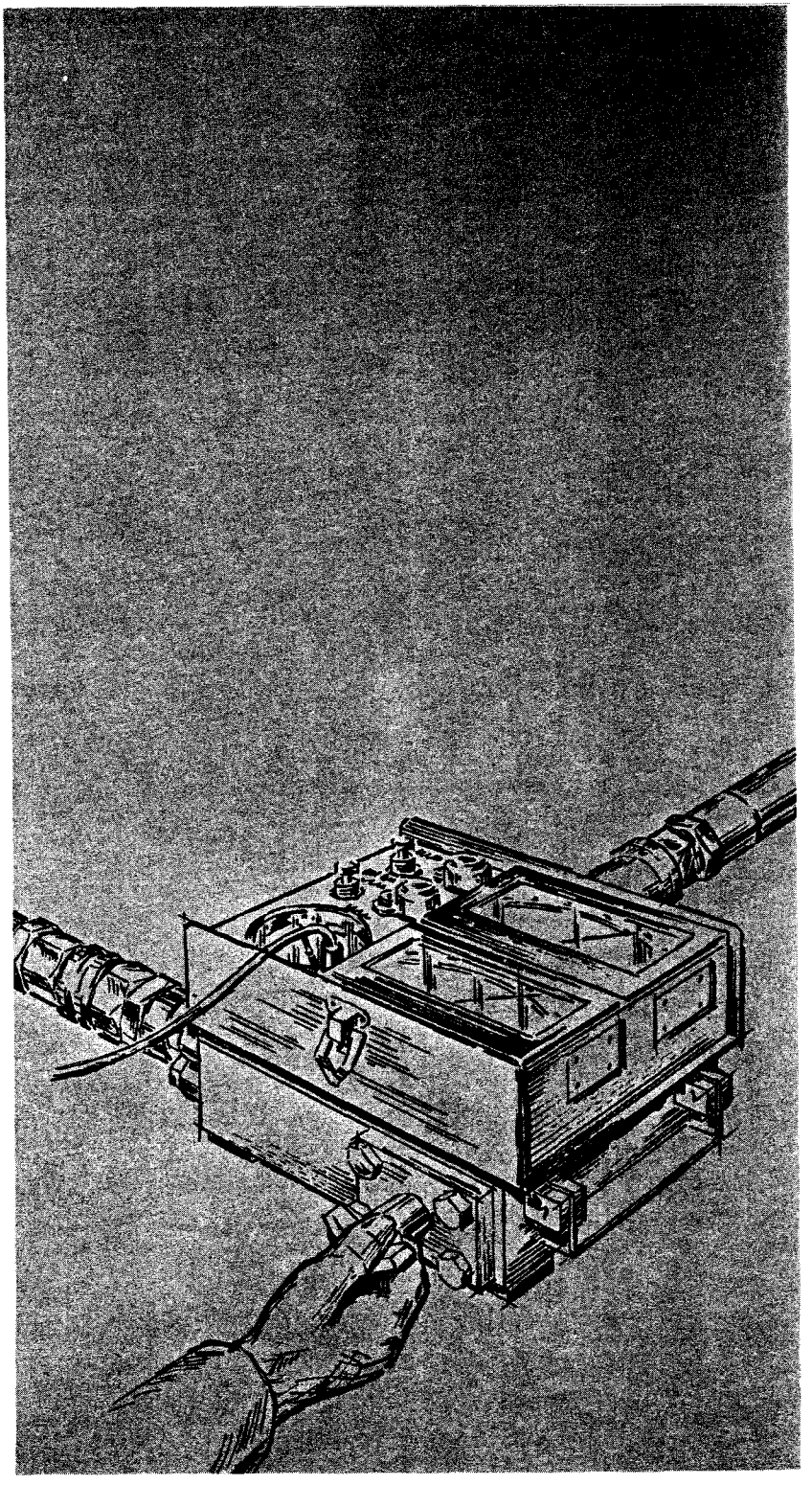

SERVICE MANUAL

FLOW METER TEE TEST PROCEDURE - II

TABLE OF CONTENTS

EQUIPMENT INSTALLATION

With the engine stopped, remove the hydraulic tank cap to relieve any pressure and then tighten. Install an appropriate Filter Cover Assembly, if the machine is not so equipped. Start the engine and raise the bucket approximately 5 ft. above ground, fully dump and lower bucket to rest cutting edge on ground. Stop the engine.

WARNING—Do not install the pump supply line adapter with the engine running.

Remove the tee test plug from the pump supply line and install the pump supply line adapter.

NOTE—Install the adapter as rapidly as possible to minimize oil loss.

Install the return line assembly and connect the flow meter to it and the pump supply line adapter with the proper connecting hose assemblies.

NOTE—Plain coupler will not open valve in pump supply line adapter on return line assembly on smaller machines.

Install the tachometer generator using the proper drive. Run the cable from the generator back to the tachometer (R.R.M.) input jack on the flow meter.

MACHINE WARM-UP

With the manual load valve fully open (counterclockwise), move the lift control lever to LOWER position and increase engine speed to 2000 RPM.

Slowly turn the manual load valve clockwise until the pressure increases to 1000 PSI. Observe the oil temperature. When the oil temperature reaches 100° F, increase the pressure to 1500 PSI (turn manual load valve clockwise). When the oil temperature reaches 160° F, cycle the bucket lift and tilt several times through full cylinder travel. This will warm the oil in the cylinders and lines. Repeat the heating and cylinder cycling as long as necessary to obtain the desired test oil temperature of 150° F throughout the system.

SYSTEM TEST (CHART A)

Record Basic Test Values

NOTE—Hydraulic system conditions must be stable before recording test data. The control levers must be held in exact detent position and not to either side of the detent. Best results are obtained when oil temperature is maintained at 150 ± 5° F.

Test 1—Maximum Pressure Relief Valve Setting

With manual load valve fully open, move lift control lever to LOWER position. Increase engine speed to 2000 RPM. Slowly close manual load valve until oil flow through the flow meter stops (0 GPM). Record the pressure. The maximum pressure relief valve setting should be as specified in the Service Manual.

CAUTION—With pressures greater than 1000 PSI, slowly open manual load valve before releasing control lever to avoid possible damage to pressure gauge.

Test 2—System Oil Temperature

With manual load valve fully open, move lift control lever to LOWER position (Test 2). Record oil temperature.

Test 3—System Base Flow Rate

With manual load valve fully open, move lift control lever to LOWER position. Increase engine speed to 2000 RPM. Check pressure to verify if it is at a minimum value of approximately 100 PSI. Record the oil flow.

The system base flow rate should equal the hydraulic pump's low pressure flow capabilities. Because there should be minimum leakage in the control valves, lines and cylinder packings at 100 PSI, this will serve for calculations of flow differential (flow loss) in Tests 4 through 9.

NOTE—If the System Base Flow Rate (Test 3) is less than the flow rate in Test 4, perform Test 4 first and then Test 3. This condition occurs when the vanes in the pump do not fully extend at low pressure.

Tests 4 through 9—Leakage Rates

These six tests are similar. Each test is performed by moving the control lever to the respective OPERATE position, increasing engine speed to 2000 RPM, adjusting the manual load valve to obtain 1000 PSI pressure, then stabilize the system with these conditions and record the oil flow for each test.

The flow differential for each test (4 through 9) is calculated by subtracting the test's flow rate from the system base flow rate (Test 3). The percent flow loss for each test (4 through 9) is calculated by dividing the tests' flow differential by the system base flow rate, (Test 3).

Test 10—System Oil Temperature

With the manual load valve fully open, move lift control lever to RAISE position. Record oil temperature.

Compare the oil temperatures from Tests 2 and 10. Test 2 should be 150 ± 5° F and Test 10 should be within 10° of Test 2. For each 10° higher deviation, subtract ½ gallon per pump cartridge from the leakage rate. For each 10° lower deviation, add ½ gallon per pump cartridge to the leakage rate.

Is Additional Testing Necessary? If so, Which Circuit(s)?

Compare the recorded test values with those listed on CHART A for the specific machine under test. CHART A data is maximum allowable for peak performance.

Worn or malfunctioning components are located by their flow differential (loss) and percent of flow loss or lower system efficiency. New and reconditioned machines should not exceed the percent of flow loss in the system test shown on CHART A for the specific machine. The flow differential (loss) that can be tolerated is determined by machine application. Decreased system efficiency of a machine on a short operating cycle (loading) is much more critical than that of a machine on a long operating cycle (hauling).

If the flow loss is acceptable, the Tee Test is completed.

If the flow loss is not acceptable in one or more circuits, the additional tests for the pump and the blocked cylinders must be performed.

Trouble Shooting

The following list of problems and probable causes will help locate the worn or malfunctioning components. Not all probable causes apply to every machine.

PROBLEM: Main relief valve setting is more or less than specified in Test 1 and percent flow loss for Tests 4 through 9 is 15%–50%.

PROBABLE CAUSE:

Incorrect main relief valve setting and excessive leakage.

RECOMMENDED ACTION:

Adjust the main relief valve to specified PSI and test for leakage in following problems.

PROBLEM: Percent flow loss for Tests 4 through 9 is 15%–UP.

PROBABLE CAUSE:

A—Bad pump.
B—Relief valve leaking.
C—Failed seals between control valve(s) and tank.
D—Cracked or worn control valve body and valve spools.

RECOMMENDED ACTION:

A—Perform the pump test.
B—If total percent flow loss is not due to a bad pump, problem is in control valves.

PROBLEM: Percent flow loss for Tests 4 and 5 is 15%–UP, but for Tests 6 and 7 is 0–15%.

PROBABLE CAUSE:

A—One or both lift cylinder piston seals leaking.
B—Cracked or worn body and spool in lift circuit.
C—Both lift circuit make-up valves leaking.
D—Failed seals at control valve lift cylinder ports.

RECOMMENDED ACTION:

Conduct blocked cylinders Tests 26, 27 and 28 for the lift circuit. If leakage is still excessive the problem is in the control valve.

PROBLEM: Percent flow loss for Test 4 is 15%–UP, Tests 5, 6 and 7 is 0–15%.

PROBABLE CAUSE:

A—Cracked or worn valve body or spool in lift circuit.
B—Lift circuit rod end make-up valve leaking.
C—Failed seal at lift control valve rod end port.
D—Lift valve spool movement excessive in LOWER position. (Spool travel is past detent position).

RECOMMENDED ACTION:

Problem is in control valve. Inspect this component.

PROBLEM: Percent flow loss for Test 5 is 15%–UP, Tests 4, 6 and 7 is 0–15%.

PROBABLE CAUSE:

A—Cracked or worn valve body or spool in lift circuit.
B—Lift circuit head end make-up valve leaking.
C—Failed seal at lift control valve head end port.
D—Lift valve spool movement excessive in RAISE position. Travel is past detent.

RECOMMENDED ACTION:

Problem is in the control valves. Inspect and repair these components.

PROBLEM: Percent flow loss for Tests 6 and 7 is 15%–UP, for Tests 4 and 5 is 0–15%.

PROBABLE CAUSE:

A—One or both tilt cylinder piston seals leaking.
B—Cracked or worn valve body or spool in tilt circuit.
C—Both tilt circuit make-up valves leaking.
D—Failed seals at control valve tilt cylinder ports.

RECOMMENDED ACTION:

Conduct blocked cylinder Tests 26, 29 and 30. If leakage is still excessive, the problem is in control valve.

PROBLEM: Percent flow loss for Test 6 is 15%–UP; for Tests 4, 5 and 7 is 0–15%.

PROBABLE CAUSE:

A—Cracked or worn valve body or spool in tilt circuit.
B—Tilt circuit head end make-up valve leaking.
C—Failed seal at head end port tilt control valve.
D—Head end tilt relief valve leaking.

RECOMMENDED ACTION:

Perform necessary repairs.

PROBLEM: Percent flow loss for Test 7 is 15%–UP; for Tests 4, 5 and 6 is 0–15%.

PROBABLE CAUSE:

A—Cracked or worn valve body or spool in tilt circuit.
B—Rod end tilt make-up valve leaking.
C—Rod end tilt relief valve leaking.
D—Failed seal at rod end port of tilt control valve.
E—Loose piston rod nut.

RECOMMENDED ACTION:

A—Conduct blocked cylinder Tests 26, 29 and 30. If leakage is still excessive, the problem is in control valve.
B—Perform necessary repairs on valves.

PROBLEM: Percent flow loss for Tests 8 and 9 is 15%–UP; for Tests 4, 5, 6 and 7 is 0–15%.

PROBABLE CAUSE:

A—Leakage in lines between main control valve and auxiliary valve.
B—Cracked or worn valve body or spool in auxiliary circuit.
C—Failed seals at auxiliary valve cylinder ports.
D—One or both auxiliary cylinder pistons leaking.
E—Auxiliary cylinder or circuit relief valve leaking.

RECOMMENDED ACTION:

Conduct blocked cylinder Tests 26, 31, and 32. If leakage is still excessive, the problem is in the control valves.

PROBLEM: Percent flow loss for Test 8 is 15%–UP; for Tests 4, 5, 6, 7 and 9 is 0–15%.

PROBABLE CAUSE:

A—Cracked or worn valve body or spool in auxiliary circuit.
B—Failed seal at rod end port of auxiliary control valve.
C—Auxiliary circuit retract relief valve leaking.

RECOMMENDED ACTION:

Problem is in control valve. Inspect those components and perform necessary repairs.

PROBLEM: Percent flow loss for Test 9 is 15%–UP; for Tests 4, 5, 6, 7 and 8 is 0–15%.

PROBABLE CAUSE:

A—Cracked or worn valve body or spool in auxiliary circuit.
B—Failed seal at head end port of auxiliary control valve.
C—Auxiliary circuit extend relief valve leaking.

RECOMMENDED ACTION:

Problem is in the control valve. Inspect and repair this component.

PUMP TEST (CHART B)

This test is to determine operating efficiency of the system hydraulic pump. By installing a Blocking Plate Assembly in the hydraulic pump pressure line, the pump is isolated from the entire system. All pump flow is through the flow meter only.

WARNING—Because the main relief valve is *NOT* included in the pump test circuit, injury to personnel or damage to the machine can result if excessive pressure is created. Fully open the manual load valve on the flow meter before starting the diesel engine.

Test 14

Fully open the manual load valve, start the diesel engine, slowly increase engine speed to 2000 RPM, slowly close the manual load valve to obtain 100 PSI. Record the oil temperature and GPM flow rate.

Test 15

With engine speed at 2000 RPM, slowly close the load valve to obtain 1000 PSI. Record oil temperature and GPM flow rate.

Test 16

Reduce engine speed to 1000 RPM and open the load valve to obtain 100 PSI. Record oil temperature and GPM flow rate.

Test 17

With engine speed at 1000 RPM, slowly close the load valve to obtain 1000 PSI. Record oil temperature and GPM flow rate. Compare the recorded test values with those in Chart B. Chart B data is maximum allowable for peak performance.

Trouble Shooting

PROBLEM: Percent flow loss for Test 15 $\left(\frac{\text{Test 14 GPM–Test 15 GPM}}{\text{Test 14 GPM}}\right) \times 100$ **is 10%–up; and flow differential for Test 15 (Test 14 GPM - Test 15 GPM) is 0–2 GPM greater than flow differential for Test 17 (Test 16 GPM - Test 17 GPM).**

PROBABLE CAUSE:

Worn pump.

RECOMMENDED ACTION:

If flow loss is determined to be excessive for the machine application, replace the worn pump.

PROBLEM: Percent flow loss for Test 15 $\left(\frac{\text{Test 14 GPM–Test 15 GPM}}{\text{Test 14 GPM}}\right) \times 100$ **is 10%–up; and flow differential for Test 15 (Test 14 GPM - Test 15 GPM) is 2–up GPM greater than flow differential for Test 17 (Test 16 GPM - Test 17 GPM).**

PROBABLE CAUSE:

A—Aerated oil (low oil level, incorrect type of hydraulic oil, air leak in pump suction line, oil leaks in the tank such as failed seals or loose connections).

B—Pump cavitation (restriction in pump suction line, incorrect oil viscosity).

RECOMMENDED ACTION:

Conduct Tests 18 through 25 to determine if cause is aeration or cavitation.

Pump Test for Aeration and Cavitation

Tests 18 through 25

Conduct these eight tests in a similar manner. Fully open the manual load valve before starting the diesel engine. Increase engine speed to 600 RPM. Slowly close the manual load valve to obtain 1000 PSI. Record the GPM and oil temperature.

Then increase the engine speed to 800 RPM (Test 20—1000 RPM, Test 21—1200 RPM, etc.) while keeping the manual load valve adjusted to 1000 PSI. Record the GPM and oil temperature for all Tests 18 through 25.

CAUTION—Immediately after stopping the diesel engine, remove the blocking plate assembly from the pump pressure line to prevent any possible damage later.

PROBLEM: Percent flow loss for Test 15 is 10%–UP and flow differential for Test 15 is more than 2 GPM greater than flow differential for Test 17 and Tests 18 through 25 has equal differential.

PROBABLE CAUSE:

Aerated oil (low oil level, incorrect type of hydraulic oil, air leak in pump suction line from the tank, oil leaks in the tank such as failed seals, loose connections or pump cartridge rotated in pump body).

RECOMMENDED ACTION:

A—Check oil level and inquire about type of hydraulic oil being used.

B—Check pump suction line for air leaking in. (Foam such as shaving cream can be put on all joints, it will be sucked in at any leakage point.)

C—Remove top cover from hydraulic tank and inspect for oil leakage (primarily above the oil level).

D—Disassemble pump and check for proper assembly.

PROBLEM: Flow differential between consecutive Tests 18 through 25 suddenly decreases at one test and the flow rate stays the same for remaining tests at higher engine speed (RPM). Example: 8 GPM differential between Tests 18 & 19, 19 & 20, 20 & 21, but 1 GPM differential between 21 & 22 and flow rate for Tests 23, 24 and 25 are equal to 22.

PROBABLE CAUSE:

Pump cavitation (restriction in pump suction line such as torn hose liner or foreign object).

RECOMMENDED ACTION:

Inspect suction line and tank.

PROBLEM: Percent flow loss for Test 15 is 10%–up, and for Tests 4 through 9 is 15%–up.

PROBABLE CAUSE:

Worn pump and also leakage in control valve and/or cylinders.

RECOMMENDED ACTION:

Conduct blocked cylinder tests to determine leakage rate in control valve and/or cylinders.

PROBLEM: Percent flow loss for Test 15 is 0–10%, and for Tests 4 through 9 is 15%–up.

PROBABLE CAUSE:

Pump is in good condition, but there is leakage in control valve and/or cylinders.

RECOMMENDED ACTION:

Conduct blocked cylinder tests to determine leakage rate in control valve and/or cylinders.

BLOCKED CYLINDER TESTS (CHART C)

The blocked cylinder tests are used *after* the system tests and pump test has indicated unacceptable leakage in the control valves and/or cylinders. Each cylinder line can be blocked with Blocking Plate Assemblies or caps and plugs. For best results, conduct these tests with the oil temperature approximately 150° F (as nearly the same as possible to the System Test and Pump Test oil temperature).

WARNING—Lower all implements to the ground in a stable position and move control lever back-and-forth through OPERATE and HOLD positions to eliminate any pressure oil in the cylinder lines. Personal injury could result from implement movement or oil spray while lines are being loosened to insert the covers.

Test 26

Place all control levers in HOLD position, fully open the manual load valve, and then start the diesel engine. Record oil temperature.

Tests 27 through 32

Conduct these six tests in a similar manner. With manual load valve fully open, move control lever to LOWER position. Slowly close the manual load valve to obtain 1000 PSI, stabilize engine speed at 2000 RPM. Record oil flow rate.

Repeat this procedure for RAISE, DUMP, TILT-BACK, auxiliary circuits' RETRACT and EXTEND control lever positions.

Test 33

Record oil temperature.

Compute the cylinder leakage rate and the control valve leakage rate using your test data from the System Tests, Pump Test and Block Cylinder Tests.

Example: Compute the lift LOWER circuit leakage rates.

Test 15—flow rate of only the pump.

Test 27—flow rate of pump and control valves.

Test 4—flow rate of pump and control valve and cylinders.

The system components being tested in Tests 15 and 27 are the same except for the control valves. Then the difference in flow rates (from the test data for Test 15, subtract the test data for Test 27) must be the leakage due to the control valves in the circuit.

The system components being tested in Tests 27 and 4 are the same except for the cylinders. Then also, the difference in flow rates (from the test data for Test 27, subtract the test data for Test 4) must be the leakage due to the cylinders in the circuit.

Compare the recorded test values with those listed in Chart C for the specific machine under test. Chart C data is maximum allowable for peak performance.

Trouble Shooting

PROBLEM: Tests 27 through 32 indicate leakage in one or more of the cylinders.

PROBABLE CAUSE:

A—Only one of a pair of cylinders in a circuit is leaking.

B—Both cylinders of a pair in a circuit are leaking.

RECOMMENDED ACTION:

Conduct the Right Hand Cylinder Blocked Test.

PROBLEM: Tests 27 through 32 indicates leakage in the control valves.

PROBABLE CAUSE:

A—Maximum pressure relief valve leaking.

B—Blown seals between control valve and tank.

C—Make-up valves in all circuits are leaking.

D—Cracked or worn control valve body and spools.

RECOMMENDED ACTION:

Remove the top from hydraulic tank, drain a portion of the oil until the valve group is exposed. By running the engine at slower speed (low idle to 1000 RPM) and operating the various circuits, the leak should be visible.

PROBLEM: Tests 27 and 28 indicate leakage in LIFT control valve.

PROBABLE CAUSE:

A—Both LIFT circuit make-up valves leaking.

B—Cracked or worn control valve body and spool in LIFT circuit.

C—LIFT circuit check valve leaking.

RECOMMENDED ACTION:

Remove the top cover from hydraulic tank and visually check for leaks.

PROBLEM: Tests 29 and 30 indicate leakage in TILT control valve.

PROBABLE CAUSE:

A—Both TILT circuit make-up valves leaking.

B—Both TILT relief valves leaking.

C—Cracked or worn control valve body and spool in TILT circuit.

D—TILT circuit check valve leaking.

RECOMMENDED ACTION:

Remove the top cover from hydraulic tank and visually check for leaks.

PROBLEM: Tests 31 and 32 indicate leakage in auxiliary control valve.

PROBABLE CAUSE:

A—Line and connections to auxiliary control valve leaking.

B—Cracked or worn control valve body and spool in AUXILIARY circuit.

C—AUXILIARY circuit check valve leaking.

D—AUXILIARY circuit relief valve leaking.

RECOMMENDED ACTION:

Remove the top cover from hydraulic tank and visually check for leaks.

Right Hand Cylinders Blocked

This sequence of tests is used only after the blocked cylinders test has indicated excessive leakage in one or more of the cylinders. For best results, operate all controls through several cycles to warm-up the cylinders to the same temperature as the hydraulic tank oil. It may be necessary to warm-up the complete system to test temperature of 150° F.

Lower all implements to the ground in a stable position and shut off the diesel engine. Move the control levers through OPERATE and HOLD positions to neutralize any oil pressure. Place the control levers in HOLD position. Open the hydraulic tank filler cap to relieve any tank pressure and close the cap. Using the blocking plate assemblies, block rod end of the right lift cylinder, head end of the right tilt cylinder, and the rod end of the right auxiliary cylinder as required.

Test 34

Fully open the manual load valve, start the diesel engine and operate at low idle speed. Move control lever to LOWER position and record oil temperature.

Test 35

With manual load valve fully open, move control lever to LOWER position. Increase engine speed to 2000 RPM, slowly close manual load valve to obtain 1000 PSI, record oil flow rate.

Test 36

Move control lever to TILT BACK position, stabilize the system at 2000 RPM engine speed, and 1000 PSI pressure, record oil flow rate.

Test 37

Move auxiliary circuit control lever to RETRACT position, stabilize the system at 2000 RPM engine speed and 1000 PSI pressure, record oil flow rate.

Test 38

With engine speed at low idle, fully open manual load valve, move control lever to LOWER position and record oil temperature.

WARNING—Because there may be residual pressure in a line, be careful when removing the plate assemblies. Avoid any possible oil spray or bucket movement.

Compute the right hand and left hand cylinder leakage rates using the test data from System Test, and Blocked Cylinders Tests.

Example: Compute the leakage rate for lift cylinders.

Test 27—flow rate of pump and control valves.

Test 35—flow rate of pump, control valves, and left hand cylinder.

Test 4—flow rate of pump, control valves, and both cylinders.

The system components being tested in Tests 27 and 35 are the same except for the left hand cylinder. Then the difference in flow rates (from the test data for Test 27, subtract the test data for Test 35) must be the leakage due to the left hand cylinder.

The system components being tested in Tests 35 and 4 are the same except for the right hand

cylinder. The difference in flow rates (from the test data for Test 35, subtract the test data for Test 4) must be the leakage due to the right hand cylinder.

Compare the recorded test values with those listed in Chart C.

PROBLEM: Leakage is occuring in right hand lift cylinder.

PROBABLE CAUSE:

A—Worn piston seals.

B—Loose piston retaining nut.

C—Scored cylinder assembly.

RECOMMENDED ACTION:

Disassemble and repair right hand lift cylinder.

PROBLEM: Leakage is occurring in left hand lift cylinder.

A—Worn piston seals.

B—Loose piston retaining nut.

C—Scored cylinder assembly.

RECOMMENDED ACTION:

Disassemble and repair left hand lift cylinder.

PROBLEM: Leakage is occurring in right hand tilt cylinder.

PROBABLE CAUSE:

A—Worn piston seals.

B—Loose piston retaining nut.

C—Scored cylinder assembly.

RECOMMENDED ACTION:

Disassemble and repair right hand tilt cylinder.

PROBLEM: Leakage is occurring in left hand tilt cylinder.

PROBABLE CAUSE:

A—Worn piston seals.

B—Loose piston retaining nut.

C—Scored cylinder assembly.

RECOMMENDED ACTION:

Disassemble and repair left hand tilt cylinder.

PROBLEM: Leakage is occurring in right hand auxiliary cylinder.

PROBABLE CAUSE:

A—Worn piston seals.

B—Loose piston retaining nut.

C—Scored cylinder assembly.

RECOMMENDED ACTION:

Disassemble and repair right hand auxiliary cylinder.

PROBLEM: Leakage is occurring in left hand auxiliary cylinder.

PROBABLE CAUSE:

A—Worn piston seals.

B—Loose piston retaining nut.

C—Scored cylinder assembly.

RECOMMENDED ACTION:

Disassembly and repair left hand auxiliary cylinder.

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