Fluid Power Design Data Sheet

REVISED SHEET 67 - EVOLUTION DESIGN DATA FILE

TROUBLESHOOTING TIPS FOR CLOSED LOOP HYDROSTATIC SYSTEMS

In this and future issues of these Design Data Sheets, we will present information that we hope will be helpful to a service person in the field who is faced with the problem of finding the cause of a breakdown in the hydraulic system.

In this issue, we will feature service tips on closed loop hydraulic systems using a variable displacement piston pump driving a piston-type hydraulic motor, both units being separate and connected with two high pressure loop lines.

While all major brands operate on similar principles, there may be differences in pressure values and physical arrangements from the units described here. The following information was taken from data sheets of a popular transmission.

The charge pump is separate from the main pump and is located in the rear cover of the main pump. Its purpose is to continually re-circulate cooled and filtered oil into the main loop. It is a fixed displacement pump delivering about 10% of the volume of the main pump.

A small control lever on the pump allows the operator to control volume and direction of oil delivered by the pump, to control direction and speed of the hydraulic motor.

GETTING READY FOR SERVICING

Before going to the job, you should obtain a copy of the factory service manual for the transmission to be serviced. Find location of all gauging ports and determine which components are located in the pump and motor covers.

Equip yourself with pressure gauges and port adapters for connecting the gauges. You will need the usual mechanics tools and may need extra fittings and lengths of high and low pressure hose. The main loop lines may have SAE split flange connectors, and the smaller ports will usually be SAE straight thread type. Be very careful not to screw tapered pipe thread fittings into straight thread ports.

Pressure gauges should include one with 500 PSI range for measuring charge pump pressure and low pressure relief valve setting. Large transmissions may require a 1000 PSI gauge. For measuring loop pressure and for setting the high pressure relief valves a 10,000 PSI gauge may be required.

One important observation will be volume of case drain flow. Measurement is more accurate if a flowmeter is available, but it can be observed by connecting an auxiliary piece of low pressure hose into the case drain of a pump or motor and discharging the flow into the reservoir in such a way that it can be observed. Measure case drain flow separately on pump and motor. Measuring combined flow from both units may not reveal any useful information. Many times the actual rate of flow is not as important as how much it changes as the pump displacement lever is moved or as load is applied to the motor.

MECHANICAL INSPECTION

Before starting tests in the hydraulic system, make a visual inspection of the installation for possible mechanical damage such as broken shafts or couplings, slipping belts, etc. Also very important, see if malfunction occurs in both forward and reverse. If it does, certain troubles can be immediately ruled out such as leaking or sticking high pressurerelief valves, leaking charge pump check valves, etc.

In systems using two pumps or two motors, if two similar units can be switched, this may also help to pinpoint whether the trouble is in a pump or a motor, or it may not be in the hydraulic system at all.

LOSS OF POWER

The malfunction encountered most often is a partial or total loss of power and/or speed in the hydraulic motor. The motor may run when unloaded but will not produce full torque or speed. After making a general inspection, proceed with tests in this order:

1. Measure Charge Pump Pressure. Install a low range gauge in one of the specified ports where this pressure can be measured. These gauging ports will have to be determined from a service drawing of the pump or motor.

On a system that is working correctly, the charge pressure will hold steady, with little fluctuation, while the control lever on the pump is in center neutral. It should remain reasonably constant as the lever is moved into forward or reverse although it will drop momentarily as the lever is shifted. This momentary drop occurs while the oil flows into the power cylinder on the control while the swash plate is being shifted. On full stroke, however, the pressure level may be slightly less than when the lever is in neutral, but this is normal.

The actual pressure of the charge pump is controlled by the setting of the low pressure relief valve (usually contained in the pump rear cover) and will vary according to the brand and model of the transmission. The correct value will have to be determined from the service manual, but will usually be 150 to 200 PSI on smaller transmissions to 500 PSI on very large transmissions.

2. Interpret Charge Pump Action. If there is no charge pressure at any position of the control lever, the charge pump is probably at fault. Suspect a broken drive shaft or coupling to the charge pump. To confirm the diagnosis, remove the charge pump cover and inspect for broken parts.

Complete lack of charge pump pressure could also be the result of spring breakage, damage, or dirt in the low pressure relief valve.

Fluctuating Charge Pump Pressure. If the charge pump pressure is erratic with control lever both in neutral and in the side positions, with pressure level a little lower than expected, this may indicate cavitation of the charge pump either from low oil level in the reservoir, from a collapsed suction hose, or from a dirty intake filter. Check each of these conditions and make any repairs needed.

Charge Pump Pressure Drops When Control Lever Is Shifted. If the charge pump pressure holds fairly steady when the control lever is in neutral, with about the right expected pressure, then falls rapidly as the control lever is moved to a side position, this usually indicates that the charge pump oil is escaping through clearances which open up as the control lever tries to put the pump on stroke.

The most likely fault is a scored valve plate. When this plate becomes scored, oil pressure gets under it and tends to lift it from tight contact with the cam plate. This allows some of the high pressure loop oil together with some of the charge pump oil to escape into the pump case. This diagnosis can be confirmed by watching the volume of case drain flow. A scored valve plate is indicated if the drain flow increases heavily at the same time the charge pump pressure falls. With this condition, the charge pump pressure may fall very low, too low to stroke the pump to more than a small cam angle. The result is that the hydraulic motor cannot develop full speed under high torque conditions. The remedy for this condition is a major pump overhaul.

3. Measure High Pressure. If the charge pump pressure seems to respond normally as the control lever is shifted, perhaps dropping slightly but not drastically, install a high range gauge in one of the gauge ports for the loop lines. Install the gauge in the side of the loop which is malfunctioning.

If system is malfunctioning in both forward and reverse, use either port, and move the control lever in a direction that would normally produce pressure in that port. The motor shaft must be blocked to obtain a maximum pressure reading. On vehicle drive systems block the drive wheels or set the brake, or stall the vehicle against a solid wall.

4. Interpret High Pressure Gauge Readings. On a properly operating system, the pressure in the loop, with the control lever in neutral, will vary with the application. If operating against a non-reactive load, for example if the vehicle brakes are set during the test, the gauge will probably read very little above charge pump pressure level. If the load is reactive, the loop pressure could read any value between charge pressure and near full operating pressure.

However, as the control lever is moved to forward or reverse, the pressure should immediately pick up to the value required by the load. If the vehicle brakes are set, the pressure would immediately pick up to the compensator setting.

No High Pressure Can Be Developed. If there is little or no rise in loop pressure when the control lever is moved out of neutral, one of the high pressure relief valves (usually located in the motor rear cover) may be stuck or damaged.

Since there are two high pressure relief valves, one for each direction of operation, try moving the lever to both forward and reverse. If pressure can be developed in one direction and not in the other, one of the relief valves may be damaged or stuck. If pressure cannot be developed in either direction, the relief valves are probably not at fault.

Suspected relief valves should be removed, the parts inspected and cleaned. Adjustable relief valves, if removed, must be reset by the procedure described in the service manual, usually to about 500 PSI higher than the compensator setting.

Full High Pressure Cannot Be Developed. If only partial pressure is obtained on the high pressure gauge when the control lever is moved out of center, one of the following faults may be present. This is assuming charge pump pressure has been measured and found to be normal when the control lever is shifted to a side position.

a. First consider the possibility that the fault may lie elsewhere than in the hydraulic system. Stripped gears, pins, or keys in a gear box attached to the pump could be the cause. Investigate other mechanical transmission items in the power train before proceeding with these tests:

b. One or both check valves that feed charge pump oil into the loop may be damaged, sticking, or leaking. The physical location of these valves must be determined from the service manual. Usually they can be removed for inspection. Oil from the main pump may be back-flowing into the charge pump circuit and escaping across the low pressure relief valve. This would cavitate the loop. Symptoms of this fault would be fairly normal operation of the hydraulic motor when unloaded, but inability to build up high torque for heavy loads. A system with this fault might also show signs of overheating. If motor will not build up torque in either forward or reverse, this is not a likely fault unless, by coincidence, both check valves started leaking or became damaged. If motor fails to build up torque in only one direction, investigate these valves.

c. Leakage across the loop lines, from high side to low side, could occur across a faulty shuttle valve. Location of this valve must be determined from the service manual.

d. Excessively worn piston shoes may cause excessive leakage of high pressure oil into the case to seriously reduce motor torque. Symptoms would be similar to leaky check valves or shuttle valve. With this fault, performance would be affected in both directions. A major factory overhaul is indicated.

e. The pressure compensator internal parts may be jammed, dirty, or damaged. If parts of the compensator are removed, it must be reset to its original setting by procedure in the service manual.

5. Interpreting Case Drain Flow. Observation of casedrain flow is useful for determining the condition of the cam plate inside the pump or motor (see first paragraph in opposite column). Measure drain flow of pump and motor separately to determine which unit is defective. Total flow from both drains (plus low pressure relief valve discharge if separate) should equal charge pump flow rating unless charge pump is cavitating because its inlet is restricted.

Pump Drain Flow. In a system operating normally, the case drain flow should not exceed the flow given in the pump specifications. If it greatly exceeds specifications, the pump may be badly worn and due for replacement. In a malfuncting system an excessive amount of drain flow, particularly if the flow increases suddenly as the pump control lever is moved out of neutral, usually indicates serious internal damage, either to the swash plate, the valve plate, or the piston shoes. If charge pump operation is normal, and the drain flow increases in a short duration spurt as the control lever is moved out of neutral, this may indicate loop oil leaking into the pump case, usually through bad charge pump check valves.

Motor Drain Flow. A sharply increased flow as the pump control lever is moved out of neutral might indicate a damaged valve plate or badly worn piston shoes in the motor.