Pump Troubleshooting Guide

Introduction

In nearly all instances, pump failure is the result of improper installation or operation rather than normal wear. One of the most common causes of pump failure is improper or unnecessary service, often as a result of the operator attempting the service.

"The high pressure pump is generally one of the most dependable and best constructed components in a pressure washer." All pumps have wear parts, which eventually need to be replaced.

"In most cases, the high pressure pump is likely to outlast most other components as long as the pump is installed correctly and the system is operated properly."

Searching for the reason for pump failure is like uncovering clues at a crime scene: you need to have a plan, be systematic, and be careful your efforts don't destroy any delicate evidence.

Your plan is relatively straight forward, just like any detective's:

- Ask questions
- Make observations
- Examine the evidence
- Develop conclusions

But the most important thing is to keep the steps in order; and especially, don't jump to conclusions before all the steps are complete.

Ask Questions

Most of these questions are those you'd normally ask when writing up a repair order. But in this case you might want more detail:

- How was the pump being used just before it failed?
- Were there any noises at the time of failure?
- Was there a vibration, water or oil leaking from the pump?
- What happened to the pressure? Smooth gradual loss or smooth sudden loss?
- When was the last service?

Make Observations

This is when the detective work starts. All of these quick checks should be done with the customer present. You don't need anything more than a pressure gauge and correct nozzle size.

Check the outside of the pump.

- Is the pump protector removed?
- Are the hose connections tight?
- Is there discoloration of inlet brass connections? Black color is chemical oxidation, dark bluish black is heat.
- Are there signs of oil leaks?

While these points may seem obvious, the information will be invaluable to your investigation.

Check the oil.

- How much is there?
- What does it look like? Cream color indicates water or detergent oil.

Naturally, you need to see if the oil level was within the normal operating range, but don't stop there. Old oil is black and a lot thicker than fresh oil, maybe even sludgy. It's typically found in pumps that have oil added, but never drained. Burned, overheated oil will be similar in appearance.

Sparkling metal particles in the oil will be a clue to the failure. Save them and check if they're magnetic.

Fresh, clean oil should make you suspect that oil was added after the failure, a little too late. If it was added after the failure, it will float on top of old, burned oil. When you drain the oil later, watch carefully to see the color of the oil as it drains.

Check the inlet strainer.

- Is the strainer clogged?
- Is the strainer damaged?
- Are there any “dirt trails” around seals and check valves, indicating dirt was bypassing the filter?
- Is the strainer installed with the arrow pointing in the right direction?

Dirt is death to a pump. If it gets into the pump through damaged strainers, abrasive damage will occur to the packing, piston, bearings, and check valves.

Dirt can be a problem even if it doesn’t get into the pump. If the strainer becomes clogged, the resulting lack of water damages packing and plungers, sometimes to the point of unloader and complete manifold failure.

Check for proper water supply.

- Is the pump cavitating?
- If pump is connected to water supply tank, does pressure increase when pump is connected directly to city water supply (garden hose)?
- Is the pump inlet port connected to a filter, 90° and bushing fittings that restrict water flow?

Pump chattering caused by heavy cavitation can be mistaken for a broken connecting rod. To determine if cavitation is the source of the problem, open the upstream chemical injector completely while operating the system. If the noise stops, it is cavitation. If the system does not have an upstream injector, hook up a positive feed system to the pump and operate the system.

Set up a check list.

Excessive noise:	Hot water
	Cavitation
	Vibrations in the system
	Worn valves
	Worn O-rings
	Belts
	Connecting rods
Excessive noise (cont):	Pulleys
	Plunger rod pins
	Bearings
	Mounting bolts
Oil leaks:	Bad seals
	Shipping cap has not been removed
Loss of pressure:	Worn nozzle
	Bad pressure gauge
	Valve seat o-rings
	Low RPM
	Low inlet pressure or flow
	Valves

How to Start

Ask the Right Question At the Right Time

Isolate the Problem

- Set Up a Diagnostic Procedure
- Simple to Hard
- Logical Progression

Use Simple Tools

- Eyes
- Ears
- Nose
- Brain

Start With Observations

- Physical Inspection and Observations
- Carefully Observe the Equipment In Operation
- Trace the Fluid Flow

Don't Skip Any Steps

- Start At Point "A" and Finish at Point "Z"
- Isolate the Problem
- "Remember, Problems Can Cause Problems"

Pump Failures: There Are Several Reasons for Pump Failure; Most Are a Result of:

- Improper Use
- Insufficient or Dirty Water
- Plugged Filters
- Kinked or Plugged Hoses
- Cavitation
- Lack of Maintenance

Fluid System

No Flow:

- No Power to the Pump
- Trigger Gun Not Opening
- No Water Source
- Clogged Spray Nozzle
- Clogged Inlet Filter
- Stuck Float Valve
- Faulty Unloader
- Pinched or Clogged Inlet Hose
- Inlet Valve(s) Not Open

Low Pressure, Adequate Flow:

- Worn, Incorrect, No Spray Nozzle
- Variable Pressure Wand on Low Pressure Setting
- Unloader/Regulator Improperly Adjusted
- Pressure Gauge Inaccurate or Broken
- Worn Pump Packings

Low Pressure, Low Flow:

- Volume Improperly Adjusted
- Discharge Leaks
- Chemical Injector Orifice Blocked
- Drive Belts Loose
- Pump or Motor Not Running at Rated Speed
- Stripped Pump Drive Coupling
- Defective Easy Start Valve
- Malfunctioning Motor or Engine

Low Pressure, Very Low Flow:

- Unloader Stuck In Bypass
- Outlet Restriction
- Clogged Nozzle
- Restriction in the High Pressure Hose and Fittings
- Debris in the System
- Cavitation
- Clogged Inlet Hose or Filter

Excessive Pressure:

- Spray Nozzle Too Small and High RPM
- Faulty Pressure Gauge
- Unloader/Regulator Improperly Adjusted
- Faulty Unloader/Regulator

Pump Chatters:

- Air in the System
- Chemical Line Not Submerged
- Inlet Line Kinked, Restricted, or Internal Hose Separation
- Inadequate Water Supply
- Float Valve Is Stuck
- Turbulence in the Float/Supply Tank
- Cavitation
- Inlet or Inlet Strainer Clogged
- Water Supply Too Hot

Inlet Line Vibration:

- Air in the System
- Debris in the Valves

Outlet Line Vibrates:

- Air in the System
- Debris in the Discharge Valves
- Damaged Pump Packings

Inlet & Outlet Lines Vibrate:

- Inlet and/or Discharge Valves Fouled
- Other Downstream Restrictions
- Air in the System

Unloaders/Regulators Very Low Or No Flow:

- Unloader Stuck In Bypass

Unloader Cycles With System Under Pressure (Flow Unloader):

- Improper Flow or Piston Sticking From Hard Water
- Nozzle Too Small
- Nozzle Clogged
- Improper Unloader Orifice
- Unloader Orifice Clogged
- Injector Orifice Clogged

Unloader Cycles With The System In Bypass (Flow Unloader):

- No Restriction in the Unloader or Hose Too Long
- Weep Gun in the System
- Downstream Leakage
- Accumulator Downstream

Unloader Produces Smooth Flow & Low Volume (Trap Unloader):

- Unloader Adjusted Too Low
- Spray Nozzle Clogged
- Spray Nozzle Too Small
- Injector Orifice Blocked

UNLOADER PRODUCES SMOOTH FLOW & LOW VOLUME (FLOW UNLOADER):

- Unloader Adjusted Too Low
- Unloader Is Stuck in Bypass
- Restriction in the System

Unloader Produces Low Flow & Normal Pressure (Trap Unloader):

- Nozzle Too Small

Unloader Produces Low Flow & Normal Pressure (Flow Unloader):

- Nozzle Too Small

Unloader Pressure Increases When The Trigger Is Released (Flow):

- Unloader Piston is Stuck or Frozen
- Bypass Port Is Clogged or Restricted
- Excessive Tension on the Main Spring

Leaking:

- ***Leaking from the Inlet:*** Bad Inlet Hose Seal, Loose Clamps or Connections
- ***Leaking from the Float Tank:*** Full of Water or Float Valve is Stuck
- ***Leaking from the Pressure Fittings:*** Fittings Not Tightened or Sealed
- ***Leaking from the Quick Disconnects:*** Bad O-Ring
- ***Leaking from the Pump:*** Bad Low Pressure Seal(s), Cracked Plunger, Damaged Manifold
- ***Leaking from the Trigger Gun:*** Bad Piston O-Ring, Stripped Connection
- ***Leaking from the Nozzle:*** Weep Gun, Damaged Gun, Valve Ball & Seat
- ***Leaking from the Pop Off Valve:*** System Over Pressure, Clogged Nozzle, Trigger Gun Not Working, Excessive Pressure Spikes, Wear on the Ball & Seat

Trigger Gun

No Flow From The Nozzle When The Trigger Is Depressed:

- Broken Rod in the Trigger Gun
- Blockage in the System Past the Trigger Gun

Excessive Pressure When The Trigger Gun Is Released:

- Excessive Pressure Spike
- Malfunctioning Unloader

Flow Does Not Stop When The Trigger Is Released:

- Broken Return Spring
- Debris in the Gun Valve

Trigger Action Sticks:

- Keeper Is Too Tight

Detergent System

No Detergent:

- Detergent Valve Is Closed
- Detergent Foot Strainer Is Clogged
- Detergent Line Is Kinked or Sucking Air
- No Adjustment for Low Pressure
- Detergent Nozzle Not Sized Properly
- Wrong Size Detergent Orifice or Float Tank Restriction

Excessive Detergent:

- Valve Improperly Adjusted or Restrictor in Float Tank and Injector to Small

SPRAY NOZZLE

- ***Spray Pattern Irregular:*** Clogged Nozzle, Worn Nozzle
- ***Volume Proper, Pressure Low:*** Nozzle Is Too Large, Internal Nozzle Wear
- ***Pressure Proper, Volume Low:*** Clogged Nozzle

PRESSURE PUMP

Oil Between The Crankcase And Pump Manifold:

- Worn Plunger Rod Oil Seals

Oil Leaking In The Crankshaft Area:

- Worn Crankshaft Oil Seal
- Bad Bearings

Excessive Play In The Crankshaft Pulley Area:

- Worn Bearings from Excessive Belt Tension

Oil From Under The Crankcase:

- Leaking Plunger Rod, Side Cover, Rear Cover, Or Crankshaft Oil Seals or O-rings

Loud Knocking Noise In The Pump:

- Pulley Loose On The Crankshaft
- Broken Or Worn Bearing, Connecting Rod, Or Plunger Rod
- Cavitation

Frequent Or Premature Packing Failure:

- Scored, Damaged, or Worn Plunger
- Overpressure to the Inlet Manifold
- Abrasive Material in the Fluid Being Pumped
- Excessive Pressure and/or Temperature of the Fluid Being Pumped
- Pump Running Dry
- Cavitation

High Crankcase Temperature:

- Wrong Oil
- Low Oil Level
- Old Oil
- Contaminated Oil
- Oil Breakdown

Water In The Crankcase:

- Worn Low Pressure Seals
- Cracked Plunger
- Worn Plunger Rod O-Ring
- Humid Air Condition
- Water Running Over The Pump, Pressure Washing Pump Injecting Water into Vent Cap

Cavitation: means different things to different people. It has been described as:

- A reduction in pump capacity.
- A reduction in the head of the pump.
- The formation of bubbles in a low pressure area of the pump manifold.
- A noise that can be heard when the pump is running.
- Damage that can be seen on the pump seals, retainers and check valves.

Just what then is this thing called cavitation? Actually it is all of the above.

Cavitation implies cavities or holes in the fluid we are pumping. These holes can also be described as bubbles, so cavitation is really about the formation of bubbles and their collapse.

The capacity of the pump is reduced

- This happens because bubbles take up space and you cannot have bubbles and liquid in the same place at the same time.
- If the bubble gets big enough at the manifold inlet, the pump will lose its suction and will require priming.

The head is often reduced

- Bubbles, unlike liquid, are compressible. It is this compression that can change the head pressure.

The bubbles form in a lower pressure area because they cannot form in a high pressure area.

- You should keep in mind that as the velocity of a fluid increase, the pressure of the fluid decreases.
  This means that high velocity liquid is by definition a lower pressure area. This can be a problem any time a liquid flows through a restriction in the piping, filter, or changes direction suddenly. The fluid will accelerate as it changes direction. The same acceleration takes place as the fluid flows in the small area between the tip of the ceramic plunger and the manifold packing assembly area.

A noise is heard

- Any time a fluid moves faster than the speed of sound in the medium you are pumping, a sonic boom will be heard. The speed of sound in water is 4800 feet per second (1480 meters/sec) or 3,273 miles per hour (5,267 kilometers per hour).
- The bubble tries to collapse on its self. This is called imploding, the opposite of exploding. The bubble is trying to collapse from all sides, but if the bubble is laying against a piece of metal such as the impeller or volute, it cannot collapse from that side, so the fluid comes in from the opposite side at this high velocity, preceded by a shock wave that can cause all kinds of damage. There is a very characteristic round shape to the liquid as it bangs against the metal creating the impression that the metal was hit with a "ball peen hammer".

Pump parts show damage

- This damage would normally occur at right angles to the metal, but experience shows that the high velocity liquid seems to come at the metal from a variety of angles. This can be explained by the fact that dirt particles get stuck on the surface of the bubble and are held there by the surface tension of the fluid. Since the dirt particle has weakened the surface tension of the bubble it becomes the weakest part and the section where the collapse will probably take place.

The higher the capacity of the pump the more likely cavitation will occur.

Connecting a pressure washer to a water supply tank:

- When the water level inside the supply tank reaches a point in which the head pressure does not exceed the suction from the pump, a vortex forms allowing air to siphon into the pump. Installing a baffle or elbow positioned to force the pump to siphon water from bottom of tank, will prevent the formation of a vortex.
- As the water level drops you have a reduction in head pressure. If the supply line is too small, a restriction to the pump will cause cavitation and damage the pump.
- The use of elbow and filters in the supply line will cause water restriction damaging the pump.

Testing for proper water supply: Record pressure from your pressure washer using a positive feed water supply. Then operate as installed too your supply tank and compare pressure readings. If there is even a slight drop in pressure you have a restriction which will damage your pump. Increase the size of filters, valves, bushings and other fittings to increase the flow of water to the pump.

TROUBLE SHOOTING CHART

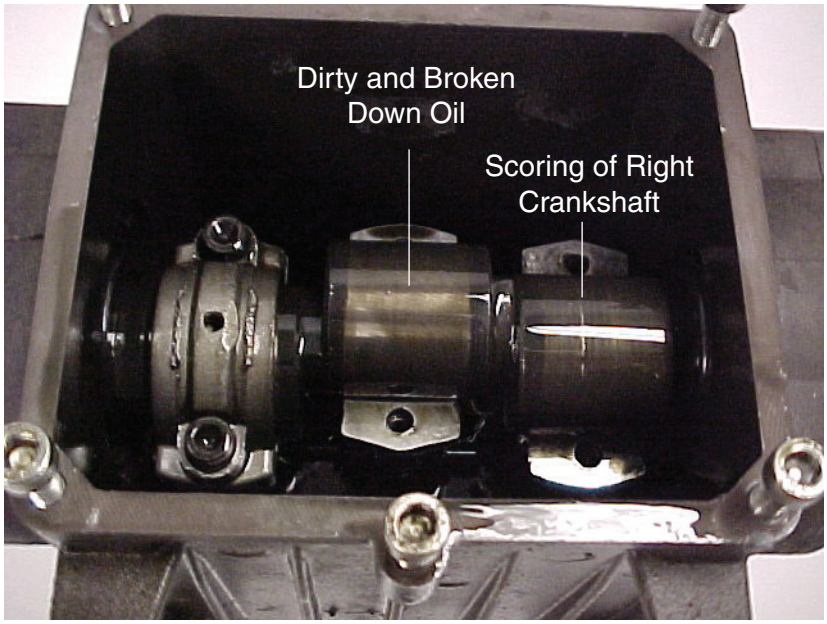
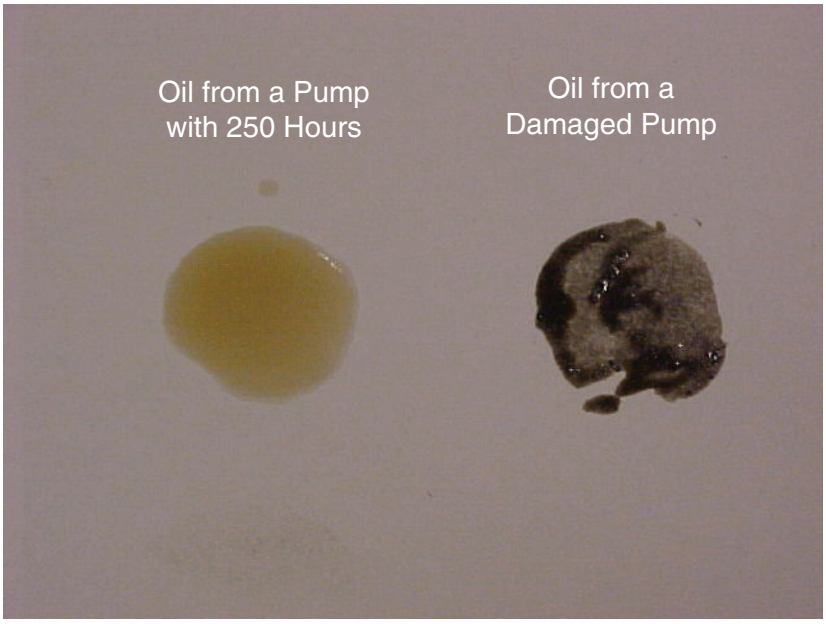
PROBLEM	POSSIBLE CAUSES	REMEDY
LOW PRESSURE	Worn nozzle	Replace nozzle, of proper size.
	Belt slippage	Tighten or replace. Use correct belt.
	Air leak in inlet plumbing	Disassemble, reseal and reassemble.
	Relief valve stuck, partially plugged or improperly adjusted valve seat worn	Clean, adjust relief valve, check for worn and dirty valve seats. Kit available.
	Inlet suction strainer clogged or improperly sized	Clean. Use adequate size. Check more frequently.
	Worn packing	Install proper filter.
	Abrasives in pumped fluid or severe cavitation. Inadequate water	Suction at inlet manifold must be limited to lifting less than 20 feet of water or -8.5 PSI vacuum.
	Fouled or dirty inlet or discharge valves.	Clean inlet and discharge valve assemblies.
	Worn inlet discharge valve blocked or dirty. Leaky discharge hose	Replace worn valves, valve seats and/or discharge hose.
PUMP RUNS EXTREMELY ROUGH, PRESSURE VERY LOW	Restricted inlet or air entering the inlet plumbing	Proper size inlet plumbing. Check for air tight seal.
	Inlet restrictions and/or air leaks. Stuck inlet or discharge valve	Replace worn cup or cups, clean out foreign material, and replace worn valves.
WATER LEAKAGE FROM UNDER MANIFOLD; SLIGHT LEAKAGE	Worn packing	Install new packing.
OIL LEAK BETWEEN CRANKCASE AND PUMPING SECTION	Worn crankcase piston rod seals, O-rings on plunger retainer worn	Replace crankcase piston rod seals. Replace O-rings.
OIL LEAKING IN THE AREA OF CRANKSHAFT	Worn crankshaft seal or improperly installed oil seal O-ring	Remove oil seal retainer and replace damaged O-ring or seals.
	Bad bearing	Replace bearing.
EXCESSIVE PLAY IN THE END OF THE CRANKSHAFT PULLEY	Worn main bearing from excessive tension on drive belt	Replace crankcase bearing and/or tension drive belt.
WATER IN CRANKCASE	May be caused by humid air condensing into water inside the crankcase	Change oil intervals; Use any high grade automotive 30 weight non-detergent oil.
	Worn packing and/or piston rod sieve, O-rings on plunger retainer worn	Replace packing. Replace O-rings.
OIL LEAKING FROM UNDERSIDE OF CRANKCASE	Worn crankcase piston rod seals	Replace seals.
OIL LEAKING AT THE REAR PORTION OF THE CRANKCASE	Damaged crankcase, rear cover O-ring, drain plug	Replace cover O-ring, drain plug O-ring, or sight glass.
	O-ring or sight glass O-ring	O-ring.
LOUD KNOCKING NOISE IN PUMP	Pulley loose on crankshaft	Check key and tighten set screw.
	Broken or worn bearing	Replace bearing.
FREQUENT OR PREMATURE FAILURE OF THE PACKING	Scored, damaged or worn plunger	Replace plungers.
	Overpressure to inlet manifold.	Reduce inlet pressure.
	Abrasive material in the fluid being pumped	Install proper filtration on pump inlet plumbing.
	Excessive pressure and/or temperature of fluid being pumped	Check pressures and fluid inlet temperature; be sure they are within specified range.

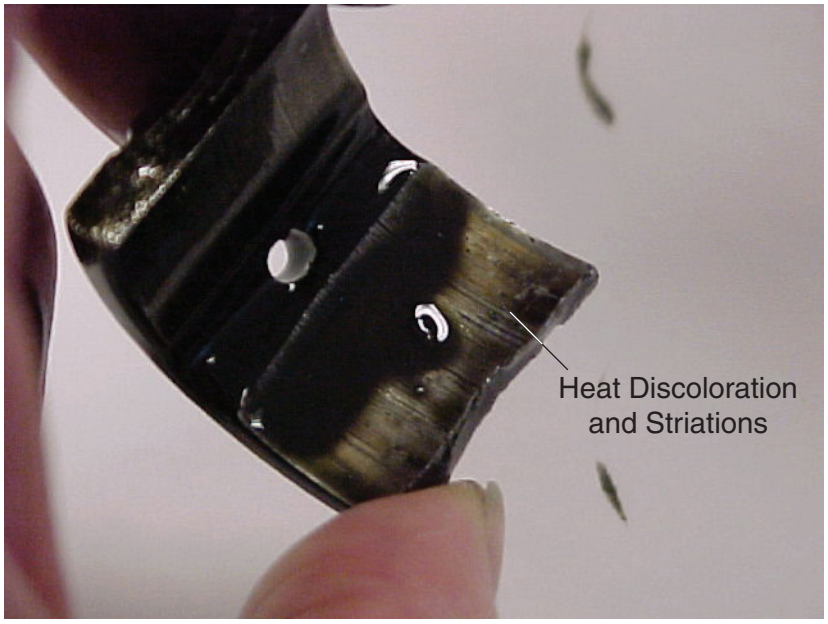
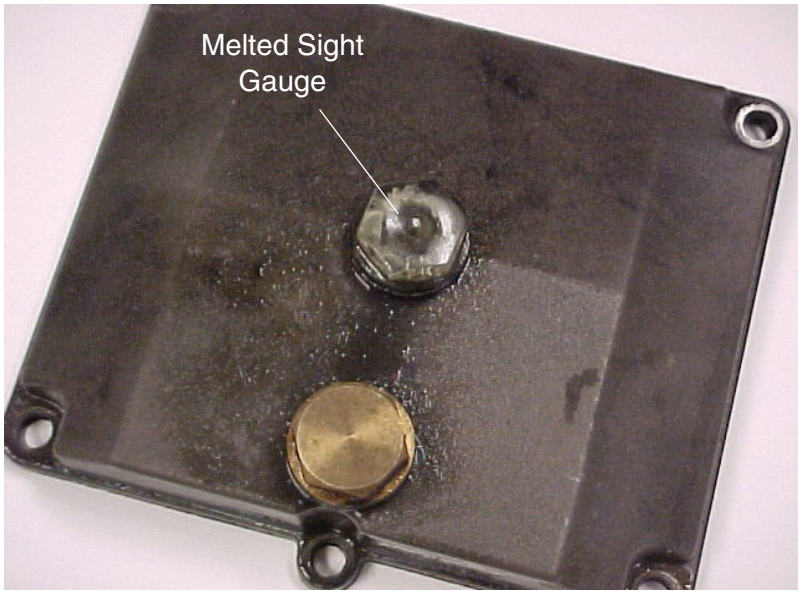
Maintenance Log

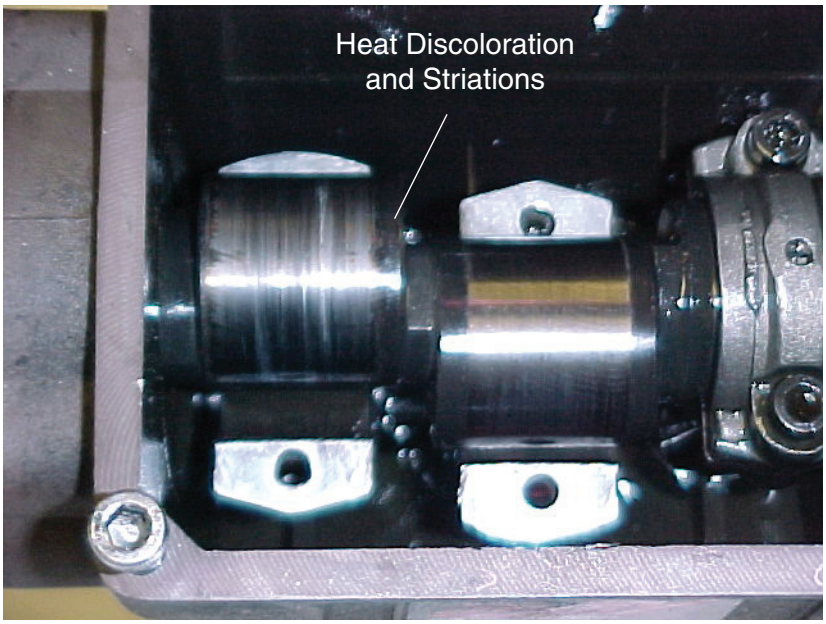
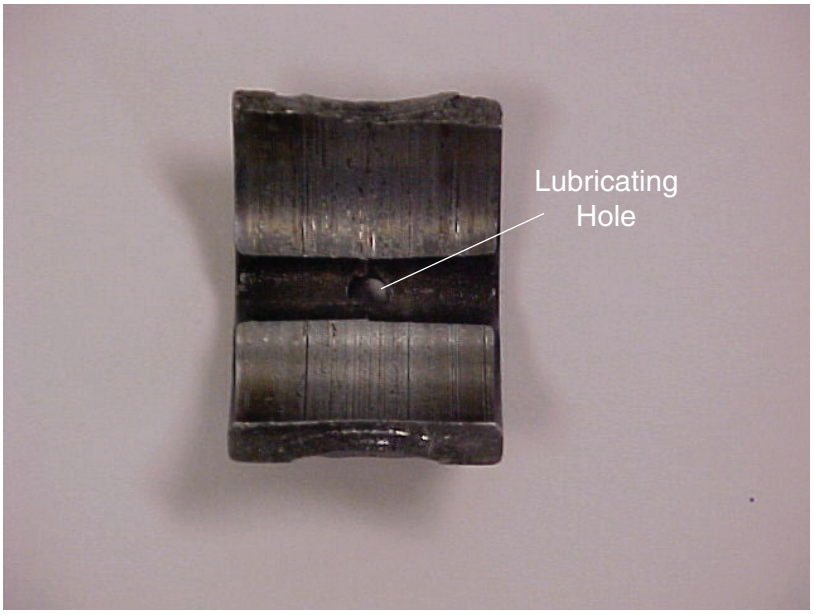
Regular maintenance can prevent many problems before they begin. Use this form to log maintenance service as it's performed on each pump. You can track service intervals by hours of operation, calendar date, or both.

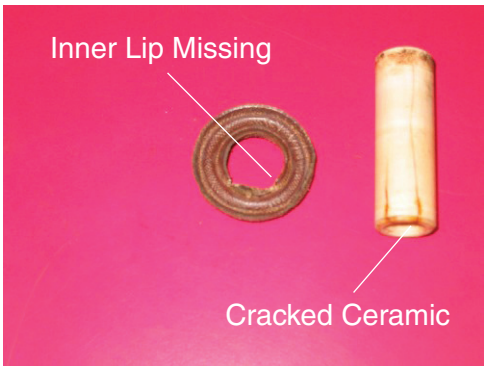
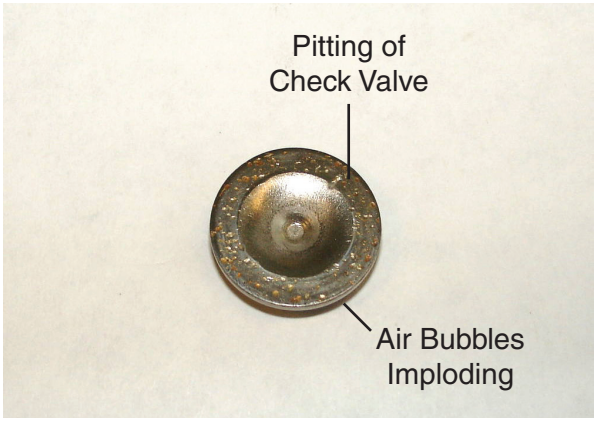
Oil Change							
Hours							
Date							
Grease							
Hours							
Date							
Packing Replacement							
Hours							
Date							
Plunger Replacement							
Hours							
Date							
Valve Replacement							
Hours							
Date							

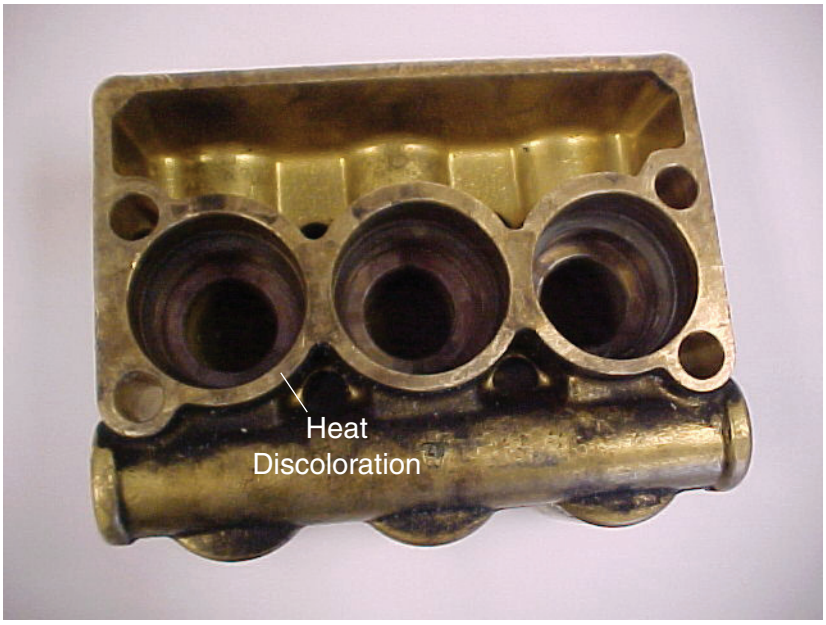
Description of Pump Failures

Description of Defect:	Response
The right crankshaft and connecting rod had abnormal striations.  	Damage was caused by lack of lubrication. After so many hours of use oil will start to break down and loose its ability to lubricate.
 	The oil from this pump was black and had particles indicating lack of maintenance. The operator's manual recommends oil change at first 25 hours, then 300 hours or every three months. When compared to a pump which had 250 hours, this pump oil was not changed as recommended.

Description of Defect:	Response
This picture shows a section of the connecting rod with dirty oil and striations.  	Inspection shows signs of lack of maintenance because the oil is dirty, black and stricky. After a length of time, oil will start to break down and will no longer lubricate. This lack of lubrication will produce heat, causing thermal expansion and scoring the connecting rod and crankshaft.
The melted sight gauge indicates heat associated with the lack of lubrication.  	The sight gauge will melt when temperatures exceed the ratings of the material.

Description of Defect:	Response
Crankshaft shows signs of heat and lack of lubrication.  	When one connecting rod and crankshaft surface is damaged and the other two look normal, except for signs of heat, then suspicion would lead to running this pump at an angle, which causes the oil to move away from the damaged surfaces. This does not negate changing the oil but could explain the damage to only one connecting rod.
Broken connecting rod.  	If the pump was not operated on a level surface the oil will move away from the lubricating hole preventing adequate lubrication. The combination of dirty oil and operating in this condition causes failure to one connecting rod, not all three.

Description of Defect:	Response
This picture also shows a crack in the ceramic plunger with associated marking on the packing. The packing lip is torn.  	This pressure washer has multiple signs of running without water as indicated in these pictures. The ceramic plungers crack from thermal shock, running without a water supply causing an increase in temperature. When water is restored the hot ceramic cracks from this rapid change in temperature. These pictures show chunks of the packing missing, which indicates lack of water supply. The check valve was pitted which is an indication of cavitation (lack of water flow). Air bubbles form then collapse on themselves. This is called imploding, the opposite of exploding.
The check valve was pitted, which is an indication of cavitation (lack of water flow). Air bubbles form, then collapse on themselves. This is called imploding, the opposite of exploding. 	The bubble is trying to collapse from all sides, but if the bubble is laying against a piece of metal such as the check valve it cannot collapse from that side, so the fluid comes in from the opposite side at a high velocity proceeded by a shock wave that can cause all kinds of damage. There is a very characteristic round shape to the liquid as it bangs against the metal creating the impression (pitting) as if the metal was hit with a "ball peen hammer". Check valve assembly showing pitting from the hammering effect of cavitation.

Description of Defect:	Response
This picture shows signs of temperature discoloration which is another sign of cavitation.  	Brass will change colors from chemicals and heat. This pump manifold shows obvious signs of heat discoloration.
This high pressure packing has a hole which is the area in which the air bubble from cavitation imploded.  	Implosion of air bubbles has the same effect on high pressure packings as it did on the afore-mentioned check valves. Air bubbles formed from cavitation collapse with a force strong enough to punch a hole in this packing.

Description of Defect:	Response
The brass retainer is damaged as shown. 	The discoloration of the brass retainer indicates heat which is caused by a restriction of water supply to pump. This restriction causes cavitation, which damages the inside of the pressure packing, and transfers this implosion force outward to the brass retainer.

Troubleshooting

Problem	Probable Cause	Solutions
Oil Leak Between Crankcase and Pumping Section	1. Worn crankcase piston rod seals.	1. Replace crankcase piston rod seals.
	2. O-rings on plunger retainer worn.	2. Replace o-rings.
Frequent or Premature Failure Of the Packing	1. Scored, damaged or worn plunger.	1. Replace plungers.
	2. Overpressure to inlet manifold.	2. Reduce inlet pressure.
	3. Abrasive material in the fluid being pumped.	3. Install proper filtration on pump inlet plumbing.
	4. Excessive pressure and/or temperature of fluid being pumped.	4. Check pressures and fluid inlet temperature; be sure they are within specified range.
	5. Over pressure of pumps.	5. Reduce pressure.
	6. Reduce pressure.	6. Do not run pump without water.
Pump Runs but Produces no Flow	Pump is not primed.	Flood suction then restart pump.
Pump Fails to Prime	Air is trapped inside pump.	Disconnect discharge hose from pump. Flood suction hose, restart pump and run pump until all air has been evacuated.
Pump Loses Prime, Chattering Noise, Pressure Thread Fluctuates	1. Air leak in suction hose or inlet fittings.	1. Remove suction line and inspect it for a loose liner or debris lodged in hose. Avoid all unnecessary bends. Do not kink hose.
	2. Clogged suction strainer.	2. Clean strainer.
Low Pressure at Nozzle	1. Unloader valve is bypassing.	1. Make sure unloader is adjusted properly and bypass seat is not leaking.

	2. Incorrect or worn nozzle.	2. Make sure nozzle is matched to the flow and pressure of the pump. If the nozzle is worn, replace.
	3. Restricted intake.	3. Refer to above priming information.
Pump is Noisy	Pump sucking air.	Check suction manifold.
Pressure Gauge Fluctuates	1. Valves worn or blocked by foreign bodies.	1. Clean or replace valves.
	2. Packing worn.	2. Replace packing.
	3. Pumped liquid temperature too high.	3. Reduce temperature of pumped liquid.
Over Pressure When Gun is Closed	Leaking in unloader valve and incorrect setting.	Control the valve and set new pressure level.
Pulsation	Faulty pulsation damper.	Check pre-charge; if low, recharge it or install a new one.
Low Pressure	1. Worn nozzle.	1. Replace with nozzle of proper size.
	2. Belt slippage.	2. Tighten or replace with correct belt.
	3. Air leak in inlet plumbing.	3. Disassemble, reseal and reassemble.
	4. Relief valve stuck, partially plugged or improperly adjusted valve seat worn.	4. Clean and adjust relief valve; check for worn or dirty valve seats. Kit available.
	5. Inlet suction strainer clogged or improperly sized.	5. Clean. Use adequate size. Check more frequently.
	6. Worn Packing. Abrasives in pumped in cavitation. Inadequate water.	6. Install proper filter. Suction at inlet manifold must be limited to lifting less than 20 feet of water or 8.5 psi vacuum.

	7. Fouled or dirty inlet or discharge valves.	7. Clean inlet and discharge valve assemblies.
	8. Worn inlet, discharge valve blocked or dirty.	8. Replace worn valves, valve seats and/or discharge hose.
	9. Leak in the discharge line.	9. Repair leak.
Pump Runs Extremely Rough, Pressure Very Low	1. Restricted inlet or air entering the inlet plumbing. Proper size inlet plumbing;	1. Check for air tight seal.
	2. Inlet restrictions and/or air leaks. Stuck inlet or discharge valve. Replace worn cup or cups.	2. Clean out foreign material. Replace worn valves.
Water Leakage From Under Manifold. Slight Leakage	Worn packing.	Install new packing.
Oil Leaking in the Area of Crankshaft	1. Worn crankshaft seal or improperly installed oil seal o-ring.	1. Remove oil seal retainer and replace damaged o-ring and/or seals.
	2. Bad bearing.	2. Replace bearing.
Excessive Play in the End of the Crankshaft Pulley	Worn main bearing from excessive tension on drive belt.	Replace crankcase bearing and/or tension drive belt.
Water in Crankcase	1. Humid air condensing into water inside the crankcase.	1. Change oil intervals. Use any high grade automotive 30 weight non-detergent oil.
	2. Worn packing and/or piston rod sleeve, o-rings on plunger retainer worn. Replace packing.	2. Replace o-rings.
Oil Leaking from Underside of Crankcase	Worn crankcase piston rod seals.	Replace seals.
Oil Leaking at the Rear Portion of the Crankcase	Worn crankcase piston rod seals.	Replace seals.
Loud Knocking Noise in Pump	1. Pulley loose on crankshaft.	1. Check key and tighten set screw.

2. Broken or worn bearing.	2. Replace bearing.