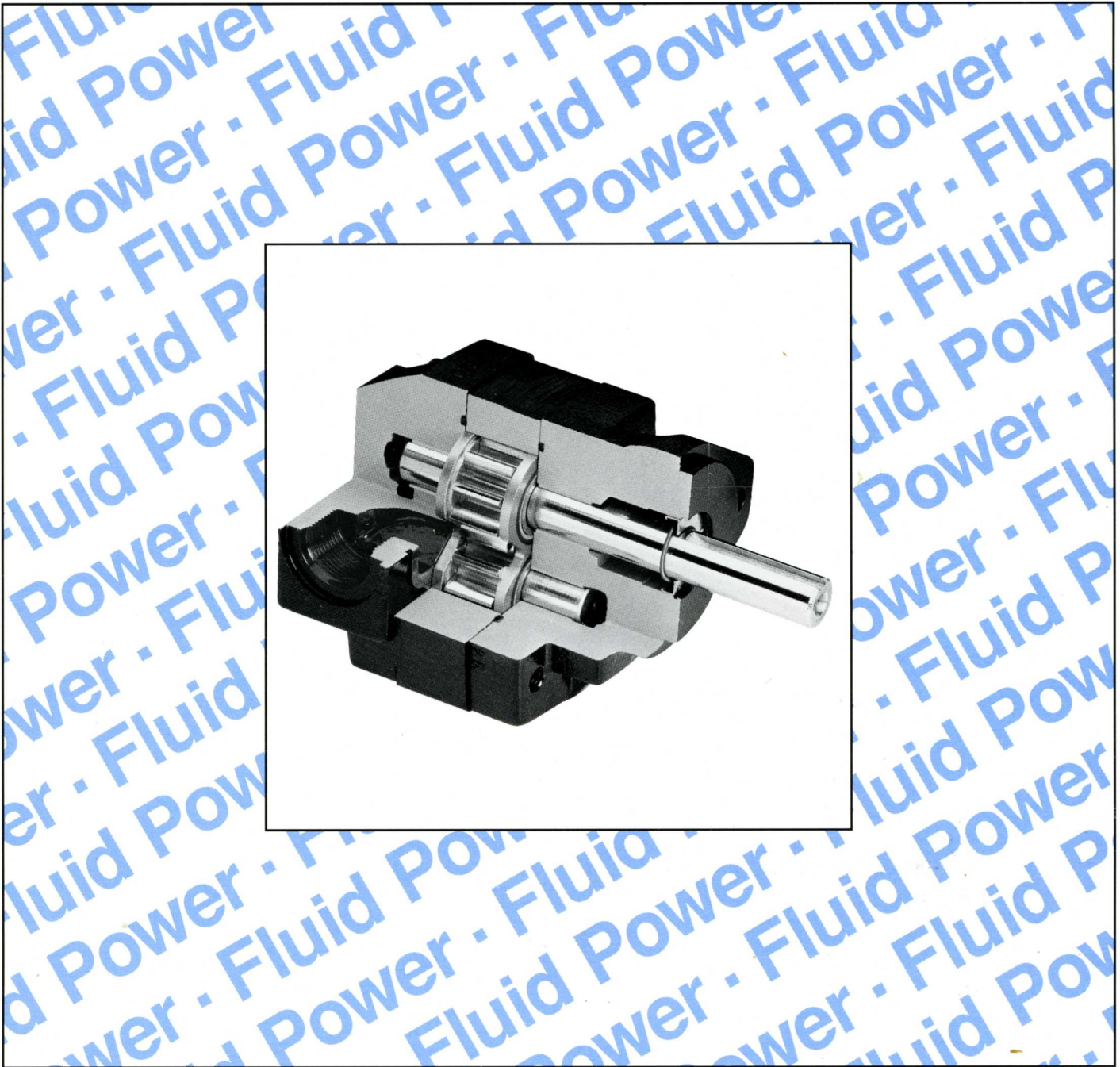


Failure Analysis

Hydraulic Gear Pumps



When pump failure occurs, the only way to prevent repeat failure is to determine the causes and eliminate them.

Edited by John Odgers

In order to handle heavier loads, faster cycles and higher travel speeds, the hydraulic systems in today's construction equipment require pumps with larger capacities and higher pressure ratings. Yet at the same time, high pressures create greater stress on all hydraulic system components. That's why careful maintenance of pumps is essential to reduce failure rate, extend service life and ensure safe machine operation.

Gear-type hydraulic pumps can be counted on to deliver dependable performance over a long period of time when operating in a properly maintained system. This includes using clean oil of the correct grade, regular filter changes and frequent inspections of all system components. But when a pump does fail, it's important to determine all the causes and eliminate them to prevent repeat failure; if a machine's records indicate that pump life shortens with each replacement pump, it's fairly safe to assume that the real problem lies elsewhere.

Why do hydraulic pumps fail?

There are several causes for gear pump failure. While there's never a clear-cut solution, identifying the nine most common causes should be a valuable tool in diagnosing hydraulic pump failure.

1. Abrasive wear caused by fine particles

Abrasive wear caused by fine particles is the most common cause of pump failure. Its symptom is usually a gradual decrease in power and speed of the hydraulic system. Fine particles of dirt or other foreign matter circulating through the system cause wear on all components, and damage is especially noticeable on pressure plates, housing bores and in the shaft bearing area.

Dirt can enter the system through worn seals, especially in dusty conditions or with dirty equipment. Always clean tank caps, funnels and other areas around the filler neck before opening the tank. Immediately

cover all disconnected lines, fittings and openings. Check the rod wiper seals to be sure they are operating effectively.

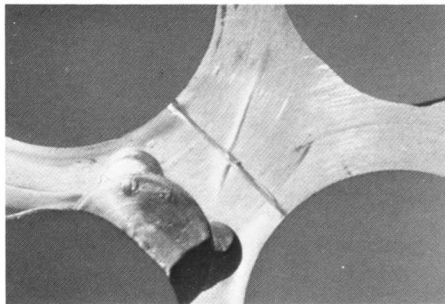
The effectiveness of the cylinder rod wiper seals can be checked as follows, depending on seal design:

V-type rod packings

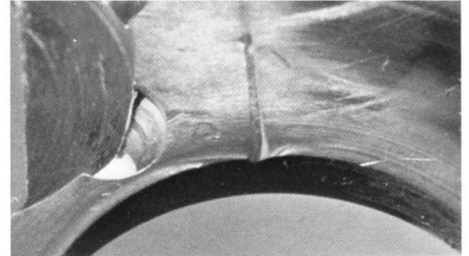
- Extend the cylinder rod.
- Remove the bolts securing the wiper seal retainer to the cylinder head.
- Coat the rod with grease.
- Slide the retainer and wiper seal up the rod.
- Examine the rod. The wiper should wipe the rod clean. If it does not remove all the grease completely around the rod, it's too loose and should not be used.

Lip-type wiper seals with buffer and U-cup rod seals

These rod seal arrangements do not have a retainer on the cylinder head that can be removed for checking the wiper seal. The wiper seal is mounted inside the counterbore of the head and can be inspected visually.



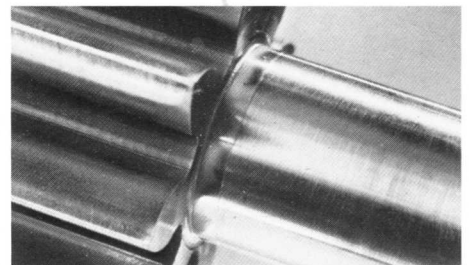
The sandblasted area is the 1/4-in. band around the pressure plate bores. A small scrape at an angle to the lube groove is often present with fine particle abrasion.



Fine particle contamination will cause lube groove edges to be rounded and the ends enlarged.

A better check can be made by inserting a .001- or .002-in. feeler gauge between the wiper seal lip and the rod. If the wiper seal is effective, the feeler gauge cannot be inserted. The rod should not be scratched, scored or otherwise damaged.

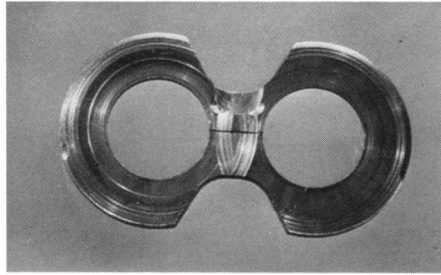
The fine particles that cause abrasive wear are usually not visible to the eye; the size of these particles is about 40 microns. Oil containing particles of this size can actually look clean while having enough abrasive particles to cause pump failure.



A dull sandblasted area may appear at the base of each tooth near the face of the gear. This is caused by contaminated oil flowing through the lubrication groove.

2. Abrasive wear caused by metal particles

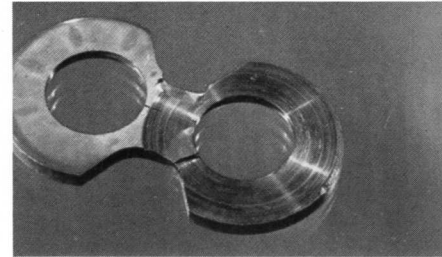
Metal contaminants usually result from wearing components in the hydraulic system or insufficient flushing after a previous failure. Metal particle damage may be gradual or fairly sudden, depending on the quantity and size of particles. Metal particle damage is indicated by surface scratches on pressure plates.



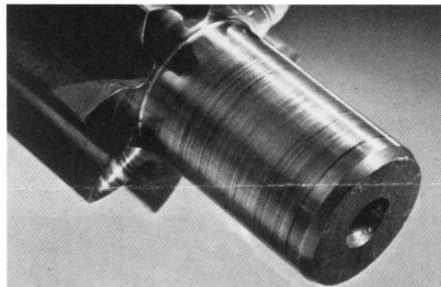
A pressure plate will have many circular scratches if particles of more than 100 microns are present. If exposed to this size particle long enough, the entire surface will be rough and heavily grooved.



Worn housing will have grooves in the gear track, caused by large particles being caught between tips of the gear teeth and body. This usually results from the failure of another component, such as the cylinder or valve.



On the pressure plate, wear is visible only at the rear of the drive gear. This is caused by the drive shaft bottoming out in the machine drive coupling, which puts a heavy thrust load on the drive shaft.



With abrasive wear from metal particles, the shaft's bearing area will have many small grooves. The severity of damage will depend on the amount of contamination in the system and operating pressure.

3. Incorrect installation

Incorrect installation can create external loads on the pump which can result in various types of failures. Piping should be attached to the pump without force. The pump should clear all machine components in all types of operation.

4. Aeration or cavitation

Aeration and cavitation act very much alike in the system. In both cases, oil vapor or air bubbles in the oil cause pump damage. This type of failure is rare, and careful

investigation is required to pinpoint it.

Aeration occurs when air mixes with the oil. Air may enter the system through a small suction leak or by agitation of the surface of the oil in the tank. Surface agitation occurs when return oil is dumped back above the surface of the oil. This can occur due to a high-pressure leak inside the tank or loose or failed lines inside the tank.

Cavitation is the formation and collapse of vapor bubbles in the oil. This is usually the result of restricted pump suction. Cavitation occurs more readily when the oil is hot.

(continued on page 6)

Installing a Replacement Hydraulic Pump

When a hydraulic pump fails, implementing this 13-step installation checklist can help prevent repeat failures.

- ✓ Determine cause of failure.
- ✓ Eliminate cause of failure.
- ✓ Retract all cylinder rods and drain tank.
- ✓ Flush tank. Using diesel fuel under pressure, flush tank thoroughly and wipe with clean cloths.
- ✓ Install new filter elements. (A) Check to make sure filter element is 10 microns or better. (B) If machine does not have filtration, install a 10 micron filter on the return line.
- ✓ Install new pumps.
- ✓ Fill the tank with new oil. (A) Be sure recommended oil is used. (B) NOTE: You're filling the system, not just the oil supply tank. Pump failure due to lack of oil can result if filling is not done correctly. Keep a close check on the oil level as you

complete the following steps.

- ✓ Disconnect all lines to cylinders and/or motors at the cylinder or motor. Be sure all implements are securely blocked and all accumulators are bled before connecting lines.
- ✓ Activate each circuit by moving the control valve handle so lines are flushed with new oil. This flushes the lines and valves from pump to all cylinders and motors. Be sure to check oil level, and add new oil if necessary.
- ✓ Connect lines to blind end of cylinders and all fluid motors. Leave rod end disconnected and with engine at one-fourth throttle, activate circuits slowly until cylinder bottoms out. New oil will be put in the blind end of the cylinder and old dirty oil flushed out the rod end. Do this for all cylinders on the machine.
- ✓ Connect lines to rod end of cylinders. Again, check oil level and add new oil as required.
- ✓ Operate all cylinders and motors

alternately for 30 min. at full throttle.

- ✓ Change filter element, check oil level and add new oil as needed.

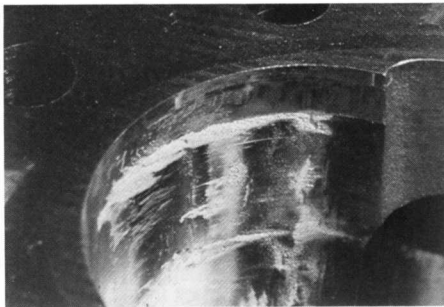
The above procedure, if followed, will allow you to install a new pump with confidence, knowing that you'll get satisfactory pump life. Cutting short these steps can cause premature pump failure; a pump will not run long on a contaminated system.

In nearly all cases, a replacement pump will fail in a shorter time than the pump preceding it unless the system is thoroughly cleaned.

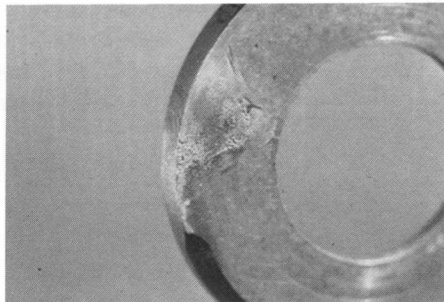
In addition, to ensure good service from your equipment, the hydraulic system must be properly maintained, including frequent oil level checks, daily inspection for leaks, filter element and oil changes at recommended intervals (using correct filters and recommended grade of oil), and finally, practicing good operating techniques.

Aeration and cavitation erode and pit the pressure plates and pump housing. As the air or vapor bubbles in the oil are compressed to pump discharge pressure, they collapse. This collapse is called an implosion. The force of the implosion removes metal from the pressure plates and housing.

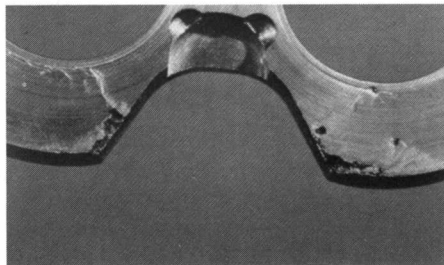
A pump that is either cavitating or operating on aerated fluid is usually noisy, and the system operates in a spongy or jerky manner.



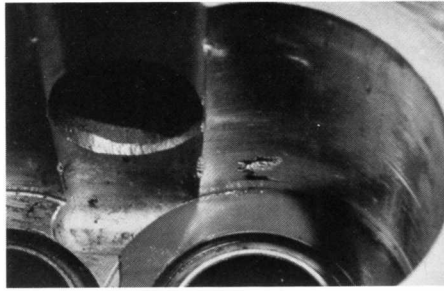
Erosion is evident on the suction side in the gear track. The cause here was due either to air bubbles in the oil or starved suction.



The pressure plate will have an eroded area near the end of the chamfer. Erosion on plates moves at a much slower rate than in the body of the pump.



There will be an eroded area on the pressure plate on the discharge side of the pump. This type of erosion usually appears in conjunction with erosion on the discharge side of the body.

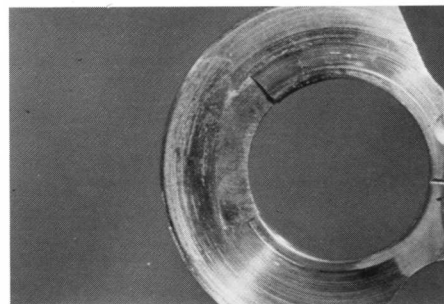


This housing has an eroded area on the discharge side of the pump. Erosion of this area is very unusual, and is usually caused by a leak in the suction line, severe oil foaming or suction line restriction.

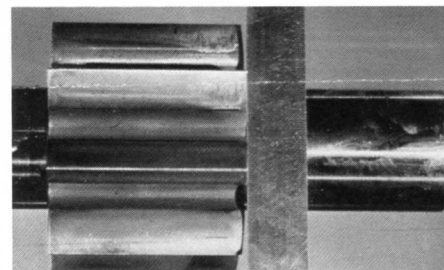
5. Lack of oil

When failure due to lack of oil occurs, deterioration is usually rapid. This type of failure can occur from either of two conditions: (1) oil level is low in reservoir, allowing suction to be uncovered due to sloshing of the oil, or (2) there's an air leak in the suction line.

This type of failure may occur with relatively little damage to the bearings. Bearings may also fail if the pump is allowed to run too long before removal.



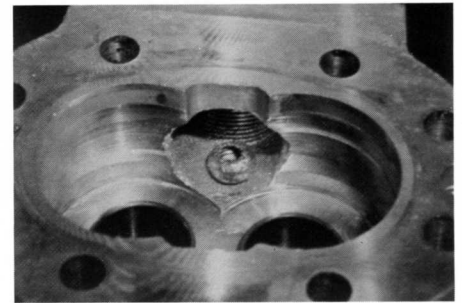
This illustrates wear on the end of the pressure plate. Low oil may allow the suction to be completely uncovered for short periods of time. This can occur during machine operation, even though suction may be well below oil level when machine is not moving.



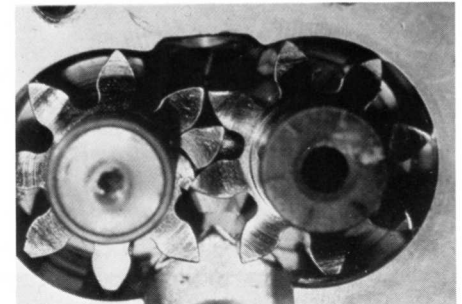
Heavy wear usually occurs on both ends of the gear. Wear is greater near the outside diameter.

6. Damage caused by metal objects

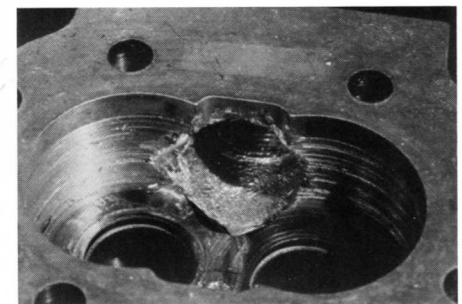
A pump failure due to large-size metal object damage is usually very sudden. It's possible, however, for the pump to completely destroy the metal object and pump it downstream. In either case, the results are easily observed and identified.



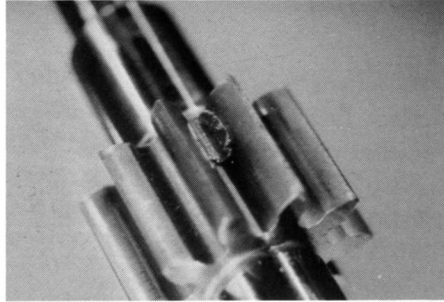
Deep grooves cut into the housing can be caused by any large metal object entering the suction side of the pump.



The broken tooth illustrated here was caused by a metal object caught between the gear teeth.



The object shown in this inlet is a hex nut; foreign objects are generally not found since they are completely destroyed if the pump continues to run.

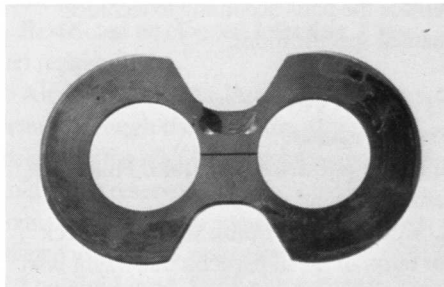


A soft metal object caught in the gear teeth will cause the pump to lock up.

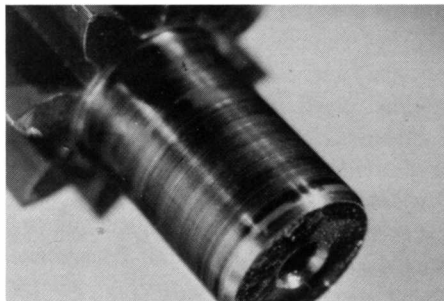
7. Excessive heat

Excessive heat will turn pressure plates and gear black, and harden O-rings and seals. If excessive heat is of short duration, a temperature of more than 300° F is required before damage occurs.

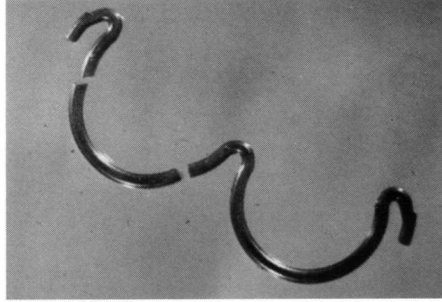
Excessive heat usually results from a sticking valve or a relief valve set too low. If a sticking valve does not return to the neutral position, the pump flow will be dumped continuously. This will overheat the system rapidly. If a relief valve is set too low, part of the oil will be dumped across the relief valve each cycle. In this instance, the machine will be very slow.



Oil temperatures well above 300° F are required to cause this type of plate damage. Overheated parts are not reusable.



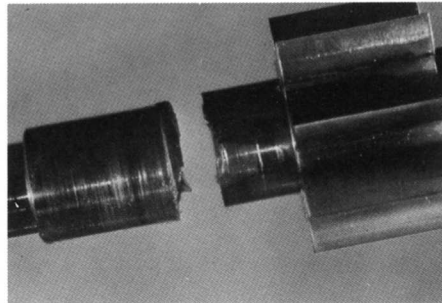
With excessive heat, the shaft and gear will be black all over. The shaft will show some bright streaks, but no real grooves.



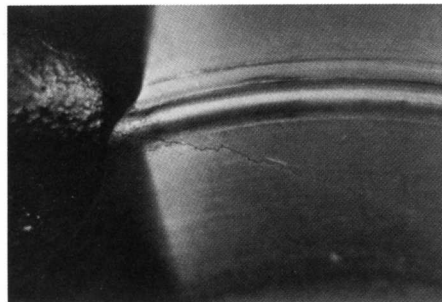
Excessive heat will cause the strip seal to become extremely hard and brittle; it usually snaps like glass.

8. Overpressure

There can be two reasons for overpressure; (1) the relief valve fails to function, which produces one extreme surge and immediate failure, or (2) the relief valve setting is too high, which results in repeated pressure peaks. Damage to the pump look very similar for both types.



This type of shaft break was probably caused by relief valve failure or by repeated surges of excessive pressure.



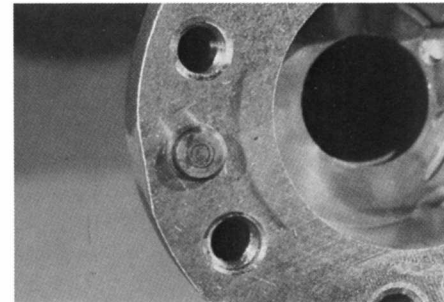
This type of housing failure was probably caused by relief valve malfunction or by repeated surges of excessive pressure.

9. Incorrect assembly

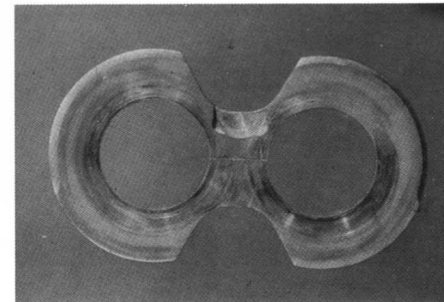
This type of failure is self-explanatory; either the components were faulty, or parts were not assembled correctly.



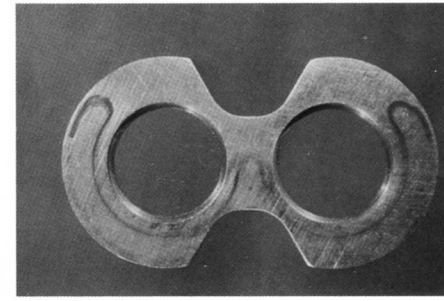
Pinching of the O-ring seal will occur if it's not properly placed in its groove.



If the O-ring is installed incorrectly, the surface of the housing will show a depressed area.

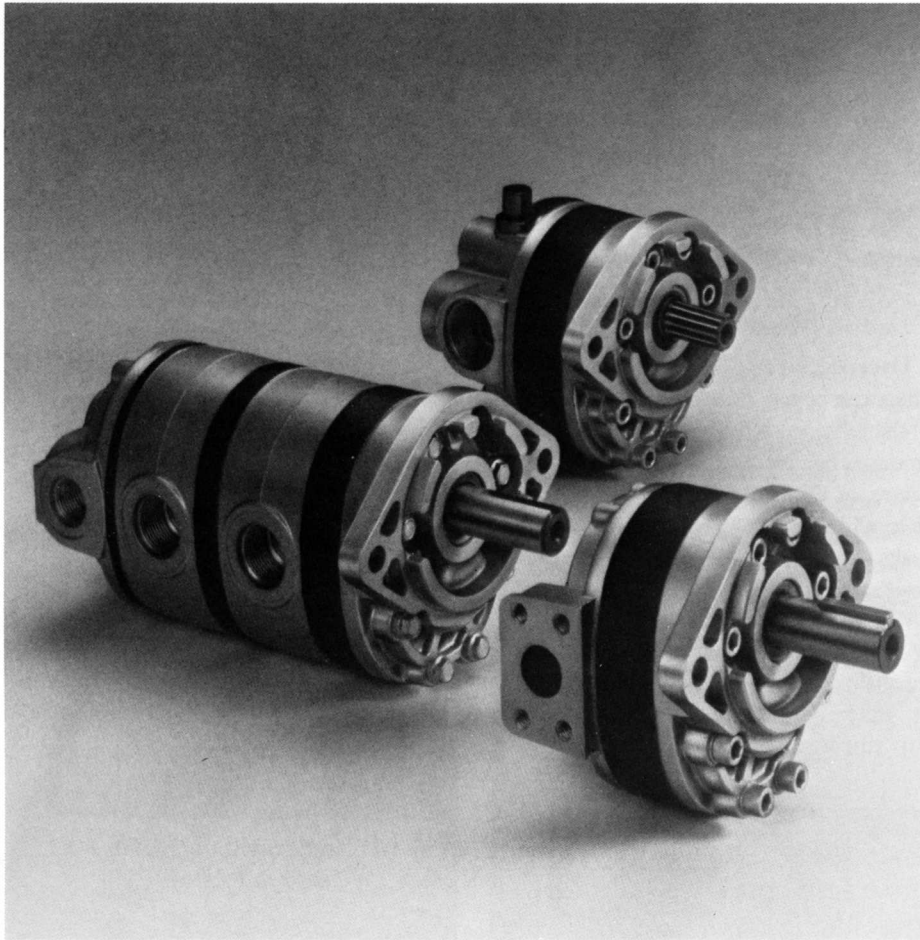


The smeared surface of the bronze side of this pressure plate was probably caused by an isolation plate without radius installed in the bottom of the housing, resulting in insufficient clearance.



The sealing strip usually leaves a faint print on the steel side of the pressure plate; observing the mark makes it possible to determine if the pump was properly assembled.

Troubleshooting Pump Problems



Problem: Pump doesn't deliver fluid

Possible causes:

- 1. Fluid in the reservoir too low.** Refill with the proper grade and type of fluid. Also check for external leaks.
- 2. Pump inlet line plugged.** Remove and clean. Check filters and reservoir for other possible obstructions.
- 3. Air leak in pump inlet line.** Locate and repair leak.
- 4. Pump speed too slow.** Increase speed to within the manufacturer's specifications. If belt-driven, check for proper tension.
- 5. Sludge or dirt in the pump.** Dismantle and clean pump. Clean entire system and fill with clean fluid.
- 6. Fluid viscosity too high.** Check manufacturer's recommendation, and refill with the same.
- 7. Variable-control mechanism out of adjustment.** Adjust according to the machine service manual specifications.
- 8. Broken or worn parts inside the pump.** Analyze the conditions that brought on the failure and correct them. Repair or replace the parts according to technical manual specifications.

Problem: No pressure

Possible causes:

- 1. Pump not delivering fluid.** Follow the remedies mentioned above.
- 2. Vanes in vane pump sticking.** Check for burrs or metal particles that might hold vanes in their slots. Repair or replace if necessary. Clean system if contaminants are found.
- 3. Fluid recirculating back to reservoir and not going to functions.** Mechanical failure of some other part of the system, especially a relief valve. If contamination is involved, clean and refill with proper fluid.
- 4. Pump piston or valve broken, or stuck open to allow fluid to return to inlet side.** Disassemble the pump, determine the cause and correct it. Repair according to technical manual instructions.

Problem: Low or erratic pressure

Possible causes:

- 1. Cold fluid.** Warm up the system. Operate only at recommended operating temperature ranges.
- 2. Wrong fluid viscosity.** Change to manufacturer's recommended grade.
- 3. Air leak or restriction at inlet line.** Repair or clean according to technical manual instructions.
- 4. Pump speed too low.** Increase speed to recommended specifications.
- 5. Internal pump parts are sticking.** Dismantle and repair according to the technical manual. Look for burrs on parts or metal particles in fluid. If contaminants are the cause, thoroughly clean the system and refill with proper grade of fluid.
- 6. Distance between internal parts has increased due to wear.** Dismantle and repair. If wear is abnormal, determine the cause by checking the operation and maintenance records as well as by examining the pump and system.

Problem: Pump too noisy

Possible causes:

- 1. Restricted or clogged inlet line.** Clean and repair.
- 2. Air leaks in intake line, or air is being drawn through the inlet line.** Repair or make sure the inlet line is submerged in fluid in the reservoir. To check for leaks, pour fluid around the joints and listen for a change in sound of operation.
- 3. Low fluid level.** Refill to correct level with proper grade and type of fluid.
- 4. Air in the system.** Check for leaks; bleed air from the system.
- 5. Fluid viscosity too high.** Fill with fluid recommended by the manufacturer.
- 6. Pump speed too fast.** Operate pump within recommended speed.
- 7. Stuck pump part.** Check for solid contaminants in fluid or burrs on parts. If burrs are the cause, repair or replace part according to machine technical manual. If contaminated, thoroughly clean system and refill with proper fluid.
- 8. Worn or broken parts.** Check and correct cause of parts failure; repair or replace as needed.

Problem: Excessive wear

Possible causes:

- 1. Abrasive contaminants or sludge in the fluid.** Check for the cause of contaminants. Install or change fluid filter. Replace or repair worn parts according to service manual specifications. Replace fluid with recommended grade and quality.
- 2. Viscosity of fluid too low or too high.** Replace fluid with proper grade and type.
- 3. Sustained high pressure above maximum pump rating.** Check for possible relief valve malfunction or other parts failures.
- 4. Air leaks or restriction in system causing cavitation.** Eliminate any leaks in the system check parts for degree of wear, and replace if necessary.
- 5. Drive shaft misaligned.** Check and correct according to technical manual specifications.

Problem: Excessive fluid leakage

Possible cause:

- 1. Damaged seals or packings around drive shaft.** Check and replace. Check to be sure that chemicals in fluid are not destroying packing or seals. Follow manufacturer's recommendations on grade and type of fluid.

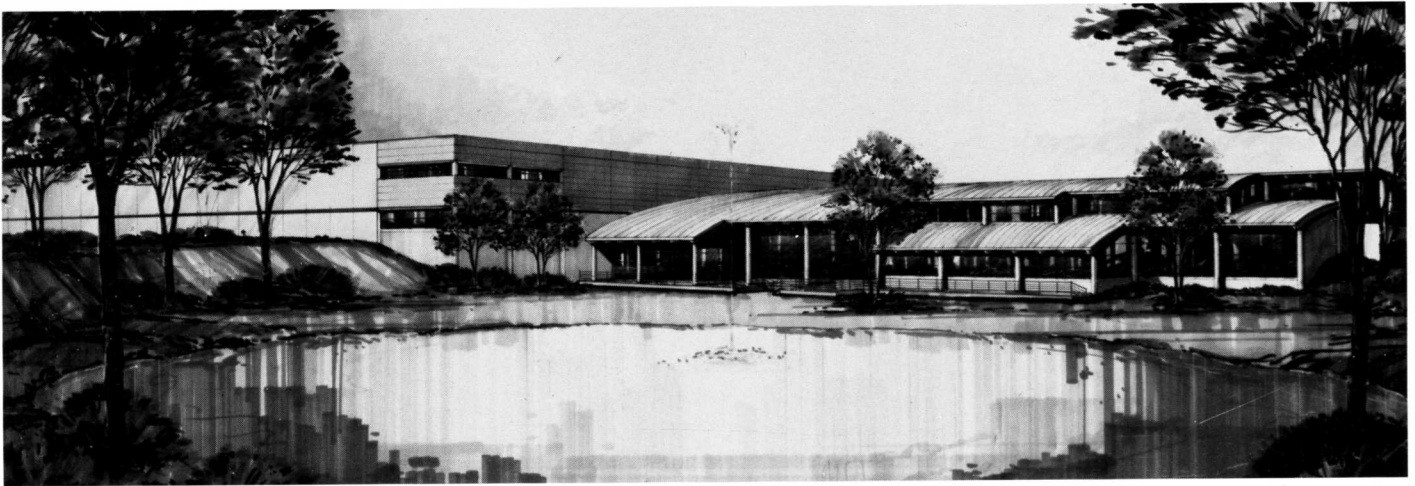
Problem: Internal parts breakage

Possible causes:

- 1. Excessive pressure above maximum limits for pump.** Check for parts malfunction and cause. Repair according to machine technical manual.
- 2. Seizure due to lack of fluid.** Check reservoir fluid level, as well as fluid inlet line for restriction or plugged filter.
- 3. Abrasive contaminants in fluid are getting past the filter.** Again, check reservoir fluid level and inspect the fluid inlet line for restriction or plugged filter.

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