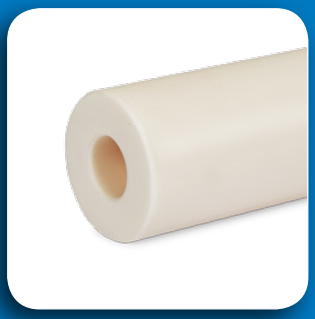
CAT PUMPS®

The Pumps with Nine Lives

Identifying Causes and Effects of Pump Damage

Product Quality, Reliability and Support You Expect

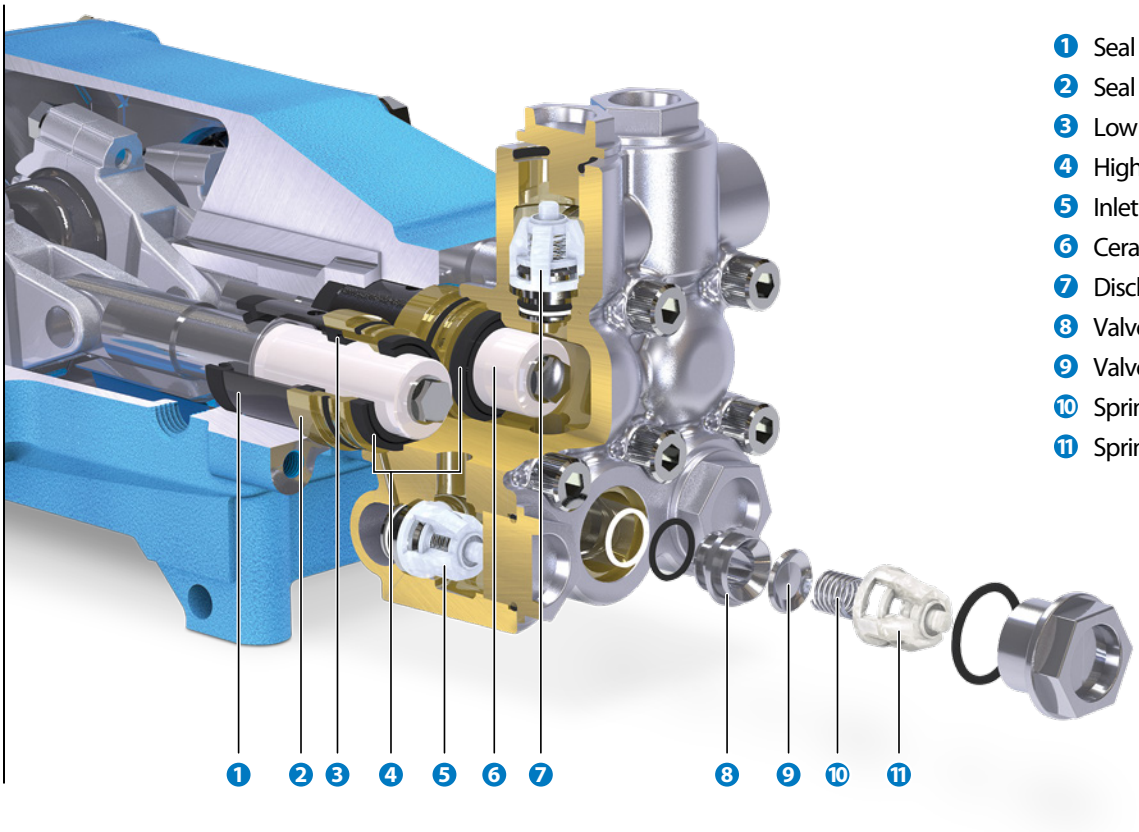
www.catpumps.com

Identifying Pump Damage

Optimum performance of the pump depends upon the entire system, determined by proper design, component selection, installation, and maintenance of the pump as well as system accessories. With proper design, installation, and care, high-pressure pumps and systems from Cat Pumps can provide thousands of hours of trouble-free service.

Use this guide to identify the various conditions that cause pump wear and damage. This guide also provides information about how to prevent these conditions to achieve optimal product service life and performance. Information is organized by the two major components of a triplex positive displacement high-pressure pump: the fluid (or manifold) end and the drive end.

Triplex Pump Components (Fluid End)



1. Seal Retainer
2. Seal Case
3. Low Pressure Seal
4. High Pressure Seal/V-Packing
5. Inlet Valve Assembly
6. Ceramic Plunger
7. Discharge Valve Assembly
8. Valve Seat
9. Valve
10. Spring
11. Spring Retainer

Low Pressure Seals

New

Normal Wear

Contamination Abrasive
Page 5

High Temperature
Page 6

Run Dry
Page 7

High Pressure Seals

New

Normal Wear

Contamination
Abrasive
Page 5

High Temperature
Page 6

V-Packings

New

Normal Wear

Contamination
Abrasive
Page 5

High Temperature
Page 6

Valves

New

Normal Wear

Contamination
Abrasive
Page 5

High Temperature
Page 6

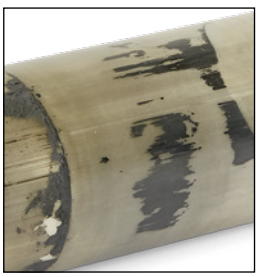
Cavitation/
Pump Speed
Page 4

Plungers

Normal

Cavitation
Page 4

Contamination
Abrasive
Page 5



Run Dry
Page 7

Thermal Shock
Page 8

Cavitation/Pump Speed

Identifying: Cavitation damage is often found first on the sealing surface between the valve and the valve seat of the inlet and discharge valves. When the cavitation persists or is severe enough, it can be seen on the surface of the plungers where the seals ride and also can break valve springs. It can cause the inlet hose to pulse and the whole pump to "vibrate." Often, a knocking noise in the drive end can be detected that is sometimes described as a small hammer tapping on the crankcase.

Causes: Cavitation is a condition created by poor inlet conditions that result in delivering agitated fluid to the pump inlet. There are many conditions that can cause this, including pumping high temperature liquid with insufficient inlet pressure. (See Cat Pumps Tech Bulletin 002). Other system causes for cavitation include: pumping fluids with high viscosities, restrictive inlet piping or fittings, rigid inlet piping, inadequate inlet supply or tank size, excessively long inlet lines and/or multiple elbows, incorrectly sized filter/strainer or air leaking in inlet piping/fittings or components.

Valve Assembly

Resolution: Inspect the pump inlet for the conditions listed above for possible causes. Review the following points and reduce or eliminate each one as much as possible.

- Excessively long inlet line
- Inadequately size piping/fittings
- Rigid piping into the pump
- Air leaks
- Inadequate tank size
- Restrictive filter/strainer
- High viscosity fluid
- High temperature fluid

Plunger

Contamination/Abrasive

Identifying: Contamination in the fluid end can cause damage in numerous pump components including the sealing surfaces on valves/seats, high and low pressure seals, v-packings and plungers. It can typically be identified by straight scoring lines in the direction of the plunger stroke of the pump on the plungers, v-packings and high/low pressure seals. On the valve and seat sealing surface, the scoring is erratic and not necessarily straight lines; it can also can create sharp edges and irregular wear on the valves.

Low Pressure Seal

High Pressure Seal

V-Packing

Valve and Seat

Causes: Contamination in the fluid end is caused by exceeding recommended fluid cleanliness levels, usually measured in parts-per-million (ppm), contaminated tank, no inlet filters, dirty/clogged or incorrect filters or operating in a highly contaminated environment.

Resolution: Always follow guidelines for ppm recommendations, use proper filtration based on the application, and isolate the pumping system from environmental conditions that can cause excessive contamination ingression. (See the Cat Pumps "High-Pressure System Design Guide" for more information.) For the drive end, use only Cat Pumps oil for optimum lubrication. Change seals on a routine maintenance schedule or as soon as there is any physical indication of leakage or loss of pressure.

Plunger

High Temperature

Identifying: Pumping high temperature fluids can damage high and low pressure seals, O-rings, valve spring retainers and seal retainers. It can be identified by softened or deformed surfaces and a glazed-over look on elastomers and plastic type materials. High temperature can cause certain types of elastomers to expand or swell, which causes premature wear.

Low Pressure Seal

High Pressure Seal

V-Packing

Valve, Seat and Spring Retainer

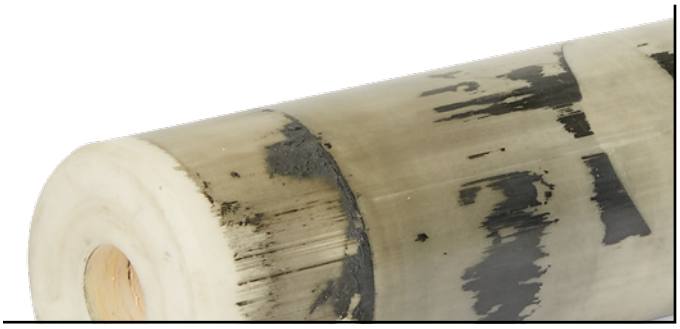
Causes: High temperature can be caused by running a system in bypass mode that has the bypass flow from the pressure regulator/ unloader plumbed back in to the pump inlet. Other causes are over-running the pump beyond its rated speed or rpm, a faulty tank heater or setting system pressure too high.

Resolution: Always follow guidelines for maximum ratings for rpm and temperature of the pump. (See individual pump Data Sheets.) Alternate seal options are available for many pumps for high temperature applications. (Consult Cat Pumps for best seal options). When a pump systems bypass flow is plumbed back to the inlet of the pump, the amount of time the system is in full bypass should be kept to a minimum. Check tank temperature setting and verify with a second source. Adding a thermal valve to the system is a simple way to protect against high temperature damage to the fluid end. Improper ventilation can be challenging to diagnose and will most likely affect other components such as the motor, electrical components and the drive end of the pump.

Run Dry

Identifying: The effects of run dry can be seen significantly on two components: the low pressure seals and the plungers. It can be identified, like high temperature, by deformed and glazed seals and melted parts. Because of the complete lack of lubrication, the damage is typically significant. The melted seals will start to adhere to the plunger and leave a heavy residue on the plungers. The melted seals may have a very thin material that is extruded and may also have chunks of the inside of the seal missing that have been ripped after attaching to the plunger.

Low Pressure Seal



Plunger

Causes: Run dry is caused by running the pump with very little or no flow passing through the pump.

Resolution: Start by reviewing the inlet plumbing and start up sequence of the system. On the inlet plumbing, inspect any component that could interrupt the flow to the pump: ball valve, solenoid, inlet regulator, booster pump, filter/strainer and piping or hose. For the start-up sequence or procedure, make sure the system is turned on with enough time to flow completely through the pump before the pump is started. The use of an inlet low pressure switch or transducer is a good practice to prevent the pump from starting or running without adequate flow. For applications that could possibly run dry, alternate seals are available to help withstand momentary run dry conditions.

A Note About Temperature

Standard pumps are rated to operate with fluid temperatures up to 160°F depending on the model. However, special elastomers are available that permit operating at temperatures to 200°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, the risk of cavitation is decreased. A pressurized inlet above 130°F, reducing pump rpm, installing an inlet stabilizer in inlet line, and increasing the inlet line size to the pump are good practices that should be considered with elevated temperatures.

Thermal Shock

Identifying: Thermal shock directly affects the ceramic plunger. It can easily be identified from the "spider web" looking cracks visible on the plunger. These cracks can be difficult to feel but any surface deformation will allow the pumped fluid to seep through the cracks and work its way past the low pressure seals.

Plunger

Causes: Thermal shock damage occurs when the ceramic plungers are subjected to a rapid change in temperature. This leads to thermal gradients and differential expansions within different regions of the plunger, creating spider web cracking. The two most common conditions that cause thermal shock are the following:

- Operating the pump without water for a period of time and then turning the water on. Running the pump dry causes high friction between the seal and plunger, thus creating extreme heat. When the water is turned on, cold water hits the hot plunger and thermal shock can result.
- Running the pump in bypass mode for an extended period of time causes the water and components in the pump to heat up. When the nozzle is finally opened downstream and fresh cold water hits the hot plunger, thermal shock can result.

Resolution: Replace individual plungers as needed. Always start the system by allowing the fluid to flow through the pump before operation. The use of the thermal valve or routing the bypass line back to tank will help eliminate heat created by running in bypass mode.

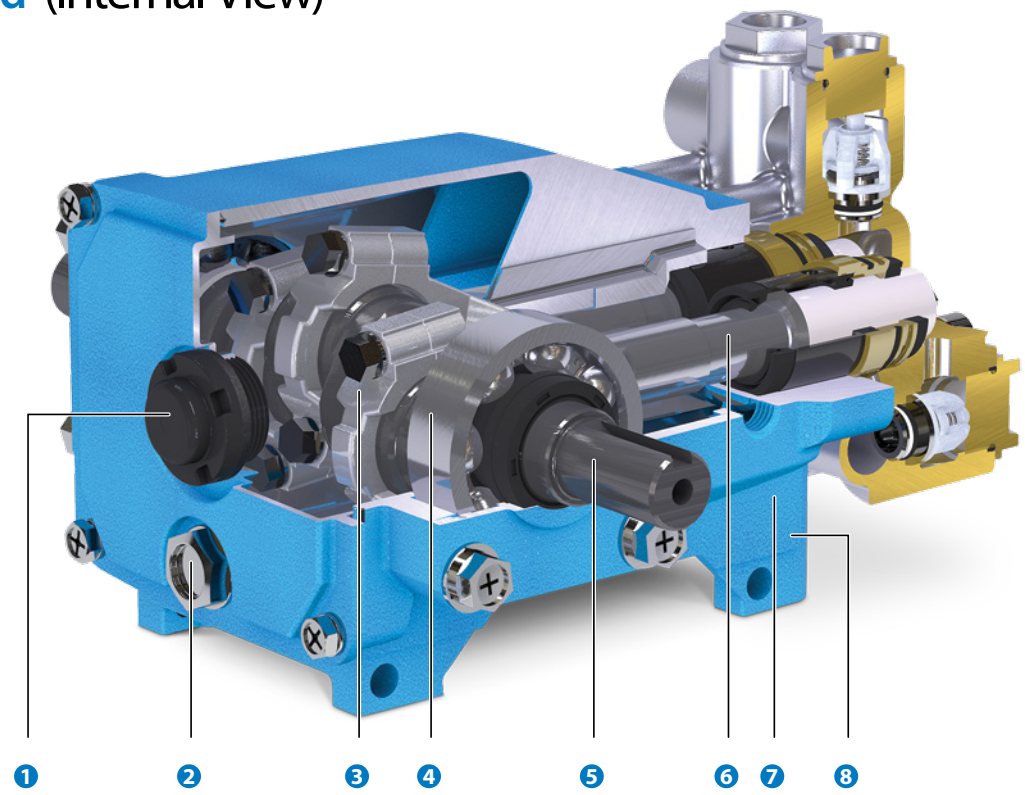
Identifying Drive End Damage

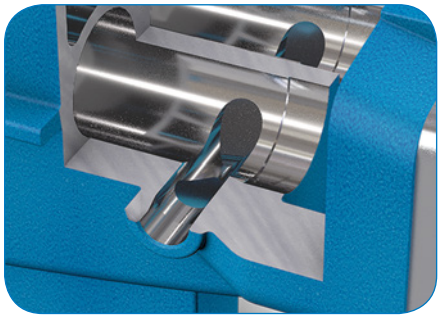
The pump drive-end provides the mechanical interface between a prime mover (electric motor, gas/diesel engine, hydraulic or pneumatic motor) and the pump itself. The internal workings of the drive-end convert the rotary motion of the power source into linear motion of the reciprocating plungers. The result is the pump's flow rate, with pressure measuring the system resistance (or work) against that flow.

The drive-end is not exposed to the pumped liquid and does not contain wear parts like those in the fluid-end. It operates in a bath of splash-oil lubricant. The petroleum-based lubricant provides an ideal environment for long-life, but there are conditions that can adversely affect drive-end performance. This section covers these conditions in detail.

Crankcase/Drive-End (Internal View)

1. Oil Sight Glass
2. Oil Drain
3. Connecting Rod
4. Bearing
5. Crankshaft
6. Plunger Rod
7. Crankcase
8. Mounting Feet





In a Cat Pumps exclusive design feature, drilled-through internal oil porting lubricates the front side of the crosshead area, providing a constant flow of lubricating oil. Coupled with the splash-oil design enhanced by the trapezoidal shape of the crankcase, every Cat Pumps model can operate efficiently down to 100 rpm. Do not operate below this limit or above maximum pump rpm.

Contamination/Water

Identifying: Contamination in a drive end can cause damage to many different parts in different ways. Typically the fluid being pumped is water. When water gets in the drive end and mixes with the oil, it can easily be identified because it turns the oil white and looks like "milk" in the sight glass.

The water oil mix does not provide good lubrication to the components in the drive end and in turn can cause damage. This damage occurs on the plunger rod where it rides in the journal of the crankcase and also on the crankshaft and connecting rods. The other negative effect of water in the drive is the development of oxidation or rust. Without the proper layer of oil on the components, rust will start to form on the bearings and crankshaft.

Plunger Rods

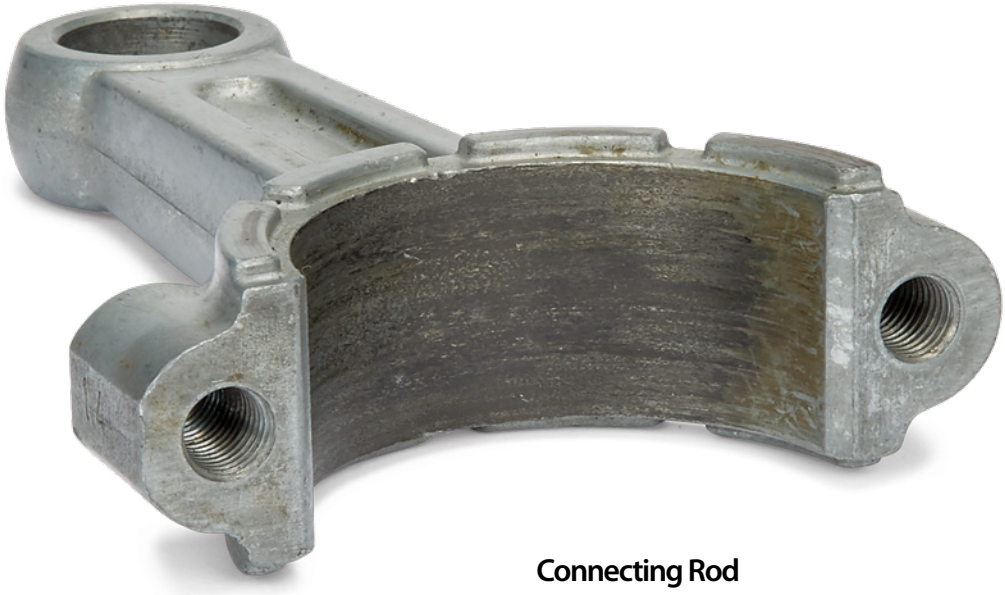
Crankshaft

Crankcase oil that appears cloudy or milky indicates the presence of water at a level above the oil's saturation point. As little as 200 to 300 parts-per-million (ppm) of water can cause this condition. When this amount of free water is present, the lubricating property of oil is greatly reduced. The oil should be changed immediately – after the source of water has been identified and fixed. The most common source is across worn low pressure seals. Water can also be ingested through the filler/breather cap in wet or humid environments.

Causes: Water contamination in the drive end originates from the fluid end leaking. Water can make its way to the drive end past the low pressure seals that are worn out or by getting to the middle of the plunger and riding the plunger rod past the low pressure seal. Once the water is past the low pressure seal, it can ride the plunger rod around the oil seal and into the drive end.

Resolution: Routine maintenance is the best way to prevent water from entering the drive end. Items such as proper filtration, operating with soft water, installing properly sealed and clean inlet lines reduces the likelihood of water contamination. If the pump begins leaking or the oil turns white in the sight glass, immediate action should be taken. Typically installing a seal kit, flushing out the drive end, and adding fresh oil resolves the situation.

Bearings



Connecting Rod

Lack of Lubrication

Identifying: Lack of lubrication in a drive end can cause significant damage in a short amount of time due to the tight tolerances of components moving at high speed. Lack of lubrication will typically cause damage to the crankshaft and connecting rods first. Extreme heat is created between the surfaces of these components. Heat will continue to build to the point a very noticeable burnt smell will be evident. Once the heat builds up to an extreme level, materials will start to adhere to each other, connecting rod(s) will break, and catastrophic damage will result.

Crankshaft

Causes: Poor lubrication can be caused by using non-approved oil or operating with a low level of oil or no oil at all in the drive end of the pump. Oil levels should be monitored on a regular basis, daily if possible.

Resolution: Always use Cat Pumps crankcase oil for proper lubrication. Fill oil to the correct level and check based on the Cat Pumps preventive maintenance schedule. (See inside back cover of this brochure or individual pump service manual.)

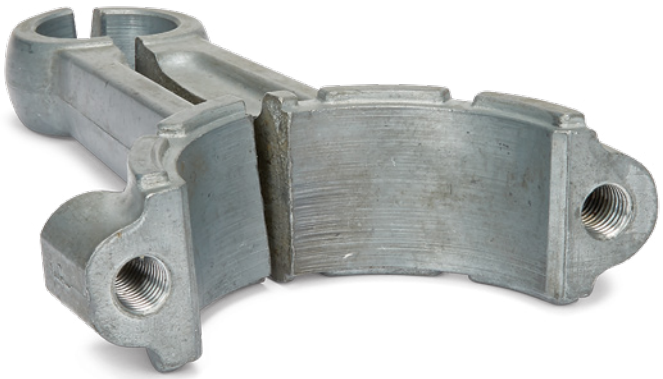
Connecting Rod

High Pressure Spikes

Identifying: Pressure spikes create a fast pulse of force on the head of the plunger that is transferred through the mechanical drive. The part that takes the most force impact is the connecting rod. The connecting rod over time cracks and can eventually split into two sections.

Causes: Pressure spikes can be created by cyclic downstream pressure fluctuations or with a regulator or unloader set incorrectly or by running a pump over the rated pressure.

Resolution: Always size your nozzle(s) or orifice(s) for the correct system pressure. Do not crank regulator or unloader to compensate for worn nozzles. Always run the system at or below maximum rating of the pump.



Connecting Rod

High Temperature

Identifying: High temperature conditions in the drive end can damage many pump components including the filler/breather cap, sight gauge, bearings, and seal retainers. High temperature can be identified first by the softening or deforming of plastic type material. High temperature can eventually melt these items and start to damage other internal elements such as O-rings and bearings.

Causes: Overrunning the pumps rated speed and installing the pump in a poorly vented space are the two primary causes of high temperature in the drive end. Another very common cause of high temperature is running the pump for extended periods with contaminated crankcase oil or the incorrect oil. (See sections covering Contamination/Water). Contaminated oil loses its lubricating properties, which does not allow the oil to lubricate and cool moving parts. This causes increased friction between the moving components in the drive end and eventually creates extreme heat that leads to permanent drive end damage.

Resolution: Always follow guidelines for maximum rating for speed and temperature of the pump. Change oil as recommended. If contamination is detected in the drive end, shut the pump down immediately and find the source of the contamination. Flush the drive end and refill with approved Cat Pumps oil to the correct level.

High Inlet Pressure

Identifying: High inlet pressure being fed into the pump can create back pressure that causes a high stress load to transfer through the drivetrain. This creates an excessive stress concentration on the wrist pin area of the connecting rod. This constant stress is not relieved on the back stroke of the plunger and does not allow proper lubrication to enter this area. The result will be an "egg-shaping" of the wrist pin hole in the connecting rod. If not caught and corrected, this will introduce slop into the stroke of the plunger and create a "piston slap." If the pressure is more of a spike on the inlet, then pressure can damage the low pressure seal and seal retainer as the stress is transferred to the drivetrain.

Causes: High inlet pressure or inlet pressure spikes can be caused by many different conditions. City water pressure can be high itself or a booster pump may be supplying too much flow that causes excessive pressure. Improper inlet regulator settings are another common cause of high inlet pressure. Spikes or water hammer is usually a result of the inlet plumbing to the pump and or in the facility.

Resolution: An inlet regulator can maintain constant pressure to an acceptable level within the rating of the pump. Inlet spikes or inlet water hammer can be difficult to control. Installing an auxiliary break tank may be necessary to eliminate this condition.

Note the egg-shaped condition of the connecting rod wrist pin, generally caused by excessive pump inlet pressure.

Connecting Rod and Pin

Low Pressure Seal

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.

ABOUT CAT PUMPS

Proven Quality, Customer Focused

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

LOCATIONS

Worldwide Headquarters

Cat Pumps
1681 94th Lane Northeast
Minneapolis, MN 55449
USA

P: 763-780-5440
F: 763-780-2958
techsupport@catpumps.com
www.catpumps.com

Territories Served
U.S., Canada

International Division
P: 763-780-5440
F: 763-785-4329
intlsales@catpumps.com
www.catpumps.com

Territories Served
Africa, Asia, Australia, Central and South America, Mexico, Middle East, New Zealand, Turkey

Cat Pump (U.K.) Ltd.
1 Fleet Business Park, Sandy Lane
Church Crookham
FLEET, Hampshire GU52 8BF
England

P: +44 1252 622031
F: +44 1252 626655
sales@catpumps.co.uk
technical@catpumps.co.uk
www.catpumps.co.uk

Territories Served
England, Ireland, Scotland, N. Ireland, Wales

Cat Pumps International N.V.
Heiveldekens 6A
2550 Kontich
Belgium

P: 32 3 450 71 50
F: 32 3 450 71 51
cpi@catpumps.be
www.catpumps.be

Territories Served
Western Europe (except U.K., Germany, and Austria)

Cat Pumps Deutschland GmbH
Buchwiesse 2, D-65510
Idstein
Germany

P: +49 6126 9303 0
F: +49 6126 9303 33
catpumps@t-online.de
www.catpumps.de

Territories Served
Austria, Commonwealth of Independent States (CIS), Germany and Eastern Europe

SALES, DISTRIBUTION, SERVICE

Call today for product and application assistance.
763-780-5440 or visit us at www.catpumps.com

The Pumps with Nine Lives

CAT PUMPS
1681 - 94TH LANE N.E. MINNEAPOLIS, MN 55449-4324
PHONE (763) 780-5440 — FAX (763) 780-2958
e-mail: techsupport@catpumps.com
www.catpumps.com

For International inquiries go to www.catpumps.com and navigate to the "Contact Us" link.

PN 99REF014 Rev A 12/17