

SECTION 01: ENGINE

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1. ENGINE

This vehicle is powered by a 6-cylinder, four-cycle, Detroit Diesel series 60 engine, equipped with an electronic control system (DDEC IV).

This vehicle Series 60 engine comes in one displacement volume: 12.7 liters. Summary information on the Electronic Control System is given in this section.

Complete maintenance and repair information on the engine will be found in the current DDEC IV Service Manual #6SE483. This maintenance manual covers engine accessories, controls and related components.

Procedures for engine removal and installation are given at the end of this section. The DDEC system is self-diagnostic. It can identify faulty components and other engine-related problems by providing the technician with a diagnostic code.

Refer to DDEC Troubleshooting Guide #6SE492 published by Detroit Diesel for more complete information on diagnosis of components and system problems.

DDEC IV (Detroit Diesel Electronic Control) controls the timing and amount of fuel injected by the electronic unit injectors (EUI). The system also monitors several engine functions using electrical sensors, which send electrical signals to the Electronic Control Module (ECM). The ECM computes the electrical signals and determines the correct fuel output and timing for optimum power, fuel economy and emissions. The ECM also has the ability to display warnings or shut down the engine completely (depending on option selection) in the event of damaging engine conditions, such as low oil pressure, low coolant level, or high oil temperature.

Two categories divide system components: engine-mounted components and engine-related components.

2. ENGINE-MOUNTED COMPONENTS

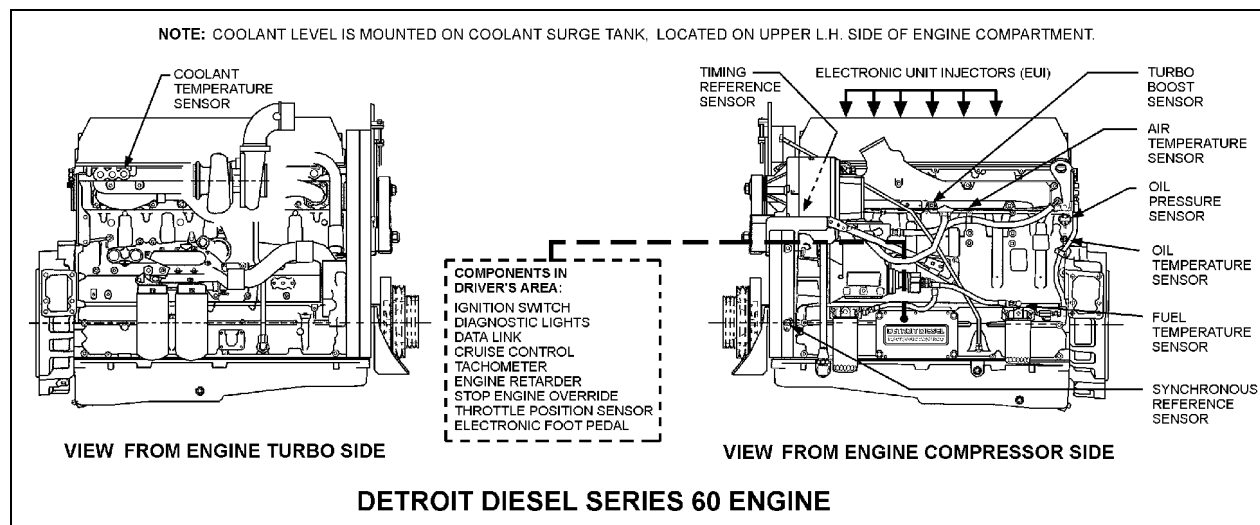


FIGURE 1: DETROIT DIESEL SERIES 60 ENGINE (TYPICAL)

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Engine-mounted components are as follows:

- Electronic Control Module
- Electronic Unit Injector
- Synchronous Reference Sensor
- Timing Reference Sensor
- Turbo Boost Pressure Sensor
- Coolant Temperature Sensor
- Fuel Temperature Sensor

- Air Temperature Sensor
- Oil Pressure Sensor
- Oil Temperature Sensor

2.1 ELECTRONIC CONTROL MODULE

The Electronic Control Module is mounted, on the starter side of the engine (Fig. 2). Considered the "Brain" of the DDEC IV system, it provides overall monitoring and control of the engine. It does so by comparing input data from the various sensors to a set of calibration

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data stored in the EEPROM (Electrically Erasable, Programmable, Read-only Memory) within the Electronic Control Module. After comparing the input data with the calibration data, the ECM sends high-current command pulses to the Electronic Unit Injectors (EUI) to initiate fuel injection. The ECM also receives feedback regarding the start and end of injection for a given cylinder. The EEPROM within the Electronic Control Module is factory programmed by Detroit Diesel. Reprogramming must be done at a Detroit Diesel authorized service center. However, some changes may be performed to the cruise control and road speed limiter using a diagnostic data reader (see paragraph "DDEC IV Diagnostic Codes" in this section).

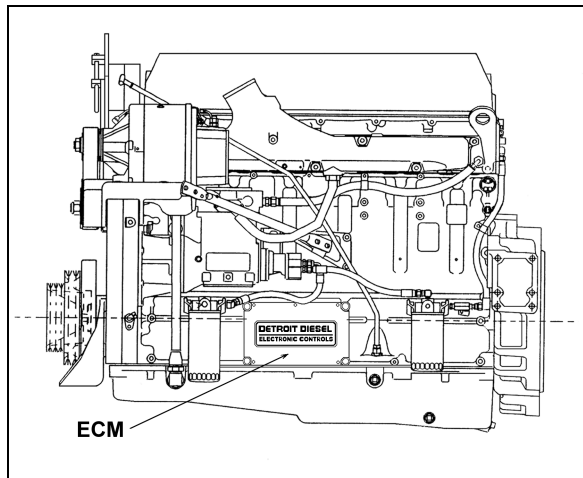


FIGURE 2: ELECTRONIC CONTROL MODULE (ECM) 01084

2.2 ELECTRONIC UNIT INJECTOR

The Electronic Unit Injector is a compact device that injects diesel fuel directly into the combustion chamber (Fig. 3). The amount of fuel injected and the Electronic Control Module (ECM) determines the beginning of injection timing. The ECM sends a command pulse, which activates the injector solenoid. The EUI performs four functions:

- Creates the high-fuel pressure required for efficient injection;
- Meters and injects the exact amount of fuel required to handle the load;
- Atomizes the fuel for mixing with the air in the combustion chamber;
- Permits continuous fuel flow for component cooling.

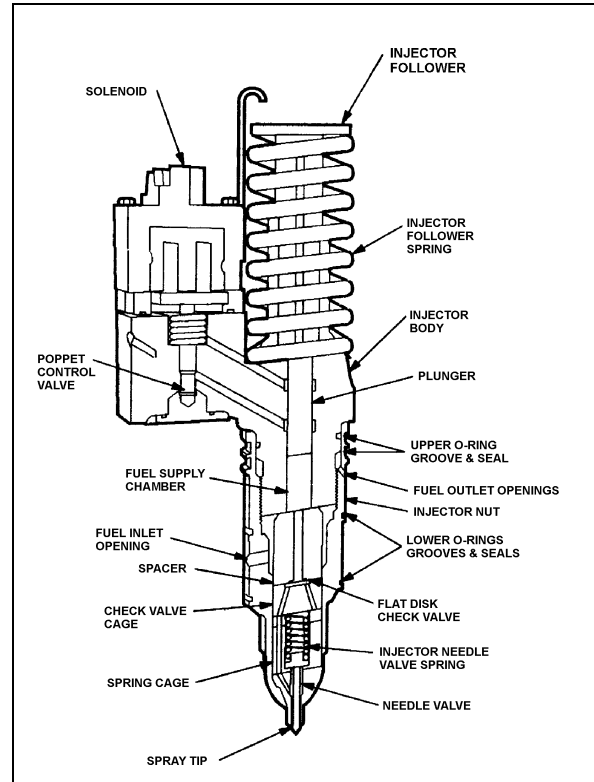


FIGURE 3: UNIT INJECTOR CROSS SECTION 01106

2.3 SYNCHRONOUS REFERENCE SENSOR

The Synchronous Reference Sensor (SRS) is an electronic component, mounted to the rear of the gear case (Fig. 4). The SRS senses a raised metal pin on the rear of the bull gear and sends a signal to the ECM via a black connector wire. The SRS extends through a hole in the gear case. It is positioned near the rear of the bull gear. A bolt, inserted through a hole in the SRS bracket, secures the SRS assembly to the gear case.

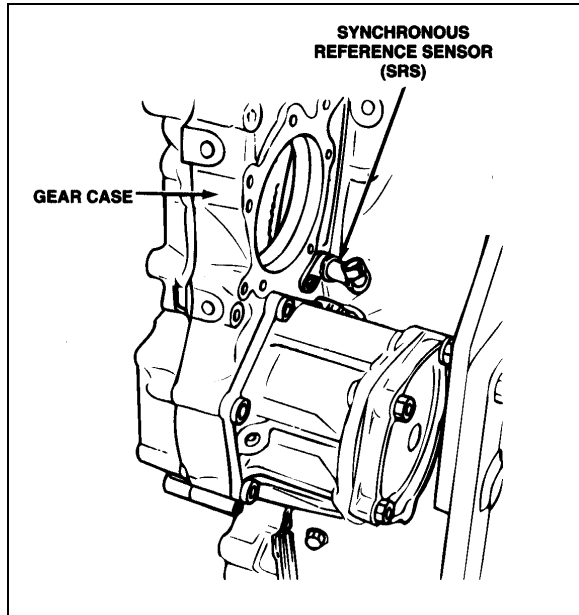


FIGURE 4: SRS LOCATION

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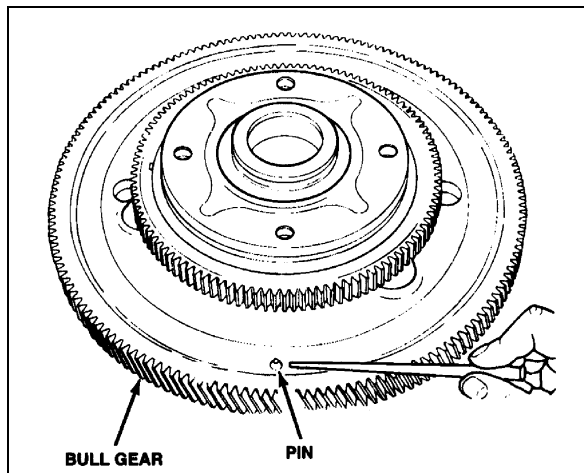


FIGURE 5: BULL GEAR

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The bull gear pin passes by the SRS as piston number one crank pin reaches 45° before Top-Dead-Center. The ECM uses this information to determine engine speed.

The SRS is non-serviceable and must be replaced as a unit. No adjustment is required.

2.4 TIMING REFERENCE SENSOR

The Timing Reference Sensor (TRS) is an electronic component mounted on the left side of the gear case (right side of coach), near the crankshaft centerline. The TRS is positioned near the timing wheel gear teeth, extends through an opening in the gear case. A bolt, inserted through a hole in the TRS bracket, secures the TRS assembly to the gear case. The TRS connector is gray. The TRS sends a

signal to the ECM. The TRS senses a series of evenly spaced special teeth on the timing wheel. A tooth passes by the TRS as each cylinder crank pin reaches 10° before Top-Dead-Center.

The ECM uses these signals to determine injector solenoid operation time. The TRS is non-serviceable and must be replaced as a unit. No adjustment is required.

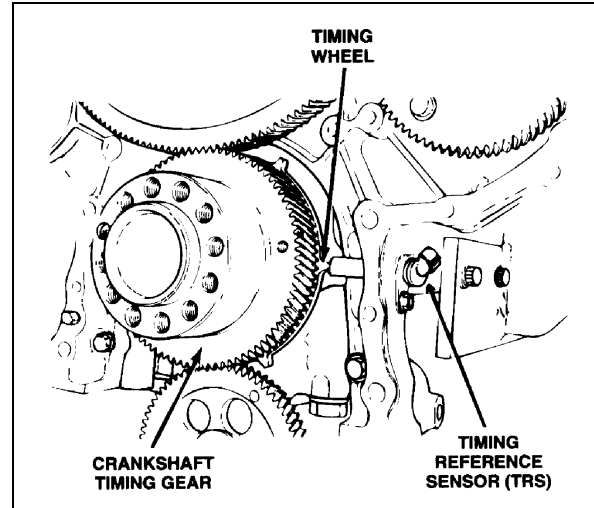


FIGURE 6: TIMING GEAR

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2.5 TURBO BOOST PRESSURE SENSOR

Two bolts mount the Turbo Boost Pressure Sensor to the intake manifold. A rubber O-ring seals the sensor to the manifold (Fig. 7). This device is a pressure sensor that sends an electrical signal to the ECM. The ECM uses this information to compute the amount of air entering the engine. Turbo boost sensor information regulates fuel supply to control engine exhaust.

The turbo boost sensor is non-serviceable and must be replaced as an assembly. No adjustment is required.

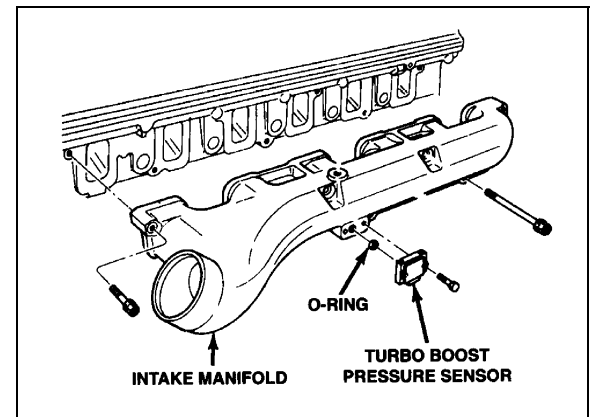


FIGURE 7: TURBO BOOST PRESSURE SENSOR

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2.6 COOLANT TEMPERATURE SENSOR

The coolant temperature sensor is mounted on the engine's right side (vehicle's left side). The sensor helps protect the engine against overheating by sensing coolant temperature.

2.7 FUEL TEMPERATURE SENSOR

The Fuel Temperature Sensor (FTS) is installed on the secondary fuel filter (Fig. 8).

The FTS sends an electrical signal to the ECM indicating fuel inlet temperature. The ECM uses this information to calculate fuel consumption.

The FTS is non-serviceable and must be replaced as a unit. No adjustment is required.

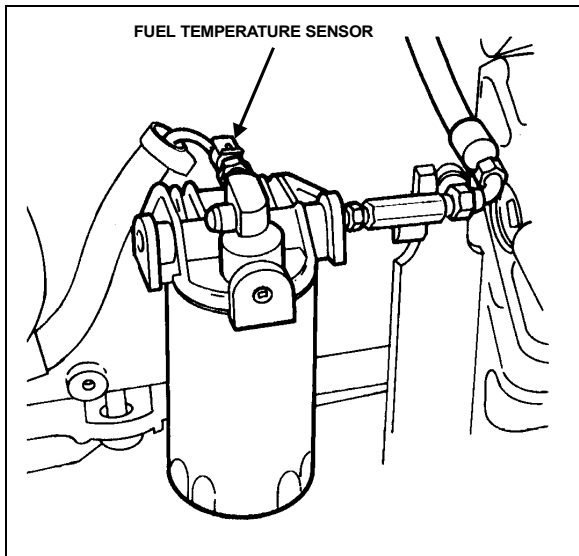


FIGURE 8: FUEL TEMPERATURE SENSOR 01024

2.8 AIR TEMPERATURE SENSOR

The Air Temperature Sensor (Fig. 1) located on the engine (starter side) near the intake manifold provides input data to vary hot idle speed and injection timing. This helps to improve cold starts and reduces white exhaust smoke.

2.9 OIL PRESSURE SENSOR

The Oil Pressure Sensor (OPS) is installed in the main engine-oil gallery. A typical location is the left rear corner of the cylinder block (Fig. 9). The OPS sends an electrical signal to the ECM indicating the engine oil pressure at any given speed. A low oil pressure signal exceeding seven seconds is used by the ECM to begin the stop engine or warning function. The OPS is non-serviceable and must be replaced as a unit. No adjustment is required.

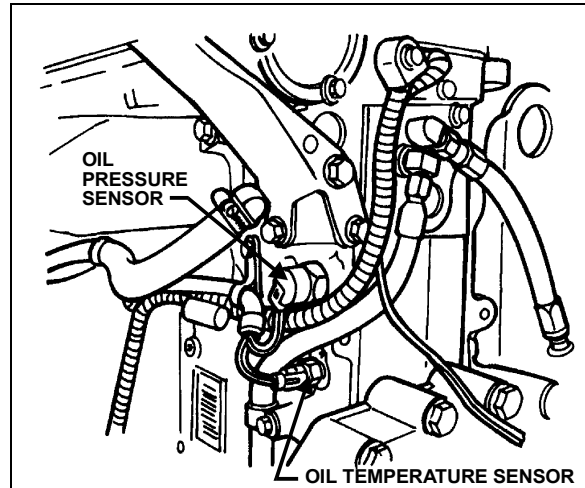


FIGURE 9: CYLINDER BLOCK 01025

2.10 OIL TEMPERATURE SENSOR

The Oil Temperature Sensor (OTS) is installed on the main engine-oil gallery. A typical location is the left rear corner of the cylinder block as shown in Figure 9. The OTS sends an electrical signal to the ECM indicating engine oil temperature. The ECM uses this information to modify engine speed for better cold weather starts and faster warm-ups. Oil temperatures exceeding engine specifications for two seconds or more will illuminate the Check Engine Light.

The OTS is non-serviceable and must be replaced as a unit. No adjustment is required.

3. ENGINE-RELATED COMPONENTS

Engine-related components include:

- Coolant Level System (CLS)
- Electronic Foot Pedal Assembly (EFPA) and Throttle Position Sensor
- Cruise Control Switch (CCS)
- Diagnostic System Accessories (DSA)

3.1 COOLANT LEVEL SYSTEM (CLS)

The coolant level system consists of a conductivity probe mounted in the surge tank and an electronic interface module located inside the rear junction box. Coolant level is determined by the change in impedance of the probe and its brass mount when immersed in coolant. The electronic device in the module conditions the signal to levels compatible with DDEC. A low coolant level will trigger the engine warning functions.

The probe and electronic interface module are non-serviceable items and should be replaced as units, if found defective. No adjustment is required.

3.2 ELECTRONIC FOOT PEDAL ASSEMBLY (EFPA) & THROTTLE POSITION SENSOR

The Electronic Foot Pedal Assembly (EFPA) connects the accelerator pedal to a Throttle Position Sensor (TPS). The (TPS) is a device, which sends an electrical signal to the Electronic Control Module (ECM). The TPS varies in voltage depending on how far the pedal is depressed. The system is installed in the space normally occupied by a mechanical foot pedal. The (EFPA) has maximum and minimum stops that are built into the unit during manufacturing (Fig. 10). The (TPS) converts the operator's foot pedal input into a signal for the ECM. The (EFPA) is shown in Figure 10.

When installed by the equipment manufacturer, the TPS should not require adjustment. If the TPS is suspected of being misadjusted, confirm that the sensor is installed in accordance with the manufacturer's specifications. It is recommended that the idle count be at 50 or higher with a full throttle count of up to 200.

The TPS is self-calibrating and therefore has no optimum closed throttle or wide open throttle count value. If the counts are within the 50 to 200 range, the sensor is properly set.

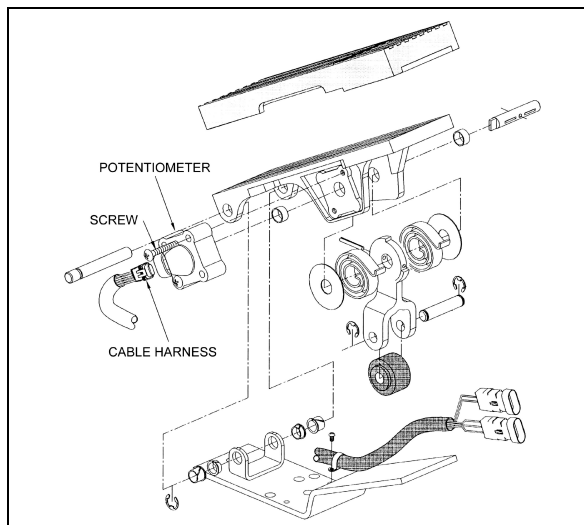


FIGURE 10: ELECTRONIC FOOT PEDAL ASSEMBLY⁰³⁰³⁵

Monitor the (TPS) as the controls move it through its full stroke. Be sure there is no misalignment or obstruction preventing the smooth movement of the TPS through the full stroke. Using a diagnostic data reader, check that the idle and

full throttle position counts do not fall within the error zones. The error zones occur when the idle position is less than 14 counts, or when the full throttle position is more than 233 counts. Should these conditions occur, the ECM will signal diagnostic codes of 21-12 for idle error and 21-23 for wide-open throttle error.

3.3 CRUISE CONTROL SWITCHES (CCS)

The four cruise control switches are located in the driver's area on the L.H. side control panel.

1. **Cruise:** This is the main switch that actuates the ECM memory in order to use the speed-regulating mode.
2. **Set:** This switch is used to set the cruise control speed or to decrease the set speed by 2 MPH at each application.

Note: Cruise control system will not accept speed settings, nor will the "Resume" switch operate below 20 mph (32 km/h) and the engine speed must be above 1100 RPM.

3. **Resume:** Each time this switch is actuated, the speed will be increased by 2 mph (3.5 km/h). This switch allows the driver return to the last regulated speed following a brake or "DECEL" switch application.

Note: On-off switch must be in the "ON" position in order to return to the last regulated speed.

4. **Decel:** Will cancel the cruise temporarily and let the vehicle coast. Set speed is still in memory for resume.

For additional information, see the "Operator's Manual" or the "Owner's Manual".

3.4 DIAGNOSTIC SYSTEM ACCESSORIES (DSA)

The DDEC IV engine Diagnostic System Accessories include the following:

- Check Engine telltale light;
- Stop Engine telltale light;
- Stop Engine Override switch;
- Diagnostic Data Link (DDL) connectors.

3.4.1 Check Engine Telltale Light

The Check Engine telltale, mounted on the telltale light panel indicates that a problem has been detected and that a code has been stored

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in the ECM memory. This light also has a 5-second bulb check when the ignition is first turned on. The Check Engine telltale illuminates when the temperature at coolant sensors exceeds 217°F (103°C) and the temperature at oil sensors exceeds 260°F (127°C). When sensors reach those temperatures, DDEC starts to decrease engine power linearly.

3.4.2 Stop Engine Warning Light

This light, also mounted on the telltale light panel, illuminates to indicate that a major engine problem is occurring (with the exception of a 5-second bulb check when the ignition is first turned on). The Stop Engine Light illuminates when the temperature at coolant sensors exceeds 222°F (106°C) and the temperature at oil sensors exceeds 239°F (115°C). When sensors detect such temperatures, DDEC shuts the engine down after a 30 seconds grace period. This 30-second delay may be extended another 30 seconds (if absolutely necessary) by using the STOP ENGINE OVERRIDE switch.

Note: *Once engine is stopped, it can not be restarted until the malfunction is corrected.*

3.4.3 Stop Engine Override Switch

This switch, mounted on the dashboard, may be used to extend the 30-second delay period before engine shutdown when the Stop engine telltale light is illuminated. This switch can be repeatedly depressed in order to move the vehicle out of traffic.

Note: *The stop engine override switch will be operative only if it has been depressed before the end of the 30 second delay period.*

Caution: *The OVERRIDE switch must be used only in emergency cases, such as to move the vehicle out of traffic. Excessive use of this switch can cause serious damage to the engine.*

This switch is also used for DDEC diagnostic code requests. Press this switch with the engine at idle or off but with the ignition in the "ON" position and active codes will be flashed on the CHECK ENGINE and STOP ENGINE telltale lights alternately. Refer to "DDEC IV DIAGNOSTIC CODES" in this section for more information.

3.4.4 Diagnostic Data Link (DDL) Connectors

A connector is mounted on the L.H. footwell wall. Another connector is located in the rear electric

compartment. They allow the connection of the Diagnostic Data Reader (DDR) to read the codes or to access pertinent data on the condition of the engine. This enables a more complete analysis of any defect found in the DDEC system operation. For more information, see Detroit Diesel Troubleshooting Guide #6SE492.

4. DDEC IV DIAGNOSTIC CODES

4.1 READING DIAGNOSTIC CODES – FLASHING LIGHT METHOD:

DDEC IV makes use of two types of codes: Active and inactive. The difference between the two types of codes is as follows:

Active Codes: Codes that are currently keeping the Check Engine or Stop Engine telltale light illuminated. Active codes are flashed via the Stop Engine Light when checked with the stop-engine-override switch.

Inactive Codes: These are all the codes logged in the ECM (whether or not they are currently turning on the Stop or Check Engine Light). Inactive codes are flashed via the Check Engine telltale light when checked with the stop-engine-override switch. In most instances, only the DDR can provide the information necessary for a quick diagnosis of the problem. If you just need to read out codes, however, and do not have a DDR available, the following procedure will let you read out codes. Make sure the rear-starting switch (located in the engine compartment) is in the normal position. With the ignition ON, the engine idling or engine shut-off, momentarily depress the Stop Engine Override switch. Active codes will be flashed on the stop engine telltale, followed by the inactive codes being flashed on the check-engine telltale panel. The cycle repeats itself until the operator depresses the stop engine override switch again. A code "43" consists of four flashes, followed by a short pause, then three flashes in quick succession.

Refer to DDEC Troubleshooting Manual 6SE497 for more information and SAE codes.

Note: *Active codes are flashed in ascending numerical flash code order. Inactive codes are flashed in most recent to least recent order.*

Note: *Fault codes can only be cleared using the DDR.*

DDEC Code Number (Flashed)	DESCRIPTION	DDEC Code Number (Flashed)	DESCRIPTION
11	Variable speed governor sensor input voltage low	12	Variable speed governor sensor input voltage high
13	Coolant level sensor input voltage low	14	Oil, coolant or intercooler temperature sensor input voltage high
15	Oil, coolant or intercooler temperature sensor input voltage low	16	Coolant level sensor input voltage high
17	Bypass or throttle valve position sensor input voltage high	18	Bypass or throttle valve position sensor input voltage low
21	TPS input voltage high	22	TPS input voltage low
23	Fuel temperature sensor input voltage high	24	Fuel temperature sensor input voltage low
25	No active codes	26	Auxiliary shutdown #1 or #2, input active
27	Air inlet or intake air temperature sensor input voltage high	28	Air inlet or intake air temperature sensor input voltage low
31	Auxiliary high side output open circuit or short to ground	32	Check Engine Light or Stop Engine Light short to battery (+) or open circuit
33	Turbo boost pressure sensor input voltage high	34	Turbo boost pressure sensor input voltage low
35	Oil pressure sensor input voltage high	36	Oil pressure sensor input voltage low
37	Fuel pressure sensor input voltage high	38	Fuel pressure sensor input voltage low
41	Too many SRS (missing TRS)	42	Too few SRS (missing SRS)
43	Coolant level low	44	Oil, coolant, intercooler or intake air temperature high
45	Oil pressure low	46	ECM battery voltage low
47	Fuel, air inlet or turbo boost pressure high	48	Fuel or air inlet pressure low
52	ECM A/D conversion fault	53	ECM non volatile memory fault
54	Vehicle speed sensor fault	55	J1939 data link fault
56	J1587 data link fault	57	J1922 data link fault
58	Torque overload	61	Injector response time long

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DDEC Code Number (Flashed)	DESCRIPTION	DDEC Code Number (Flashed)	DESCRIPTION
62	Auxiliary output short to battery (+) or open circuit or mechanical fault	63	PWM drive short to battery (+) or open circuit
64	Turbo speed sensor input fault	65	Throttle valve position input fault
66	Engine knock sensor input fault	67	Coolant or air inlet pressure sensor input voltage fault
68	TPS idle validation switch open circuit or short to ground	71	Injector response time short
72	Vehicle overspeed	73	Gas valve position input fault or ESS fault
74	Optimized idle safety loop short to ground	75	ECM battery voltage high
76	Engine overspeed with engine brake	77	Fuel temperature high
81	Oil level, crankcase pressure, dual fuel BOI or exhaust temperature voltage high	82	Oil level, crankcase pressure, dual fuel BOI or exhaust temperature voltage low
83	Oil level, crankcase pressure, exhaust temperature or external pump pressure high	84	Oil level low or crankcase pressure low
85	Engine overspeed	86	External pump or barometer pressure sensor input voltage high
87	External pump or barometer pressure sensor input voltage low	88	Coolant pressure low

5. ENGINE OIL LEVEL

Check the oil level daily with the engine stopped. If the engine has just been stopped and is warm, wait at least 10 minutes to allow the oil to drain back to the oil pan before checking. Wipe the dipstick clean then check oil level. The level should always be within the safe range on the dipstick (Fig. 11). Add the proper grade of oil to maintain the correct level on the dipstick. All diesel engines are designed to consume some oil, so a periodic addition of oil is normal.

Warning: Touching a hot engine can cause serious burns.

Caution: Do not overfill. Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Caution: Clean end of tube before removing the dipstick to prevent oil contamination.

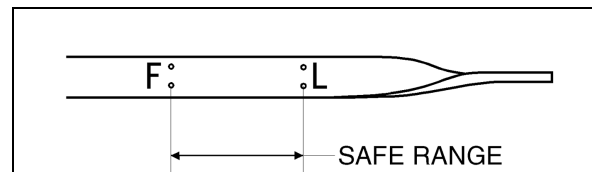


FIGURE 11: ENGINE OIL LEVEL DIPSTICK 01027

Caution: If the oil level is constantly above normal and excess lube oil has not been added to the crankcase, consult with an authorized Detroit Diesel service outlet for the cause. Fuel or coolant dilution of lube oil can result in serious engine damage.

The vehicle is provided with an oil reserve tank above the engine. To adjust oil level, open the oil reserve tank valve and allow oil to discharge into the engine until the "Full" mark on the dipstick is

reached then close the valve. Check oil reserve tank level and pour oil in the reserve tank if necessary (Fig. 12).

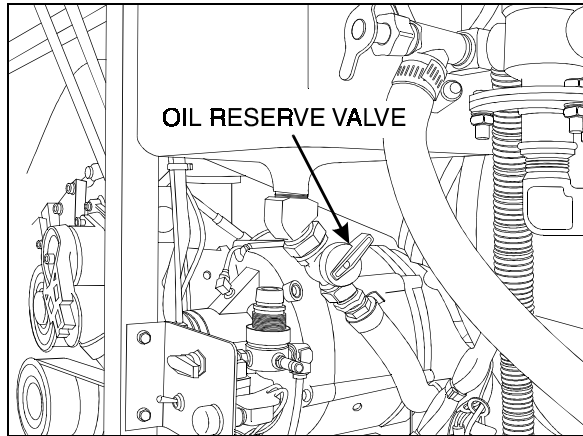


FIGURE 12: ENGINE COMPARTMENT

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6. ENGINE OIL AND FILTER CHANGE

Both the oil and filter should be changed every 12,500 miles (20,000-km) or once a year, whichever comes first. However, changes that are more frequent may be required when the engine is subject to high levels of contamination and/or overheating. Change intervals may be decreased or gradually increased with experience on specific lubricants until the most practical service condition has been established. Always refer to the lubricant manufacturer's recommendations (analysis of drained oil can be helpful).

Caution: Do not use solvents to dilute the engine oil when draining. Dilution of fresh oil can occur which may be detrimental to the engine.

Change engine oil with the vehicle on a flat and level surface and with the parking brake applied. It is best to drain the oil when the engine is still warm.

1. From under the vehicle, remove the engine drain plug on the oil pan. Allow oil to drain (Fig. 13).

Warning: Hot engine oil can cause serious burns. Wear coveralls with sleeves pulled down and gloves to protect hands.

2. Reinstall the drain plug.

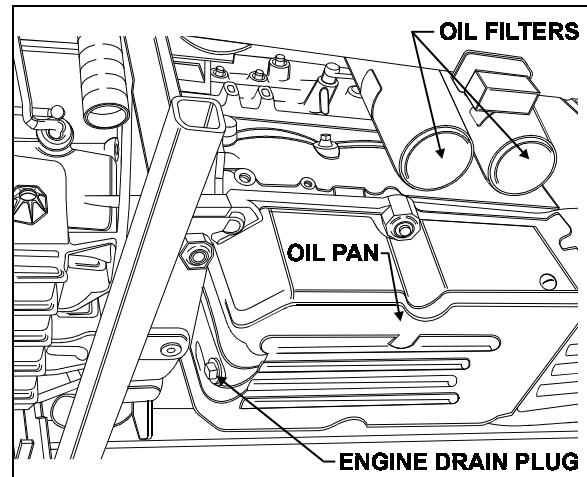


FIGURE 13: UNDER VEHICLE VIEW

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3. Remove the spin-on filter cartridge using a 1/2" drive socket wrench and extension.
4. Dispose of the used oil and filter in an environmentally responsible manner in accordance with state and/or federal (EPA) recommendations.
5. Clean the filter adapter with a clean rag.
6. Lightly coat the filter gasket (seal) with clean engine oil.
7. Install the new filter on the adapter and tighten manually until the gasket touches the mounting adapter head. Tighten full-flow filters an additional two-thirds of a turn manually. Then, manually tighten bypass filter one full turn.

Caution: Overtightening may distort or crack the filter adapter.

8. Remove the engine-oil filler cap and pour oil in the engine until it reaches the "FULL" mark on the dipstick (Fig. 11).
9. Start and run the engine for a short period and check for leaks. After any leaks have been corrected, stop the engine long enough for oil from various parts of the engine to drain back to the crankcase (approximately 20 minutes).
10. Add oil as required to bring the level within the safe range on the dipstick (Fig. 11).

7. RECOMMENDED ENGINE OIL TYPE

To provide maximum engine life, lubricants shall meet the following specifications: SAE Viscosity Grade: 15W-40 API Classification: CH-4.

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Note: Monograde oils should not be used in these engines regardless of API Service Classification.

Note: The use of supplemental oil additives is discouraged from use in Detroit Diesel Engines.

Synthetic oils: Synthetic oils may be used in Detroit Diesel engines provided they are API-licensed and meet the performance and chemical requirements of non-synthetic oils outlined previously. Synthetic oils do not permit extension of recommended oil drain intervals.

Lubricant Selection World Wide: Oils meeting API CD or CC specifications may be used if they also meet military specification MIL-L-2104 D or E. Oils which meet European CCMC D4 specifications may also be used.

Modification of drain interval may be necessary, depending on fuel quality. Contact Detroit Diesel Corporation for further guidance.

8. POWER PLANT ASSEMBLY REMOVAL

To access the engine or engine-related components, the vehicle power plant assembly must be removed as a whole unit by means of a slide-out cradle. The power plant assembly includes the engine, transmission (including retarder if so equipped), air compressor, alternator and transmission oil cooler.

Remove the power plant assembly as follows:

Caution: Tag hoses and cables for identification before disconnecting in order to facilitate reinstallation. Plug all openings to prevent dirt from entering the system.

Note: No parts within the ECM are serviceable. If found defective, replace the complete ECM unit.

1. Disconnect the battery or batteries from the starting system by removing one or both of the battery cables from each battery system. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start. In addition, the Electronic Unit Injectors (EUI) will be disabled, preventing any fuel delivery to the injector tips.

Warning: Due to the heavy load of the rear bumper assembly, it must be adequately supported before attempting to remove it.

2. Remove the rear bumper assembly from the vehicle. Refer to Section 18, BODY, under "REAR BUMPER REMOVAL AND INSTALLATION".
3. Drain the engine cooling system. Refer to Section 05, COOLING under "DRAINING COOLING SYSTEM".

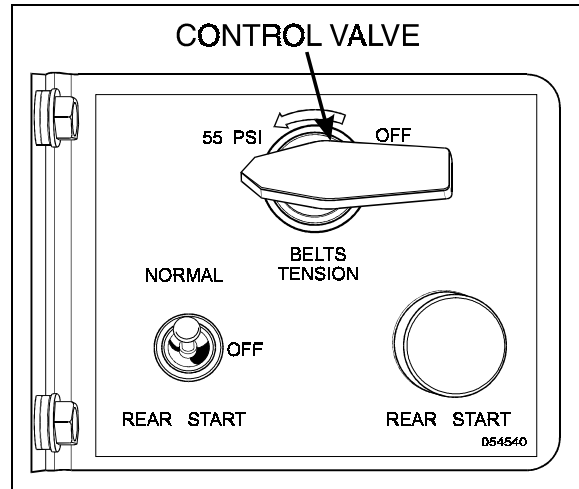


FIGURE 14: ENGINE COMPARTMENT

01044

4. Locate the belt tensioner control valve (Fig. 14). Turn handle clockwise in order to release pressure in belt-tensioner air bellows and loosen belts. Remove the belts.
5. Release all pressure from the air system. Refer to Section 12, BRAKES & AIR SYSTEM for instructions.
6. Disconnect and remove the engine-air intake duct mounted between air cleaner housing and turbocharger inlet (1, Fig. 16).

Caution: To avoid damage to turbocharger, cover the turbocharger inlet opening to prevent foreign material from entering.

7. Disconnect and remove the air intake duct mounted between the air cooler outlet and the engine intake (2, Fig. 16).
8. Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet (3, Fig. 16).
9. Disconnect the coolant delivery hose located close to the water pump.
10. Disconnect the electric fan-clutch connector, close to the water pump (Fig. 15).

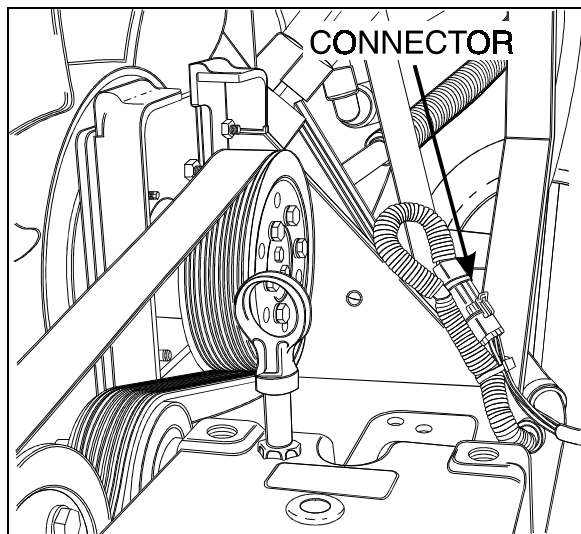


FIGURE 15: ENGINE COMPARTMENT

01069

11. Dismantle the air bellow from the upper bracket of the fan-drive assembly tensioner. Remove the upper bracket (4, Fig. 16).
 12. If necessary, remove the fan drive from the motor compartment by removing the four retaining bolts, washers and nuts securing the fan drive to the floor.
 13. Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet (5, Fig. 16).
 14. Disconnect two vent hoses from the thermostat housing and from the coolant pipe assembly.
 15. Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housings and the radiator inlet.
 16. Disconnect and remove the small hose connected to the heater line valve and to the water pump.
 17. Disconnect the small heater hose located on the cylinder head at the back of the engine.
 18. Disconnect and remove the exhaust pipe mounted between the turbocharger outlet and the exhaust bellows. If necessary, refer to Section 04: EXHAUST SYSTEM under "Muffler Removal And Installation".
- Caution:** To avoid damage to turbocharger, cover the turbocharger outlet opening to prevent foreign material from entering.
19. Disconnect the block heater connector above the power steering pump (6, Fig. 16).
 20. Disconnect the steel-braided airline from the A/C compressor air bellows.
 21. Disconnect the oil delivery hose from the valve located at the reserve tank drain (7, Fig. 16).
 22. Disconnect the power steering pump supply and discharge hoses. Cap hose openings immediately to limit fluid loss. Remove retaining clips from cradle (8, Fig. 16).
 23. Close engine fuel supply shutoff valve on primary fuel filter. Disconnect the fuel line connected to inlet port. On vehicles equipped with the optional water-separator-fuel-filter, disconnect the connector and remove cable ties from cradle.
 24. Disconnect the air compressor discharge, governor steel-braided airlines and manual filling airlines from compressor. Remove retaining clips.
 25. Disconnect the hose connecting the compressor head to the sump tank.
 26. Disconnect ground cables from rear subframe ground-stud located close to the starter motor.
 27. Disconnect positive cable (red terminal) from starting motor solenoid.
 28. Disconnect the power plant wiring-harness main connectors from ECM and remove retaining clips from engine compartment backwall.
 29. On vehicles equipped with an automatic transmission provided with a hydraulic output retarder, disconnect steel-braided airline from pressure regulator output. The pressure regulator is mounted in the upper section of engine compartment backwall and is accessible through the engine compartment R.H. side door.
 30. Disconnect fuel return line from bulkhead fixed on engine cylinder head end.
 31. On vehicles equipped with an electrically operated cold-starting aid, disconnect the delivery hose from the starting-aid cylinder solenoid valve. Remove cable ties securing hoses.
 32. Disconnect turbo boost pressure gauge airline from engine air intake.

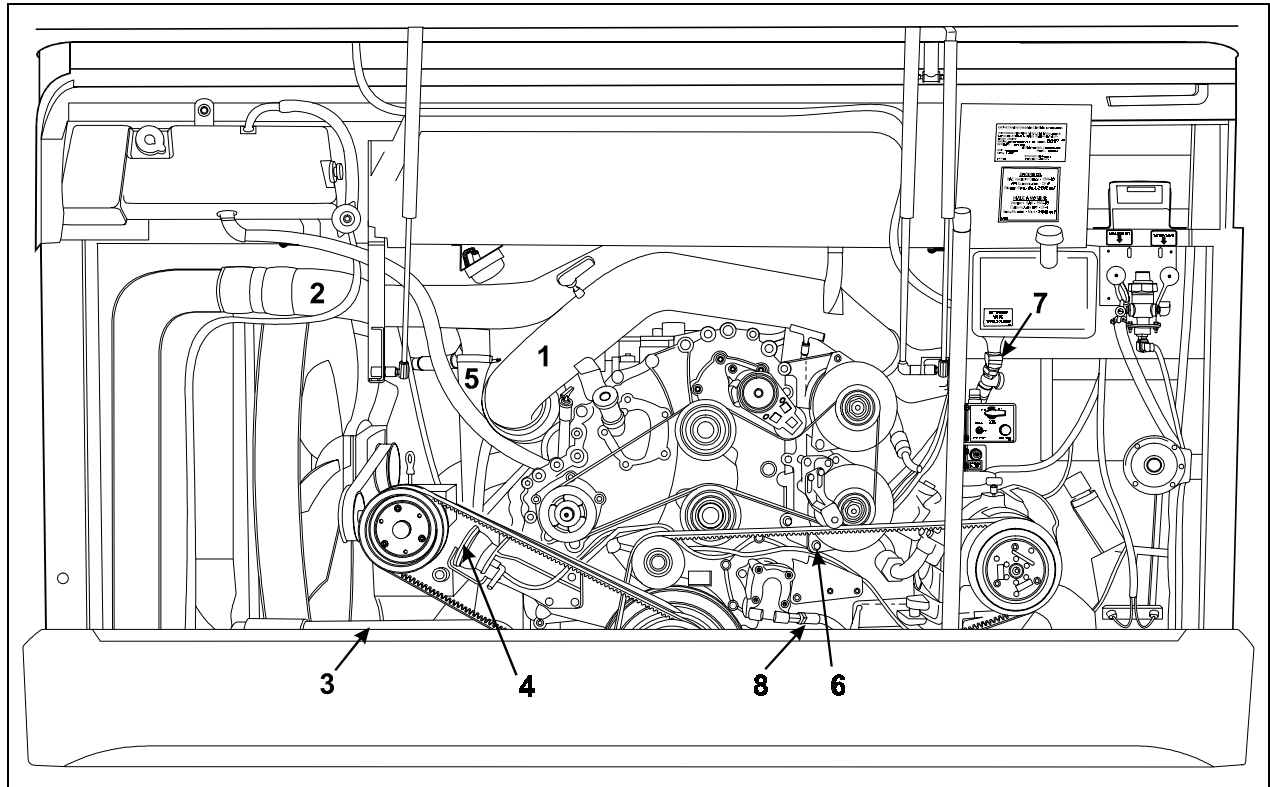


FIGURE 16: ENGINE COMPARTMENT

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33. Only if the vehicle is equipped with a retarder, remove the transmission rubber-damper assembly above transmission by removing: nut, bushing, rubber damper, rubber damper guide, bolt and washer. Remove the rubber damper bracket from transmission
34. Disconnect connectors from transmission. On the left side: four on rear side with one close to yoke. On right side: close to the solenoid valve of the output retarder.
35. From under the vehicle, disconnect the propeller shaft as detailed in Section 09, under heading "Propeller Shaft Removal".
36. Inspect the power plant assembly to ensure that nothing will interfere when sliding out the cradle. Check for connections or hoses not mentioned in this list as some vehicles are equipped with special or aftermarket components.
37. Remove the six retaining bolts, washers and nuts securing the power plant cradle to the vehicle rear subframe (Fig. 18).

Note: Check if any spacer(s) have been installed between power plant cradle and vehicle rear subframe, and if so, note position of each washer for reinstallation purposes.

38. Using a forklift, with a minimum capacity of 4,000 lbs (1 800 kg), slightly raise the power plant cradle.
39. Pull engine out slowly from the engine compartment. Make sure all lines, wiring and accessories are disconnected and are not tangled.

Caution: Due to the minimum clearance between the power plant equipment and the top of the engine compartment, extreme care should be used to raise the power plant cradle, just enough to free the cradle. Clearance between power plant cradle and mounting rail should range between 1/4" and 1/2" (6-12 mm).

9. POWER PLANT ASSY. INSTALLATION

To install a power plant assembly, follow the same procedure as in "Power Plant Assembly Removal" except in reverse order, then proceed with the following:

1. Torque the power plant cradle mounting bolts to 113-144 lbf•ft (153-195 N•m).
 - For vehicles equipped with an Allison automatic transmission and a retarder:

- a) Install transmission bracket (Fig. 17), tighten to 71-81 lbf·ft (96-110 N·m).
 - b) Install the transmission's rubber damper assembly above transmission by assembling: bolt, washer, rubber damper guide, rubber damper, bushing nut.
 - c) Respect damper tolerance of 58 mm (Fig. 17).
2. If fan drive has been removed, reinstall and align as per Section 05, COOLING SYSTEM, under "FAN DRIVE ALIGNMENT".
 3. Refill cooling system with saved fluid (refer to Section 05, COOLANT SYSTEM).
 4. Once engine fuel system has been drained, it will aid restarting if fuel filters are filled with fuel oil (refer to Section 03, FUEL SYSTEM).

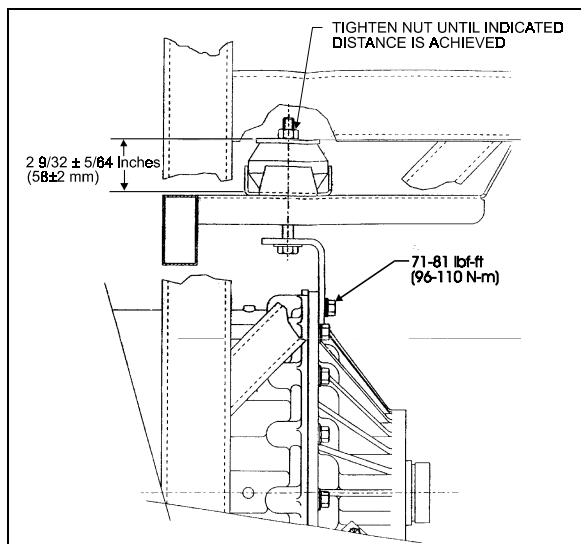


FIGURE 17: RUBBER DAMPER TOLERANCE 07014

5. Start engine for a visual check. Check fuel, oil, cooling, pneumatic and hydraulic system connections for leakage. Test operation of engine controls and accessories.

10. VALVE COVER REMOVAL

The following instructions explain how to remove the valve cover for valve, injector or Jake Brake maintenance, without having to remove the engine:

1. Remove air intake duct (1, Fig. 16).
2. Remove the air intake duct mounted between the air cooler outlet and the engine intake (2, Fig. 16).
3. Disconnect ventilation pipe from valve cover.

4. Remove engine cover.
5. Adjust Jake Brake (if applicable), injectors and valves following instructions in the Detroit Diesel service manual for series 60 engines.
6. Verify engine cover gasket and replace if necessary.

Note: New gasket must be ordered directly from Detroit Diesel.

7. Reinstall engine cover and tighten bolts to 18-22 Lbf·ft (25-30 N·m), in a criss-cross pattern.
8. Reconnect ventilation pipe to engine cover.
9. Reinstall air ducts.

11. JAKE BRAKE

Refer to both "The Jake Brake Troubleshooting and Maintenance Manual" and "Jake Brake Series 60 Service Manual" for troubleshooting and installation procedures. They are annexed at the end of this section.

12. ENGINE MOUNTS

The power plant assembly on a vehicle powered with a series 60 engine is mounted to the cradle by means of four rubber mounts.

Two rubber mounts are used at the front of the engine while two others are mounted on each side of the flywheel housing (Fig. 18).

It is recommended that new rubber mounts be installed at each major overhaul.

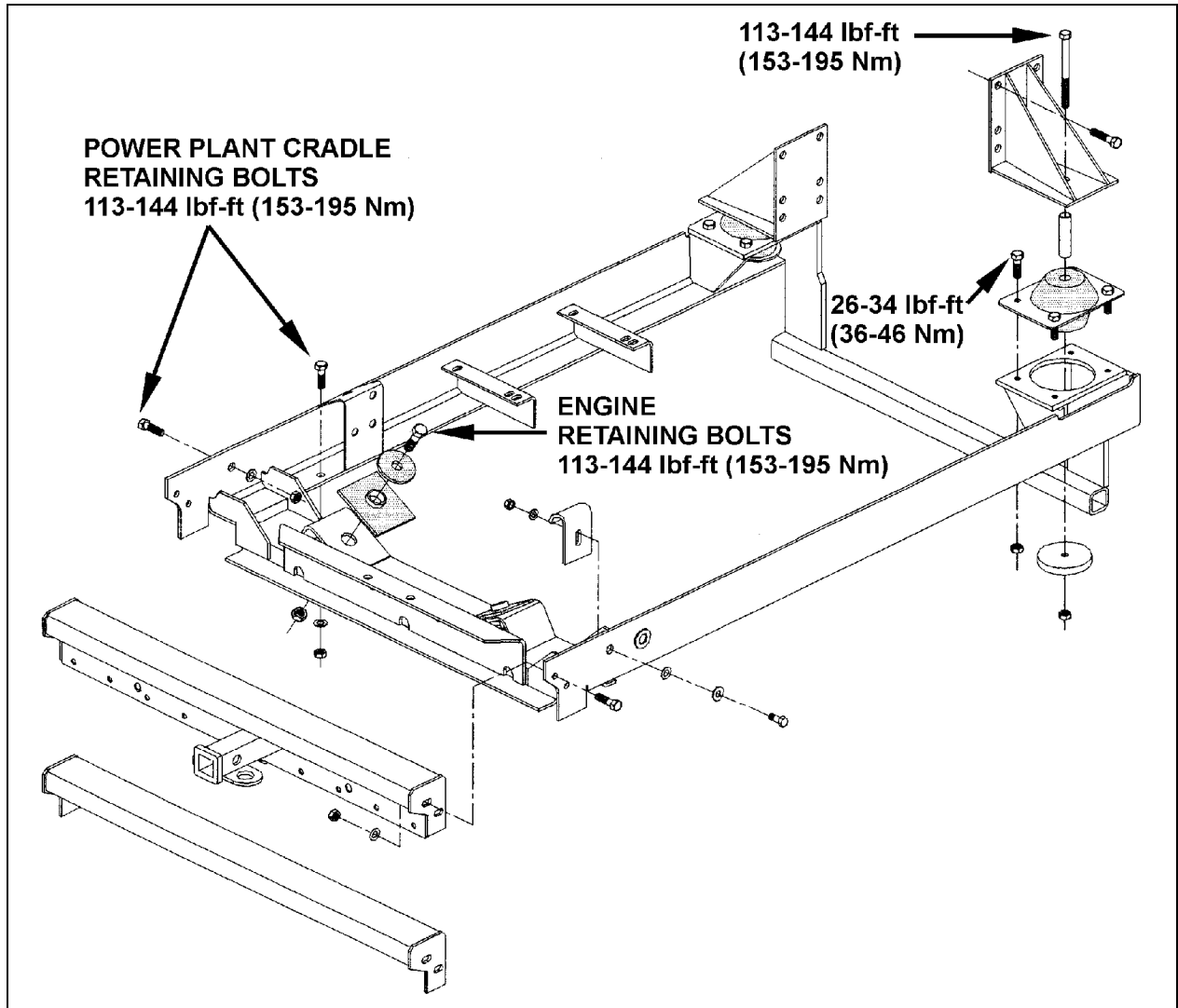
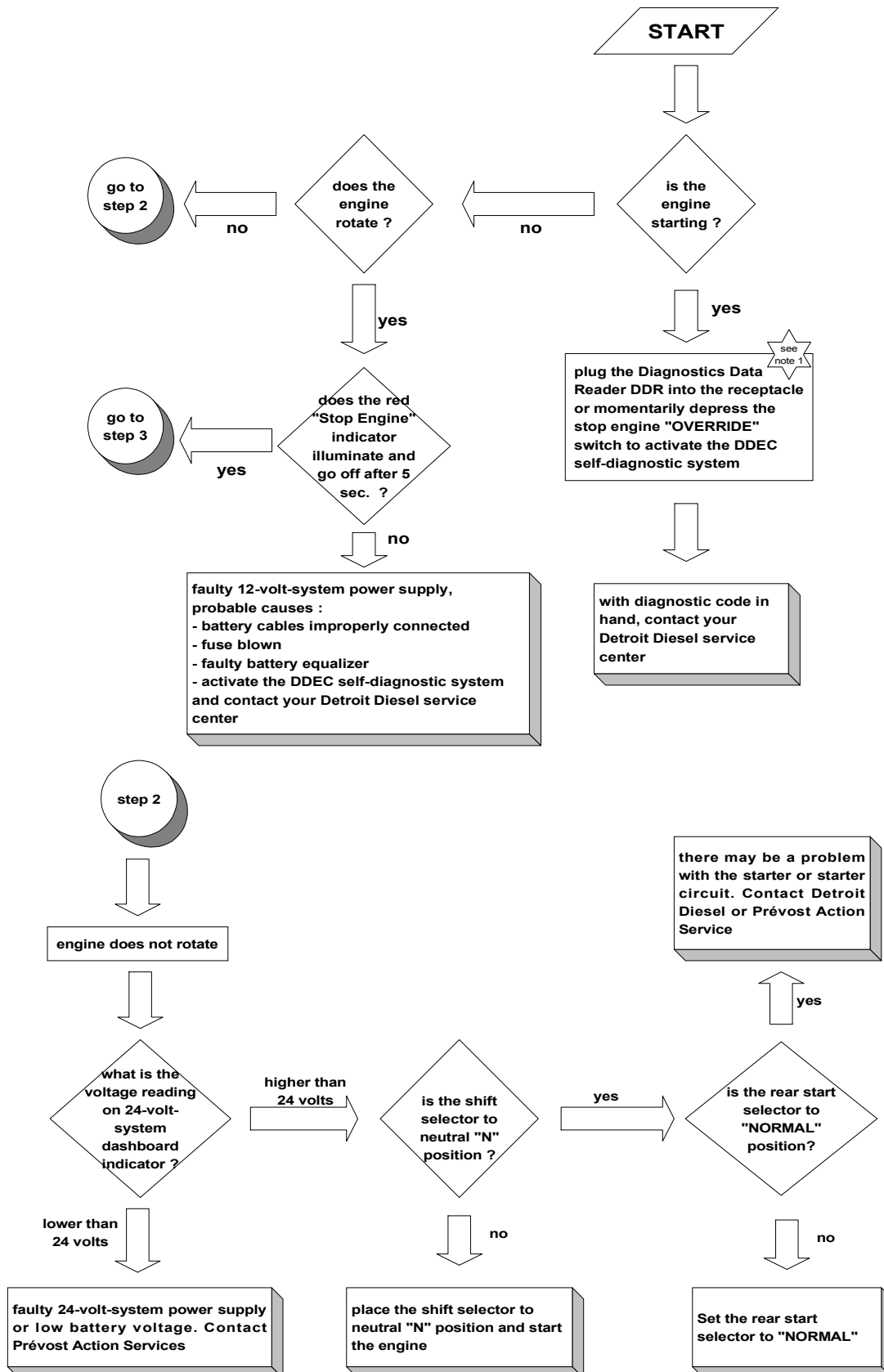


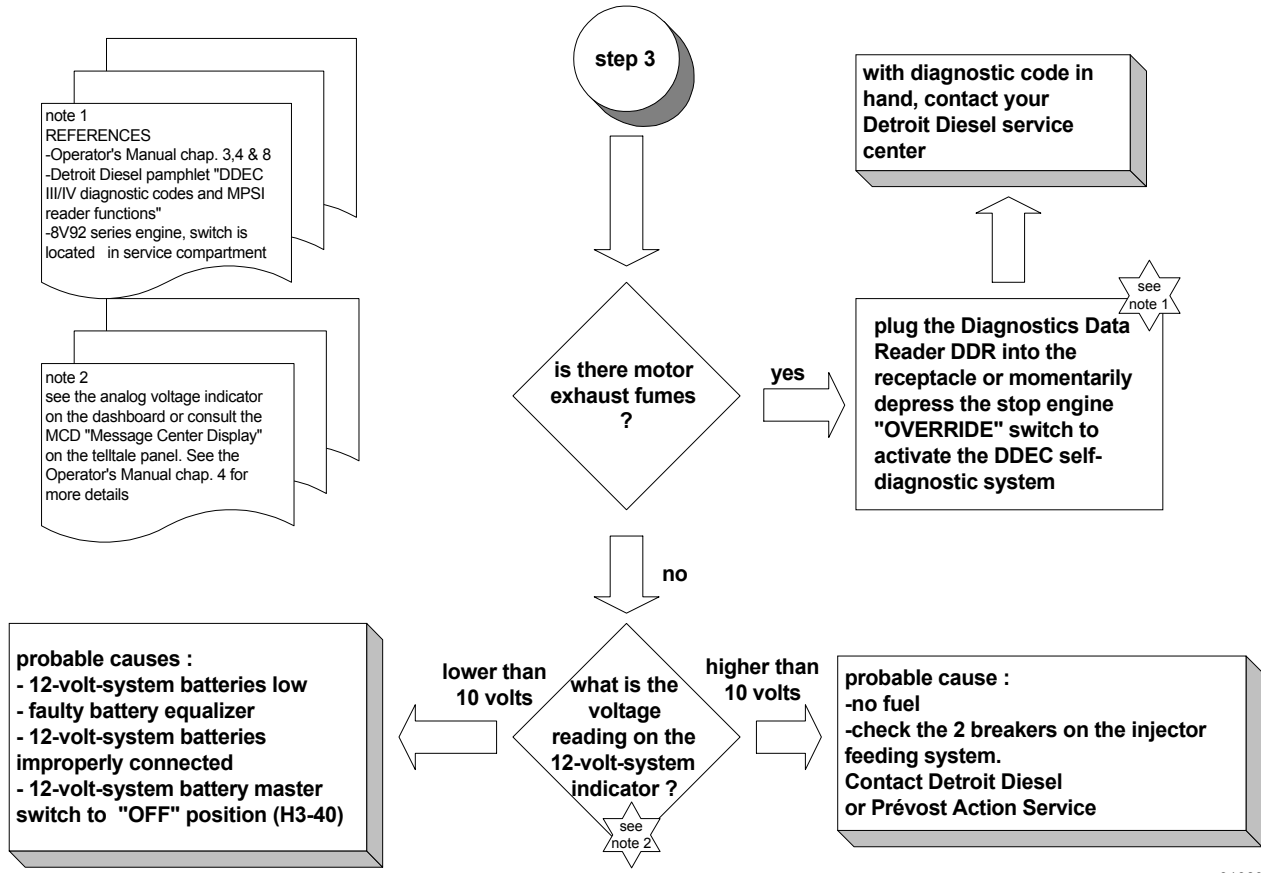
FIGURE 18: POWER PLANT CRADLE INSTALLATION

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13. ENGINE TROUBLESHOOTING GUIDE



Section 01: ENGINE



01089

14. SPECIFICATIONS

Series 60 Engine

Make	Detroit Diesel
Type	Diesel four cycle/in-line engine
Description	Turbo/Air to air charge cooled
No. of cylinders.....	6
Operating range	1200-2100 RPM
Maximum RPM.....	2100
Displacement, 12.7 Liters:	
Bore & Stroke.....	5.12 X 6.30 in (130 X 160 mm)
Horsepower Range	330 BHP, 400 BHP, 500 BHP

Lubricant

Heavy-duty engine oil SAE Viscosity Grade 15W-40, API Classification CH-4 and meeting MIL-L-2104 D or E specifications. Synthetic oil may be used if it meets the performance and chemical requirements of non-synthetic oils outlined previously. Some engine operating conditions may require exceptions to this recommendation.

Caution: To avoid possible engine damage, do not use single grade (Monograde) lubricants in Detroit Diesel four-cycle Series 60 engines, regardless of API classification.

Capacity

Oil reserve tank 10 US qts (9.5 L)

Engine oil level quantity

Oil Pan Capacity, Low Limit 26 quarts/25 liters

Oil Pan Capacity, High Limit..... 32 quarts/30 liters

Total Engine Oil Capacity with Filters..... 41 quarts/39 liters

Lubricating oil filter elements

MakeAC Rochester Div. GMC # 25014505

MakeA/C Filter # PF-2100

Type Full Flow

Prévost number510458

Torque specification

Engine oil filter.....Tighten 2/3 of a turn after gasket contact

Filters

Engine Air Cleaner Filter

MakeNelson # 70337-N

Prévost number530197

Engine Coolant Filter/Conditioner

MakeNalco Chemical Company # DDF3000

Make Detroit Diesel # 23507545

Prévost number.....550630

Note: For primary and secondary fuel filters, refer to Specifications in section 03.

4. Install the bolts that secure the accessory drive housing to the gear case cover and tighten to 30–38 N·m (22–28 lb·ft) torque using the pattern shown. See Figure 1–413.

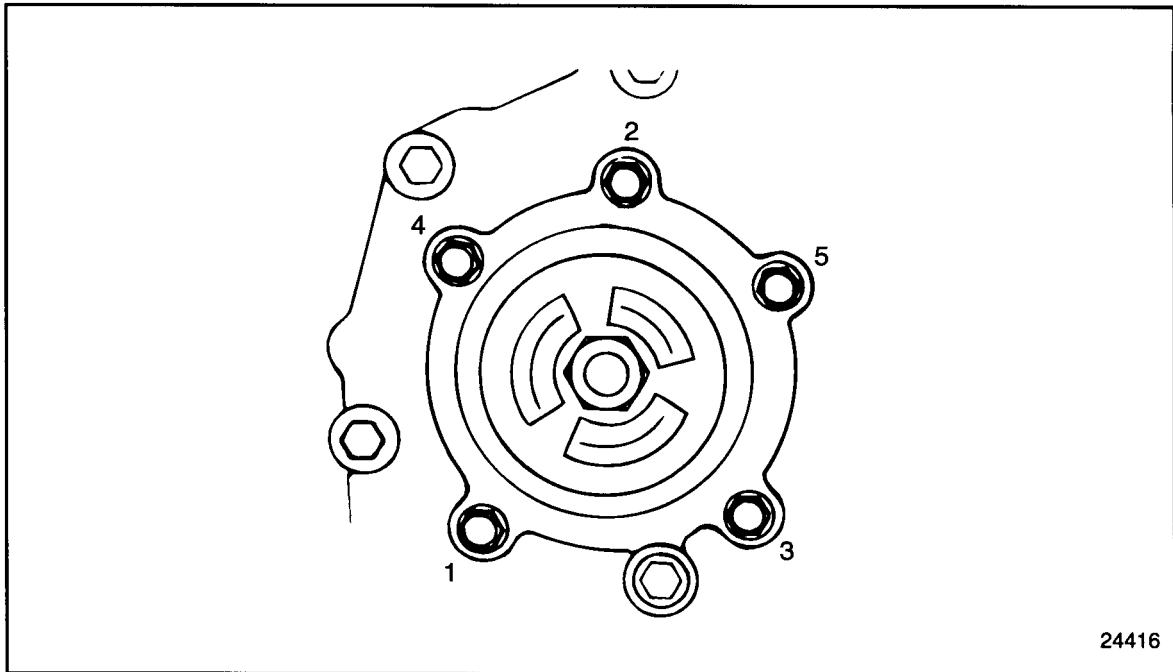


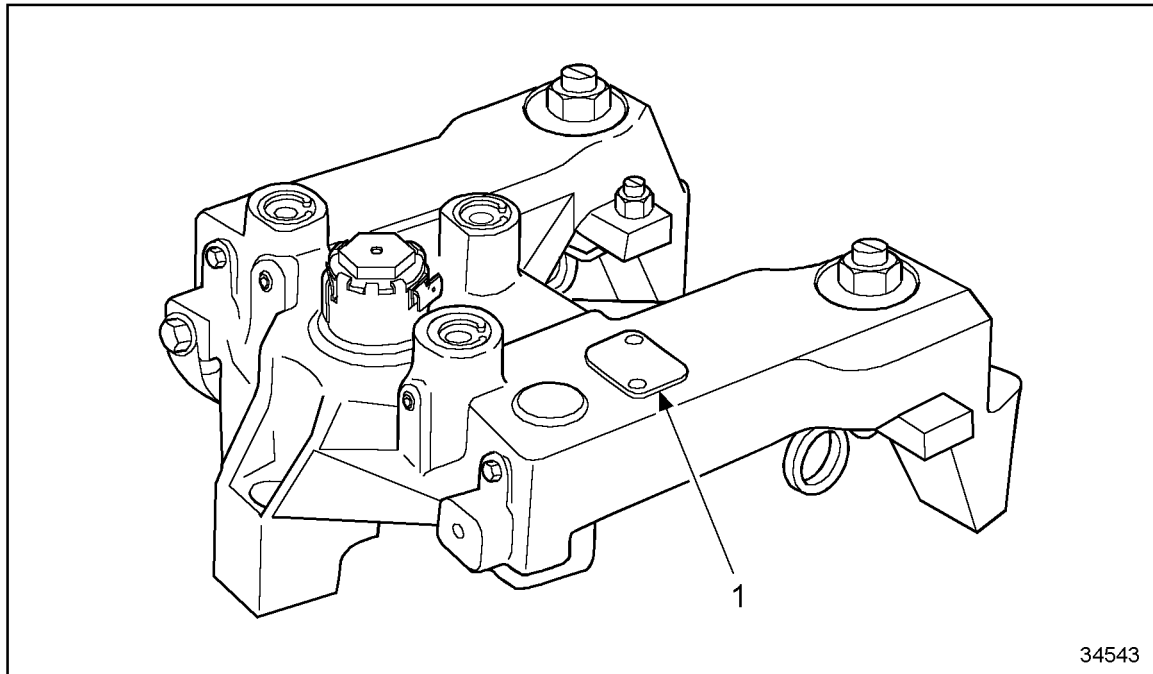
Figure 1-413 Accessory Drive Housing Bolt Torque Sequence

5. Check the bull gear-to-accessory drive gear backlash. Refer to section 1.21.2.1.
6. Adjust the alternator belts. Refer to section 13.12.10.
7. Tighten the alternator mounting bolts.
8. Install any other components removed for this procedure.
9. Refer to section 11.3 for verification of proper accessory drive installation.

1.29 JAKE BRAKE

The engine brake has been designed to fit on the Series 60 engine with no additional valve cover spacers. There are three styles of valve covers for the Series 60 engine. On engines equipped with a two-piece aluminum valve cover, it is NOT necessary to remove the lower valve cover to install the engine brake. However, one style of upper valve cover may require modification at the breather housing location (inside) for engine brake clearance.

The model, part number and serial number are located on the nameplates at the top of each housing. See Figure 1-414.



1. Identification Plate

Figure 1-414 Nameplate Location on Housing

NOTICE:

Only the specific brake model can be used with the engine model it was designed for. Also, the correct slave piston adjustment specification must be used. Failure to follow these instructions may result in serious engine or engine brake damage.

Listed in Table 1-9 are the different Jake Brake models used and the slave piston adjustment specification.

Model Number	Model Year	Engine Displacement	Engine Brake	Slave Piston Adjustment
6067WU40	Pre-1991	11.1L	760/760A	0.660 mm (0.026 in.)
6067GU40	Pre-1991	12.7L	760/760A	0.508 mm (0.020 in.)
6067WU60	1991	11.1L	760/760A	0.660 mm (0.026 in.)
6067GU40	1991	12.7L	765	0.660 mm (0.026 in.)
6067GU28	1991	12.7L	765	0.660 mm (0.026 in.)
6067GU91	1991	12.7L	765	0.660 mm (0.026 in.)
6067WK60	1994	11.1L	760A	0.660 mm (0.026 in.)
6067GK60	1994	12.7L	765	0.660 mm (0.026 in.)
6067GK28	1994	12.7L	765	0.660 mm (0.026 in.)
6067EK60	1998	11.1L	760B	0.584 mm (0.023 in.)
6067PK60	1998	12.7L	765A	0.584 mm (0.023 in.)
6067TK60	1998	12.7L	765A	0.584 mm (0.023 in.)
6067TK45	1998	12.7L	765A	0.584 mm (0.023 in.)
6067MK60	1998	12.7L	770	0.660 mm (0.023 in.)
6067BK60	1998	12.7L	770	0.660 mm (0.023 in.)
6067HKXX	1998 (Non-Line Haul)	14L	770	0.660 mm (0.023 in.)
6067MK28, 6067MK45, 6067MK57, 6067MK60	2000	12.7L Standard	790	0.660 mm (0.026 in.)
6067BK28, 6067BK45, 6067BK57, 6067BK60	2000	12.7L Premium	790	0.660 mm (0.026 in.)
6067HK45, 6067HK60	2000	14L U.S.	790A	0.660 mm (0.026 in.)
6067WK28, 6067WK60	2000	11.1L	790B	0.660 mm (0.026 in.)
6067LK28, 6067LK45, 6067LK60	2000	11.1L	790B	0.660 mm (0.026 in.)
6063GK60, 6067GK28, 6067GK45, 6067GK91, 6067PK62, 6067TK28, 6067TK60, 6067TK62	2000	12.7L	790B	0.660 mm (0.026 in.)
6067HK62	2000	14L Australian	790C	0.660 mm (0.026 in.)

All slave piston adjustments shown here are current as of the date of this manual and supersede all previous adjustments.

XXXX = Model numbers to be determined.

Table 1-9 Jake Brake Model Information

NOTE:

All engines built after serial number 06R0004455 have the correct engine parts for engine brake installation. The model numbers have changed because of design changes in the engine brakes.

NOTE:

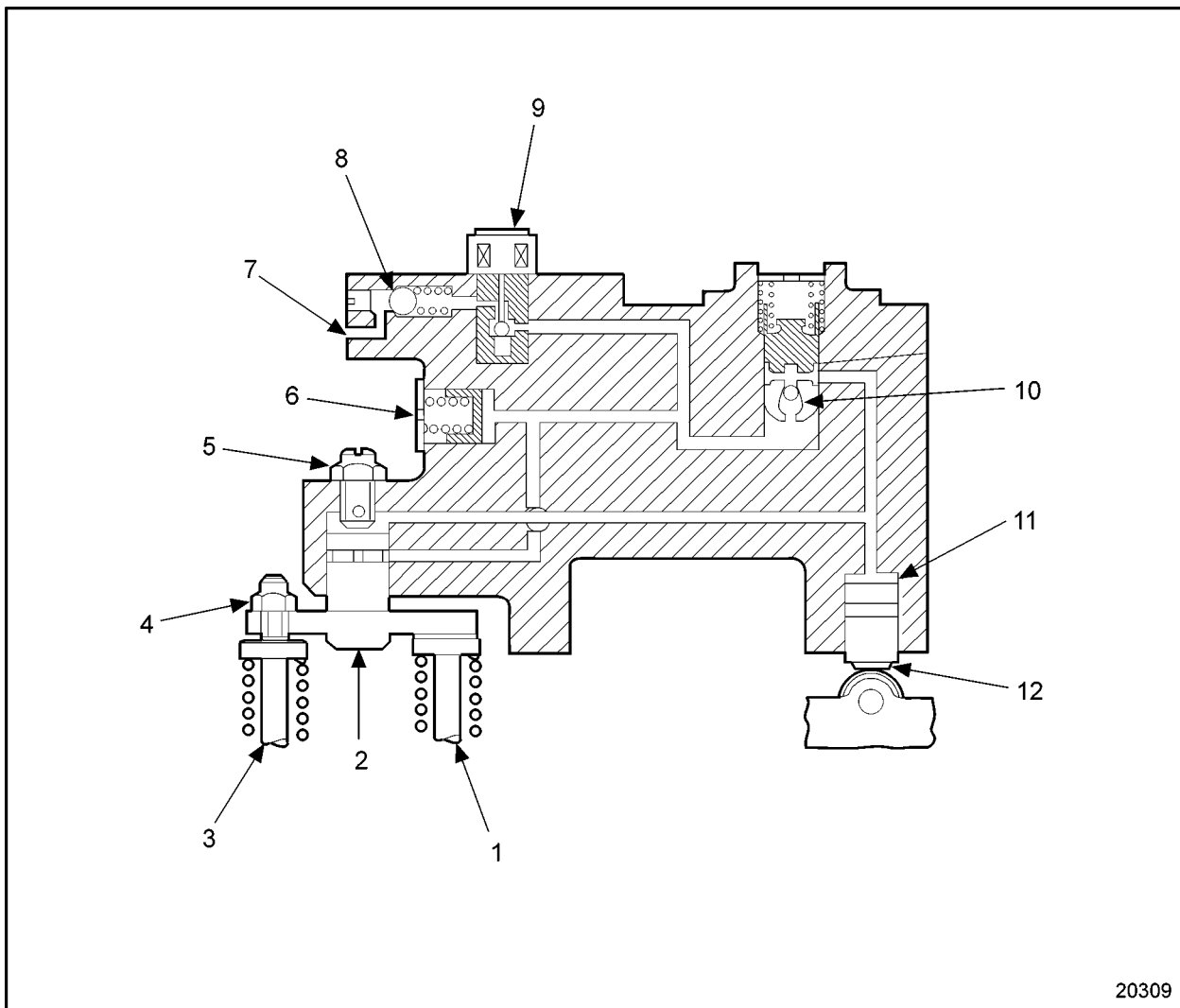
All Series 60 engines with serial numbers 06R0004455 or higher are Jake Brake ready. Do not install a Jake Brake on engines with lower serial numbers.

Effective December 16, 1999, Model 790 Jake Brakes are used on all Series 60 engines requiring an engine brake.

Former Jake Brake production models for the Series 60 engine were the 760A (which replaced model 760), 760B, 765, 765A, and 770.

Detroit Diesel engine model Nos. 6067GU28 and 6067GK28 are for bus/coach applications. Due to interference fits on some coach chassis, a two-housing Jake Brake kit may be required. Contact your Detroit Diesel Distributor for information on these kits.

Energizing the engine brake effectively converts a power-producing diesel engine into a power-absorbing air compressor. This is accomplished through motion transfer using a master-slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke, releasing the compressed cylinder charge to exhaust. See Figure 1-415.



- | | |
|---------------------------------|-----------------------------|
| 1. Exhaust Valve | 7. Oil In |
| 2. Slave Piston Assembly | 8. Check Valve (Model 760) |
| 3. Exhaust Valve | 9. Solenoid Valve |
| 4. Leveling Screw | 10. Control Valve |
| 5. Slave Piston Adjusting Screw | 11. Master Piston |
| 6. Accumulator | 12. Injector Pin and Roller |

Figure 1-415 Jake Brake Schematic

The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the expansion stroke, the effect being a net energy loss, since the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown occurs as 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. See Figure 1-415.

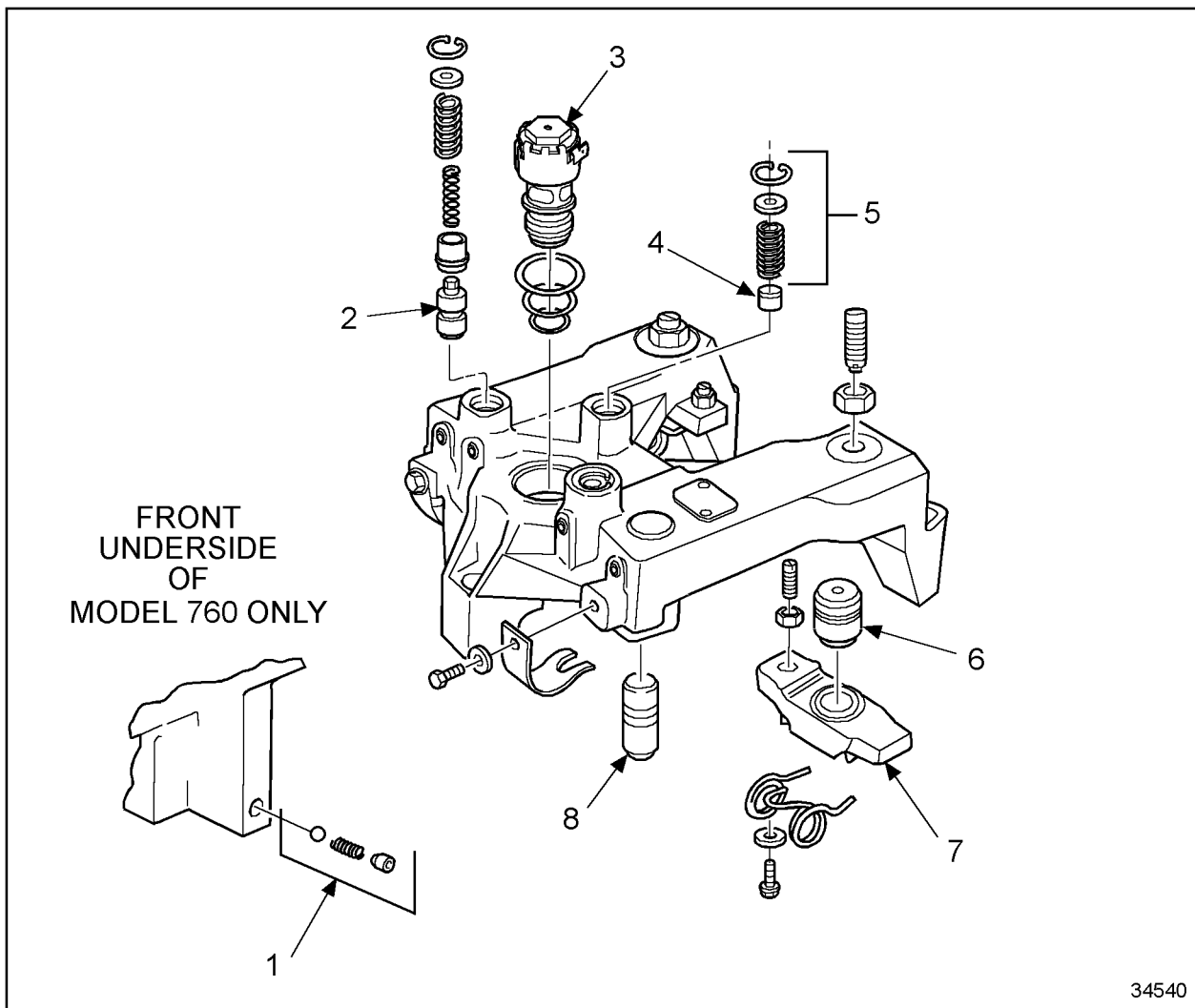
Oil pressure causes the master piston to move down, coming to rest on the injector rocker arm roller.

The injector rocker arm begins its travel as in the normal injection cycle, moving the master piston upward and directing high-pressure oil to the slave piston. The ball check valve in the control valve traps high-pressure oil in the master-slave piston system.

High pressure oil causes the slave piston to move down, momentarily opening the exhaust valves, while the engine piston is near its top-dead-center position, releasing compressed cylinder air to the exhaust manifold.

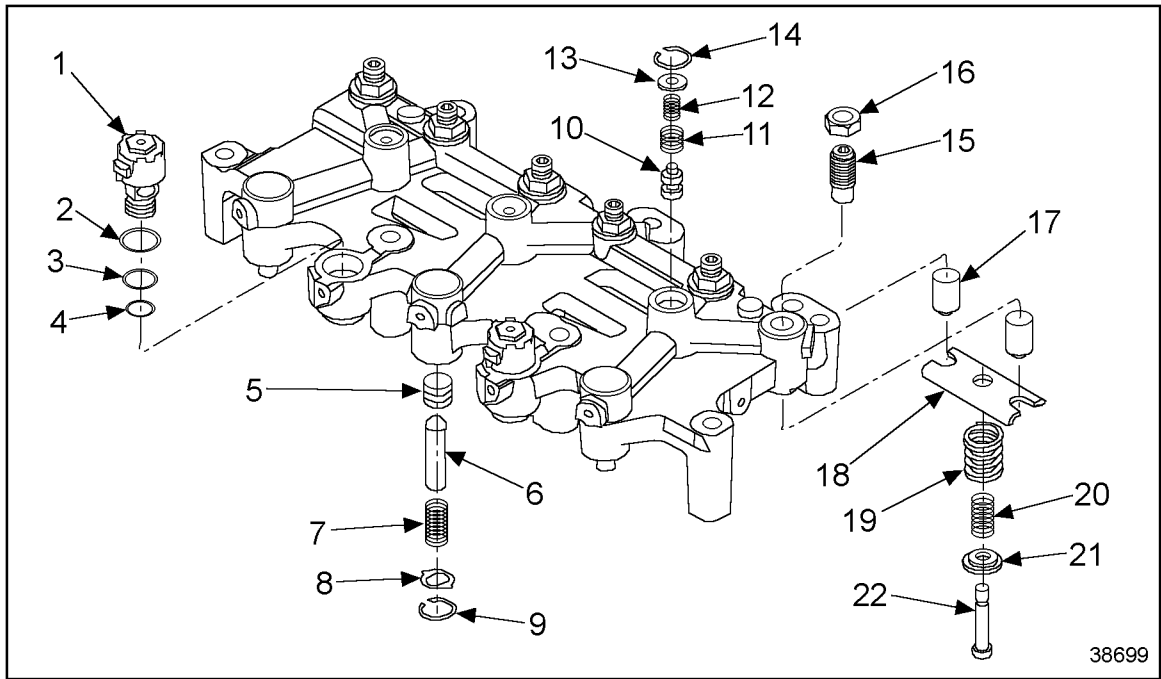
At the bottom of its stroke, the slave piston separates from the valve in the slave piston adjusting screw, allowing high pressure oil to flow into the accumulator. This reduces the pressure in the high pressure circuit, permitting the slave piston to retract and the exhaust valves to close in preparation for the normal exhaust valve cycle. The oil pressure reserved in the accumulator ensures that the hydraulic circuit is fully charged for the next cycle. Compressed air escapes to the atmosphere, completing a compression braking cycle.

The Jake Brake is electronically controlled. Jake Brake control system wiring will vary depending on the vehicle manufacturer. For a general overview of the Jake Brake, see Figure 1-416 and see Figure 1-416a.



- | | |
|--------------------------------------|------------------------|
| 1. Ball Check Valve (Model 760 Only) | 5. Power Lash Assembly |
| 2. Control Valve | 6. Slave Piston |
| 3. Solenoid Valve | 7. Bridge |
| 4. Accumulator Piston | 8. Master Piston |

Figure 1-416 Typical Model 760, 765, or 770 Jake Brake Assembly



- | | |
|--------------------------------|--------------------------------|
| 1. Solenoid Valve | 12. Inner Control Valve Spring |
| 2. Upper Seal | 13. Washer |
| 3. Center Seal | 14. Retaining Ring |
| 4. Lower Seal | 15. J-Lash® Screw |
| 5. Master Piston | 16. Locknut |
| 6. Master Piston Pushrod | 17. Slave Piston |
| 7. Master Piston Spring | 18. Slave Piston Bridge |
| 8. Washer | 19. Outer Slave Piston Spring |
| 9. Retaining Ring | 20. Inner Slave Piston Spring |
| 10. Control Valve | 21. Slave Piston Spring Seat |
| 11. Outer Control Valve Spring | 22. Shoulder Bolt |

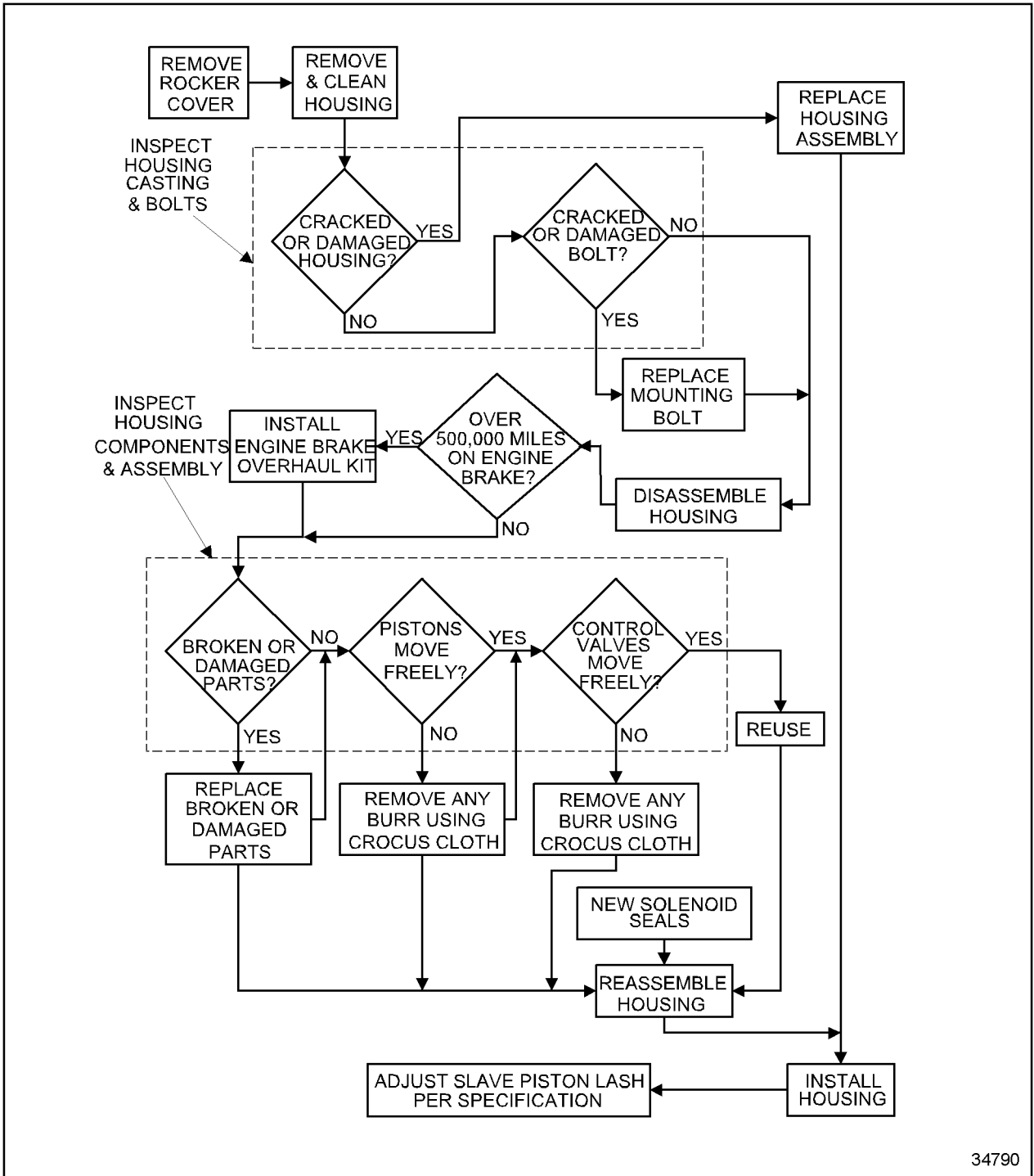
Figure 1-416a Typical Model 790 Jake Brake Assembly

NOTICE:

This application and adjustment information must be strictly followed. Failure to follow these instructions may result in serious engine or engine brake damage.

1.29.1 Repair or Replacement of Jake Brake

To determine if repair is possible or replacement is necessary, perform the following procedure. See Figure 1-417.



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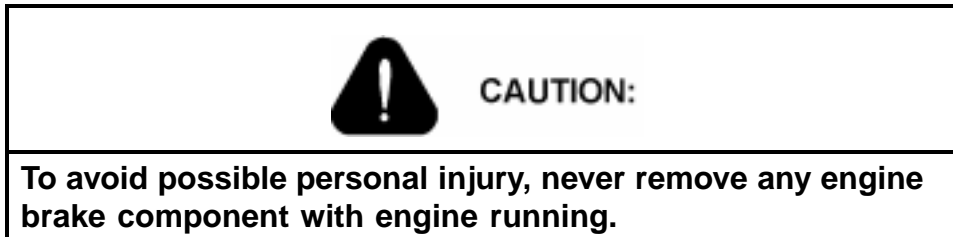
Figure 1-417 Jake Brake Repair or Replacement Flowchart

1.29.2 Removal of Model 760, 765, or 770 Jake Brake

Remove the model 760, 765, or 770 Jake Brake as follows:

NOTE:

The following procedures apply to Model 760, 765, and 777 Jake Brakes. For Model 790 Jake Brake removal procedures, refer to section 1.29.6.

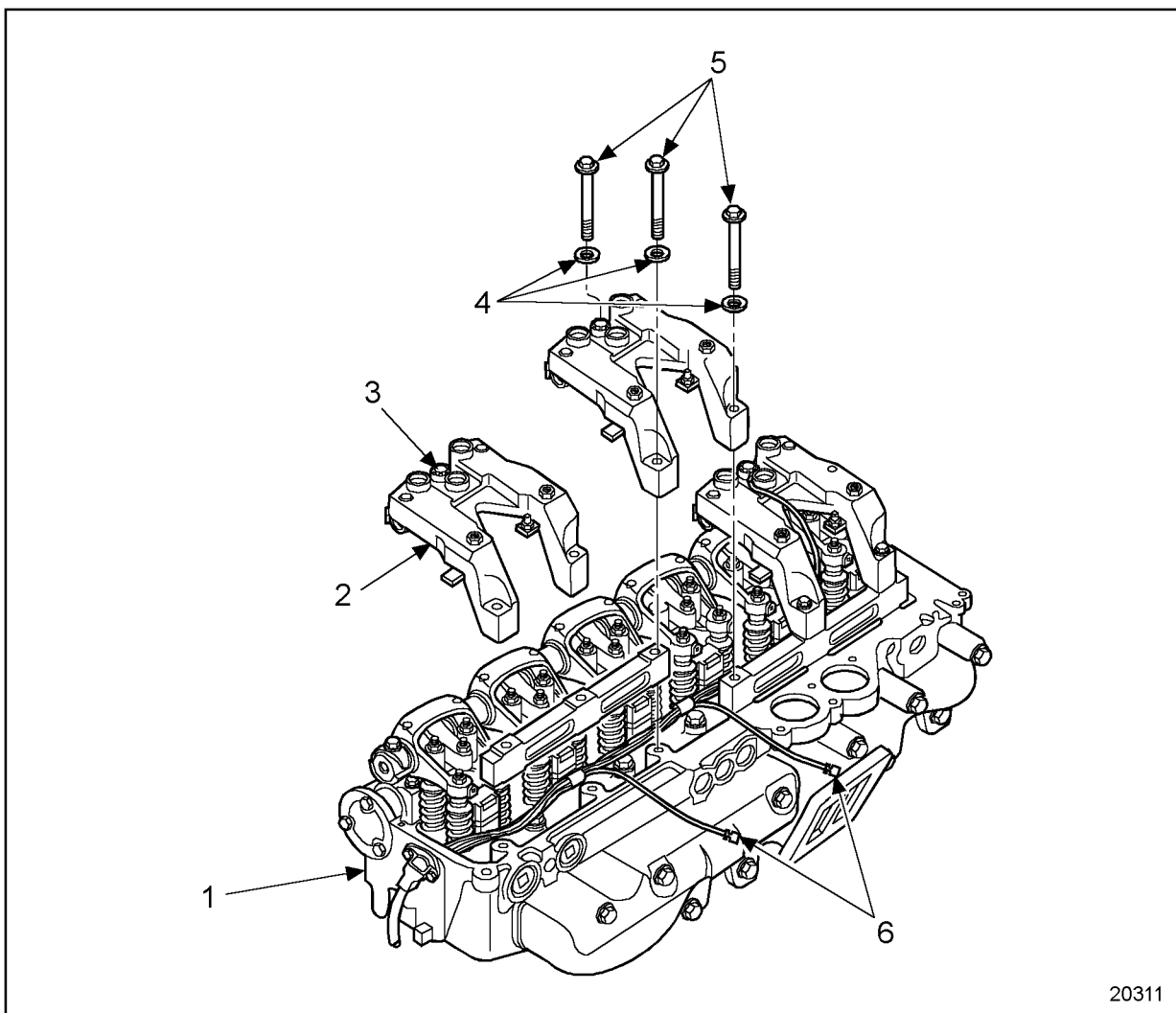


1. Disconnect starting power for engine. Refer to OEM guidelines.
2. Remove the engine rocker cover. Refer to section 1.6.2 for one-piece, refer to section 1.6.3 for two-piece and refer to section 1.6.5 for three-piece.

NOTE:

If the engine is equipped with an aluminum two-piece valve cover, remove only the upper valve cover when installing the engine brake.

3. Note the location of the rocker arm shaft, the exhaust valve rocker arm, the fuel injector rocker arm, and the intake valve rocker arm.
4. Disconnect the solenoid wiring harness connectors from the engine brake solenoids. See Figure 1-418.



- | | |
|------------------------|----------------------------|
| 1. Cylinder Head | 4. Washers (3 each) |
| 2. Jake Brake Assembly | 5. Mounting Bolts (3 each) |
| 3. Solenoid | 6. Engine Brake Harness |

Figure 1-418 Jake Brake Assembly

- Remove the nine mounting bolts and washers that secure the engine brake assemblies to the cylinder head. See Figure 1-418.

NOTE:

Only the Model 760 Jake Brake uses two different length mounting bolts. Six bolts, 120 mm (4.72 in.) long, are used on the exhaust side of the engine. Three bolts, 110 mm (4.33 in.) long, are used on the intake side of the engine. These bolts must be reinstalled in their correct positions.

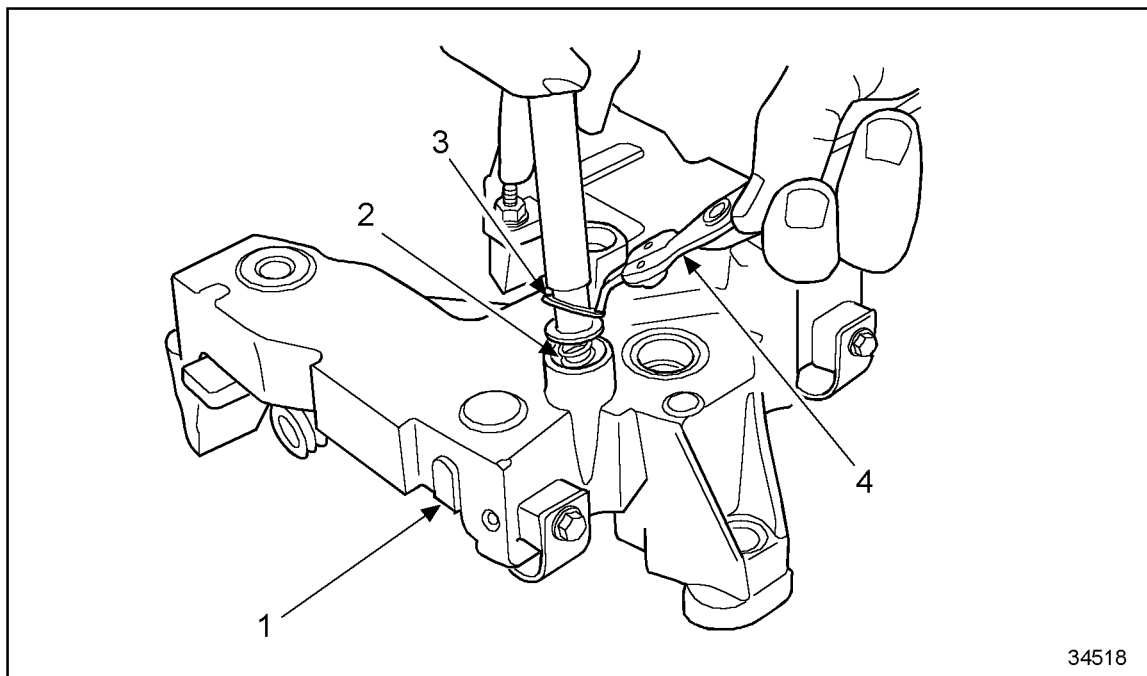
- Remove the engine brake assemblies and the spacer bar.

1.29.3 Disassembly of Model 760, 765, or 770 Jake Brake

Remove the control valve as follows:

	CAUTION:
To avoid personal injury, remove control valve covers carefully. Control valve covers are under load from the control valve springs.	

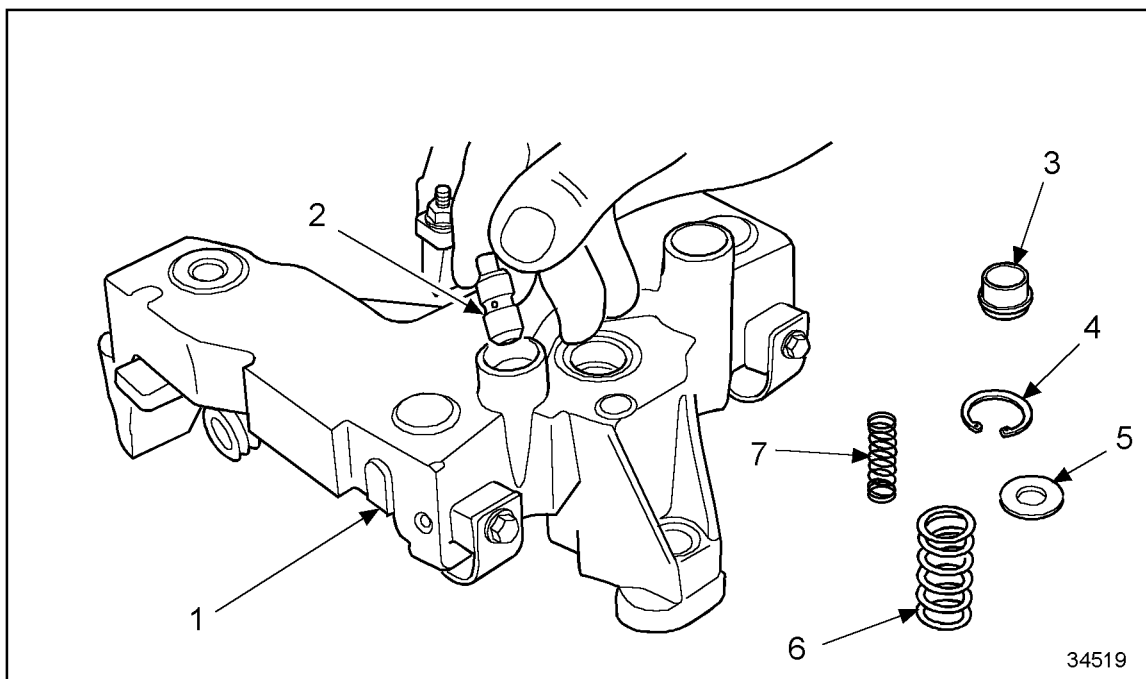
1. Press down on control valve washer using an appropriate diameter rod to relieve spring pressure. See Figure 1-419.



- | | |
|------------------------|-----------------------|
| 1. Jake Brake Assembly | 3. Snap Ring Retainer |
| 2. Spring | 4. Snap Ring Pliers |

Figure 1-419 Relieving Spring Pressure

2. Using retaining ring pliers, remove retaining ring.
3. Slowly remove cover until spring pressure ceases, then remove the two control valve springs and collar. See Figure 1-420.



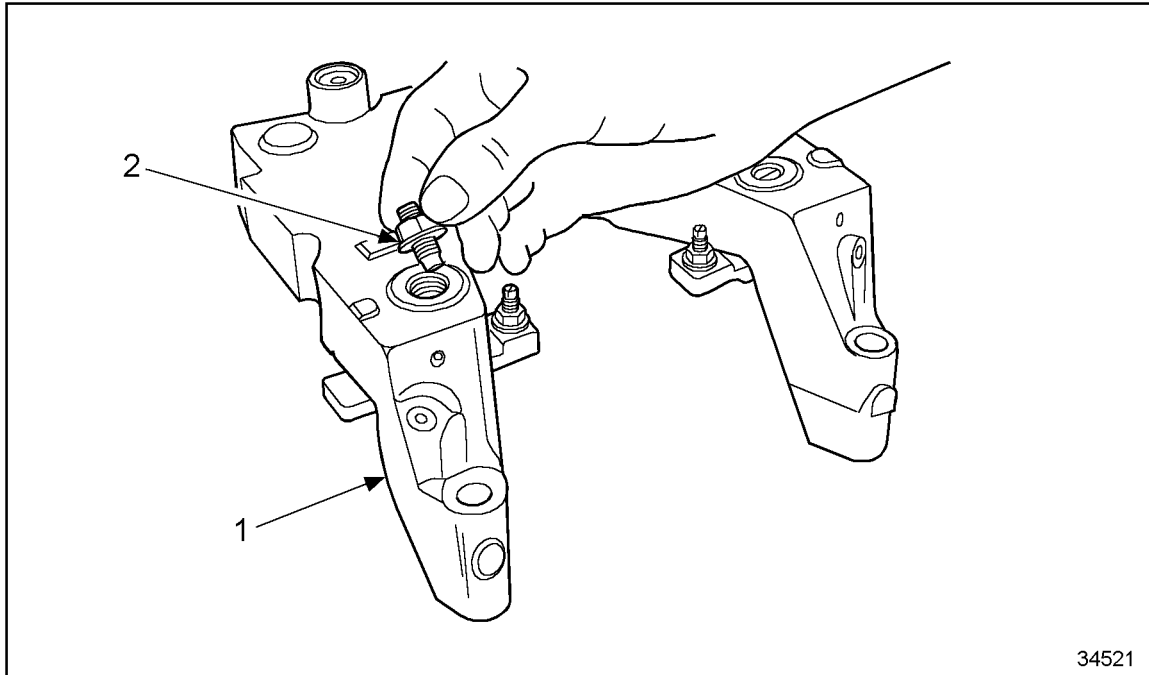
- | | |
|------------------------|-------------------------|
| 1. Jake Brake Assembly | 5. Washer |
| 2. Control Valve | 6. Collar Spring |
| 3. Collar | 7. Control Valve Spring |
| 4. Snap Ring Retainer | |

Figure 1-420 Removing Control Valve Springs and Collar

4. Using needle-nose pliers, reach into the bore and grasp the stem of the control valve. Remove control valve.

Remove the slave piston adjusting screw as follows:

1. Loosen slave piston adjusting screw locknut.
2. Remove adjusting screw from housing. See Figure 1-421.



1. Jake Brake Assembly

2. Slave Piston Adjusting Screw

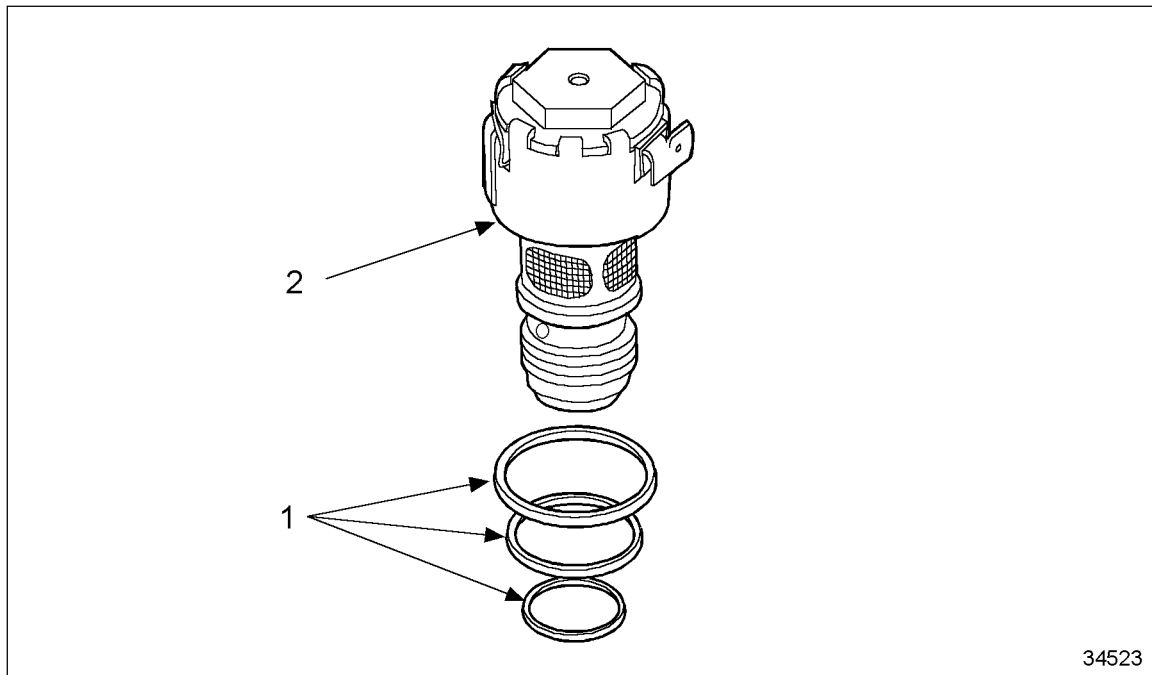
Figure 1-421 Removing Slave Piston Adjusting Screw

Remove the solenoid valve as follows:

NOTICE:

To avoid possible engine damage, do not disassemble or tamper with the solenoid valve.

1. Disconnect solenoid valve harness.
2. Using a 7/8 in. socket and extension for former solenoids or a 3/4 in., 6 point socket and extension for current solenoids, unscrew solenoid valve.
3. Remove and discard the three rubber seal rings. See Figure 1-422.



1. Seal Rings (3)

2. Solenoid

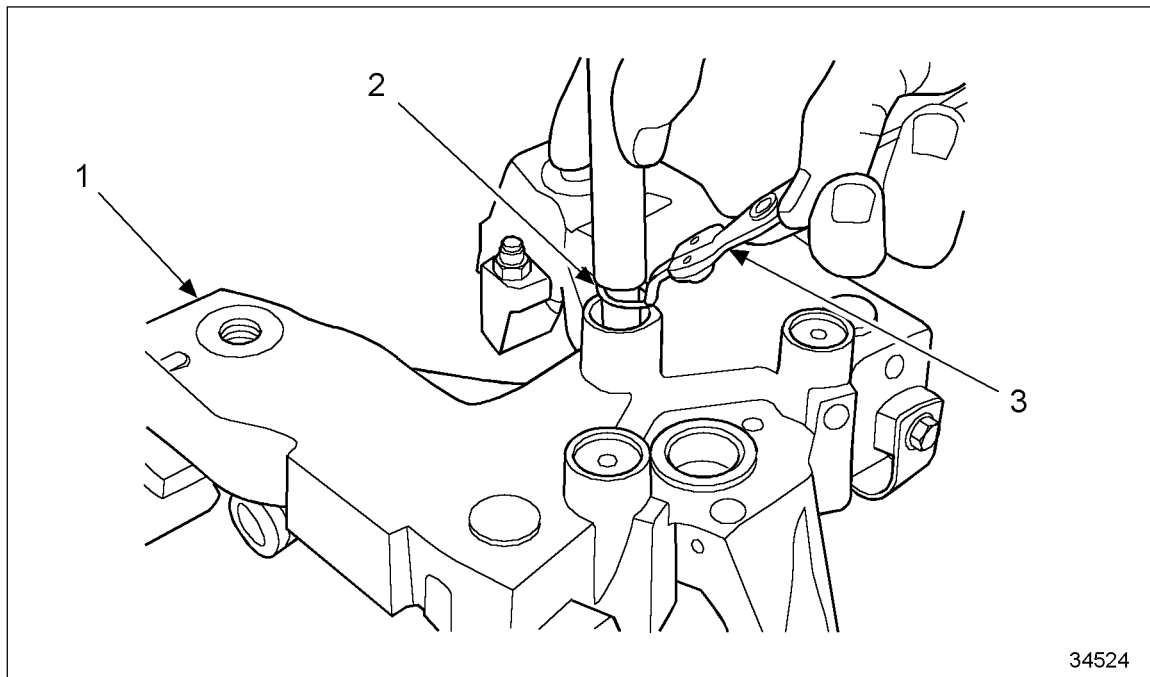
Figure 1-422 Removing Rubber Seal Rings

4. If the lower ring stays in the bottom of the housing bore, remove with a piece of wire.

Remove the accumulator as follows:

	CAUTION:
The accumulator spring is under strong compression. To avoid possible personal injury if the accumulator spring is discharged, wear safety glasses and use caution when removing the retaining ring and cover.	

1. Push down on the accumulator cover using the appropriate diameter rod, and remove the retaining ring. See Figure 1-423.



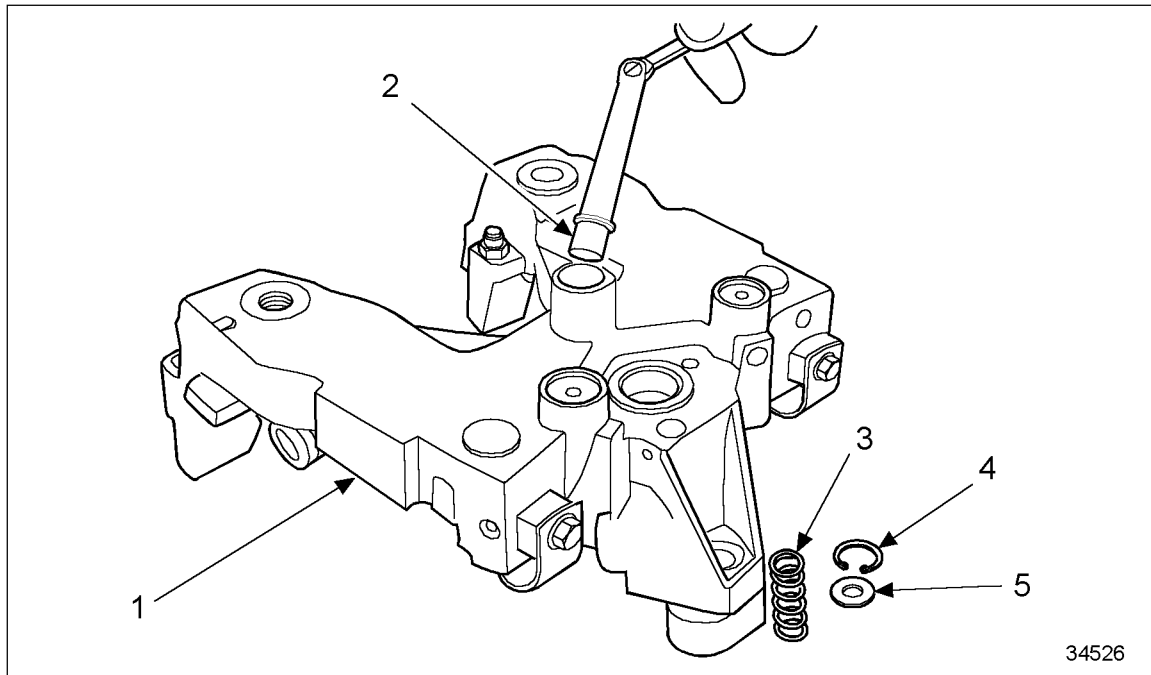
1. Jake Brake Assembly
2. Retaining Ring

3. Retaining Ring Pliers

Figure 1-423 Removing Retaining Ring

2. Relieve pressure on the accumulator cover.
3. Remove the cover and spring.

4. Use a magnet to remove the piston from the accumulator bore. See Figure 1-424.



- | | |
|------------------------|-------------------|
| 1. Jake Brake Assembly | 4. Retaining Ring |
| 2. Piston | 5. Washer |
| 3. Spring | |

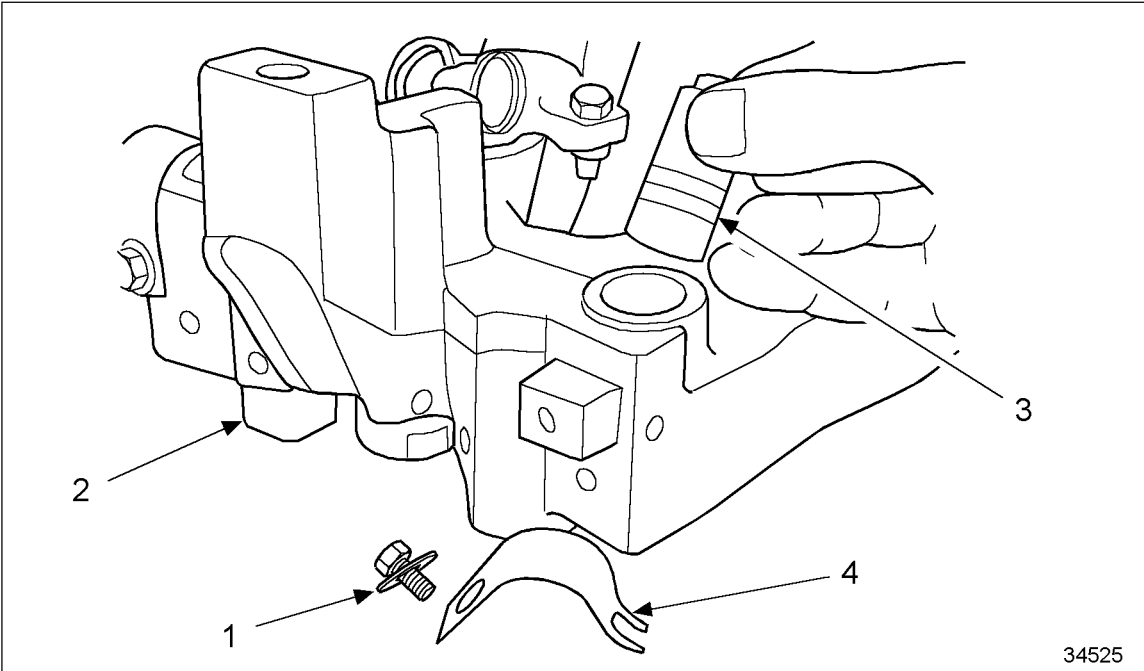
Figure 1-424 Removing Piston from Accumulator Bore with Magnet

Remove the master piston as follows:

1. Remove the screw, washer, and master piston spring from the housing.
2. Remove the master piston. See Figure 1-425.

NOTE:

Use needle-nose pliers, if necessary.



- | | |
|------------------------------|-------------------------|
| 1. Washer and Screw Assembly | 3. Master Piston |
| 2. Jake Brake Assembly | 4. Master Piston Spring |

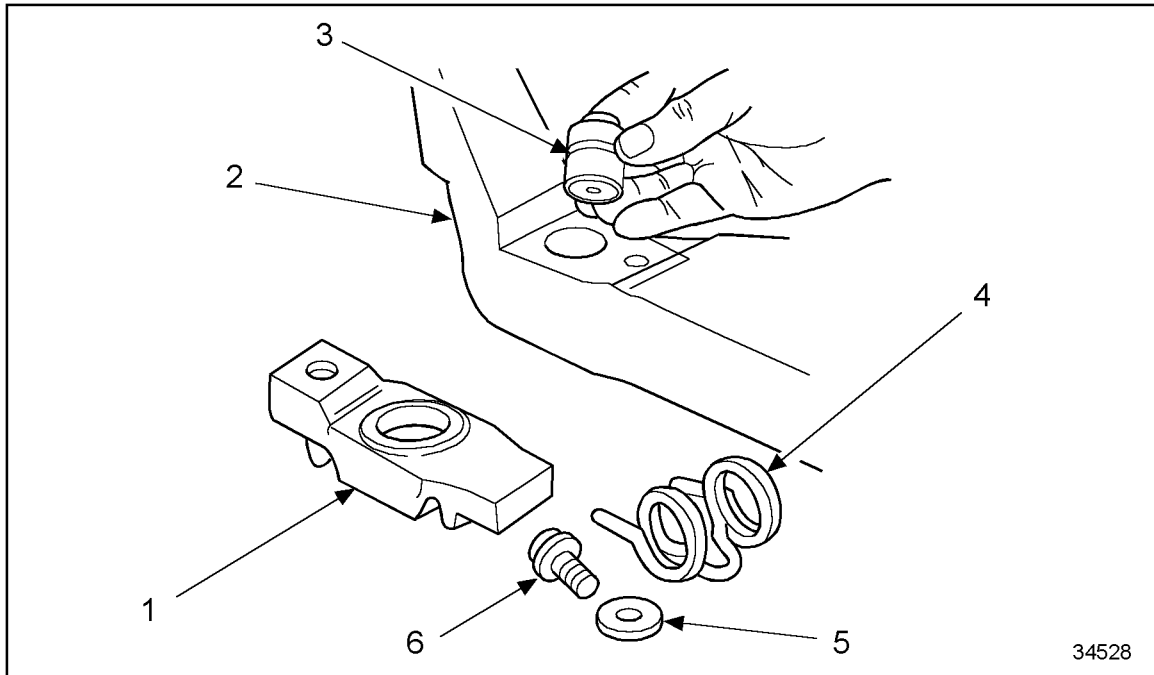
Figure 1-425 Removing The Master Piston

On Model 760 only, remove the ball check valve as follows:

1. Remove the plug.
2. Remove the ball check valve and spring.

Remove the slave piston as follows:

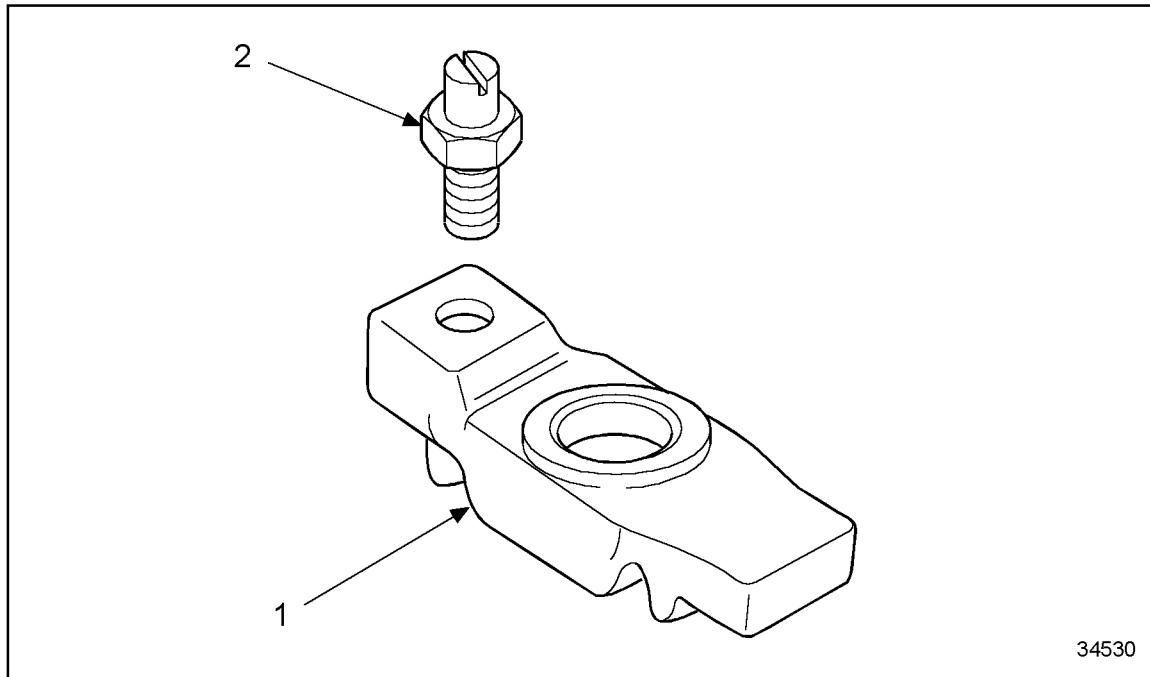
1. Remove the screw and spring that retains the slave piston return spring.
2. Remove the bridge and the slave piston. See Figure 1-426.



- | | |
|------------------------|------------------|
| 1. Slave Piston Bridge | 4. Return Spring |
| 2. Jake Brake Housing | 5. Washer |
| 3. Slave Piston | 6. Screw |

Figure 1-426 Removing Bridge and Slave Piston

3. Loosen the leveling screw locknut and remove the leveling screw from the bridge.
See Figure 1-427.



1. Slave Piston Bridge

2. Slave Piston Leveling Screw

Figure 1-427 Removing the Leveling Screw from the Bridge

The injector rocker arm contains a pin and roller for actuating the engine brake master piston. If excessive wear or damage to the roller is present, replace the rocker arm assembly. Refer to Section 1.6.2.

1.29.3.1 Cleaning of Model 760, 765, or 770 Jake Brake

Clean the Jake Brake as follows:

NOTE:

Use an OSHA-approved cleaning solvent when washing parts. Be sure to coat parts with clean engine oil when reinstalling them.

1. Wash the control valves with approved cleaning solvent.
2. Push a wire through the hole in the base of the valve to the distance required to ensure that the ball check is free.

NOTE:

The ball should lift with light pressure on the wire.



CAUTION:

To prevent possible personal injury when using compressed air, wear adequate eye protection (face plate or safety glasses) and do not exceed 40 psi (276 kPa) air pressure.

3. Dry the valve with compressed air, and wipe clean with a paper towel.
4. Thoroughly clean the control valve bore in the housing using clean paper towels.
5. Clean slave piston adjusting screw in an approved cleaning solvent.
6. Clean out the solenoid valve bore in the housing.

NOTICE:

Use clean paper towels to clean the solenoid valve bore. Never use rags, as they may leave lint and residue which can plug the oil passageways, causing Jake Brake malfunction.

7. Clean the master piston in approved cleaning solvent.

| 1.29.3.2 Inspection of Model 760, 765, or 770 Jake Brake

The Jacobs engine brake is typically a trouble-free device. However, inspections are necessary and some maintenance is required. Use the following procedures to keep the engine brake in top condition.

Inspect the Jake Brake as follows:

1. Inspect slave piston adjusting screw for protrusion, spring pressure and freedom of movement.

NOTE:

The plunger should protrude from the bottom of the screw, have light spring pressure apparent when depressed, and move freely. Be sure the retaining ring is fully engaged in its groove (groove is located on the bottom of the reset screw and top of the POWER-LASH assembly).

- [a] If the plunger does not protrude, the spring does not have light pressure or does not move freely, replace the entire screw assembly. Refer to Section 1.29.4
- [b] If the slave piston adjusting screw meets specifications, continue with inspection.
2. Inspect the accumulator for wear or damage.
 - [a] If worn or damaged, replace the accumulator. Refer to Section 1.29.4.
 - [b] If accumulator is not worn or damaged, continue with inspection.
3. Inspect the master piston bore for wear or damage.

NOTE:

Some wear marks are permissible.

- [a] If worn or damaged, replace the master piston. Refer to Section 1.29.4.
- [b] If not worn or damaged, continue with inspection.
4. Apply clean lube oil to the piston, and insert into bore.

NOTE:

Master piston should move in and out freely with no binding.

- [a] If binding occurs, replace master piston and/or housing. Refer to Section 1.29.4.
- [b] If no binding occurs, continue with inspection.
5. Inspect master piston spring for relaxation.

NOTE:

The spring should hold the master piston completely in the housing.

- [a] If relaxed, replace the spring. Refer to Section 1.29.4.
- [b] If spring holds tightly, continue with inspection.

6. Inspect the ball check valve (Model 760 only) for wear or damage.
 - [a] If worn or damaged, replace ball check valve. Refer to Section 1.29.4.
 - [b] If not worn or damaged, proceed with inspection.
7. Inspect slave piston components for excessive wear or damage.
 - [a] If worn or damaged, replace slave piston component.
 - [b] If not worn or damaged, proceed with inspection.

1.29.3.3 Inspection of Control Valve

Inspect the control valve as follows:

1. Dip the control valves in clean lube oil.
2. Holding the control valve by the stem, let it drop into the bore.
 - [a] If binding occurs or if the ball sticks in the valve, replace the control valve. Refer to Section 1.29.4.
 - [b] If no binding occurs and the ball does not stick in the control valve, assemble the Jake Brake. Refer to Section 1.29.4.

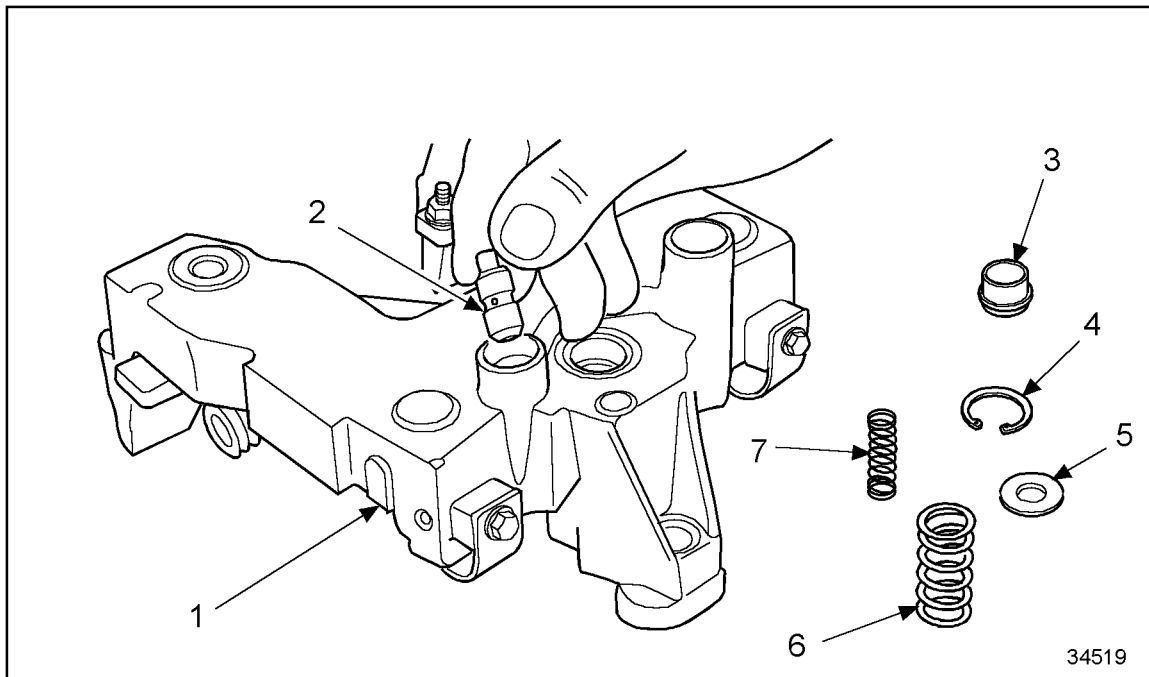
1.29.4 Assembly of Model 760, 765, or 770 Jake Brake

Install the control valve as follows:

1. Slip the control valve into the bore. See Figure 1-428.

NOTE:

Make sure the control valve collar is installed with the longer sleeve area facing up. If the collar is installed upside down, the engine brake cylinder will not operate.



- | | |
|------------------------|-------------------------|
| 1. Jake Brake Assembly | 5. Washer |
| 2. Control Valve | 6. Collar Spring |
| 3. Collar | 7. Control Valve Spring |
| 4. Snap Ring Retainer | |

Figure 1-428 Installing the Control Valve

2. Install the control valve collar and two springs.

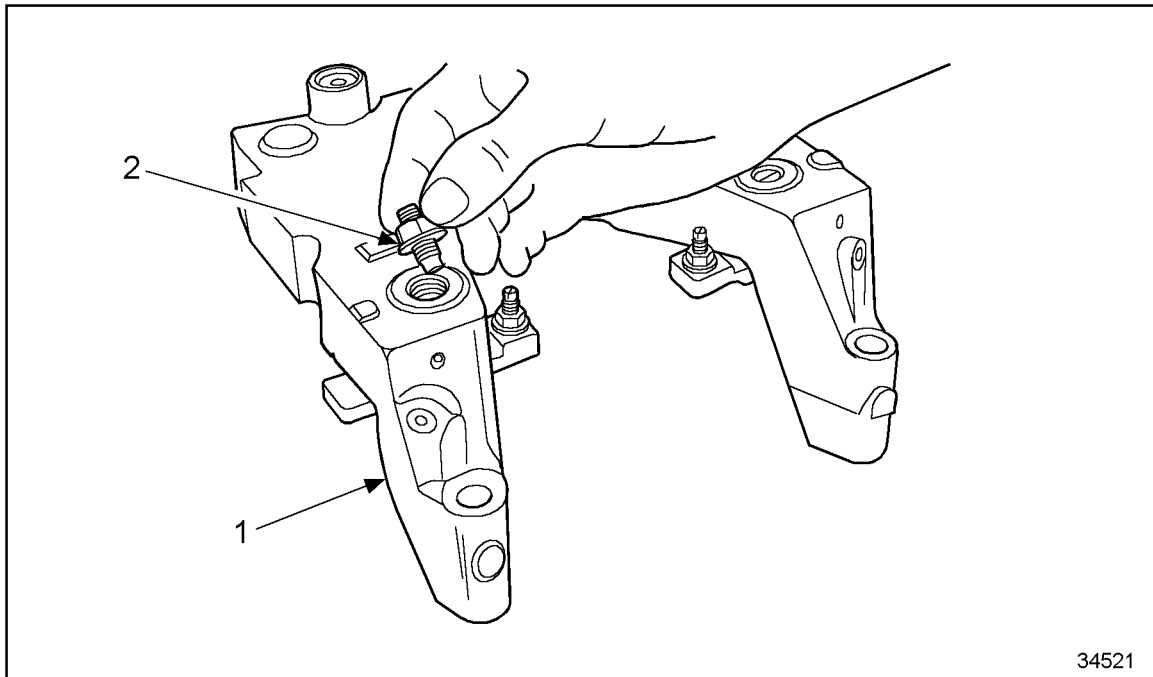
NOTE:

Ensure the collar is installed with the longer sleeve area facing up. If the collar is installed upside down, the engine brake cylinder will not operate.

3. Press the cover (washer) into place.
4. While holding the cover tightly in place, install the retaining ring.
5. Rotate retaining ring ears 90 degrees to assure ring is seated in groove.

Install the slave piston adjusting screw as follows:

1. Place the screw in the housing. See Figure 1-429.



1. Jake Brake Assembly

2. Slave Piston Adjusting Screw

Figure 1-429 Installing the Slave Piston Adjusting Screw

2. Torque the slave piston adjusting screw locknut to 35 N·m (25 lb·ft).

Install the solenoid valve as follows:

NOTE:

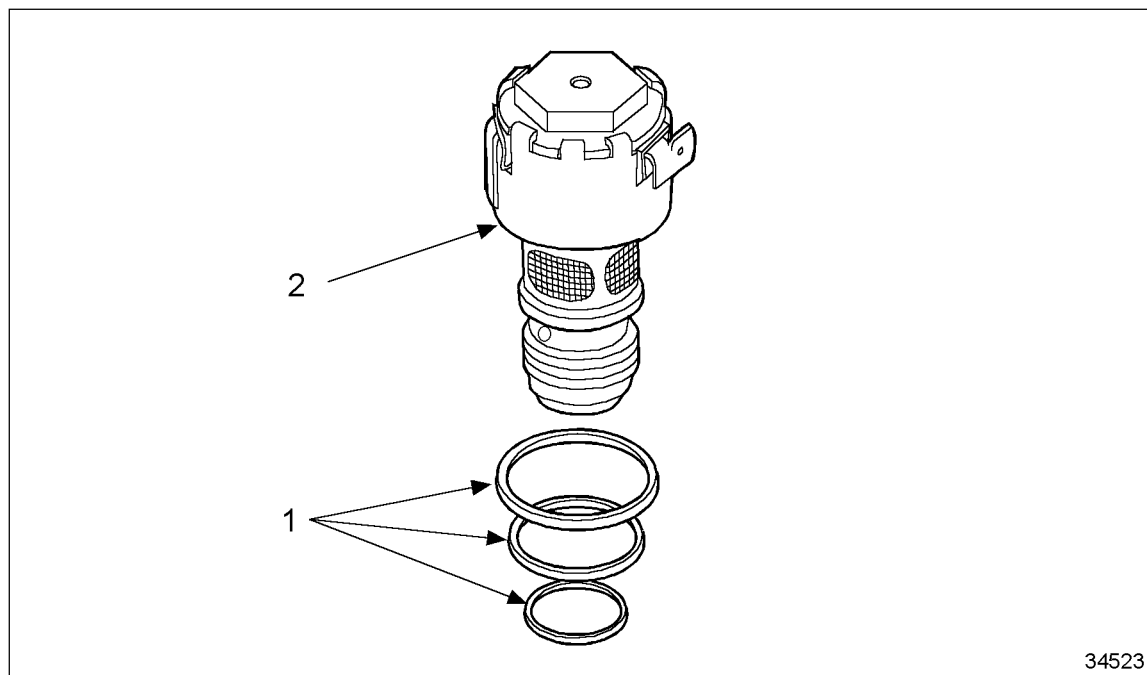
As of October 19, 1997, former solenoids have been replaced with the current improved solenoids. The current solenoids have an increased installation torque and improved durability. The current solenoid is interchangeable with the former.

1. Coat new solenoid valve seal rings with clean lube oil.

NOTE:

Use current upper seals when installing current solenoids. New seals are identified with yellow stripes.

2. Install the upper and center seal rings on the solenoid valve body and the lower seal ring into the bottom of the bore in the housing. See Figure 1-430.



1. Seal Rings (3)

2. Solenoid

Figure 1-430 Installation of Solenoid Valve Seal Rings

3. Make sure the seals are seated properly.
4. Using a 7/8 in. socket and extension for former solenoids or a 3/4 in., 6 point socket and extension for current solenoids, carefully screw the solenoid valve into the housing without unseating the seals.
5. Torque the former solenoid to 12.4 N·m (9 lb·ft). Torque the current solenoid to 20 N·m (15 lb·ft.)

NOTE:

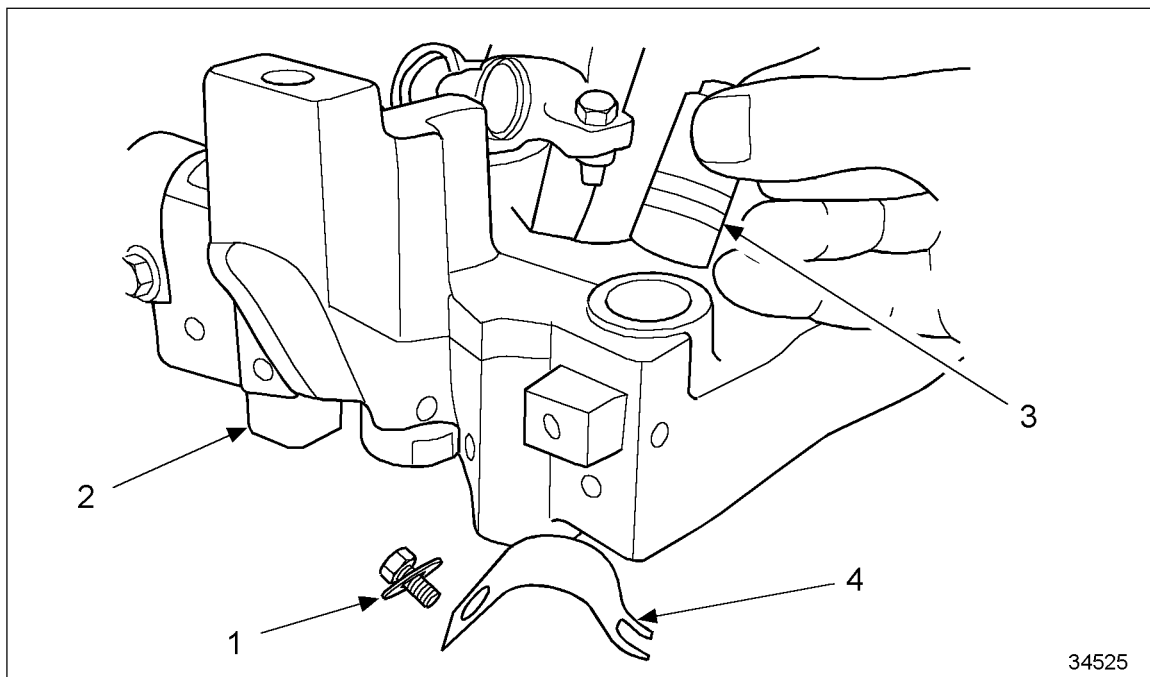
Be careful not to twist the seals while installing.

Install the accumulator as follows:

1. Place the piston into the accumulator bore.
2. Insert the spring, and install the cover.
3. Push down the accumulator cover, and insert retaining ring.

Install the master piston as follows:

1. Apply clean lube oil to the piston.
2. Insert master piston into bore. See Figure 1-431.



- | | |
|------------------------------|-------------------------|
| 1. Washer and Screw Assembly | 3. Master Piston |
| 2. Jake Brake Assembly | 4. Master Piston Spring |

Figure 1-431 Inserting Master Piston into Bore

3. Install spring, washer, and screw.

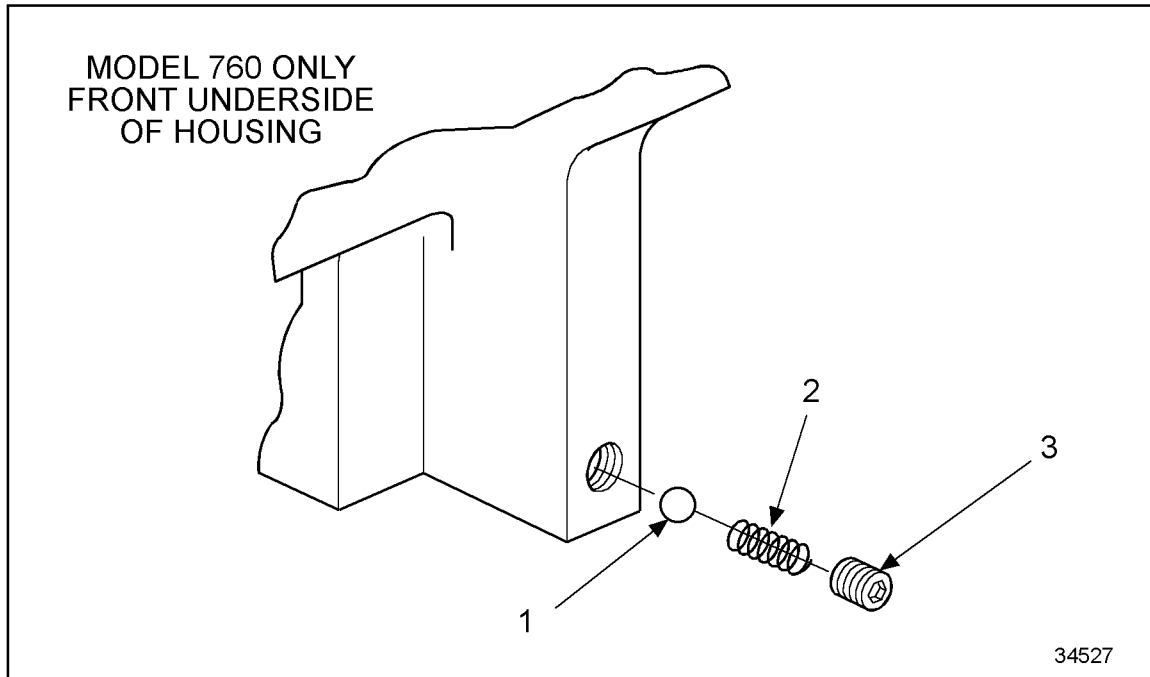
NOTE:

Make sure spring legs are centered around master piston boss.

4. Torque screw to 10 N·m (7.4 lb·ft).

On model 760 only, install the ball check valve as follows:

1. Install the ball check valve and spring. See Figure 1-432.



1. Ball Check Valve

3. Pipe Plug

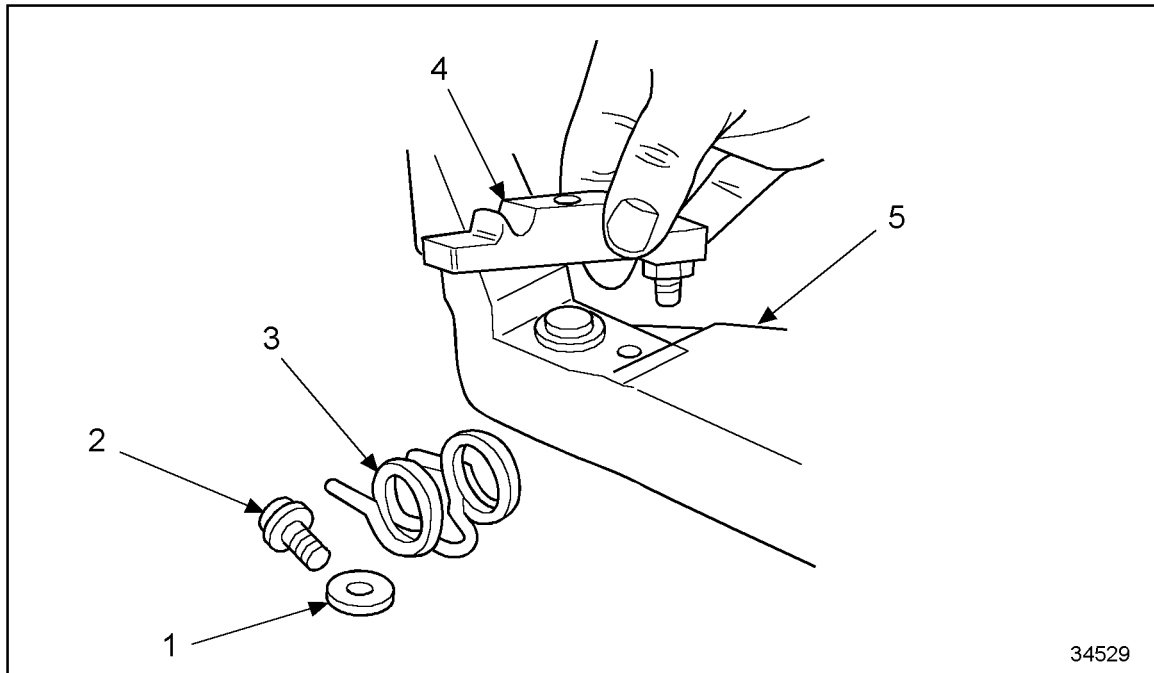
2. Spring

Figure 1-432 Installation of Ball Check Valve

2. Insert the plug. Torque pipe plug to 11.2 N·m (8.3 lb-ft).

Install the slave piston as follows:

1. Install the screw from the slave piston side of the bridge.
2. Install the leveling screw locknut.
3. Install the bridge with the leveling screw toward the center of the housing.
See Figure 1-433.



- | | |
|-------------------|-----------------------|
| 1. Washer | 4. Bridge Assembly |
| 2. Screw | 5. Jake Brake Housing |
| 3. Torsion Spring | |

Figure 1-433 **Installing Bridge with Leveling Screw Toward Center of Housing**

4. Install the slave piston assembly torsion spring with the ends over the bridge.
See Figure 1-434.

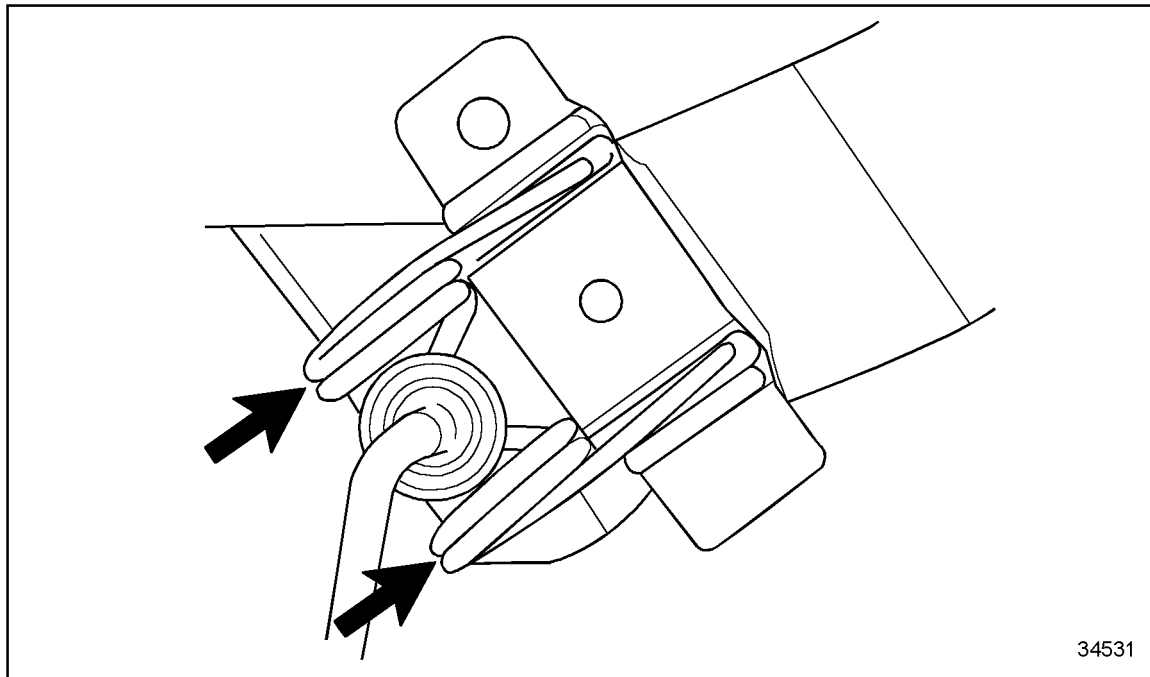


Figure 1-434 **Installing the Slave Piston Assembly Torsion Spring**

5. Install the screw over the center part of the spring.

NOTICE:
While tightening the screw on the torsion spring, push the spring toward the slave piston assembly. Failure to do so may result in contact between the intake valve adjusting screw and torsion spring. Serious engine damage may result.

6. Torque the screw to 20 N·m (15 lb·ft.).
7. Torque the slave piston leveling screw locknut to 47 N·m (35 lb·ft.).

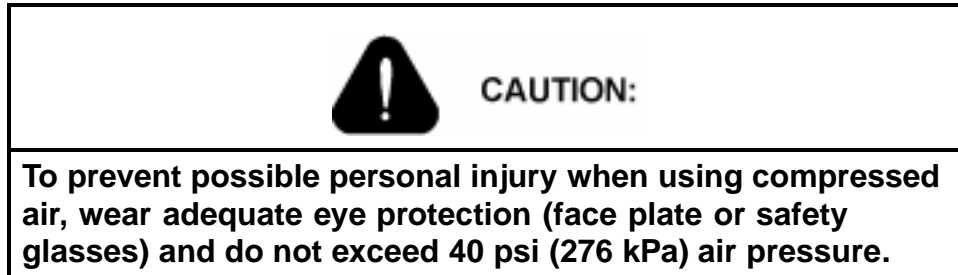
1.29.5 Installation of Model 760, 765, or 770 Jake Brake

Install the model 760, 765, or 770 Jake Brake as follows:

NOTE:

The following procedures apply to Model 760, 765, and 770 Jake Brakes. For Model 790 Jake Brake installation procedures, refer to section 1.29.10.

1. Adjust the intake and exhaust valve clearances and set the injector heights. Refer to section .



2. Attach the length of tubing to a blow gun nozzle, and blow out the oil from the bolt holes.
3. Cover the holes with hand towels to minimize oil spray.

NOTE:

Removing the oil from the bolt holes prevents the cylinder head from cracking when tightening the bolts.

4. Place the spacer bar on the exhaust manifold side of the cylinder head with the "OUT" markings adjoining each other and facing the exhaust manifold. See Figure 1-435, and see Figure 1-436.

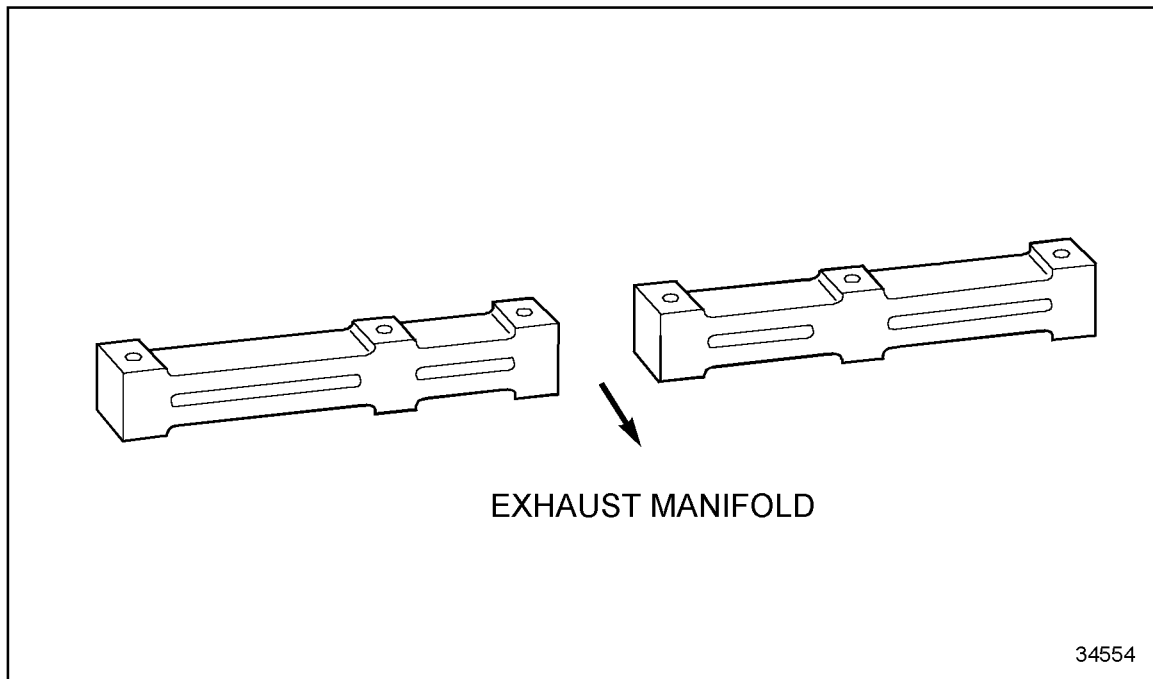


Figure 1-435 **Spacer Bars with "Out" Marks Adjoined**

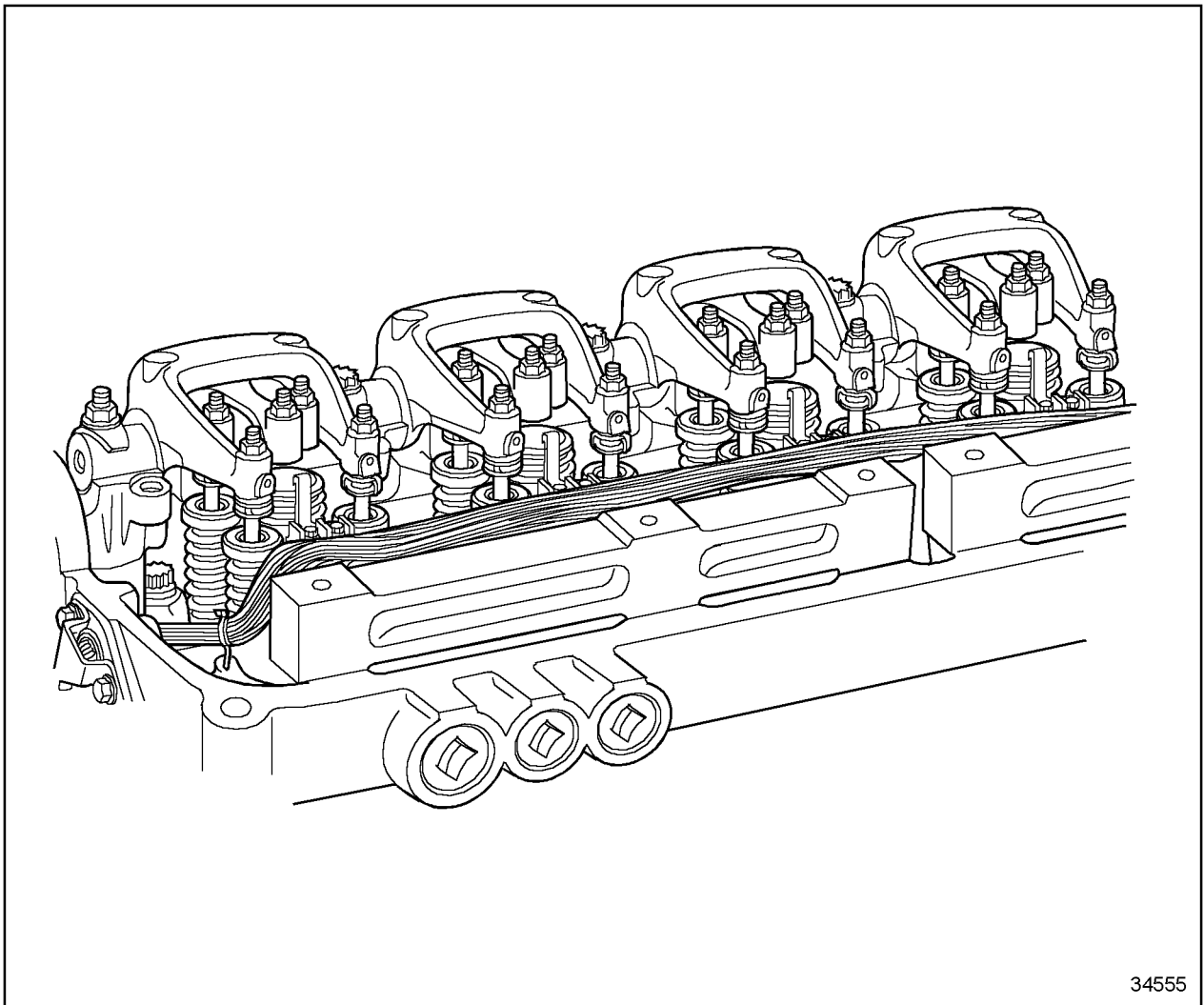


Figure 1-436 **Location of Spacer Bars**

5. Place the three engine brake housings over the rocker shafts with the solenoid valves toward the camshaft side of the engine.

NOTE:

Be sure housings do not interfere with wiring harness.

NOTICE:

Do not mix the rocker arm shaft bolts and the Jake Brake mounting bolts. If the rocker arm shaft bolt is mistakenly used to mount the Jake Brake housing, the longer shoulder on the bolt will block the oil supply to the Jake Brake on the camshaft side of the housing. The brake will not retard the engine as designed. This condition could cause loss of vehicle braking control on downgrades, which may create a risk of personal injury to the vehicle operator or other persons and damage to the vehicle or property of others.

NOTE:

The rocker arm shaft mounting bolt and Jake Brake mounting bolt, part of the Jake Brake assembly, are similar in appearance. Both are M12 x 110 mm (4.33 in.) long and have 12-point heads.

NOTE:

In the event of a housing hold down bolt failure on a Jacobs engine brake housing, replace all bolts on that particular housing.

NOTICE:

Use bolts that have the Jacobs logo, circled "J". Installation of bolts that do not have the circled "J" may result in damage to the engine, engine brake or both.

- [a] The Jake Brake bolt has the Jacobs logo (circled "J") and the letters "EF" marked on the head. The bolt length is no longer marked atop the bolt head.
- [b] The DDC rocker arm shaft bolt has the DDC logo (spinning arrows) and the vendor I.D. (F-C) on its head.
- [c] Jake Brake model 760 requires two bolts along with one bolt and new washers.

NOTE:

Be sure that only Jake Brake bolts, see Figure 1-437, are installed in the Jake Brake housing.

[d] The DDC bolt shoulder is much longer, 17.0 mm (0.669 in.) versus 4 mm (0.157 in.) than the Jake Brake bolt. See Figure 1-437.

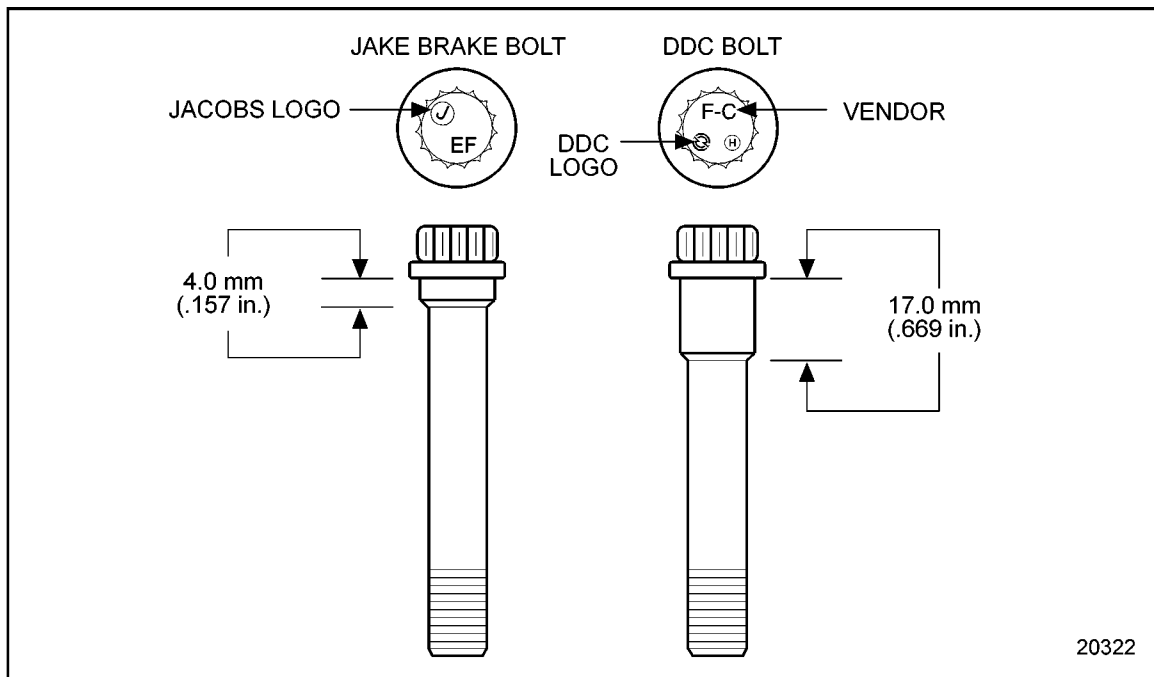
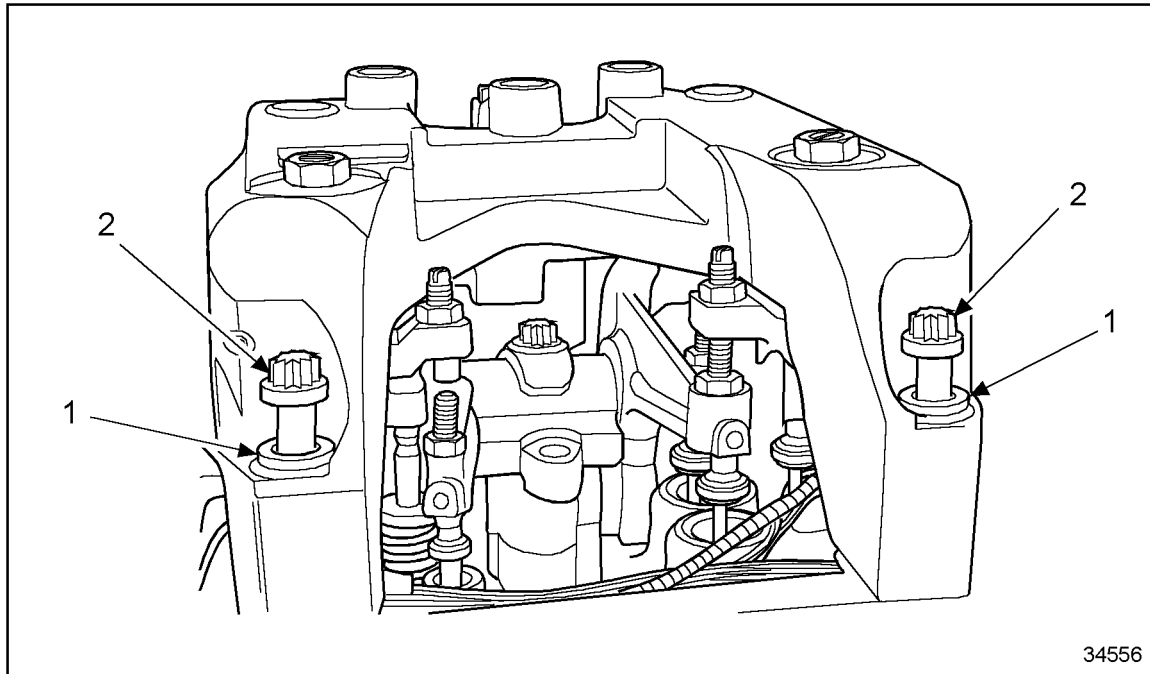


Figure 1-437 Jake Brake and DDC Bolt Identification

NOTICE:

The model 760 uses two lengths of mounting bolts. Six 120 mm bolts should be installed on the exhaust side of the engine. Three 110 mm bolts should be installed on the camshaft side of the engine. Failure to do so will result in engine damage.

6. On model 760, install one washer onto each 120 mm (4.75 in.) bolt, and insert into brake housing on the exhaust manifold side (two per housing). See Figure 1-438.

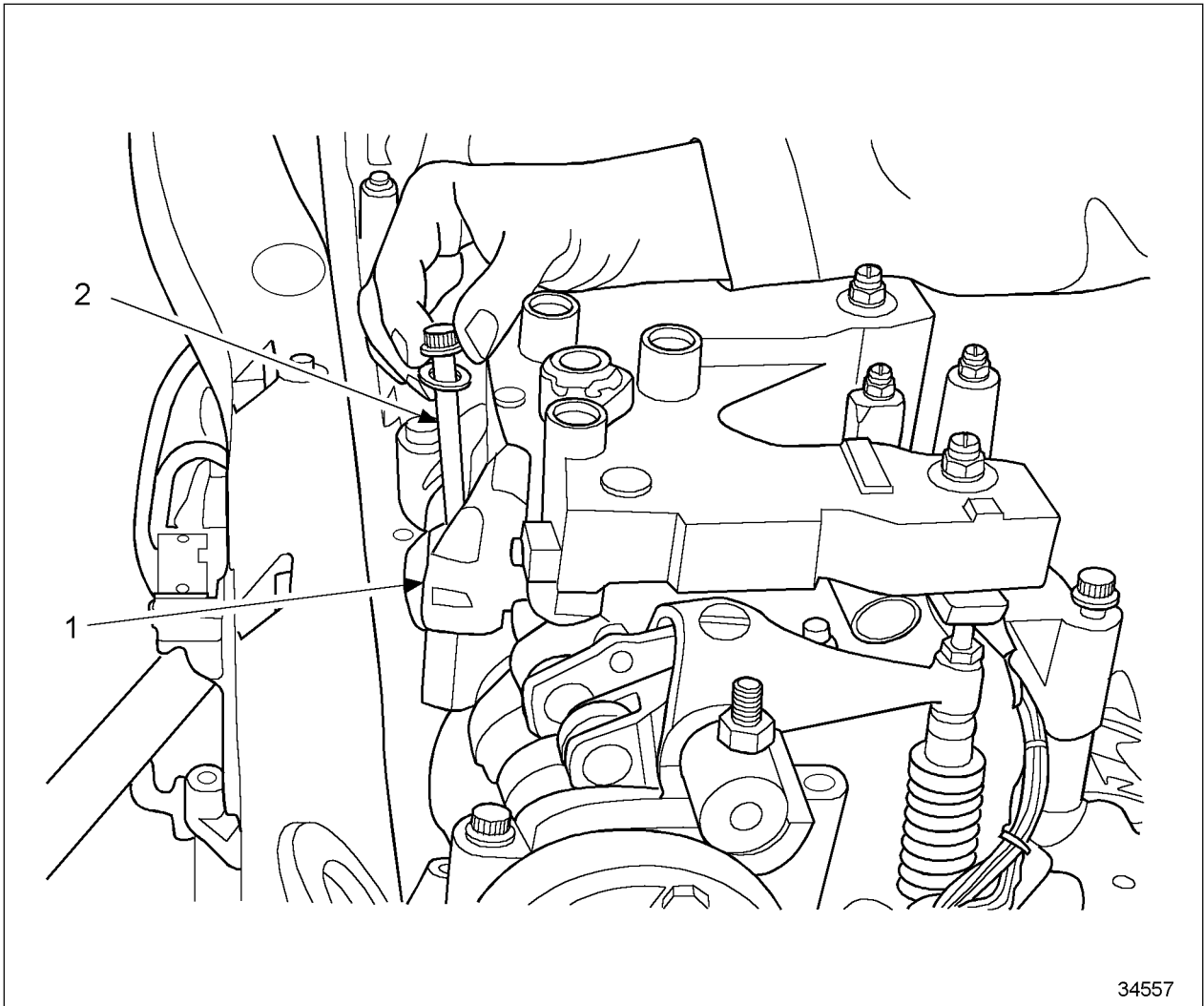


1. Washer

2. Long Bolt

Figure 1-438 Installation of Brake Housing Bolts on Exhaust Manifold Side

7. On model 760, install one washer on the 110 mm (4.375 in.) bolt, and insert into brake housing at the camshaft side (one per housing). See Figure 1-439.



1. Jake Brake Housing Assembly

2. Mounting Bolt

Figure 1-439 Installation of Brake Housing Bolts on Camshaft Side

8. On models 760A, 760B, 765, and 765A, lubricate each hold down bolt with clean engine oil.

NOTE:

All the housing mounting bolts for these models are the same length of 110 mm (4.375 in.).

9. On models 760A, 760B, 765, and 765A, install a washer on each bolt, and install into housings (three bolts per housing).

10. On models 760A and 765, move the housing from side to side, and locate the housing in the center position of the movement. See Figure 1-440.

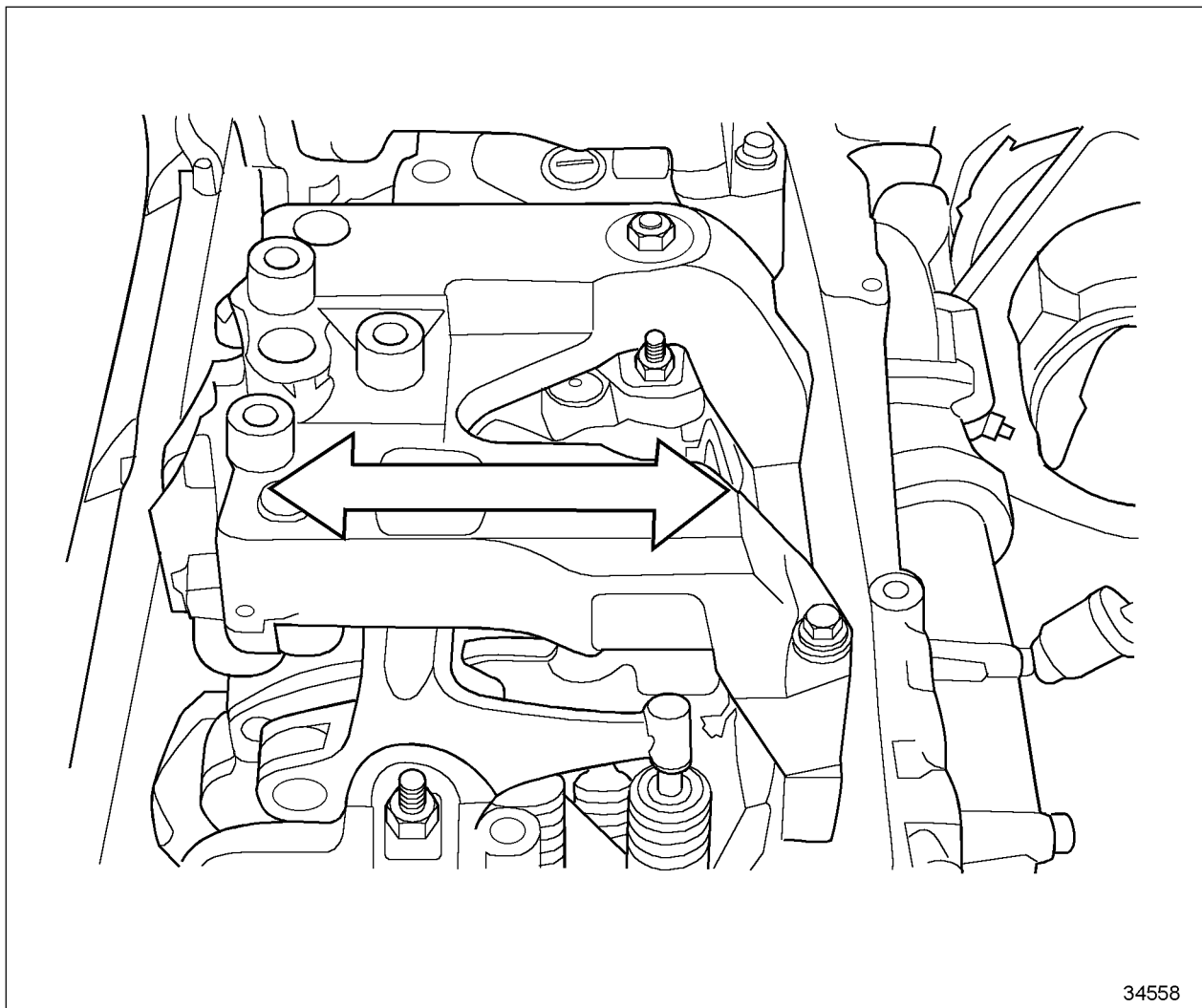


Figure 1-440 Locating Center Position of Housing

11. On models 760B and 765A, move the housing from side to side, and locate as far toward the camshaft side of the engine as possible.
12. On all models, torque the engine brake mounting bolts using the following sequence:
 - [a] Torque the three bolts on the camshaft side of the engine to 55 N·m (40 lb·ft).
 - [b] Torque the six bolts on the exhaust manifold side of the engine to 55 N·m (40 lb·ft).
 - [c] Repeat the tightening sequence and re-torque all bolts to 136 N·m (100 lb·ft).
 - [d] Check the torque to 136 N·m (100 lb·ft).
13. Secure wire harness to spacer bars with plastic ties.
14. Connect wiring harness solenoid connectors to solenoids.

1.29.5.1 Adjustment of Slave Piston on Model 760, 765, or 770 Jake Brake

Make the following adjustment with the engine stopped and cold, and the oil temperature at 60°C (140°F) or below. The exhaust valves on the cylinder *must* be in the closed position (rocker arm roller on the base circle of the camshaft). When setting the engine brake lash, the exhaust valves must be in the closed position. Adjust the slave piston on all models as follows:

NOTE:

The following procedures apply to Model 760, 765, and 770 Jake Brakes. For Model 790 Jake Brake slave piston lash setting procedures, refer to section 1.29.10.1.

NOTE:

Model 770 Jacobs engine brake requires a special procedure for adjusting the slave piston. The procedure is clearly indicated in the following adjustment steps.

NOTICE:
Improper slave piston adjustment can result in engine or brake housing damage.

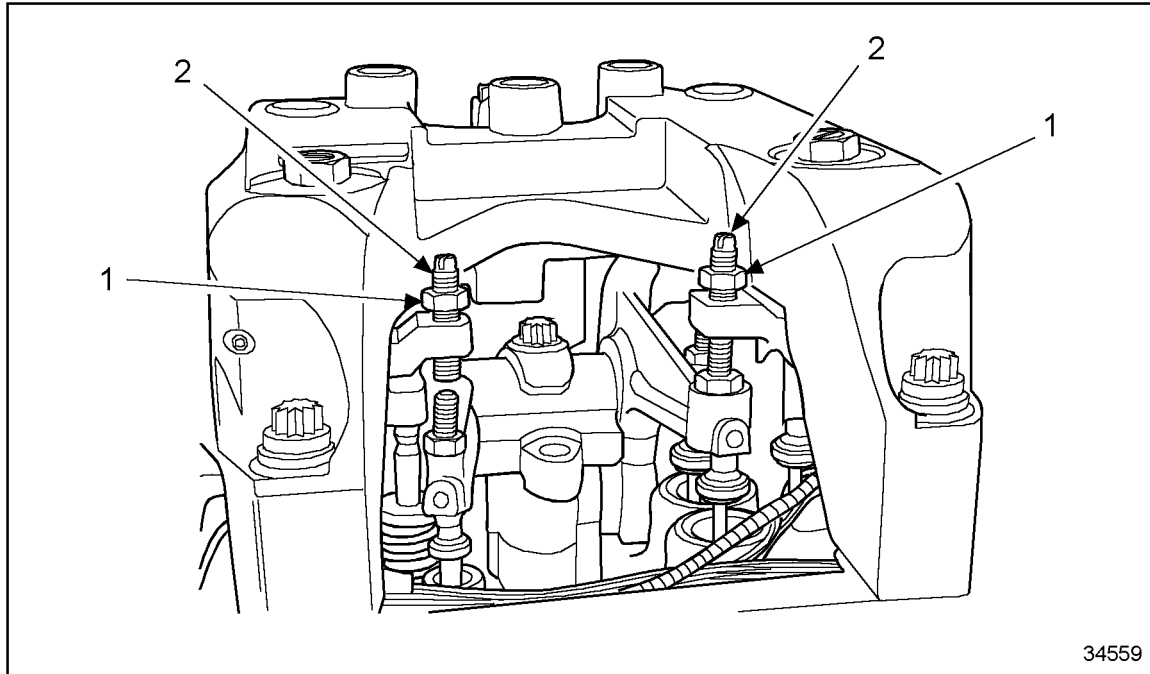
NOTICE:
Strictly follow the slave piston adjustment procedure. Failure to use the proper adjustment procedure will result in poor engine brake performance and/or serious engine damage.

1. Refer to section 1.29 for proper slave piston clearance setting.

2. Back out the leveling screw in the slave piston assembly until the end of the screw is beneath the surface of the bridge in the slave piston assembly. See Figure 1-441.

NOTE:

The leveling screw is located in the bridge member of the slave piston assembly.



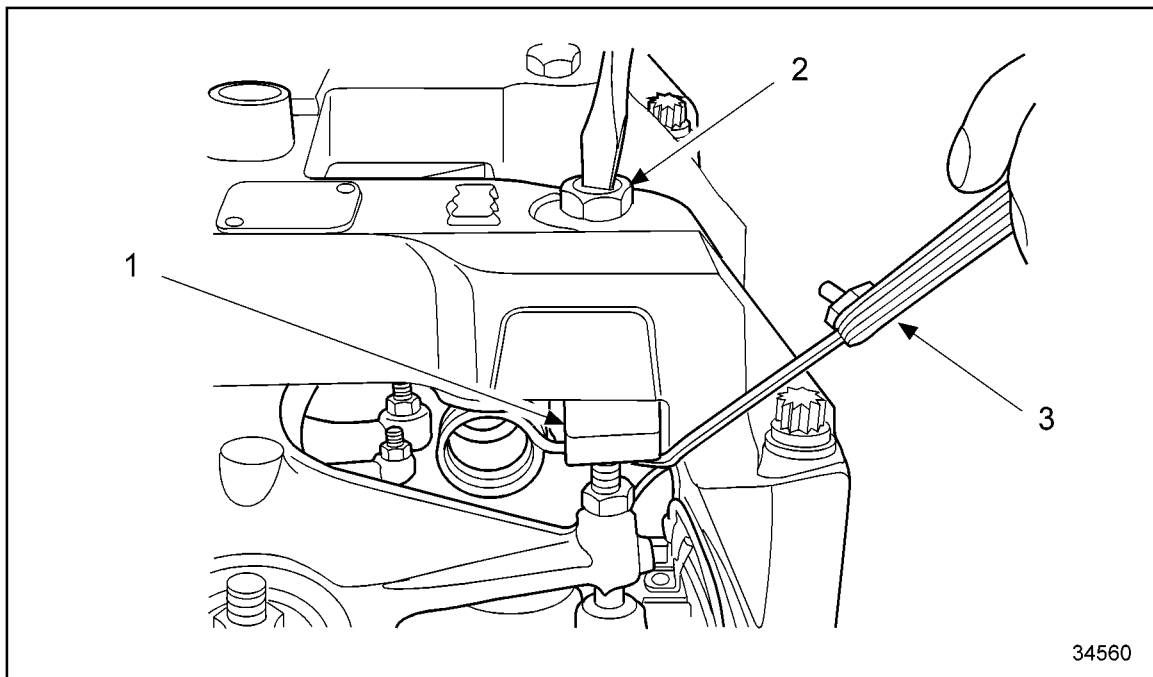
1. Leveling Screw

2. Locknut

Figure 1-441 Location of Leveling Screw

3. On models 760, 760A, 760B, 765, and 765A, place the correct size feeler gage between the solid side of the slave piston (the side without the leveling screw) and the exhaust rocker arm adjusting screw. Feeler gage sizes are listed in Table 1-9.

4. On models 760, 760A, 760B, 765, and 765A, turn the slave piston adjusting screw clockwise until a slight drag is felt on the feeler gage. See Figure 1-442.



- | | |
|---------------------------------|----------------|
| 1. Slave Piston Bridge | 3. Feeler Gage |
| 2. Slave Piston Adjusting Screw | |

Figure 1-442 Turn Slave Piston Adjusting Screw Clockwise

5. Perform the following additional steps on model 770:

- [a] Turn in the J-Lash[®] adjusting screw until the solid side of the slave piston bridge assembly contacts the exhaust valve and the valve springs begin to compress. Turn in one additional turn.

NOTICE:

All oil must be purged from the J-Lash adjusting screw. Oil remaining in the J-Lash screw will cause inaccurate clearance adjustment, resulting in possible engine or engine brake damage. If oil is below room temperature (below 60°F), wait at least two minutes for oil to be purged from the J-Lash adjusting screw.

NOTE:

Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.

- [b] Back out the adjusting screw **only** until the correct size feeler gage can be inserted between the solid side of the slave piston bridge assembly and the exhaust valve.
- [c] Adjust the J-Lash so that a light drag is felt on the feeler gage.

NOTE:

Do not back out the J-Lash more than required to obtain a light drag on the feeler gage.

- [d] Use a screwdriver to hold the J-Lash in place, and torque the lock nut to 34 N·m (25 lb·ft).

NOTE:

If the J-Lash screw is backed out until it no longer compresses the slave piston spring, oil will enter the screw and the adjustment will be incorrect. If this occurs, repeat the J-Lash adjustment procedure.

- [e] Recheck the lash settings. If clearance setting is incorrect, repeat the J-Lash adjustment procedure.

NOTE:

Once the engine brake has been run, oil enters the J-Lash screw making the engine brake adjustment unreadable. If unsure of the adjustment, repeat the J-Lash adjustment procedure.

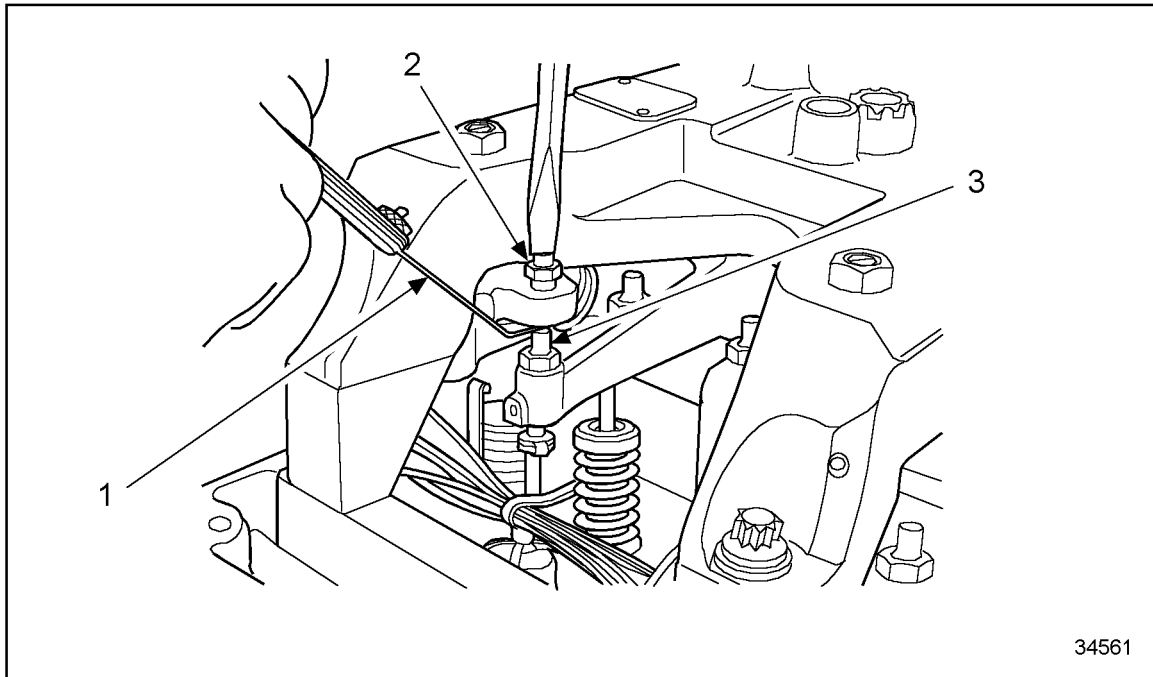
6. On all models, hold the screw in position, and torque the locknut to 35 N·m (26 lb·ft).
7. Check the adjustment, and repeat if necessary.

NOTE:

Do not disassemble the slave piston adjusting screws.

8. Place the correct feeler gage between the leveling screw and the rocker arm adjusting screw.

9. Turn the leveling screw clockwise until a slight drag is felt on the feeler gage. See Figure 1-443.



- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Feeler Gage 2. Slave Piston Leveling Screw | <ol style="list-style-type: none"> 3. Rocker Arm Adjusting Screw |
|--|---|

Figure 1-443 Setting Clearance on Leveling Screw and Rocker Arm Adjusting Screw

10. Hold the leveling screw in position, and torque the locknut to 47 N·m (35 lb·ft).
11. Check adjustment, and repeat if necessary.
12. Repeat the adjustment procedures for the remaining cylinders. Refer to step 2 through step 11.


NOTE:

Bar over the engine when necessary to place the exhaust valves in the closed position for slave piston adjustment.

13. Install the engine rocker cover. Refer to section 1.6.2 for one-piece, refer to section 1.6.3 for two-piece, and refer to section 1.6.5 for three-piece.
14. Install all remaining components that were removed for this procedure.
15. Connect starting power for the engine.
16. Verify proper Jake Brake installation by driving the vehicle, then checking engine brake performance.

1.29.6 Removal of Model 790 Jake Brake Assembly

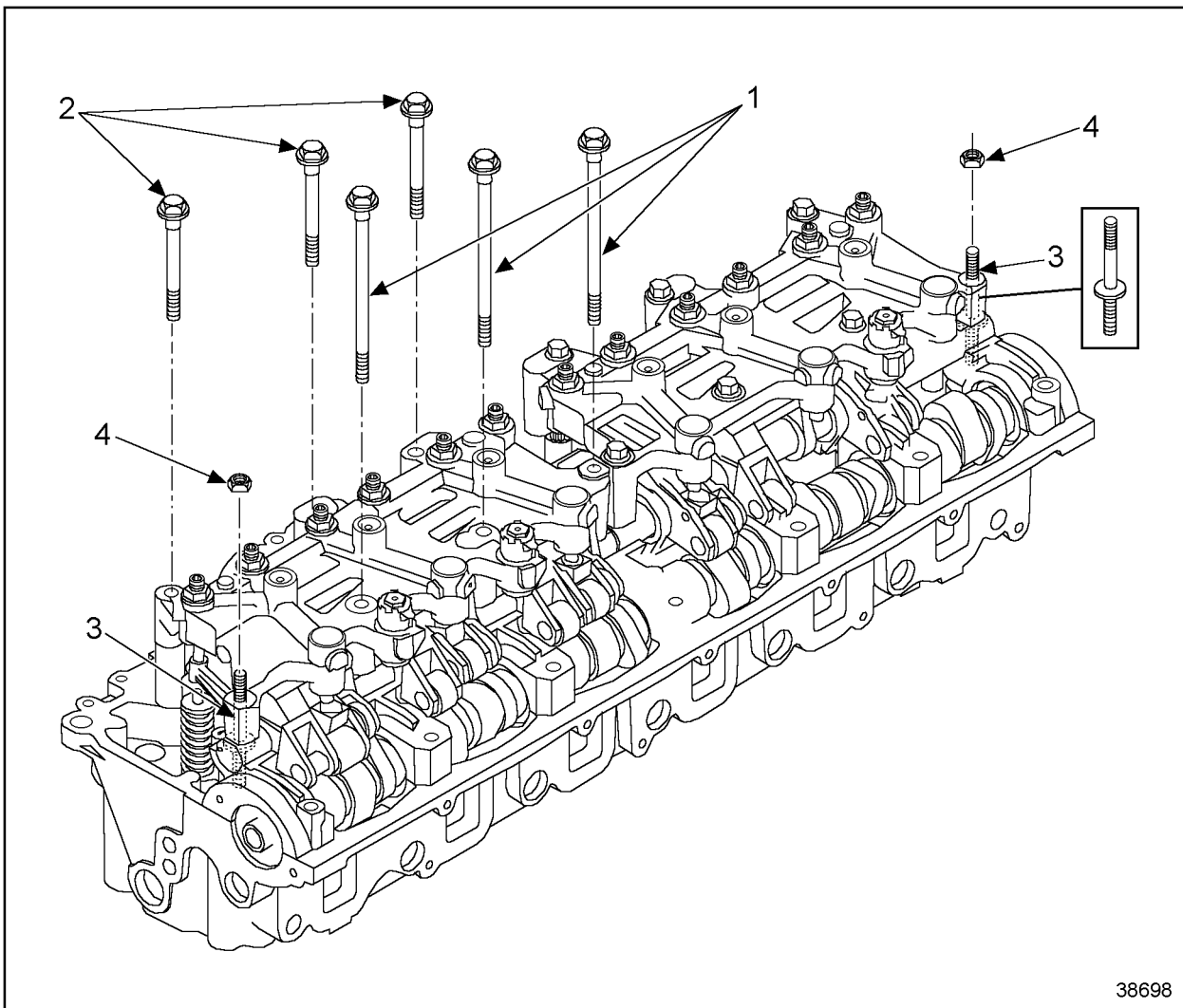
Remove the Model 790 Jake Brake as follows:

 CAUTION:
To avoid injury from hot engine surfaces, stop the engine and allow it to cool ambient temperature before working on it.

 CAUTION:
To avoid injury from accidental engine start-up, disable/disconnect power to the engine starting system.

1. With the engine at ambient temperature and power to the starting system disconnected, Refer to section of the *Series 60 Service Manual*, 6SE483 and remove the engine rocker cover.
2. Note the location of the rocker arm shaft, the exhaust valve rocker arm, the fuel injector rocker arm, and the intake valve rocker arm.
3. Disconnect the solenoid wiring harness connectors from the Jake Brake solenoids.

4. Remove the three (3) 140 mm long mounting bolts that secure the engine brake to the cylinder head. See Figure 1-443a.



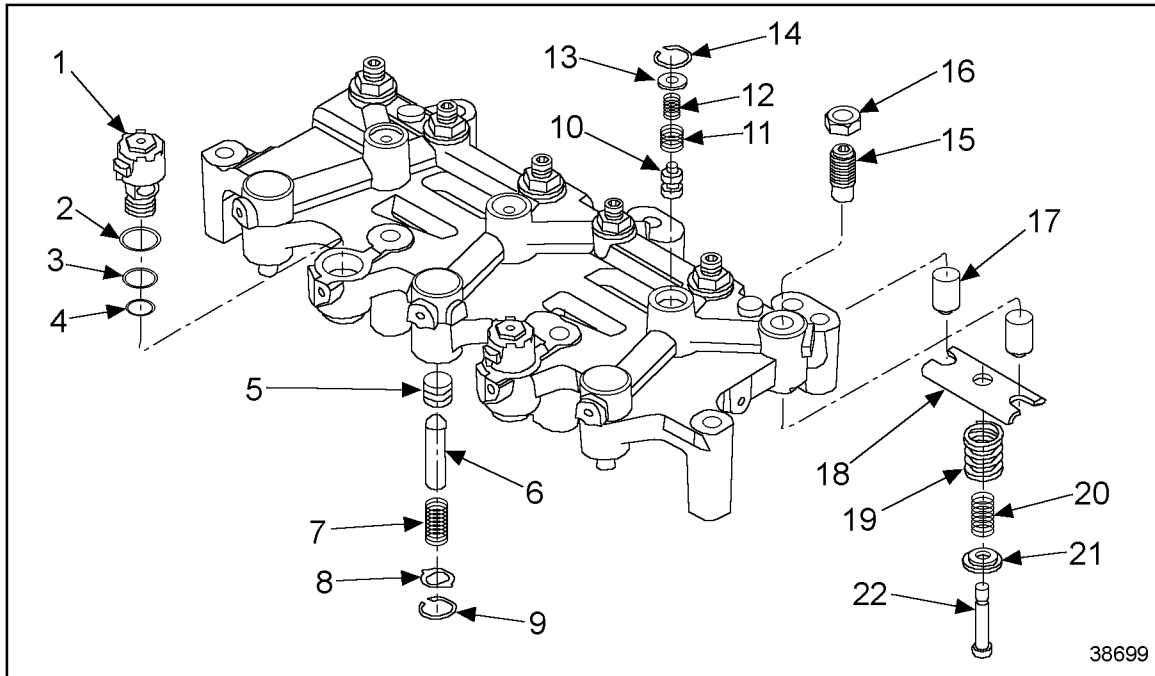
- | | |
|--------------------------------|--------------|
| 1. Mounting Bolt — 170 mm Long | 3. Stud Bolt |
| 2. Mounting Bolt — 140 MM Long | 4. Nut |

Figure 1-443a Model 790 Jake Brake Fasteners

5. Remove the three (3) 170 mm long mounting bolts and the two (2) nuts that secure the engine brake to the cylinder head.
6. Remove the engine brake assembly.
7. Repeat steps 1 through step 5 and remove the second Jake Brake assembly from the engine.

1.29.6.1 Disassembly of Model 790 Jake Brake

Instructions for disassembly of Model 790 Jake Brakes are incomplete at time of publication, but will be provided at a future date. For components of Model 790 Jake Brakes, see Figure 1-443b.



- | | |
|--------------------------------|-------------------------------|
| 1. Solenoid Valve | 12. Washer |
| 2. Center Seal | 13. Retaining Ring |
| 3. Center Seal | 14. J-Lash® Screw |
| 4. Lower Seal | 15. Locknut |
| 5. Master Piston | 16. Slave Piston |
| 6. Master Piston Pushrod | 17. Slave Piston Bridge |
| 7. Master Piston Spring | 18. Outer Slave Piston Spring |
| 8. Retaining Ring | 19. Inner Slave Piston Spring |
| 9. Control Valve | 20. Slave Piston Spring Seat |
| 10. Outer Control Valve Spring | 21. Shoulder Bolt |
| 11. Inner Control Valve Spring | 22. Shoulder Bolt |

Figure 1-443b Typical Model 790 Jake Brake Assembly

1.29.7 Cleaning of Model 790 Jake Brake

Instructions for cleaning of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.8 Inspection of Model 790 Jake Brake

Instructions for inspection of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.9 Assembly of Model 790 Jake Brake

Instructions for assembly of Model 790 Jake Brake are incomplete at the time of publication, but will be provided at a future date.

1.29.10 Installation of Model 790 Jake Brake Assembly

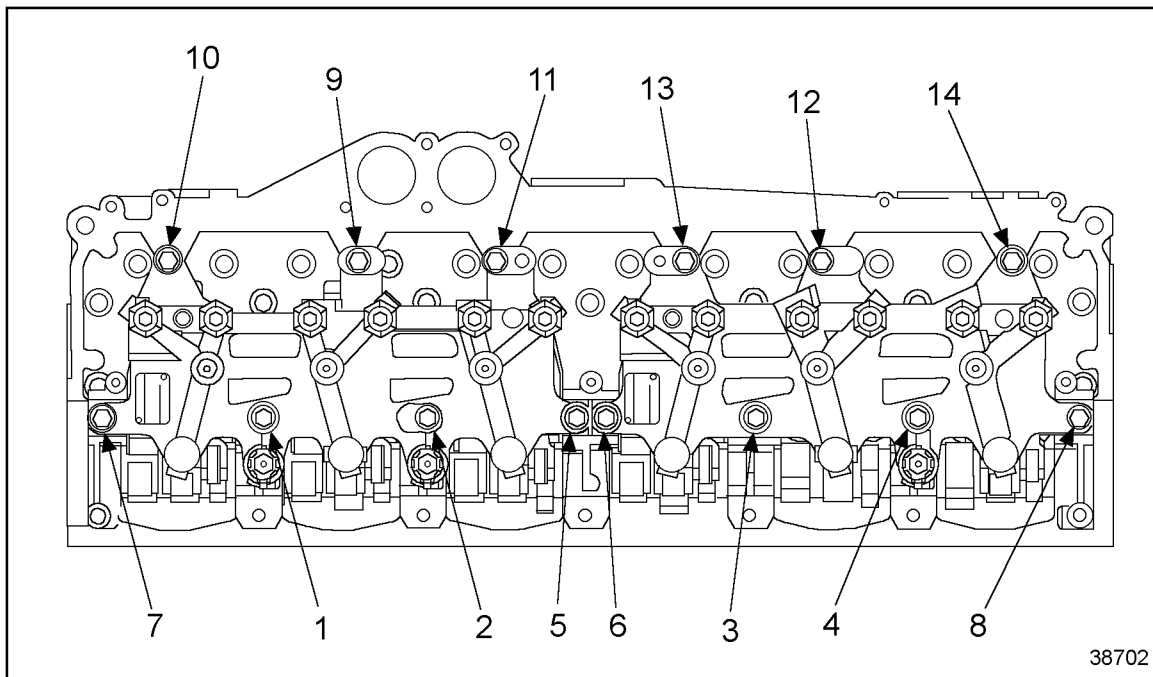
The installation procedures for the model 790 Jake Brake assemblies differ slightly from the former engine brakes. Two brake housings are used, instead of three, and spacer bars are not required. Install the model 790 Jake Brake assemblies as follows:

1. With the engine at ambient temperature, install front Jake Brake housing (with two solenoids) over the front three cylinders. Position with solenoids on camshaft side of engine.
2. Install the rear housing (with one solenoid) over the rear three cylinders. Position with solenoid on camshaft side of engine.

NOTE:

There is one extra mounting hole drilled on the slave piston side of each housing. These holes are for manufacturing purposes only and are not used for installation.

3. Install six (6) 170 mm bolts through the housings into the rocker shafts in locations 1 through 6, and install two (2) nuts in locations 7 and 8. See Figure 1-443c.



38702

Figure 1-443c Housing Hold-Down Bolt Locations

NOTICE:

To ensure proper engine brake housing installation, Jake Brake mounting bolts (identified by a circle "J" on the heads) and required one-piece spacers *must* be used when mounting the brake assemblies.

4. Install six (6) 140 mm bolts into each housing and through the spacers in locations 9 through 14.
5. Torque all mounting bolts to 136 N·m (100 lb-ft) in bolt location number sequence shown. See Figure 1-443c.
6. Route the wire to the solenoid for cylinder 1 through the front retaining clip on the front housing and connect to the solenoid. Torque screw to 1.13 N·m (10 lb-in.).
7. Route wire to the solenoid for cylinders 3 and 4 through the rear retaining clip on the front housing and connect to the solenoid. Torque screw to 1.13 N·m (10 lb-in.).
8. Route wire to the solenoid for cylinders 4, 5 and 6 through the single retaining clip on the rear housing and secure to the terminal screw on the solenoid. Torque screw to 1.13 N·m (10 lb-in.).
9. Secure any excess wire to the injector harness with wire ties.

1.29.10.1 Set Slave Piston Lash

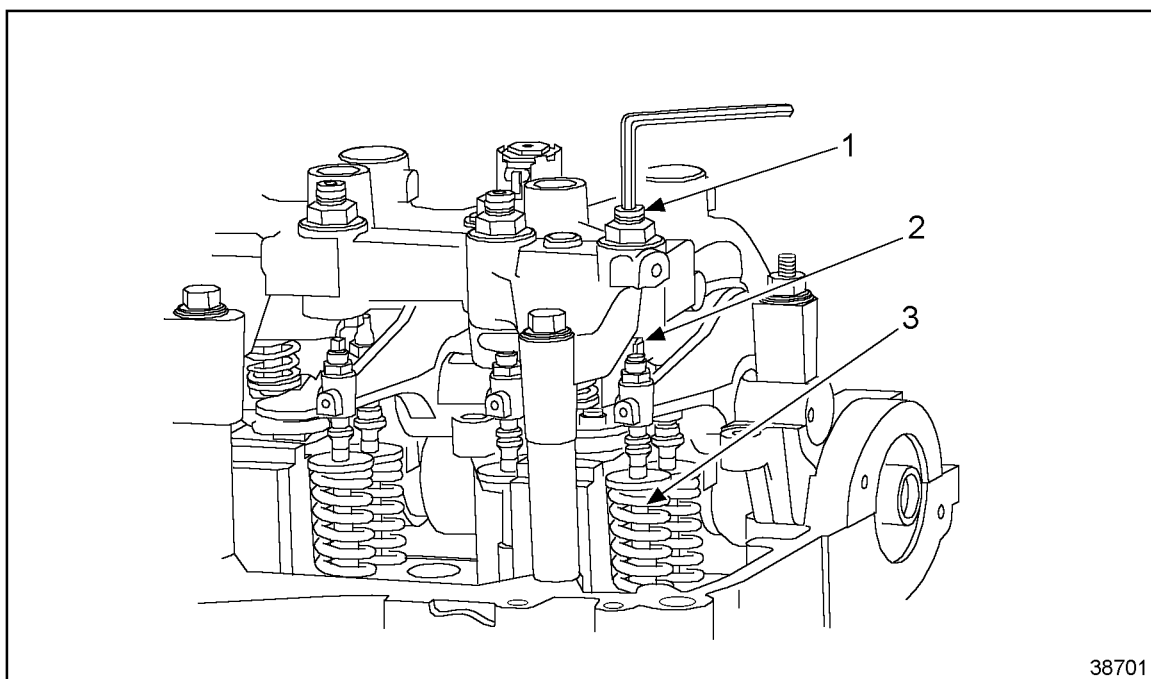
The slave piston lash must be set after Jake Brake housings are installed. Adjustments must be made with the engine stopped and cold and the oil temperature at 60°C (140°F) or below. Exhaust valves on the cylinder must be in the closed position (rocker arm roller should be on the base circle of the camshaft).

NOTICE:

The slave piston adjustment procedure *must* be followed exactly. Failure to properly adjust Jake Brakes will result in inefficient engine brake performance and may lead to severe engine or Jake Brake damage.

Adjust Jake Brake Model 790 slave piston lash as follows:

1. Loosen the locknut. Then, using a 5/16 in. Allen wrench, turn the J-Lash adjusting screw counter-clockwise until a 0.660 mm (0.026 in.) feeler gauge can be inserted between the slave piston and the exhaust rocker adjusting screw. Insert the feeler gauge.
2. Using the 5/16 in. Allen wrench, turn the J-Lash adjusting screw in (clockwise) until the slave piston contacts the feeler gauge and the exhaust rocker adjusting screw. When the valve spring begins to compress, turn the screw clockwise *one* additional turn. *Wait at least 30 seconds for oil to be purged from the J-Lash adjusting screw.* See Figure 1-443d.



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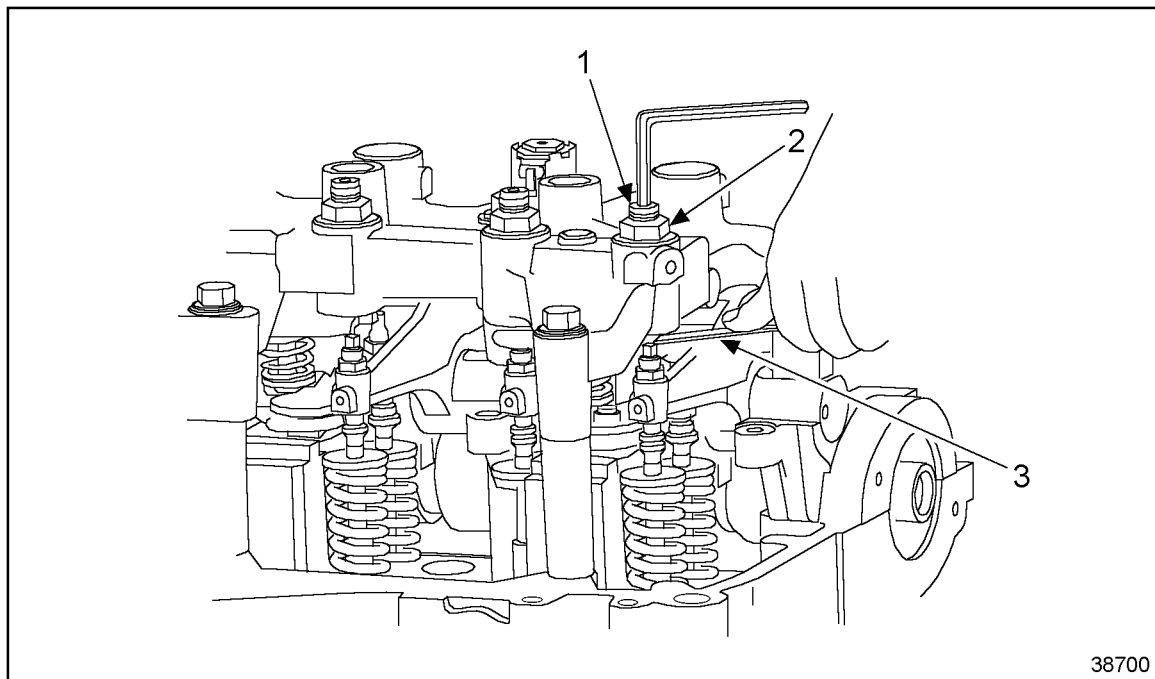
- | | |
|---------------------------|-------------------------|
| 1. J-Lash Adjusting Screw | 3. Exhaust Valve Spring |
| 2. Slave Piston | |

Figure 1-443d Turn the Adjusting Screw Until the Valve Spring Compresses

NOTICE:

Oil *must* be purged from the J-Lash adjusting screw. Oil remaining in the J-Lash screw will cause inaccurate clearance adjustment, which could result in damage to the engine or Jake Brake. ***If oil is below room temperature (below 16° C or 60° F), wait at least two minutes for oil to be purged from the J-Lash adjusting screw.***

- After waiting the required interval to purge oil from the J-Lash adjusting screw, back out the adjusting screw (turn counter-clockwise) ***only*** until a 0.660 mm (0.026 in.) feeler gage can be moved with a slight resistance. See Figure 1-443e. ***Do not back out the J-Lash adjusting screw more than required to obtain a light drag on the feeler gage.*** Using the Allen wrench to hold the J-Lash adjusting screw in place, torque the lock nut to 35 N·m (25 lb-ft).



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- J-Lash Adjusting Screw
- Locknut
- Feeler Gage

Figure 1-443e Adjusting Slave Piston Lash**NOTE:**

If the J-Lash adjusting screw is backed out until it no longer compresses the slave piston spring, oil will enter the screw and the adjustment will be incorrect. If this occurs, repeat step 1 and step 2.

4. After torquing the adjusting screw lock nut, recheck lash setting. If lash is incorrect, repeat step 1 and step 2.

NOTE:

Once the engine brake has been run, you will not be able to check Jake Brake adjustment. This is because of oil retained in the J-Lash adjusting screw. If unsure of the adjustment, you must repeat step 1 through step 3.

5. Repeat step 1 through step 3 for the remaining slave piston on the same cylinder.
6. Repeat step 1 through step 4 for the remaining cylinders.
7. Complete the installation by installing the rocker cover. Refer to section 1.6 of the service manual.
8. Install all remaining components that were removed for this procedure.
9. Connect starting power for the engine.
10. Start and drive the vehicle to verify proper Jake Brake performance.

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