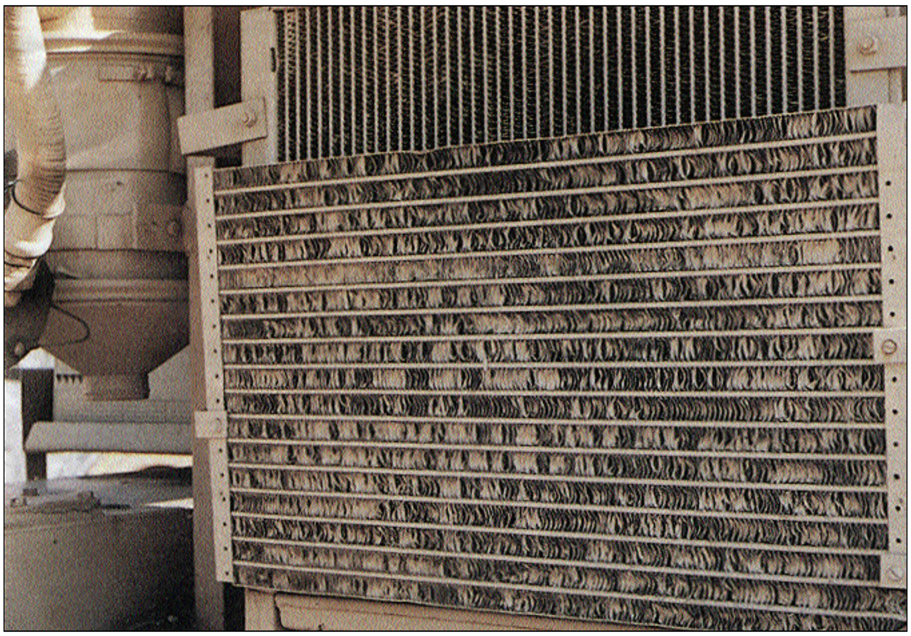
Troubleshooting hydraulic systems

By John A. Koski

Insanity has been defined as doing the same thing over and over again and expecting different results each time. Unfortunately, that definition all too often applies to hydraulic system maintenance practices.

For example, when a pump breaks down, a mechanic replaces it. If it breaks down again in three weeks, the mechanic replaces it again—with little thought given to what might be causing the breakdowns. Much of the time, it is simply assumed that the replacement pump was defective.

Maintaining today's complex hydraulic systems with a parts changer's mentality is both ineffective and costly in terms of lost production and increased parts and labor costs. Effective hydraulic system troubleshooters need to be more than just parts changers. They need to know how to analyze a hydraulic system to get to the root of a problem. Once the root cause is known, it can be repaired or corrected before it causes other problems or repeated damage. Following the guidelines presented here is a starting point.



A damaged oil cooler can cause hydraulic fluid to overheat, damaging system components. Note how the bent fins on this cooler prevent air from flowing freely through the cooler.

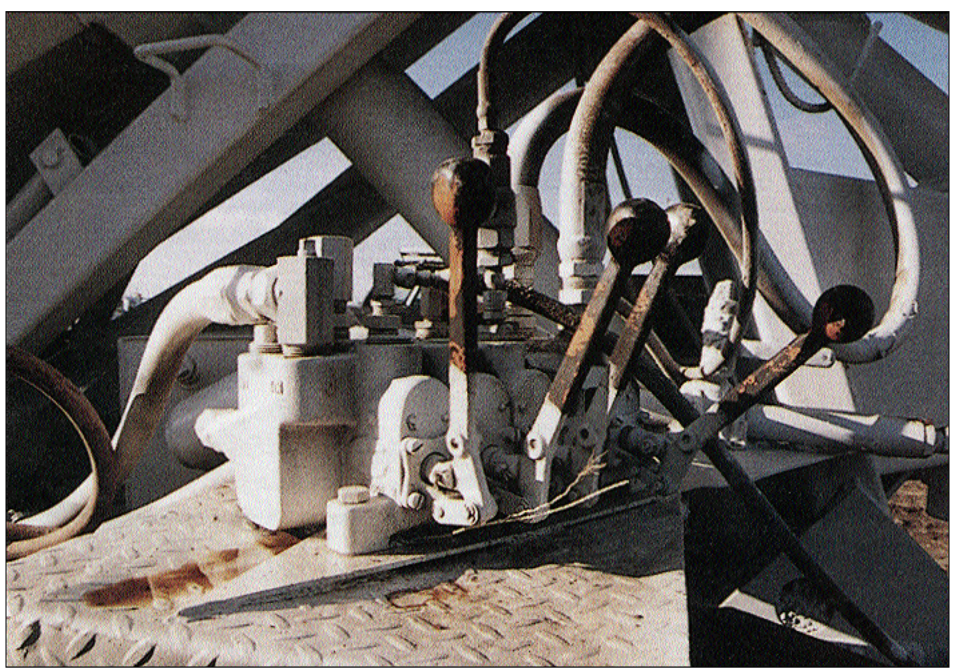
BASIC TROUBLESHOOTING STEPS

Five basic steps to effective hydraulic system troubleshooting are:

1. Identify the problem. Is the entire machine affected or just one function? How long had the system been operating before the problem occurred? Has the problem gotten worse. Is this a recurring problem, or is this the first time it has occurred? What type of environment was the system working in (for example, hot, cold, dusty, or wet)? Was the system speed high, medium, or low?

To help answer these questions, talk to the machine's operator. As you do, remember that one of the major causes of hydraulic problems is incorrect or abusive machine operation.

If possible, have the operator operate the machine so that you can observe the problem for yourself (see the sidebar on troubleshooting hydraulic systems safely). While the system is running look for hot or cold spots in the fluid flow path; listen for any hissing, screeching, or chattering; carefully feel various components for vibration; and look for any unusual pulsation in components and gauges. If necessary, operate the machine yourself. Also, visually inspect the hydraulic system, looking for leaks, crimped or broken lines, bent cylinder rods, blackened oil, and similar indicators of trouble.



Overheating can be caused by operators who keep pressure on control levers while the hydraulic system is at rest. To avoid problems caused by overheating, instruct operators to keep their hands away from control levers when they are not actually using them.

2. Establish background information. Check with other operators and examine maintenance records for similar, previous problems. Review system schematics and technical manuals for potential causes.

3. Review all data. Carefully examine the information you have collected. Then, list all probable causes. Lastly, arrange the list according to what you think are the most likely causes of the problem.

4. Reorder the list. At the top of the list, place those problems that require the least time to test or repair. Look for the cause of the problem by going through the list in order until the problem is located.

5. Repair the system. Once the problem is located and repaired, keep a written record of what was done. This record should include a summary of the problem, how the problem was located, a list of parts repaired or replaced, and should answer the question, "Why did this problem occur at this particular time?" For example, if the problem was caused by pump failure, determine why the pump failed: Was the wrong pump installed, was the pump installed incorrectly, or was the pump defective?

TROUBLESHOOTING EQUIPMENT

Basic hydraulic test equipment includes a metal ruler; a watch with a second hand; flow meters; and pressure, temperature, and field viscosity gauges.

A metal ruler and a watch with a second hand are used to determine the drift rate of hydraulic cylinders. For example, on a wheel loader, raise the bucket and place the bucket hoist control lever in the hold position. Then, measure the rate at which the bucket hoist cylinder rod travels into the cylinder. If the drift rate is greater than that recommended by the manufacturer, then there is excessive internal leakage within the system.

Flow meters are used to determine the rate of fluid flow through a hydraulic circuit. Measured in gallons per minute, this information is important to determining if a pump is operating up to specifications. For example, if the pump flow is too low it may indicate internal leakage within the pump or that the pump speed is incorrect.

Pressure gauges are available in both mechanical and electronic models. They are used to determine system pressures. High system pressure can generate excessive heat which can damage system components.

Temperature gauges also come in both mechanical and electronic models. Most inexpensive mechanical models relay on a coil spring that expands or contracts in response to temperature. Although relatively accurate, the response time is longer than that of electronic temperature gauges.

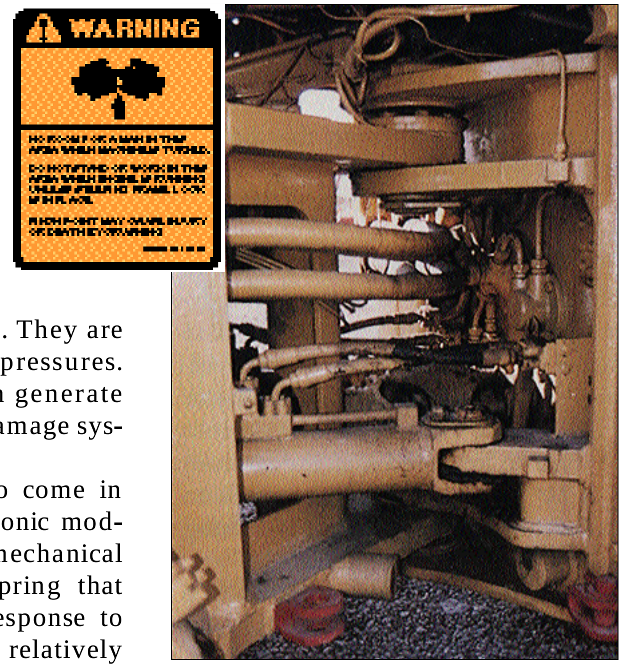
Electronic infrared thermometers, on the other hand, feature almost instantaneous response. The greatest advantage of an infrared thermometer is its ability to take readings without coming in direct contact with system surfaces.

Field viscosity gauges are used to determine the viscosity of an oil sample. The gauges are inexpensive and consist of a plastic cup of known volume with a hole of known diameter in its bottom. The cup is dipped into the fluid to be tested and the amount of time it takes for the sample to drain from the cup is recorded using a watch with a second hand.

This reading is then compared to a chart that accompanies the viscosity cup. The chart indicates the viscosity of the sample based on the time it took the oil to drain from the cup.

Hydraulic fluid with a viscosity that is too high can result in pump cavitation, heat buildup, sluggish operation, and poor efficiency. Low-viscosity fluid can cause pumps to slip, result in internal leakage in cylinders, cause actuators to work sluggishly, and allow heat buildup.

In addition, using the wrong type of hydraulic fluid can cause seals to swell, leak, and wear prematurely. The wrong fluid also may not contain the additives needed to prevent rust and foam.



Out of necessity, hydraulic system components often are placed in areas that are hard to get at. When working on a hydraulic system, such as this one on a wheel loader, always heed warning labels and other cautionary advice.

TESTS WITHOUT EQUIPMENT

Some hydraulic system tests can be completed quickly and accurately without test equipment. One technique, known as "look, feel, and listen," is performed in the operator's seat. For example:

Look at the movement of the boom or bucket as the pilot controller valve is metered. Movement in the opposite direction to which the valve is metered indicates a leak within the cylinder or a faulty balance valve.

Feel for a temperature difference between the oil cooler inlet and outlet lines. If the inlet line does not feel warmer than the outlet line, then the oil cooler bypass valve may be stuck open or the cooler itself may be restricted.

Listen as cylinders are extended, retracted, and then bottomed. Excessive engine rpm drop in one function indicates leakage in that circuit.

A quick method of testing and checking hydraulic fluids without using test instruments involves feeling and looking at the fluid in the reservoir.

Feel the fluid. First, touch the reservoir wall to make certain the fluid is cool. Then, carefully place

TROUBLESHOOTING HYDRAULIC SYSTEMS SAFELY

Hydraulic systems generate heat, fluid pressure, and mechanical movement. Because of this, never assume it is safe to work on the system just because the power has been turned off. Troubleshooting safety guidelines include:

1. Lockout the system. Wherever possible, a lockout lock should be used to prevent accidental starting of the system while it is being worked on. In some cases, such as a wheel loader, it may not be possible to use a lockout lock. In these situations, securely attach a "Do Not Operate" warning tag to the steering wheel and make sure the keys are removed from the ignition. The warning tag should indicate which part of the machine is being worked on, the date, and the name of the person who attached the tag. If other mechanics also are working in the area, make sure they know that you are there and what you are doing.

2. Assume pressure is present. Even in systems where the pump may have been idle for several hours, pressure may be present. Sources of this pressure include charged accumulators, loaded actuators, springs under load, and compressed air.

3. Watch for hot lines and other components. Hydraulic systems run hot. Always touch lines and other components lightly and carefully at first. Use an infrared thermometer in areas where it is difficult to reach. Gloves should be used as necessary.

4. Watch for leaks. High pressure leaks can literally turn into blow torches if they are ignited. Always wear goggles with side shields or a face shield when working on hydraulic systems. Uncontained oil is hazardous. Always clean up leaks and spilled oil without delay.

your thumb and forefinger into the fluid and rub them together. If you can either see or feel any particulate matter, it probably indicates that the system's filters are not working properly. This can be caused by a poor filter change program or inadequate sizing of the filter element.

Look at the fluid. The fluid in the reservoir should be the same color and clarity as new fluid. Dark fluid indicates that excessive heat has been generated somewhere in the system. Overheating also causes hydraulic fluid to smell burned.

Milky fluid is caused by water in the system. Water can enter through humidity in the air that passes in and out of the reservoir through the breather cap as the tank level rises and falls during system operation. Water in a hydraulic system can lead to varnish and sludge buildup and cause component malfunctions and fluid deterioration.

Foamy fluid results when air mixes with the hydraulic fluid. The air can come from an air leak on the suction side of a pump or be caused by fluid returning to a reservoir with a low fluid level. Foamy hydraulic fluid can cause pump cavitation.

HOSES AND COUPLINGS

When replacing a hydraulic hose and coupling assembly, it is important to choose a replacement that delivers the same service and pressure as the original assembly. To do this, check the machine's service manual for a description of the hose and coupling, then choose a replacement assembly with equivalent specifications.

When choosing hydraulic hose, be sure that it is the right hose for the job. For example, will the hose be subject to abrasion; exposed to oil, grease, diesel fuel, or temperature extremes; or used in an application where it will undergo repeated flexing?

Measure the old hose carefully. To accurately determine the hose's inside diameter, cut the old hose to obtain a clean, undamaged, cross-section and use an inside caliper or telescoping micrometer to get a reliable measurement.

DIAGNOSING PROBLEMS

Internal leakage in a pump will show up as a loss of speed when operating hydraulic circuits. If internal leakage is suspected, operate the pump at low rpm. This results in a greater percentage loss of flow to circuit components which magnifies the internal pump leakage.

Internal leakage within circuit components often will show up as hot spots. This is caused by the hydraulic oil, under pressure, leaking through a small opening.

Oil delivery problems can be the result of an incorrectly assembled pump, a pump being driven in the wrong direction, failure to prime the pump, or a pump with a broken driveshaft. The causes of no prime include improper start-up, pump inlet restrictions, and a low reservoir oil level.

Overheated system components often are caused by inexperienced operators. For example, excessive heat buildup may be noticed by only one operator. That excessive heat can be the result of the operator constantly feathering the controls.

Overheating also can be caused by an operator who keeps pressure on the control levers while the hydraulic system is at rest. Most hydraulic systems, especially open-centered systems, are not designed to operate in a continuous, partially pressurized situation. Doing so displaces the valve enough to raise the pressure felt by the hydraulic pump, which leads to overheating. To avoid the problem, instruct operators to keep their hands away from the control levers when they are using the bucket, boom, or other attachment.

Open-centered systems also may become overheated if the hydraulic system is not used periodically. This is caused by the oil circulating in a hot loop from the pump through the relief valve and back into the reservoir tank. Because the oil never travels to any of the systems components, it gets hot. To avoid the problem, instruct operators to occasionally raise and lower the bucket or boom. Doing so takes some of the hot oil out of the loop and

KEEP IT CLEAN

Dirt is the cause of most hydraulic system problems. To achieve maximum efficiency and productivity, keep hydraulic systems spotlessly clean when working on them. This is especially true with hydrostatic systems where tolerances are much closer and the possibility of damage from contamination much higher. Here are some tips for maintaining cleanliness when working on hydraulic systems:

1. Thoroughly clean the area around the filter cap before removing the cap.
2. Seal all reservoir openings after cleaning the reservoir.
3. Don't use dirty containers to transfer oil from bulk storage to the reservoir.
4. When a hydraulic system is opened, cap or plug all ports to keep dirt and moisture-laden air out. Keep them plugged except when repairing or connecting a component.
5. Examine pipe fittings, hoses, and tubes for scale, nicks, burrs, and dirt. Hoses and tubes should be capped when stored.
6. No welding should be done in areas where hydraulic systems are open.
7. Don't use teflon tape or pipe joint compound on straight threads. Stray bits and pieces of tape and compound can easily plug filters and ports.
8. When assembling individual components, a light coating of clean hydraulic oil aids initial lubrication until the system is fully primed.

allows it to cool in the system's hoses and cylinders.

Other causes of overheating include too many elbows in the system, inadequate oil dwell time in the reservoir, or an oil inlet line that is too close to the suction line.

Cavitation sounds like marbles rolling around in the bottom of a coffee can. Cavitation is caused by air getting into the hydraulic system and being compressed as it passes through the pump. Inside the pump, the highly compressed air bubbles implode. These implosions destroy the pump by removing metal from high-tolerance rotor and housing surfaces. Severe cavitation can destroy a pump in a matter of seonds. Sources of cavitation include turbulent flow in the reservoir that can allow air to mix with hydraulic fluid and air leaks in hoses and components on the pump's suction side.

To check for air in a hydraulic system, allow the system to warm up thoroughly, then take a 100 ml sample of hydraulic fluid in a beaker. Set the beaker aside for 24 hours to allow any air in the sample to dissipate. After 24 hours, if the oil level is down more than 5 ml, the hydraulic system has an aeration problem that needs attention.

One method of locating an air leak is to place a few drops of oil on suction line fittings while the pump is running. If the pump quiets down when oil is placed on a fitting, it indicates the spot of an air leak. As soon as the oil on the fitting has been drawn into the system, the cavitation noise should begin again.

Occasionally, air will be drawn into the system only when its circuits are under load. Because the system only draws air while in operation, finding these air leaks can be difficult and dangerous. One solution is to put foam-type shaving cream on suspect fittings and then operate the machine.

Dirt is the number one enemy of hydraulic systems. Ineffective practices—such as using a rag in place of a lost or misplaced filler cap on this hydraulic reservoir filler spout—allow dirt to enter the system and destroy valuable components.

Later, when the machine has been shut down, any air entry points will stand out where the shaving cream has been drawn into the system.

Pump wear problems most often occur on the inlet side. So look there first if pump problems are suspected. A common inlet-side problem is using high-pressure fittings on inlet lines. Because high-pressure fittings have smaller inside diameters, they may restrict flow.

Dismantling a pump and examining its components also can help pinpoint a problem. For example, if the slipper plates and slipper faces in a piston pump are scored, it can be an indication of particle contamination in the hydraulic fluid. Eroded slipper faces can be caused by water contamination, and if the slippers have rolled edges, it may indicate pump overspeeding.

PUBLICATION #J940805