Arab Academy for Science, Technology and Maritime Transport

Industrial Hydraulic Systems Assignment #2

Troubleshooting Problems in Hydraulics

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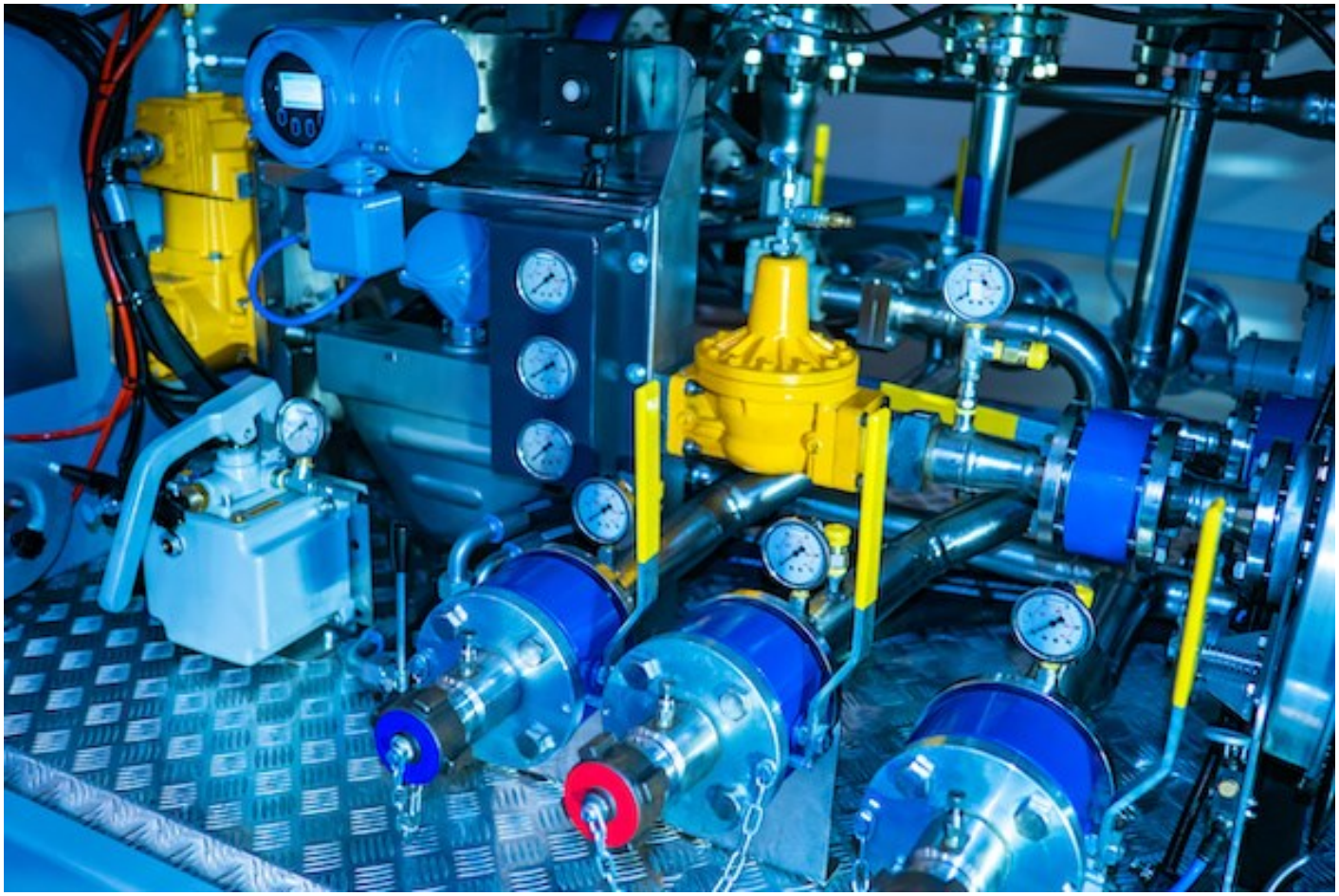

- ## Introduction

Hydraulic systems are widely used in various manufacturing industries. Many of the failures in a hydraulic system show similar symptoms: a gradual or sudden loss of pressure or flow, resulting in loss of power or speed in the cylinders or hydraulic motors. In fact, the cylinders may stall under light loads or may not move at all. Often the loss of power is accompanied by an increase in pump noise, especially as the pump tries to build up pressure.

Any one of the system's components - pump, relief valve, directional valve, or cylinder could be at fault.

By following an organized step-by-step testing procedure, the problem can be traced to a general area, then, if necessary, each component in that area can be tested, repaired or replaced.

Familiarize yourself with the circuitry of the hydraulic system to be tested. Review of the Service Manual is critical to learn the circuitry and location of various components: reservoir, hydraulic pump, relief valve, control valves, cylinders and hydraulic motors. The Service Manual should also provide operating specifications on fluid temperature, relief valve setting and pump delivery at specific RPMs.

- ## Hydraulic System Troubleshooting

Tools to find out most hydraulics problems

When troubleshooting a hydraulic system there are **a few tools which will aid in finding and repairing a problem.**

1. Pressure Gauge; To measure the System Pressure (P.S.I.).

2. Flow Meter; To measure Gallons per Minute (G.P.M.).

3. Temperature Gauge; To measure Heat.

4. Needle Valve; To Load / Restrict the System being tested.

5. And Your Senses;

   A) Seeing; Is that supposed to be **bent**?
   B) Hearing; Is it supposed to be that **loud**?
   C) Smell; Is it supposed to smell **burnt**?
   D) Touch; I can't it's too **hot**

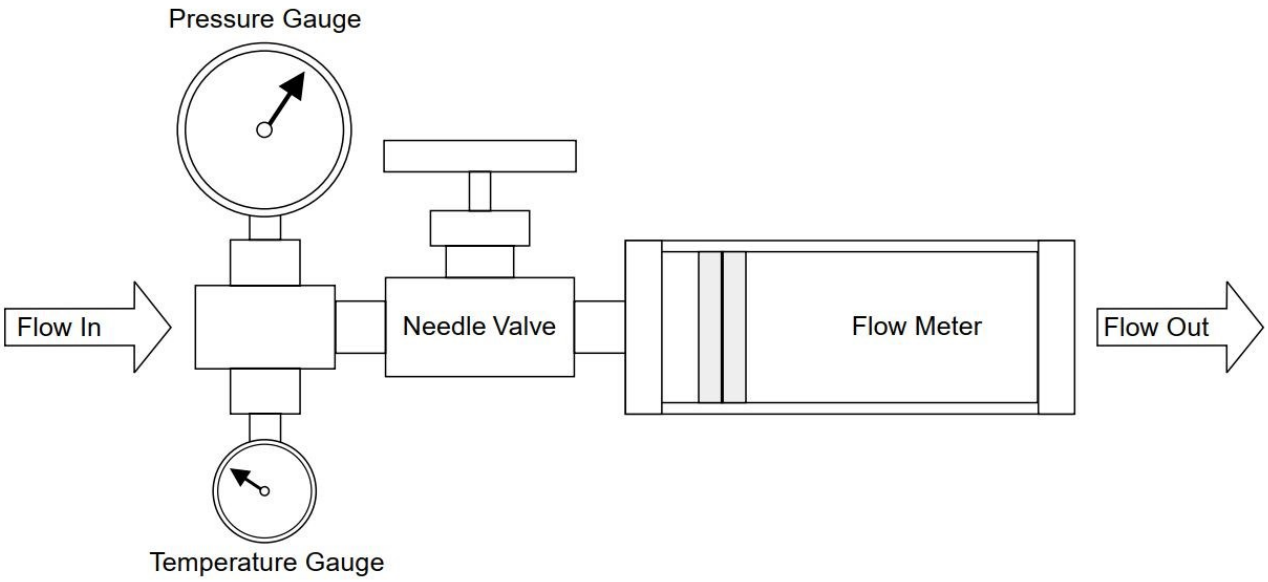

Figure 1 Hydraulic System Analyzer

With items 1, 2, 3, 4, and the necessary fittings and hoses, a Hydraulic System Analyzer can be built and most hydraulic system problems can be diagnosed and repaired.

Make sure the items are sized properly for the system being tested, don't use a 200 PSI Gauge in a 3000 PSI. System or a 5 GPM Flow Meter or Needle Valve in a 50 GPM System. Verify and make sure that all the components are rated at, or exceed the pressures and flows being tested.

A Hydraulic Analyzer can be used to check the following:

1) **Fluid Temperatures**, using the temperature gauge provided. Fluid should be flowing through the analyzer for several minutes to obtain an accurate reading.
2) **Flow rates**, using the flow meter provided. With the needle valve wide open, the monitor will show the rate at minimum pressure loss. The flow rate can be restricted by turning in on the needle valve from wide open to show the flow at various pressure loads.
3) **System or operating pressure**, by referring to the pressure gauge. To prevent possible component damage, always be sure the needle valve on your analyzer is in the wide open position prior to starting system and if possible, have a relief valve between pump and analyzer.

Troubleshooting Heated Fluid:

When analyzing a hydraulic system in which the fluid temperature is higher than normal, it should be kept in mind that hot fluid can produce unusual flow and operating characteristics. A flow monitor with a minimal sensitivity to temperature variation should be used. When fluid gets hot, the viscosity decreases (the fluid gets much thinner). This thinner fluid can pass through much smaller openings or, in other words, more fluid will pass through the same original opening.

When the System Heats Up:

1) Pumps usually slip more fluid through standard clearances. High pressure settings usually cannot be obtained.
2) When the fluid thins down, the parts run closer together and wear faster. Particles of dirt which may not have been a problem with thicker fluid may now be very damaging.
3) Valves, cylinders and actuators will slip more fluid through standard clearances.

Excessive heat in a system will not only cause excessive and faster wear, but the system will seem very sluggish because of the lack of fluid supply and operating pressure.

Knowing the potential of your analyzer, the effects of fluid temperature and pressure drop will always ensure confidence in analyzing and troubleshooting any service problem areas.

Basic Troubleshooting Steps:

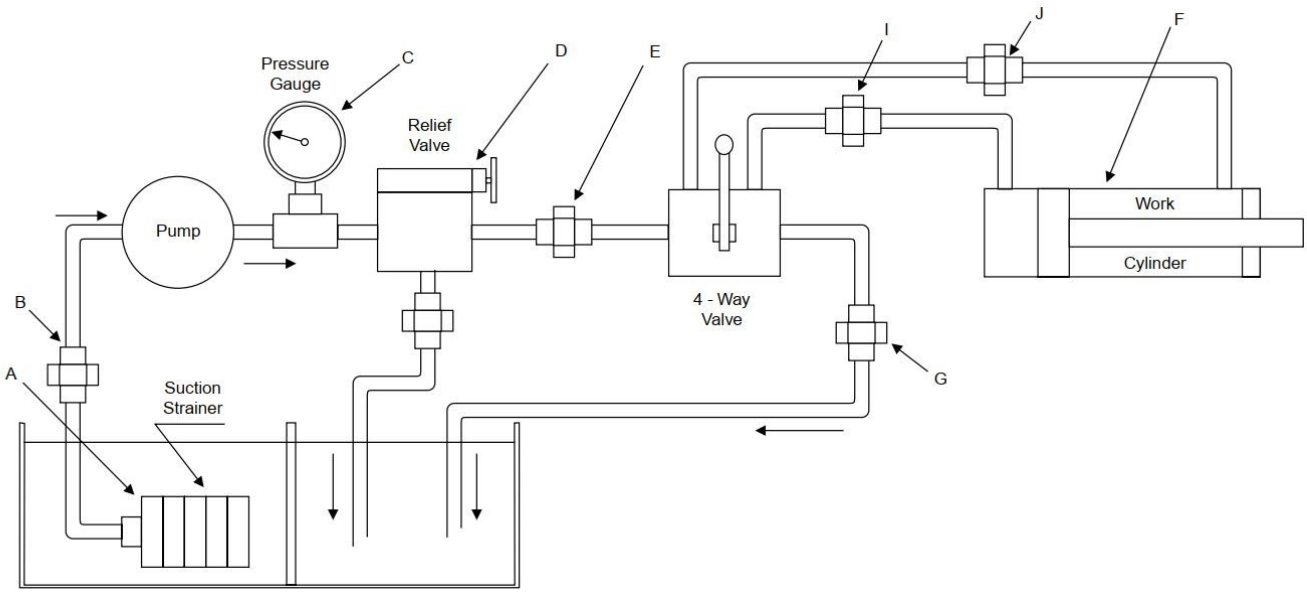

Figure 2 Basic Hydraulic System

Step 1 - Pump Suction Strainer

Probably the field trouble encountered most often is cavitation of the hydraulic pump inlet caused by restriction due to a dirt build-up on the suction strainer. This can happen on a new as well as on an older system. It produces systems such as: increased pump noise, loss of high pressure and / or speed.

If the strainer is not located in the pump suction line it will be found immersed below the oil level in the reservoir, as at Point A. Some operators of hydraulic equipment never give the equipment any attention or maintenance until it fails. Under these conditions, sooner or later, the suction strainer will probably become sufficiently restricted to cause a breakdown of the whole system and damage to the pump.

The suction strainer should be removed for inspection and should be cleaned before reinstallation. Wire mesh strainers can best be cleaned with an air hose, blowing from inside out. They can also be washed in a solvent which is compatible with the reservoir fluid. Kerosene may be used for strainers operating in petroleum-based fluid.

Do not use gasoline or other explosive or flammable solvents. The strainer should be cleaned even though it may not appear to be dirty. Some clogging materials cannot be seen except by close inspection. If there are holes in the mesh or if there is mechanical damage, the strainer should be replaced.

When reinstalling the strainer, inspect all joints, as at Point B for possible air leaks, particularly at union joints.

Step 2 - Pump and Relief Valve

If cleaning the pump suction strainer does not correct the trouble, isolate the pump and relief valve from the rest of the circuit by disconnecting at Point E so that only the pump, relief valve, and pressure gauge remain in the pump circuit. Cap or plug both ends of the plumbing which was disconnected. The pump is now deadheaded into the relief valve. Back out relief valve pressure adjustment. Start the pump and watch for pressure buildup on the gauge while tightening the adjustment on the relief valve. If full pressure can be developed, obviously the pump and relief valve are operating correctly, and the trouble is to be found further down the line. If full pressure cannot be developed in this test, continue with Step 3.

Step 3 - Pump or Relief Valve?

If high pressure cannot be obtained in Step 2 by running the pump against the relief valve, further testing must be conducted to see whether the fault lies in the pump or in the relief valve. Proceed as follows:

If possible, disconnect the reservoir return line from the relief valve. Attach a short length of hose to the relief valve outlet. Hold the open end of this hose over the reservoir filler opening so the rate of oil flow can be observed. Start the pump and run the relief valve adjustment up and down while observing the flow through the hose. If the pump is bad, there will probably be a full stream of oil when relief valve adjustment is backed off, but this flow will diminish or stop as the adjustment is increased. If a flowmeter is available, the flow can be measured and compared with the pump catalog rating.

If a flowmeter is not available, the rate of flow on small pumps can be measured by discharging the hose into a bucket while timing with the sweep hand on a watch. For example, if a volume of 10 gallons is collected in 15 seconds, the pumping rate is 40 GPM, etc.

If the gauge pressure does not rise above a low value, say 100 PSI, and if the volume of flow does not substantially decrease as the relief valve adjustment is tightened, the relief valve is probably at fault, and should be cleaned or replaced as instructed in Step 5.

If the oil flow substantially decreases as the relief valve adjustment is tightened, and if only a low or moderate pressure can be developed; this indicates trouble in the pump. Proceed to Step 4.

Step 4 - Pump

If a full stream of oil is not obtained in Step 3, or if the stream diminishes as the relief valve adjustment is tightened, the pump is probably at fault. Assuming that the suction strainer has already been cleaned and the inlet plumbing has been examined for air leaks, as in Step 1, the oil is slipping across the pumping elements inside the pump. This can mean a worn-out pump, or too high an oil temperature. High slippage in the pump will cause the pump to run considerably hotter than the oil reservoir temperature. In normal operation, with a good pump, the pump case will probably run about 20o F above the reservoir temperature. If greater than this, excess slippage, caused by wear, may be the cause.

Step 5 - Relief Valve

If the test of Step 3 has indicated the trouble to be in the relief valve, the quickest remedy is to replace the valve with another one known to be good. The faulty valve may later be disassembled for inspection and cleaning. Pilot operated relief valves have small orifices which may be blocked with accumulations of dirt. Blow out all passages with an air hose and run a small wire through orifices. Check also for free movement of the spool.

In a relief valve with pipe connections in the body, the spool may bind if pipe fittings are over tightened. If possible, test the spool for bind before unscrewing threaded connections from the body.

Step 6 - Cylinder

If the pump will deliver full pressure when operating across relief valve in Step 2, both pump and relief valve can be considered good, and the trouble is further downstream. The cylinder should be tested first for worn out or defective seals.

Run the cylinder to one end of its stroke. Disconnect the fluid line which was allowing oil to exhaust from the cylinder. Plug or cap the valve side of this disconnected line to avoid oil spillage caused by any back pressure in the tank return line. Attach a hose to the cylinder fitting where the fluid line was disconnected. Place open end of attached hose into a barrel or bucket. Start the pump and activate the valve to continue to stroke the cylinder the same direction. With the cylinder at the end of its stroke, check for any oil flowing from hose into barrel. If flow is excessive the cylinder may need repaired or replaced.

Pistons with metal rings can be expected to have a small amount of leakage across the rings, and even those “leak tight” soft seals may have a small bypass during break in of new seals or after the seals are well worn. After checking, reinstall the lines and run the piston to the opposite end of the barrel and repeat the test. Occasionally a cylinder will leak at one point in its stroke due to a scratch or dent in the barrel. Check suspected positions in mid stroke by installing a positive stop at the suspected position and run the piston rod against it for testing. Once in a great while a piston seal may leak intermittently. This is usually caused by a soft packing or O-ring moving slightly or rolling into different positions on the piston, and is more likely to happen on cylinders of large bore.

Step 7 - Directional Control Valve

If the cylinder has been tested (Step 6) and found to have reasonably tight piston seals, the 4-way valve should be checked next. Although it does not often happen, an excessively worn valve spool can slip enough oil to prevent build-up of maximum pressure. Symptoms of this condition are a loss of cylinder speed together with difficulty in building up to full pressure even with the relief valve adjusted to a high setting. This condition would be more likely to occur with high pressure pumps of low volume output, and would develop gradually over a long period of time.

Other Components

Check other components such as by-pass flow controls, hydraulic motors, etc. Solenoid 4-way valves of the pilot operated type with tandem or open center spools may not have sufficient pilot pressure to shift the spool.

- ## Primary Areas of Trouble Shooting Problems in Hydraulics

System Inoperative:

1. **Insufficient or No fluid in system.**

Refill system with proper grade and type of fluid. Filter new oil being added as recommended. Refill oil reservoir with cylinders in closed position. If refilled while cylinders are extended the reservoir may over flow when or as the cylinders retract. Check for leaks.

2. **Pump is not engaged.**

Is pump shaft turning? Check if PTO (power take off) is engaged. Variable control mechanism out of adjustment. Adjust to machine service manual specifications.

3. **Slipping or broken pump drive.**

Check pump drive mechanism (drive key, flex coupler) for damage. Check for proper alignment or tension.

4. **Pump inlet line plugged.**

Drain oil and replace filter or filter element. Check for clogged oil strainers. Oil lines dirty or collapsed. Check if correct inlet hose is used, inner liner may be collapsed. Never use a pressure type hose as a pump inlet suction hose. Check if supply shut off or gate valve is closed. Check in reservoir for other possible obstructions.

5. **Pump speed too slow.**

Check minimum drive speed. May be too slow to prime pump.

6. **Wrong fluid in system.**

Oil viscosity too heavy for pump to pick up a prime. Drain complete system. Add new fluid of proper viscosity.

7. **Air leaks at intake. Pump not priming.**

Circuit must be tested at inlet connections. At pump intake piping joints, test by pouring oil on joints while listening for a change in sound of operation. Determine where air is being drawn into line connection and tighten. At pump shaft, Test by pouring oil on shaft seal while listening for a change in sound of operation. Follow manufacturer's recommendation when changing seals. Air drawn in through intake pipe opening. Check to be certain suction and return lines are well below oil level in reservoir. Add oil to reservoir if necessary.

8. **Worn or dirty pump.**

Clean, repair or replace. Check alignment. Check for contaminated oil. Drain and flush system.

9. **Pump driven in wrong direction of rotation.**

Most pump assemblies will have an arrow showing correct rotation. On gear type pumps, the pressure port / output will be on the side where the gears come together and mesh. Check to assure correct pump rotation was applied during assembly.

10. **Leakage.**

Check all components, particularly the relief valve for proper settings. Refer to technical manuals.

11. **Broken or badly worn components (pump, valves, cylinders, etc.).**

Examine and test for internal or external leakage. Analyze the conditions that brought on the failure and correct them. Repair or replace the faulty components according to technical manual specifications.

12. **Excessive load.**

Check unit specifications for load limits.

System Develops No Pressure:

1. **Pump not delivering fluid.**

Follow the remedies mentioned above.

2. **Incorrect valve position or setting.**

Check and engage valve. Install pressure gauge and adjust to correct pressure.

3. **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.

4. **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.

5. **Piston pump or valve broken, or stuck open**

allowing fluid to return to inlet side. Disassemble the pump, determine the cause and correct it. Repair according to technical manual instructions.

System Operates Erratically:

1. **Air in system.**

Check suction side for leaks. Repair.

2. **Cold oil.**

Allow ample warm-up period. Operate only at recommended operating temperature ranges.

3. **Wrong fluid viscosity.**

Oil viscosity too heavy. Drain complete system. Add new fluid of proper viscosity.

4. **Pump speed too slow.**

Increase engine speed. Check manual for recommendations.

5. **Dirty or damaged components.**

Clean or repair as necessary.

6. **Restriction in filters or lines.**

Clean and/or replace elements or lines.

7. **Internal pump parts are sticking.**

Dismantle and repair according to technical manual instructions. Look for burrs on parts or metal particles in fluid. If contaminants are the cause, clean and refill with

proper fluid.

8. **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.

System Operates Slowly:

1. **Oil viscosity too high, cold oil.**

Allow oil to warm up before operating machine.

2. **Low pump drive speed.**

Increase engine speed (check manual for recommendations). If clutch or belt-driven, check for proper tension.

3. **Low oil level.**

Check reservoir and add oil as necessary.

4. **Air in system.**

Check suction side for leaks. repair.

5. **Badly worn pump, valves, cylinders, etc.**

Repair or replace as needed.

6. **Restriction in filters or lines.**

Clean and/or replace elements or lines.

7. **Improper adjustments.**

Check orifices, relief, unloading, flow control valves, etc. Adjust per manual.

8. **Oil leaks.**

Tighten fittings, replace seals or damaged lines.

System Operates Too Fast:

1. **Wrong size or incorrectly adjusted restrictor or flow control.**

Replace or adjust as necessary.

2. **Engine running too fast.**

Reduce engine speed.

Overheating of Oil in System:

1. **Oil passing thru relief valve for excessive time.**

Return control valve to neutral when not in use. System stalling under load, etc. Fluid viscosity too high.

2. **Relief or unloading valve set too high.**

Install pressure gauge and adjust to correct pressure.

3. **Incorrect oil, low oil, dirty oil.**

Use recommended oil, fill reservoir, clean oil, replace filter element.

4. **Engine running too fast.**

Reduce engine speed.

5. **Excessive component internal leakage.**

Check stall leakage past pump, valve, motor, cylinder or other components. Repair or replace component as necessary.

6. **Restriction in filters or lines.**

Check if line I.D.’s is too small causing high velocity. Check if valving too small, causing high velocity. Clean and/or replace elements or lines.

7. **Malfunctioning oil cooler / heat exchanger.**

Check if water is shut off, if water cooled. Check for clogging. Clean repair.

8. **Insufficient heat radiation.**

Check for proper air circulation around reservoir. Ambient temperature too high for system design. Clean dirt and mud from reservoir and components.

9. **Reservoir sized too small.**

Increase reservoir size. Add oil cooler or heat exchanger.

10. **Reservoir assembled without or insufficient**

baffling. Add baffling to allow fluid time to cool.

Foaming of Oil:

1. **Incorrect oil, low oil, dirty oil.**

Replace, clean or add as needed.

2. **Air leaks.**

Check suction line and component seals for suction leaks. Repair or replace.

3. **Return of tank line not below fluid level.**

Repair or replace.

4. **Inadequate baffles in reservoir.**
5. **Lack of anti-foaming additives in oil.**

Replace fluid with proper grade.

Noisy Pump:

1. **Air leak in intake, or air is being drawn through the inlet lines.**

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.

2. **2. Low oil level, incorrect oil, foamy oil.**

Check if oil viscosity too high or operating temperature too low. Replace, clean or add proper grade and type of fluid as needed. With rare exception all return lines should be below fluid level in reservoir.

3. **Pump inlet line or inlet screen is restricted or clogged.**

Clean or replace as needed.

4. **Reservoir breather vent clogged.**

Clean or replace as needed.

5. **Worn or damaged pump.**

Check and correct cause of parts failure. Repair or replace as needed.

6. **Pump speed too fast.**

Operate pump within recommended speed.

7. **Drive coupling mis-aligned.**

Align unit and check condition of seals and bearings. Misalignment will cause wear and subsequent high noise level in operation.

8. **Relief or unloading valve set too high.**

Use reliable gauge to check operating pressure. Relief valve may have been set too high with a damaged pressure gauge. Check unloading devices to see that they are properly controlling the pump delivery.

Excessive Pump Wear:

1. **Abrasive contaminants or sludge in the fluid.**

Check for the cause of contaminants. Replace or repair worn parts according to service manual. Install or change fluid filter. 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 failure.

4. **Air leaks or restriction in system causing cavitation**.

Eliminate any leaks in system.

5. **Drive shaft misaligned.**

Check and correct according to technical manual specifications.

Leaky Pump or Motor:

1. **Damaged or worn shaft seal.**

Check and replace. Check for misalignment. Check that chemicals in fluid are not destroying packing or seals

2. **Loose or damaged parts.**

Tighten or replace.

Internal Pump Parts Breakage:

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. Check for plugged inlet filter or strainer.

3. **Abrasive contaminants in fluid are getting past the filter.**

Check for plugged inlet filter or strainer. Check for malfunctioning filter bypass valve.

4. **Excessive torquing of housing bolts.**

Replace damaged parts. Torque to proper specifications.

Load Drops with Control Valve in Neutral:

1. **Leaking cylinder seals or fittings.**

Replace worn parts.

2. **Control valve not centering when released.**

Check linkage. Check spool for binding.

Control Valve Sticking (Binding):

1. **Valve linkage misaligned.**

Repair.

2. **Tie-bolts too tight (stack valves).**

Loosen and retighten as necessary.

3. **Valve damaged.**

Repair or replace.

Control Valve Leaks:

1. **Tie-bolts too loose (stack valves).**

Tighten as necessary.

2. **Seals damaged or worn.**

Replace.

Relief Valve Noisy:

1. **Relief valve setting too close to operating pressure.**

Install pressure gauge and adjust to correct pressure.

2. **Worn or scored poppet and seat.**

Replace.

3. **Spring in relief valve broken.**

Replace spring and adjust to correct pressure.

- ## Preventing repeat failures:

When a hydraulic system (pump or cylinder or other major component) has a failure, implementing this 13 steps checklist can help prevent repeat failures.

#	Preventive Repeated Failure Activities	Done
1	Determine cause of failure.	
2	Eliminate cause of failure	
3	Retract all cylinders and drain tank	
4	Flush tank. Using diesel fuel under pressure, flush tank thoroughly and wipe with clean cloths.	
5	Install new filter elements	
A	Check to make sure filter is 10 microns or better	
B	If machine does not have filtration, install a 10-micron filter on the return line.	
6	Install new component	
7	Fill the tank with new oil	
A	Be sure recommended oil is used.	
B	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.	
8	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 disconnecting lines.	
9	Activate each circuit by moving 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.	
10	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.	
11	Connect lines to rod end of cylinders. Again, check oil level and add new oil as required.	
12	Operate all cylinders and motors alternately for 30 minutes at normal operating speed.	
13	Change filter element, check oil level and add oil as needed	