CATERPILLAR®

FORM NO. REG00637-01

# Systems Operation Testing & Adjusting

## 141 & 143 Hydraulic Control

| 141 & 143: | D4D: | D4D: |
|---|---|---|
| 54G1-UP | 47H1-UP | 69K1-UP |
| 62G1-UP | 49J1-UP | 74U1-UP |
| 89U1-UP | 59J1-UP | 82J1-UP |
| 97G1-UP | 60J1-UP | 97F1-UP |
| | 65J1-UP | |

## INTRODUCTION

This publication has instructions and procedures for the subject on the front cover. The information, specifications, and illustrations in this publication are on the basis of information that was current at the time this issue was written.

Correct operation, maintenance, test and repair procedures will give this product a long service life. Before starting a test, repair or rebuild job, the serviceman must read the respective sections of the Service Manual, and know all the components he will work on.

Your safety, and the safety of others, is at all times very important. When you see this symbol  or this symbol  in the manual, you must know that caution is needed for the procedure next to it. The symbols are warnings. To work safely, you must understand the job you do. Read all instructions to know what is safe and what is not safe.

It is very important to know the weight of parts. Do not lift heavy parts by hand. Use a hoist. Make sure heavy parts have a good stability on the ground. A sudden fall can cause an accident. When lifting part of a machine, make sure the machine has blocks at front and rear. Never let the machine hang on a hoist, put blocks or stands under the weight.

When using a hoist, follow the recommendation in the manual. Use correct lift tools as shown in illustrations to get the correct balance of the component you lift. This makes your work safer at all times.

40400X3

## SYSTEMS OPERATION



## TESTING AND ADJUSTING

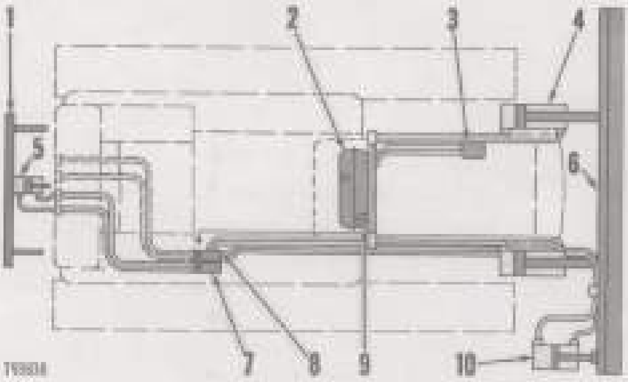


## SPECIFICATIONS

NOTE: For Specifications with illustrations, make reference to HYDRAULIC SPECIFICATIONS FOR 141 & 143 HYDRAULIC CONTROLS, Form No. REG01692. If the Specifications in Form REG01692 are not the same as in the Systems Operation and the Testing and Adjusting, look at the printing date on the back cover of each book. Use the Specifications in the book with the latest date.

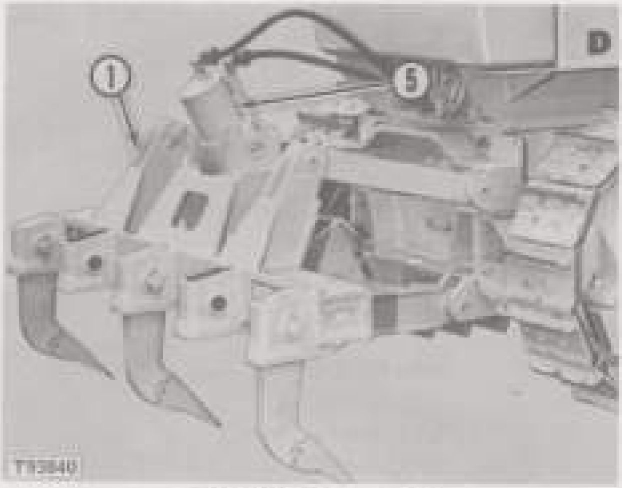
# HYDRAULIC SYSTEM

## INTRODUCTION




COMPONENT LOCATION

1. Ripper. 2. Tank. 3. Pump. 4. Blade lift cylinders (two). 5. Ripper cylinder. 6. Bulldozer blade. 7. External control valve. 8. External control valve. 9. Filter. 10. Tilt cylinder.




COMPONENT LOCATION

1. Ripper. 5. Ripper cylinder.

The hydraulic control may have one, two or three control valves, dependant upon machine equipment.

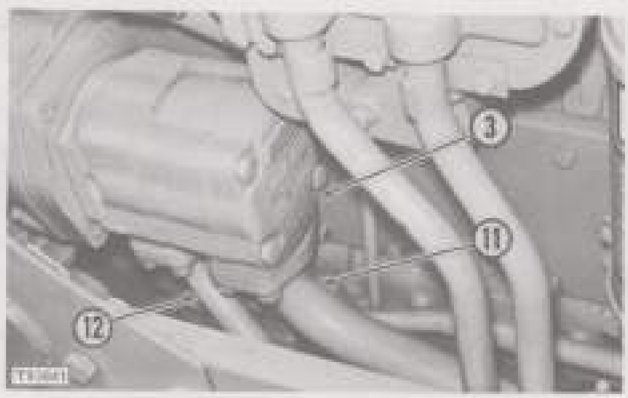
The dash-mounted hydraulic tank contains the filter and one control valve. The control valve consists of a control valve spool, relief valve and makeup valve. This valve controls either the bulldozer lift, tool bar, or rear implement in a one valve system. In a two or three valve system, the tank valve controls either the bulldozer lift or a tool bar. This valve has four positions: RAISE, HOLD, LOWER and FLOAT.

Either one or two additional external valves can be mounted to the right fender. The external valve in a two valve system (the valve nearest the operator in a three valve system) controls either the tilt cylinder, ripper or rear attachment. The outside valve controls either a ripper or a rear attachment in a three valve system. Both external valves have three positions: ROD EXTEND, HOLD and ROD RETRACT. In the two and three valve systems the valves are arranged in series.

Oil for the system is supplied by a single section, insert vane-type pump. The pump is mounted on the left rear side of the timing gear cover and is driven by the engine camshaft gear.


COMPONENT LOCATION

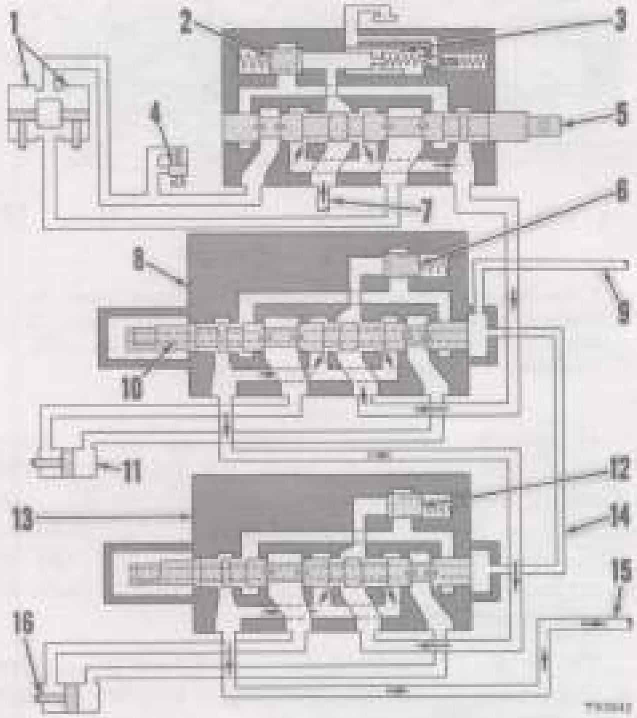
4. Blade lift cylinders (two). 6. Bulldozer blade. 10. Tilt cylinder.




PUMP AND LINES

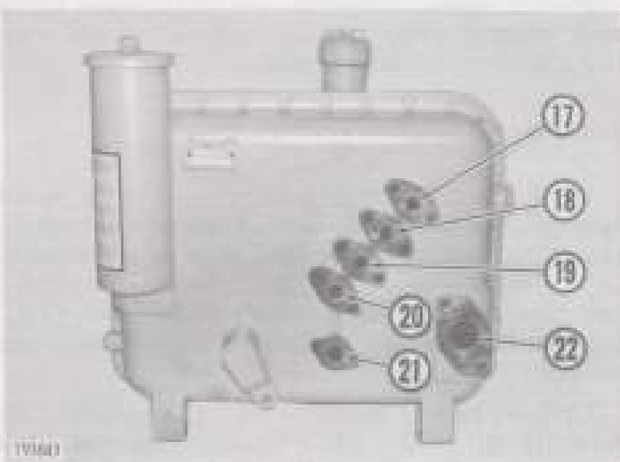
3. Pump. 11. Pump inlet line. 12. Pump outlet line.

## HOLD POSITION OPERATION




SCHEMATIC OF THREE VALVE SYSTEM
(Spools in HOLD position)

1. Cylinders. 2. Check valve. 3. Pilot operated relief valve. 4. Make-up valve. 5. Tank control valve. 6. Check valve. 7. Supply line from pump. 8. External control valve. 9. Drain line (connects to tank). 10. Drain passage (one in each external valve spool). 11. Cylinder. 12. Check valve. 13. External control valve. 14. Drain line. 15. Return line to filter. 16. Cylinder.




FRONT OF TANK

17. Port (connects to head ends of cylinders). 18. Port (connects to outlet side of pump). 19. Port (connects to rod ends of cylinders). 20. Port (connects to port (21) in a one valve system). (Supply port to external valves in a two and three valve system). 21. Port (connected internally to filter). 22. Supply port (connects to inlet side of pump).

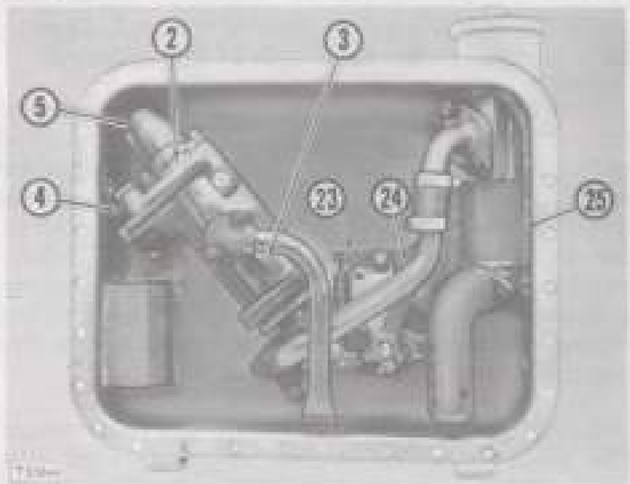
The valve spools are held in HOLD position by centering springs. The oil in the head ends and rod ends of the cylinders is blocked.

The oil flow through a three valve system when the control levers are in HOLD position is as follows:

The pump draws supply oil from the tank. The oil is directed to the control valve in the tank, flows past the valve spool and is directed through the external control valves (if so equipped). The oil then flows through the external control valves, filter and into the tank.

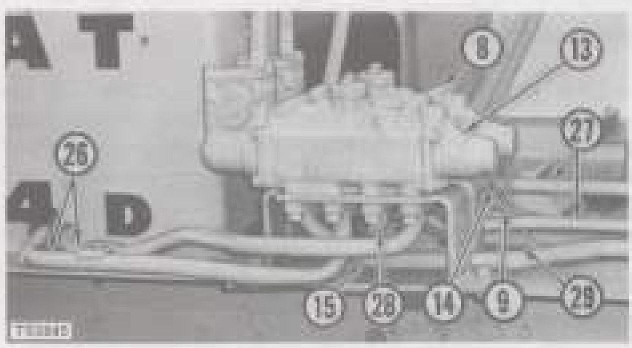
In a one valve system, an external connection on the tank directs the oil flowing through the tank control valve to the filter.

If the filter elements become blocked or the oil becomes extremely viscous due to cold weather, the oil pressure opens a bypass valve located in the filter.




COMPONENT LOCATION

2. Check valve location. 3. Relief valve location. 4. Make-up valve. 5. Tank control valve. 23. Float-lock cam. 24. Filter inlet line. 25. Filter.




LOCATION OF EXTERNAL CONTROL VALVES

8. External control valve. 9. Drain line (connects to tank). 13. External control valve. 14. Drain line. 15. Return line to filter. 26. Lines to rear attachment. 27. Lines to tilt cylinder. 28. Supply line to outside external control valve (13). 29. Supply line to inside external control valve (8).

## TANK CONTROL VALVE

The following describes the operation of the tank control valve when used to operate either the blade lift or tool bar:

When the operator pulls the tank control lever back (RAISE position), the valve spool is moved outward. Pump flow is directed to the check valve. The check valve remains seated until the oil pressure becomes greater than the combined force of the oil in the rod ends of the cylinders and the force of the check valve return spring. This prevents reverse oil flow and resulting cylinder drift. The oil unseats the check valve and pump flow is directed to the rod ends of the cylinders, raising either the blade or tool bar. Oil in the head end of the cylinders is directed to the external control valves (if so equipped) and then passes through the filter.

When the tank control lever is moved forward (LOWER position), the valve spool is moved into the valve body. The oil flow is reversed. Pressure oil is directed to the head ends of the cylinders.

In FLOAT position, the valve spool is moved further into the valve body. The head ends, rod ends, pressure chambers and return chambers within the valve body are open to each other. As the implement follows the contour of the ground, the pistons move in either direction. Oil is furnished to the rod ends or head ends of the cylinders, as required, or the oil can return to the tank. The valve spool is locked in FLOAT position by a cam and roller arrangement within the tank.

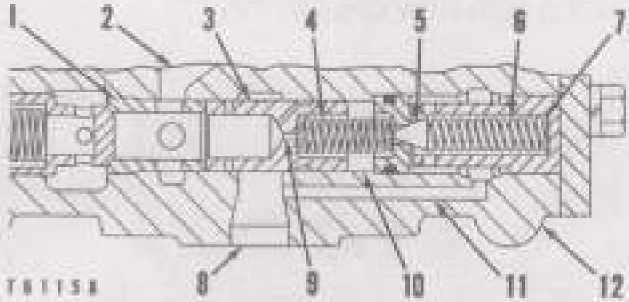
Each blade lift cylinder piston has relief valves. The relief valves are seated by pressure oil. The relief valves open when the piston bottoms in the cylinder, either at extreme lift or lower. This allows the oil on the pressure side of the piston to pass through the piston and be returned to the tank.

### Make-up Valve

The make-up valve housing is mounted to the control valve body and is connected to the head end of the blade lift or tool bar circuits. The make-up valve will unseat and supplement pump flow when the piston rods extend faster than the pump can supply oil to the head ends of the cylinders.

### Pressure Relief Valve

The pressure relief valve is contained within the tank control valve. The relief valve limits the pressure that can be imposed on the pump. It also protects all circuits when they are in operation. The relief valve consists of a spring-loaded dump valve (3) and a spring-loaded pilot valve (5).




PRESSURE RELIEF VALVE

1. Check valve seat. 2. Inlet passage. 3. Dump valve. 4. Dump valve spring. 5. Pilot valve. 6. Pilot valve spring. 7. Shims. 8. Relief valve dump port. 9. Orifice. 10. Chamber. 11. Passage. 12. Control valve body.

If system pressure exceeds the relief valve setting, the pressure unseats the pilot valve (5) allowing oil to flow from the chamber into the tank. This causes a pressure drop in the chamber. The pressure oil forces the dump valve (3) to compress its spring (4), allowing pump flow to return to the tank.

The shims (7) control the force of the pilot valve spring on the pilot valve. Adding or removing shims adjusts the relief valve setting.

## EXTERNAL CONTROL VALVES

The external control valves are used to control the blade tilt, ripper or another rear attachment.

The external control valves are basically the same as the TANK CONTROL VALVE with the following exceptions:

The external control valves do not have FLOAT position. Also, they have neither a make-up valve nor relief valve. However, the relief valve in the tank control protects the external control valve circuits during valve operation.

### Tilt Circuit

When the machine is equipped with a tilt cylinder, an external control valve controls its operation. Pulling the control lever back directs oil to the head end of the tilt cylinder. The rod is extended lowering the left side of the blade (TILT LEFT). Pushing the control lever forward lowers the right side of the blade (TILT RIGHT).

Orifice plates in the tilt cylinder lines restrict the flow of oil to the tilt cylinder. This restriction causes part of the pump flow to bypass to the tank through the relief valve in the tank control valve, when the tilt circuit is operated. This provides a slow, but controlled movement of the blade tilt.

Any oil leakage past the external control valve spools into the cavities at the ends of the spools is returned to the tank by a drain line.

# HYDRAULIC SYSTEM

## INTRODUCTION

When analyzing the hydraulic system, remember that proper oil flow and correct oil pressure are necessary for proper operation. Oil flow is dependent on the pump output which is a function of engine speed. Oil pressure is a result of restriction to the oil flow.

When making a check of the hydraulic system, do the visual checks and measurements first. Then do the operational checks and then the instrumentation checks.

Use the 5S5123 Hydraulic Testing Group, a stop watch, a magnet and an inch (mm) scale for basic test of the hydraulic system.

The analysis of a system malfunction will be easier and the conclusion more certain if the following hydraulic system fundamentals are remembered.

When the machine is equipped with one or two external control valves, the circuits are arranged in series. The hydraulic pump and pressure relief valve are common to all circuits. Each circuit has a check valve to prevent cylinder drift during valve spool movement. The control valve in the tank has a make-up valve to supplement pump flow.

⚠ WARNING: When testing and adjusting the hydraulic system, move the machine to a location in dirt, not rock or concrete. Move away from job traffic and away from personnel. Allow only one man on the machine. Keep all other personnel off to one side and in view of the operator.

## VISUAL CHECKS

A visual inspection of the system is the first step when troubleshooting a problem. Perform the following inspections with the engine stopped and equipment lowered to the ground.

1. Make a check of the oil level. Slowly loosen the tank filler cap. If oil comes out the bleed hole when the filler cap is loosened, let the tank pressure bleed off before removing the filler cap.
2. Remove the filter elements and check for foreign material. A magnet will separate ferrous metal material from non-ferrous metal and non-metallic sealing material (piston rings, O-ring seals, etc.)
3. Inspect all lines and connections for damage or leaks.
4. Inspect all lines and all cylinders for external leakage or damage.
5. Inspect the control linkage for bent, damaged or broken components.

## OPERATIONAL CHECKS

The operational check of the system is useful in detecting possible internal leakage, faulty valves or a faulty pump.

**PROBLEM: Noisy pump, erratic cylinder movement and/or excessive oil foaming.**

**PROBABLE CAUSE:**

Air in system:
1. Air leak on inlet side of pump.
2. Worn pump.
3. Improper oil viscosity.
4. Low pressure relief valve setting.

**PROBLEM: Overheating.**

**PROBABLE CAUSE:**
1. Improper oil viscosity.
2. Overloading system.
3. Worn pump.
4. Line restriction.
5. Improper pressure relief valve setting.

**PROBLEM: Pump not delivering sufficient oil.**

**PROBABLE CAUSE:**
1. Low oil level.
2. Oil viscosity too high.
3. Improperly assembled pump.
4. Worn pump.

**PROBLEM: Low oil pressure.**

**PROBABLE CAUSE:**
1. Low pressure relief valve setting.
2. Vanes stuck in pump rotor.
3. Fault control valve.
4. O-ring seal failure in circuit.
5. Improperly assembled pump.

**PROBLEM: Slow Cylinder movement.**

**PROBABLE CAUSE:**
1. Low pump output.
   a. Worn pump.
   b. Improperly assembled pump.
2. Pressure relief valve setting too low.
3. Cylinder piston seal failure.
4. O-ring seal failure in circuit.

**PROBLEM: Excessive blade lift or tool bar cylinder drift.**

**PROBABLE CAUSE:**
1. Worn piston seal rings.
2. Worn valve spool.
3. Make-up valve not seating properly.
4. O-ring seal failure in circuit.
5. Worn valves in lift cylinder pistons (machine equipped with blade lift circuit).

**PROBLEM: Excessive tilt cylinder drift.**

**PROBABLE CAUSE:**

1. Worn piston seal rings.
2. Worn valve spool.
3. O-ring seal failure in circuit.

**PROBLEM: Excessive ripper cylinder drift.**

**PROBABLE CAUSE:**

1. Worn piston seal rings.
2. Worn valve spool.
3. O-ring seal failure in circuit.

### Checking Pump Efficiency

For any pump test, the pump flow, measured in gpm (lit/min) at 100 psi (7.0 kg/cm$^2$) will be larger than the pump flow at 1000 psi (70.3 kg/cm$^2$) at the same rpm.

The difference between the pump flow of two operating pressures is the flow loss.

Method of finding flow loss . . .

| | |
|---|---|
| Pump flow at 100 psi . . . . . . | 57.5 gpm (lit/min)* |
| Pump flow at 1000 psi . . . . . | −52.0 gpm (lit/min)* |
| Flow loss . . . . . . . . . . . . . . | 5.5 gpm (lit/min)* |

Flow loss when expressed as a percent of pump flow is used as a measure of pump performance.

Example of finding percent of flow loss . . .

$$\left(\frac{\text{gpm flow loss}}{\text{Pump flow @ 100 psi}}\right) \times 100 = \text{Percent of flow loss}$$

or $$\left(\frac{*5.5}{*57.5}\right) \times 100 = 9.5\%$$

If the percent of flow loss is more than 10% (15% for bench test of gear pump) pump performance is not good enough.

*Numbers in examples are for illustration and are not values for any specific pump or pump condition. See HYDRAULIC SPECIFICATIONS FOR 141 & 143 HYDRAULIC CONTROLS, Form No. REG01692, for pump flow of a new pump at 100 psi and 1000 psi.

#### Test On The Machine

NOTE: See Tee Test Tooling Chart, Form Number REG00910.

Formula I:

$$\left(\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi}}\right) \times 100 = \text{Percent of flow loss}$$

#### Test On The Bench

If the test bench can not be run at 1000 psi at a high rpm, do the first part of the test with the pump shaft rotation at 1320 rpm. Measure pump flow at 100 psi (7.0 kg/cm$^2$) and at 1000 psi (70.3 kg/cm$^2$). Then in order to measure the pump flow for the last part of the test, see HYDRAULIC SPECIFICATIONS FOR 141 & 143 HYDRAULIC CONTROLS, Form No. REG01692, for: Pump rpm at 100 psi with the engine at 1400 rpm.

Formula II:

$$\left(\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi @ pump rpm}}\right) \times 100 = \text{Percent of flow loss}$$

## HYDRAULIC SYSTEM TEST PROCEDURES

### Lift Circuit Drift Test

TEST NO. 1: Raise the front of the machine off the ground by lowering a level blade. Place the control lever in HOLD position. Stop the engine and observe if the lift cylinder rods retract.

TEST NO. 2: Raise the front of the machine off the ground by lowering a level blade. Stop the engine. Hold the lift control lever in LOWER position. Observe if the lift cylinder rods retract.

| TEST RESULTS | MOST PROBABLE CAUSES |
|---|---|
| Drifting occurs in Test No. 1 | 1. Lift circuit make-up valve (head end) leaking. |
| Drifting occurs in Tests No. 1 and No. 3 | 1. Leakage between pistons and cylinders. Bad piston valves in cylinders. |
| | 2. Leakage between lift circuit control valve spool and body. |
| Drifting occurs in Tests No. 2 and No. 4 | 1. Lift circuit check valve leaking. (Leakage between valve and seat and/or seat and body.) |
| NOTE: Remember that an O-ring seal failure in the circuit will have the same effect as a component failure. | |

TEST NO. 3: Raise the blade off the ground. Place the control lever in HOLD position. Stop the engine and observe if the lift cylinder rods extend.

TEST NO. 4: Raise the blade off the ground. Stop the engine. Hold the lift control lever in RAISE position. Observe if the lift cylinder rods extend.

### Tool Bar Circuit Drift Test

TEST NO. 1: Raise the rear of the machine off the ground by lowering the tool bar. Place the control lever in HOLD position. Stop the engine and observe if the cylinder rods retract.

TEST NO. 2: Raise the rear of the machine off the ground by lowering the tool bar. Stop the engine. Hold the control lever in LOWER position. Observe if the cylinder rods retract.

TEST NO. 3: Raise the tool bar off the ground. Place the control lever in HOLD position. Stop the engine and observe if the cylinder rods extend.

TEST NO. 4: Raise the tool bar off the ground. Stop the engine. Hold the control lever in RAISE position. Observe if the cylinder rods extend.

| TEST RESULTS | MOST PROBABLE CAUSES |
|---|---|
| Drifting occurs in test No. 1 | 1. Make-up valve (head ends) leaking. |
| Drifting occurs in Tests No. 1 and No. 3 | 1. Leakage between pistons and cylinders. 2. Leakage between control valve spool and body. |
| Drifting occurs in Tests No. 2 and No. 4 | 1. Check valve leaking. (Leakage between valve and seat and/or seat and body.) |
| NOTE: Remember that an O-ring seal failure in the circuit will have the same effect as a component failure. | |

### Tilt Circuit Drift Test

TEST NO. 1: Place the blade flat on the ground. Raise the front of the machine off the ground by lowering the right side of the blade (TILT RIGHT). Place the tilt circuit in HOLD position. Stop the engine and observe if the tilt cylinder rod retracts.

TEST NO. 2: Place the blade flat on the ground. Raise the front of the machine off the ground by lowering the right side of the blade (TILT RIGHT). Stop the engine. Move the control lever forward (TILT RIGHT). Observe if the tilt cylinder rod retracts.

TEST NO. 3: Place the blade flat on the ground. Raise the front of the machine off the ground by lowering the left side of the blade (TILT LEFT). Place the tilt circuit in HOLD position. Stop the engine and observe if tilt cylinder rod extends.

TEST NO. 4: Place the blade flat on the ground. Raise the front of the machine off the ground by lowering the left side of the blade (TILT LEFT). Stop the engine. Move the control lever back (TILT LEFT). Observe if tilt cylinder rod extends.

| TEST RESULTS | MOST PROBABLE CAUSES |
|---|---|
| Drifting occurs in Tests No. 1 and No. 3. | 1. Leakage between piston and cylinder. 2. Leakage between tilt circuit valve spool and body. |
| Drifting occurs in Tests No. 2 and No. 4. | 1. Tilt circuit check valve leaking. (Leakage between valve and seat and/or seat and body.) |
| NOTE: Remember that an O-ring seal failure in the circuit will have the same effect as a component failure. | |

### Ripper Circuit Drift Test

TEST NO. 1.: Raise the rear of the machine off the ground by lowering the ripper. Place ripper control lever in HOLD position. Stop the engine and observe if the ripper cylinder rod retracts.

TEST NO. 2: Raise the rear of the machine off the ground by lowering the ripper. Stop the engine. Hold the ripper control lever in LOWER position. Observe if the ripper cylinder rod extends.

TEST NO. 3: Raise the ripper off the ground. Place the control lever in HOLD position. Stop the engine and observe if the ripper cylinder rod extends.

TEST NO. 4: Raise the ripper off the ground. Stop the engine. Hold the ripper control lever in RAISE position. Observe if the ripper cylinder rod extends.

| TEST RESULTS | MOST PROBABLE CAUSES |
|---|---|
| Drifting occurs in Tests No. 1 and No. 3. | 1. Leakage between piston and cylinder. 2. Leakage between ripper circuit valve spool and body. |
| Drifting occurs in Tests No. 2 and No. 4. | 1. Ripper circuit check valve leaking. (Leakage between valve and seat and/or seat and body.) |
| NOTE: Remember that an O-ring seal failure in the circuit will have the same effect as a component failure. | |

## TESTING THE PRESSURE RELIEF VALVE

The pressure relief valve can be tested on the machine with the 5S5123 Hydraulic Testing Group or the control valve can be removed and tested on a hydraulic test bench. The oil must be at normal operating temperature.

The pressure at which the relief valve opens should be checked occasionally and, if necessary, reset to insure correct operating pressure. The tank or control valve need not be disturbed to check the pressure settings.

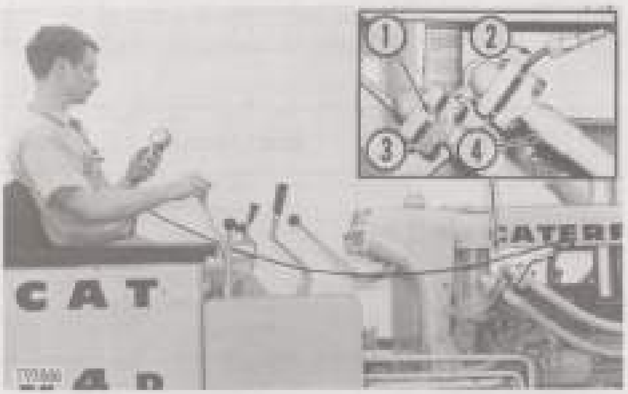
CAUTION: Use only high pressure testing equipment; pressure can be more than 1750 psi (123.0 kg/cm²).

Before installing the test equipment, place the blade flat on the ground. Lower the ripper, if so equipped, to the ground. Stop the engine, move all hydraulic control levers to all positions to relieve pressure in the hydraulic lines. Return the control levers to the HOLD position.

If the machine is equipped with a ripper, tool bar or tilt circuit, the relief valve may be checked in either of these circuits using the correct pressure plate assembly. The covers (1) are not used. Simply bottom the piston in the cylinder to obtain relief valve pressure.

The following procedure describes testing the pressure relief valve when the machine is equipped with a blade lift circuit only.

The covers (1) are used to block the oil in the head ends of the cylinders. The relief valve cannot be checked by bottoming the pistons in the cylinders. The pistons have valves which open the pressure oil to the tank when the pistons are bottomed in either direction.




TESTING PRESSURE RELIEF VALVE

1. 5H4018 Cover and 5F1768 O-ring seal (two each, one on each side). 2. Test Equipment: 5S4648 Hose Assembly, 4M5317 Bushing, 1S8937 Valve, 1S8936 Gauge (0–4000 psi) and a 5S4965 Pressure Plate Assembly. 3. Rod end line. 4. Head end line.

Disconnect the lines (3) (on both sides of tank). Disconnect line (4). Insert covers (1) in the head end lines. Insert test equipment (2) in the rod end line. Tighten all bolts securely.

Start the engine. Pull the lift control lever slowly to RAISE the blade. Hold the control lever in RAISE position and increase the engine speed to HIGH IDLE. The pressure reading on the gauge should be 1725 ± 25 psi (121.3 ± 1.7 kg/cm²). If the pressure is not within this range, stop the engine, remove the tank and disassemble the control valve.

Add or remove the shims located behind the pilot valve spring to obtain the correct pressure setting. Adding shims increases the pressure; removing shims decreases the pressure.

| PRESSURE CHANGE BY REMOVAL OR ADDITION OF ONE SHIM | | |
|---|---|---|
| SHIM | SHIM THICKNESS | CHANGE IN psi |
| 3J7473 | .005 in. (0.127 mm) | 25 psi (1.7 kg/cm²) |
| 3J7470 | .048 in. (1.219 mm) | 235 psi (16.5 kg/cm²) |

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