Jacobs Vehicle Systems™

Jacobs Engine Brake™

349 Series

TROUBLESHOOTING

Table of Contents

General Information

This manual covers Jacobs Engine Brake Models 349 and 349A. The troubleshooting procedures are the same for both of these models.

How to Use This Manual

"Understand how the system is supposed to work before trying to figure out why it doesn't."

To properly diagnose problems with the Jacobs Engine Brake, it is important to understand the operation of the product and its components.

This manual provides a system overview of both the electrical and hydraulic/mechanical aspects of the brake, in addition to component descriptions. This is followed by some operational tests to help you isolate the problem, troubleshooting sequences and a Final Test to verify correct operation.

If you are unfamiliar with engine brakes, we recommend that you read this manual completely before attempting to troubleshoot. If you have some experience, we suggest that you review the figures and illustrations for any information that may be specific to the models covered here before proceeding to the Testing and Troubleshooting sections.

Service Tools and Parts

Item	Jacobs P/N
Caterpillar Tool Kit	017465
Oil Pressure Test Kit	018280
Slave Piston Removal Tool	018238
Distribution Kit	020736
Trigger Adjusting Group	018196
Feeler Gage 0.018"	003087
Master Piston Holding Wedge	018279
Dowel Pin Extractor	007397
Tune-up Kit, 349 & 349A	019461
Boost pressure gage/attachments	
Mechanics hand tools	
Volt/ohm meter	

Safety Precautions

The following symbols in this manual signal potentially dangerous conditions to the mechanic or equipment. Read this manual carefully. Know when these conditions can exist. Then, take necessary steps to protect personnel as well as equipment.

⚠ WARNING

THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

⚠ CAUTION

THIS SYMBOL REFERS TO POSSIBLE EQUIPMENT DAMAGE.

NOTE:
INDICATES AN OPERATION, PROCEDURE OR INSTRUCTION THAT IS IMPORTANT FOR CORRECT SERVICE.

Fuels, electrical equipment, exhaust gases and moving engine parts present potential hazards that could result in personal injury. Take care when installing an engine brake. Always use correct tools and proper procedures as outlined in this manual.

Section 1: Electrical System

Overview

The engine brake electrical control system is designed to permit engine brake operation under the following conditions:

1. The driver has turned the ON/OFF switch on.
2. No fuel to the engine;
3. Clutch engaged (manual transmission) or torque converter locked (automatic transmission).
4. Engine speed must be above idle on engines equipped with a low speed cutoff, or engines with electronic fuel control.

When all of these conditions are met, there should be voltage to the solenoids.

The system is protected from short circuits by a fuse or circuit breaker.

Electronic Fuel Control (PEEC)

The Programmable Electronic Engine Control (PEEC) is a fuel control system used on Caterpillar 3406B PEEC engines which have engine serial numbers beginning with 8TC, 5YG and 2 EK prefixes. A wiring diagram for these PEEC engines is shown in Fig. 1 for reference.

WIRING DIAGRAM FOR CATERPILLAR 3406B ENGINES WITH PEEC FUEL CONTROL

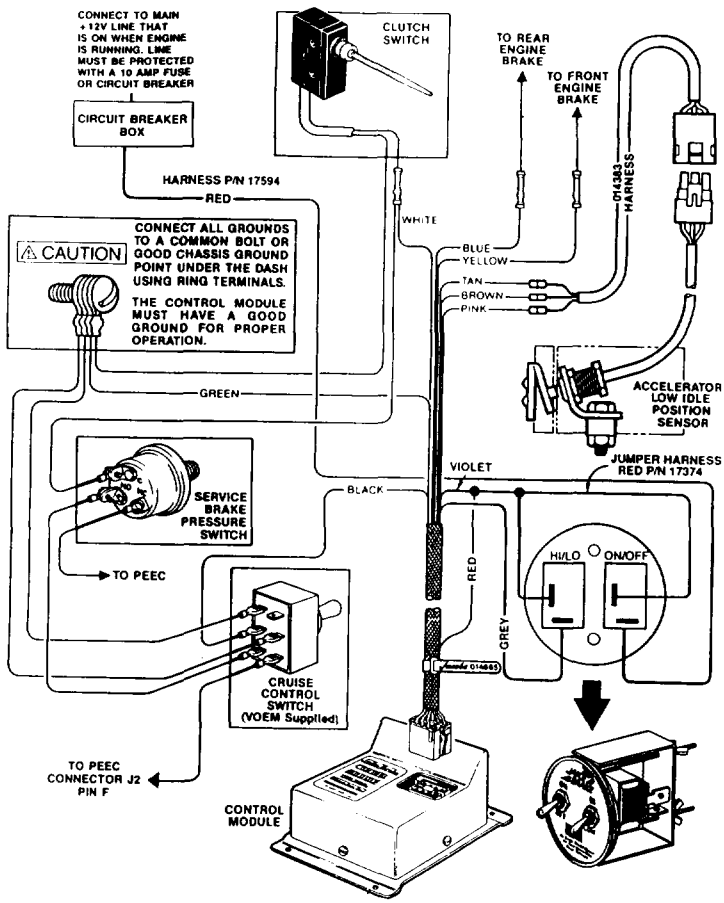


FIG. 1

Electronic Fuel Control (PEEC III)

Engines with the newer PEEC III fuel control system (engine serial numbers beginning with 4CK) use one of two different control groups. One group is used if the vehicle is equipped with an Anti-lock Braking System (ABS), and the other is for vehicles without ABS. The wiring diagrams for these two groups are shown in Fig. 2 for reference. These diagrams, along with the appropriate components, are included in their respective Jacobs PEEC III Retarder Control Groups.

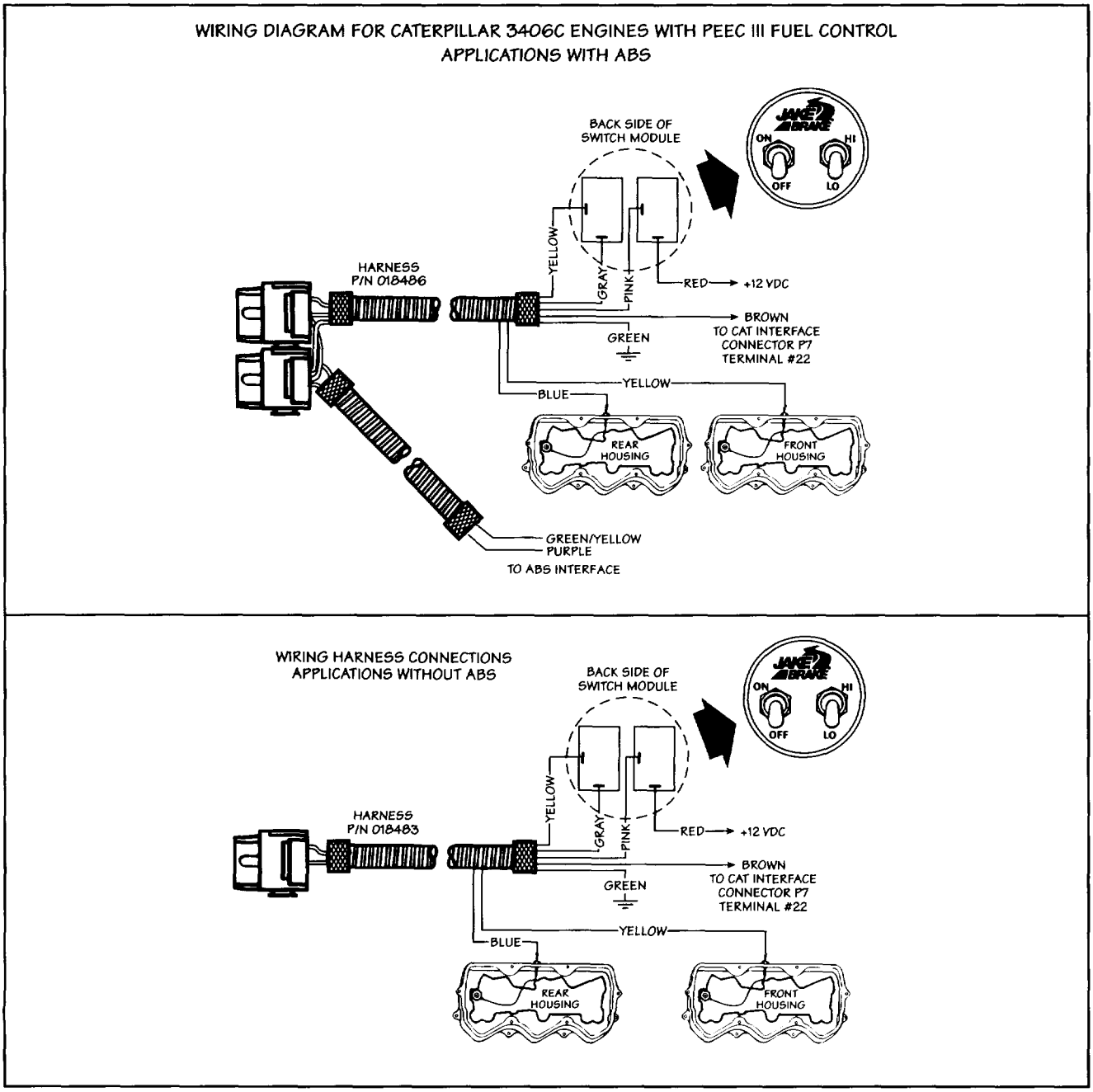


FIG. 2

Mechanical Fuel Control

The electrical control system for mechanical fuel control engines consists of the following:

1. Two dashboard switches, one for system on/off and the other to control the desired level of braking. Low position activates one housing (3 cylinders), and high position activates both housings (6 cylinders).

2. A switch assembly, mounted in the fuel pump. This switch is incorporated to permit engine brake operation only when the engine is in a "no fuel" condition. Diodes installed at the fuel pump switch provide longer service life for all switches. The diodes prevent high voltage surges from the solenoids when the system is shut off.

3. A clutch switch, permitting engine brake operation only when the clutch is engaged. This prevents engine brake operation during gear shifting. In vehicles with automatic transmissions a torque converter pressure switch is substituted.

4. The electrical circuit is protected by a circuit breaker or fuse (10 amp recommended).

5. A solenoid valve (12- or 24-volt), located in the brake housing, is a three-way, electrically activated valve. When activated, the solenoid valve permits engine lube oil to enter the brake housing and when deactivated, provides an exhaust feature for brake shut off. There are 12- and 24-volt solenoid valves available and the control system can be used with either 12- or 24-volt solenoids. Electrical specifications for solenoid valves are listed in section 4 electrical troubleshooting, Fig. 10.

WIRING DIAGRAM FOR CATERPILLAR 3406B/3406C MECHANICAL ENGINES

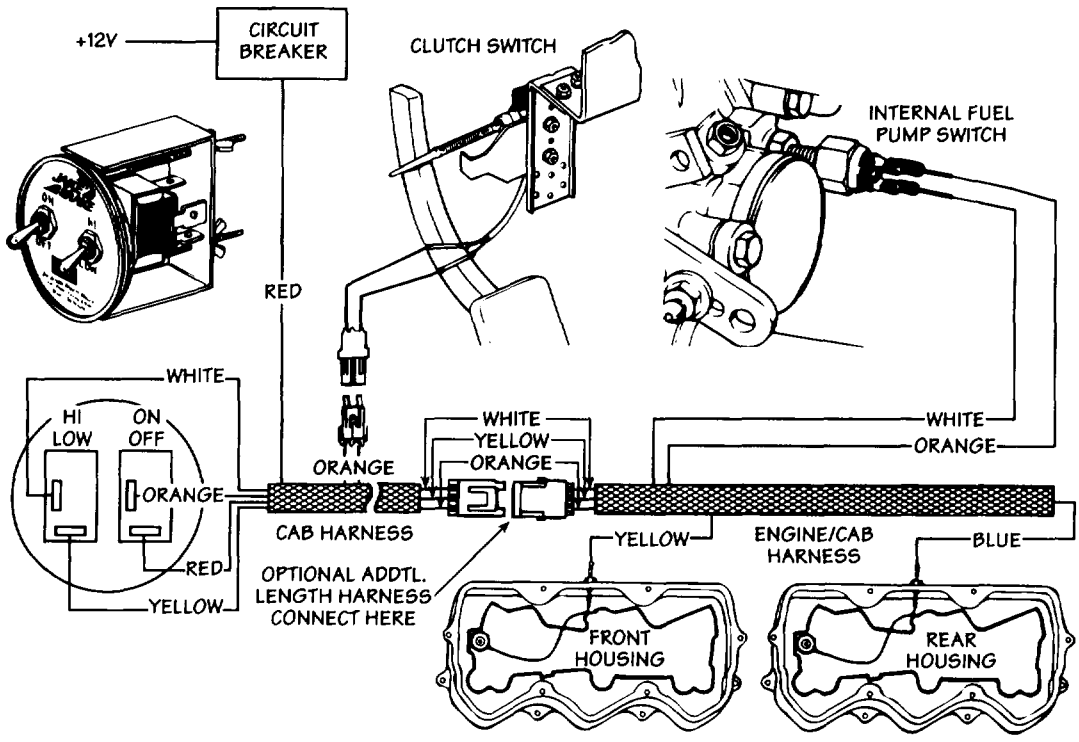


FIG. 3

Mechanical Fuel Control with Optional Low Engine Speed Retarder Cutoff

This control system incorporates an electronic control module in addition to the standard components used on engines with mechanical fuel control. The control module counts flywheel teeth to determine engine RPM, and turns off the retarder as the engine approaches idle speed.

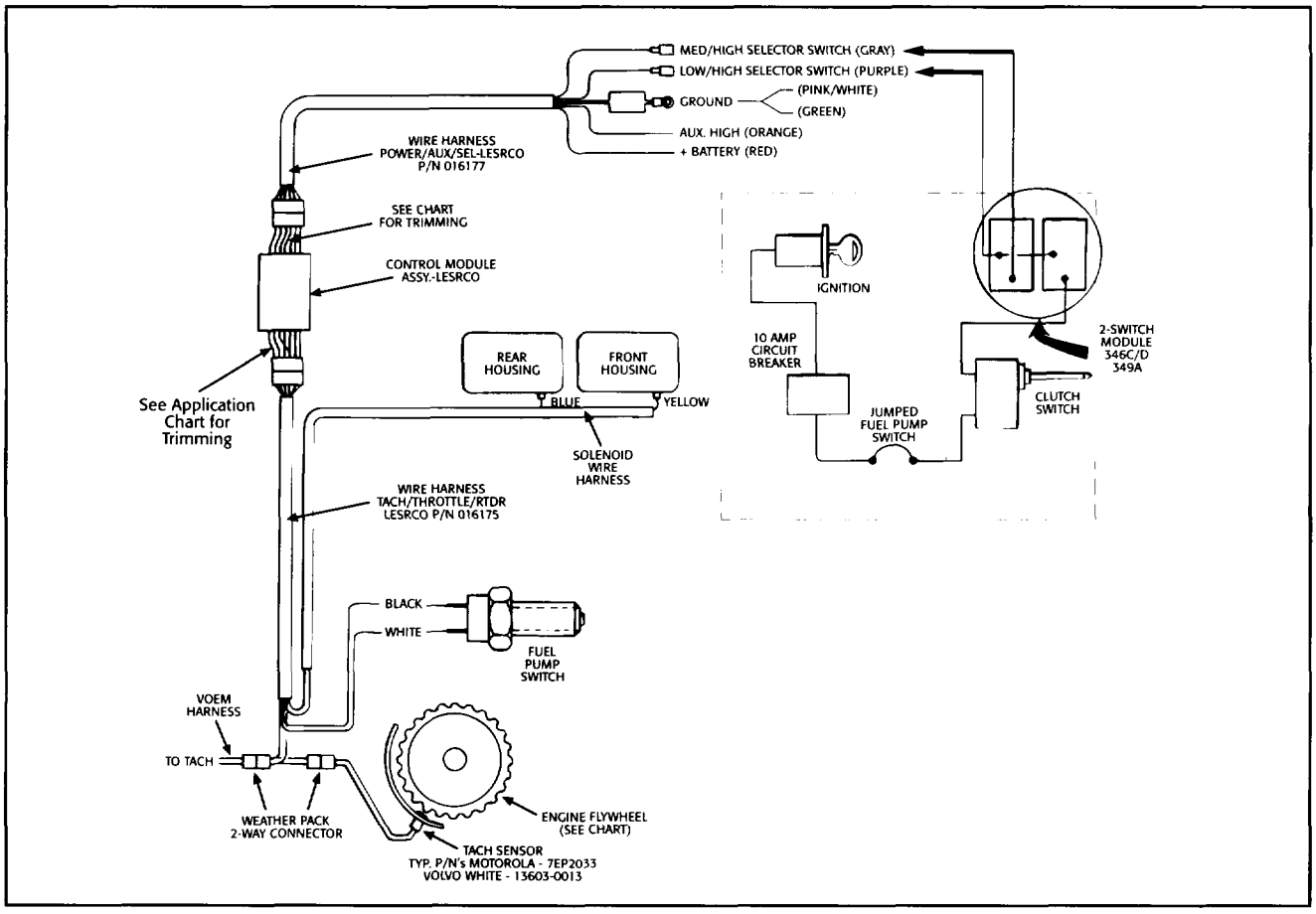


FIG. 4

Section 2: Hydraulic/Mechanical

Overview

The braking cycle is accomplished by utilizing the pushrod motion of an exhaust valve of another cylinder during its normal exhaust cycle. For example, Cylinder No. 1 exhaust pushrod opens the exhaust valves of Cylinder No. 3 in the following sequences:

Component Relationships

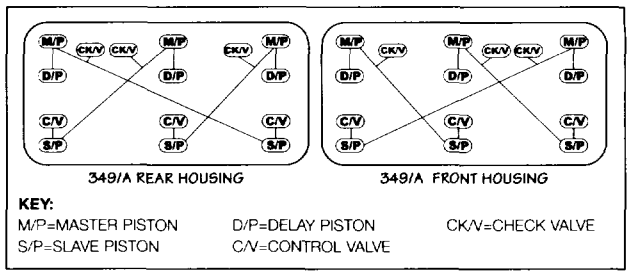
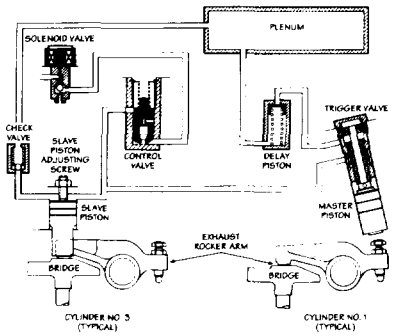
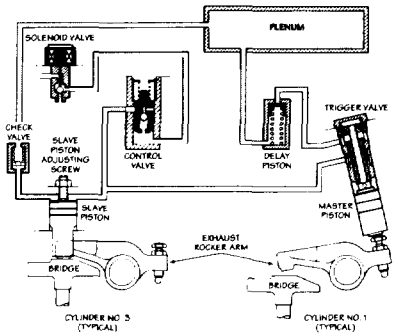


FIG. 5



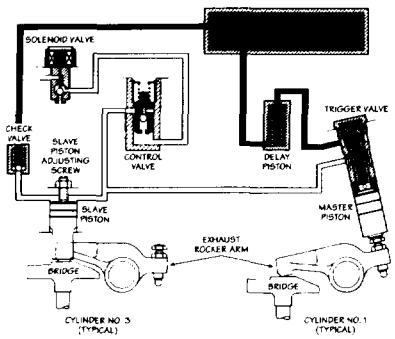
1. Brake Off

- The volume of oil contained in the 349A engine brake is several times the volume of a standard engine brake. Consequently, the brake should be cycled on & off several times each time the engine is brought up to operating temperature. This ensures that the brake is completely full of oil, and no pockets of air remain trapped inside.



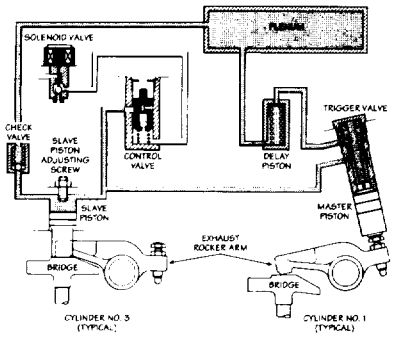
2. Brake Charging

- The energized solenoid valve permits engine lube oil to flow under pressure through the control valve to both the master piston and the slave piston and through the check valve to fill the plenum.
- Oil pressure causes the master piston to move down, coming to rest on the corresponding exhaust rocker arm adjusting screw. See Fig. 5 for component relationships.



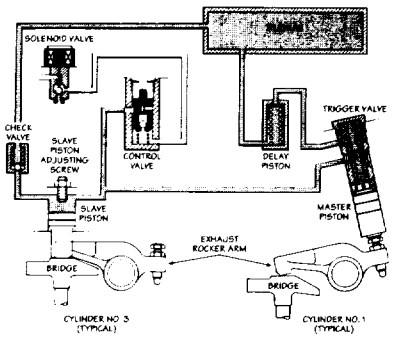
3. Brake Pressurizing

- The exhaust rocker pushrod begins upward travel *(as in normal exhaust cycle) forcing the master* piston upward and creating a high pressure oil flow to the delay piston.
- The delay piston moves and compresses the plenum oil to high pressure. The delay piston and plenum act as a high pressure "spring" storing energy to activate the slave piston at the appropriate time.



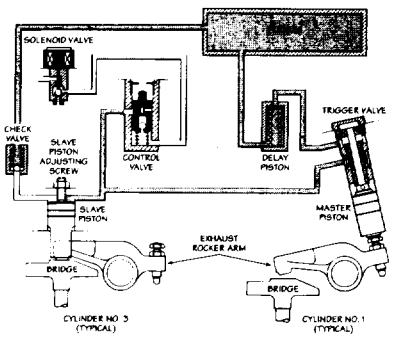
4. Brake Triggering

- The master piston moves upward and at the appropriate time, opens the trigger valve.
- High pressure oil flows from the delay piston through the trigger valve to the slave piston.
- The slave piston moves down, contacts the exhaust valve bridge and opens the exhaust valves releasing compressed cylinder air to the exhaust manifold.
- Compressed air escapes to atmosphere completing a compression release braking cycle.



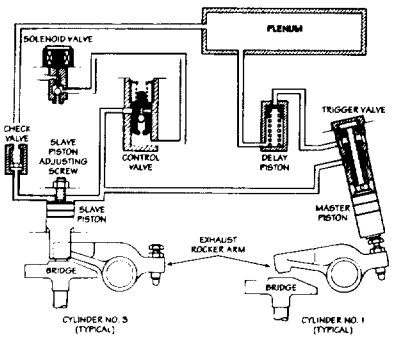
5. Slave Piston Extended

- Master piston continues to move up, rocker rides over top of cam and master piston begins to move down. Trigger valve approaches its seat. During this time there is negligible change in pressures or slave piston position (it remains extended).



6. Slave Piston Returns

- Master piston continues to drop. Downward motion of master piston increases volume and decreases pressure in trigger/delay circuit. Pressure cannot be recovered from delay piston as it is in bottom of bore. High pressure oil in master slave circuit keeps trigger valve off its seat. Slave piston returns as master piston continues to drop.



7. Brake Refills

- At bottom of stroke any necessary make up oil is added through control valve. Equal pressures in master/delay and master/slave circuits allow trigger valve to seat due to trigger valve spring. The brake is now ready to begin the next cycle - starting from step 3.

Components

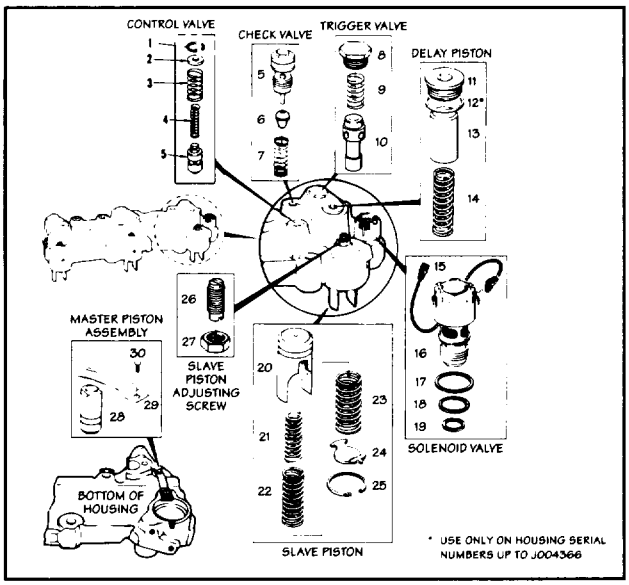


FIG. 6

Solenoid Valve (15)

An electrically operated valve that, when activated, permits engine oil to flow into the engine brake housing. When deactivated, shuts off supply of engine oil and provides a means for exhausting the pressure from the housing.

Control Valve (5)

Controls the flow of oil within the brake housing. Prevents the pressure that is developed in the master/slave piston circuit from feeding back into the engine oil supply.

Master Piston (28)

Follows the motion of the exhaust rocker. Pressurizes oil for storage in delay circuit and plenum.

Slave Piston (20)

High pressure oil from the master piston moves the slave piston down, opening the exhaust valves near top center of the compression stroke. This allows the compressed air to escape to the atmosphere. A slave piston spring returns the slave piston to its starting position.

Slave Piston Adjusting Screw (26)

Provides a means for adjusting clearance between the slave piston and exhaust bridge. These screws incorporate a plunger that rides on top of the slave piston. The plunger uncovers a hole that bleeds off pressure, thereby preventing overtravel of the slave piston.

Exhaust Rocker Lever Adjusting Screw (Not Shown)

With brake on, makes contact with the master piston.

Oil Supply Adapter (Not Shown)

Installed in the rocker brackets to supply engine oil to the engine brake solenoid (not illustrated).

Trigger Valve (10)

Follows the motion of the master piston and releases high pressure oil to the slave piston at the correct moment.

Check Valve (5)

Controls the flow of oil into the plenum. When the master piston compresses the oil, the high pressure oil opens the check valve, and flows into the plenum. As the master piston comes down, the oil is prevented from leaving the plenum by the check valve. The plenum now has a great deal of energy stored in the form of high pressure oil, ready for release by the trigger valve.

Delay Piston (13)

The delay piston provides a moveable boundary between the plenum and the trigger valve. When the trigger valve releases the high energy oil between it and the delay piston, the force of the pressure in the plenum drives the delay piston up. This motion of the delay piston is transferred hydraulically to the slave piston.

Section 3: Operational Tests

Before beginning the troubleshooting procedures, try to determine the exact nature of the problem. Talk to the driver, owner and/or mechanic to try and pinpoint the complaint or problem. The following list of checks may be helpful in trying to determine the nature of the problem.

Before Starting the Engine

If there is a report of engine or engine brake mechanical noise, remove the engine valve covers to determine the cause.

1. Check for broken or loose parts.
2. Check engine valve, engine brake lash, and trigger valve settings.
3. Check for possible bent valves.

Possible causes of bent valves could be:

- Engine overspeeding, usually several valves are affected
- One bent exhaust valve indicates a possible problem with a stuck slave piston, misadjusted trigger valve, damaged slave piston adjusting screw (Power Lash or D-Lash) or too high oil pressure. See Fig. 14 for oil pressure requirements. A bent exhaust valve may be caused by the valve stem stuck in its guide, bad bridge adjustment, or broken or weak valve springs.

Test Drive

1. Test drive the vehicle and verify that the engine is working properly in positive power. The problems that cause low positive power also cause low engine braking, for example: turbo problems leading to low boost pressures, aftercooler leakage, poor compression, air filter restriction, and high exhaust back pressure. Positive power boost and back pressure specifications are available from Caterpillar to help verify the health of your engine.
2. Measure intake manifold boost pressure with the engine brake operating.

RETARDING BOOST PRESSURE
CATERPILLAR 3406 & 3406B
PRE-1991

RPM	BOOST
1100	4
1300	5
1500	8
1700	11
1900	14
2100	16

FIG. 7

RETARDING BOOST PRESSURE
CATERPILLAR 3406B
1991-1994

RPM	BOOST
1100	4
1300	6
1500	9
1700	13
1900	16
2100	18

FIG. 8

RETARDING BOOST PRESSURE
CATERPILLAR 3406C
1994-PRESENT

RPM	BOOST
1100	4
1300	6
1500	8
1700	12
1900	16
2100	16

FIG. 9

NOTE:
IF THE VEHICLE DOES NOT HAVE A BOOST PRESSURE GAGE, ONE MUST BE INSTALLED. A PIPE FITTING IS LOCATED BETWEEN THE TURBO AND THE INTAKE MANIFOLD FOR THIS PURPOSE.

3. It is best to test with a loaded vehicle, engine at maximum rated RPM and the engine brake ON. Downhill operation is desirable to stabilize RPM.

4. Record the maximum boost pressure with both housings operating (HI position).

5. Record the boost pressure with the switch in the "LO" position.

NOTE:
LO POSITION MAY BE EITHER FRONT OR REAR HOUSING.

6. Disconnect the "LO" position harness to the solenoid and rerun the test with the switch in the "HI" position. This will test each housing independently. Record the results.

NOTE:
THE INDIVIDUAL HOUSING READINGS WILL NOT BE 1/2 OF THE MAXIMUM BOOST PRESSURE READING DUE TO THE EFFECT OF THE TURBOCHARGER. THE INDIVIDUAL BOOST PRESSURE READINGS, HOWEVER, SHOULD BE APPROXIMATELY THE SAME. A SIGNIFICANTLY LOWER READING IN ONE HOUSING INDICATES A POSSIBLE PROBLEM WITH THE HOUSING.

7. Compare the maximum boost pressure in high mode with the boost pressures in Figs. 7-9. A low reading indicates a possible problem. Readings within 3 psi of the values shown indicate proper operation of the engine brake.

Section 4: Electrical Troubleshooting

No Engine Brake Operation

1. Check for blown fuse or circuit breaker.

2. With electrical power OFF, check the control system for a short to ground. Check systems separately to isolate where the short is occurring. If the control system is OK up to the engine brake spacer connection, measure the resistance to the solenoid valve. Low resistance means a short in the solenoid or solenoid wire.

   NOTE:
   IF AN OPTIONAL LOW-SPEED SHUT-OFF DEVICE IS INCORPORATED, IT MUST BE BYPASSED FOR THESE CHECKS. REFER TO THE SPECIFIC LOW-SPEED INSTALLATION OR TROUBLESHOOTING DOCUMENTS FOR PROCEDURES.

Only One Housing Operating

1. Determine which housing is not operating by closing all the switches and checking for power at the wires leading to the solenoid valves (front and rear).

2. Remove the wire to the solenoid valve at the spacer and check for resistance between the spacer terminal and the engine block (Fig. 10). A high resistance indicates an open circuit in the wire or solenoid coil. A low reading indicates a short to the ground either in the solenoid wire or solenoid coil.

Intermittent Braking

1. Inspect all wiring for loose connections and all switches for proper adjustment.

Poor Performance

Connect a trouble light to the electrical connector on the spacer. Verify that the light is on steady when the engine brake is active. If not, check for loose connections or faulty switches. Repeat for all spacer terminals.

SOLENOID SPECIFICATIONS

P/N	Voltage	Resistance (Ohms) Cold	Resistance (Ohms) Hot	Current Draw (Amps) Cold	Current Draw (Amps) Hot	Minimum Pull in Voltage Cold	Minimum Pull in Voltage Hot
16440	12	9.62 to 10.75	11.8 to 14.3	1.12 to 1.23	0.84 to 1.02	8.0	9.5
20239	12	9.0 to 10.0	11.0 to 12.0	1.0 to 1.2	0.8 to 1.0	8.5	10.0

FIG. 10

For more detailed electrical troubleshooting information, please refer to the appropriate manual as indicated in Fig. 11.

Control System	Troubleshooting Document	P/N
PEEC III	Contact Caterpillar for Troubleshooting information	
PEEC	Troubleshooting for 346B/C/D PEEC	18884
Mechanical	Troubleshooting and Maintenance Manual, Section 1	13680
Low Engine Speed Retarder Cutoff	Low Engine Speed Retarder Troubleshooting	021649

FIG. 11

Section 5: Hydraulic/Mechanical Troubleshooting

Remove the engine valve covers to begin inspecting the brake housings and attendant hardware.

If the report is no engine braking but some noise when the engine brake is ON, check to be sure the housings are installed correctly — front housing (gold tag) on cylinder 1, 2 and 3 and rear housing (blue tag) on cylinders 4, 5 and 6. Name tags on the housings identify front and rear. Be sure the housings are installed in the correct position.

NOTE:
NO DAMAGE WILL OCCUR IF THE HOUSINGS ARE REVERSED, BUT THERE WILL BE SOME NOISE AND NO ENGINE BRAKING.

1. Visually inspect parts for obvious damage or missing parts. Replace as necessary.

2. Check the intake and exhaust valve clearance. Readjust if necessary.

NOTE:
IF THE VALVE LASH NEEDS TO BE RESET, THE SLAVE LASH AND TRIGGER SETTINGS MUST ALSO BE RESET. REFER TO STEPS 4 AND 5.

3. Visually inspect parts for obvious damage or missing parts. Replace as necessary.

⚠ WARNING

WEAR EYE PROTECTION AND DO NOT EXPOSE YOUR FACE OVER THE ENGINE AREA. KEEP HANDS AWAY FROM MOVING PARTS. TAKE PRECAUTIONS TO PREVENT OIL LEAKAGE DOWN ONTO THE ENGINE.

WHENEVER ENGINE IS RUNNING AND THE VALVE COVERS ARE REMOVED, OIL SPLASHING IN THE ENGINE BRAKE AREA COULD CAUSE PERSONAL INJURY.

NEVER REMOVE ANY ENGINE BRAKE COMPONENT WITH THE ENGINE RUNNING. PERSONAL INJURY MAY RESULT.

4. Verify that the slave piston adjustment is correct.

NOTE:
SLAVE PISTON CLEARANCE SETTINGS MUST BE MADE WITH THE ENGINE STOPPED AND COLD AND WITH THE EXHAUST VALVES CLOSED.

Adjust following the firing order: 1, 5, 3, 6, 2, 4.

Slave Piston Clearance Settings

Engine	Engine Brake Model	Adjustment	Slave Piston Adjusting Tool
3406/B/C	349 349A	0.018	003087

FIG. 12

5. Check and record the trigger valve adjustment. Verify that the trigger valves move freely in the bore, and the trigger valve springs are in good condition. There should be a tell tale ring around the portion of the valve that comes in contact with the valve seat. This ring should be complete with no signs of breaks. A break indicates a leak path for high pressure oil and possible loss of performance. Replace the trigger valve or spring if necessary. Check the inside of the trigger valve caps for signs of contact. If the trigger valve cap has been contacted by the trigger valve, the location of the trigger sleeve should be checked. This sleeve is pressed into the trigger valve bore. The top of this sleeve should be .565 minimum from the surface of the housing. This can be checked with the end of a dial or vernier caliper. If the trigger sleeve does not fall within this range, the housing should be replaced.

Trigger Valve Adjustment

Cylinder Number	Pre-1991 Model Year 3406B	'91 & Later Model Year 3406B/3406C 400HP	3406B/3406C All Others
1	0.100"	0.130"	0.100"
2,3,4,5,6	0.100"	0.095"	0.100"
All adjustments are ± 0.003"			

FIG. 13

6. With the engine idling, place a protective cover over the top of the control valve area. Be careful to keep away from moving parts. Actuate the solenoid, either electrically or by hand, and inspect for leaks. There should be no oil coming from the areas around the trigger caps, the delay piston caps, the check valves, the plenum plugs, the solenoids, or any of the pipe plugs. There should be 1 or 2 droplets of oil hanging from the master and slave pistons. If oil is coming from any of these areas, remove and inspect the component that is leaking.

⚠ WARNING

DELAY PISTONS ARE UNDER EXTREME PRESSURE. THE CHECK VALVES MUST BE REMOVED BEFORE REMOVING THE DELAY PISTON CAP. THIS WILL ALLOW THE PRESSURE TO ESCAPE. READ STEP 10 BEFORE REINSTALLATION.

A spray of oil near the master pistons may indicate a worn bore. A leaky delay piston cap may indicate improper torque. With the high pressures involved in the model 349A engine brake, any leakage will affect performance.

7. When the engine is shut down for several minutes, the oil in the brake housings will bleed down. To refill the brake housings for immediate operation, depress solenoid cap (or pin) several times to fill the housing with engine oil.

NOTES:
THE ENGINE BRAKE REQUIRES A MINIMUM OIL PRESSURE TO OPERATE. TO DETERMINE THE OIL PRESSURE AT THE ENGINE BRAKE HOUSING SOLENOID VALVES, USE THE JACOBS OIL PRESSURE TEST KIT AND FOLLOW THE INSTRUCTIONS INCLUDED IN THE KIT. SEE FIG. 14 FOR OIL PRESSURE REQUIREMENTS.

IF THE OIL PRESSURE IS NOT AS SHOWN FOR THE SPECIFIC MODEL AT IDLE, RUN THE ENGINE AT HIGHER RPM (800-900) WHEN TROUBLESHOOTING THE BRAKE.

OPERATING ABOVE THESE PRESSURES WILL CAUSE THE BRAKE TO SHUT OFF, REFER TO FIG. 14 FOR MAXIMUM ALLOWABLE OIL PRESSURE FOR SPECIFIC ENGINE BRAKE MODELS.

8. With the engine brake on, notice the master pistons moving out of the housing and making contact with the exhaust rocker adjusting screws. They should move in and out freely. It they do not, shut down the engine and check the control valves and control valve springs for those cylinders.

BRAKE MODEL	FULL FLOW PSI	BAR	OVER PRESSURE PSI	BAR
349, 349A	20-87	-	95	-
349A*	20-87	-	-	-
*Some models contain a spacer in place of the stop spring.				

FIG. 14

Refer to Fig. 5 to identify the control valve, master piston and slave piston relationship.

⚠ WARNING

REMOVE CONTROL VALVE COVERS CAREFULLY TO AVOID PERSONAL INJURY. CONTROL VALVE COVERS ARE UNDER LOAD FROM THE CONTROL VALVE SPRINGS.

The control valves should move freely in the bore, the check balls should have light spring pressure, and there should be no broken springs. With the Control Valve covered with fresh engine oil, hold the control valve at the top of the bore and release. When released, the valve should slowly settle to the bottom of the bore. If a spring failure has occured, insert a magnet in the control valve bore to remove any small pieces. If the engine brake has a history of control valve system failures, replace all control valve components in the housing with the latest configuration.

NOTE:
IF THE BORE IS DAMAGED (SCORED), USE A LIGHT CROCUS CLOTH TO SMOOTH THE BORE. CLEAN THE BORE AND INSTALL A NEW CONTROL VALVE. IF SEVERE DAMAGE TO THE BORE IS FOUND, REPLACE THE HOUSING.

Replace any broken springs.

9. Remove and inspect the check valves. They should be P/N 19957. This design has a ball seat that provides a better seal than previous part numbers. There should be a polished ring on the seal surface indicating contact with the check valve seat. If this polished area does not form a complete ring, or if there is damage to this sealing surface, the check valve should be replaced. Some early P/N 19957 check valves may have bent pins. These pins can be checked by passing a .057" dowel (or drill bit shank) around between the pin and the check valve body. If the dowel does not pass freely completely around the pin, the pin is bent and the check valve should be replaced.

⚠ WARNING

REMOVE THE CHECK VALVES BEFORE REMOVING THE DELAY PISTON CAPS THIS RELIEVES PRESSURE IN THE PLENUM CHAMBER SO THAT THE DELAY PISTON CAPS CAN BE SAFELY REMOVED.

10. Remove the delay piston cap slowly. Use a magnet to remove delay piston and spring. If the piston binds or is damaged in any way, replace it.

Reinstall the spring, delay piston and cap. If the housing was originally equipped with a copper seal, use a new copper seal. Housing with serial numbers J004367 and up do not use a copper seal.

Clean the oil from the cap threads and apply Loctite 271 (or equivalent) before installing. Tighten the delay piston cap to 65 lb.-ft. (88 N•m).

11. Inspect the flux ring on each solenoid. With the engine idling, electrically actuate the solenoid watching the crimp joint between the sides and the flux ring (the ring that surrounds the top of the solenoid). If the crimp joint allows any movement at all, the flux ring is bad, and the solenoid should be replaced. Check the oil pressure drop across each solenoid. With the engine idling, use a Jacobs Oil Pressure Test Kit to determine the oil pressure in a control valve bore.

NOTE:
THE BRAKE MAY NEED TO BE ACTIVATED SEVERAL TIMES BEFORE IT FILLS WITH OIL AND A STEADY STATE PRESSURE READING CAN BE OBTAINED, PARTICULARLY IF THE ENGINE BRAKE HASN'T BEEN USED RECENTLY.

Shut off the engine, and remove the solenoid. Insert the pressure probe in the solenoid bore, restart the engine, and record the oil pressure in the solenoid bore. If the difference in oil pressure between the control valve bore and the solenoid bore is greater than 5 PSI, there is a restriction in the solenoid and it should be replace.

12. If the control valves and springs are OK and the master and slave pistons were observed not to be operating, remove the housings for inspection.

Visually inspect the following:

Master piston springs—if broken or worn, replace.

Master pistons—must move freely in the bore. Check the hard facing on the master piston—this is the area that contacts the rocker adjusting screw.

Adjusting screw—check the hex head for excessive wear. If a depression of 0.005" or deeper is found in the top of the hex head or if the pattern of "wipe" extends beyond the hex, replace the adjusting screw. Also replace the companion master piston. The spherical end should be checked for proper contour and smooth appearance. Replace if necessary.

Oil supply adapters—check for damage and replace if necessary. Install new seals.

13. Exhaust valve bridges—inspect for wear. A shiny area will be seen on the top surface where the slave piston contacts the bridge. This area should be less than 0.005" deep. Replace if necessary.

14. Slave piston adjusting screw—remove and inspect. A spring-loaded plunger located at the bottom of the screw seals the hole in the slave piston to provide proper master/slave operation. At maximum travel, the hole in the slave piston will be uncovered, dumping oil pressure and preventing further travel. See Fig. 14 for pressure requirements.

NOTE:
SCREW ASSEMBLIES ARE NOT FIELD SERVICEABLE.

15. Remove the slave pistons using the following procedure.

⚠ WARNING

WEAR SAFETY GLASSES.

THE SLAVE PISTON IS RETAINED BY SPRINGS THAT ARE UNDER HEAVY COMPRESSION. IF THE FOLLOWING INSTRUCTIONS ARE NOT FOLLOWED AND PROPER TOOLS NOT USED, THE SPRINGS WILL BE DISCHARGED WITH ENOUGH FORCE TO CAUSE PERSONAL INJURY.

Remove the hex jam nut on the slave piston adjusting screw. Back out the adjusting screw until the slave piston is fully retracted (screw is loose). Install the slave piston removal tool. Turn the tool handle in to relieve the spring pressure. Using retaining ring pliers, rotate the retaining ring to the slot in the housing and remove the retaining ring. Turn the tool handle out to relieve the spring force and remove the retainer, springs and slave piston.

Reassemble the slave piston, springs, retainer, slave piston adjusting screw, and hex jam nut using the Jacobs slave piston tool. Rotate the slave piston retaining ring 90° from the slot in the housing to ensure that it is properly seated.

Section 6: Final Test

Follow the instructions in the installation manual to reassemble the housings. Install a new oil supply seal ring.

Install the housings on the engine and adjust the slave piston and trigger valve clearance to proper settings as shown in Figures 12 & 13.

NOTE:
BE SURE TO INSTALL THE HOUSINGS CORRECTLY, FRONT (GOLD TAG) ON CYLINDERS 1, 2 AND 3, AND REAR (BLUE TAG) ON CYLINDERS 4, 5 AND 6.

Before installing the engine covers, start the engine and allow to warm up for a few minutes.

Depress the solenoid valve several times to fill the housing with engine oil.

NOTE:
ENGINE BRAKES REQUIRE A MINIMUM OIL PRESSURE FOR OPERATION. IF THERE IS LESS THAN MINIMUM AT IDLE, RUN THE ENGINE AT HIGHER RPM (800-900) WHEN MAKING CHECKS. SEE FIG. 14 FOR OIL PRESSURE REQUIREMENTS.

Check for oil leaks at the oil supply screw, solenoid valve, trigger caps, delay piston caps, check valves, plenum plugs and housing pipe plugs. If leakage is noticed, shut down the engine and repair.

NOTE:
SOME LEAKAGE WILL BE SEEN AT THE MASTER PISTON, SLAVE PISTON AND CONTROL VALVES. THIS IS NORMAL EXCESSIVE LEAKAGE MUST BE INVESTIGATED (SEE SECTION 5).

After final inspection and necessary repair, shut down the engine, replace gaskets if neccesary and reinstall the valve covers and any other components that may have been removed.

Test drive the vehicle following the procedures in section 3 to verify corrective action.

Section 7: Cause and Effect Guide

Problem: Engine fails to start

Probable Cause: Solenoid valve stuck in "on" position.

Correction: Ensure that electrical current is off to engine brakes. If solenoid valve remains "on" (cap or pin down) with current off, replace solenoid valve.

Problem: Engine Brake will not operate

Probable Cause: Blown fuse, open electrical leads.

Correction: Look for short circuit in wiring. Replace any broken, brittle or chafed wires. Check solenoid tab for signs of shorting; replace if necessary. Replace fuse (10 amp).

Probable Cause: On/Off switch, clutch switch, throttle switch or multi-position switch out of adjustment or defective.

Correction: Use a volt/ohm meter to make certain that there is electrical voltage available to both terminals of each switch. Readjust if needed or replace if voltage will not pass through switch.

⚠ WARNING

DO NOT TOUCH ELECTRICAL CONNECTION WHEN SYSTEM IS ENERGIZED.

Probable Cause: Incorrect electrical power source.

Correction: Check that the supply voltage is the appropriate voltage. Recommended power source is from the key switch "on" position. Ensure that power is not taken from a source with an additional on/off switch, i.e., light switch. See solenoid specifications Fig. 10. Make sure wiring is in accordance with Caterpillar and Jacobs wiring instructions.

Probable Cause: Low engine oil pressure.

Correction: Determine oil pressure at engine brakes [Solenoid Valve and Control Valve] see oil pressure requirements, Fig. 14. If oil pressure is below specifications, engine should be repaired in accordance with manufacturers' procedures.

Problem: Engine Brake activates with switches open (off).

Probable Cause: Center solenoid valve seal ring damaged.

Correction: Remove solenoid. Replace all seal rings.

Probable Cause: Engine brake improperly wired.

Correction: Check wiring in accordance with diagrams.

Problem: Engine Brake slow to operate or weak in effect.

Probable Cause: Lube oil cold and thick.

Correction: Allow engine to warm before operating brakes.

Probable Cause: Improper slave piston adjustment or slave piston binding in bore.

Correction: Readjust in accordance with Jacobs procedures. Ensure that slave piston responds smoothly to the adjusting screw by loosening jam nut and screwing the screw through its full travel for full slave piston motion. Make sure piston travels full range without binding or sticking.

⚠ WARNING

REMOVE SLAVE PISTON CAREFULLY WHEN DISASSEMBLY IS NECESSARY. USE JACOBS SLAVE PISTON TOOL. SLAVE PISTON SPRINGS ARE UNDER HEAVY COMPRESSION.

Probable Cause: Solenoid screen clogged stopping supply of oil to brake.

Correction: Remove solenoid valve and clean screen.

Probable Cause: Master piston not moving in bore.

Correction: Inspect master piston and bore for scoring or burrs. If any present, clean surface with crocus cloth. If unable to remove burrs, replace piston or housing. Inspect lube oil for signs of contaminants. If any are present, replace oil and filter and correct cause of contamination.

Probable Cause: Control valves binding in housing bore.

Correction: Remove control valve. If body is scored, replace control valve. Check for contaminants in lube oil. Clean housing and control valve. If binding continues, replace housing.

Probable Cause: Control valve defective.

Correction: Remove control valve. Make sure check ball is seated in bore and can be moved off seat. Make sure there is spring pressure against ball. Flush in cleaning solvent. Replace if necessary.

Probable Cause: Switch operation sluggish. Check dash switches, clutch switch, throttle switch, or other control switches.

Correction: Readjust or replace switch. Check throttle or clutch return springs for proper operation. Check all controls for correct operation, replace as required.

Probable Cause: Solenoid Valve operation erratic.

Correction: Check solenoid valve using electrical specifications explained on Fig. 10, with key on, brake switches on, and engine off, activate solenoid electrically. Ensure solenoid cap depresses.

⚠ WARNING

DO NOT TOUCH ELECTRICAL CONNECTION WHEN SYSTEM IS ENERGIZED.

Probable Cause: Outer control valve spring broken, or engine oil pressure extremely high (see Section 1.2).

Correction: Outer control valve spring broken allowing control valve to over-index or, problem is in engine lube system. Consult appropriate engine repair manual for causes of high lube oil pressure.

Probable Cause: Housing external plugs leaking.

Correction: Tighten or replace plugs.

Probable Cause: Oil supply adapter broken.

Correction: Replace adapter and "O" ring.

Probable Cause: Adapter "O" ring damaged or missing.

Correction: Replace "O" ring

Problem: Oil pressure dropping below minimum required for engine brake operation.

Probable Cause: Upper solenoid seal ring damaged.

Correction: Remove solenoid. Inspect seal ring and replace all seal rings.

Probable Cause: Damaged oil supply seals under housings.

Correction: Remove housing and replace seals.

Probable Cause: Aeration of lubricating oil.

Correction: Check for aeration of the oil. Activate, then deactivate engine brake. Watch escape oil coming from control valve cover. If oil has bubbles or is foamy, air is present in system. Aeration can be caused by an overfilled or underfilled crankcase, crack in oil pickup tube or leaks in oil suction tube or hose. Correct in accordance with manufacturer's procedures.

Probable Cause: Lubricating oil being diluted by fuel oil.

Correction: Have an oil analysis of lube oil to determine if fuel is present. Correct per engine manufacturer's procedures.

Probable Cause: Low engine oil level.

Correction: Consult engine manual for specifications. Add oil or re-calibrate dipstick as required.

Probable Cause: Worn engine rocker bushings.

Correction: Replace bushings in accordance with engine manufacturer's procedures.

Probable Cause: Oil leaking from around cylinder head.

Correction: Repair causes of leaks.

Probable Cause: Restrictions in the oil passages leading to engine brake.

Correction: Inspect all the passageways, remove any items restricting oil flow.

Problem: One or more cylinders fail to stop braking or engine stalls.

Probable Cause: Control valve inner spring broken.

Correction: Replace inner spring.

Probable Cause: One or more control valves stuck in "on" or up position.

Correction: Check control valves for binding. Remove and clean or replace if necessary. Inspect lube oil for contaminates.

Probable Causes: Solenoid valve sticking in "on" position.

Correction: If solenoid valve cap remains down with no electric current being supplied, replace solenoid valve.

Probable Cause: Center solenoid seal ring damaged. Allows oil to enter brake with solenoid valve closed.

Correction: Remove solenoid and replace all seal rings.

Probable Cause: Solenoid valve exhaust plugged.

Correction: Remove any restrictions at exhaust (bottom) of solenoid valve.

Probable Cause: Clutch switch or throttle switch stuck in "on" position or out of adjustment.

Correction: Check for proper operation. Readjust or replace as needed.

Problem: Engine misses or loses power.

Probable Cause: Slave piston adjustment too tight.

Correction: Readjust slave piston clearance in accordance with Fig. 12.

Problem: Sudden drop in engine lube oil pressure.

Probable Cause: Upper solenoid valve seal missing or damaged.

Correction: Remove solenoid and replace upper seal ring.

Problem: Engine Brake works partially or intermittently.

Probable Cause: Solenoid failure.

Correction: With system electrical power to solenoid, armature (cap) should move down. If not, replace solenoid.

Probable Cause: Oil flow to one housing restricted.

Correction: Check oil pressure to housing. Possible restriction at oil supply adapter. Repair as required.

Problem: Weak retarding performance.

Probable Cause: Misadjusted trigger.

Correction: Readjust per installation manual. Insure locking mechanism is ok.

Probable Cause: Leaking check valve.

Correction: Inspect mating surfaces of check valve and seat and replace as needed. Clean bores before installing.

Probable Cause: Slave piston adjusting screw damaged or inoperative.

Correction: Check plunger surface and replace if necessary. Plunger protrusion must be .103" to .110".

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Rev. 4/97