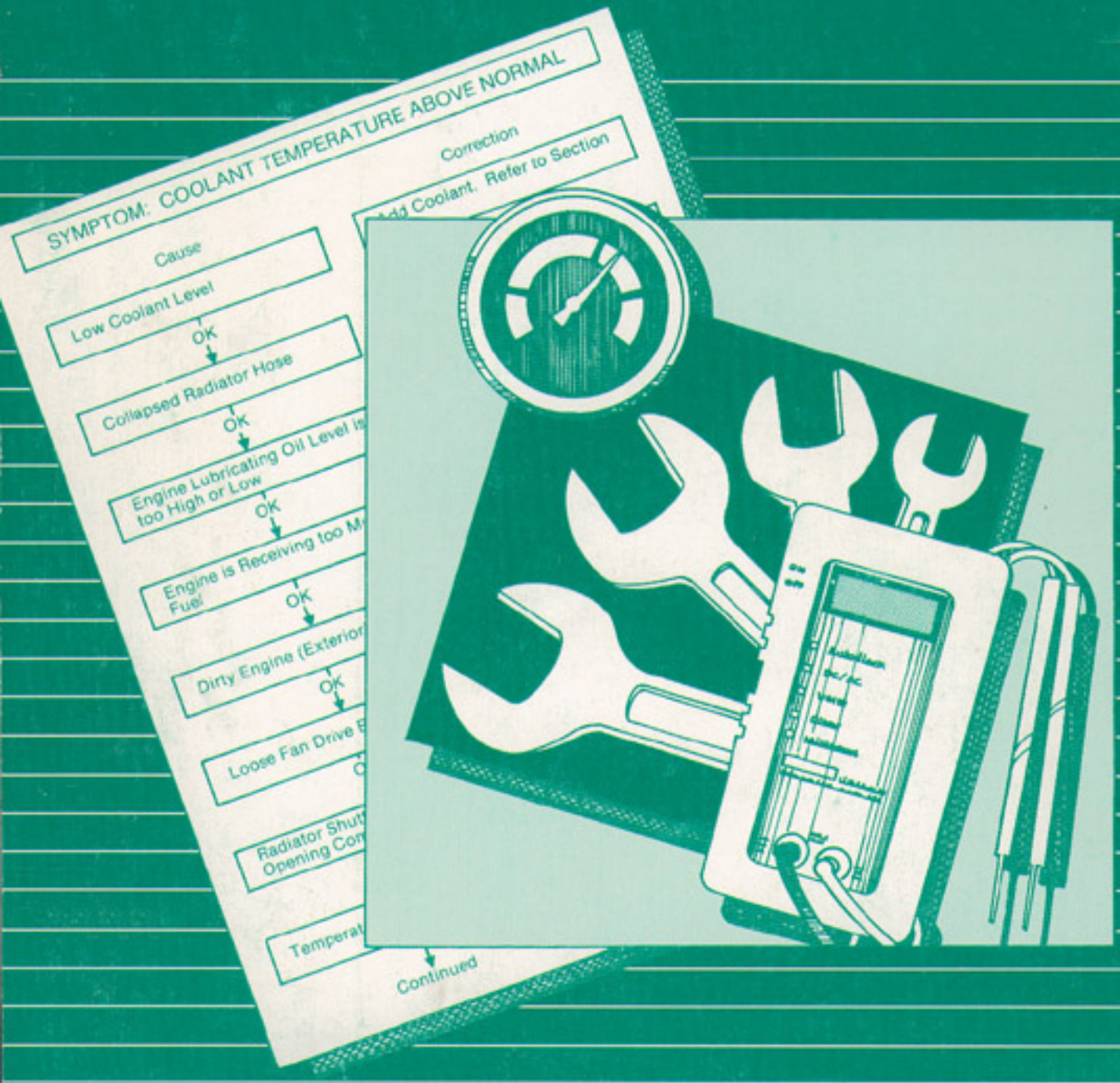
Troubleshooting and Repair Manual B Series Engines 1991 and 1994 Certification Levels



Symboles

Les symboles suivants sont utilisés dans ce manuel pour aider à communiquer le but des instructions. Quand l'un de ces symboles apparaît, il évoque le sens défini ci-dessous:

AVERTISSEMENT - De graves lésions corporelles ou des dommages matériels considérables peuvent survenir si les instructions données sous les rubriques "Avertissement" **ne** sont **pas** suivies.

ATTENTION - De petites lésions corporelles peuvent survenir, ou bien une pièce, un ensemble ou le moteur peuvent être endommagés si les instructions données sous les rubriques "Attention" **ne** sont **pas** suivies.

Indique une opération de **DEPOSE.**

Indique une opération de **MONTAGE.**

L'INSPECTION est nécessaire.

NETTOYER la pièce ou l'ensemble.

EFFECTUER une **MESURE** mécanique ou de temps.

GRAISSER la pièce ou l'ensemble.

Indique qu'une **DIMENSION DE CLE** ou **D'OUTIL** sera donnée.

SERRER à un couple spécifique.

EFFECTUER une **MESURE** électrique.

Se reporter à un autre endroit dans ce manuel ou à une autre publication pour obtenir des informations plus complètes.

Le composant pese 23 kg [50 lb] ou davantage. Pour eviter toute blessure, employer un appariel de levage ou demander de l'aide pour le soulever.

Automotive Engine Specifications

General Engine Data	B3.9	B5.9
Bore - mm [in.]	102 [4.02]	
Stroke - mm [in.]	120 [4.72]	
Displacement - litre [in.^{3}]	3.9 [239]	5.9 [359]
Engine Weight (Dry) Less Flywheel and Electrics-kg [lbs]	308-329 [680-725]	388-411 [855-905]
Firing Order	1.3.4.2	1.5.3.6.2.4
Valve Clearances		
-Intake- mm [in.]	0.25 [0.010]	
-Exhaust- mm [in.]	0.51 [0.020]	
Compression Ratio	(Rotary Pump) 17.6:1	(In-Line Pump) 17.9:1
Rotation, viewed from the Front of the Engine	Clockwise	
Aspiration		
- Turbocharged	X	X
-Charge Air Cooled	X	X
Lubrication System		
Lubricating Oil Pressure at Idle - (Minimum Allowable) kPa [PSI]	69 [10]	
Lubricating Oil Pressure at Rated - (Minimum Allowable) kPa [PSI]	207 [30]	
Regulating Valve Opening Pressure kPa [PSI]	449 [65]	
Differential Pressure to Open the Bypass Valve - kPa [PSI]	138 [20]	
Lubricating Oil Capacity		
Standard Pan Only - Liter [U.S. Quarts]	9.5 [10]	14.2 [15]
Total System - Liter [U.S. Quarts]	11 [11.6]	16.4 [17.3]
Number of Liters [U.S. Quarts] from Low to High	0.9 [1]	1.9 [2]
Cooling System		
Coolant Capacity (Engine Only) - Litre - [U.S. Qts.]	7. [7.4]	10.5 [11.1]
Standard Modulating Thermostat - Range - °C [°F]	Start 83 [181]	Fully Open 95 [203]
Pressure Cap (kPa [PSI])		
104°C [220°F] Systems	103 [15]	
99°C [210°F] Systems	48 [7]	

Engine Cranks But Will Not Start - No Smoke From Exhaust

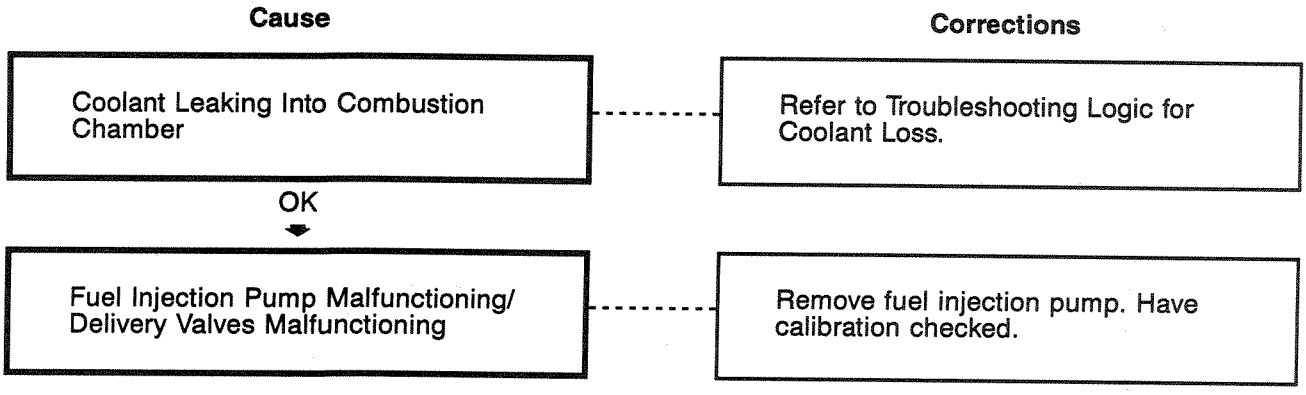
Cause	Corrections
No Fuel in Supply Tank	Check/replenish fuel supply
OK ↓	
Electrical or Manual Fuel Shutoff Not Open	Check for loose wires and verify that the valve is functioning. Check to be sure manual shutoff lever is in the run position. Refer to Procedures 5-05 or 5-11.
OK ↓	
Improper Starting Procedure	Verify proper starting procedure. Refer to the Operation and Maintenance Manual.
OK ↓	
Fuel Filter Plugged With Water or Other Contamination	Drain fuel/water separator or replace fuel filter. Refer to Procedure 5-04.
OK ↓	
Inspect Fuel Transfer Pump Operation	Refer to Procedure 5-02.
OK ↓	
Fuel Injection Pump Not Getting Fuel or Fuel is Aerated	Check fuel flow/bleed fuel system. Refer to Procedures 5-03 and 5-15.
OK ↓	
Check Fuel Inlet Restriction	Maximum inlet restriction to fuel transfer pump must not exceed 100 mm Hg [4 in. Hg].
OK ↓	
Air Intake or Exhaust System Plugged	Visually check; remove the obstruction. Check exhaust system for obstruction.
OK ↓	

(Continued)

Engine Runs Rough Or Misfiring (Continued)

Cause	Corrections
Valve Adjustment Incorrect	Check for a bent push rod and adjust valves. Refer to Procedures 7-03 and 7-04.
OK ↓	
Injection Pump Timing Incorrectly Adjusted	Check top dead center (TDC). Refer to Procedure 7-21. Check/adjust injection pump timing. Refer to Procedure 5-36. Check/time the fuel injection pump using the spill port timing if equipment is available. Refer to Procedure 5-36.
OK ↓	
Compression in One or More Cylinders Low	Perform a compression check and repair as required. Refer to Procedure 7-01.
OK ↓	
Injectors Malfunctioning	Check/replace injectors. Refer to Procedures 5-13 and 5-40.
OK ↓	
Injection Pump (Delivery Valves) Defective	Remove fuel injection pump. Have calibration checked.
OK ↓	
Camshaft Out of Time	Check/correct gear train timing alignment. Refer to Procedure 5-36.
OK ↓	
Camshaft or Tappets Damaged	Inspect camshaft and tappets. Refer to Procedure 7-19.

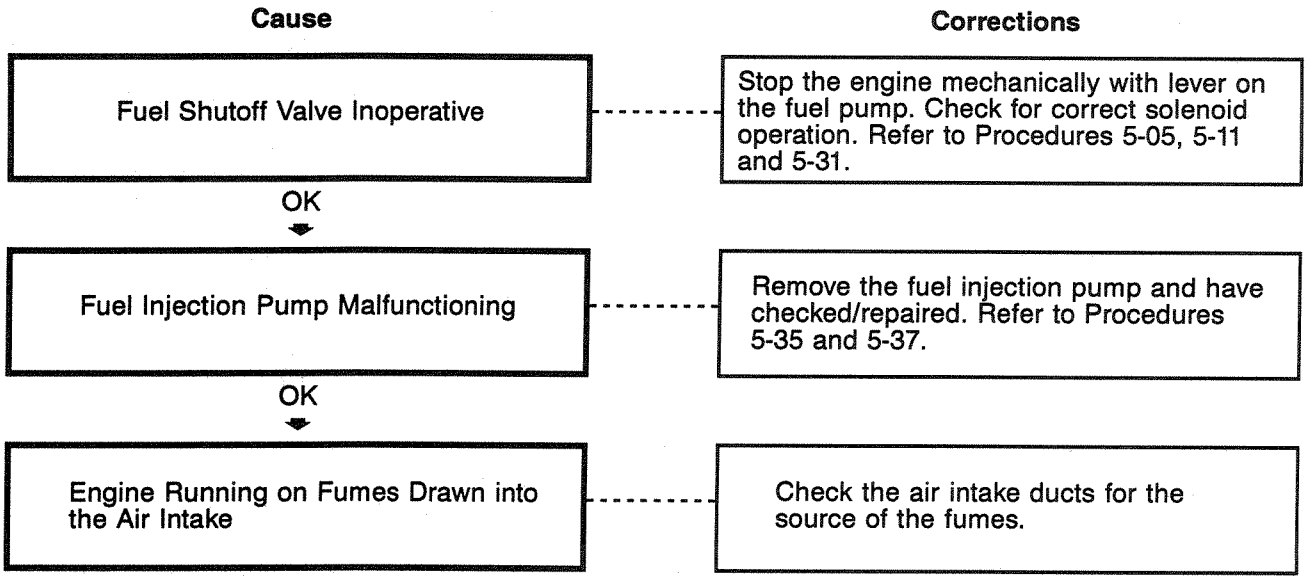
Exhaust White Smoke Excessive (Continued)

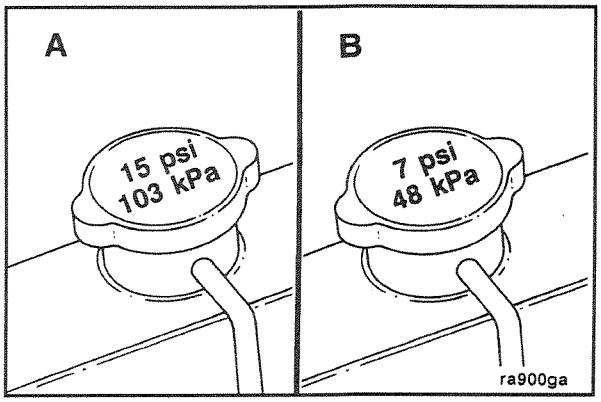


Lubricating Oil Pressure Low (Continued)

Cause	Corrections
If Lubricating Oil Cooler was Replaced, Shipping Plugs Left in Cooler	Check/remove shipping plugs.
OK ↓	
If Replaced, Four Cylinder Lubricating Oil Pump Installed in a Six Cylinder Engine	Verify that the correct lubricating oil pump is installed. Refer to Procedure 2-07.
OK ↓	
If Replaced, a Pre-1991 Lubricating Oil Pump Installed in a 1991 or Later Engine.	Verify that the correct lubricating oil pump is installed. Refer to Procedure 2-07.
OK ↓	
Cylinder Block or Cylinder Head Plugs Loose or Missing	Check/replace expansion plugs. Refer to Procedure 2-08.
OK ↓	
Suction Tube Loose or Broken Seal Leaking	Check/replace seal. Refer to Procedure 2-06.
OK ↓	
Lubricating Oil Pump Worn	Check/replace lubricating oil pump. Refer to Procedure 2-07.
OK ↓	
Main Bearing Cap Loose	Check/install new bearings and tighten cap. Refer to Procedure 7-13.
OK ↓	
Bearings Worn	Inspect/replace bearings; also check/ replace piston cooling nozzles. Refer to Procedure 7-13.

Engine Will Not Shut Off



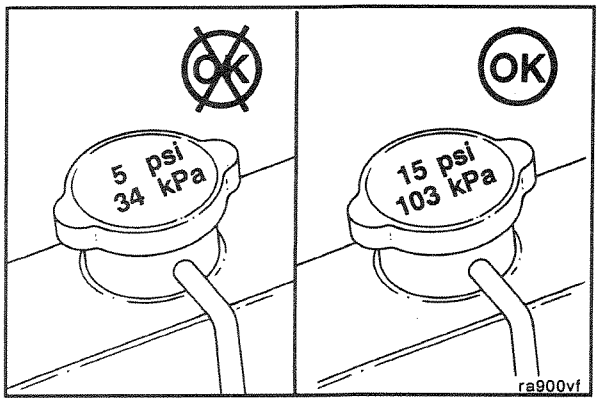


Pressure Caps

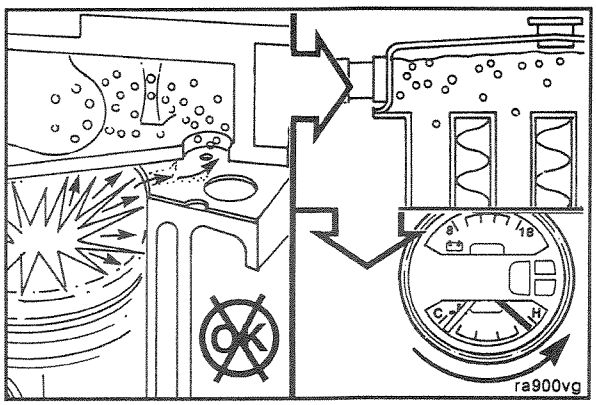
The system is designed to use a pressure cap to prevent boiling of the coolant.

Different caps are specified for the two recommended systems:

	System	Cap
A (Normal Duty)	104°C [220°F]	103kPa [15 PSI]
B (Light Duty)	99°C [210°F]	48kPa [7 PSI]

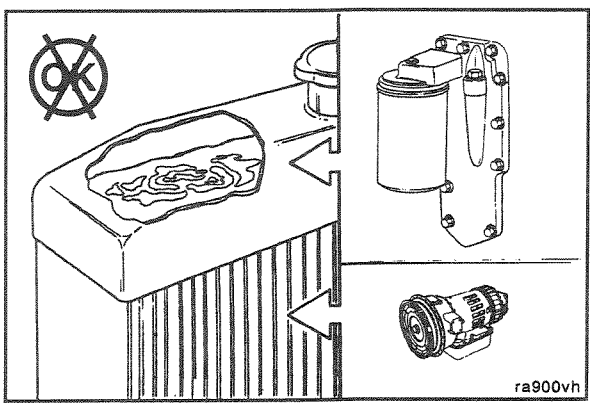


An incorrect or malfunctioning cap can result in the loss of coolant and the engine running hot.



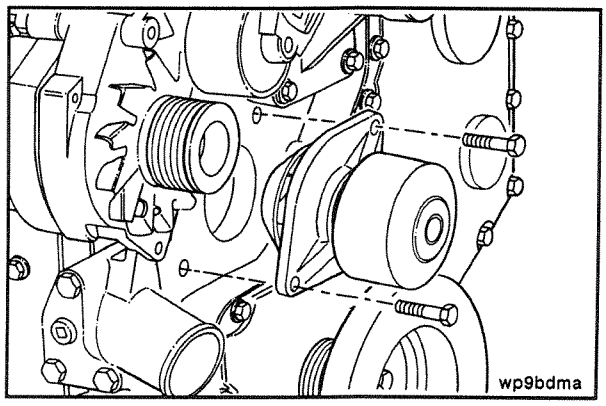
Air in the coolant can result in loss of coolant from the overflow when the aerated coolant is hot. The heated air expands, increasing the pressure in the system causing the cap to open.

Similarly, coolant can be displaced through the overflow if the head gasket leaks compression gasses to the coolant system.



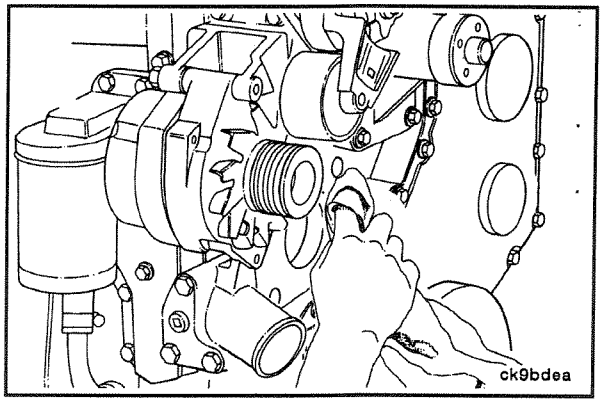
The operating pressure of the coolant system and the lubricating system can result in the mixing of the fluids if there is a leak between the systems: head gasket, oil cooler, etc. (refer to the Lubricating System).

NOTE: Transmission fluid can also leak into the coolant through radiator bottom tank transmission oil coolers.

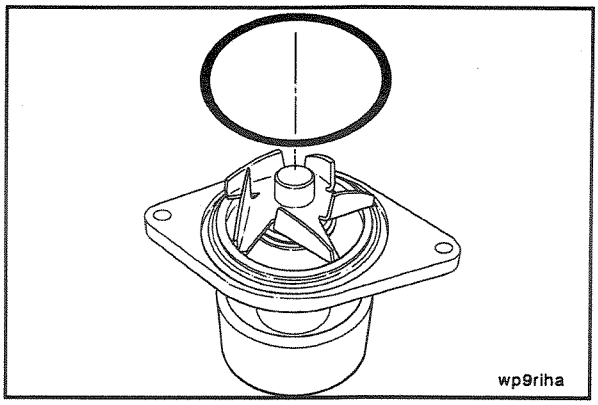


13 mm

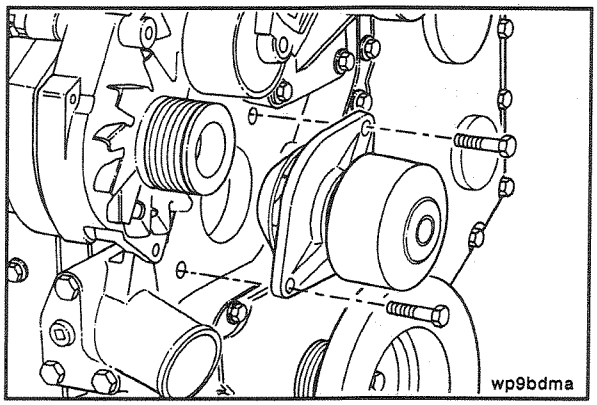
Remove the two capscrews and water pump, and complete the following steps.



Clean the sealing surface on the cylinder block.



Install the new sealing ring into the pump groove.

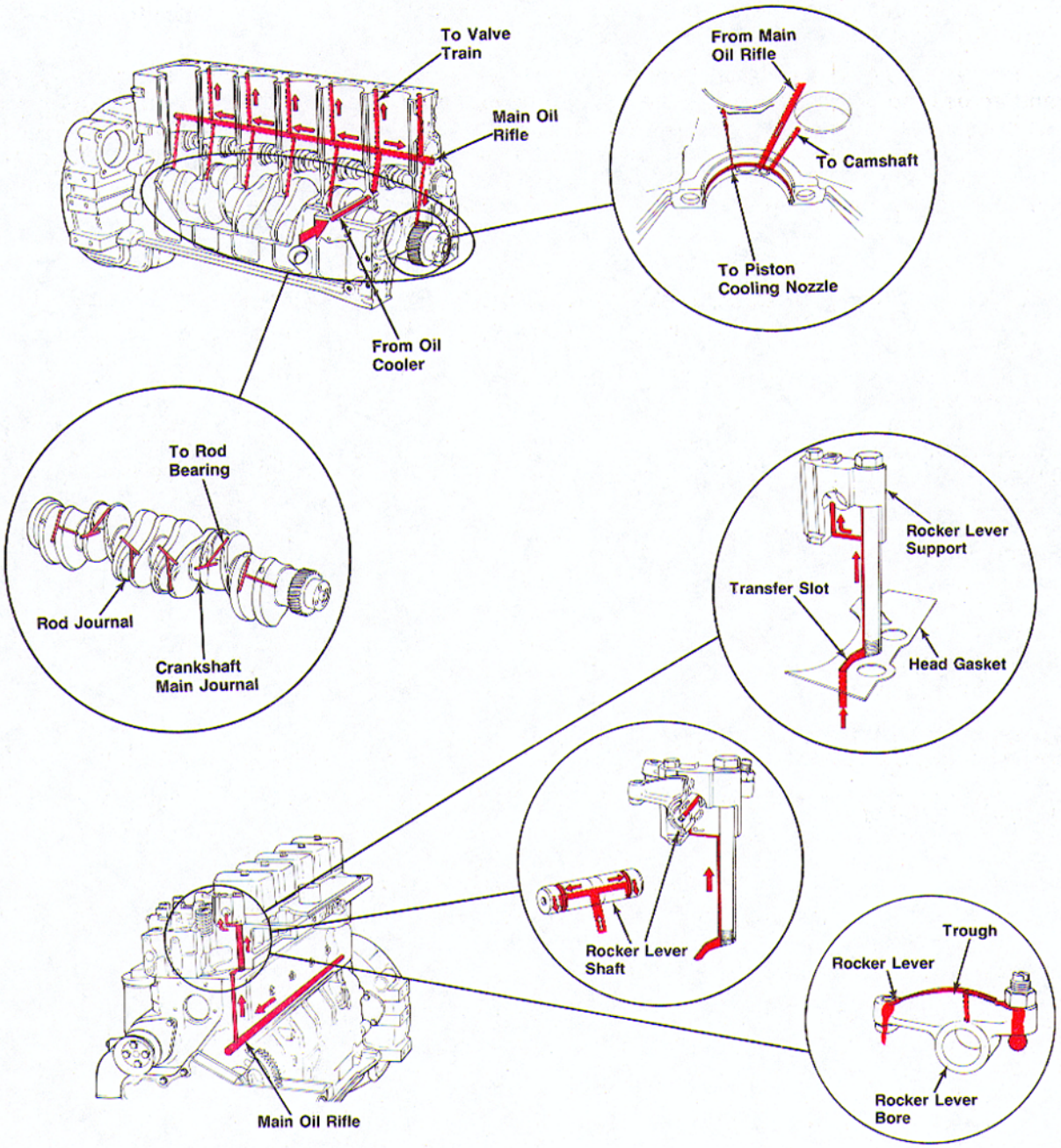


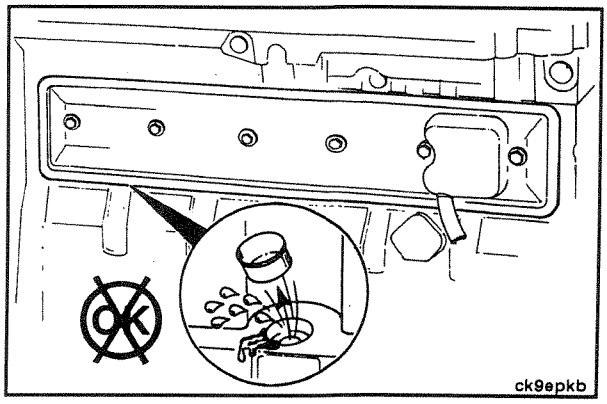
13 mm

Install the water pump.

Torque Value: 24 N•m [18 ft-lb]

Lubrication for the Power Components

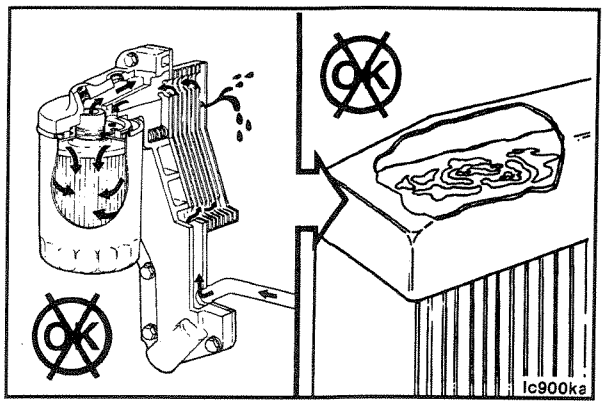




A blown expansion plug can allow a relatively large quantity of lubricating oil to escape resulting in a sudden drop in the lubricating oil pressure.

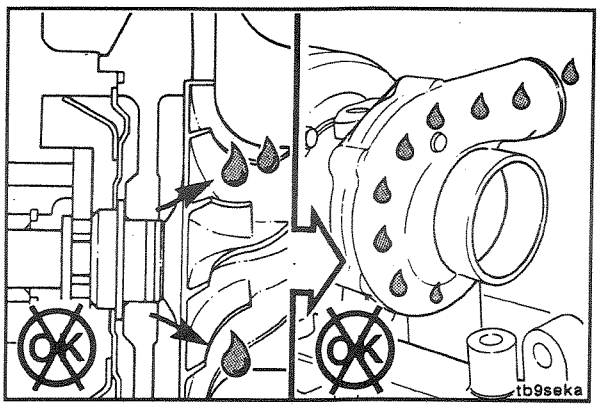
When checking for such a leak, be sure to check the expansion plug behind the tappet cover as well as those that may be obscured by chassis parts.

Lubricating oil blowing out the breather is a good sign of a blown expansion plug. This is usually more obvious on a four cylinder engine.



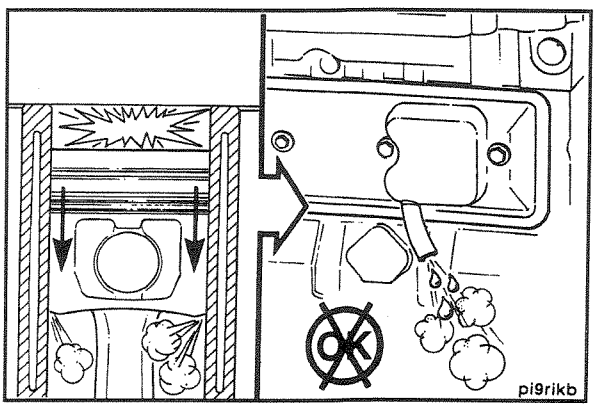
If the lubricating oil cooler element ruptures, the lubricating oil pressure will force lubricating oil into the coolant system. Lubricating oil in the coolant should be visible when the radiator cap is removed.

Refer to page 2-18 for lubricating oil cooler element replacement and testing.

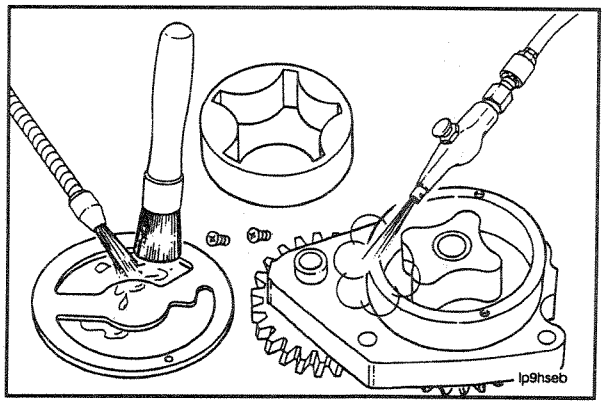


Worn or damaged seals in the turbocharger can also allow lubricating oil to leak into the air crossover pipe and be burned in the engine.

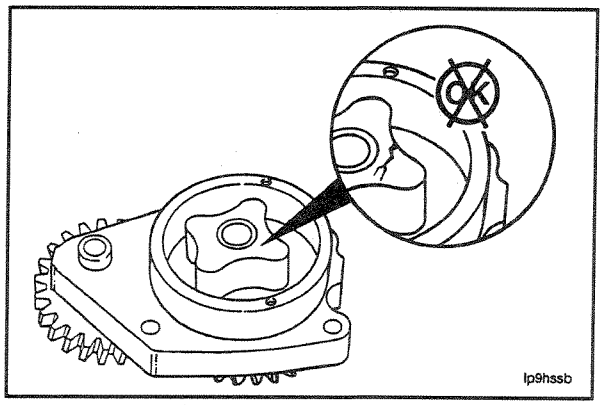
The condition can be verified by removing the air crossover tube or charge air cooler tubing and looking for oil.



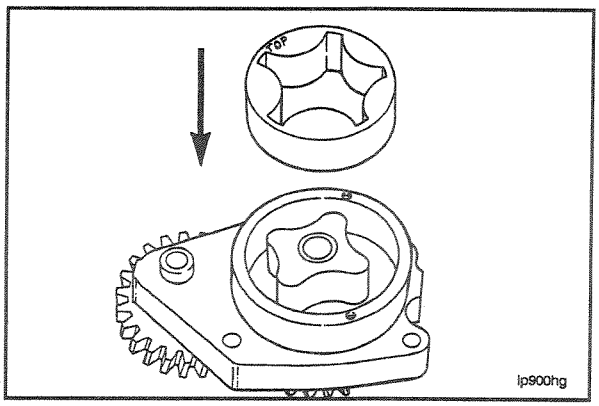
Inadequate sealing of the piston rings will result in lubricating oil being blown out the breather tube and/or consumed by the engine (refer to the Base Engine Components Section for measuring blow-by).



Clean all parts in solvent and dry with compressed air.

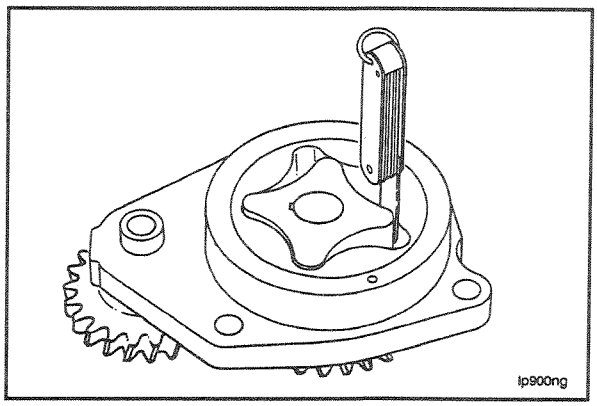


Inspect the lubricating oil pump housing and gerotor drive for damage and excessive wear.



Caution: Be sure the gerotor planetary is installed in the original position.

Install the gerotor planetary.



Measure the tip clearance.

Limit
Maximum Clearance: 0.1778 mm [0.007 in]

Intake Air and Exhaust System Specifications

- Maximum allowable intake restriction (compressor inlet) (with dirty air filter element)
  - Non turbo ..... 20 in/H_2O (50.8 cm/H_2O)
  - Turbo ..... 25 in/H_2O (63.5 cm/H_2O)
- Maximum exhaust restriction at rated speed and load
  - Non automotive ..... 3 in/Hg (76.2 mm/Hg)
  - 91 EPA Cert ..... 4.5 in/Hg (114.3 mm/Hg)
  - 94 EPA Cert. with oxidation catalyst ..... 6 in/Hg (152.6 mm/Hg)

Turbocharger Boost Pressure Specificlations

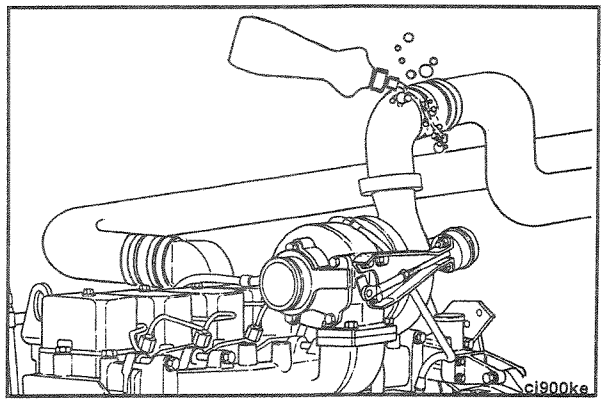
Refer to the following table for the critical parts list (CPL), engine model, engine rating and corresponding rated turbocharger boost pressure.

NOTE: Measurement of boost pressure is not a short cut to logical troubleshsooting. Low power can be caused by the fuel used, filter maintenance and several engine components. Follow the logic charts for "Engine Power Output Low" and measure boost pressure as indicated. Refer to page 3-13 for measurement instructions.

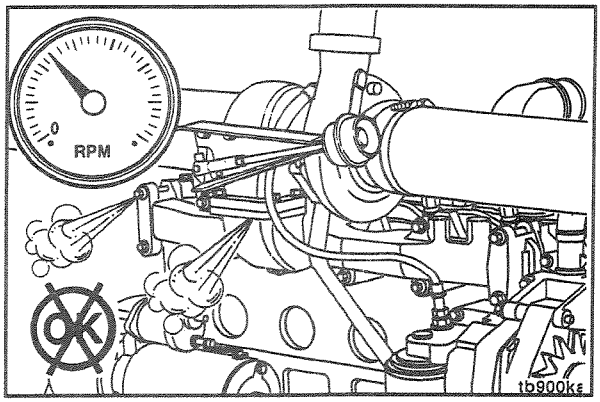
These pressures are valid only at rated conditions (rated speed and power). Any attempt to use the values at engine speeds and loads other than those specified will result in an incorrect diagnosis.

Table 1. B Series Boost Pressure Specifications

CPL	ENGINE MODEL	ENGINE RATING (HP @ RPM)	RATED BOOST PRESSURE (in. Hg)
0592	4BT3.9	100 @ 2500	22 to 28
		96 @ 2300	19 to 25
		94 @ 2200	18 to 24
		93 @ 2200	18 to 24
		92 @ 2100	16 to 22
		80 @ 2200	14 to 20
		71 @ 2200	12 to 18
		70 @ 2100	11 to 17
0594	4BTA3.9	91 @ 2200	17 to 23
		95 @ 2200	18 to 24
		107 @ 2100	21 to 27
		109 @ 2200	23 to 29
		112 @ 2300	24 to 30
		116 @ 2500	27 to 35
		125 @ 2200	27 to 33
0595	4BTA3.9	120 @ 2500	32 to 40
		120 @ 2800	34 to 42

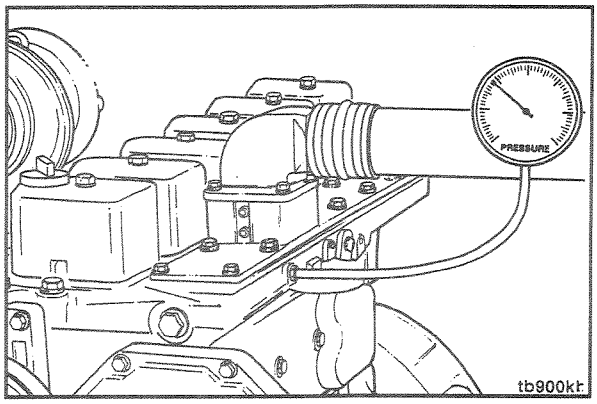


In addition to the visual inspection for cracks and loose fittings, liquid soap can be applied to the charge air cooler, connections and the manifold cover sealing surfaces to find the leaks. The leaks will create bubbles that are easier to detect. Measurement of manifold pressure is described in this Section.



Turbocharged Engines - Exhaust Leaks

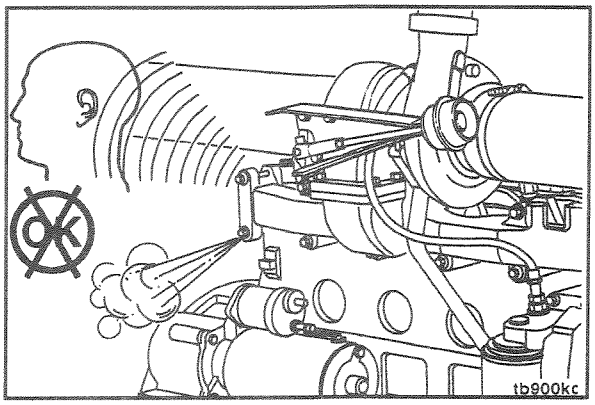
Inspect for exhaust leaks at the exhaust manifold and turbocharger, gasket leaks, or exhaust pipe, muffler or catalyst restrictions. Leaks or restrictions will cause the turbine and impeller to operate at a lower speed and reduce the amount of air being forced into the cylinders. Again, the symptom will be excess smoke, low manifold pressure and low power.



Turbocharger Boost Pressure - Measurement

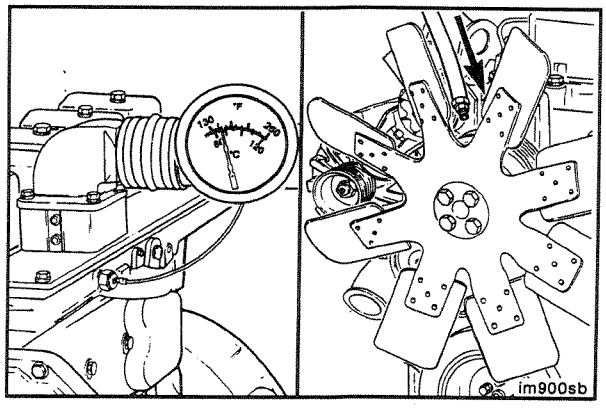
Measure the boost pressure at the intake manifold by using one of the tapped or plugged intake access holes shown in the illustration. Refer to the specifications in this section.

NOTE: If the engine has charge air cooling, testing must be done to ensure that the charge air cooler system is not leaking or restricting the turbo boost pressure - refer to Procedure (3-08) for charge air cooler testing.



Exhaust leaks can usually be detected audibly or visually by a discoloration caused by the escaping hot gases.

Don't overlook exhaust restriction as a cause of low power. If the exhaust gasses can not flow freely, the turbocharger will not operate efficiently.

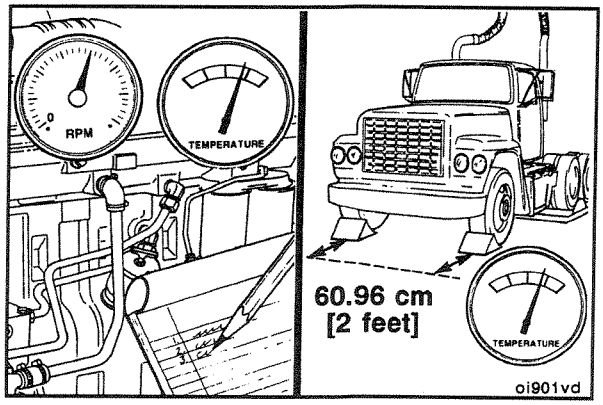


Intake Manifold Temperature - Check

Install a temperature gauge in the intake manifold.

Lock the fan drive in the ON mode to prevent erratic test results. This can be done by installing a jumper across the temperature switch or supplying shop air to the fan. Refer to the fan drive manufacturer for lock-up procedure.

NOTE: Some trucks have a manual switch that will lock on the fan.

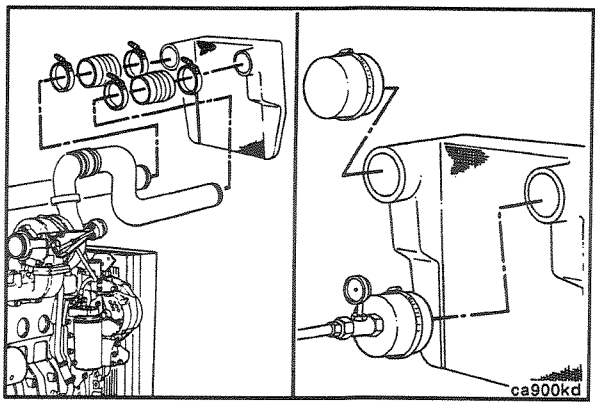


Operate the engine at rated RPM and load. Record the intake manifold temperature.

Measure the ambient temperature at least two feet in front of the vehicle.

The maximum temperature differential **must not** be greater than 25°C [45°F].

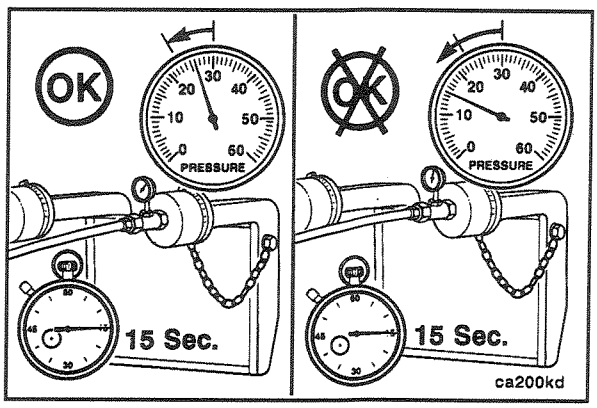
If the temperature differential is greater than 25°C [45°F], check the charge air cooler for dirt and debris on the fins, and clean as necessary. If the problem still exists, check the cooler for internal contamination or plugging.



To check the charge air cooler for cracked tubes or header, remove the inlet and outlet hoses from the cooler.

Remove the charge air cooler.

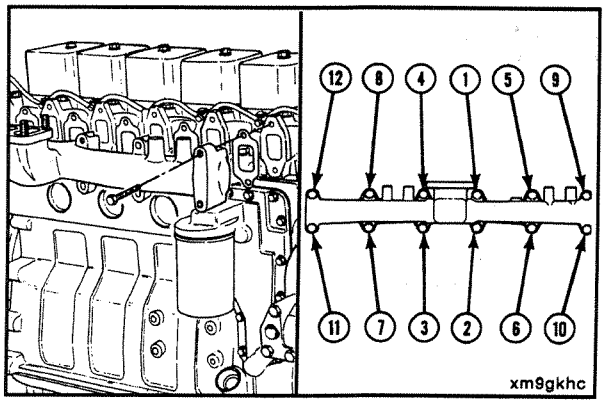
Install a cap over the outlet side of the cooler. Install a pressure gauge and a shop air supply line to the inlet side of the cooler.



Apply 207 kPa [30 psi] of air pressure to the cooler. If the pressure drop is 48 kPa [7 psi] or less in 15 seconds, the cooler is okay.

If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, the charge air cooler **must** be repaired or replaced. Refer to the CAC manufacturer for repair instructions.

NOTE: A leak tank can be used to locate the air leak.



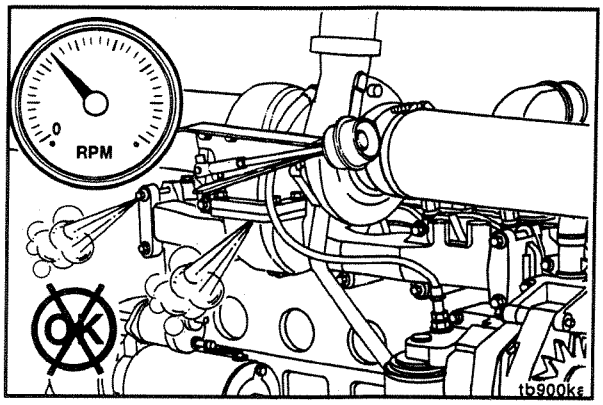
Installation

15 mm

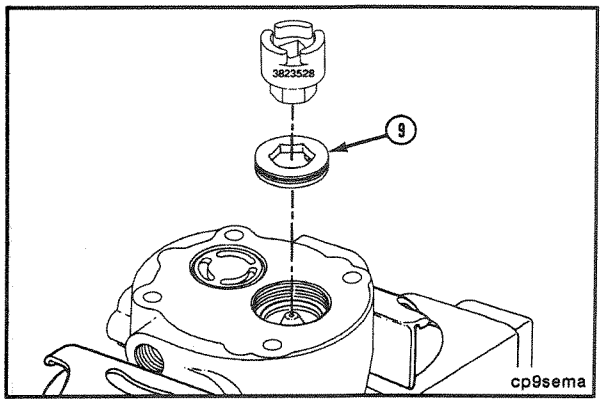
Install the exhaust manifold and new gaskets.

Torque Value: 43 N•m [32 ft-lb]

Follow the tightening sequence shown in the illustration.



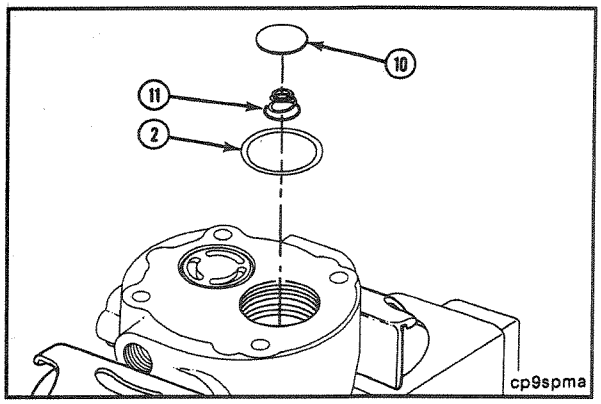
Install the parts previously removed. Operate the engine and check for leaks.



Part No. 3823528, Air Compressor Seat Socket or 3/4 inch Allen Wrench.

Install the head with the bottom side up in a soft jawed vise.

Remove the exhaust valve seat (9).

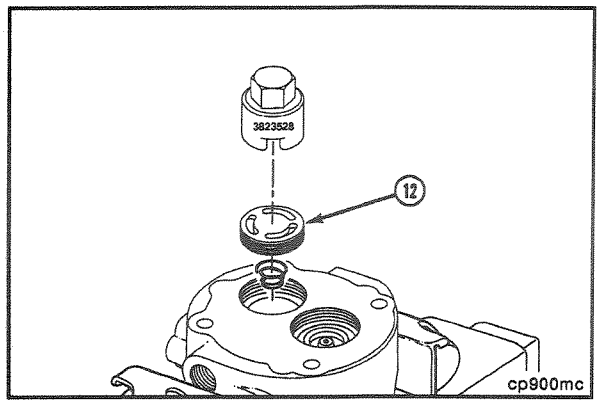


Remove the following parts:

- Exhaust valve disc (10)
- Spring (11)
- Copper washer (2)

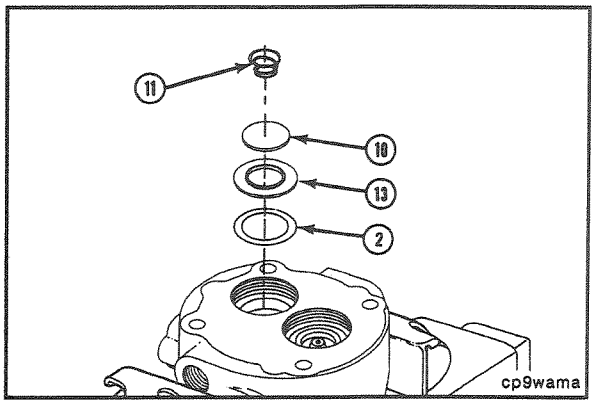
Discard the copper washer.

NOTE: The exhaust valve stop is pressed in place and **must not** be removed.



Part No. 3823528, Air Compressor Seat Socket

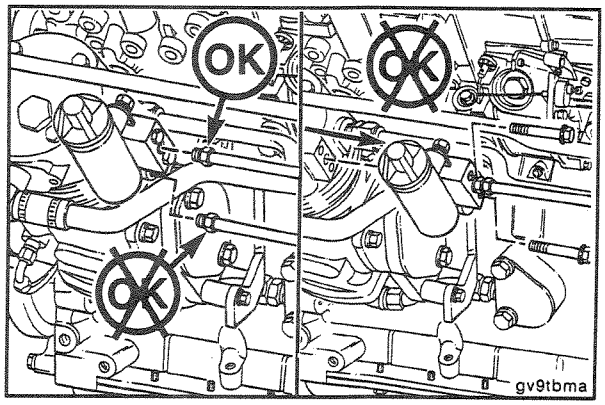
Remove the inlet valve cage (12).



Remove the following parts:

- Spring (11)
- Inlet valve disc (10)
- Inlet valve seat (13)
- Copper washer (2)

Discard the copper washer

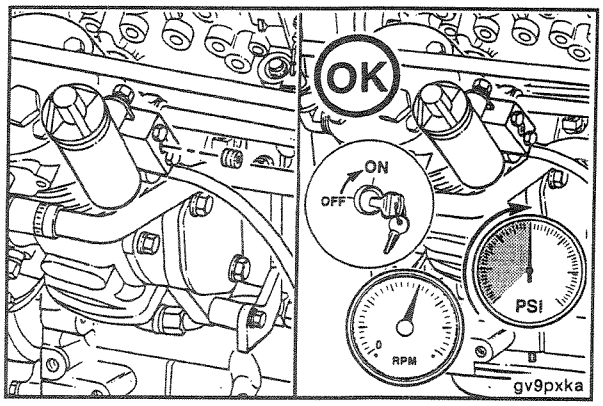


Air Governor - Check (4-05)

Air Compressor Pumps Continuously

Remove the accessory air lines from the air governor unloader port.

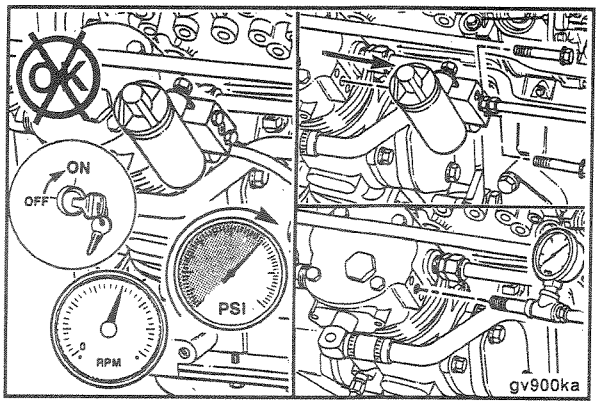
NOTE: Do not disconnect the line from the air compressor unloader valve. Do not disconnect the reservoir air line from the air governor. If the governor is mounted on the compressor, do not remove the governor from the compressor.



Install pipe plugs in the air governor unloader ports where accessory air lines were removed.

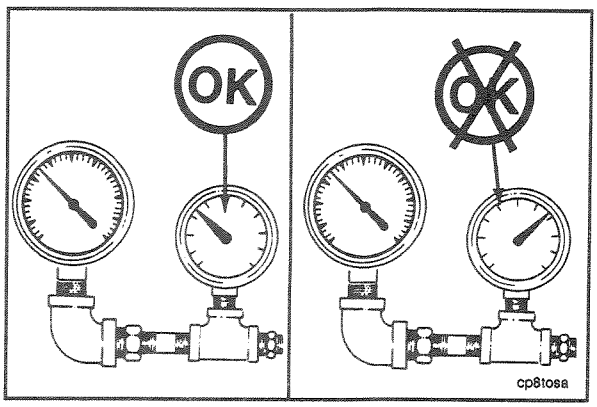
Operate the engine to activate the air compressor.

If the air compressor stops pumping (air pressure stops rising) at the governed air pressure, there is a leak in an accessory or an accessory air line. Refer to the equipment manufacturer's instructions for troubleshooting and repair.



If the air compressor does not stop pumping (air pressure continues to rise) at the governed air pressure, connect a regulated shop air pressure line to the the air compressor unloader valve port.

NOTE: If the governor is mounted on the air compressor, then the governor will have to be removed.

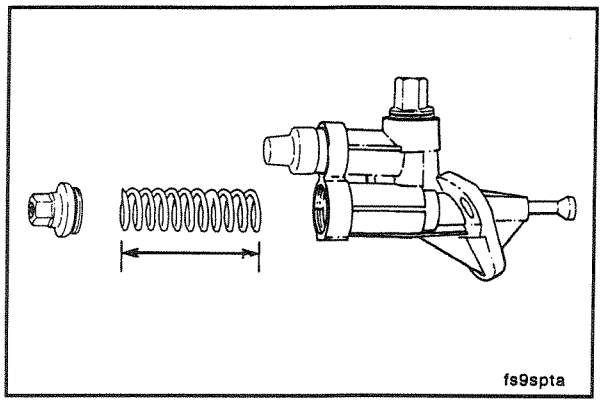


NOTE: Be sure the air pressure gauge is accurate and the supply lines and fittings are in good condition before performing any air pressure checks.

Use a master gauge of known accuracy to check the air pressure gauge.

Fuel Transfer Pump (Piston Style) - Diagnosing Malfunctions

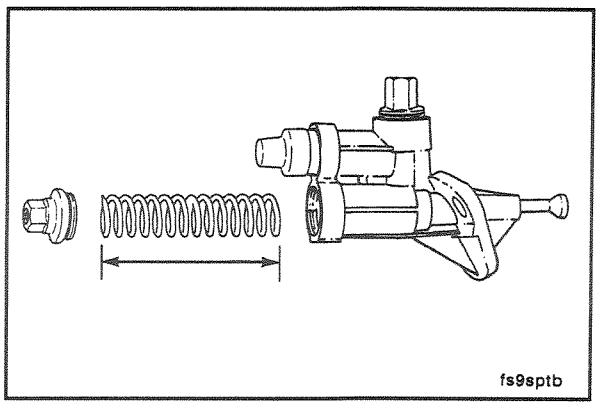
The B series engine uses three different piston style fuel transfer pumps. All three deliver different flow volumes.



Piston style fuel transfer pump, Part No. 3918076, is offered as an option on B series engines equipped with distributor type fuel injection pumps.

NOTE: Part No. 3918076 and 3918000 are identical in appearance. The pumping spring free length can be measured to identify the fuel transfer pump.

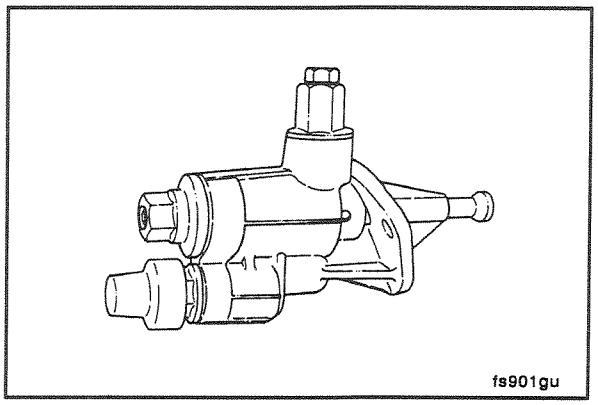
Fuel transfer pump 3918076 spring free length 53.5 mm [2 7/64 in].



Piston style fuel transfer pump, Part No. 3918000, comes standard on the 300 HP marine B series engine.

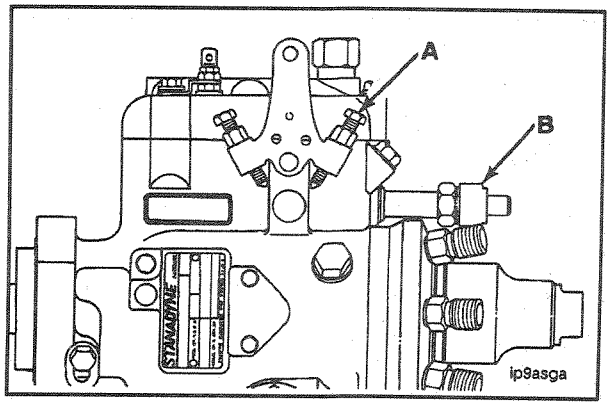
NOTE: Part No. 3918076 and 3918000 are identical in appearance. The pumping spring free length can be measured to identify the fuel transfer pump.

Fuel transfer pump 3918000 spring free length 58 mm [2 9/32 in].



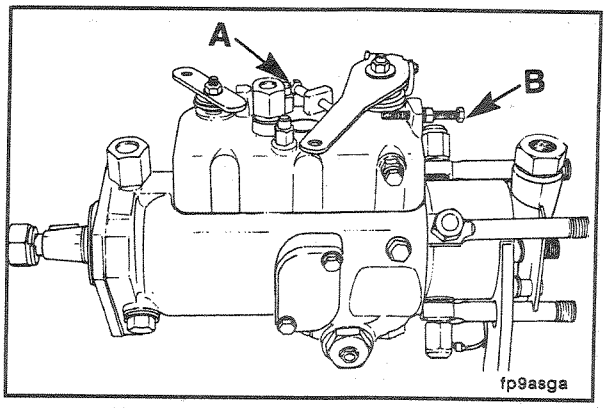
Piston style fuel transfer pump, Part No. 3921550 comes standard on the 91 B series engines equipped with the Bosch P7100 in-line fuel injection pumps.

Piston style fuel transfer pump, Part No. 3925709, comes standard on the 94 B series engines equipped with the Bosch P7100 in-line fuel injection pumps.



The high idle adjustment screw (A) is sealed. The adjustment screw on the DB4 fuel injection pump is mounted on the control level assembly. The high idle adjustment screw must be adjusted by an authorized service dealer.

The speed droop adjustment screw (B) is located above the delivery head. The fuel pump governor sensitivity can be adjusted to increase or decrease governor regulation.

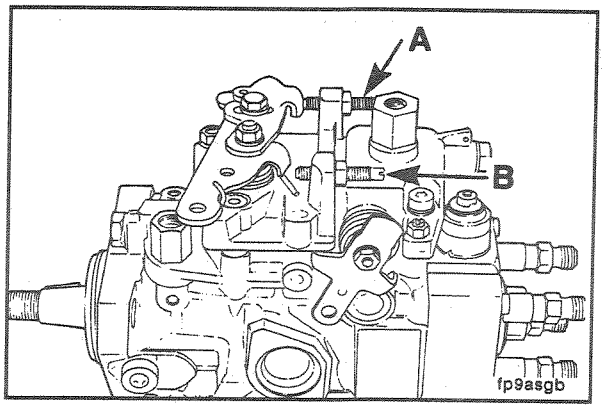


Lucas CAV DPA/DPS Fuel Injection Pump Adjustment Screws

The idle adjustment screw provides a stop for the lever at low speed. The adjustment screw can be used to increase idle speed for accessory loading or, if required, to lower the idle speed. The high idle screw is sealed and must be adjusted by an authorized repair shop, and then resealed.

A - Idle screw

B - High idle screw



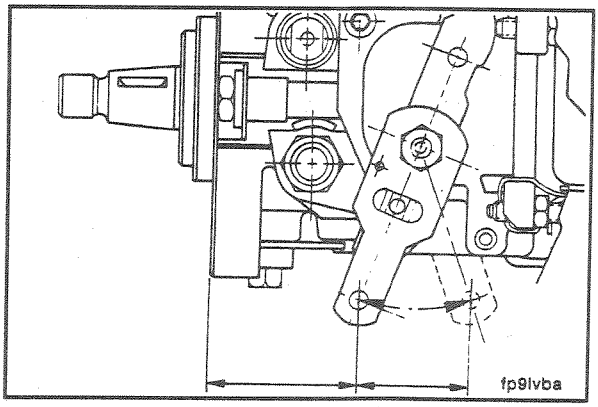
Robert Bosch VE Fuel Injection Pump Adjustment Screws

A - Idle Screw

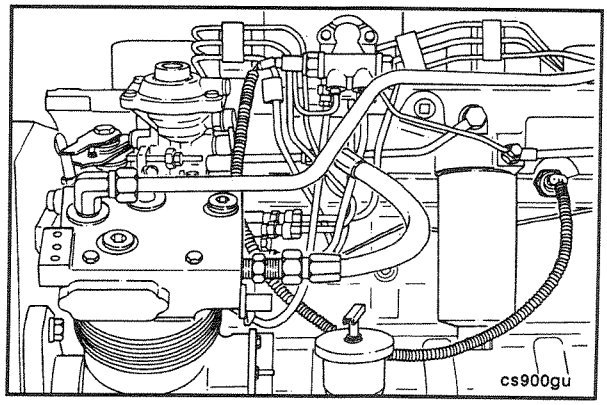
B - High Idle Screw

The high speed adjustment screw on both fuel injection pumps provides the stop for full speed. The high speed adjusting screws are sealed. Adjustment of this screw must be performed only by an authorized fuel injection pump service center, and then resealed.

The high speed adjusting screw can be used to derate engines.

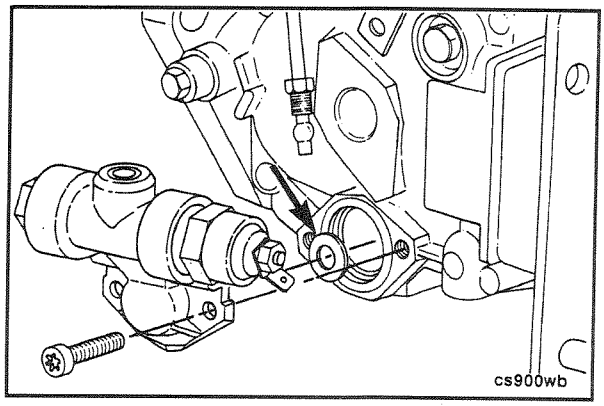


Caution: The fuel control lever on the Robert Bosch VE fuel injection pump is indexed to the shaft during pump calibration. If the lever has been removed and reinstalled incorrectly, engine speed and power will be affected.

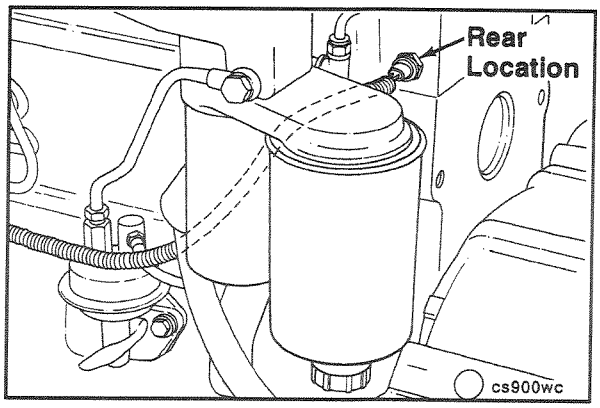


Remote Mounted KSB

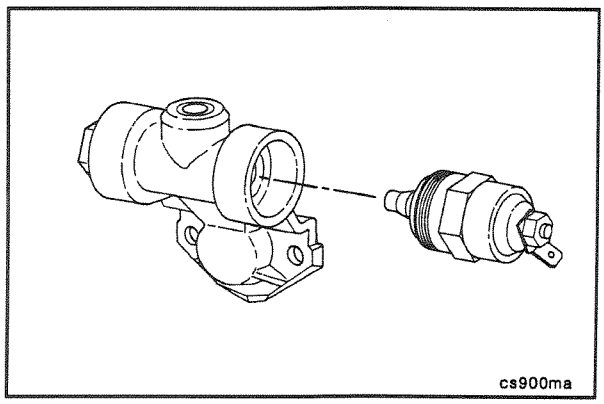
The remote mounted KSB is used on B series automotive engines which have an air compressor.



Caution: Most pumps will have a shim between the KSB and the timing piston. This shim must be reassembled between the cover plate and the timing piston. If this shim sticks to the KSB and is installed with the remote mounting hardware, it will block the regulating valve drain path and damage the pump. This damage is usually evidenced by a fuel leak.



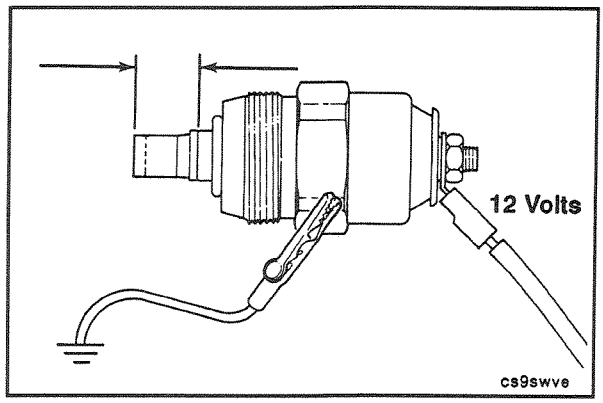
The four cylinder engine using remote mounting requires the temperature switch to be installed in the cylinder head as illustrated.



KSB Electrical Solenoid - Inspection

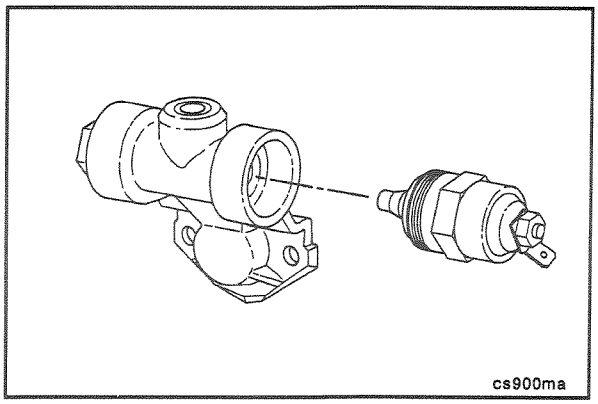
24 mm

Remove the KSB electrical solenoid from the KSB housing.



Apply 12 volts to the electrical terminal and ground the hexagonal portion of the element. The magnetic coil of the solenoid must push the plunger outward.

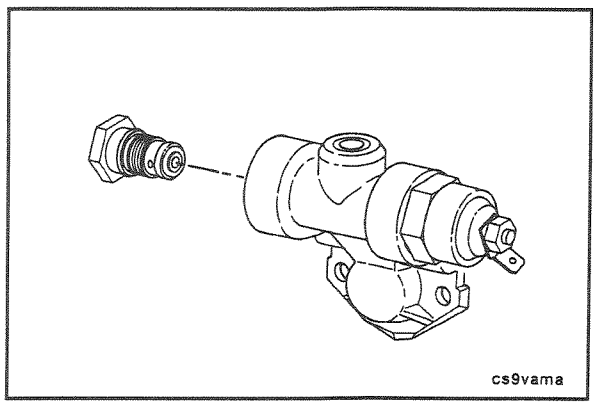
If the plunger does not push outward when voltage is applied, the solenoid is defective and must be replaced.



24 mm

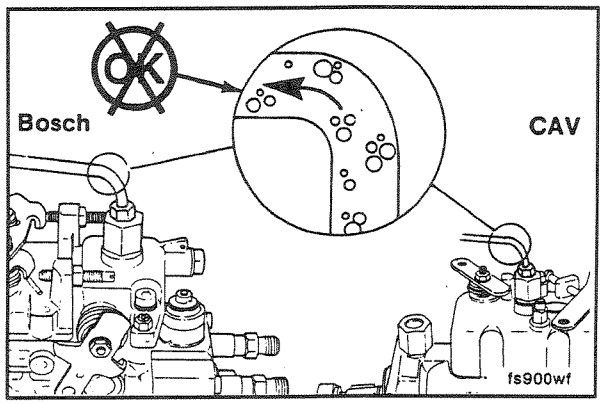
Install the original solenoid or a replacement into the KSB housing.

Torque Value: 22 N•m [16 ft-lb]



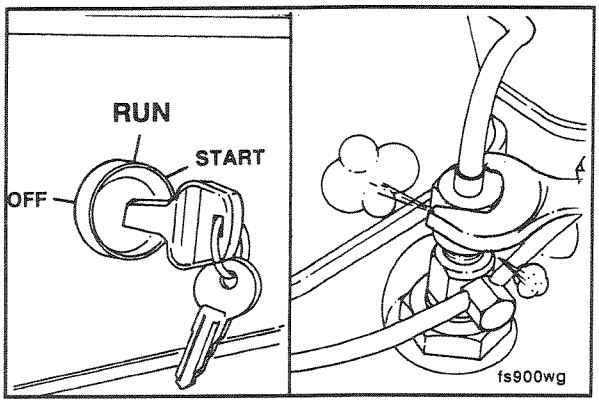
17 mm

Remove the pressure relief valve.



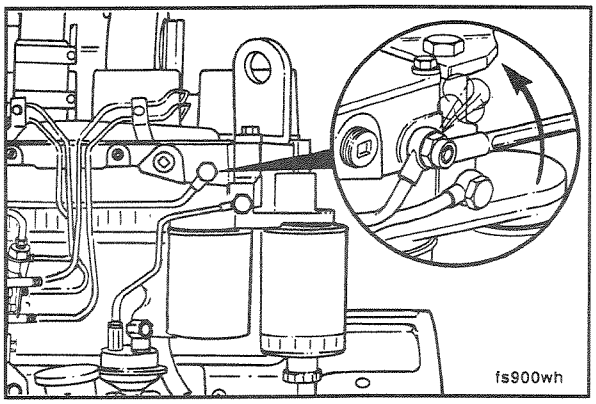
Venting the Fuel Systems (5-15)

Controlled venting is provided at the injection pump through the fuel drain manifold. Small amounts of air introduced by changing the filters or injection pump supply line will be vented automatically if the fuel filter is changed in accordance with the instructions.



However, manual bleeding will be required if:

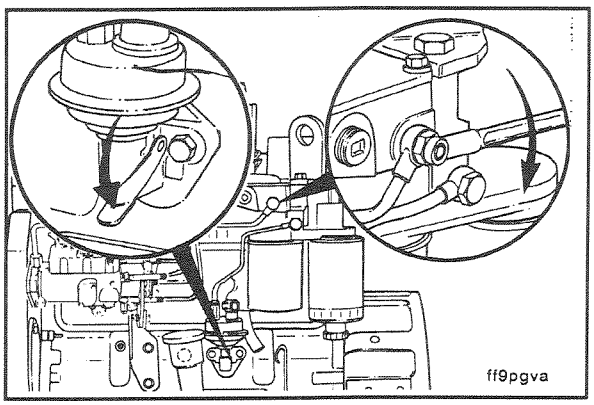
- The fuel filter is not filled prior to installation.
- Fuel injection pump is replaced.
- High pressure fuel line connections are loosened or lines replaced.
- Initial engine start up or start up after an extended period of no engine operation.



Low Pressure Lines and Fuel Filter - Venting

10 mm

Open the bleed screw.



Operate the hand lever until the fuel flowing from the fitting is free of air.

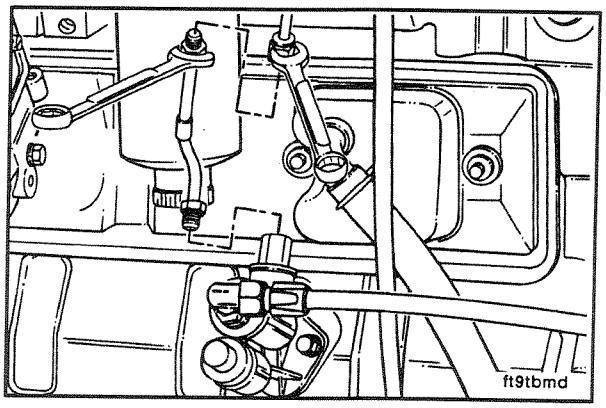
Tighten the bleed screw.

Torque Value: 9 N•m [7 ft-lb]

Fuel Transfer Pump Replacement/ Rebuild - Piston Style (5-22)

Preparatory Step:

- Clean debris from the fuel line fittings and the fuel transfer pump.

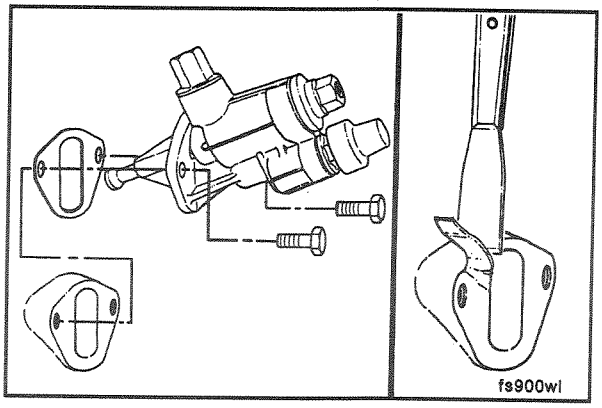


Removal

14 mm, 17 mm, 20 mm Wrench

Disconnect the fuel line from the fuel transfer pump and fuel filter head.

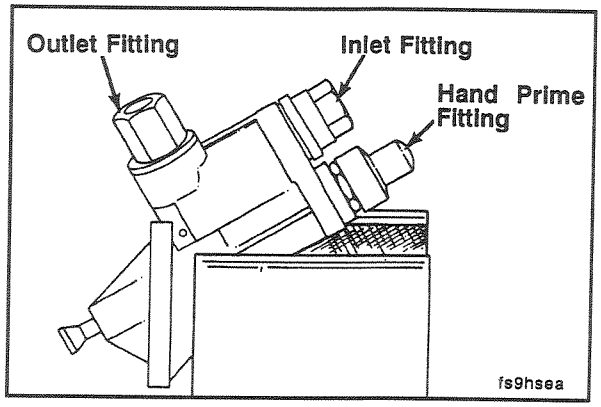
Use two wrenches to disconnect the fuel line from the fuel transfer pump.



10 mm Wrench

Remove the fuel transfer pump.

Clean the mounting surfaces on the cylinder block.



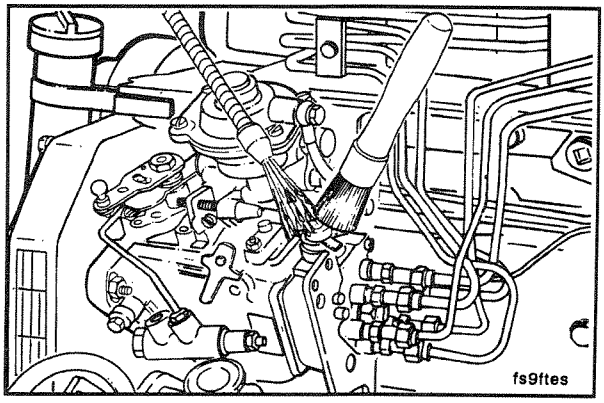
20 mm, 26 mm Wrench

Caution: The hand-prime fitting and inlet fitting are spring loaded. Sudden removal of these two fittings can cause personal injury.

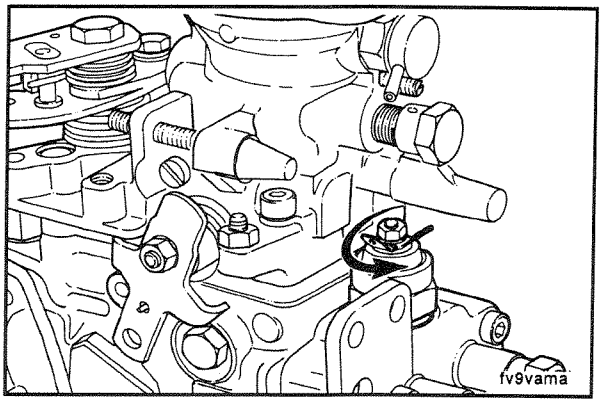
Secure the fuel transfer pump in a vise, taking care not to damage the pump housing.

Remove the rubber boot from the hand-prime fitting.

Remove the three illustrated fittings.



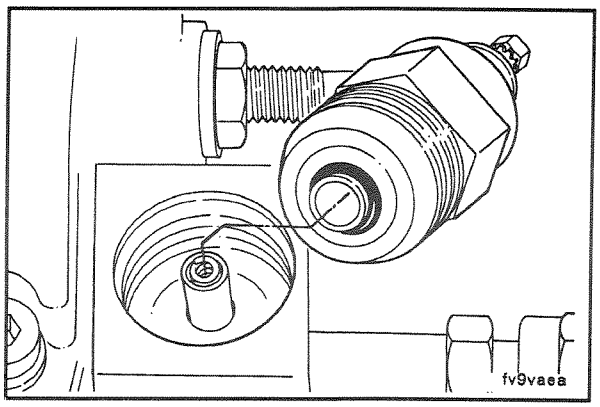
Clean around the valve.



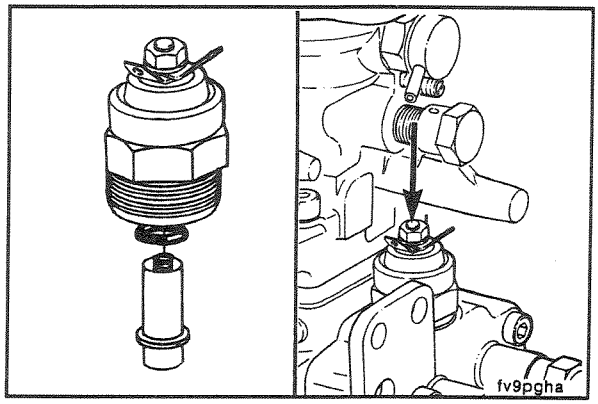
24 mm

Remove the valve.

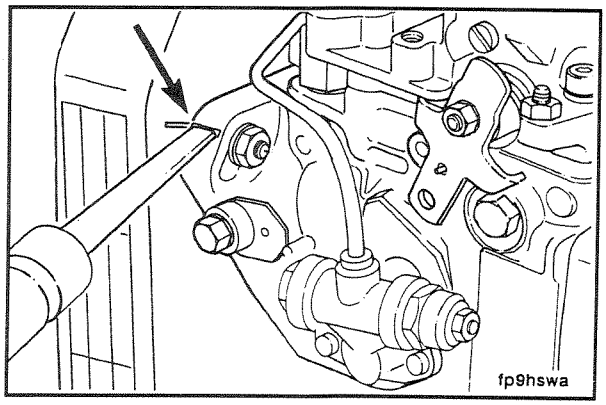
NOTE: The Bosch VE valve is shown. The valve for Lucas CAV is located at the bottom of the pump.



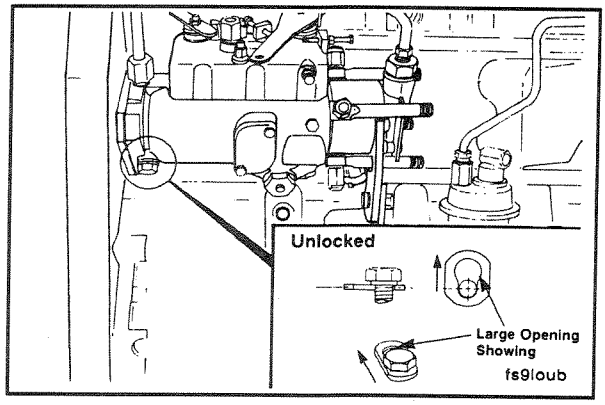
Caution: When removing the valve, be careful not to drop the plunger and spring.



"Package" the solenoid, o-ring, spring and plunger.



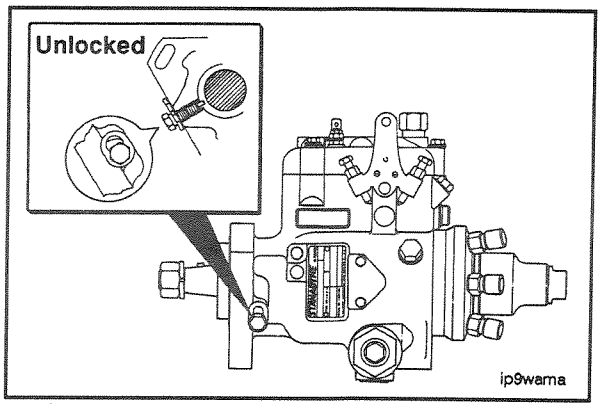
Permanently mark the injection pump flange to match the mark on the gear housing.



9/16 inch

Loosen the CAV pump lockscrew and position the special washer behind the lockscrew head.

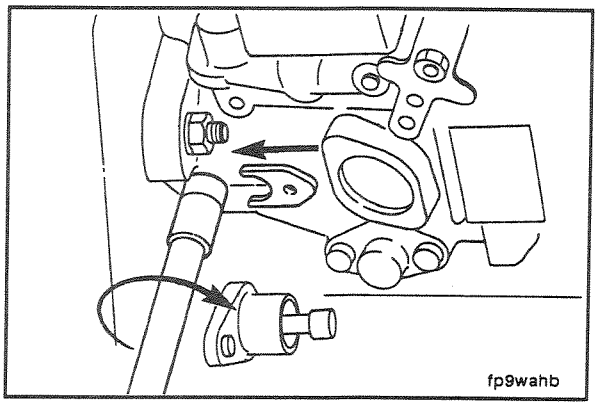
Torque Value: 20 N•m [15 ft-lb]



3/8 Inch

Loosen the Stanadyne DB4 fuel injection pump lock screw and position the special washer behind the lock screw head.

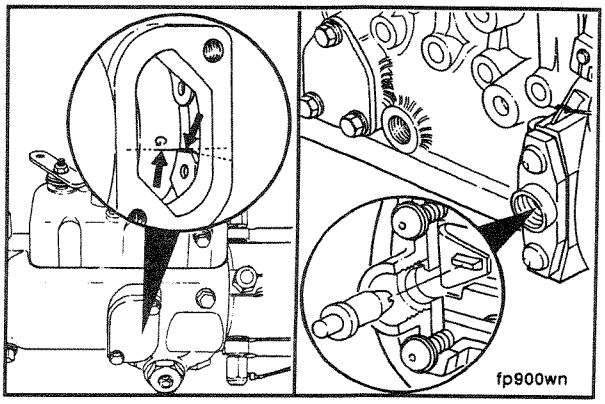
Tighten the lock screw.



8 mm Allen or 10 mm Hex

On the Bosch pump, the special washer is wired to the pump and must be installed under the lockscrew.

Torque Value: 13 N•m [10 ft-lb]

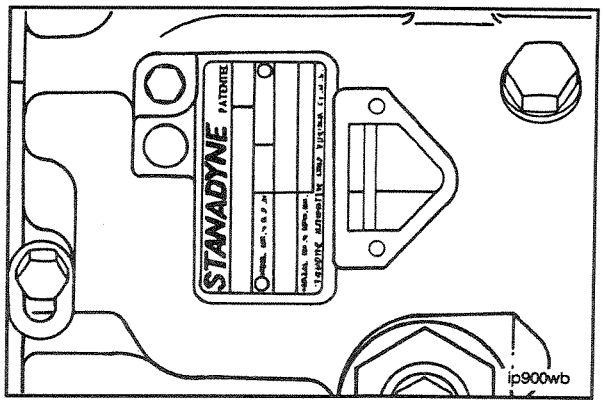


Correct timing of the Lucas CAV DPA and Stanadyne DB4 fuel injection pump can be verified by removing the timing window cover plate.

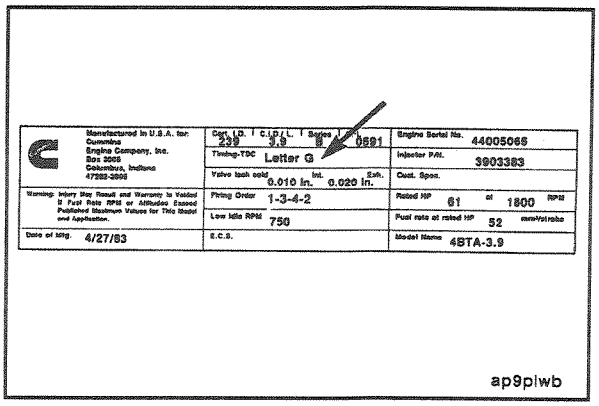
The Nippendenso EP-9 and Bosch P-7100 fuel injection pumps are checked by removing the timing pin access plug and verifying the slot in the pin will fit over the timing tooth in the fuel injection pump.

NOTE: Special equipment in an authorized shop is required to precisely time the Lucas CAV DPA fuel injection pump. However, for troubleshooting and in an emergency, visual alignment of the timing mark is close enough for the engine to run.

To correct the timing on the Bosch P-7100 and Nippendenso EP-9 refer to the replacement procedure for the respective pump.

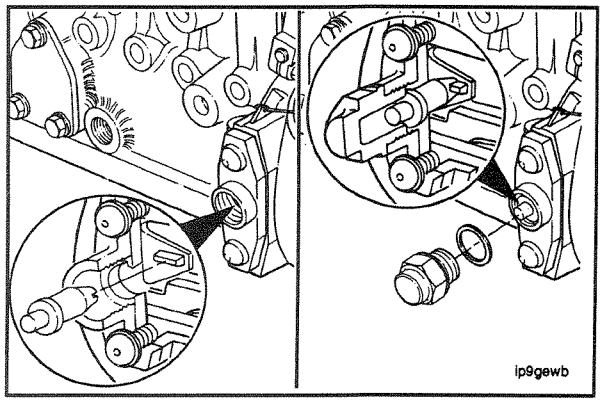


Two injection pump timing marks are used on the Stanadyne DB4 for timing injection of fuel into the No. 1 cylinder. One mark is located on the governor weight retainer hub. The other is located on the internal cam ring. These two marks **must** be aligned at No. 1 cylinder Top Dead Center.



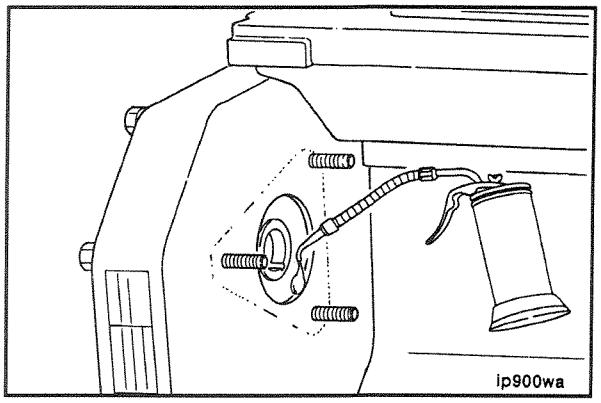
On the Lucas CAV DPA the correct timing letter can be located on the engine data plate as shown.

The letter G indicated refers to the correct timing letter alignment as shown in the previous frame.

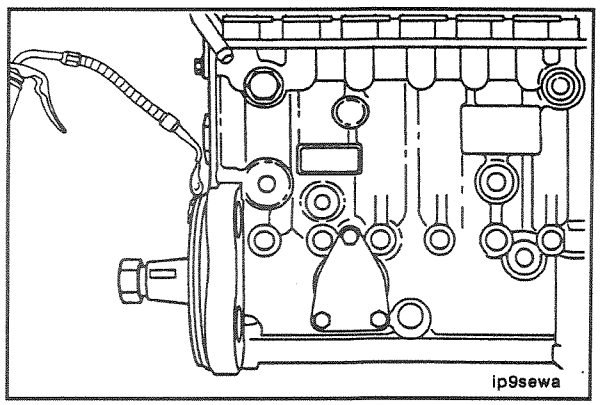


Reverse the position of the timing pin so the slot of the timing pin will fit over the timing tooth in the pump.

Install and secure the timing pin with the access plug.



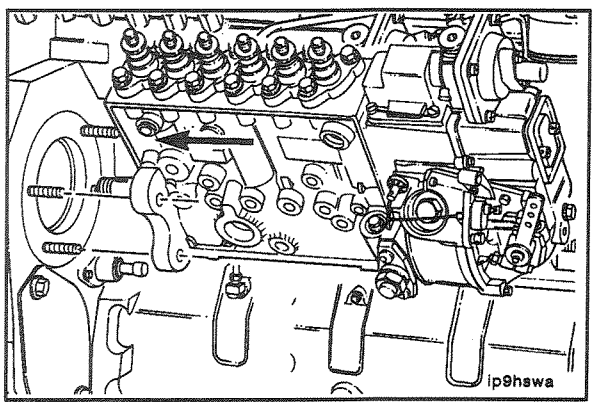
Use a 50/50 mixture of clean engine oil and STP or equivalent to lubricate the gear cover housing to ensure the fuel injection pump will slide into the gear cover housing easily.



Also lubricate the mounting flange of the fuel injection pump.

NOTE: The P7100 fuel injection pump driveshaft has a provision for a Woodruff key, however, it is not required. Timing mark alignment is not required for the P7100 drive gear.

Caution: The fuel injection pump drive gear inside diameter and the shaft outside diameter must be clean and dry before installing the gear.



Slide the pump shaft through the drive gear and position the pump flange onto the mounting studs.

Push the pump forward until the mounting flange and o-ring are properly fitted into the gear housing bore.

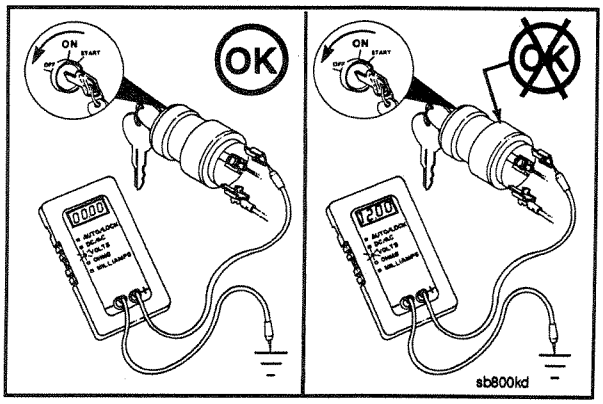
General Information - Electrical System

The electrical system basically consists of the starting motor and the alternator.

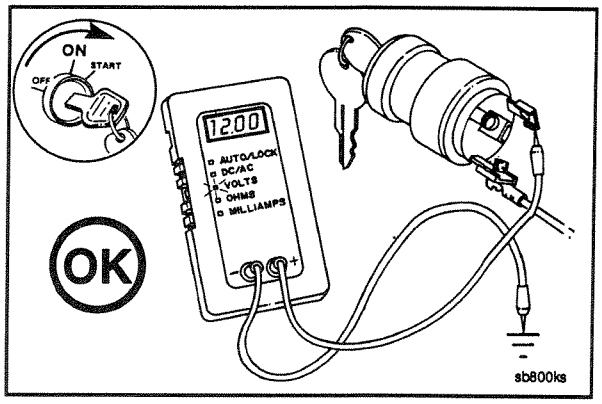
The rotary injection pump uses an electrical fuel shut off valve. The in line injection pump use an electrically activated solenoid shut down system. The function of the valve is discussed in the fuel system section.

The engine should have temperature and oil pressure sensors connected to indicators or wired for automatic shutdown. The engine may also be fitted with a block heater, an oil pan heater, or an intake manifold air heater.

NOTE: When troubleshooting a Cummins B Series generator set, refer to the Operation and Maintenance Manual Bulletin No. 3810208.

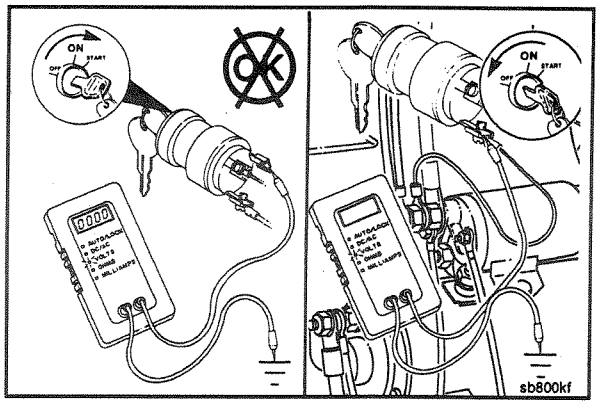


NOTE: With the starting motor switch in the "OFF" position, there must not be voltage at the starting motor switch terminal. If the meter indicates voltage, the starting motor switch is malfunctioning and must be replaced.



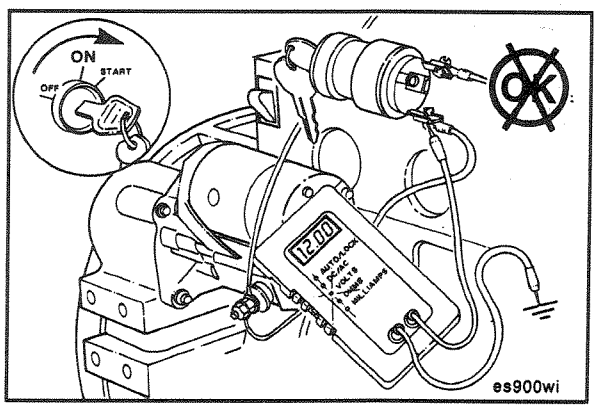
Turn the starting motor switch to the "START" position.

The multimeter must indicate system voltage.



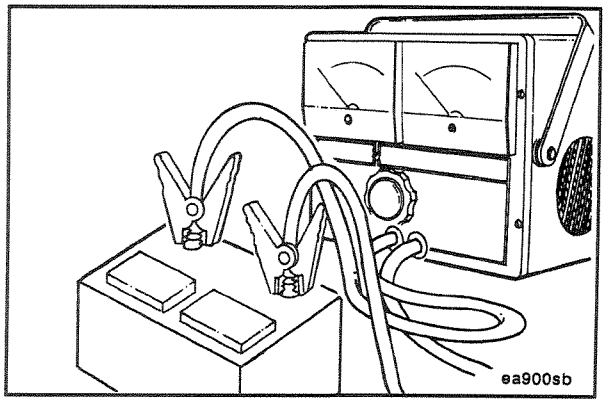
If there is not voltage:

- Turn the starting motor switch to the "OFF" position.
- Connect the multimeter positive lead to the starting motor switch terminal having a wire connecting the starting motor switch to the starting motor solenoid "B" terminal.



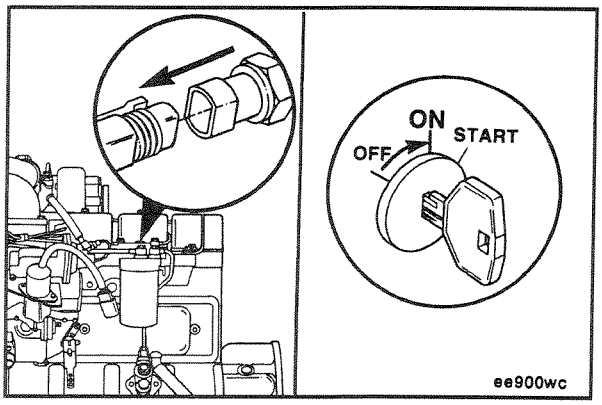
If the meter indicates system voltage at the starting motor switch input terminal, the starting motor switch is defective and must be replaced.

Intake Manifold Heater - Check (6-09)



Check the battery voltage.

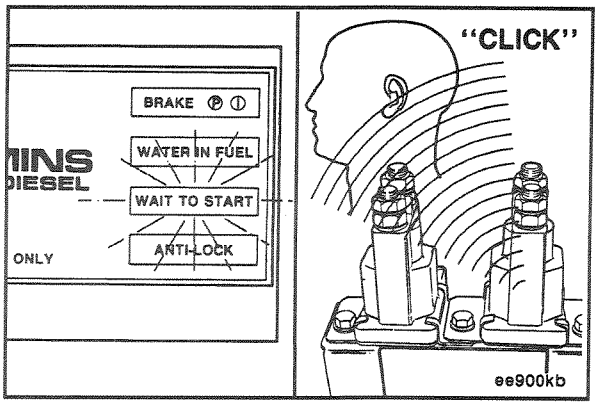
Minimum: 6.5 Volts



Check the thermistor.

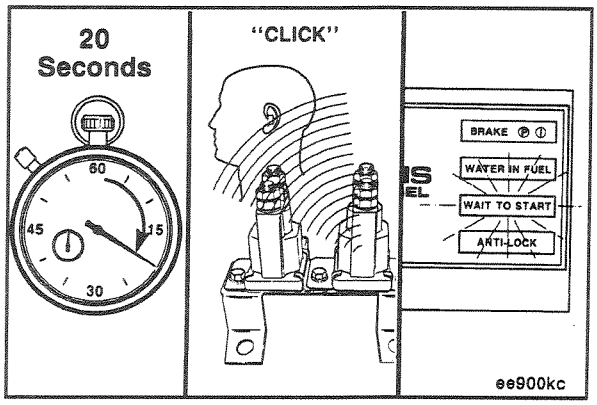
Disconnect the thermistor.

Turn the ignition switch to the "ON" position.



NOTE: The "Wait to Start" light should come on.

The solenoids should click on.



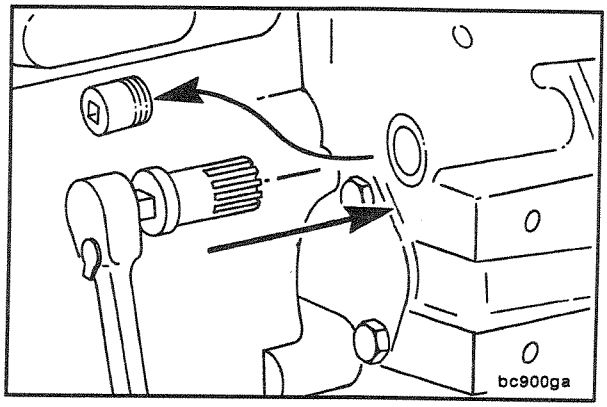
Wait 20 seconds.

The solenoids should click off.

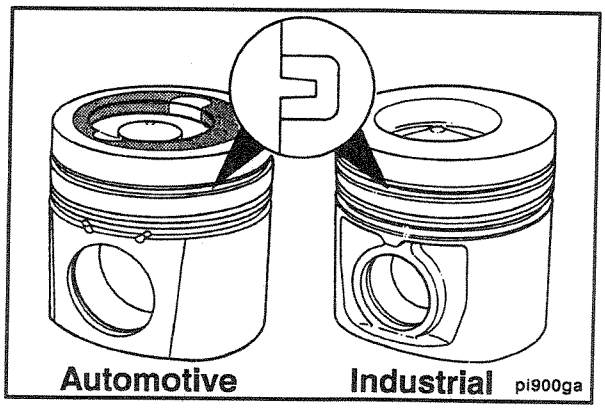
The "Wait to Start" light should begin flashing.

NOTE: The "Wait to Start" light will flash indicating an open circuit in the thermistor wiring. Disconnecting the thermistor simulates this condition.

NOTES



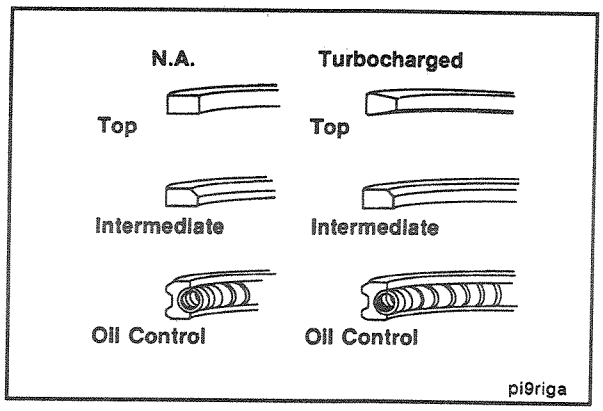
Some flywheel housings are machined for the use of an optional engine barring device.



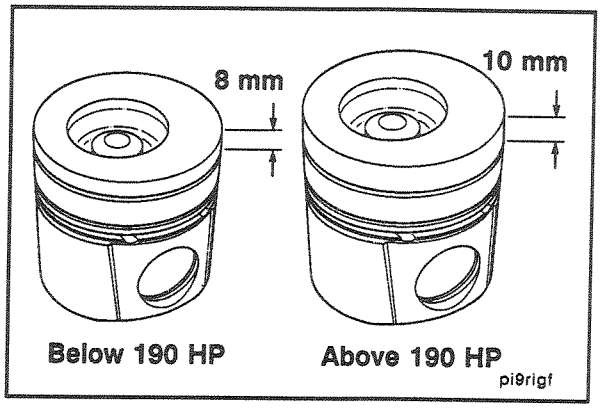
Piston and Connecting Rod Assemblies

Piston features include: high swirl combustion bowl cast aluminum body and 3 ring grooves. The piston for turbocharged, turbocharged/aftercooled engines includes a ni-resist insert with a keystone profile for the top piston ring. Always check the part number to be sure the correct configuration is used during piston replacement.

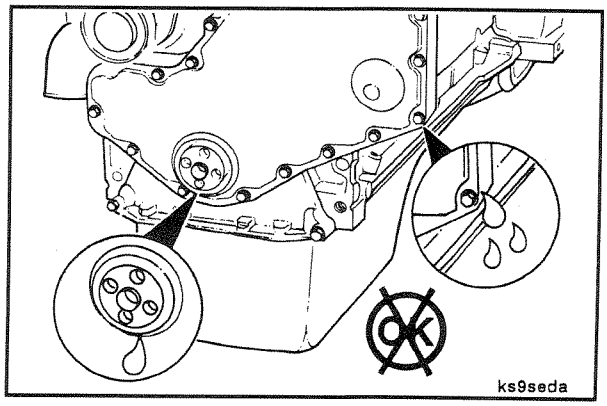
In addition to the ni-resist insert, automotive turbocharged engines also feature pistons with a hard-anodized combustion surface.



The piston ring sets are also different. While both sets consist of three rings, the top ring of the turbocharged/aftercooled set has a keystone profile which operates in a ni-resist insert cast into the piston. The naturally aspirated top ring is square cut and operates in a groove machined into the aluminum piston.



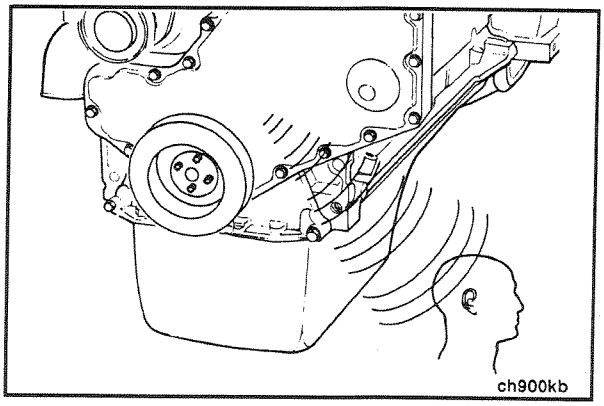
The 1994 automotive pistons utilize different top ring locations. The 160 hp to 175 hp ratings use 8 mm crown to ring land pistons and 190 hp, 210 hp and 230 hp use 10 mm. The 1994 industrial pistons continue with the 14 mm ring position.



Front Gear Housing and Gear Train

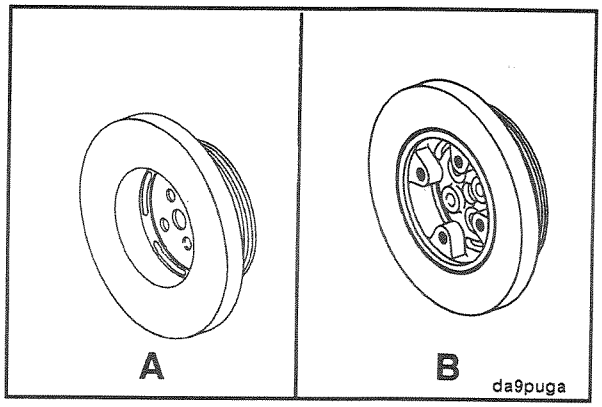
Troubleshooting the front gear housing and gear train consists of checking for leaks at the gaskets (front cover, timing pin assembly and fuel injection pump) and the front crankshaft lubricating oil seal, inspecting the gears and measuring backlash when required.

Refer to Procedure 7-16 to replace the front crankshaft oil seal.



Gear noise emitted from the cover can indicate worn gear teeth.

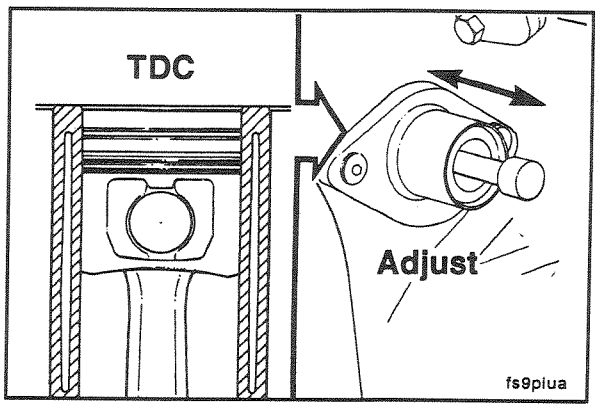
NOTE: Excessive backlash can affect engine timing and engine performance.



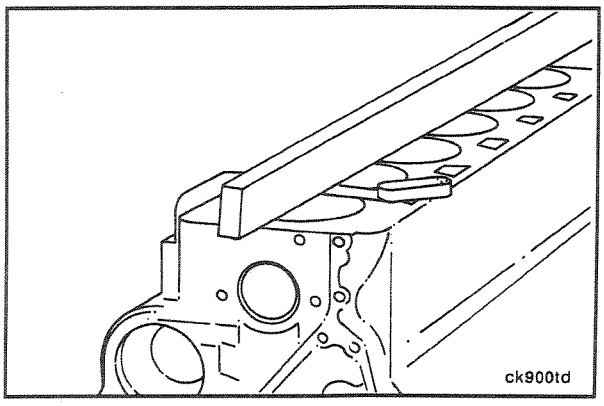
Vibration Damper

NOTE: There are two different design vibration dampers used:

- Viscous damper (A) for certain marine engines and some automotive applications
- Rubber element damper (B) for all other applications



As previously discussed in the fuel system, replacement of the gear housing or the timing pin assembly necessitates a realignment of the pin assembly on the housing to correspond to TDC for Cylinder Number 1. Refer to Procedure 7-20 for replacement instructions.

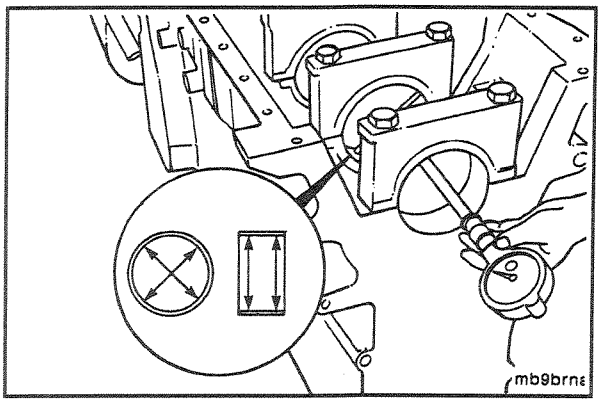


Cylinder Block

Use a straight edge and feeler gauge to measure the overall flatness of the cylinder block. The overall flatness, must not exceed .076 mm [0.003 in] end-to-end, and .051 mm [.002 in] side-to-side.

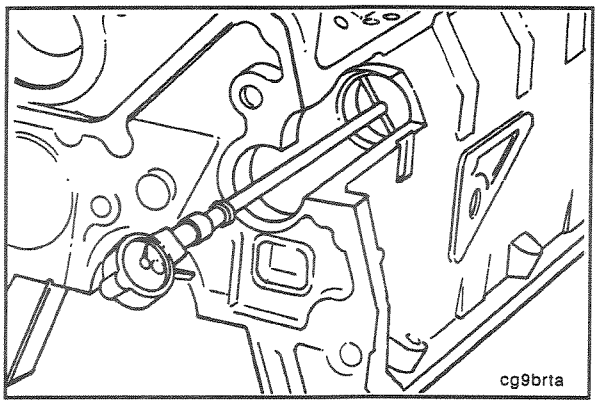
Visually inspect for any localized dips or imperfections. If present, the cylinder block head deck must be reground.

Refer to the Alternative Repair Manual, Bulletin No. 3810234, for regrind/milling procedures and limits.



Main Bearing Bore Diameter (Maximum)

83.106 mm [3.272 in] (with bearing installed)

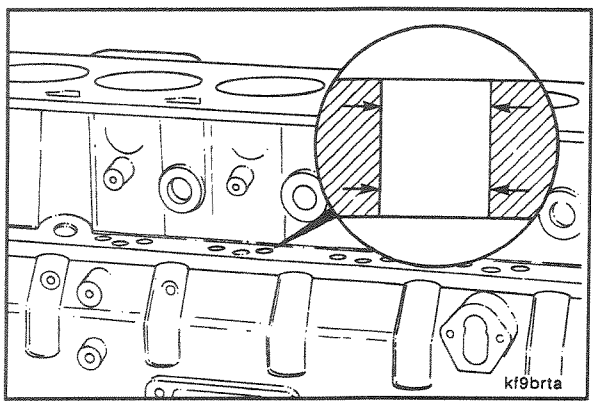


Camshaft Bore Diameter (Maximum)

57.258 mm [2.2543 in] (without bushing) No. 1 only

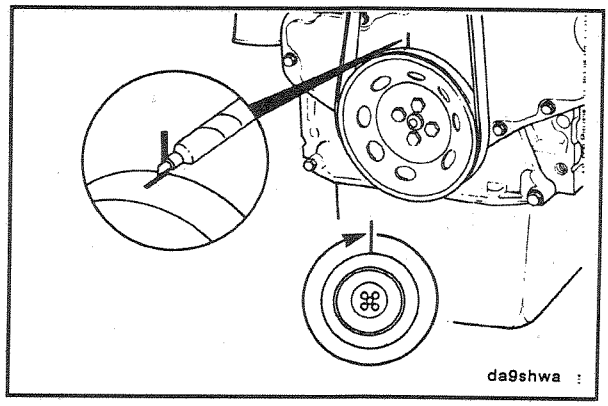
54.146 mm [2.1317 in] No. 1 with bushing

54.164 mm [2.1324 in] No. 2 through No. 7



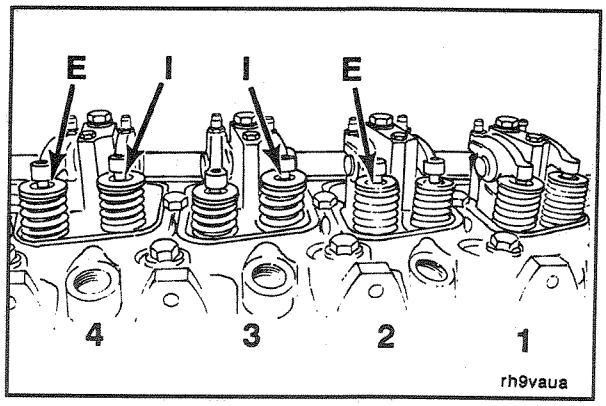
Tappet Bore Diameter (Maximum)

16.055 mm [0.632 in]



Mark the vibration damper and rotate the crankshaft 360 degrees.

Caution: To prevent engine or pin damage, be sure timing is disengaged.

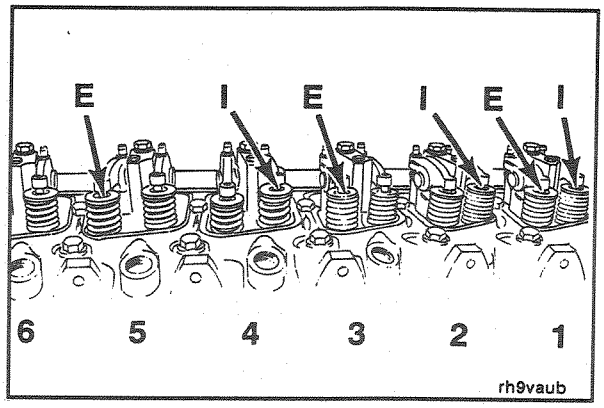


14 mm, Flat Blade Screwdriver

Adjust the valves as indicated in the illustration.

Tighten the locknut and measure the valve lash again.

Torque Value: 24 N•m [18 ft-lb]



Six-Cylinder Engine Adjustment

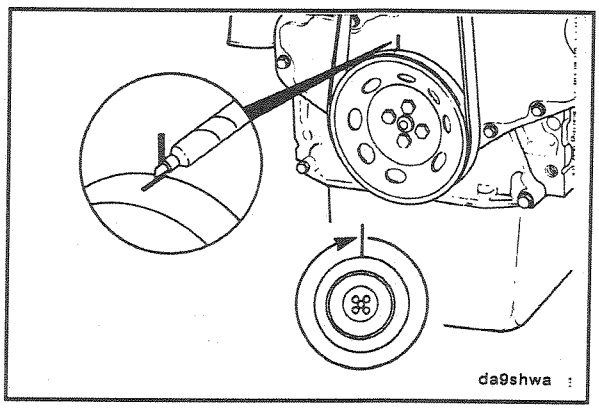
14 mm, Flat Blade Screwdriver

Locate Top Dead Center (TDC) for Cylinder Number 1.

Check/adjust the valves as indicated in the illustration (I = Intake, E = Exhaust).

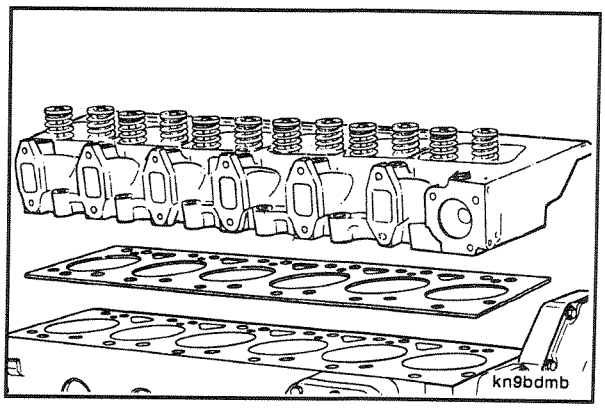
Tighten the locknut and measure the valve lash again.

Torque Value: 24 N•m [18 ft-lb]



Mark the pulley and rotate the crankshaft 360 degrees.

Caution: To prevent engine or pin damage, be sure timing pin is disengaged.

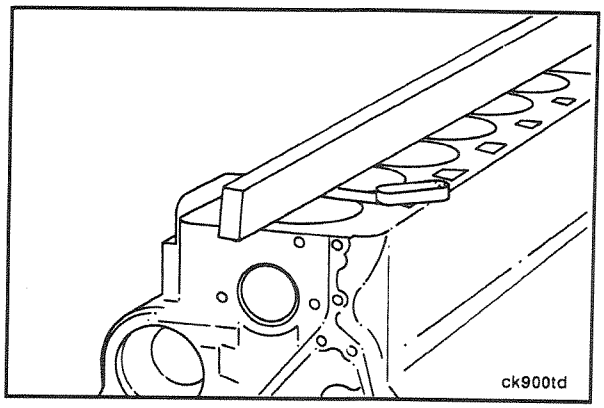


Remove the cylinder head and gasket from the cylinder block.

Cylinder Head Weight:

4 Cylinder - 36 Kg [80 lb]
6 Cylinder - 51.3 Kg [114 lb]

NOTE: Inspect the coolant passages. A large build up of rust and lime will require removal of the cylinder block for cleaning in a hot tank.

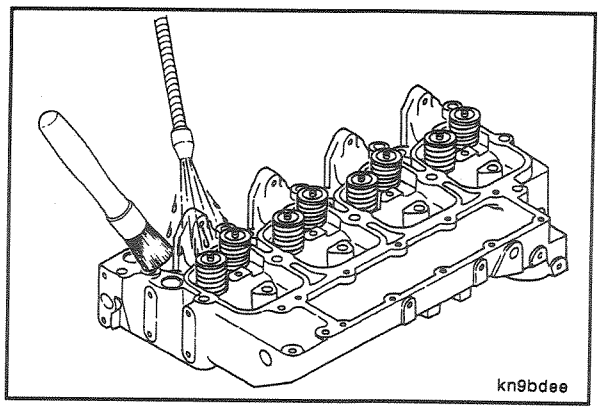


Straight Edge and Feeler Gauge

Use a straight edge and feeler gauge to measure the overall flatness of the cylinder block. The overall flatness, end to end and side to side, must not exceed 0.075 mm [0.003 in].

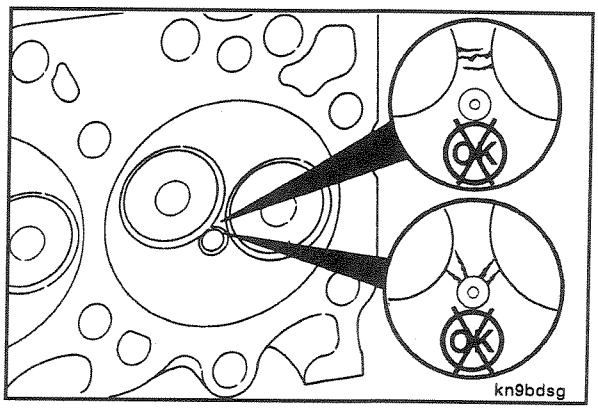
Visually inspect the combustion deck for any localized dips or imperfections. If present, the cylinder block head deck must be ground.

Refer to the Alternate Repair Manual for regrind/milling procedures and limits.

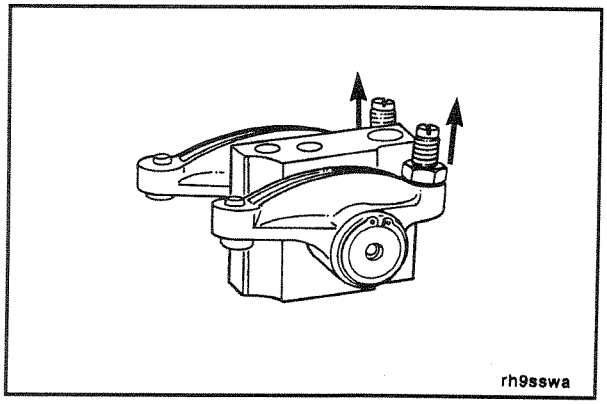


Cylinder Head - Precheck Before Disassembly

Clean the cylinder head with solvent.

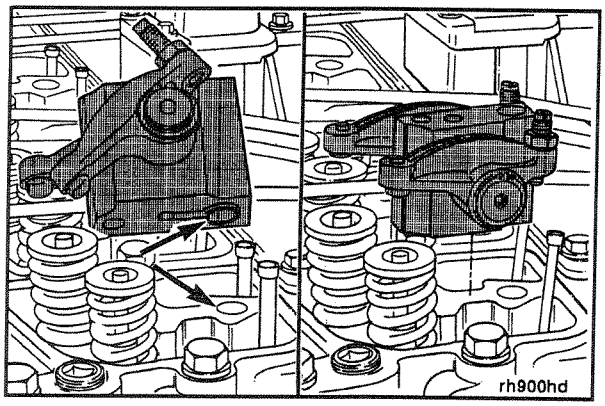


Visually inspect the cylinder head for obvious damage that would prohibit reuse. Check for cracks and damage to the deck surface that would result in loss of sealing.



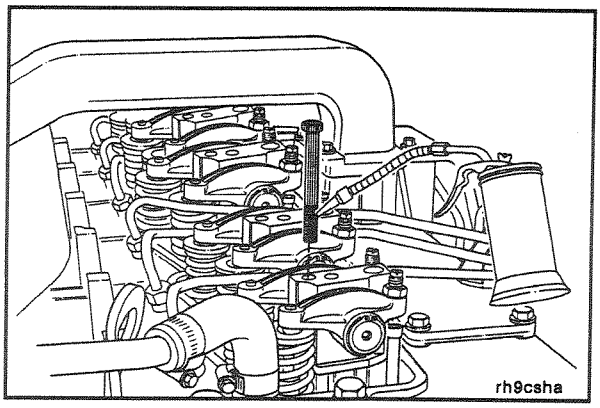
14 mm, Flat Blade Screwdriver

Completely loosen the rocker lever adjusting screws.



NOTE: The rocker lever pedestals are aligned with dowels.

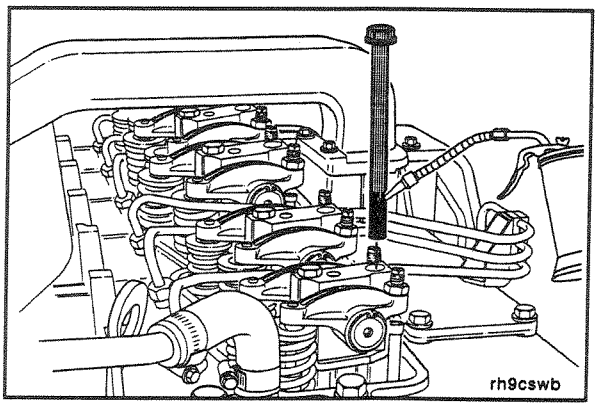
Install the pedestals.



Inspect all cylinder head capscrews for proper length using Service Tool Part No. 3823921.

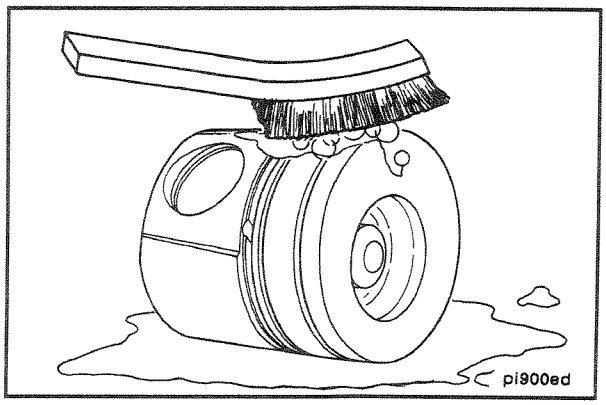
Lubricate the 8 mm pedestal capscrew threads and under the capscrew heads with engine lubricating oil.

Install the capscrews finger tight.



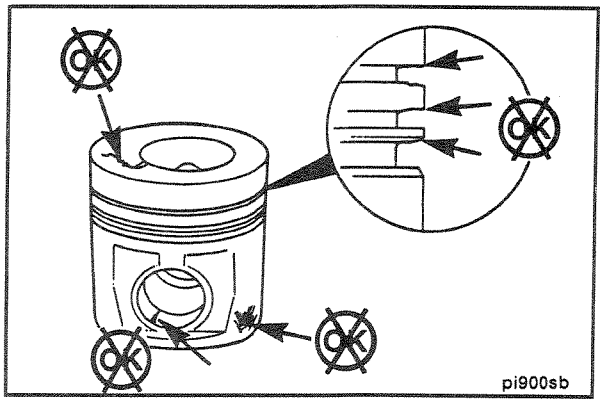
Lubricate the 12 mm pedestal/head capscrew bolt threads and under the capscrew heads with engine lubricating oil.

Install the capscrews finger tight.



Wash the pistons again in a detergent solution or solvent.

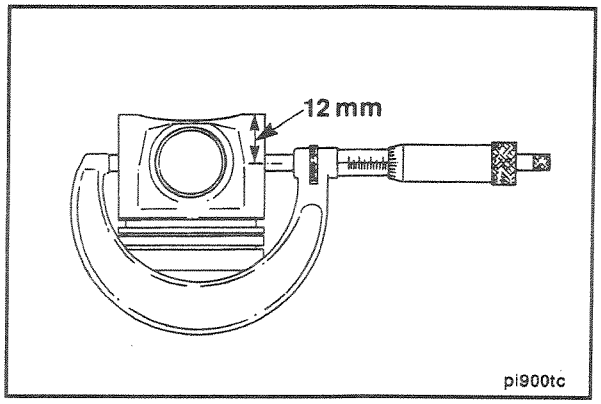
After rinsing, use compressed air to dry.



Piston Inspection (7-09)

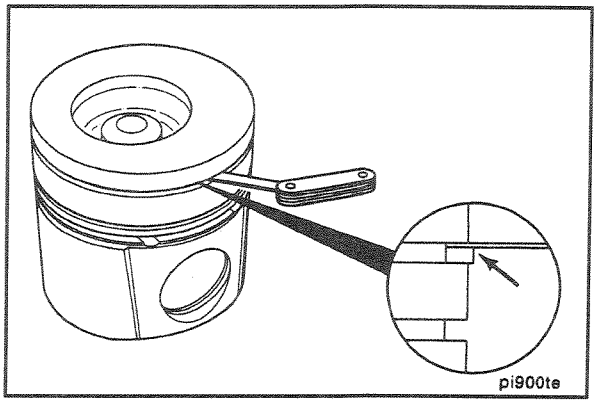
Inspect the piston for damage and excessive wear. Check the top, ring, grooves, skirt and pin bore.

NOTE: If severe piston damage has occurred, check the turbocharger and other exhaust components for damage from debris.



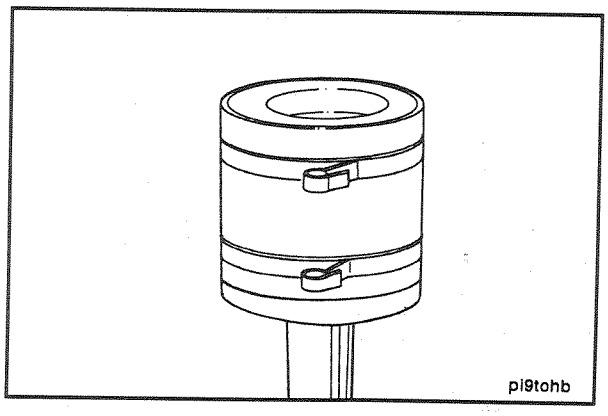
Measure the piston skirt diameter as illustrated.

Diameter		
mm		in
101.823	MIN	[4.0088]
101.887	MAX	[4.0107]



Use a new piston ring to measure the clearance in the ring groove.

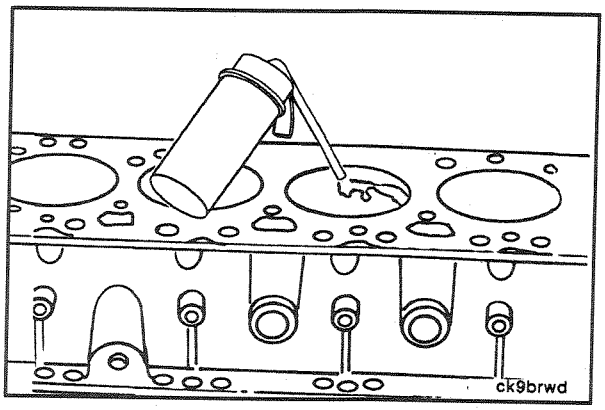
Ring Clearance			
	mm		in
Top			
• (Turbocharged)	No Check Needed		
• (Naturally Aspirated)	0.075	MIN	[0.003]
	0.150	MAX	[0.0059]
Intermediate	0.075	MIN	[0.003]
	0.150	MAX	[0.0059]
Oil Control	0.040	MIN	[0.0016]
	0.130	MAX	[0.0051]



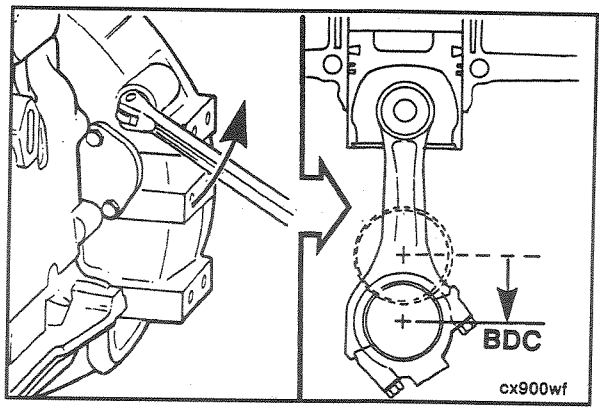
75-125 mm [3-5 in]

Caution: If using a strap type ring compressor, make sure the inside end of the strap does not hook on a ring gap and break the ring.

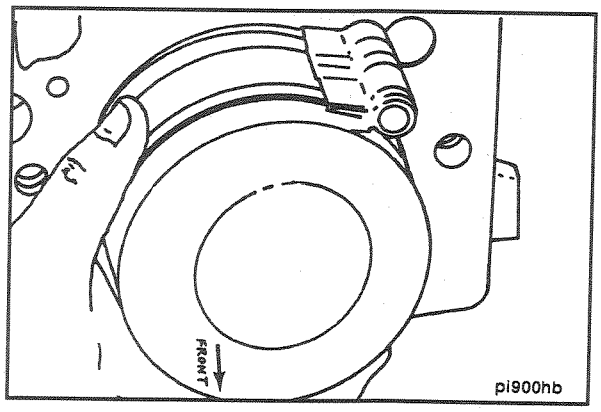
Compress the rings.



Lubricate the cylinder bore with clean engine lubricating oil.

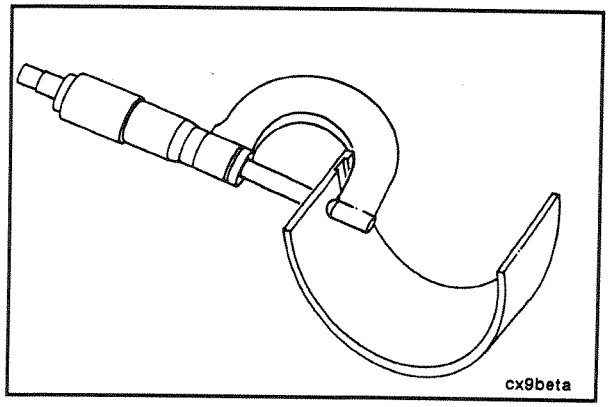


Position the connecting rod journal for the piston to be installed to bottom dead center (BDC).

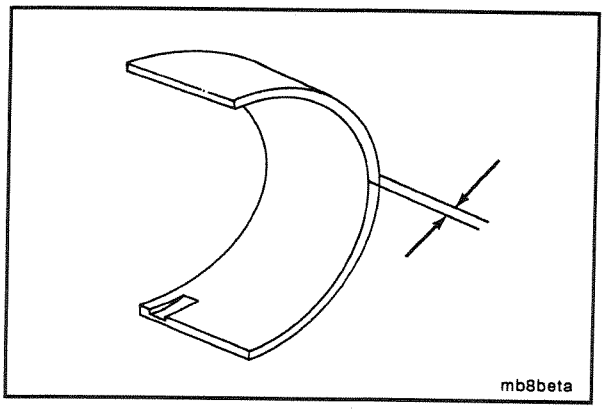


Take care not to damage the cylinder wall when inserting the connecting rod.

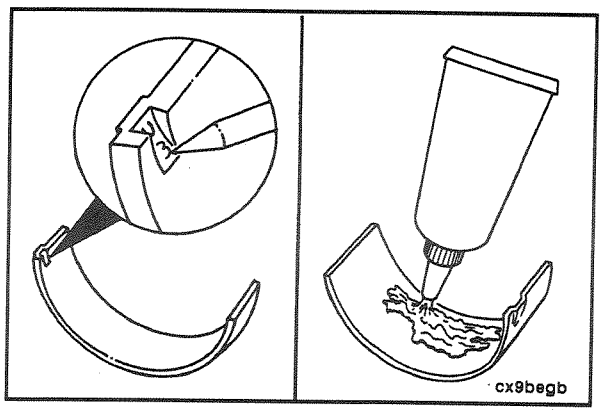
Position the piston and connecting rod assembly into cylinder bore with the word "front" on piston towards the front of the cylinder block.



Use an outside diameter ball tipped micrometer to measure the connecting rod bearing thickness.



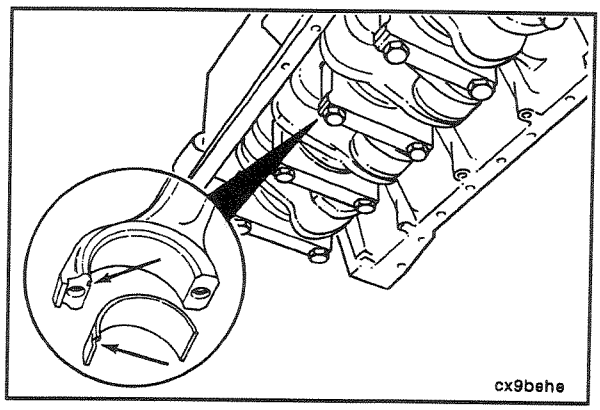
Connecting Rod Bearing Dimensions		
Standard	1.955-1.968 mm	[.0770-.0775 in]
.25 mm O/S	2.080-2.093 mm	[.0819-.0824 in]
.50 mm O/S	2.205-2.218 mm	[.0868-.0873 in]
.75 mm O/S	2.330-2.343 mm	[.0917-.0922 in]
1.00 mm O/S	2.455-2.468 mm	[.0967-.0972 in]



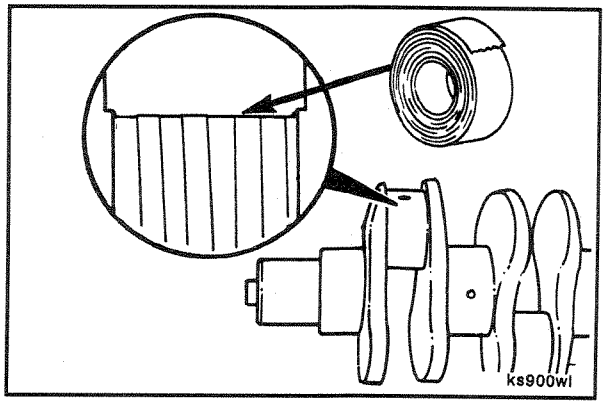
Installation

NOTE: Used bearings must be installed in the same location from which they were removed.

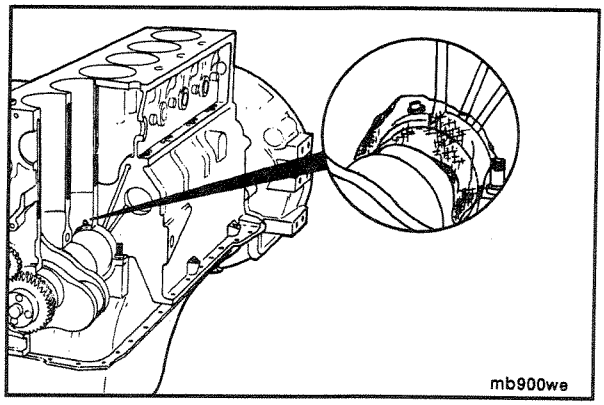
Use Lubriplate 105® or equivalent to coat the inside diameter of the bearing shell.



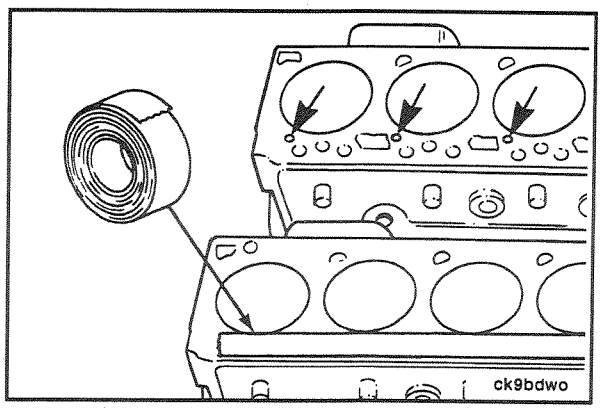
Install the upper bearing shell in the connecting rod with the tang of the bearing in the slot of the connecting rod.



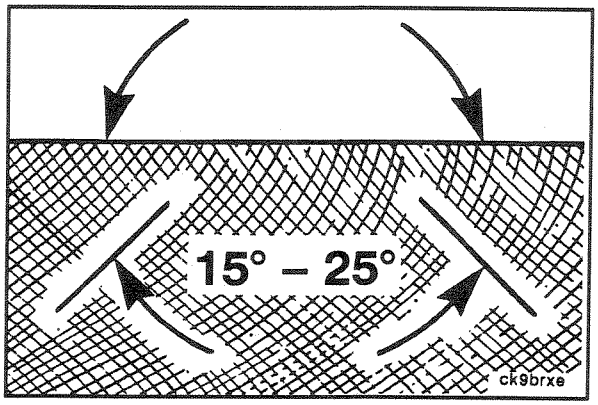
Cover the cloth with waterproof tape.



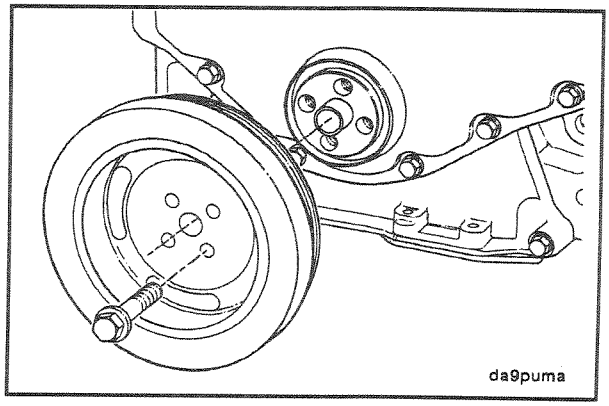
Place a clean shop towel around the top main bearing saddle to deflect water and residue from the piston cooling nozzles.



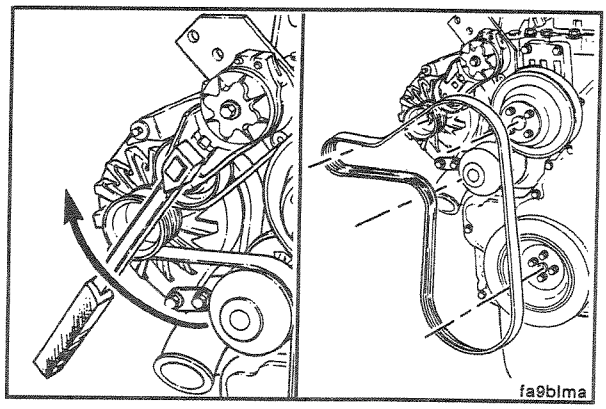
Also cover the lubricating holes and tappet holes in the top of the cylinder block with waterproof tape.



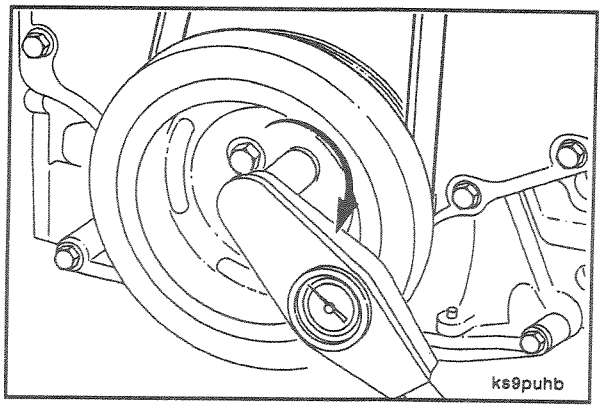
A correctly deglazed surface will have a crosshatched appearance with the lines at 15 to 25 degree angles with the top of the cylinder block.



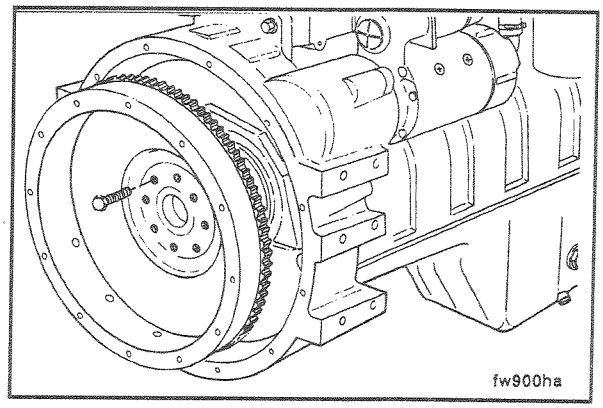
Install the crankshaft pulley. Do not tighten the capscrews to the correct torque value at this time.



Install the drive belt.



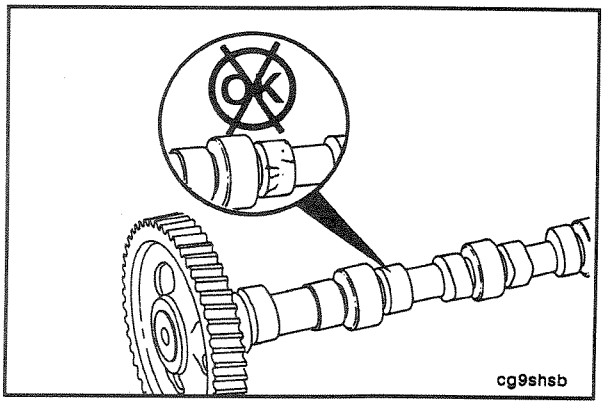
Tighten the crankshaft pulley capscrews.
Torque Value: 125 N•m [92 ft-lb]



Rear Seal - Replacement (7-17)

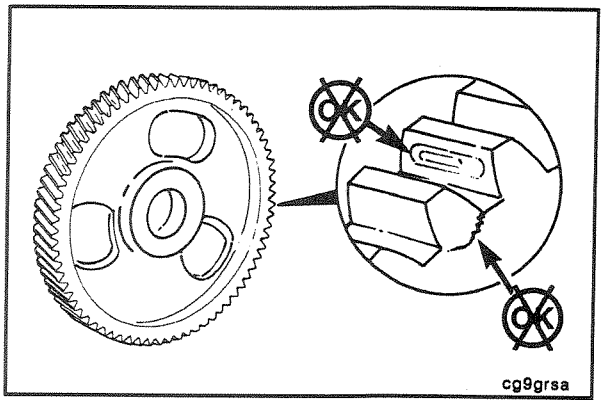
Preparatory Step:

- Remove the transmission.
- Remove the flywheel.

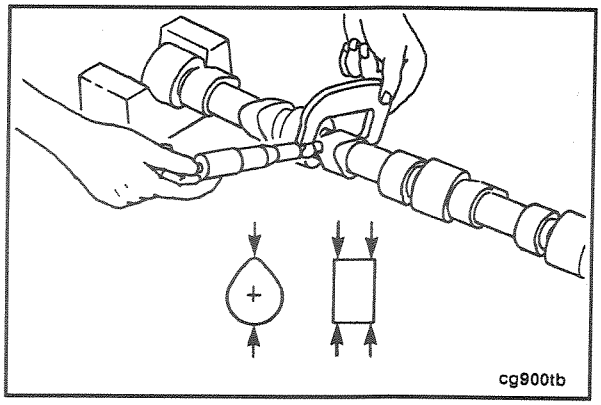


Camshaft and Gear - Inspection

Inspect the fuel transfer pump lobe, valve lobes and bearing journals for cracking, pitting or scoring.

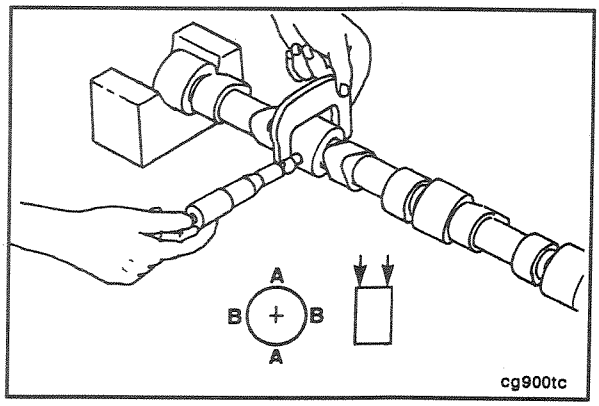


Inspect the camshaft gear teeth for pitting; look for cracks at the root of the teeth.



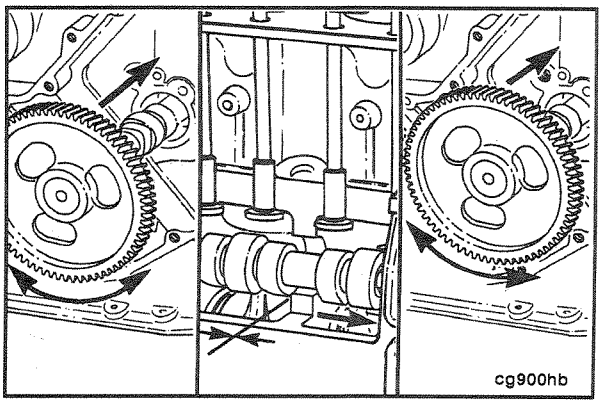
Measure the fuel transfer pump and valve lobes.

Diameter at Peak of Lobe			
	mm		in
Intake	47.040	MIN	1.852
	47.492	MAX	1.870
Exhaust	46.770	MIN	1.841
	47.222	MAX	1.859
Lift Pump	35.50	MIN	1.398
	36.26	MAX	1.428

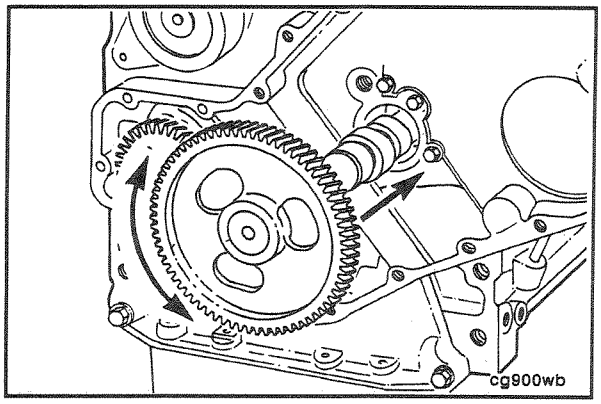


Measure the bearing journals.

Journal Diameter		
mm		in
53.962	MIN	2.1245
54.013	MAX	2.1265

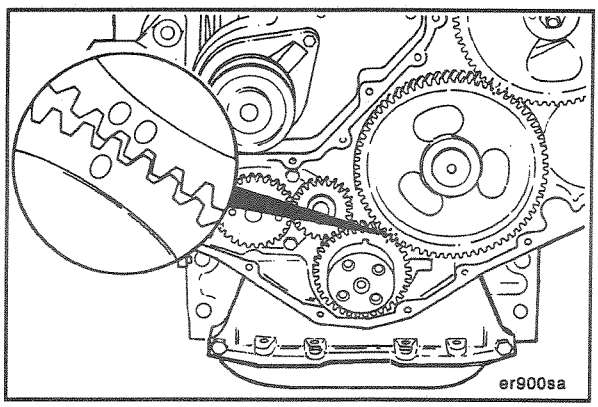


Install the camshaft. While pushing in slightly, rotate the camshaft and carefully work the camshaft through the camshaft bushings. As each camshaft journal passes through a bushing, the camshaft will drop slightly and the camshaft lobes will catch on the bushings. Rotating the camshaft will free the lobe from the bushing and allow the camshaft to be installed.

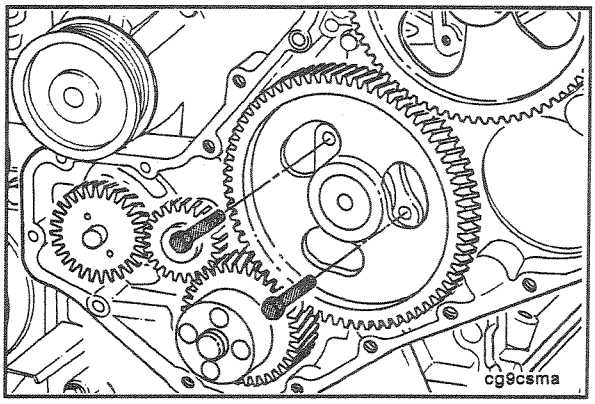


Caution: Do not try to force the camshaft into the camshaft bore as damage to the camshaft bushing can result.

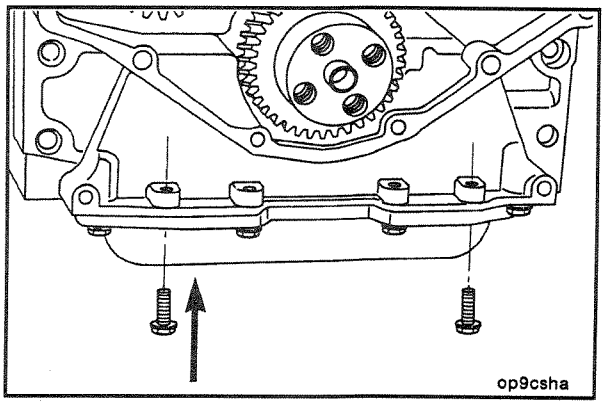
Before the camshaft gear engages the crankshaft gear, check the camshaft for ease of rotation. When installed properly, the camshaft should rotate freely.



Install the thrust washer, Align the timing marks as illustrated and finish installing the camshaft.

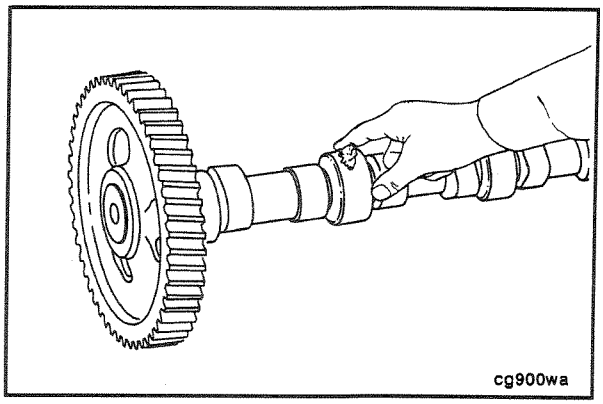


Install the thrust washer capscrews and tighten to 24 N•m [18 ft-lb].

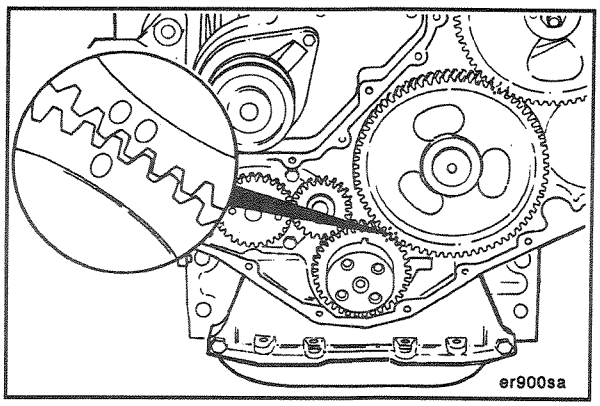


10 mm

Install the remaining two capscrews and tighten the capscrews to 24 N•m [18 ft-lb].



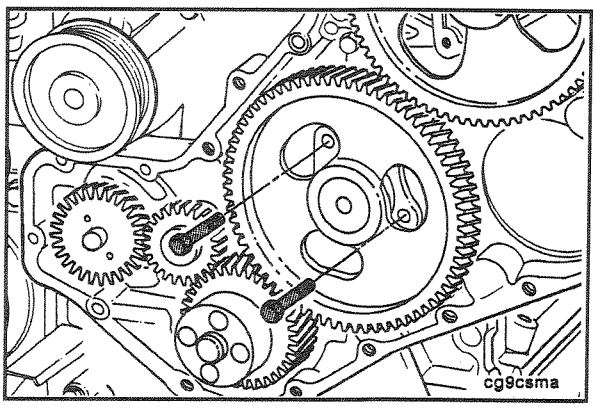
Lubricate the camshaft and thrust washer with Lubriplate™ 105.



Install the camshaft/thrust washer.

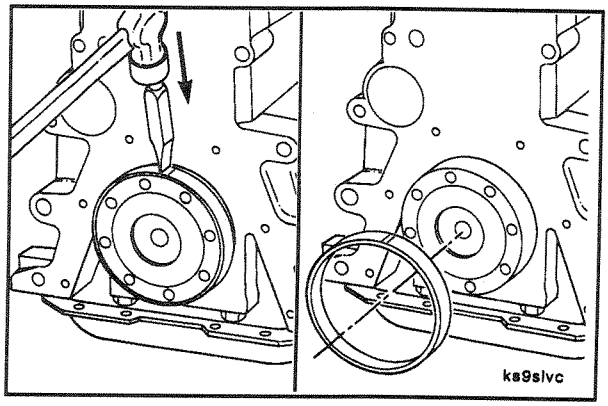
Make sure the alignment marks on the camshaft and camshaft gears are aligned.

Refer to the camshaft installation procedure procedure (7-19) if additional information is needed.



Install the thrust washer capscrews.

Torque Value: 24 N•m [18 ft-lb]



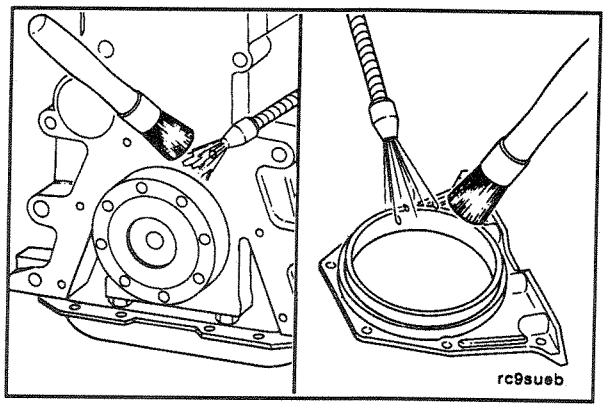
Hammer, Chisel

If the crankshaft currently has a wear sleeve, it **must** be removed before installing a new one.

Caution: Do not nick or gouge the crankshaft with the chisel. If the crankshaft is damaged, it must be replaced.

Use a dull chisel that is only as wide as the wear sleeve.

Make one or two soft blows with a hammer to make chisel marks across the wear sleeve. This will expand the wear sleeve allowing the sleeve to be removed.

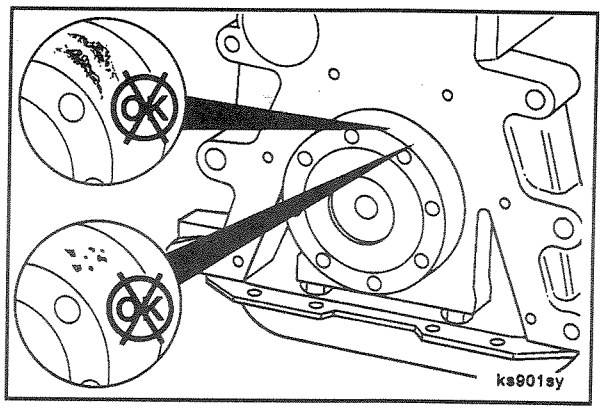


Cleaning and Inspection

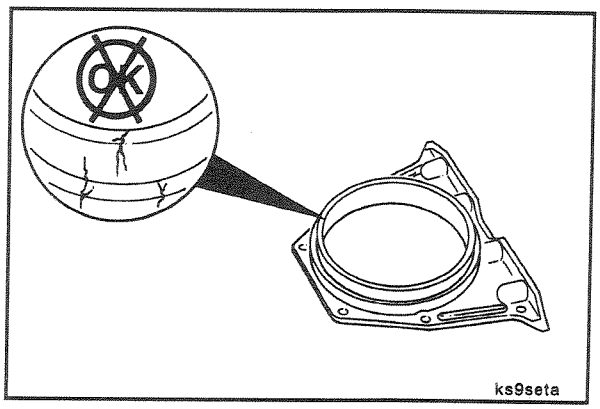
Clean the gasket surface of the cylinder block and rear cover.

Use a crocus cloth to remove any rust or other deposits from the crankshaft flange.

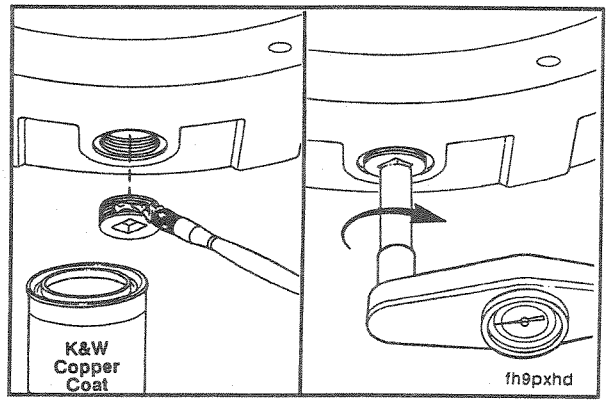
Use a clean cloth to clean the crankshaft flange.



Inspect the crankshaft flange for dirt or nicks.



Inspect the rear cover for cracks or other damage.



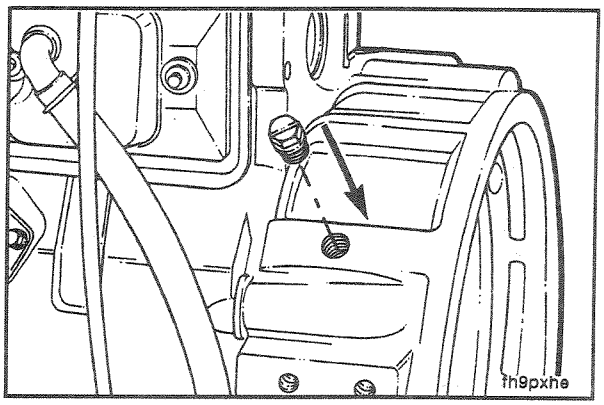
Installation (Wet Clutch Application)

Perform all the steps in the procedure for dry clutch installation in addition to the following:

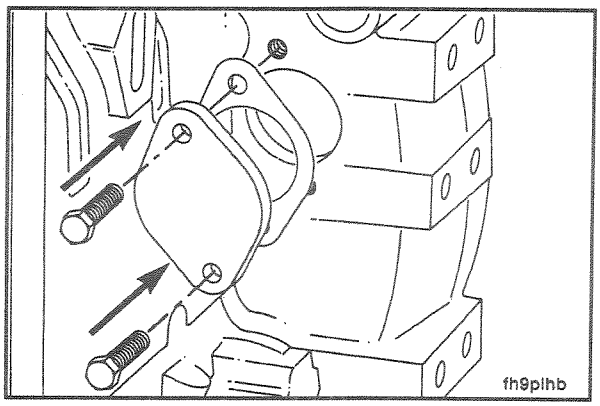
Coat the flywheel housing drain plug with pipe sealant and install in the hole in the bottom of the flywheel housing.

Tighten the plug.

Refer to the pipe plug torque values in Section 10 for different plug sizes.



Install the plastic plug in the tachometer drive access hole.

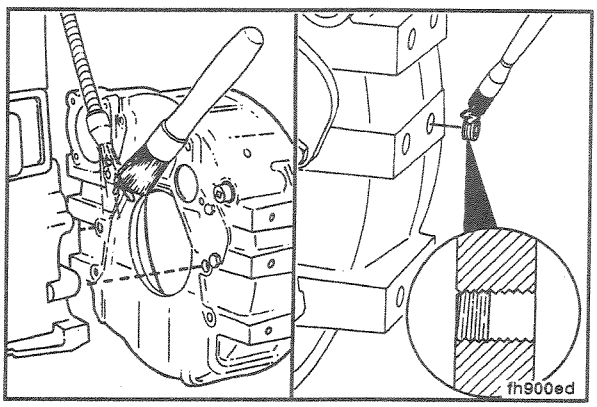


13 mm

Install the access plate and new gasket.

Install the capscrews and tighten.

Torque Value: 24 N•m [18 ft-lb]



Thoroughly clean the flywheel housing and cylinder block mating surfaces. These surfaces must be clean and free of oil or debris.

NOTE: The capscrew holes on the mounging pads are drilled through. Coat set screws with Loctite™ 277 and install into holes.

Set Screw Installation Depth

mm		in
0.00	MIN	0.000
3.00	MAX	0.118

Engine Testing - General Information

The engine test is a combination of an engine run-in and a performance check. The engine run-in procedure provides an operating period that allows the engine parts to achieve a final finish and fit. The performance check provides an opportunity to perform final adjustments needed to optimize the engine performance.

An engine test can be performed using **either** an engine dynamometer **or** a chassis dynamometer. If a dynamometer is **not** available, an engine test **must** be performed in a manner that simulates a dynamometer test.

Check the dynamometer before beginning the test. The dynamometer **must** have the capability to test the performance of the engine when the engine is operating at the maximum RPM and horsepower range (full power).

The engine crankcase pressure, often referred to as engine blowby, is an important factor that indicates when the piston rings have achieved the correct finish and fit. Rapid changes of blowby or values that exceed specificatin more than 50 percent indicate that something is wrong. The engine test **must** be discontinued until the cause has been determined and corrected.

General* Engine Test Specifications

Maintain the following limits during a chassis dynamometer test:

Intake Restriction (Maximum)

- Clean Filter (light duty) ..... 254 mm H_2O [10 in H_2O]
  (medium duty) ..... 305 mm H_2O [12 in. H_2O]
  (heavy duty) ..... 381 mm H_2O [15 in. H_2O]
- Dirty Filter (light duty) ..... 635 mm [25 in]
  (medium duty) ..... 635 mm [25 in]
  (heavy duty) ..... 635 mm [25 in]

Exhaust Back Pressure (maximum) Non Automotive ..... 76 mm Hg [3.0 in Hg]

Exhaust Back Pressure (maximum) Automotive With Catalyst ..... 152 mm Hg [6.0 in. Hg]

Exhaust Back Pressure (maximum) Automotive Without Catalyst ..... 114 mm Hg [4.5 in. Hg]

Oil Pressure

- Low Idle (minimum allowable) ..... 69 kPa [10 psi]
- Rated Speed (minimum allowable) ..... 207 kPa [30 psi]

Fuel Inlet Restriction (maximum) ..... 100 mm Hg [4 in Hg]

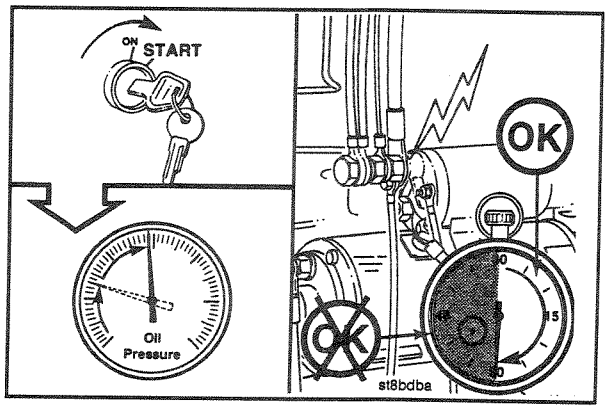
Fuel Return Restriction (maximum) ..... 518 mm Hg [20.4 in Hg]

* Due to variations in ratings of different engine models, refer to the specific engine data sheet for the particular engine model being tested.

Blowby** (at Given Speed, 100% Load)

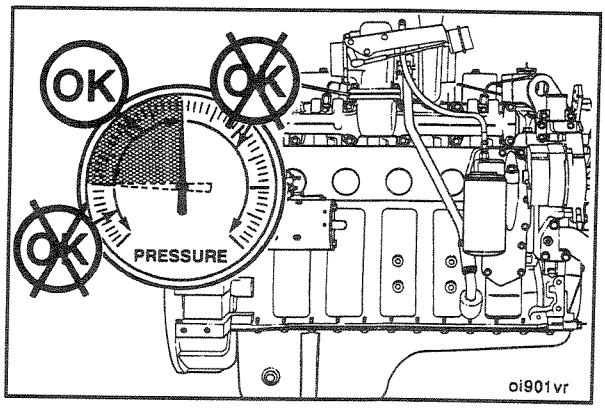
	New (L/Min)	Worn (L/Min)
4B @ 2200	18	36
4B @ 2500	20	40
4B @ 2800	23	46
4BT @ 2200	45	90
4BT @ 2500	51	102
4BT @ 2800	57	114
6B @ 2200	26	52
6B @ 2500	30	60
6B @ 2800	34	68
6BT @ 2200	63	126
6BT @ 2500	76	152
6BT @ 2800	85	170

** Blowby checking tool, Part No. 3822476, has a special 5.613 mm [0.221 in.] orifice that **must** be used to get an accurate reading.



Caution: Do not crank the engine for more than 30 seconds. Excessive heat will damage the starting motor.

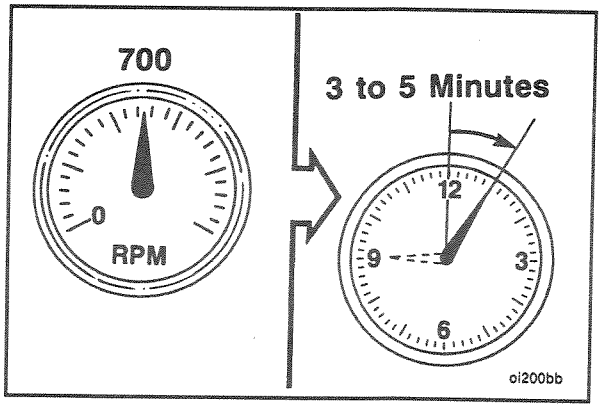
Crank the engine and observe the lubricating oil pressure when the engine starts. If the engine fails to start within 30 seconds, allow the starting motor to cool for 2 minutes before ranking the engine again.



Engine lubricating oil pressure **must** be at least 69 kPa [10 psi] at 700 RPM.

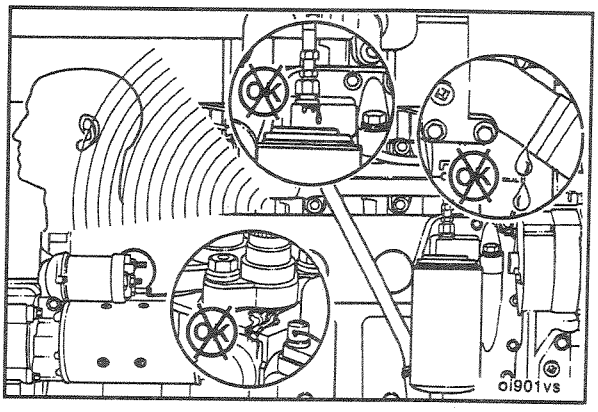
Caution: If the lubricating oil pressure is not within specifications, shut off the engine immediately. Low lubricating oil pressure will cause engine damage.

Correct the problem if the lubricating oil pressure is **not** within specifications.



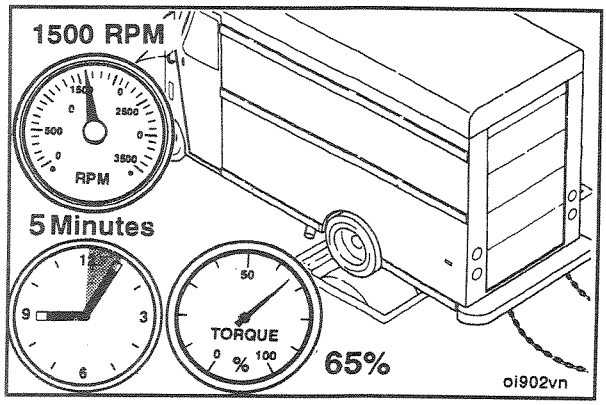
Caution: Do not operate the engine at idle speed longer than specified during engine run-in. Excessive carbon formation will cause damage to the engine.

Operate the engine at approximately 700 RPM for 3 to 5 minutes.

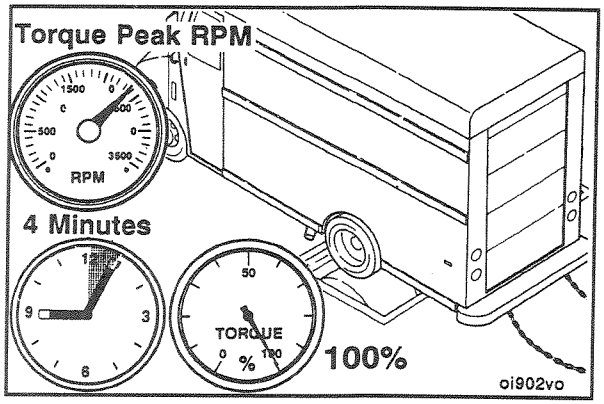


Listen for unusual noises; watch for coolant, fuel, and lubricating oil leaks; and check for correct engine operation in general.

NOTE: Repair all leaks or component problems before continuing the engine run-in.

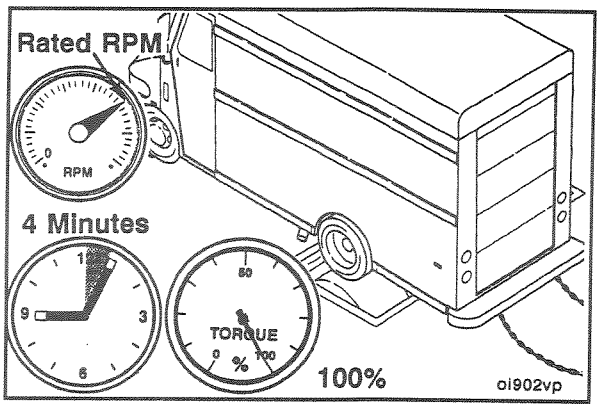


Operate the engine at 1,600 RPM and 65 percent of torque peak load for 5 minutes. Check the gauges, and record the readings.



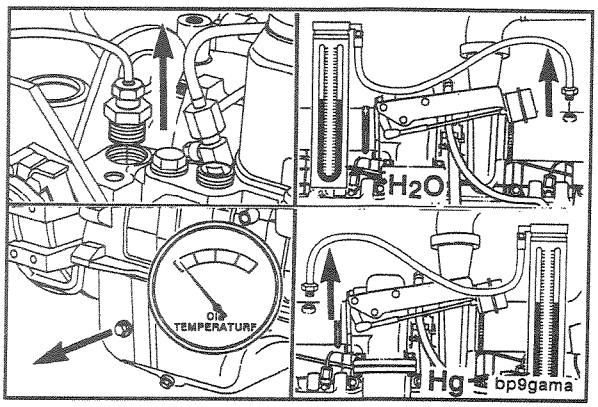
Operate the engine at torque peak RPM and full load for 4 minutes. Check the gauges, and record the readings.

NOTE: Refer to the engine data sheet for the torque peak RPM of the engine model being tested.

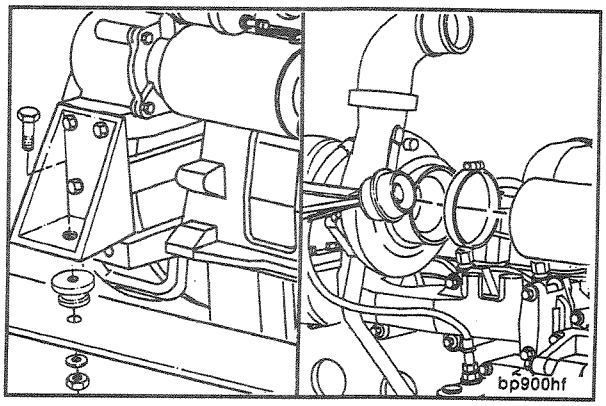


Operate the engine at rated speed (RPM) and full load for 4 minutes. Check the gauges, and record the readings. Compare the readings to those published on the appropriate engine data sheet.

Caution: Do not shut off the engine immediately after the run-in is completed. Allow the engine to cool by operating it at low idle for a minimum of 3 minutes to avoid internal component damage.



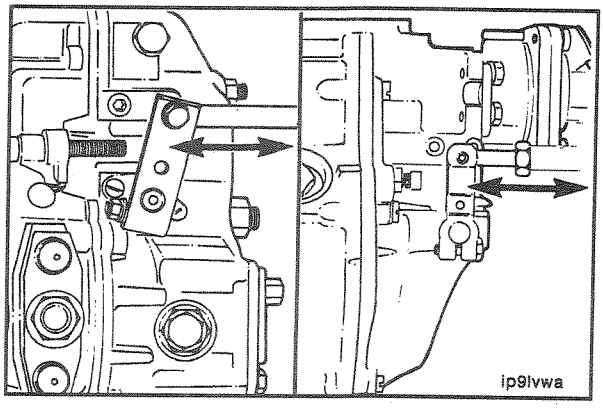
Make sure all instrumentation is removed before removing the vehicle from the dynamometer.



Align the engine in the chassis and tighten the engine mounting capscrews. Refer to the equipment manufacturer's torque specifications.

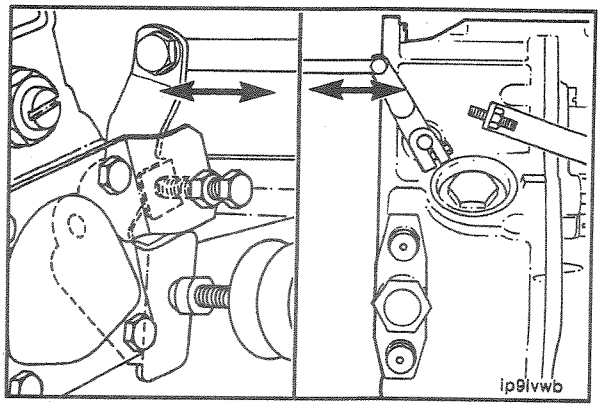
Connect all engine and chassis mounted accessories that were removed.

NOTE: Be sure all lines, hoses, and tubes are properly routed and fastened to prevent damage. Be sure the air intake and exhaust pipe connections are tight and free of leaks.

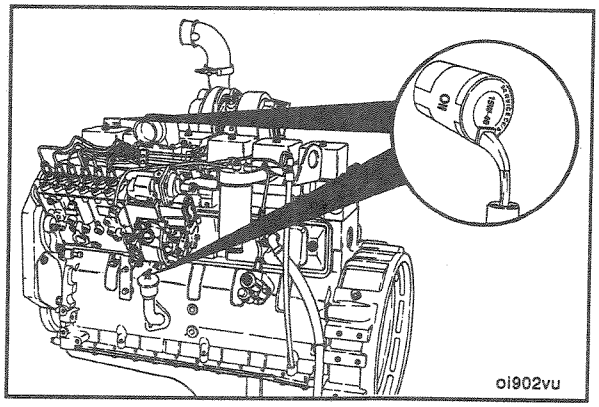


Throttle Control Lever Connection

When connecting the cable/rod to the control lever, adjust the length so the lever has stop-to-stop movement.



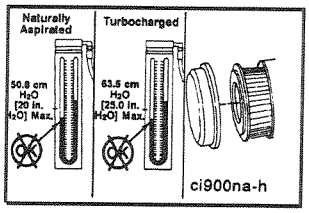
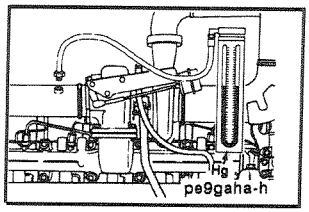
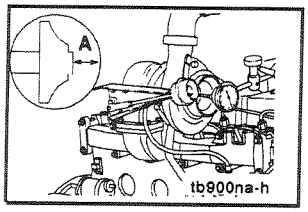
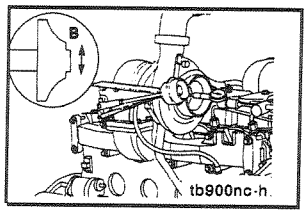
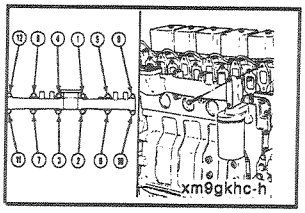
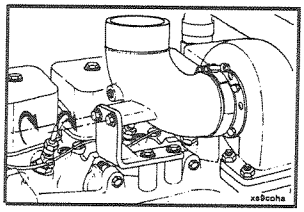
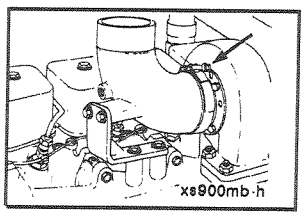
Adjust the length of the cable/rod to the mechanical shut down lever so there is stop-to-stop movement.

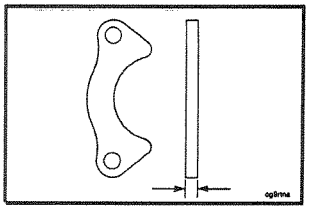
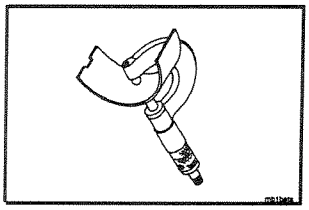
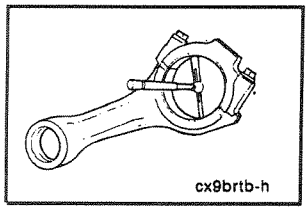
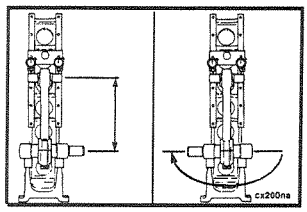
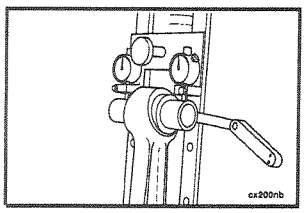
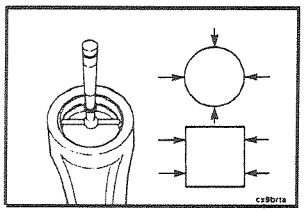
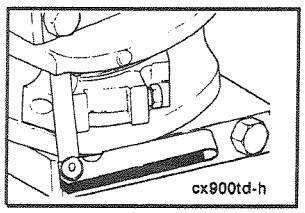


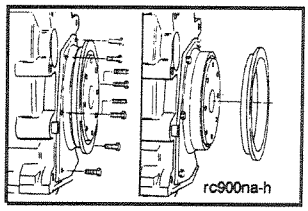
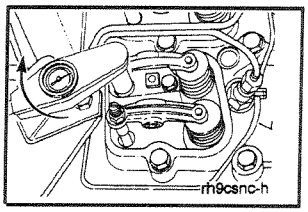
Fill the engine with clean 15W-40 lubricating oil.

NOTE: The total oil system capacity, including lubricating oil filters is:

	Liters	U.S. Qt.
4 Cylinder.....	11.0	11.6
6 Cylinder.....	16.4	17.3
Optional 6 Cylinder	12.6	13.3
Optional 6 Cylinder (Ford).....	18.9	20.0

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
	**Intake Air Restriction**	65.5 cm H_2O	MAX	25.0 in H_2O
	**Exhaust Gas Restriction** Non Automotive 91 EPA Cert 94 EPA Cert. with oxidation catalyst	 76.2 mm/Hg 114.3 mm/Hg 152.6 mm/Hg	 MAX MAX MAX	 3 in Hg 4.5 in/Hg 6 in/Hg
	**Turbocharger Axial Clearance** Holset With Engine Serial Numbers Before 840638 With Engine Serial Numbers After/Including 840638	A 	 0.030 mm 0.46 mm 0.10 mm 0.16 mm 0.03 mm 0.08 mm	 MIN MAX MIN MAX MIN MAX	 0.012 in 0.018 in 0.004 in 0.006 in 0.001 in 0.003 in
	**Turbocharger Radial Clearance - Side to Side**	B	0.03 mm 0.08 mm	MIN MAX	0.001 in 0.003 in
	**Combustion Air System Torque Values** **Exhaust Manifold** Torque Value and Sequence		43 N•m		32 ft-lb
	**Exhaust Outlet Pipe Bracket**		43 N•m		32 ft-lb
	**Exhaust Outlet Pipe, V-Band**		8 N•m		72 in-lb

	Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
	**Camshaft Thrust Plate Thickness**		9.340 mm 9.580 mm	MIN MAX	0.368 in 0.377 in
	**Connecting Rod Bearing Thickness (Standard)**		1.955 mm 1.968 mm	MIN MAX	0.0769 in 0.0775 in
	**Connecting Rod Crankshaft Bore I.D.** (Without Bearings)		72.987 73.013	MIN MAX	2.8735 in 2.8745 in
	**Connecting Rod Length (Center to Center)** **Connecting Rod Alignment** • With Bushing		191.975 mm 192.025 mm 0.150 mm	MIN MAX MAX	7.5581 in 7.5600 in 0.006 in
	**Connecting Rod Twist** • With Bushing		0.150 mm	MAX	0.006 in
	**Connecting Rod Pin Bore Diameter I.D.** (with bushing installed)		40.019 mm 40.042 mm	MIN MAX	1.5755 in 1.5764 in
	**Connecting Rod Side Clearance Limits**		0.100 mm 0.330 mm	MIN MAX	0.004 in 0.013 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
	Rear Seal Cover Mounting	9 N•m	48 in-lb
	Rocker Support Capscrews	24 N•m	18 ft-lb

Component Manufacturers' Addresses

NOTE: The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins engines. Suppliers may be contacted directly for any specifications **not** covered in this manual.

Air Compressors

Bendix Heavy Vehicles Systems
Div. of Allied Automotive
901 Cleveland Street
Elyria, OH 44036
Telephone: (216) 329-9000

Midland-Grau
Heavy Duty Systems
Heavy Duty Group Headquarters
10930 N. Pomona Avenue
Kansas City, MO 64153
Telephone: (816) 891-2470

Air Cylinders

Bendix Ltd.
Douglas Road
Kingswood
Bristol
England
Telephone: 0272-671881

Catching Engineering
2101 Roberts Drive
Broadview, IL 60153
Telephone: (312) 344-2334

Air Heaters

Fleetguard, Inc.
P.O. Box 6001
Cookeville, TN 38502
Telephone: (615) 526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

Air Starting Motors

Ingersoll Rand
Chorley New Road
Horwich
Bolton
Lancashire
England
BL6 6JN
Telephone: 0204-65544

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
Telephone: (312) 530-3800

StartMaster
Air Starting Systems
A Division of Sycon Corporation
P. O. Box 491
Marion, OH 43302
Telephone: (614) 382-5771

Alternators

Robert Bosch Ltd.
P.O. Box 98
Broadwater Park
North Orbital Road
Denham
Uxbridge
Middlesex UD9 5HG
England
Telephone: 0895-833633

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

C. E. Niehoff
2021 Lee Street
Evanston, IL 60202
Telephone: (708) 866-6030

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st St.
Cleveland, OH 44013
Telephone: (216) 431-0740

Auxiliary Brakes

The Jacobs Manufacturing Company
Vehicle Equipment Division
22 East Dudley Town Road
Bloomfield, CT 06002
Telephone: (203) 243-1441

Belts

Dayco Rubber U.K.
Sheffield Street
Stockport
Cheshire
SK4 1RV
England
Telephone: 061-432-5163

T.B.A. Ind. Products
P.O. Box 77
Wigan
Lancashire
WN2 4XQ
England
Telephone: 0942-59221

Dayco Corp.
Belt Technical Center
P.O. Box 3258
Springfield, MO 65804
Telephone: (417) 881-7440

Gates Rubber Company
5610 Crawfordsville Road
Suite 2002
Speedway, IN 46224
Telephone: (317) 248-0386

Goodyear Tire and
Rubber Company
49 South Franklin Road
Indianapolis, IN 46219
Telephone: (317) 898-4170

Catalyst

Donaldson Company, Inc.
1400 West 94th Street
P.O. Box 1299
Minneapolis, MN 55440
Telephone: (612) 887-3131

Nelson Industries, Inc.
Exhaust and Filtration Systems
Highway 51 West, P.O. Box 428
Stoughton, WI 53589
Telephone: (608) 873-4373

Walker Manufacturing
3901 Willis Road
P.O. Box 157
Grass Lake, MI 49240
Telephone: (517) 522-5500

Clutches

Twin Disc International S.A.
Chaussee de Namur
Nivelles
Belguim
Telephone: 067-224941

Twin Disc Clutch Co.
Racine, WI 53403
Telephone: (414) 634-1981

Coolant Heaters

Fleetguard, Inc.
P.O. Box 6001
Cookeville, TN 38502
Telephone: (615) 526-9551

Drive Plates

Detroit Diesel Allison
Division of General Motors
Corporation
P.O. Box 894
Indianapolis, IN 46206
Telephone: (317) 244-1511

Electric Starting Motors

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663