created by collapsing cavities, causing pitting and erosion of metallic or ceramic components. Cavitation also produces excessive pump noise. The noise will be less pronounced when the pump is in bypass due to lower pressure changes. Piston pumps sound like the connecting rods are knocking or a bearing is bad. Plunger pumps sound similar to piston pumps, but most of the noise can be heard in the valve area of the head.

Cavitation will also decrease the pumps output due to the combination of liquid and vapor in the pumps inlet chamber. Cavitation will not only cause pitting in the valves and manifold, but also reduces the lubrication of the seals, resulting in reduced seal life.

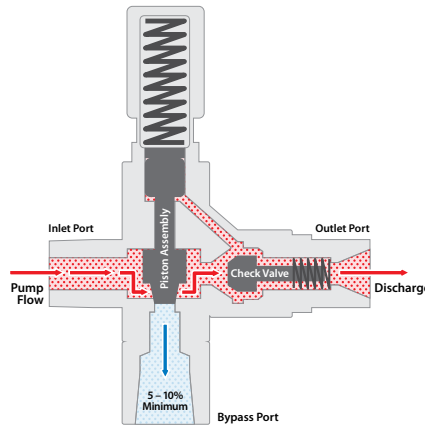


Conditions	Solutions
Inadequate inlet line size	Increase line size one size larger than the pump inlet port
Water hammering liquid	Install C.A.T. at pump inlet Move pump closer to liquid supply Add pulsation dampener
Rigid inlet plumbing	Use flexible wire reinforced hose at inlet and discharge pump port to absorb pulsation and pressure spike
Excessive elbows in inlet plumbing	Keep elbows to a minimum and less than 90°
Excessive liquid temperature	Use thermo valve in bypass line Substitute closed loop with dual baffled holding tank Size tank for frequent or high volume bypass Pressure feed high temperature liquids Properly ventilate cabinets and rooms
Air leaks in plumbing	Check all connections Use PTFE thread tape or pipe thread sealant
Agitation in supply tank	Size tank according to pump output (minimum 6 times pump performance rating) Baffle tank to purge air from liquid and separate inlet / discharge
High viscosity liquids	Verify viscosity against pump specifications before operation Elevate liquid temperature enough to reduce viscosity Lower RPM of pump Pressure feed pump Increase inlet line size
Clogged filters	Clean filters regularly Use clear filters to monitor build up Use adequate mesh size for liquid and pump specifications (80 mesh recommended for fresh water, 50 micron for reclaim applications)

Discharge Design

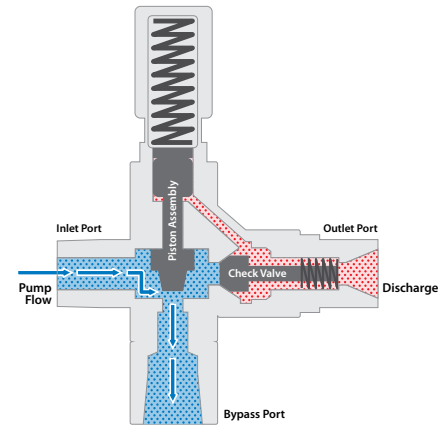
Regulator vs. Unloader

One common inquiry from system designers is the difference between a pressure regulator and a pressure regulating unloader. When using a pressure regulator, both the pump and downstream components will always be at the set system pressure. A pressure regulating unloader performs the same function as a regulator but also contains a check valve on the discharge side. When a shut-off device downstream is closed, the check valve seats against the body of the unloader, trapping the high pressure from the check valve to shut-off device, relieving pressure between the unloader valve and pump head. This not only reduces wear on pump and drive components, but also protects against rapid heat rise. If the bypass is being redirected to the pump inlet, a thermal valve is recommended as a safeguard against excessive heat.



Normal Operation

When the check valve on the unloader is open during normal operation, the valve operates the same as a pressure regulator. The valve is used to set and maintain consistent pressure from pump head to discharge line while bypassing a minimum of 5-10% of the flow.



Bypass Operation

When downstream flow is stopped, the check valve seats with the body of the unloader, trapping high pressure in the discharge line. The high pressure trapped in the discharge line holds open the piston assembly, relieving pressure between the valve and pump head, directing low pressure water out the bypass port.

Primary and Secondary Relief

To protect your system from damage or costly downtime caused by over pressurization, be sure that your system is equipped with both a primary and secondary safety relief device. A pressure regulator or pressure regulating unloader can be used as primary relief device, but it is important to always include a secondary pressure relief or pop-off valve. This provides additional protection for your pump and system components in the event that the discharge or downstream plumbing becomes restricted.

Setting System Pressure and Relief

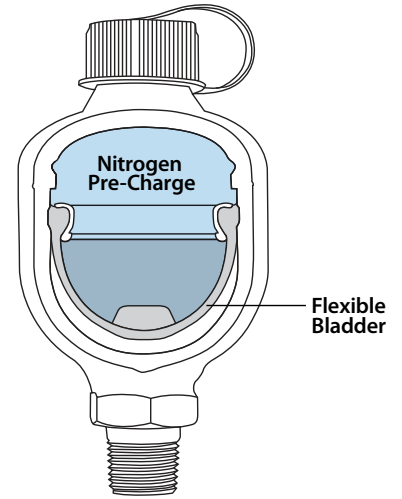
1. Tighten pressure adjustment nut on the relief valve 2-3 turns.
2. Start the system with the regulator or unloader at the lowest setting.
3. Tighten the pressure adjustment nut on the regulator or unloader in small increments until you get to the desired system pressure. If the relief valve starts to leak from the bypass port, tighten the pressure adjustment nut on the relief valve until leak stops.
4. After system pressure is set with the regulator or unloader, the relief valve needs to be set. Loosen the adjustment nut on the relief valve until fluid starts to come out the bypass port. Then tighten it until it stops bypassing fluid plus an additional 1-2 turns. Then the relief valve pressure will be set 200-300 psi higher than the regulator or unloader valve.

NOTE: When using an unloader, there will be a small pressure spike when the check valve engages. If there is a leak out of the relief valve during this operation, tighten the relief valve adjustment an additional half turn.

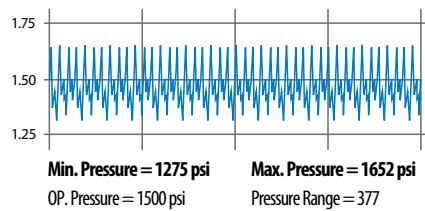
Pulsation

Due to the design of the positive displacement pumps, small pressure spikes are created during each rotation. These spikes can cause accelerated wear or damage to the pump or downstream components in certain applications. The installation of a pulsation dampener is your best safeguard against the effects of pressure pulsation.

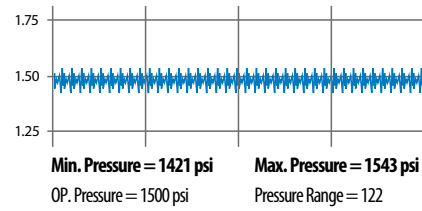
A pulsation dampener contains a dry nitrogen charged bladder that is used to absorb both the high and low fluctuations of pressure produced by a positive displacement pump. During each triplex pump rotation, the flow demand changes direction 6 times, which causes a pressure variance of 16-20% from nominal. A pulsation dampener's bladder not only absorbs the pressure spikes during operation, but due to the nitrogen charged bladder, it pushes flow back into the stream during the low pressure wave, reducing the total fluctuation to 2-3% with a properly sized dampener.



Model 1530 w/o Pulsation Dampener



Model 1530 w/ Pulsation Dampener



Pulsation Dampener Benefits:

- Produces smooth, consistent flow
- Protects downstream system components (i.e., regulator, unloader, relief valve)
- Reduces water hammer
- Improves performance at low rpm
- High cycle rate application improvement
- Reduces operator fatigue in hand-operated systems

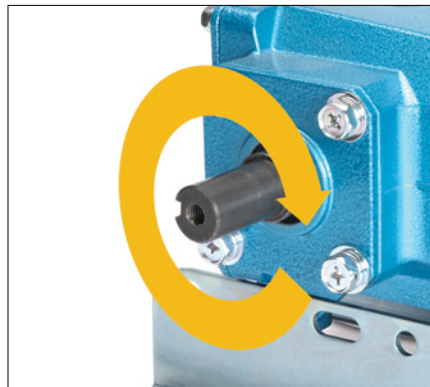
For best results, the dampeners should be mounted as close to the pump head as possible, preferably in a vertical position. Dampener should be charged at 60% of operating pressure.

TECH TIP

Pump Rotation

Forward rotation (towards the manifold) is recommended to allow optimum lubrication of the crosshead area. If your installation does not allow for forward rotation, reverse rotation is acceptable if the crankcase oil is above the red dot in the oil gauge. This indicates adequate lubrication.

Forward Rotation



Reverse Rotation



Preventive Maintenance

The best safeguard against unplanned shut-down or system failure is establishing good preventive maintenance practices. Cat Pumps triplex pump design offers easy on-site maintenance without the use of special tools, making a routine maintenance achievable without difficulty. Each pump has a data sheet and service manual to simplify the periodic servicing required.

This schedule is intended as a guide only. Each system/application is different and should be evaluated/serviced according to its own custom maintenance schedule.

Check	Daily		Weekly	50 Hrs.	1500 Hrs.	3000 Hrs.
Filters	•	or	•			
Oil Level/Quality	•	or	•	①		
Water Leaks	•	or	•			
Oil Leaks	•					
Plumbing			•			
Belts, Pulley			•			
Accessories					•	
Seals					②	
Valves						③

Water leaks or loss of system performance can be an indicator of seal wear. Seal wear has many causes, including contaminated liquid or high-temperature/run dry operation. If the low-pressure seals show wear, the high-pressure seals most likely are in a similar condition. It is a good practice to replace both low and high pressure seals and inspect plungers when leaks are present.

- ① Cat Pumps recommends using our custom-blend premium grade hydraulic oil, formulated to meet Cat Pumps specifications. For best results, perform an initial oil change after the first 50 hours of operation, then every 500 hours.
- ② Past performance and maintenance history are the best indicators of future performance. **If system performance degrades or changes, check seals and valves. Service as required to restore system performance.** Depending upon operating conditions, maintenance intervals for seal kits range between 1,500 and 8,000 hours.
- ③ Valves typically require changing every other seal change.

Industrial Duty Products to Meet your Application Demands

Cat Pumps has developed a reputation in the industry for the quality, reliability and durability of our products. Serving thousands of industries and application around the globe, Cat Pumps offers a wide range of pump and accessory options to meet your application needs.

Pumps

- Flow: 0.13 to 240 gpm (.49 to 908 lpm)
- Pressure: 100 to 10,000 psi (7 to 689 bar)
- Liquid Temperature: -10° to 240°F (-23° to 115°C)
- Manifold Materials : Brass, Nickel Aluminum Bronze, 304 and 316 Stainless Steel, Duplex Stainless Steel



Accessories:

- Oil
- Regulators
- Unloader Valves
- Relief/Pop Off Valves
- Pressure Gauges
- Pulsation Dampeners
- Inlet Filters
- Guns
- Thermal Valves
- Oil Drain Kits
- Throttle Controllers
- Quick Start Valves
- Specialty Controls
- And More...

Extended Storing

For systems that are used in a seasonal application or as a standby system, proper precautions must be taken to preserve the life of the pump/pumping system when subjected to extended storage. For optimum system performance, use the following guidelines.

Prior to storage

Location

Selecting an appropriate location is an important aspect of the storage process. Your pump/pumping system should ideally be stored in a dry location at ambient indoor temperature, preferably with a poly or canvas cover. Avoid areas that are subject to excessive heat, humidity, freezing, dust or damage from passing equipment.

Climate

If freezing conditions are a possibility, flush your pump with 50/50 solution of anti-freeze/water. Any supply tanks, hoses or feed lines should be drained. The use of Cat Pumps Pump Protector is highly recommended.

If extremely humid conditions exist, coat any surfaces or hardware that are subject to corrosion with a light film of protective oil. Note: Do not lubricate motor bearings during storage. Bearings are packed with grease at the factory. Excessive grease can damage insulation quality.

If damp or humid conditions exist, the motor windings must be protected from moisture. Apply power to the motor's space heater (if available) while the motor is in storage.

Pump Protection

Apply light film of protective oil to pump crankshaft.

Fill crankcase to the top of the bubble gauge with oil to protect the pump bearings.

Loosen the tension on any belts during extended storage.

During Storage

Rotate motor shaft at least 10 turns every two months during storage (more frequently if possible). This will prevent bearing damage.

Stored motors require using a "Megger" periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance. Review all motor manufacturer requirements for storing.

Prior to initial start-up after storage

After extended storing, seals and O-rings may take a set and require replacement. Hand-rotate the pump crankshaft to check for smooth operation. If shaft is extremely tight or will not turn, replace seals and O-rings before resuming operation. O-rings in the relief valves may also require replacement. Typical shelf life of seals and O-rings is 5 years.

Change oil at start-up and fill to the red dot on the bubble gauge prior to resuming operation.

If belts were loosened prior to storage, check for proper tension before starting system.



Online Resources Available 24/7

Catpumps.com offers a variety of helpful tools to assist in all phases of system design. In addition to browsing our complete line of pumps and accessories using the online product selector, there are also a variety of training resources including:

- **Training Articles**
- **Maintenance and Repair Information**
- **Troubleshooting**
- **FAQ's**
- **Helpful Resource Documents**
- **Service Videos**

Reference Documents

Standard Nozzle Selection Chart

Std. Nozzle (Size)* Number	Equiv. Orifice Diam. (inches)	NOZZLE FLOW (GPM) AT VARIOUS PRESSURES (PSI)													
		250	500	600	700	800	1000	1200	1500	2000	2500	3000	3500	4000	5000
2.0	.034	.50	.71	.77	.80	.89	1.00	1.10	1.20	1.40	1.60	1.70	1.90	2.00	2.23
2.5	0.039	0.63	0.88	0.97	1.05	1.12	1.25	1.37	1.53	1.77	1.98	2.17	2.34	2.5	2.8
3.0	.043	.75	1.05	1.19	1.25	1.34	1.50	1.60	1.85	2.10	2.35	2.60	2.85	3.00	3.35
3.5	.048	.87	1.23	1.40	1.47	1.56	1.75	1.90	2.17	2.45	2.73	3.05	3.32	3.50	3.90
4.0	.052	1.00	1.40	1.60	1.70	1.80	2.00	2.20	2.50	2.80	3.10	3.50	3.80	4.00	4.50
4.5	.055	1.10	1.50	1.70	1.90	2.00	2.20	2.40	2.80	3.00	3.60	3.90	4.30	4.50	5.03
5.0	.057	1.30	1.80	1.90	2.10	2.20	2.50	2.80	3.10	3.80	4.00	4.40	4.70	5.00	5.60
5.5	.060	1.40	1.90	2.10	2.30	2.50	2.80	3.00	3.40	3.90	4.40	4.80	5.20	5.50	6.20
6.0	.062	1.50	2.10	2.30	2.50	2.70	3.00	3.20	3.70	4.20	4.80	5.20	5.60	6.00	6.70
6.5	.064	1.70	2.30	2.50	2.70	2.90	3.30	3.60	4.00	4.60	5.20	5.70	6.00	6.50	7.30
7.0	.067	1.80	2.50	2.70	2.90	3.10	3.50	3.80	4.30	5.00	5.60	6.10	6.60	7.00	7.80
7.5	.070	1.90	2.70	2.90	3.20	3.40	3.80	4.10	4.60	5.30	6.00	6.50	7.00	7.50	8.40
8.0	.072	2.00	2.80	3.10	3.40	3.60	4.00	4.40	5.00	5.60	6.20	7.00	7.50	8.00	8.90
8.5	.074	2.20	3.00	3.30	3.60	3.80	4.30	4.60	5.30	6.00	6.70	7.40	8.00	8.50	9.50
9.0	.076	2.30	3.20	3.50	3.80	4.00	4.50	5.00	5.50	6.40	7.10	7.80	8.50	9.00	10.10
9.5	.078	2.40	3.40	3.70	4.00	4.30	4.80	5.20	5.80	6.80	7.60	8.30	9.00	9.50	10.60
10.0	.080	2.50	3.50	3.90	4.20	4.50	5.00	5.40	6.10	7.00	8.00	8.70	9.40	10.00	11.20
12.0	.087	3.00	4.20	4.60	5.00	5.40	6.00	6.40	7.30	8.40	9.50	10.40	11.20	12.00	13.40
15.0	.094	3.80	5.30	5.80	6.40	6.80	7.50	8.20	9.20	10.60	12.00	12.90	14.00	15.00	16.80
20.0	.109	5.00	7.10	7.80	8.40	9.00	10.00	10.80	12.20	14.20	16.00	17.40	18.80	20.00	22.40
30.0	.141	7.50	10.60	11.60	12.80	13.60	15.00	16.40	18.40	21.20	24.00	26.00	28.00	30.00	33.50

***A commonly used standard for nozzle size is the "nozzle number" which is equivalent to the nozzle capacity in GPM at 4000 PSI. Spray angle does not affect nozzle flow.**

- If psi and nozzle gpm is known, then nozzle number can be calculated as follows:

$$\text{Nozzle number} = \text{gpm} \times \sqrt{\frac{4000}{\text{psi}}}$$

- If psi and nozzle number is known, then gpm can be calculated as follows:

$$\text{gpm} = \text{nozzle number} \times \sqrt{\frac{\text{psi}}{4000}}$$

- If gpm and nozzle number is known, then psi can be calculated as follows:

$$\text{psi} = \left(\frac{\text{gpm}}{\text{nozzle number}}\right)^2 \times 4000$$

Hose Friction Loss

Water* Flow Gal/Min	PRESSURE DROP PER 100 FT OF HOSE (PSI)						
	Hose Inside Diameters, Inches						
	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"	1"
.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

* Note: 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 FT																				
Water Gallons Per Min	Steel Pipe – Nominal Diameter							Brass Pipe – Nominal Diameter							Copper Tubing O.D. Type L					
	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	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					

Reference Documents

Resistance of Valves and Fittings

		EQUIVALENT LENGTH OF STANDARD PIPE IN FEET							
Nominal Pipe Size (inches)	Inside Diameter (inches)	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
1¼	1.380	0.90	41.0	20.5	1.73	3.70	8.22	2.08	7.40
1½	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
2½	2.469	1.62	73.5	36.8	3.09	6.61	14.70	3.68	13.20
3	3.038	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.

CONVERSION CHART			
From English Units (US) to Système International (Metric)			
From	To	Multiply By	or Divide By
C.U. in. (in ³)	CC (cm ³)	16.39	0.06102
C.U. in. (in ³)	Liters	0.01639	61.02
Pounds Feet	Newton Meters (Nm)	1.356	0.7376
Gallons (US)	Liters	3.785	0.2642
Horsepower	BTU	2545.0	0.00093
Horsepower	Watts	745.7	0.001341
Horsepower	kW	0.7457	1.341
PSI (Pounds/in ²)	Bar	0.06895	14.5
PSI (Pounds/in ²)	Kilopascal (kPa)	6.895	0.145
Pound	Kilogram	0.4536	2.2046
Inch	Millimeter (mm)	25.4	0.03937
Gallons per Minute (GPM)	Barrels Per Day (BPD–Petroleum)	34.29	0.02916
Gallons per Minute (GPM)	Cu. Meters/hr	0.227	4.403

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Cat Pumps is an industry leader in providing customers with quality custom-engineered pumping systems to meet a wide range of application needs. By selecting a Cat Pumps pumping system, customers eliminate the hassle and expense of designing, multiple source buying, fabrication and testing. Our knowledgeable and helpful technical sales team assists with proper component selection as well as installation, operation and maintenance support.

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Typical Configurations

Base

- Standard • Vertically Stacked • Portable • Enclosed • Multiple Pump

Power Source

- Electric • Gas • Diesel • Hydraulic • Pneumatic

Drive Package

- Belt • Direct Drive • Gearbox • Flex Coupling/Bell Housing • Clutch

Accessories

- Regulator • Unloader • Relief / Pop-off Valve • Pressure Gauge • Pulsation Dampener • Captive Acceleration Tube (C.A.T.)
- Inlet Filter / Strainer • Guns • Oil

Call or go online to start your quote today.



ABOUT CAT PUMPS

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Founded in 1968, Cat Pumps is a world leader in the design, manufacture and marketing of the most dependable high-pressure positive displacement reciprocating triplex pumps and systems in the market.

With an emphasis on immediate product availability and outstanding customer service, the family-owned and operated business prides itself on a commitment to quality and product reliability as the foundation of its ongoing success. It is the mission to exceed customer expectations for quality, reliability, availability, delivery, technical expertise and aftermarket support to assure the best value in all the industries served.

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