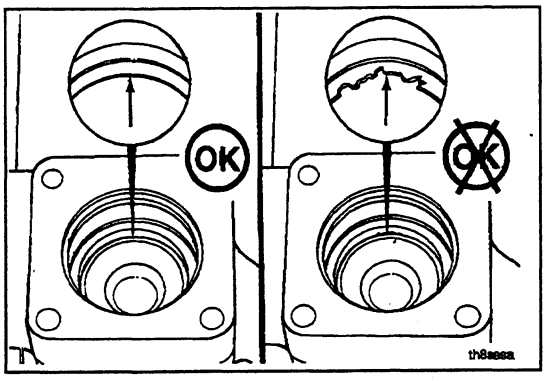
Troubleshooting and Repair Manual ISB and QSB5.9 Engines

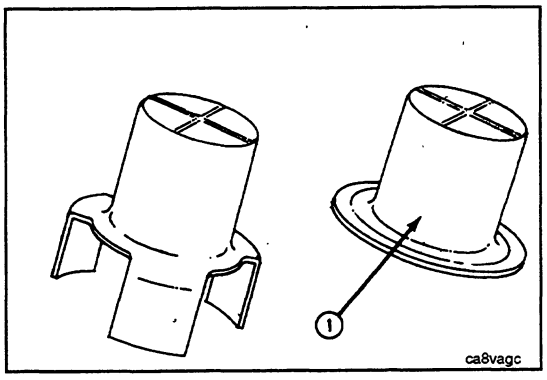
U.S.A., Canada, Australia, New Zealand, and Puerto Rico

Illustrations

Some of the illustrations throughout this manual are generic and will **not** look exactly like the engine or parts used in your application. The illustrations can contain symbols to indicate an action required and an acceptable or **not** acceptable condition.



The illustrations are intended to show repair or replacement procedures. The procedure will be the same for all applications, although the illustration can differ.



Specifications

General Specifications

Horsepower (refer to engine dataplate)

Bore and Stroke ..... 102 mm [4.02 in] X 120 mm [4.72 in]

Displacement ..... 5.9 liters [359 C.I.D.]

Compression Ratio 16.5:1

Firing Order 1-5-3-6-2-4

Engine Weight (with standard accessories):
- Dry Weight ..... 458 kg [1010 lb]

Crankshaft Rotation (viewed from the front of the engine) ..... **Clockwise**

Valve Clearance:
- Intake ..... 0.025 mm [0.010 in]
- Exhaust ..... 0.051 mm [0.020 in]

NOTE: The ISB engine features a no-adjust overhead. The ISB valve train is designed such that adjustment of the valve lash is **not** required for normal service during the first 241,402 km [150,000 mi]. The valve train operates acceptably within the limits of 0.152- to 0.381-mm [0.006- to 0.015-in] intake valve lash and 0.381- to 0.762-mm [0.015- to 0.030-in] exhaust valve lash.

Fuel System

For performance and fuel rate values, refer to the Engine Data Sheet or the fuel injection pump for the particular model involved.

Engine Idle Speed ..... 700 to 1000 rpm

Maximum Fuel Inlet Restriction to Lift Pump ..... 20 kPa [6 in Hg]

Maximum Fuel Pressure at Fuel Filter Outlet (engine cranking) ..... 28 to 55 kPa [4 to 8 psi]

Minimum Fuel Pressure at Fuel Filter Inlet (engine running) ..... 55 to 117 kPa [8 to 17 psi]

Maximum Pressure Drop Across Fuel Filter ..... 34 kPa [5 psi]

Fuel Drain Line Maximum Restriction ..... 69 kPa [10 psi]

Fuel Inlet Maximum Temperature ..... 74°C [165°F]

Engine Minimum Cranking Speed ..... 150 rpm

Lubricating Oil System

Oil Pressure:
- Low Idle (minimum allowed) ..... 103 kPa [15 psi]
- At Rated Speed (minimum allowed) ..... 310 kPa [45 psi]

Regulated Pressure ..... 414 kPa [60 psi]

Oil Capacity of Standard Engine:
- Standard
  - Pan **Only** ..... 14.2 liters [15 qt]
  - Total System ..... 16.4 liters [17 qt]
- Deep Sump
  - Pan **Only** ..... 16.1 liters [17 qt]
  - Total System ..... 18.3 liters [19 qt]
- Oil Pan High - Low
  - Standard Pan ..... 12 to 14.2 liters [13 to 15 qt]
  - Deep Sump Pan ..... 14.2 to 16.1 liters [15 to 17 qt]

NOTE: Some applications use a slightly different lubricating oil pan capacity. Contact your local Cummins Distributor if you have questions.

Troubleshooting Procedures and Techniques

A thorough analysis of the customer's complaint is the key to successful troubleshooting. The more information known about a complaint, the faster and easier the problem can be solved.

The Troubleshooting Symptom Charts are organized so that a problem can be located and corrected by doing the easiest and most logical things first. Complete all steps in the sequence shown from top to bottom.

It is **not** possible to include all the solutions to problems that can occur; however, these charts are designed to stimulate a thought process that will lead to the cause and correction of the problem.

Follow these basic troubleshooting steps:

- Get all the facts concerning the complaint
- Analyze the problem thoroughly
- Relate the symptoms to the basic engine systems and components
- Consider any recent maintenance or repair action that can relate to the complaint
- Double-check before beginning any disassembly
- Solve the problem by using the symptom charts and doing the easiest things first
- Determine the cause of the problem and make a thorough repair
- After repairs have been made, operate the engine to make sure the cause of the complaint has been corrected

Air Compressor Will Not Pump Air

This is symptom tree T009.

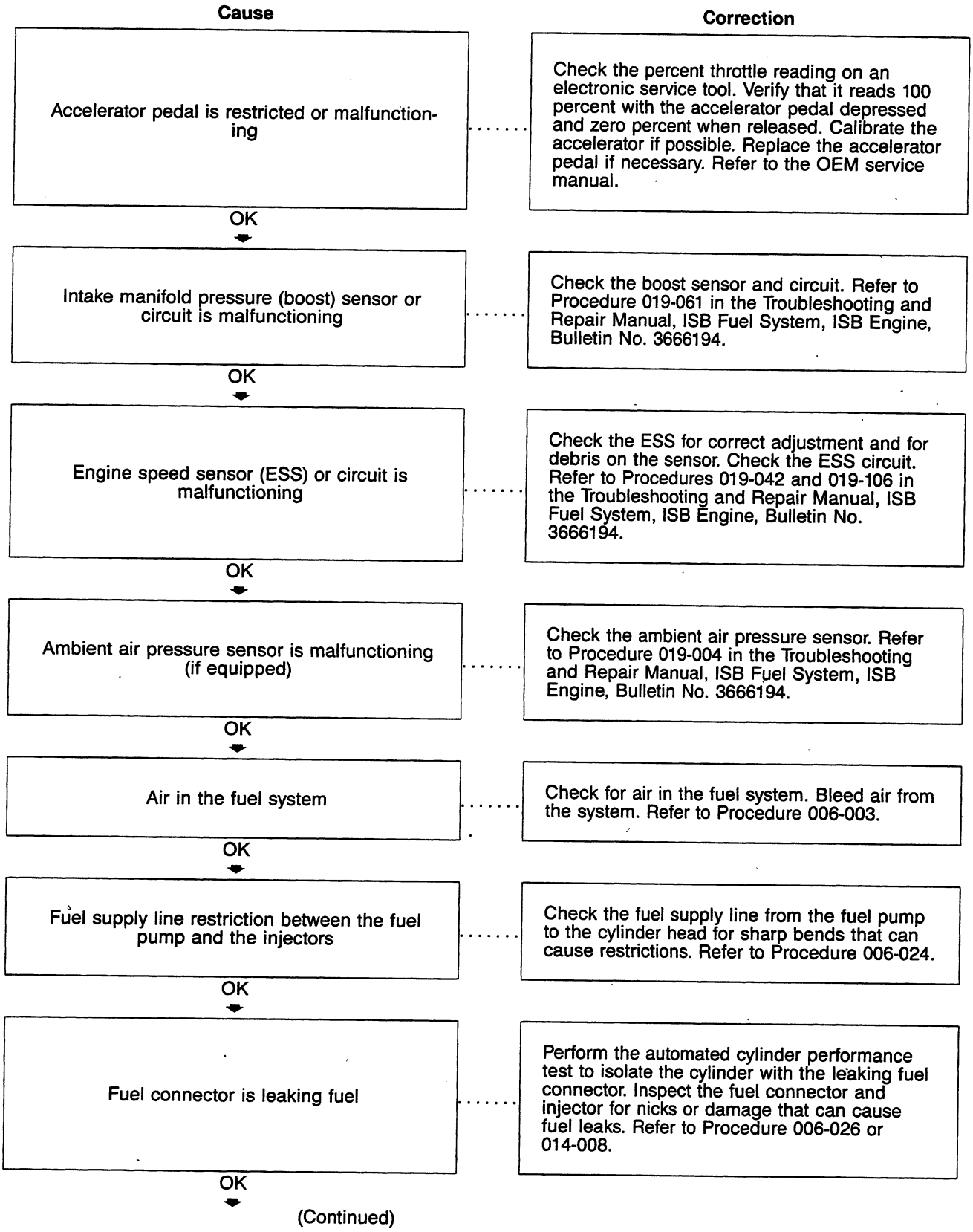
Cause	Correction
Air system leaks	Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, and valves. Refer to Procedure 012-019 and the OEM service manuals.
OK ▼	
Air dryer desiccant cartridge is saturated	Replace the desiccant cartridge on the air dryer. Refer to the OEM service manual.
OK ▼	
Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the Master Repair Manual, Holset® Air Compressor, Bulletin No. 3666121.
OK ▼	
Air governor is malfunctioning	Check the air governor for correct operation. Make sure the air governor is located less than 2 feet from the air compressor. Refer to the Master Repair Manual, Holset® Air Compressors, Bulletin No. 3666121, and the OEM service manual.
OK ▼	
Splined drive coupling or gear is excessively worn	Check the coupling for wear. Refer to Procedure 012-014.
OK ▼	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to Procedure(s) 012-019.
OK ▼	
Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to the Master Repair Manual, Holset® Air Compressors, Bulletin No. 3666121.

Coolant Temperature Above Normal – Gradual Overheat (Continued)

Cause	Correction
Fan drive belt is broken	Check the fan drive belt. Replace the belt if necessary. Refer to Procedure 008-002.
OK ↓	
Cooling system hose is collapsed, restricted, or leaking	Inspect the radiator hoses. Refer to Procedure 008-045.
OK ↓	
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, ISB Fuel System, ISB Engine, Bulletin No. 3666194, for fault code trouble-shooting.
OK ↓	
Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge if necessary. Refer to Procedure 008-004 and the OEM service manual.
OK ↓	
Intake manifold air temperature is above specification	Refer to the Intake Manifold Air Temperature Above Specification symptom tree.
OK ↓	
Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Refer to Procedure(s) 008-027.
OK ↓	
Lubricating oil level is above or below specification	Check the oil level. Add or drain oil if necessary. Refer to Procedure 007-025. Check the dipstick calibration. Refer to Procedure 007-009.
OK ↓	
Vent lines or fill line are restricted, obstructed, or **not** routed correctly	Check the vent lines and the fill line for correct routing and for restriction. Refer to OEM specifications.
OK ↓	

(Continued)

Engine Acceleration or Response Poor (Continued)



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Engine Difficult to Start or Will Not Start (No Exhaust Smoke) (Continued)

Cause	Correction
Air in the fuel system	Check for air in the fuel system. Bleed air from the system. Refer to Procedure 006-003.
OK ⬇	
Fuel inlet restriction	Check for fuel inlet restriction. Refer to Procedure 006-020.
OK ⬇	
Injector shim thickness is **not** correct	Remove the injectors and verify the injector shim thickness. Refer to Procedure 006-026.
OK ⬇	
Electronic control module (ECM) is locked up	Disconnect the battery cables for 30 seconds. Connect the battery cables, and start the engine. Refer to Procedure 013-009.
OK ⬇	
Electronic control module (ECM) is malfunctioning	Replace the ECM. Refer to Procedure 019-031 in the Troubleshooting and Repair Manual, ISB Fuel System, ISB Engine, Bulletin No. 3666194.
OK ⬇	
Fuel injection pump is malfunctioning	Replace the fuel injection pump. Refer to Procedure 005-012 or 005-014.
OK ⬇	
Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-002.

Engine Power Output Low (Continued)

Cause	Correction
Fuel pump overflow valve is malfunctioning	Check the overflow valve. Refer to Procedure 005-066 or 006-044.
OK ↓	
Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Procedure 005-011.
OK ↓	
Engine is operating above recommended altitude	Engine power decreases above recommended altitude. Refer to the Engine Data Sheet for specifications.
OK ↓	
Engine duty cycle has changed	Verify the engine duty cycle with an electronic service tool. Refer to the appropriate electronic service tool manual.
OK ↓	
Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again if necessary. Refer to the appropriate electronic service tool manual.
OK ↓	
Electronic control module (ECM) calibration is **not** correct	Compare the calibration stored in the ECM with the engine rating and the Control Parts List (CPL), Bulletin No. 3379133. If necessary, calibrate the ECM. Refer to the appropriate electronic service tool manual and Procedure 019-032 in the Troubleshooting and Repair Manual, ISB Fuel System, ISB Engine, Bulletin No. 3666194.
OK ↓	
J1939 control devices are interfering with the engine controls	Alternately disconnect all other J1939 control devices from the datalink circuit until communications or functionality is restored. Refer to the OEM service manual to locate and repair J1939 control devices.
OK ↓	

(Continued)

Engine Runs Rough or Misfires (Continued)

Cause	Correction
Injectors are **not** correct	Remove the injectors and compare the part numbers to the Control Parts List (CPL), Bulletin No. 3379133. Replace the injectors if necessary. Refer to Procedure 006-026.
OK ⬇	
Injector shim thickness is **not** correct	Remove the injectors and verify the injector shim thickness. Refer to Procedure 006-026.
OK ⬇	
Static injection timing is **not** correct	Check the static injection timing. Refer to Procedure 005–037.
OK ⬇	
Fuel injection pump is malfunctioning	Replace the fuel injection pump. Refer to Procedure 005–014.
OK ⬇	
Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-002.

Engine Speed Surges Under Load or in Operating Range (Continued)

Cause	Correction
Fuel grade is **not** correct for the application, or the fuel quality is poor	Operate the engine from a tank of good fuel. Refer to Fuel Recommendations and Specifications in the Operation and Maintenance Manual, ISB Engine, Bulletin No. 3666170.
OK ↓	
Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin No. 3379133. Replace the turbocharger if necessary. Refer to Procedure 010-033.
OK ↓	
Turbocharger wastegate is malfunctioning (if equipped)	Check the wastegate for correct operation. Refer to Procedure 010-050.
OK ↓	
Turbocharger wheel clearance is out of specification	Check the radial bearing clearance and axial clearance. Inspect the turbocharger. Repair or replace the turbocharger if necessary. Refer to Procedures 010-038 and 010-047.
OK ↓	
Fuel injection pump is malfunctioning	Check pump to engine timing. Refer to Procedure 005-037.
OK ↓	
Fuel injection pump is malfunctioning	Replace the fuel injection pump. Refer to Procedure 005-016 or 005-014.
OK ↓	
Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-002.

Engine Will Not Crank or Cranks Slowly (Electric Starter) (Continued)

Cause	Correction
Starting circuit component is malfunctioning	Check the starting circuit components. Refer to the OEM service manual.
OK ▼	
Starting motor pinion or ring gear is damaged	Remove the starting motor, and inspect the gear. Refer to Procedure 013-020 and the manufacturer's instructions.
OK ▼	
Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-013. Use the oil type recommended in Section V of the operation and maintenance manual.
OK ▼	
Lubricating oil temperature is below specification	Install an oil pan heater, or drain the oil and fill the system with warm oil.
OK ▼	
Hydraulic lock in a cylinder	Remove the injectors, and rotate the crankshaft. Look for the source of fluid in the cylinder. Refer to Procedures 006-026 and 001-016.
OK ▼	
Lubricating oil level is above specification	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-009 or 007-025.
OK ▼	
Lubricating oil pressure switch, gauge, or sensor is malfunctioning or is **not** in the correct location	Check the oil pressure switch, gauge, or sensor for correct operation and location. Refer to Procedure 007-052.
OK ▼	
Lubricating oil temperature switch, gauge, or sensor malfunctioning or **not** in the correct location	Check the oil temperature switch, gauge, or sensor for correct operation and location.
OK ▼	

(Continued)

Fuel Consumption Excessive (Continued)

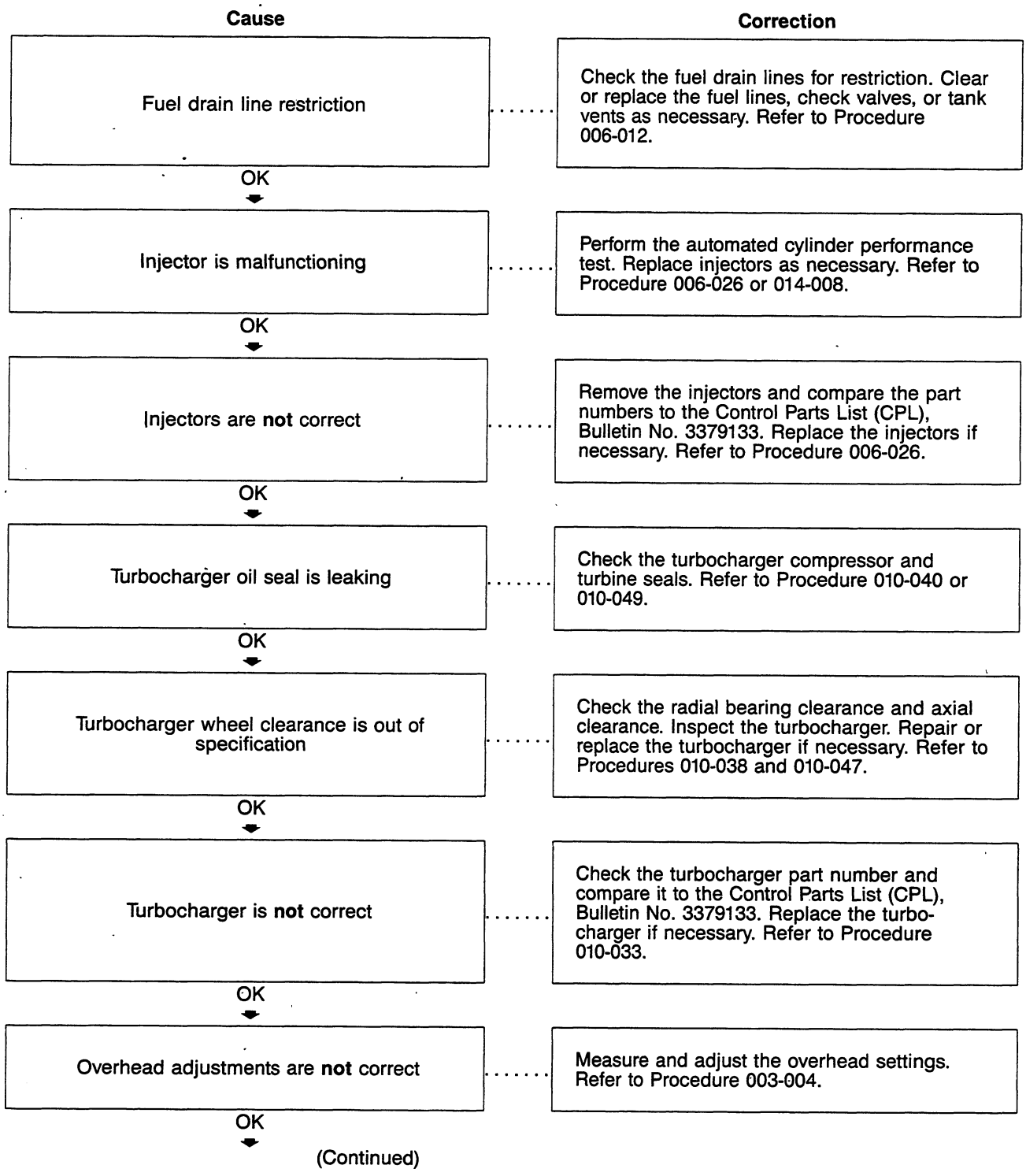
Cause	Correction
Exhaust system restriction is above specification	Check the exhaust system for restrictions. Refer to Procedure 011-009.
OK ↓	
Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-004.
OK ↓	
Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to Procedure 005-045.
OK ↓	
Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-002.

Lubricating Oil Contaminated

This is symptom tree T103.

Cause	Correction
Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filters. Refer to Procedure 007-025 or 007-013.
OK ▼	
Fuel in the lubricating oil	Refer to the Fuel in the Lubricating Oil symptom tree.
OK ▼	
Internal coolant leaks	Refer to the Coolant Loss - Internal symptom tree.
OK ▼	
Lubricating oil sludge is excessive	Refer to the Lubricating Oil Sludge in the Crankcase is Excessive symptom tree.
OK ▼	
Identify lubricating oil contamination	Perform an oil analysis to determine the contaminants.

Smoke, Black — Excessive (Continued)



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Fuel Consumption - General Information

The cause of excessive fuel consumption is hard to diagnose and correct because of the potential number of factors involved. Actual fuel consumption problems can be caused by any of the following factors:

- — Engine factors
- — Vehicle factors and specifications
- — Environmental factors
- — Driver technique and operating practices
- — Fuel system factors
- — Low power/driveability problems.

Before troubleshooting, it is important to determine the exact complaint. Is the complaint based on whether the problem is real or perceived, or does **not** meet driver expectations? The Fuel Consumption - Customer Complaint Form (on the next page) is a valuable list of questions that can be used to assist the service technician in determining the cause of the problem. Complete the form before troubleshooting the complaint. The following are some of the factors that **must** be considered when troubleshooting fuel consumption complaints.

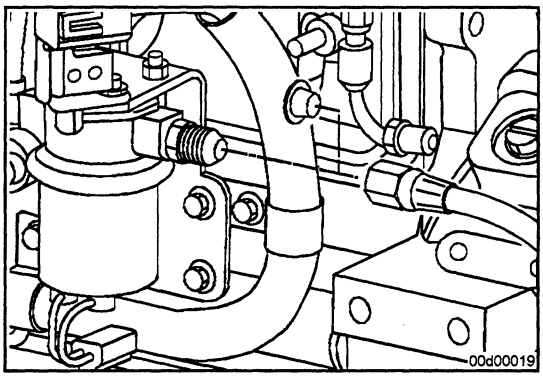
1. **Result of a Low Power/Driveability Problem:** An operator will change driving style to compensate for a low power/driveability problem. Some things the driver is likely to do are: (a) shift to a higher engine rpm or (b) run on the droop curve in a lower gear instead of upshifting to drive at part throttle conditions. These changes in driving style will increase the amount of fuel used.
2. **Driver Technique and Operating Practices:** As a general rule, a 1 mph increase in road speed equals a 0.1 mpg increase in fuel consumption. This means that increasing road speed from 50 to 60 mph will reslut in a loss of fuel mileage of 1 mpg.
3. **Environmental and Seasonal Weather Changes:** As a general rule, there can be as much as a 1 to 1.5 mpg difference in fuel consumption depending on the season and the weather conditions.
4. **Excessive Idling Time:** Idling the engine can use from 0.5 to 1.5 gallons per hour depending on the engine idle speed.
5. **Truck Route and Terrain:** East/west routes experience almost continuous crosswinds and head winds. Less fuel can be used on north/south routes where parts of the trip are **not only** warmer, but also have less wind resistance.
6. **Vehicle Aerodynamics:** The largest single power requirement for a truck is the power needed to overcome air resistance. As a general rule, each 10 percent reduction in air resistance results in a 5 percent increase in mpg.
7. **Rolling Resistance:** Rolling resistance is the second largest consumer of power on a truck. The type of tire and tread design have a sizeable effect on fuel economy and performance. Changing from a bias ply to low profile radial tire can reduce rolling resistance by about 36 percent.

Additional vehicle factors, vehicle specifications, and axle alignment can also affect fuel consumption. For additional information on troubleshooting fuel consumption complaints, refer to Troubleshooting Excessive Fuel Consumption, Bulletin No. 3387245.

Engine Removal (000-001)

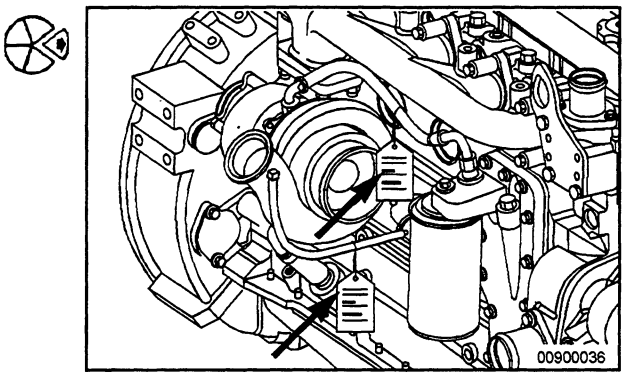
Initial Check (000-001-001)

Shut off and cap the fuel supply line.



Remove (000-001-002)

Place a tag on all hoses, lines, linkage, and electrical connections as they are removed to identify their locations.



Disconnect the battery cables, negative (-) cable first.

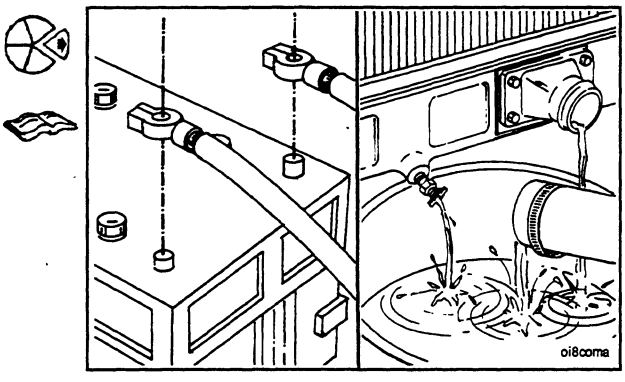
⚠ WARNING ⚠

Coolant is toxic. Keep away from pets and children. If not reused, dispose of in accordance with local environmental regulations.

⚠ WARNING ⚠

Wait until the temperature is below 50°C [120°F] to avoid personal injury from hot coolant.

Drain the engine coolant. Refer to Procedure 008-018.



⚠ WARNING ⚠

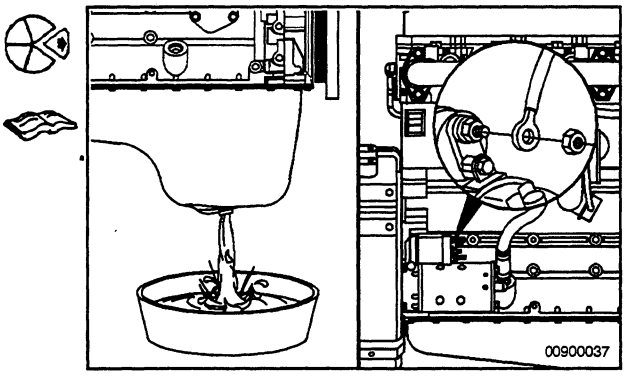
Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.

⚠ WARNING ⚠

Avoid direct contact of hot oil with your skin. Hot oil can cause personal injury.

Drain the lubricating oil. Refer to Procedure 007-025.

Disconnect the starter cable, engine ground straps, cab or chassis to engine hoses, tubing, electrical wires, wire harnesses, and hydraulic lines.



Section 1 - Cylinder Block - Group 01

Section Contents

Bearings, Main (001-006)

Initial Check (001-006-001)

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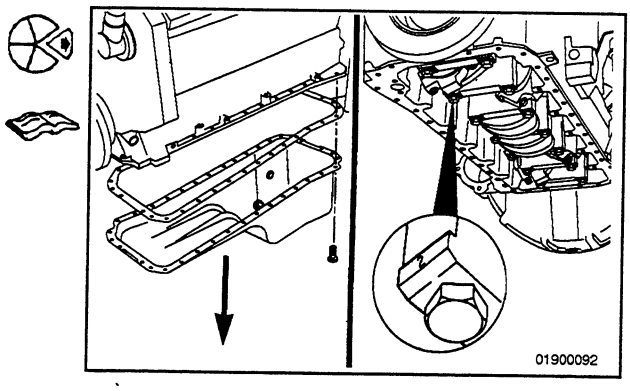
⚠ WARNING ⚠

Avoid direct contact of hot oil with your skin. Hot oil can cause personal injury.

Drain the lubricating oil. Refer to Procedure 007-025.

Remove the lubricating oil pan and gasket. Refer to Procedure 007-025.

NOTE: Before removing the main bearing caps, make certain that the caps are clearly marked for their location on the lubricating oil cooler side of the main bearing cap.

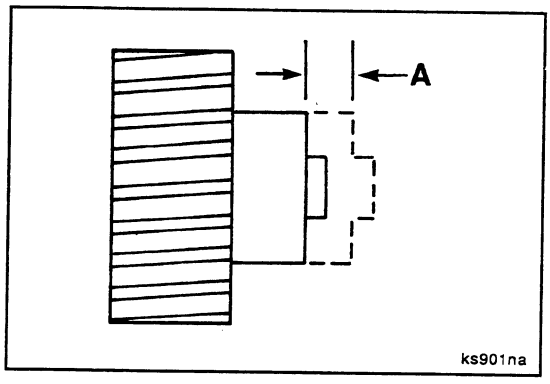


Dial Indicator Assembly, Part No. 3376050

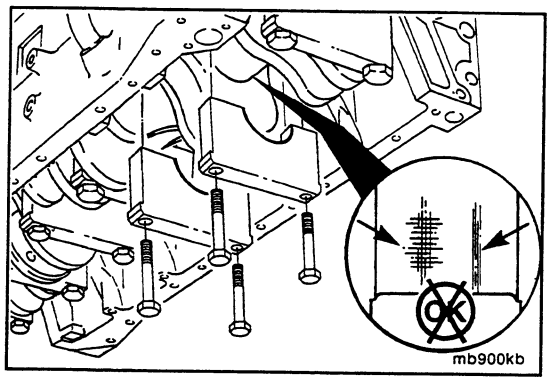
NOTE: The dimensions of the thrust bearing and crankshaft journal determine end play.

Measure the crankshaft end play with a dial indicator assembly, Part No. 3376050.

Dim. (A) End-Play Limits		
mm		in
0.102	MIN	0.004
0.432	MAX	0.017

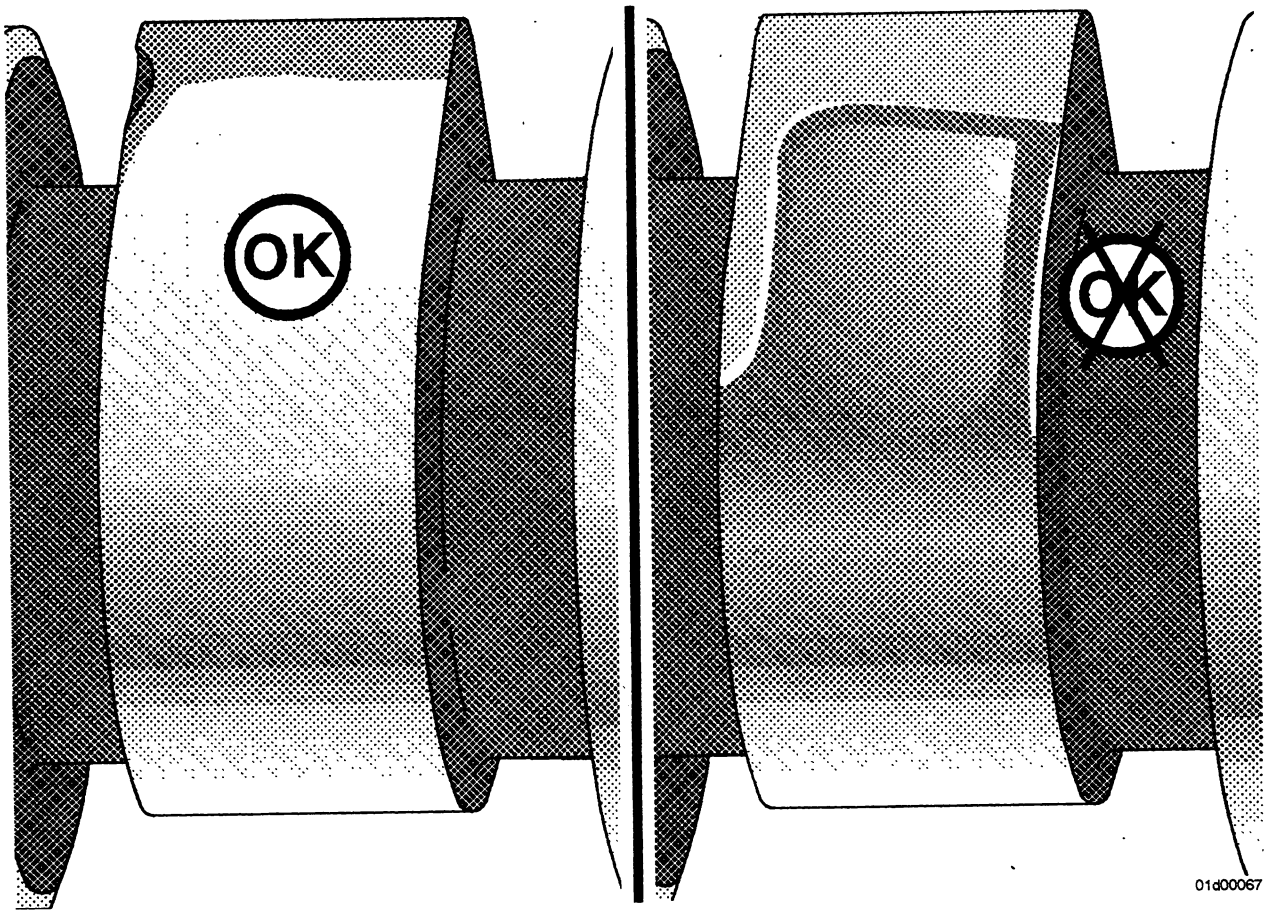


Perform an inspection of the main bearings and crankshaft journals. Remove the No. 2 and 3 caps, and check the crankshaft journals for signs of overheating, deep scratches, or other damage. If there is no damage, there is no need to pull the other main bearing caps at this time, unless the crankshaft end play is excessive.

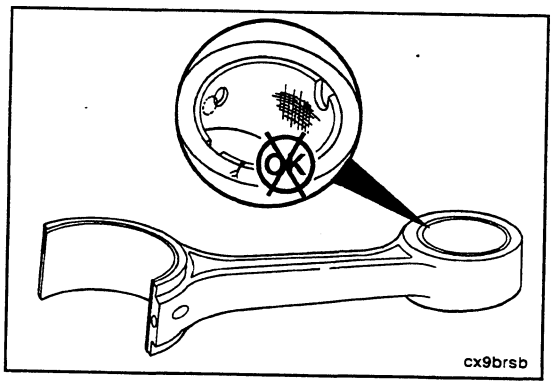


The first illustration shows normal grain pattern and a casting flaw within the nose area. Both of these conditions are acceptable for reuse.

The subsequent three illustrations show wear patterns that are **not** acceptable for reuse.

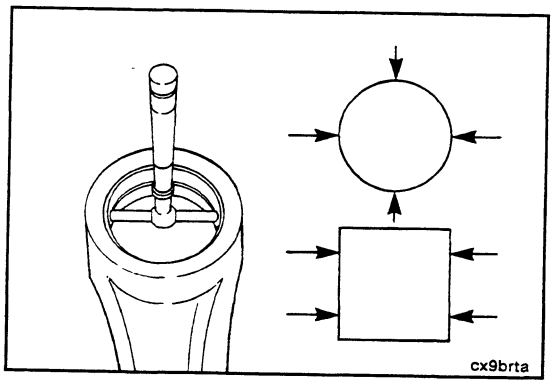


Inspect the piston pin bore for damage or misalignment of the oil passage and bushing.



Measure the connecting rod piston pin bushing inside diameter.

Connecting Rod Piston Pin Bushing Diameter		
mm		in
40.019	MIN	1.5755
40.042	MAX	1.5765



⚠ CAUTION ⚠

Use a vise with brass jaws to hold the connecting rod. Notches, scratches, or dents in the I-beam area can cause engine failure.

⚠ CAUTION ⚠

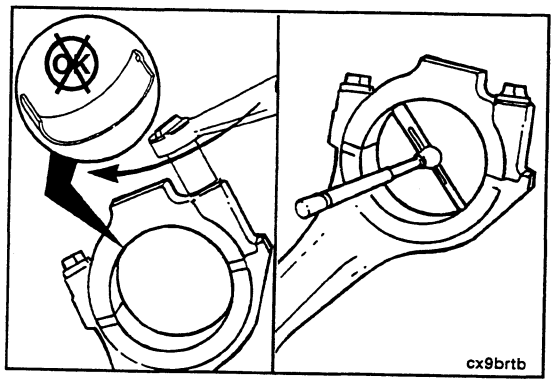
The number on the connecting rod must be the same as the number on the rod cap. Never assemble a new cap to a used rod or a used rod cap to a new connecting rod.

Use clean 15W-40 engine oil to lubricate the connecting rod capscrews.

Assemble the connecting rod, rod cap, washers, and capscrews.

Tighten the capscrews.

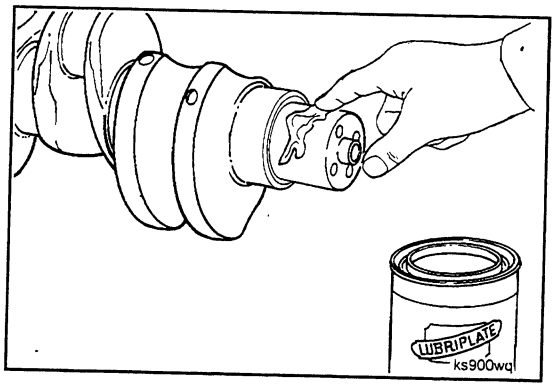
Torque Value: 100 N•m [73 ft-lb]



Connecting Rod Crankshaft Bore Diameter-Bearings Removed		
mm		in
72.99	MIN	2.874
73.01	MAX	2.875

NOTE: If the crankshaft bore measurements are **not** within specifications, the connecting rod **must** be replaced.

Apply a thin coating of lubricant to the nose of the crankshaft.

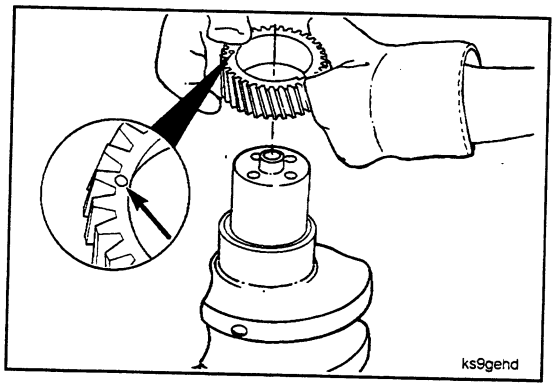


⚠ WARNING ⚠

To avoid severe burns, wear protective gloves when installing the heated ring gear.

Install the hot gear up to the crankshaft shoulder with the timing mark out.

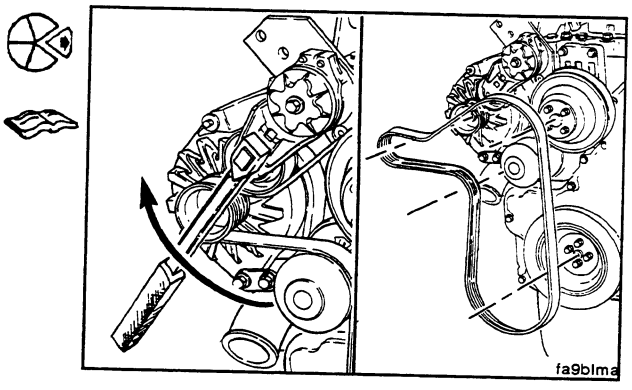
Install crankshaft. Refer to Procedure 001-016.



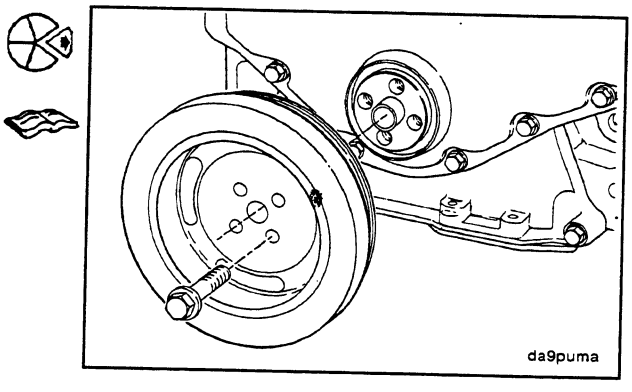
Crankshaft Seal, Front (001-023)

Remove (001-023-002)

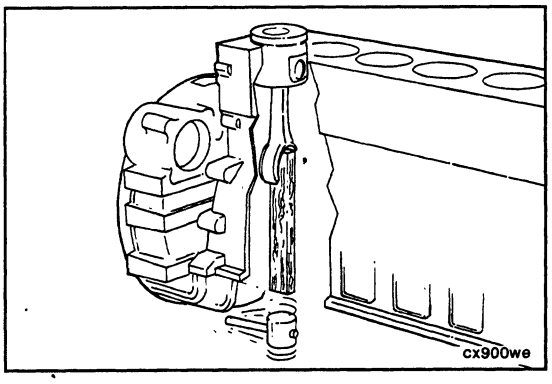
Remove the drive belt. Refer to Procedure 008-002.



Remove the vibration damper. Refer to Procedure 001-051 or 001-052.



Remove the piston and connecting rod assemblies. Refer to Procedure 001-043.

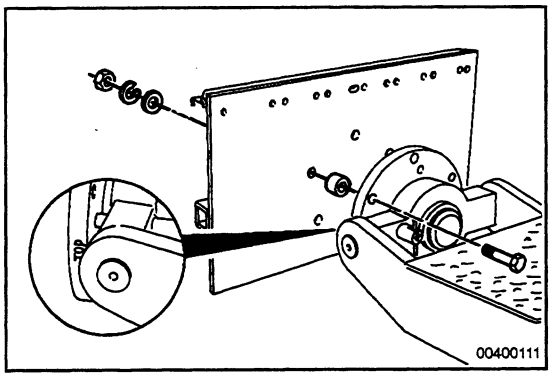


Clean (001-026-006)

⚠ WARNING ⚠

This component weighs more than 23 kg [50 lb]. To avoid personal injury, use a hoist or get personal assistance to lift the component.

Remove the block from the engine stand.



⚠ WARNING ⚠

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

△ CAUTION △

Use a cleaning solution that will not damage the camshaft bushings.

Follow the manufacturer's operating instructions for the cleaning tank.

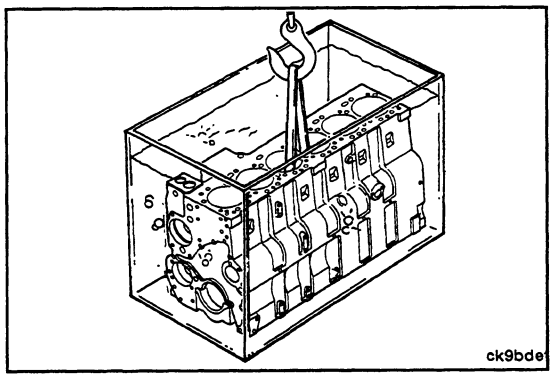
Follow the solvent manufacturer's instructions for using the solvent.

NOTE: Cummins Engine Company, Inc. does **not** recommend any specific cleaning solution.

NOTE: Experience has shown that the best results are obtained by using a cleaning solution that can be heated from 80 to 95°C [180 to 200°F].

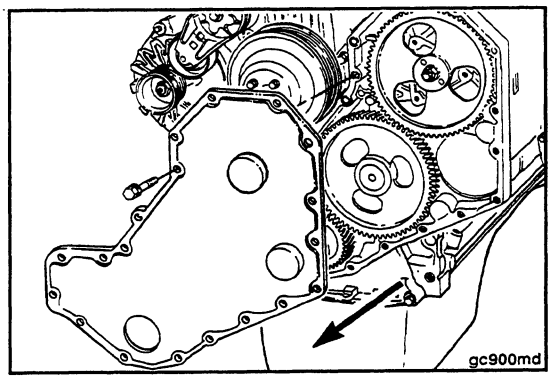
NOTE: A cleaning tank that **will** mix and filter the cleaning solution will give the best results.

Clean the cylinder block in the cleaning tank.



Remove the front gear cover mounting capscrews.

Remove the front gear cover.



Clean (001-031-006)

⚠ WARNING ⚠

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

⚠ WARNING ⚠

When using a steam cleaner, wear protective clothing in addition to safety glasses or a face shield. Hot steam can cause serious personal injury.

⚠ WARNING ⚠

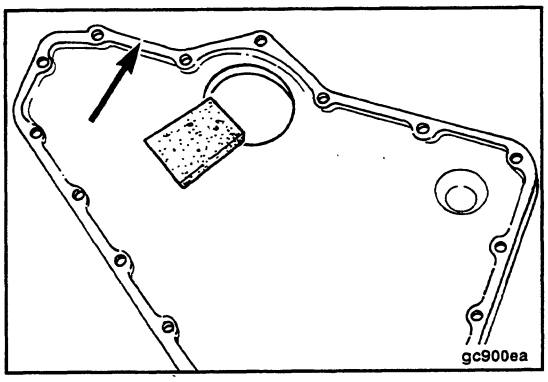
Compressed air used for cleaning should not exceed 207 kPa [30 psi]. Wear protective clothing and goggles to avoid personal injury.

Use a gasket scraper or Scotch-Brite 7448, or equivalent, to remove all gasket material and Three-Bond™ sealant.

Clean the gasket sealing surfaces and the surface between the oil seal and gear cover.

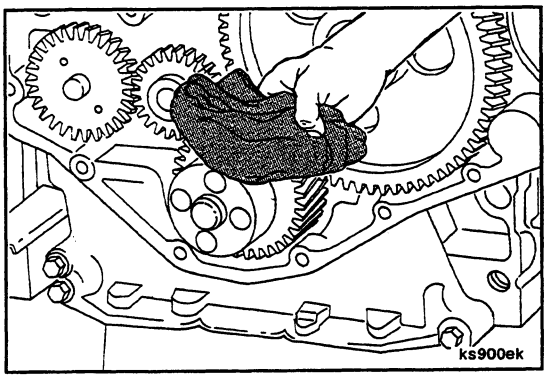
Use solvent or steam to clean the gear housing cover.

Dry the cover with compressed air.



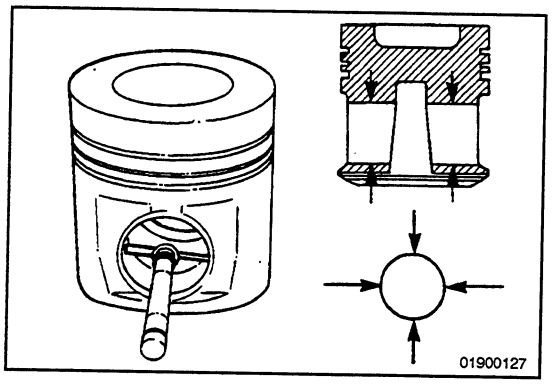
⚠ CAUTION ⚠

The crankshaft must be clean, dry, and oil-free before installing the gear cover. Failure to clean the sealing surface properly will result in an oil leak.



Measure the piston pin bore.

Piston Pin Bore Diameter		
mm		in
40.006	MIN	1.5750
40.012	MAX	1.5753

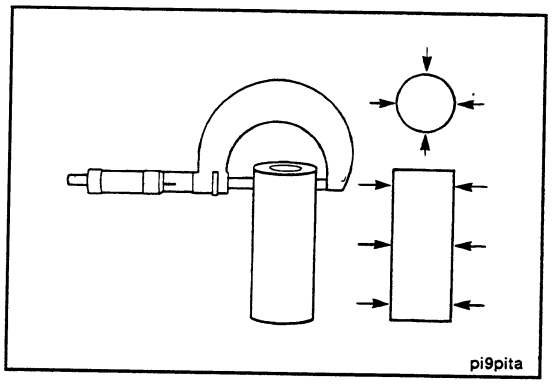


Piston Pin - Inspection

Inspect the piston pin for nicks, gouges, and excessive wear.

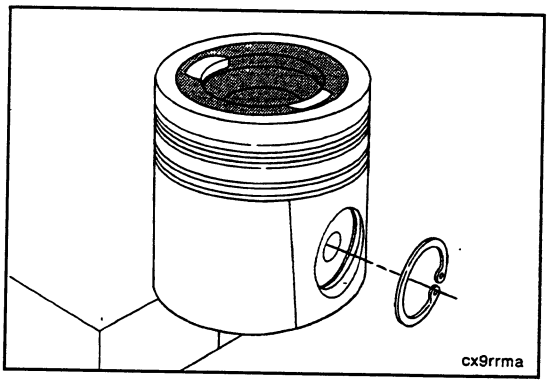
Measure the pin diameter.

Piston Pin Diameter		
mm		in
39.990	MIN	1.5744
40.003	MAX	1.5749



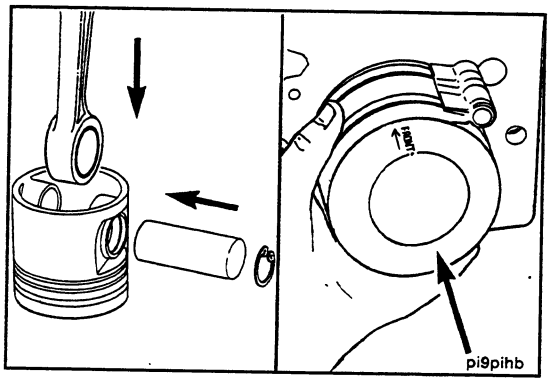
Assemble (001-043-025)

Assemble piston and connecting rod assembly. Refer to Procedure 001-054.

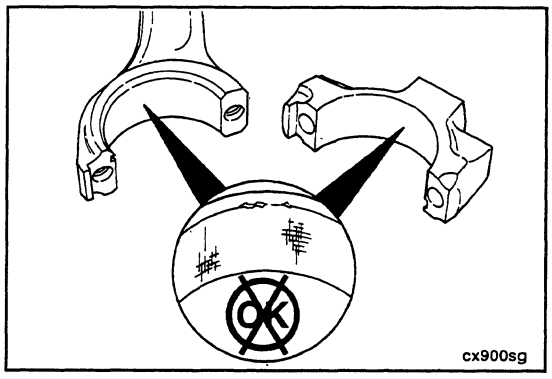


Install (001-043-026)

The piston and connecting rod **must** be installed as an assembly. Refer to Procedure 001-054.

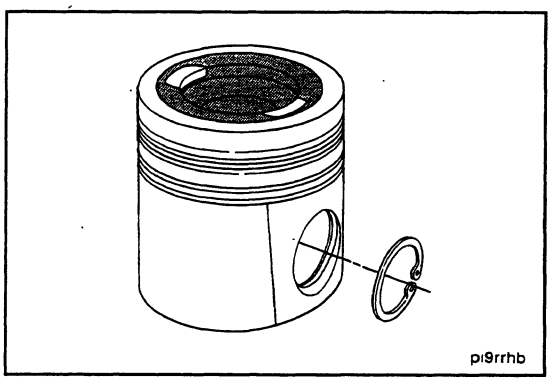


Inspect the connecting rod. Refer to Procedure 001-014.

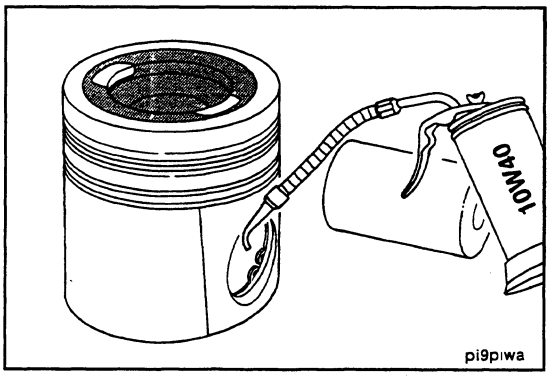


Assemble (001-054-025)

Install the retaining ring in the pin groove on the frontside of the piston.



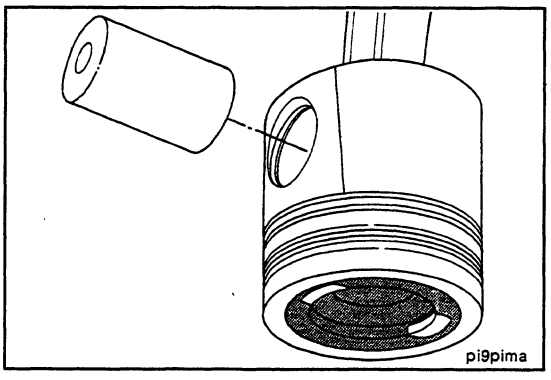
Lubricate the pin and pin bores with clean 15W-40 engine oil.



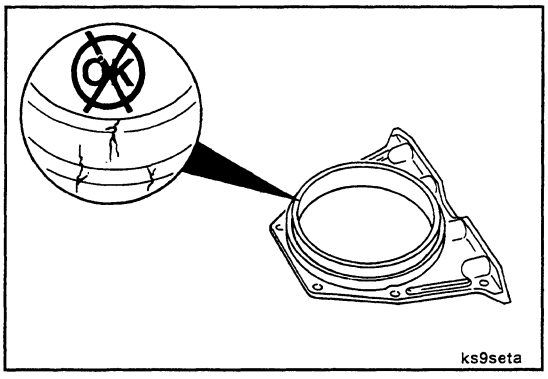
NOTE: The pistons do **not** require heating to install the piston pin. However, the pistons do need to be at room temperature or above.

Install the connecting rod.

Install the piston pin.



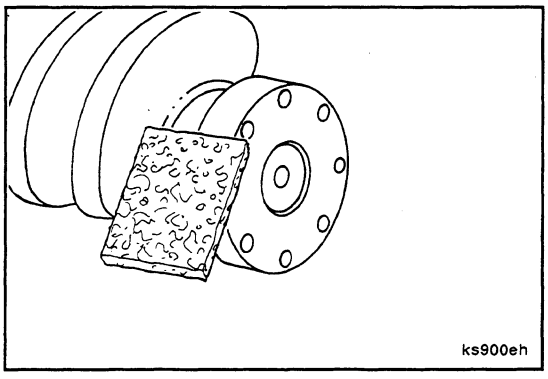
Inspect the rear cover for cracks or other damage.



Install (001-067-026)

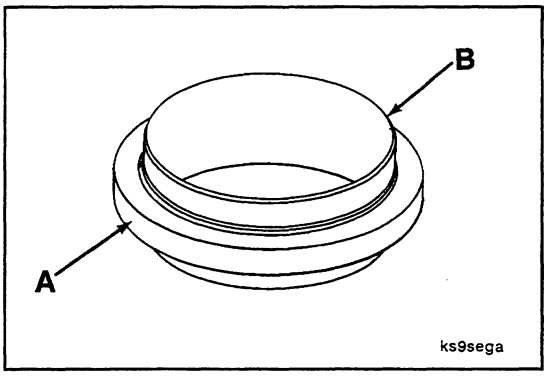
NOTE: Do **not** use any kind of lubricant to install the seal. The oil seal **must** be installed with the lip of the oil seal and the crankshaft clean and dry to secure a proper oil seal.

Clean the lip of the oil seal of any existing lubricant.



NOTE: The combination crankshaft oil seal (A) and wear sleeve (B) replacement kit for service usage is installed on the crankshaft as an assembly.

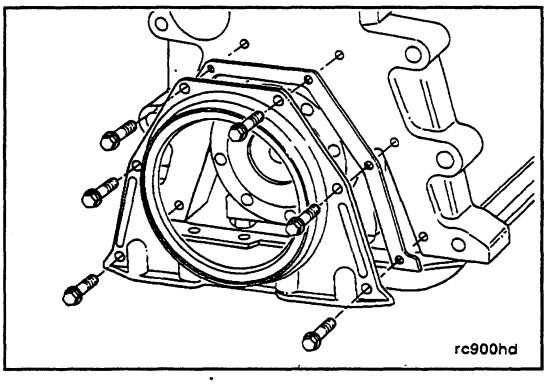
NOTE: The crankshaft rear oil seal should **not** be removed from the crankshaft rear seal wear sleeve.



Install the rear cover and gasket.

Install the rear cover capscrews. Do **not** tighten.

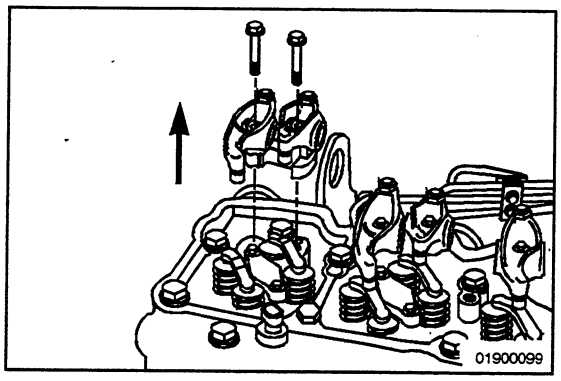
NOTE: The seal installation is being used to align the rear cover properly. Do **not** push or force the cover in any direction to prevent irregular seal lip position after seal installation.



Crosshead (002-001)

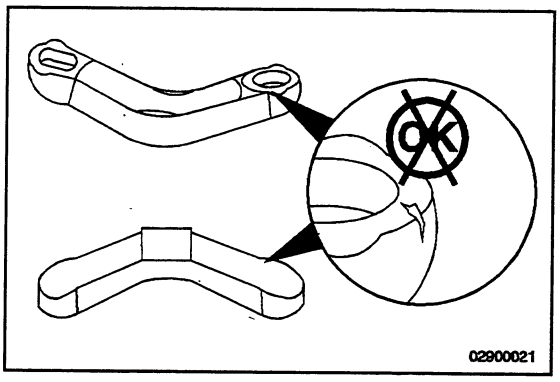
Remove (002-001-002)

Remove rocker lever assembly. Refer to Procedure 003-008.

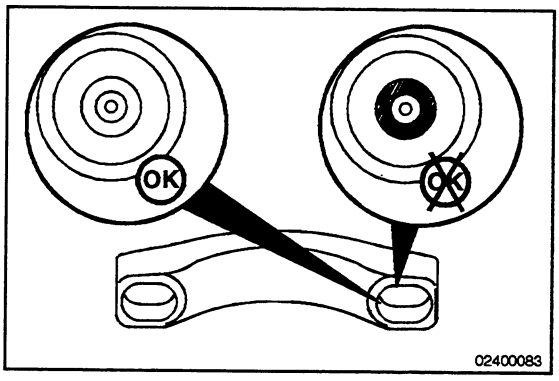


Inspect for Reuse (002-001-007)

Check crossheads for cracks and/or excessive wear on rocker lever and valve tip mating surfaces.



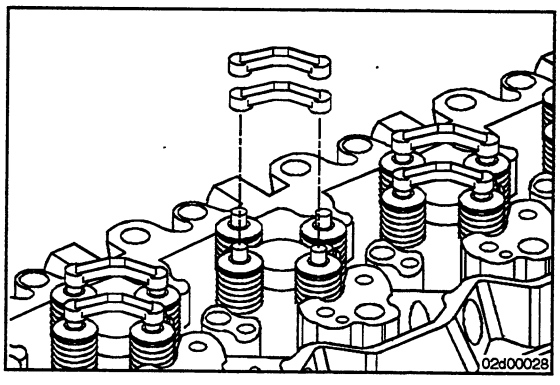
Check the contact pad for cracks and other damage.



Install (002-001-026)

Install the crossheads on the valve stems.

Install rocker lever assembly. Refer to Procedure 003-008.

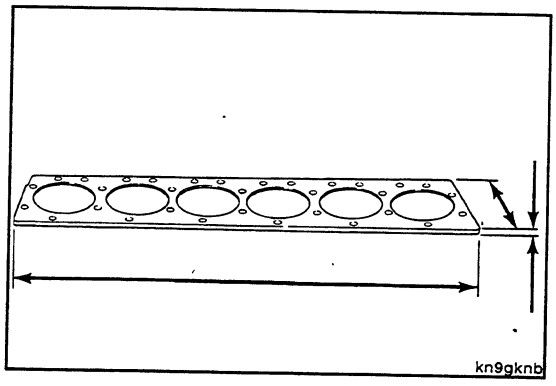


NOTE: A cylinder head test fixture can be fabricated from a flat piece of steel or aluminum. Refer to the following table for test fixture dimensions.

Test Fixture Dimensions		
16 mm	Thickness	0.625 in
749 mm	Length	29.5 in
193 mm	Width	7.6 in

NOTE: Use the cylinder head gasket as a pattern for drilling the capscrew holes.

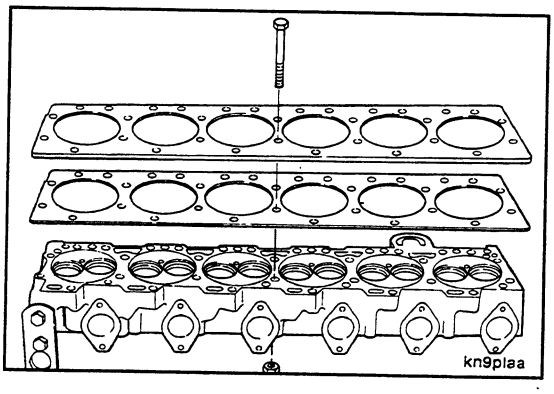
NOTE: An additional piece of metal will need to be machined to cover the thermostat housing.



Install the cylinder head water test fixture.

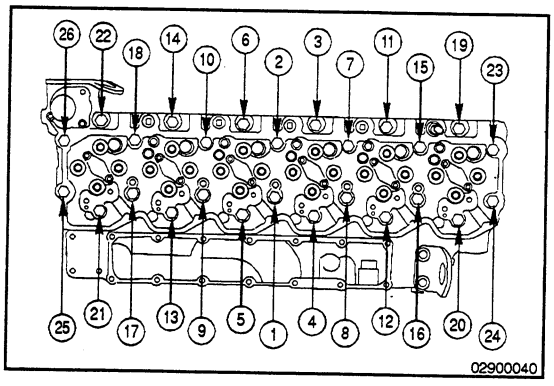
- Install a new head gasket.
- Install the test plate.
- Install the following:
- 26 - 180 mm-long B Series head capscrews; Cummins Part No. 3920781
- 26 - M12 x 1.75 hex flange nuts; Cummins Part No. 3900781
- 52 - 12 mm washers; Cummins Part No. 3900269.

NOTE: Cummins recommends a washer be placed between each capscrew and the head, and between each nut and test plate. This will prevent mutilation on the surface of the cylinder head.



Use the illustrated sequence to tighten the nuts.

Torque Value: 80 N•m [59 ft-lb]



⚠ WARNING ⚠

This component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift this component.

Connect a regulated air supply hose to the test fixture plate.

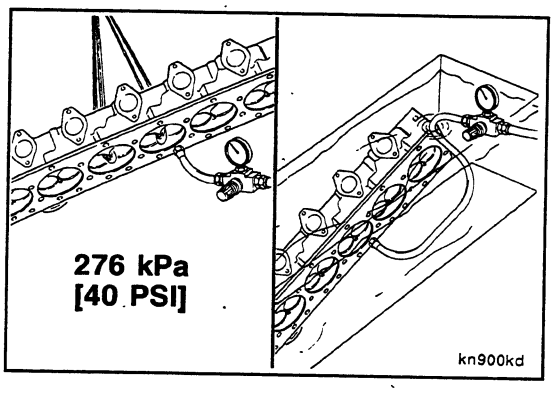
Apply air pressure.

Air Pressure 276 kPa [40 psi]

Use a nylon lifting strap and a hoist to place the cylinder head in a tank of heated water.

Temperature 60 °C [140 °F]

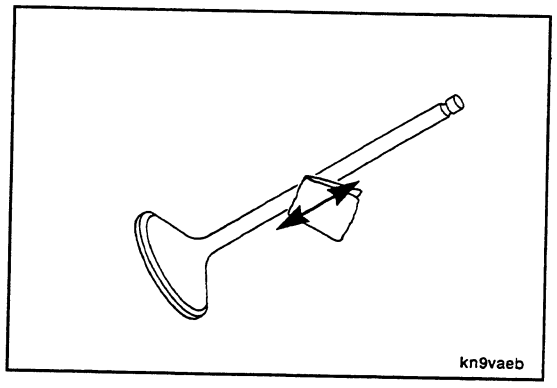
NOTE: The cylinder head **must** be completely submerged in the water.



⚠ WARNING ⚠

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

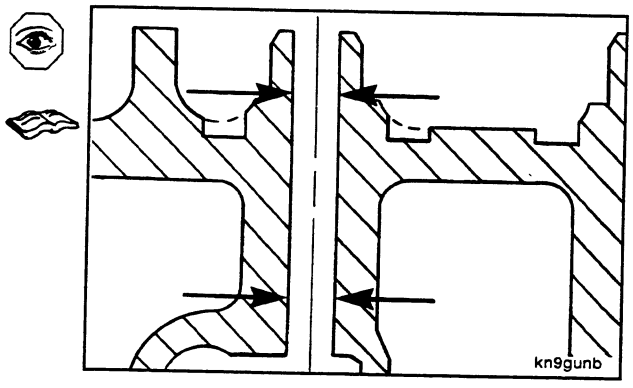
Polish the valve stems with a Scotch-Brite pad, or equivalent, and solvent.



Inspect for Reuse (002-020-007)

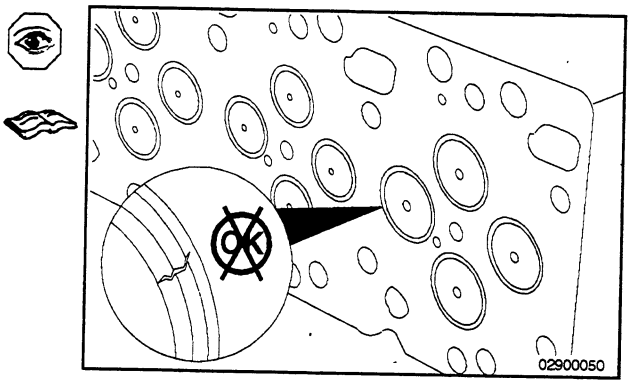
Valve Guide Inspection

Inspect the valve guides. Refer to Procedure 002-017.

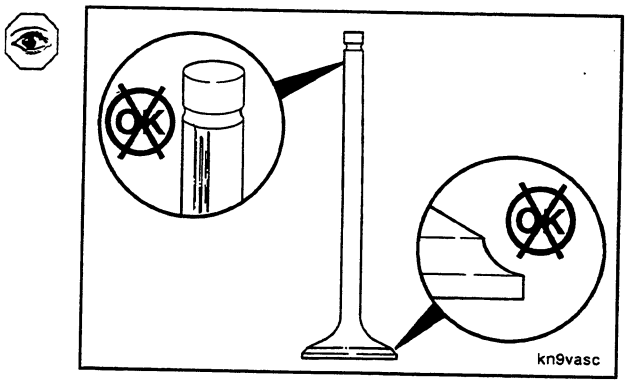


Valve Seat Inspection

Inspect the valve seats. Refer to Procedure 002-017.



Inspect for abnormal wear on the heads and stems.

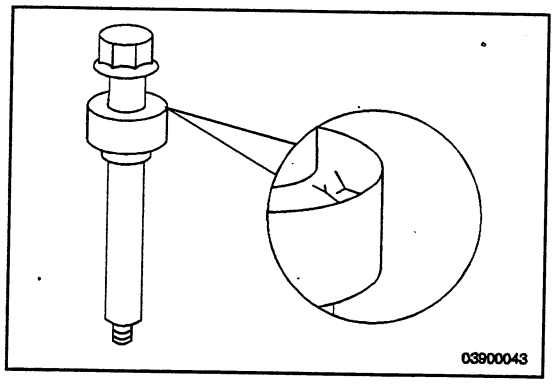


Section 3 - Rocker Levers - Group 03

Section Contents

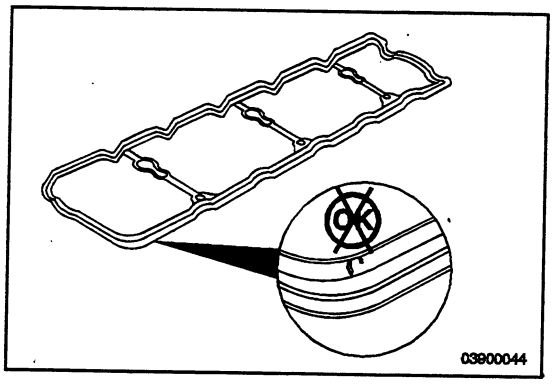
Inspect for Reuse (003-011-007)

Check the isolators for cracks, tears, or brittleness.

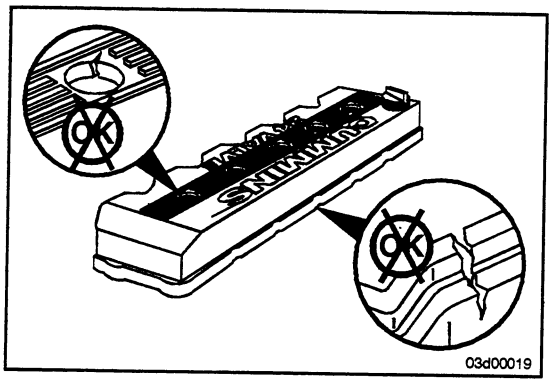


Check the gasket for cracks in the silicone covering.

Replace the gasket if cracks are present.



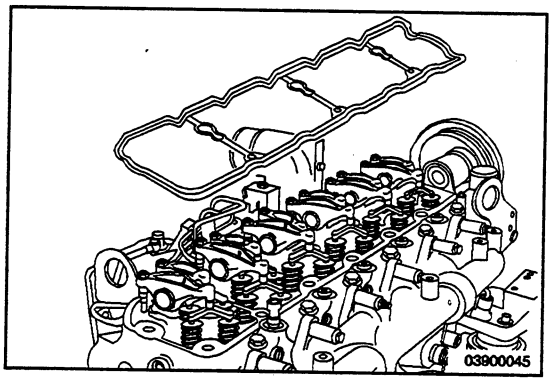
Inspect the rocker lever cover for cracks or other damage.



Install (003-011-026)

Place the rocker lever cover gasket on the cylinder head.

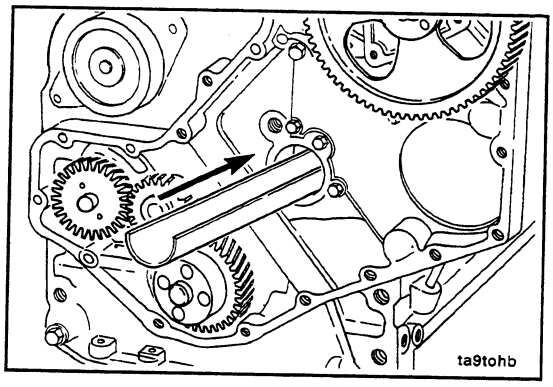
NOTE: Make sure the gasket is properly aligned around the cylinder head capscrews.



Tappet Replacement Kit, Part No. 3822513

Insert the trough from the tappet replacement kit, Part No. 3822513, to the full length of the cam bore.

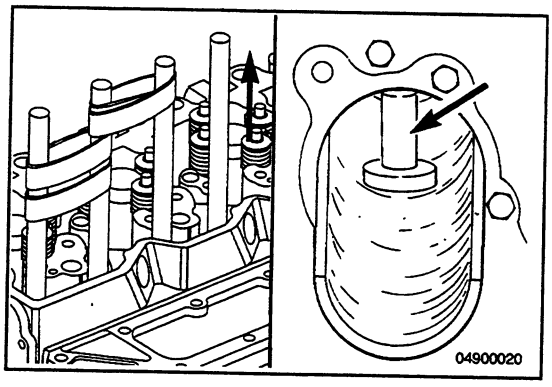
NOTE: Make sure the trough is positioned so that it will catch the tappet when the wooden dowel is removed.



Only remove one tappet at a time.

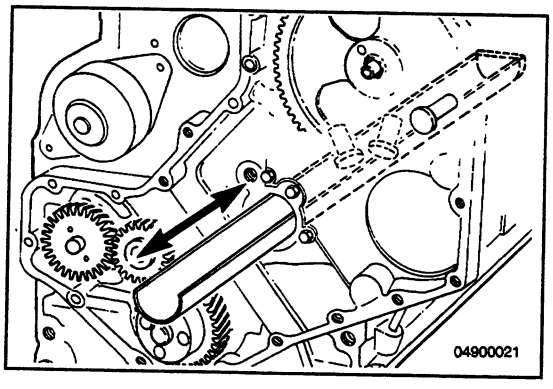
Remove the rubber band from the two companion tappets.

Secure the tappet that is **not** to be removed with the rubber band.

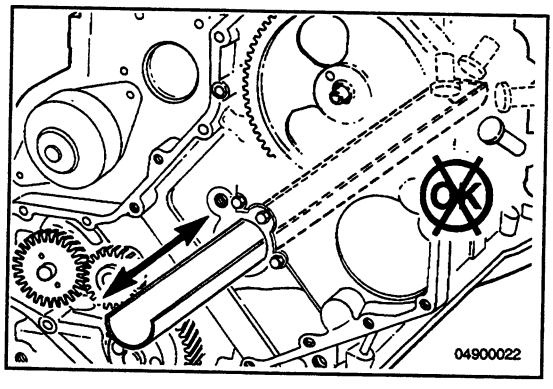


NOTE: When the tappet is dropped into the trough, most of the time it will fall over. However, if it does **not**, gently shake the trough just enough to allow the tappet to fall over before removing.

Pull the wooden dowel from the tappet bore allowing the tappet to fall into the plastic trough.



NOTE: When removing the No. 6 cylinder tappets, take special care **not** to knock or shake the tappets over the end of the trough.

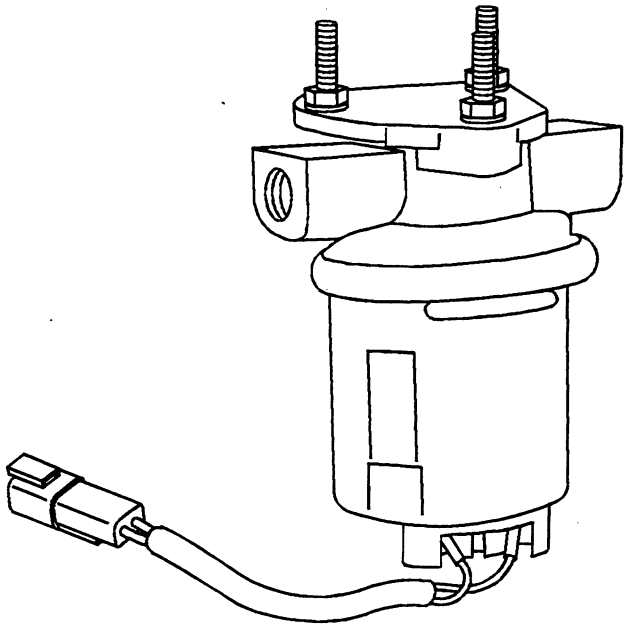


The ISB engine is equipped with an electric-powered lift pump. Fuel flow begins as the fuel lift pump pulls fuel from the supply tank. This electric lift pump supplies low-pressure fuel (10 to 12 psi) to the filter head, through the filter, and then to the electronic distributor injection pump.

The electronic distributor pump builds the high injection pressures required for combustion and routes the fuel through individual high-pressure fuel lines to each injector.

When the high-pressure fuel reaches the injector, the pressure lifts the needle valve against the spring tension to let the fuel enter the combustion chamber.

Any leakage past the needle valve enters the fuel drain manifold in the cylinder head. The fuel in the manifold exits at the rear of the cylinder head and is routed to the fuel tank. The fuel that is returned from the fuel injection pump is also routed back to the fuel tank.



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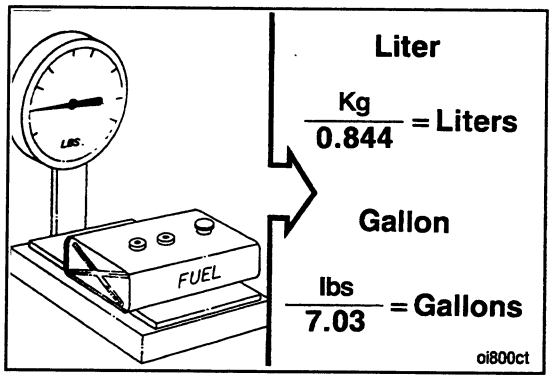
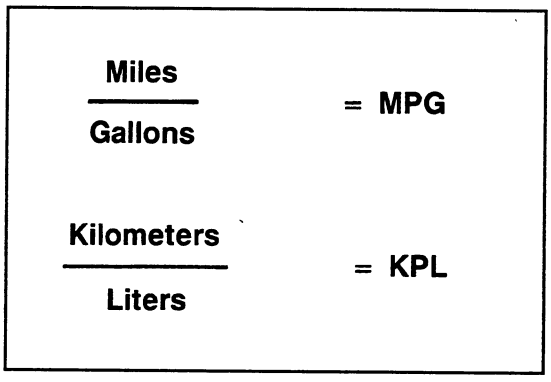
After traveling the route, remove the tanks, and weigh the remaining fuel. Compute the fuel used in liters [gallons] as required.

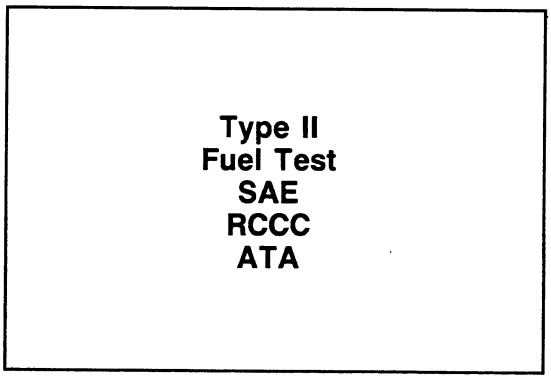


Compute the kilometers per liter or miles per gallon.



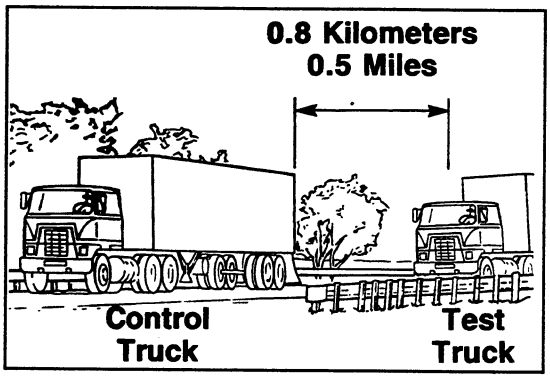
In addition to the measurement of the fuel used, the following factors provide points for running a test similar to the recognized Type II Society of Automotive Engineers Fuel Test.

These procedures are helpful in determining differences in fuel consumption between two vehicles under the same environmental, road, and test conditions.



Perform the test with the test vehicle and a control vehicle. The control vehicle compensates for changes in traffic conditions.

The vehicles **must** stay close together to experience the same varying traffic and weather conditions, but **not** so close as to affect each other's driving or headwind.



17 mm

Install the low-pressure fuel lines. Refer to Procedure 006-024.

17 mm

Install the fuel Inlet. Refer to Procedure 006-024.

17 mm

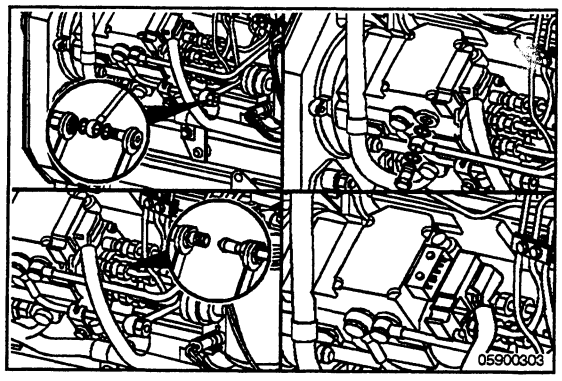
Install the fuel return lines. Refer to Procedure 006-013.

19 mm

Install the high-pressure line at the fuel pump. Refer to Procedure 006-051.

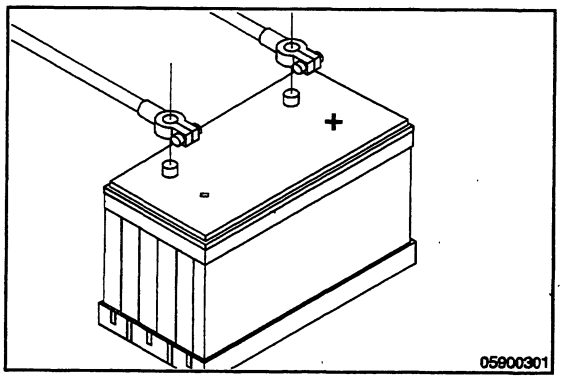
19 mm

Install a high-pressure line at the cylinder head. Refer to Procedure 006-051.

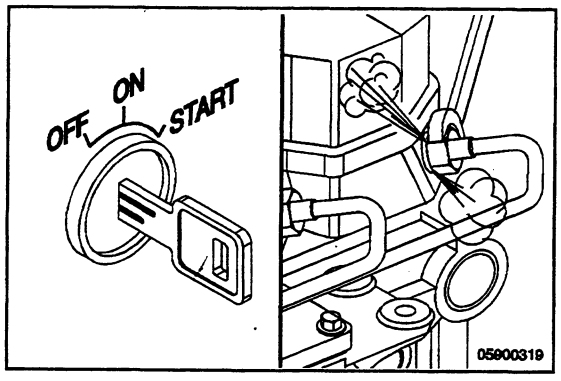


Connect the 9-pin connector to the VP44 fuel pump.

Connect the battery cables, negative (-) cable last.

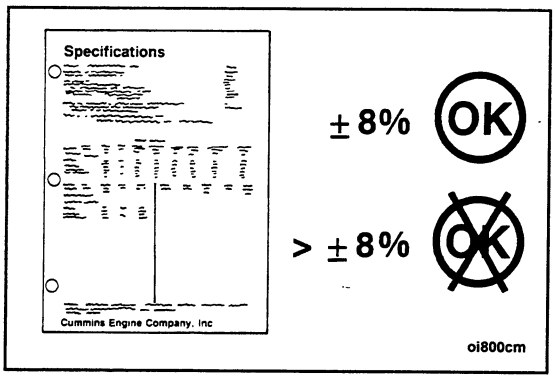


Bleed all air from the fuel system, if needed. Refer to Procedure 006-003.



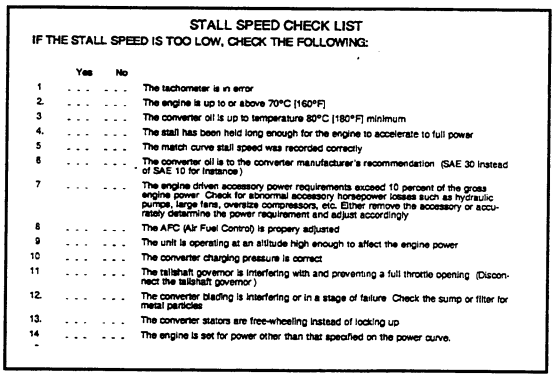
Check the speed (rpm) against the specifications for the equipment, converter, or automatic transmission.

NOTE: The stall speed for the engine and converter/ transmission can vary ± 8 percent from the manufacturer's specifications.



If the stall speed is **not** within the specifications, refer to the Stall Speed Checklist at the end of this section.

Check the equipment manufacturer's troubleshooting procedures for other reasons for stall speed problems.



STALL SPEED CHECK LIST

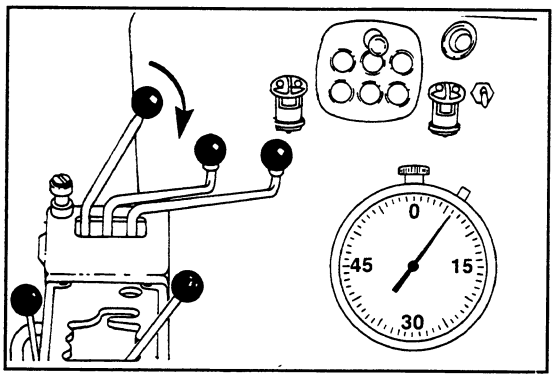
IF THE STALL SPEED IS TOO LOW, CHECK THE FOLLOWING:

	Yes	No	
1	. . .	. . .	The tachometer is in error
2.	. . .	. . .	The engine is up to or above 70°C [160°F]
3	. . .	. . .	The converter oil is up to temperature 80°C [180°F] minimum
4.	. . .	. . .	The stall has been held long enough for the engine to accelerate to full power
5	. . .	. . .	The match curve stall speed was recorded correctly
6	. . .	. . .	The converter oil is to the converter manufacturer's recommendation (SAE 30 instead of SAE 10 for instance)
7	. . .	. . .	The engine driven accessory power requirements exceed 10 percent of the gross engine power. Check for abnormal accessory horsepower losses such as hydraulic pumps, large fans, oversize compressors, etc. Either remove the accessory or accurately determine the power requirement and adjust accordingly
8	. . .	. . .	The AFC (Air Fuel Control) is propery adjusted
9	. . .	. . .	The unit is operating at an altitude high enough to affect the engine power
10	. . .	. . .	The converter charging pressure is correct
11	. . .	. . .	The tailshaft governor is interfering with and preventing a full throttle opening (Disconnect the tailshaft governor)
12.	. . .	. . .	The converter blading is interfering or in a stage of failure. Check the sump or filter for metal particles
13.	. . .	. . .	The converter stators are free-wheeling instead of locking up
14	. . .	. . .	The engine is set for power other than that specified on the power curve.

Time Speed Check (005-054-047)

Perform the previous Stall Speed Check procedure through the "Bring the engine speed back to low idle" step; then:

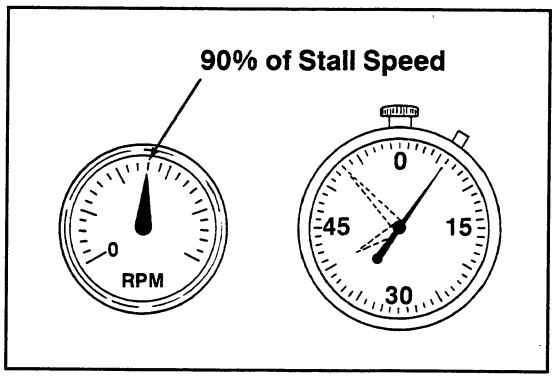
- Quickly move the throttle to the full-open position, and start the stopwatch at the same time.



- When the engine speed is 90 percent of the stall speed rpm, stop the stopwatch.

Example: Stall speed 2089 [2089 x 0.90 = 1880 rpm]

NOTE: The type of unit and the stall speed rpm can make the stall speed time a maximum of 10 seconds.

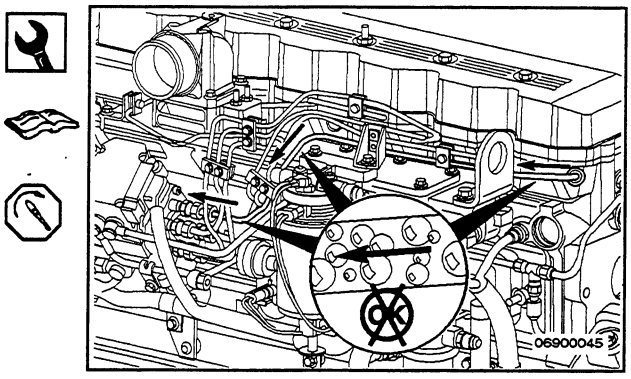


19 mm

A stuck-open injector can also blow combustion gas back into the pump and cause air to be present in the overflow. If the engine seems to be misfiring or running rough, break all the injector supply lines loose at the pump end. Crank the engine, and observe the lines. If combustion gas seems to be blowing back through the line, the injector is stuck open. Remove the injector. Take the vehicle to a Authorized Cummins Dealer Location for testing.

Torque Value: 24 N•m [18 ft-lb]

NOTE: Use two wrenches when loosening the lines at the fuel pump; one to hold the delivery valve and one to loosen the line.



Measure (006-003-010)

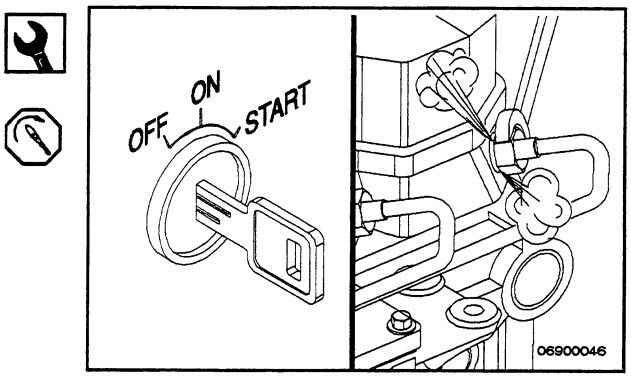
19 mm

⚠ CAUTION ⚠

The pressure of the fuel in the line is sufficient to penetrate the skin and cause serious bodily harm.

To check for air in the high-pressure lines, loosen the fittings at the head. Crank the engine to allow entrapped air to bleed from the line. Tighten the fittings.

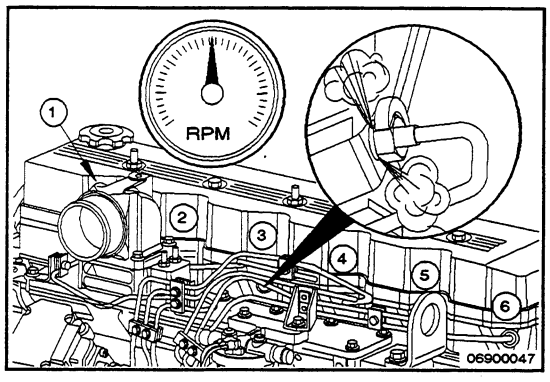
Torque Value: 38 N•m [28 ft-lb]



⚠ CAUTION ⚠

Do not bleed a hot engine as this can cause fuel to spill onto a hot exhaust manifold creating a danger of fire.

Operate the engine, and vent one line at a time until the engine runs smoothly.



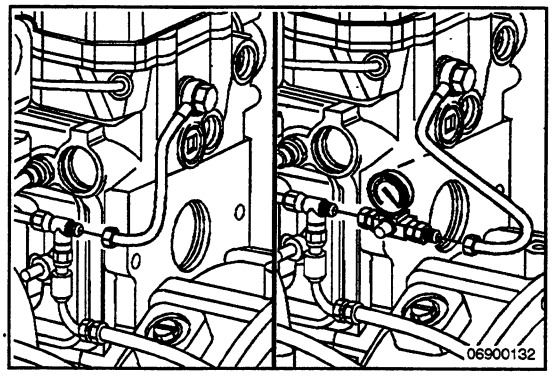
Fuel Drain Line Restriction (006-012)

Measure (006-012-010)

Remove the fuel drain line from the fitting at the rear of the head.

Install the 0- to 30-psi pressure gauge.

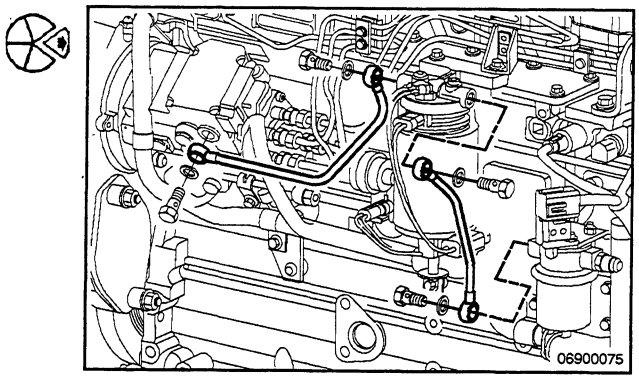
NOTE: The disconnected return line tee (return from the pump) needs to be capped.



Remove (006-024-002)

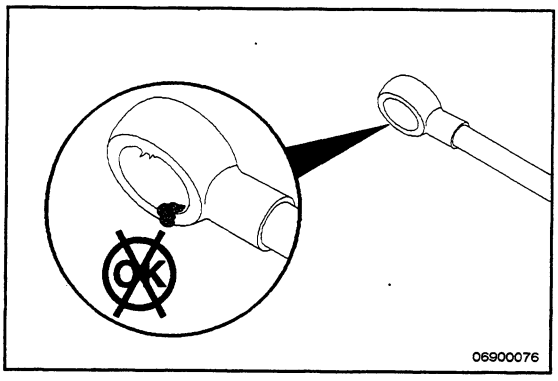
Remove supply lines, banjo capscrews, and sealing washers.

Discard sealing washers.



Inspect for Reuse (006-024-007)

Inspect for burrs or debris around the banjo fittings that can cause a leak.

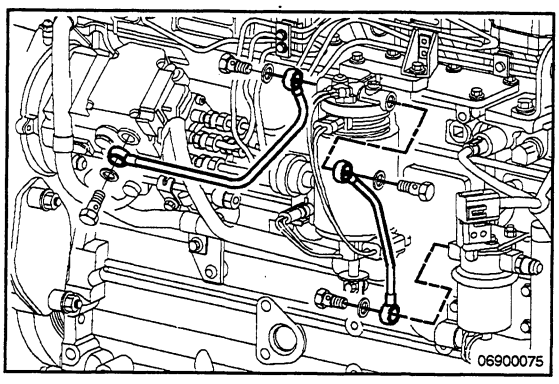


Install (006-024-026)

Install new sealing washers.

Install fuel supply lines and banjo capscrews.

Torque Value: 24 N•m [18 ft-lb]



Injector (006-026)

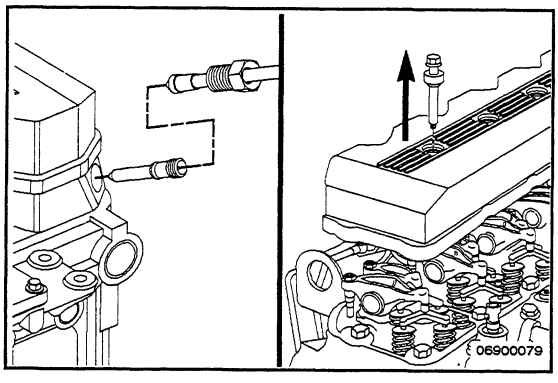
Remove (006-026-002)

Remove the rocker lever cover. Refer to Procedure 003-011.

Remove the injector supply lines. Refer to Procedure 006-051.

Remove the fuel connector. Refer to Procedure 006-052.

NOTE: The fuel connector **must** be removed before removing the injector or damage to the connector will result.

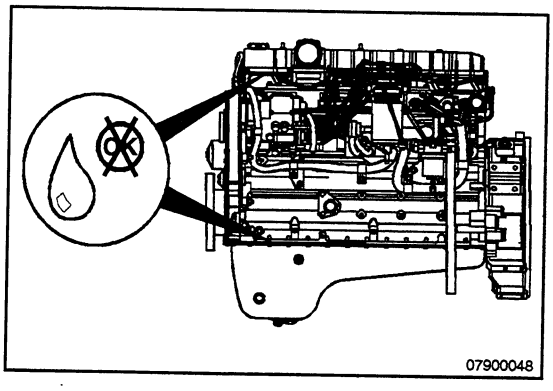


Section 7 - Lubricating Oil System - Group 07

Section Contents

Lubricating Oil Leaks

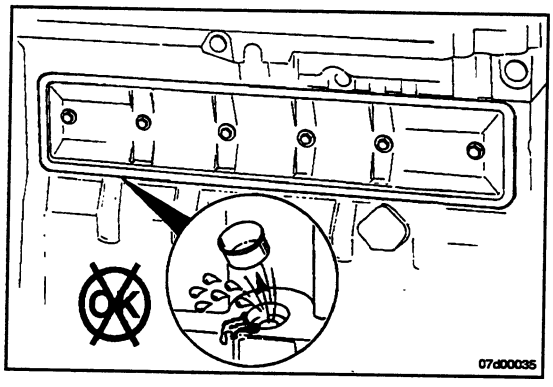
Various gaskets, seals, and plugs are used to contain the lubricating oil. Most leaks can be identified during routine inspections of the engine and vehicle.



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

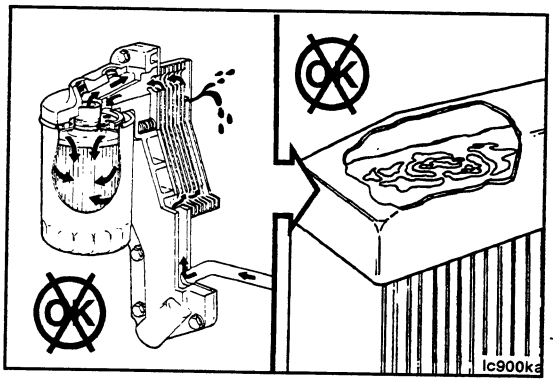
When checking for such a leak, be sure to check the expansion plug behind the tappet cover as well as those that can be obscured by chassis parts.

Oil blowing out the breather could be a sign of a blown expansion plug.



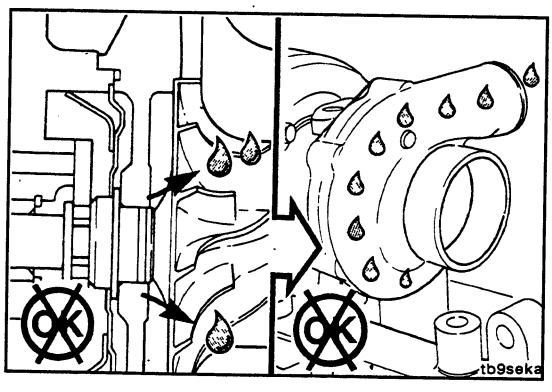
If the oil cooler element ruptures, the oil pressure will force oil into the coolant system.

Oil in the coolant should be visible when the radiator cap is removed. Refer to Procedure 007-003.



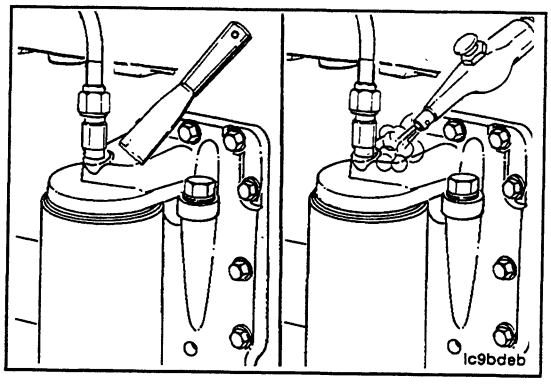
Worn or damaged seals in the turbocharger can also allow oil to leak into the air crossover tube and be burned in the engine.

The condition can be verified by removing the air crossover tube or charge air cooler tubing and looking for oil. Refer to Procedures 010-019 and 010-027.

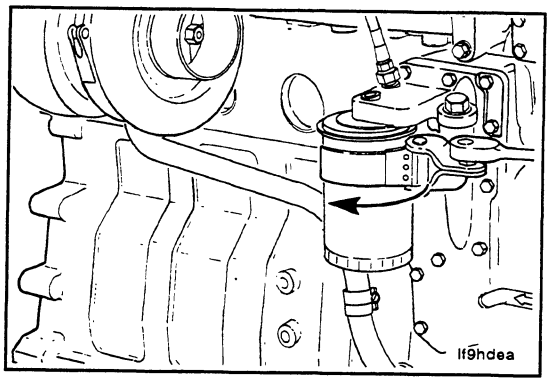


Remove (007-003-002)

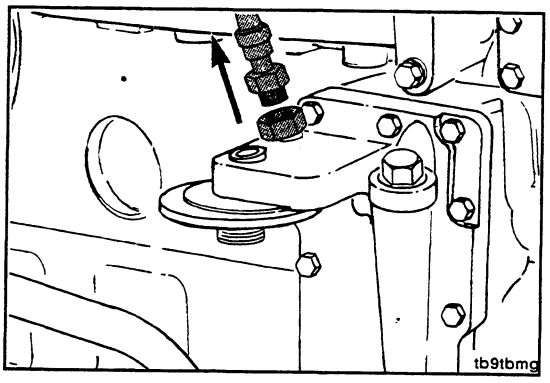
Clean around the lubricating oil cooler cover.



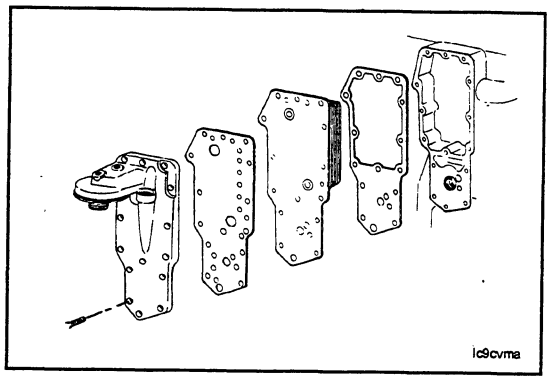
Remove the lubricating oil filter.



Disconnect the turbocharger supply line.

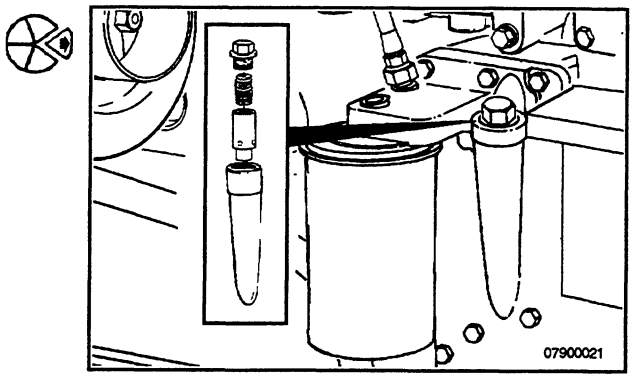


Remove the lubricating oil cooler cover, gaskets, and cooler element.



Remove the pressure regulator valve plug, spring, and plunger.

Service Tip: The plunger normally can be removed by inserting a finger into the plunger bore until snug and pulling up. If the plunger can **not** be removed in this manner, the plunger is probably stuck and will require removal of the housing.



Clean (007-029-006)

⚠ WARNING ⚠

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

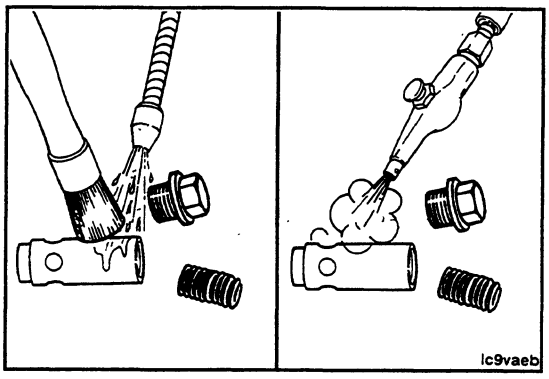
⚠ CAUTION ⚠

Compressed air used for cleaning/drying should not exceed 207 kPa [30 psi]. Use only with protective clothing and goggles.

Use solvent to clean the spring, plunger, plug, washer, and pressure regulator valve housing.

Dry the parts with compressed air.

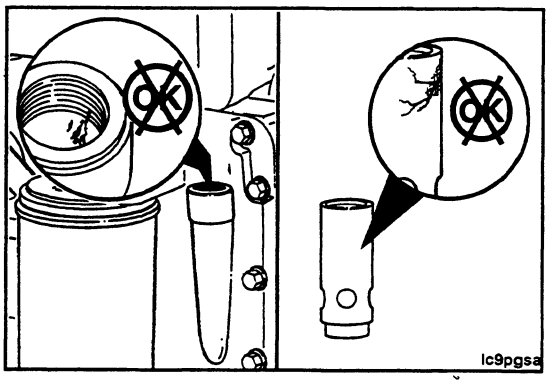
NOTE: If the plunger bore requires cleaning, remove the housing so as **not** to flush debris into the engine.



Inspect for Reuse (007-029-007)

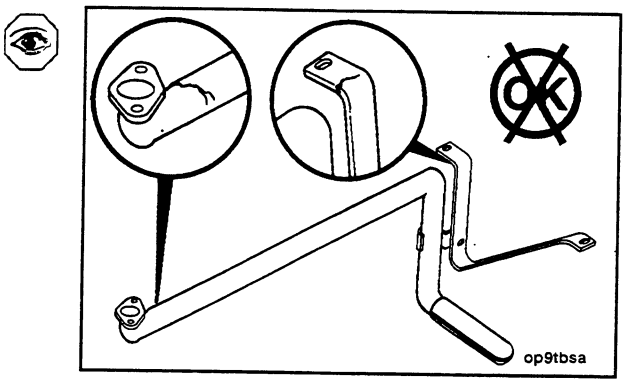
Inspect the plunger and plunger bore for nicks or scratches.

NOTE: Polished areas on the plunger and bore are acceptable.



Inspect for Reuse (007-035-007)

Inspect the suction tube for cracks.

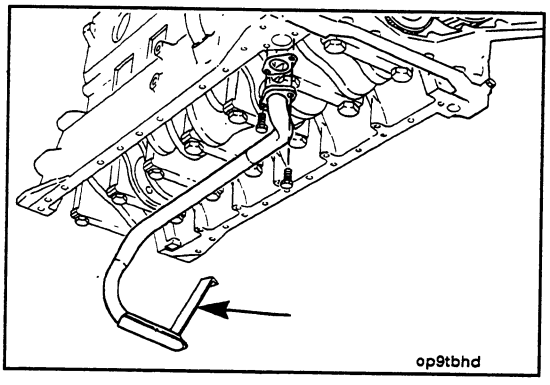


Install (007-035-026)

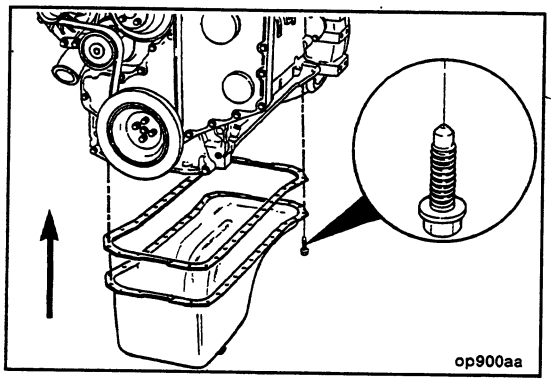
Install the lubricating oil suction tube gasket and suction tube.

Install and tighten the suction tube mounting capscrews.

Torque Value: 24 N•m [18 ft-lb]



Install oil pan and gasket. Refer to Procedure 007-025.

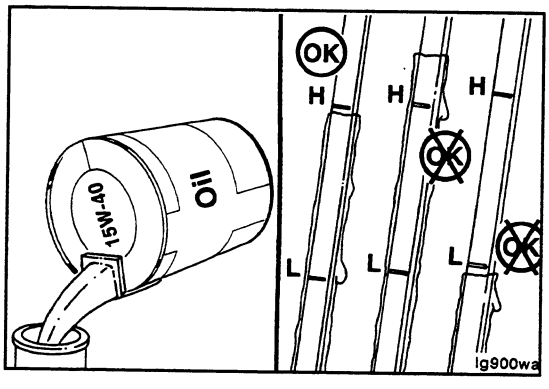


Fill (007-035-028)

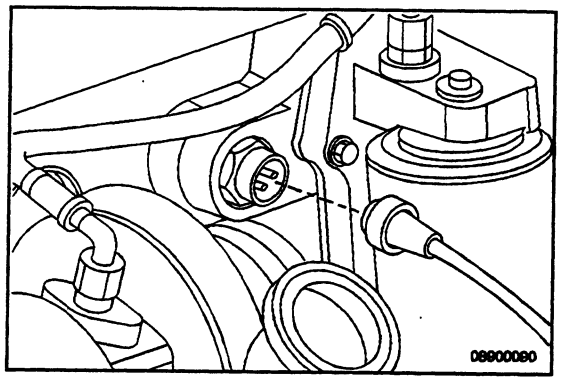
Fill the engine with 15W-40 lubricating oil. Refer to Procedure 007-025.

Operate the engine and check for leaks.

Stop the engine, and check the lubricating oil level with the dipstick.



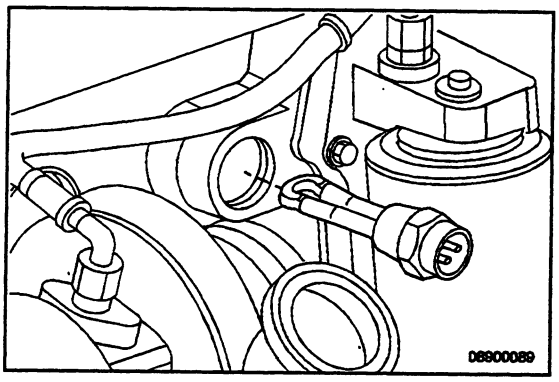
Disconnect the block heater electrical cord.



Remove (008-011-002)

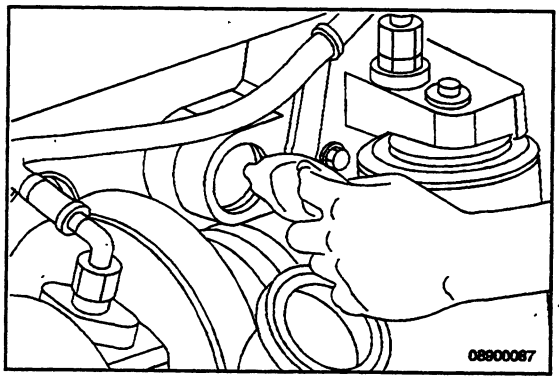
Loosen the block heater retaining nut.

Remove the block heater from the block.



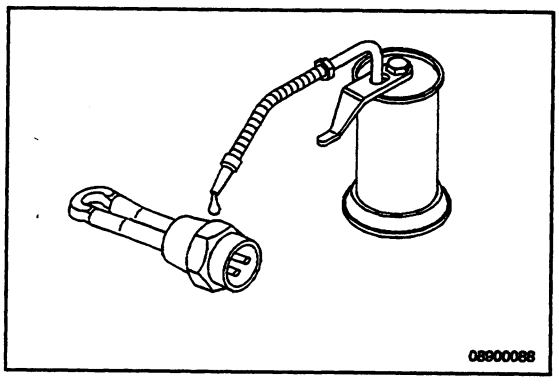
Clean (008-011-006)

Clean the heater top thoroughly with a clean rag. Make sure there are no burrs or sharp edges that might cut the o-ring.



Install (008-011-026)

Lubricate the new heater o-ring with clean 15W-40 engine oil.



Good-quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion.

Water Quality	
Calcium Magnesium (Hardness)	Maximum 170 ppm as ($CaCO_3$ + $MgCO_3$)
Chloride	40 ppm as(Cl)
Sulfur	100 ppm as (SO_4)

18200001

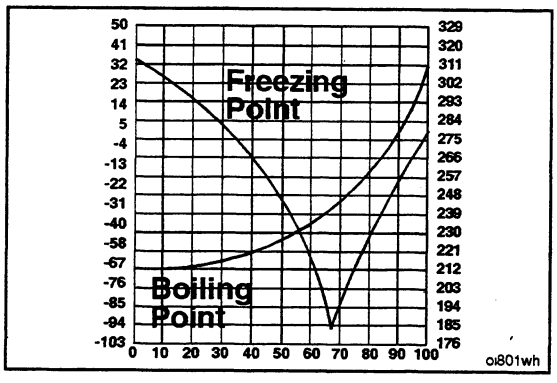
Cummins Engine Company, Inc. recommends using Fleetguard® Compleat. It is available in both glycol forms (ethelyne and propylene) and complies with TMC standards.

oi805vn

Fully formulated antifreeze **must** be mixed with good-quality water at a 50/50 ratio (40- to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-34°F] freezing point and a boiling point of 110°C [228°F], which is adequate for locations in North America. The actual lowest freezing point of ethelyne glycol antifreeze is at 68 percent.

⚠ CAUTION ⚠

Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silicate gel problem.

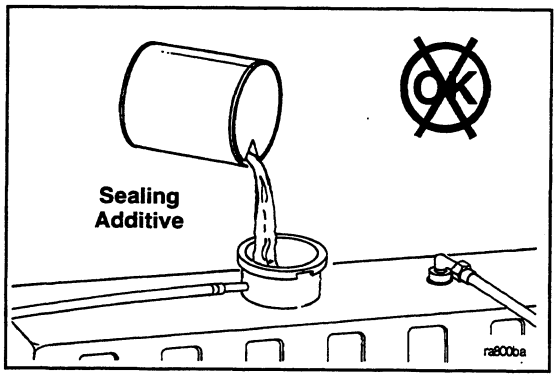


oi801wh

Cooling System Sealing Additives

Do **not** use sealing additives in the cooling systems. The use of sealing additives will:

- Build up in coolant low-flow areas
- Clog coolant filters
- Plug radiator and oil cooler.



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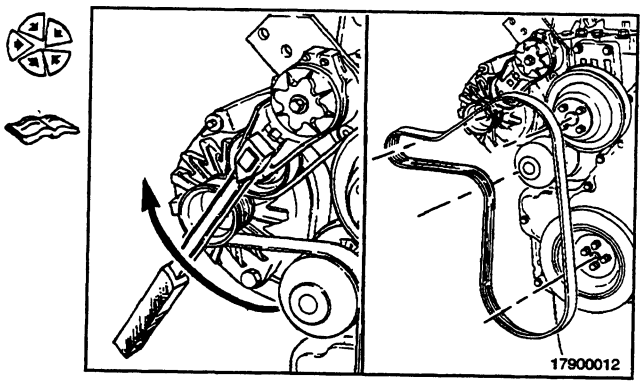
Install (008-039-026)

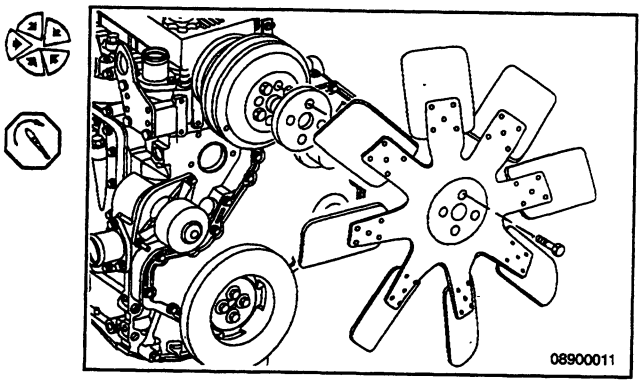
Install the cooling fan drive belt. Refer to Procedure 008-002.



Install the fan pulley.

Install the spacer, fan, and fan capscrews.

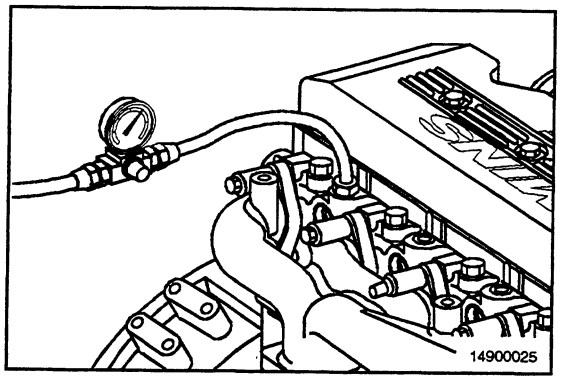
Torque Value: 24 N•m [18 ft-lb]



Measure the coolant pressure at a coolant tap on the exhaust side of the cylinder head.

Minimum Gauge Capacity: 415 kPa [60 psi]

Open Thermostat		
RPM	**Location on Engine**	**Pressure**
2000	Pump Out	98 kPa [14.2 psi]
2000	1/2-NPT Head Port	78 kPa [11.3 psi]
2000	3/4-NPT Head Port	83.4 kPa [12.1 psi]
2500	Pump Out	159.3 kPa [23.1 psi]
2500	1/2-NPT Head Port	123.4 kPa [17.9 psi]
2500	3/4-NPT Head Port	133.8 kPa [133.8 psi]

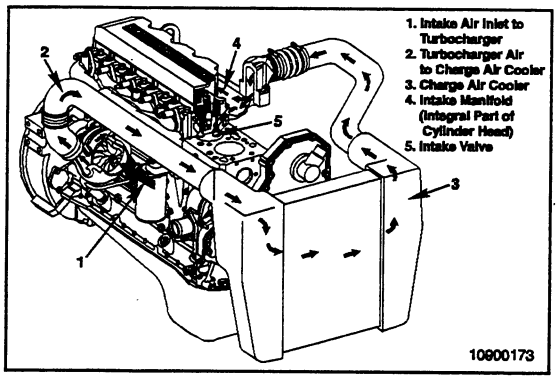


Air Intake System - General Information

General Information

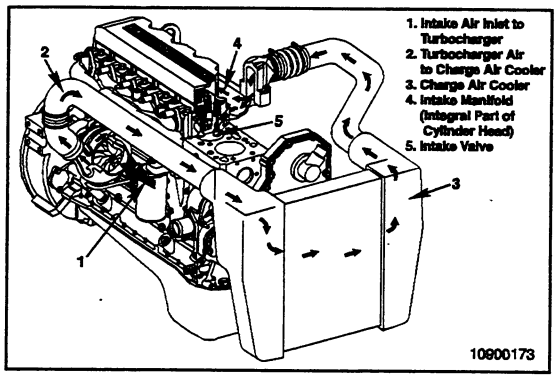
The combustion air system on the ISB engine consists of the following:

- Air cleaner
- Intake air piping
- Turbocharger
- Charge air piping
- Charge air cooler
- Exhaust manifold
- Intake air heater
- Exhaust gas piping.

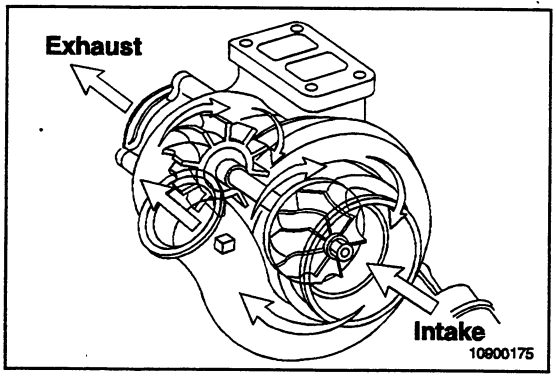


Air is drawn through the air cleaner into the compressor side of the turbocharger. It is then forced through the charge air cooler piping to the charge air cooler, the intake air heater (if applicable), and into the intake manifold. From the intake manifold, air is forced into the cylinders and used for combustion.

1. Intake air inlet to turbocharger
2. Turbocharger air to charge air cooler
3. Charge air cooler
4. Intake Manifold (integral part of cylinder head)
5. Intake valve.



The turbocharger uses exhaust gas energy to turn the turbine wheel. The turbine wheel drives the compressor impeller, which provides pressurized air to the engine for combustion. The additional air provided by the turbocharger allows more fuel to be injected to increase the power output from the engine.

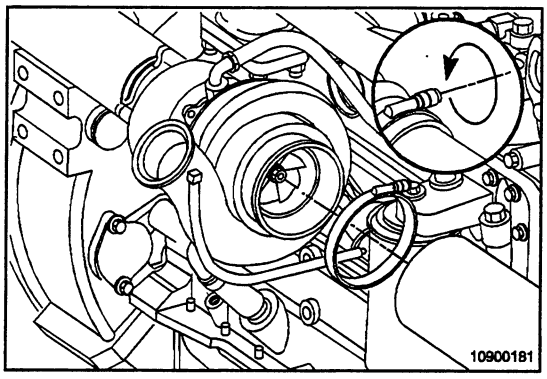


Install (010-022-026)

Install the air inlet connection.

Tighten air inlet clamps.

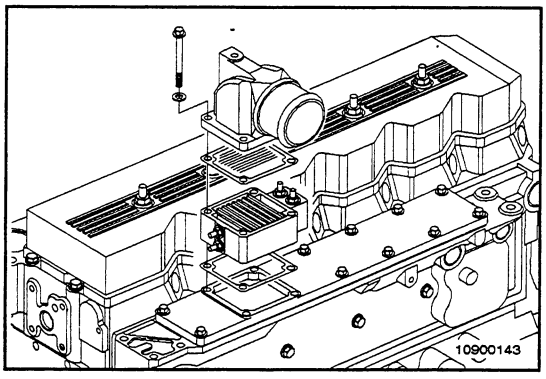
Run the engine and check for leaks.



Air Intake Manifold (010-023)

Preparatory (010-023-000)

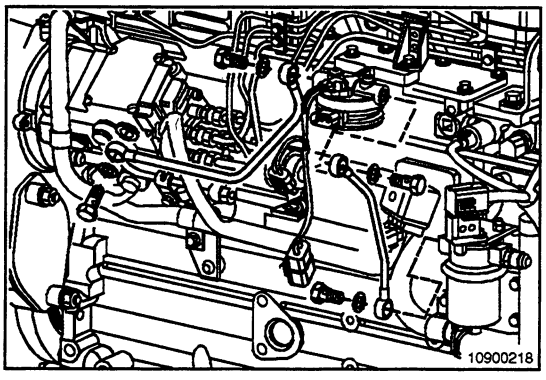
- Disconnect the cold starting aid, if used. Refer to Procedure 010-029.
- Remove the cooler air crossover tube, if used. Refer to Procedure 010-019.
- Disconnect the charge air cooler hose, if used. Refer to Procedure 010-027.
- Remove the air intake connection and grid heater, if equipped. Refer to Procedures 010-022 and 010-029.



Remove (010-023-002)

Remove the high- and low-pressure fuel lines. Refer to Procedures 006-051 and 006-024.

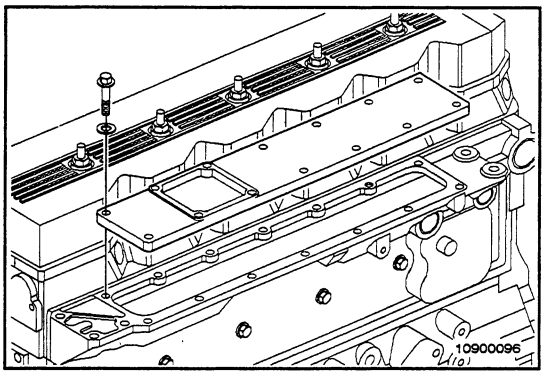
Remove the fuel filter mount. Refer to Procedure 006-018.



Remove the mounting capscrews and the intake cover.

Tape off the intake manifold opening to prevent debris from entering the intake system.

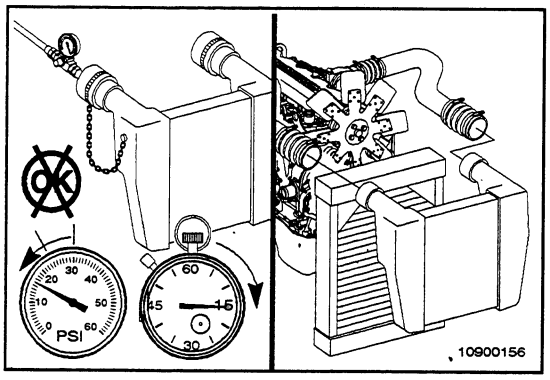
NOTE: Be sure **not** to tape over all manifold edges so that the surface can be cleaned.



If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, the charge air cooler **must** be replaced.

Refer to the equipment manufacturer's service manual for replacement instructions.

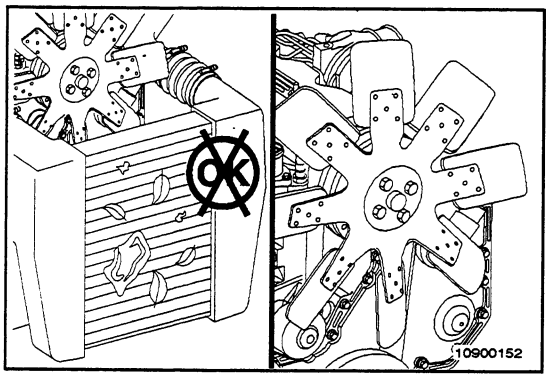
NOTE: Charge air coolers are **not** designed to be 100-percent leak free. If the pressure drop is less than 48 kPa [7 psi] in 15 seconds, then the charge air cooler does **not** need to be replaced.



Temperature Differential Test (010-027-049)

Inspect the charge air cooler (CAC) fins for obstructions to airflow. Remove obstructions such as a winterfront or debris. Manually lock shutters in the open position, if equipped.

Lock the fan drive in the ON mode to prevent erratic test results. This can be done by installing a jumper wire across the temperature switch.

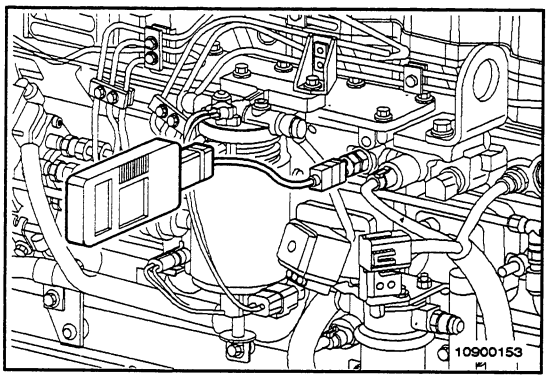


Fluke Digital Thermometer, Part No. 3822666

Install fluke digital thermometer, Part No. 3822666, and thermocouple wire kit, Part No. 3822988, into the intake manifold at the 1/8-inch NPT tap near the air horn connection with the intake manifold.

Another alternative would be to use the monitor mode on the INSITE™ service tool.

Install another thermocouple at the air cleaner inlet to measure ambient air temperature.



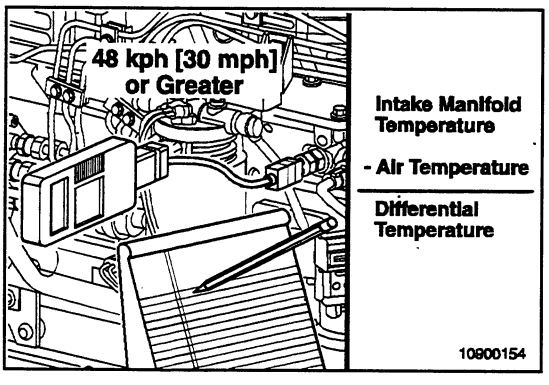
Perform a road test with the engine at peak power and a vehicle speed of 48 kph [30 mph] or greater.

Record the intake manifold temperature and the ambient air temperature.

Calculate the differential temperature:

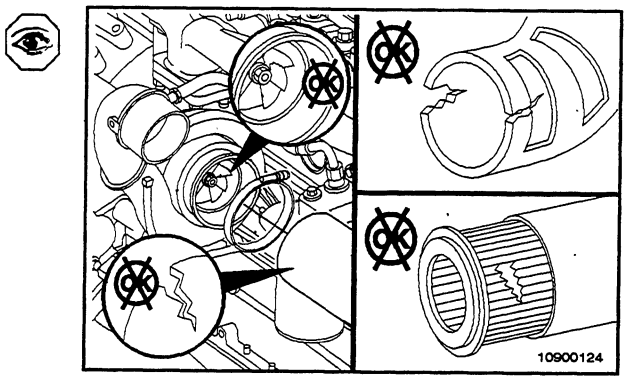
Intake manifold temperature - ambient air temperature = differential temperature.

Maximum differential temperature = 28°C [50°F].



If the compressor impeller is damaged, inspect the intake piping and filter element for damage.

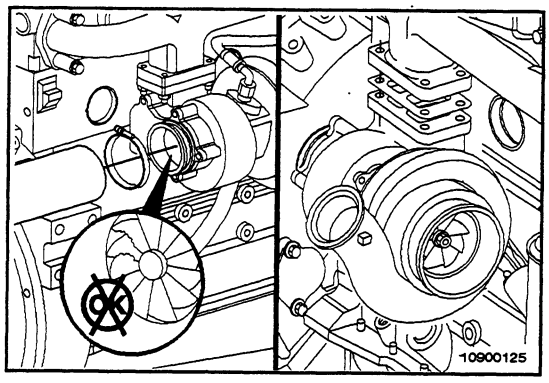
Repair any damage before operating the engine.



Remove the exhaust pipe from the turbocharger.

Inspect the turbine wheel for damage.

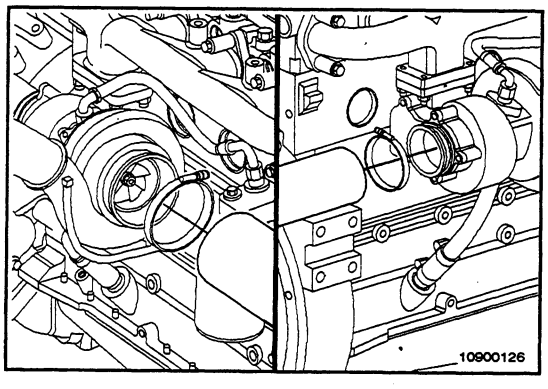
Replace the turbocharger if damage is found. Refer to Procedure 010-033.



Install the intake pipe, and tighten the clamp.

Install the exhaust pipe, and tighten the clamp.

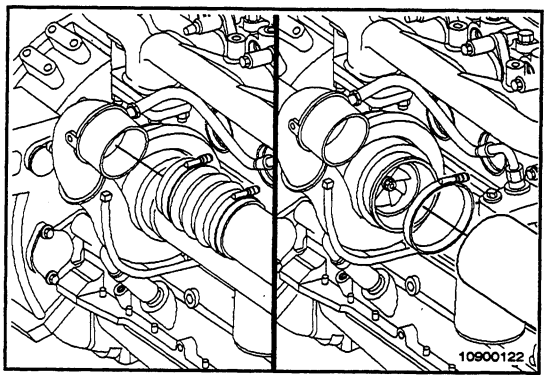
Torque Value: 8 N•m [71 in-lb]



Turbocharger Compressor Seal Leaks (010-040)

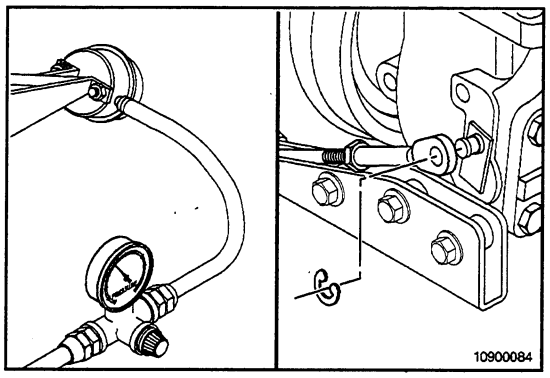
Leak Test (010-040-014)

Remove the air intake and charge air cooler (CAC) piping from the turbocharger.



Slowly apply regulated shop air to the boost capsule until the control rod is activated long enough to slip over the turbo wastegate pin.

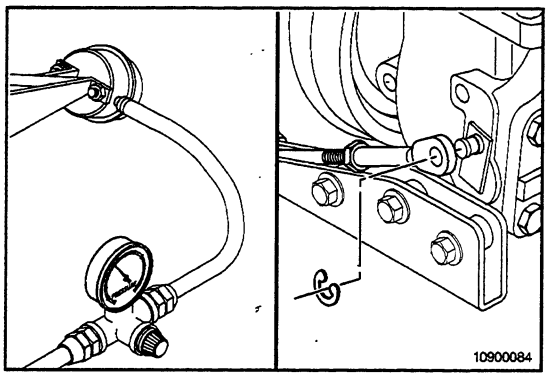
Install the control rod retaining clip.



⚠ CAUTION ⚠

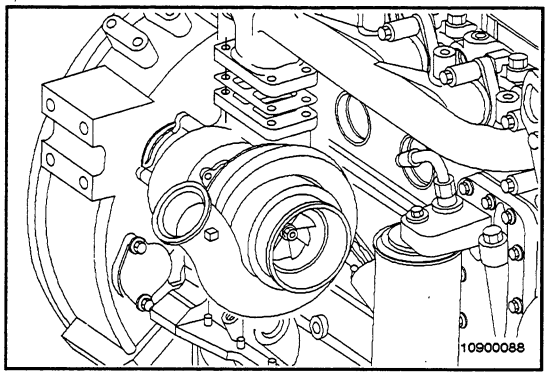
Operating an engine with an incorrectly calibrated wastegate can result in turbo overspeed and damage to the engine.

All new wastegate actuators **must** be calibrated before operating the engine.



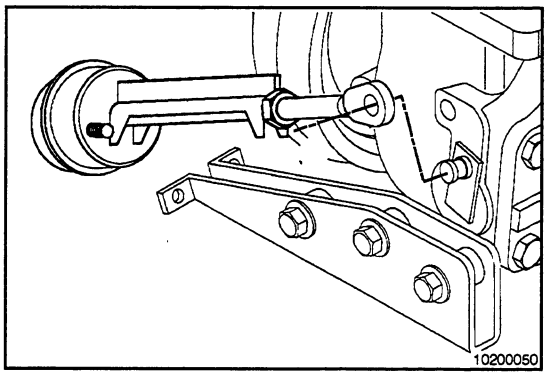
Precalibrated Wastegate Actuator

NOTE: In most applications, the turbocharger **must** be removed in order to remove the wastegate actuator. Refer to Procedure 010-033.

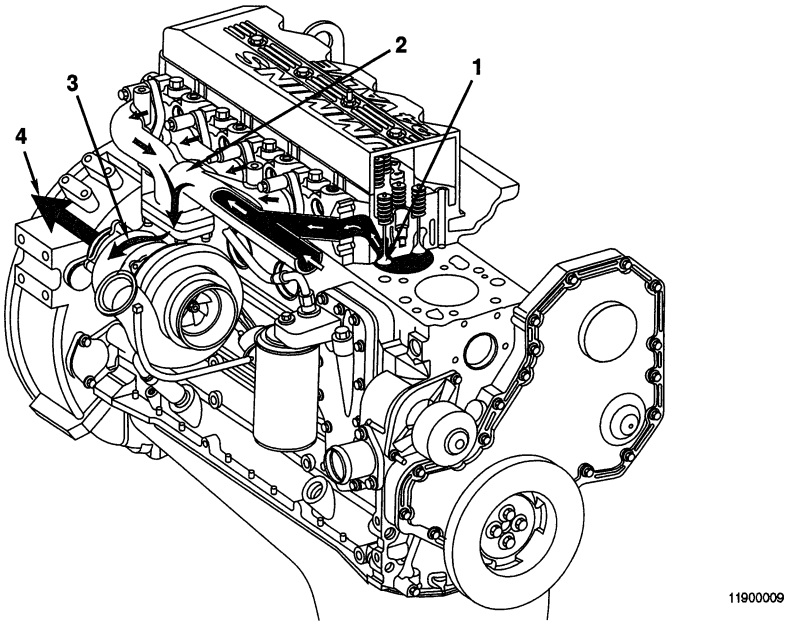


Fit the end-link over the turbocharger wastegate lever pin. With the spine of the spacer visible and the turbocharger wastegate lever pushed toward the rod, lay the actuator alongside the mounting bracket.

NOTE: Do **not** fit the two studs into the mounting holes at this time.



Flow Diagram, Exhaust System

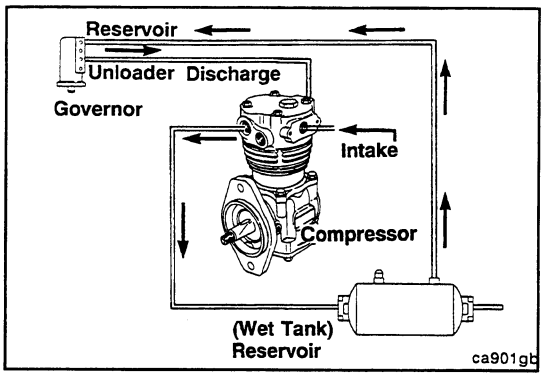


1. Exhaust Valve
2. Exhaust Manifold (pulse type)
3. Dual-Entry Turbocharger
4. Turbocharger Exhaust Outlet.

Compressed Air System - General Information

General Information

The compressed air system normally consists of a gear-driven air compressor, an air governor, air tanks, and all necessary plumbing.



The Holset® QE296B air compressor is an engine-driven, piston-type compressor that supplies compressed air to operate air-activated devices. The compressor operates continuously but has a "loaded" and "unloaded" operating mode. The operating mode is controlled by a pressure-activated governor and the compressor unloading assembly. When the air system reaches a predetermined pressure, the governor applies an air signal to the air compressor unloader assembly, causing the unloader valve to hold the compressor intake valve open, which stops compressed air from flowing into the air system. As air in the air system is used, the pressure drops. At a predetermined pressure, the governor exhausts the air signal to the compressor unloader assembly, allowing the compressor to again pump compressed air into the air system.

This air compressor is available in an air-cooled or water-cooled version, the **only** difference being that changes have been made to the cylinder head to incorporate a water passage.

This air compressor is also available with or without a power steering pump housing.

Other brands of compressors can be used on the ISB engine. Troubleshooting procedures are very similar for these air compressors compared to the Holset® QE296B. Refer to the specific air compressor manufacturer's manual for detailed repair information, including torque values.

NOTE: The cylinder head and unloader components of the Holset® QE296B air compressor can be serviced without removal of the air compressor on many engine applications. This troubleshooting manual will cover servicing the air compressor unloader components while the compressor is still on the engine. All other servicing of the air compressor internal components should be done after the compressor has been removed from the engine. Reference the Holset® Air Compressor Master Repair Manual, Bulletin No. 3666121, for detailed disassembly and assembly information of the air compressor.

The Holset® QE296B single-cylinder air compressor is an engine-driven, piston-type compressor that supplies compressed air to operate air-activated devices. The compressor runs continuously but has a loaded and unloaded operating mode. The operating mode is controlled by a pressure-activated governor and the compressor unloading assembly.

The QE296B air compressor used on ISB engines uses an (E-type) unloader. The economy (E-type) unloader system was designed to reduce pumping losses and engine boost-pressure losses through the compressor intake valve while operating in unloaded mode.

When the air system reaches a predetermined pressure, the governor applies an air signal to the air compressor unloader assembly, causing the unloader cap to seal off incoming air at the intake valve and compressed air to stop flowing into the air system.

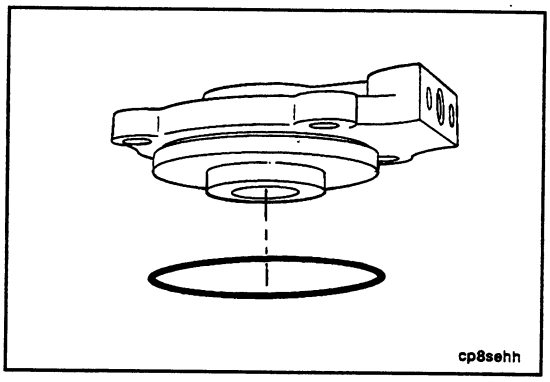
NOTE: System pressure **must** be maintained on the outlet side of the discharge valve to keep the discharge valve closed.

As air in the air system is used, the pressure drops. At a predetermined pressure, the governor exhausts the air signal to the compressor unloader assembly, allowing the compressor to again pump compressed air into the air system.

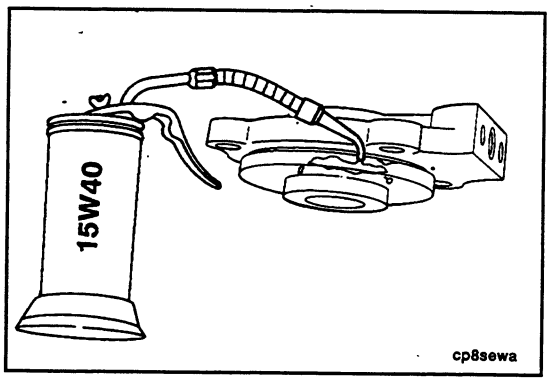
△ CAUTION △

Vehicles equipped with air dryers vented to atmosphere during unloaded compressor operation, using the Holset® (E-type) air compressor, require the installation of an Econ valve to prevent excessive oil consumption.

Install a new o-ring seal on the unloader valve body.



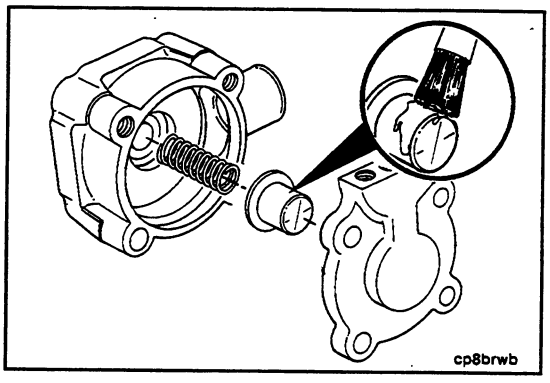
Use clean 15W-40 oil or Accrolube lubrication Teflon grease, or equivalent, to lubricate the seal.



Liberally lubricate the unloader valve body bore and unloader cap with high temperature grease (Accrolube lubrication Teflon grease, or equivalent).

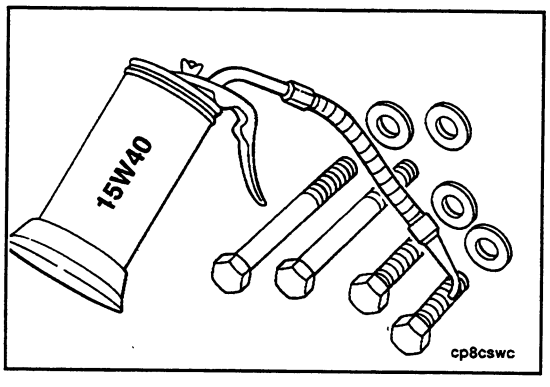
Install the unloader cap.

Install the unloader spring.



Lubricate the unloader screw threads and underhead with clean engine oil (SAE 15W-40) before installation.

NOTE: The two unloader body screws **must not** be used to attach any brackets.



⚠ WARNING ⚠

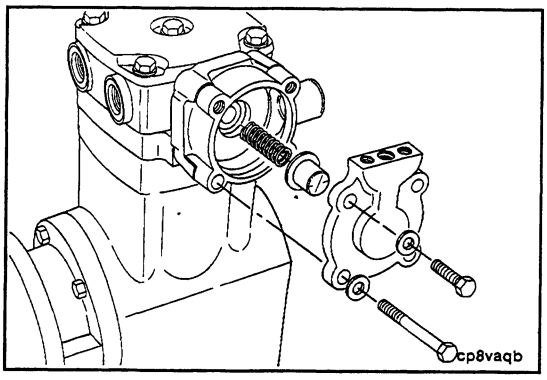
The unloader body is installed with spring tension. Use care when removing to prevent personal injury. Always wear protective eyewear.

Hold the unloader valve body down, and remove the four capscrews.

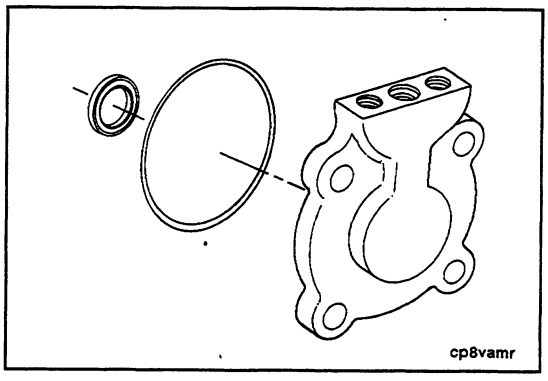
Remove the unloader valve body.

Remove the unloader valve spring.

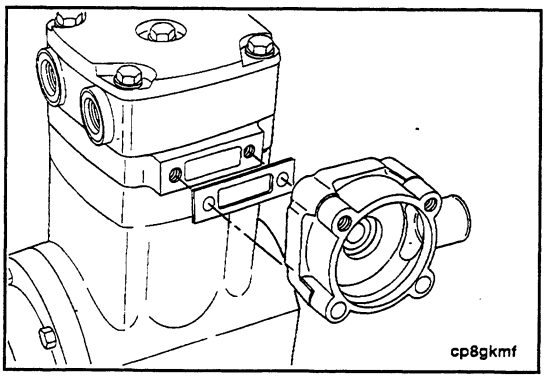
Remove the unloader valve cap.



Remove the unloader body gasket and unloader valve cap rectangular ring seal.

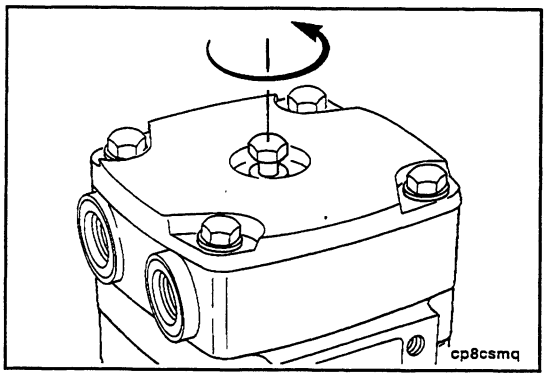


Remove the compressor intake manifold and gasket.



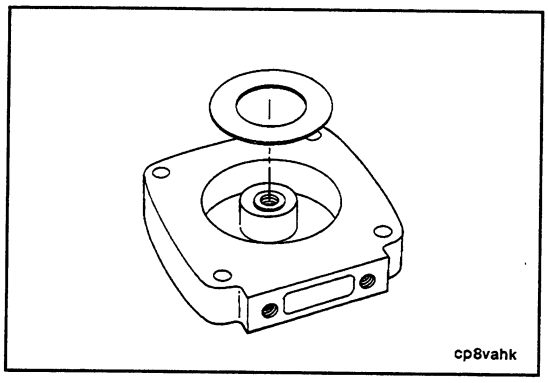
Loosen, but do **not** remove, the center head capscrew.

Mark the head for orientation during assembly.

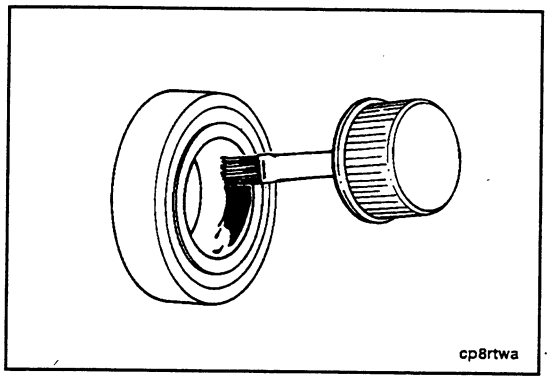


QE, European

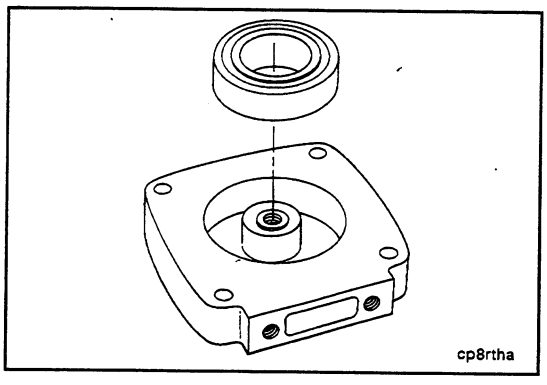
Install the exhaust valve over the post in the valve plate.



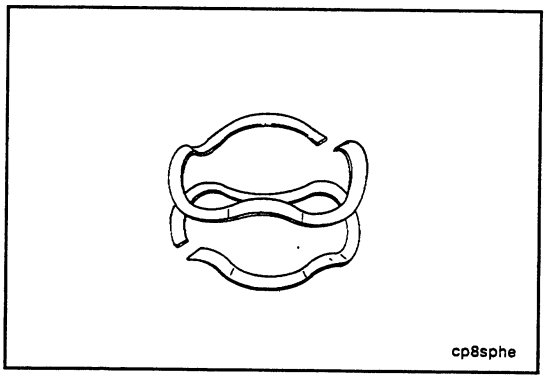
Apply a thin coating of antiseize to the inside circumference of the exhaust valve retainer.

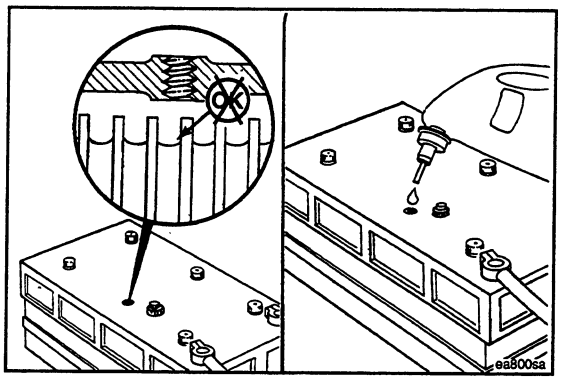


Slide the exhaust valve retainer over the valve plate. Make sure that the end of the retainer with the groove faces upward.



Align the wave spring gaps 180 degrees from each other so they do **not** overlap.





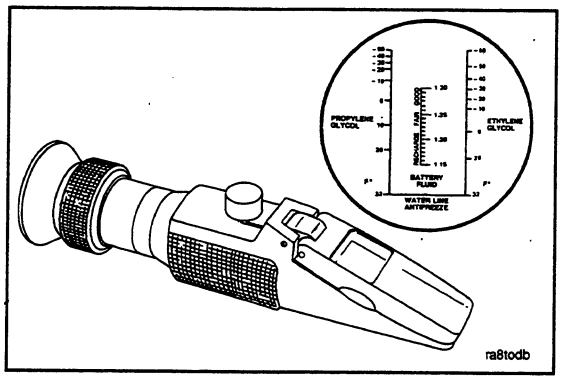
Batteries (013-007)

Initial Check (013-007-001)

If conventional batteries are used, remove the cell caps or covers, and check the electrolyte level.

NOTE: Maintenance-free batteries are sealed and do **not** require the addition of water.

Fill each battery cell with distilled water. Refer to the battery manufacturer's specifications.

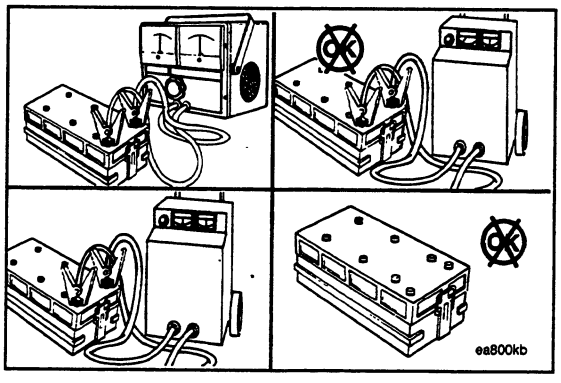


Fleetguard® Refractometer, Part No. CC-2800

Use the Fleetguard® refractometer, Part No. CC-2800, to check the specific gravity of the battery electrolyte.

Refer to the battery fluid column in the refractometer to determine the state of charge of each battery cell.

If water has been added to a dry cell, recharge the battery to mix the added water with the existing battery electrolyte, to prevent incorrect readings.



△ CAUTION △

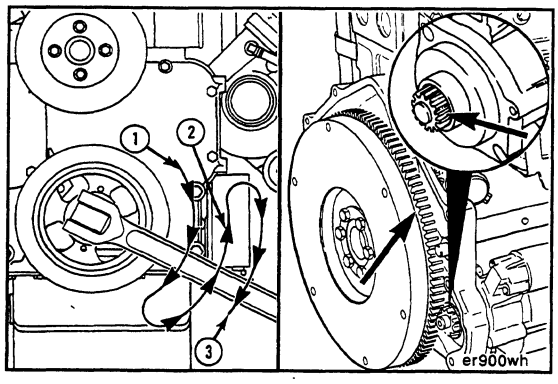
Do not connect battery charging cables to any electronic control system part. This can damage the electronic control system parts.

Inductive Charging-Cranking Systems Analyzer, Part No. 3377193

Use the inductive charging-cranking systems analyzer, Part No. 3377193, to test the output amperage of maintenance-free or conventional vent cap batteries.

If the output amperage is low, use a battery charger to charge the battery. Refer to the manufacturer's instructions.

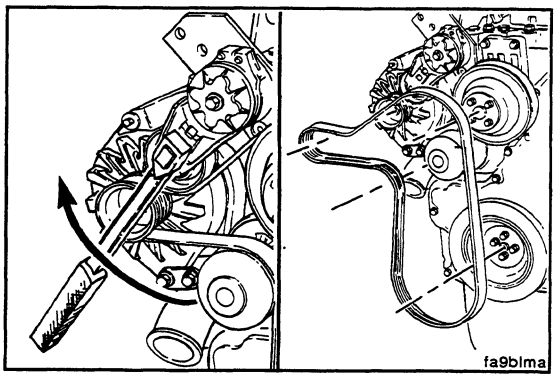
Replace the battery if it will **not** charge to the manufacturer's specifications or will **not** maintain a charge.



Bar the crankshaft as follows:

1. Direction of engine rotation
2. Direction opposite engine rotation
3. Direction of engine rotation.

If the crankshaft will bar at step No. 3, attempt to start the engine. If the starter motor cranks the engine, check the starter motor pinion gear and flywheel ring gear for damage.

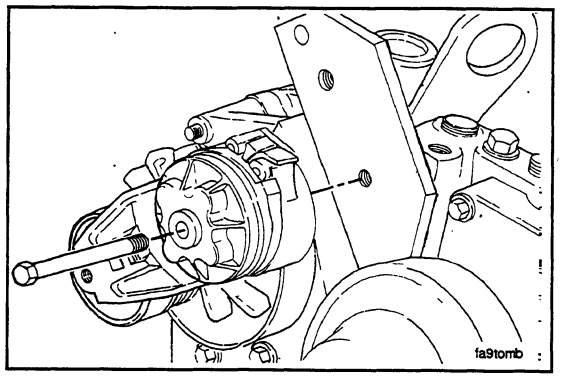


Belt Tensioner, Automatic (013-021)

Remove (013-021-002)

3/8-Inch Square Drive

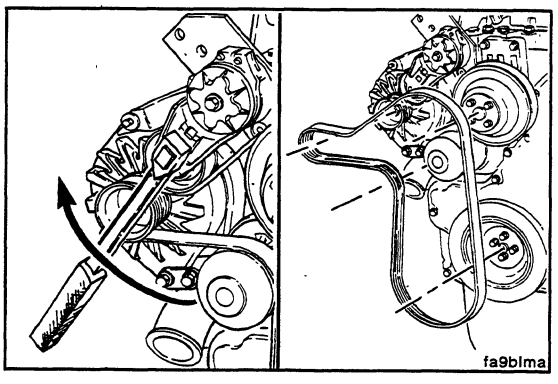
Remove the drive belt. Refer to Procedure 008-002.



15 mm

Remove the belt tensioner mounting capscrew.

Remove the belt tensioner from the bracket.



Install (013-021-026)

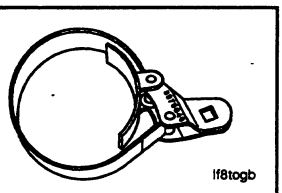
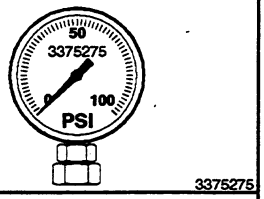
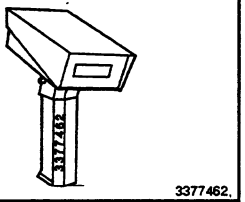
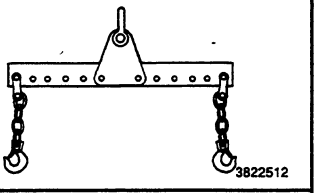
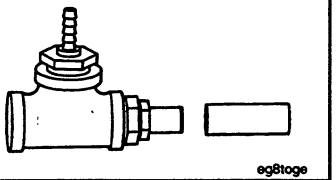
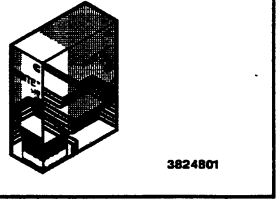
3/8-Inch Square Drive

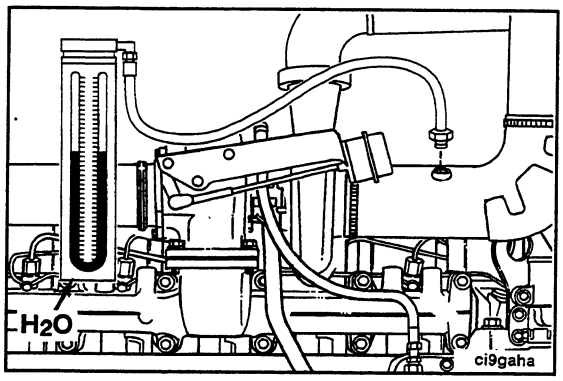
Install the drive belt. Refer to Procedure 008-002.

Service Tools

Engine Testing

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3375049	**Oil Filter Wrench** Used to remove spin-on type oil and fuel filters.	
3375275	**Pressure Gauge 0 to 1103 kPa [0 to 160 psi]** Used to measure lubricating oil pressure.	
3377462	**Digital Optical Tachometer** Used to measure engine speed (rpm).	
3822512	**Engine Lifting Fixture** Used to remove and install the engine.	
3822566	**Blowby Tool** Used to check engine crankcase blowby.	
3824801	**INSITE™ Software Kit** Used to troubleshoot, program, and adjust the fuel system.	



Air Inlet Restriction

Manometer, Part No ST-1111-3

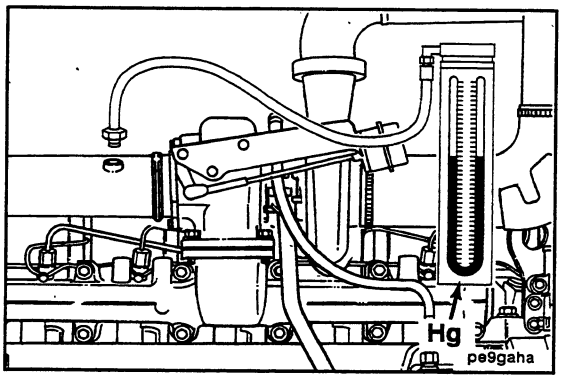
Vacuum Gauge, Part No. ST-434

Connect a water manometer, Part No ST-1111-3, to the turbocharger air inlet pipe to test air restriction.

NOTE: The manometer connection **must** be installed at a 90-degree angle to the airflow in a straight section of pipe, one pipe diameter before the turbocharger.

NOTE: A vacuum gauge, Part No. ST-434, can be used in place of the water manometer.

Minimum Gauge Capacity: 760 mm H_2O [30 in H_2O]



Exhaust Restriction

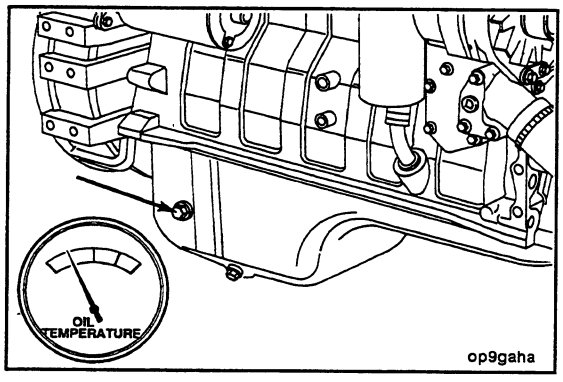
Pressure Gauge, Part No. ST-1273

Connect a mercury manometer to a straight section of the exhaust piping near the turbocharger outlet to check the exhaust restriction.

NOTE: A pressure gauge, Part No. ST-1273, can be used in place of the mercury manometer.

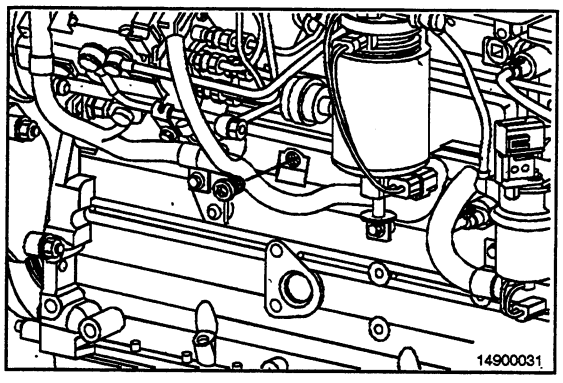
NOTE: For automotive applications, a tapped hole is provided on the inlet side of the catalyst for checking exhaust restrictions.

Minimum Gauge Capacity: 254 mm Hg [10 in Hg]



Attach the lubricating oil temperature sensor in the location shown.

Minimum Gauge Capacity: 150°C [300°F]



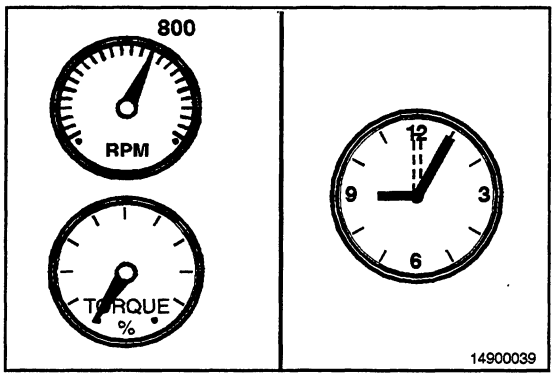
Priming the Lubricating System

△ CAUTION △

The lubricating oil system must be primed before operating the engine after it has been rebuilt to avoid internal damage.

Remove the plug.

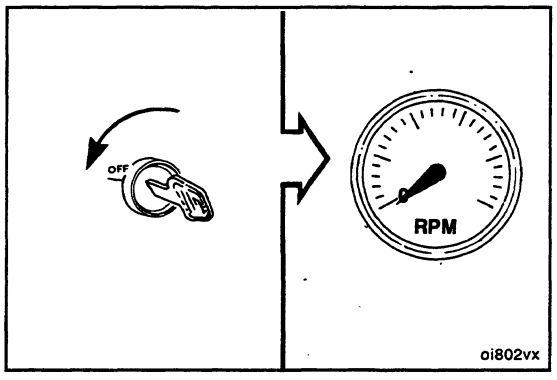
To prime the system using external pressure, connect the supply to a tapped hole in the main oil rifle.



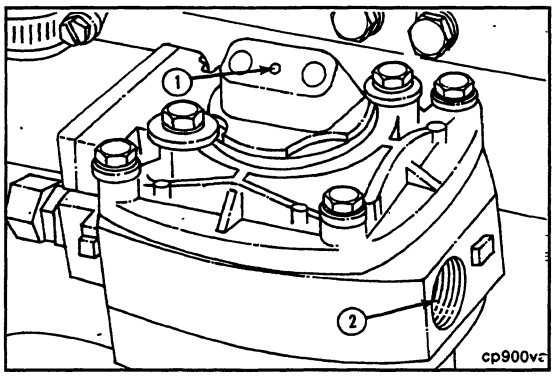
⚠ CAUTION ⚠

Shutting off the engine immediately after operating at full load will damage the turbocharger and internal components. Always allow the engine to cool before shutting it off.

Remove the dynamometer load completely, and operate the engine at 800 rpm for 3 to 5 minutes. This period will allow the turbocharger and other components to cool.



Shut off the engine.

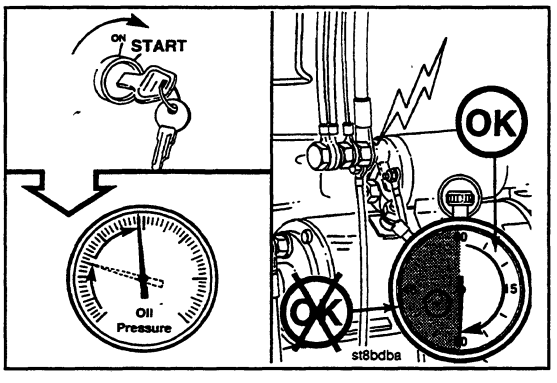


Engine Dynamometer Test - Performance Check

Make sure the air compressor will be unloaded during the performance check.

Apply regulated air pressure of 655 kPa [95 psi] to the air compressor unloader (1).

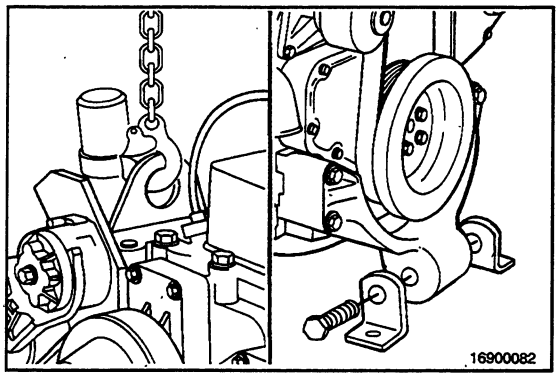
NOTE: The compressed air load in the accompanying illustration **must** be attached to the air compressor outlet (2).



⚠ CAUTION ⚠

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

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

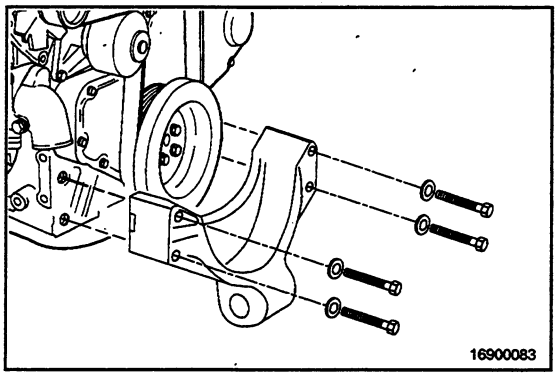


Engine Support Bracket, Front (016-002)

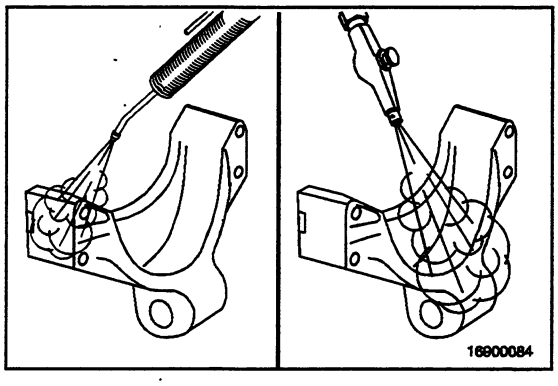
Remove (016-002-002)

Use a hoist or lifting fixture to support the front of the engine.

Remove the capscrews from the front engine mount.



Remove the four mounting capscrews and the front engine support.



Clean (016-002-006)

⚠ WARNING ⚠

When using a steam cleaner, wear protective clothing as well as safety glasses or a face shield. Hot steam can cause serious personal injury.

⚠ WARNING ⚠

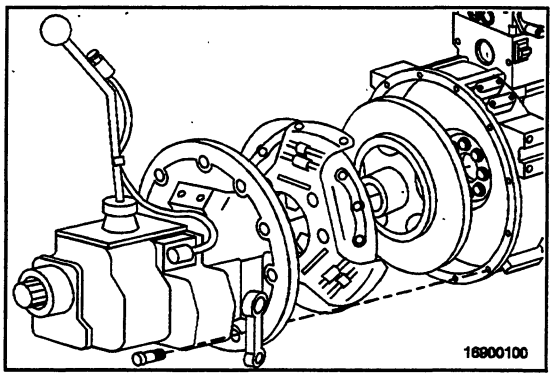
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles as well as protective clothing to avoid personal injury.

⚠ WARNING ⚠

Compressed air used for cleaning should not exceed 207 kPa [30 psi]. Use only with protective clothing, as well as goggles/shield, and gloves to avoid personal injury.

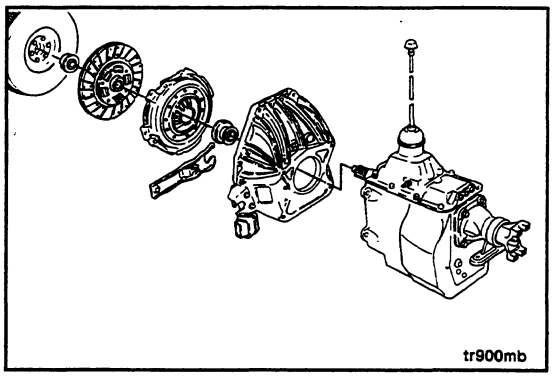
Use steam or solvent to clean the front engine support.

Dry with compressed air.



Install the clutch discs, pressure plate, transmission, and driveline (if equipped) in reverse order of removal. Refer to the manufacturer's instructions.

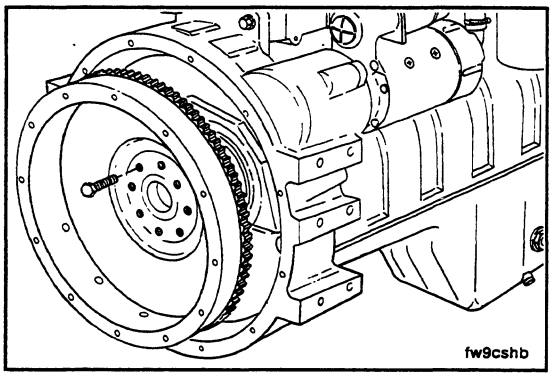
NOTE: Align the universal joints on each end of the driveshaft to prevent vibration.



Flywheel Housing (016-006)

Remove (016-006-002)

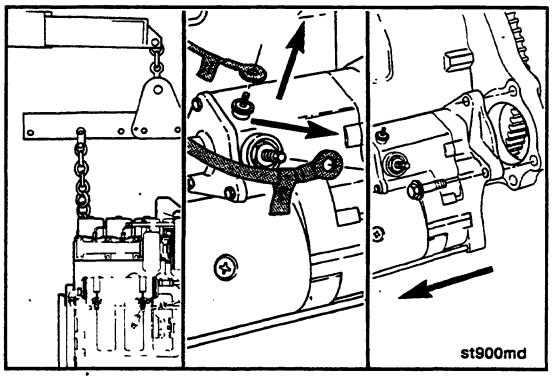
Remove the transmission, clutch, and all related components (if equipped). Refer to the manufacturer's instructions.



⚠ WARNING ⚠

The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

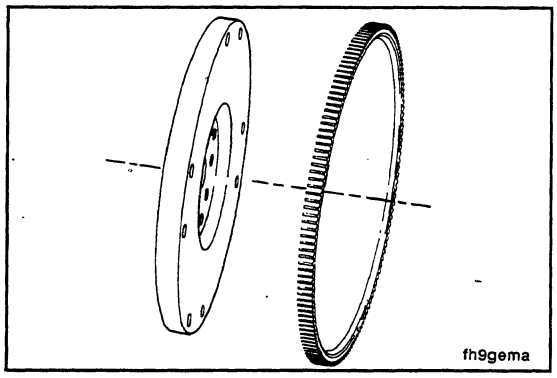
Remove the flywheel/ring gear assembly. Refer to Procedure 016-005.



Adequately support the engine to prevent damage.

Disconnect the battery cables.

Remove the starter motor.

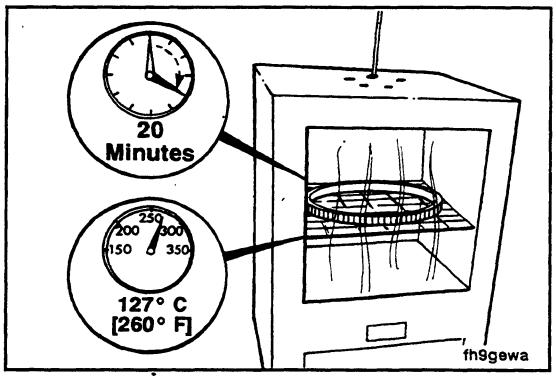


Brass Drift Pin

⚠ WARNING ⚠

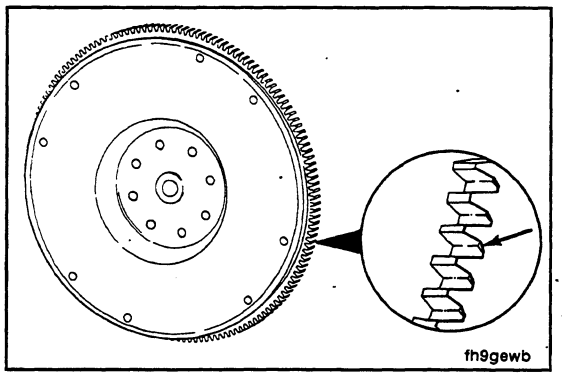
To avoid severe eye damage, wear eye protection when you drive the gear from the flywheel. Do not use a steel drift pin.

Use the drift pin to drive the ring gear from the flywheel.



Install (016-008-026)

Heat the new ring gear for 20 minutes in an oven preheated to 127°C [260°F].

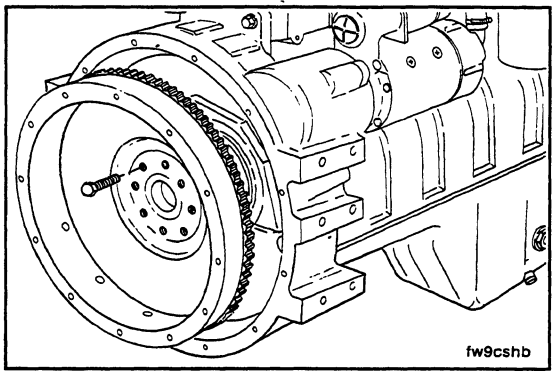


⚠ WARNING ⚠

To avoid severe burns, wear protective gloves when installing the heated gear.

NOTE: The ring gear **must** be installed so the bevel on the teeth is toward the crankshaft side of the flywheel.

Install the ring gear.



Barring Tool, Part No. 3824591

Use two capscrews and the barring tool, Part No. 3824591, in the front of the crankshaft to hold the crankshaft when the flywheel capscrews are being tightened.

Straight Thread O-Ring Plugs				
Thread Size Inches	Torque - lbf			
	Nem	in-lb	Nem	ft-lb
1/4	4	35		
3/8	6	50		
1/2	8	70		
9/16	12	105		
5/8	16	145		
3/4			20	15
7/8			35	20
1			40	30
1-1/16			45	35
1-3/16			55	40

oi203vg

Tighten the straight-thread plugs. Refer to the adjoining chart for the appropriate torque values.

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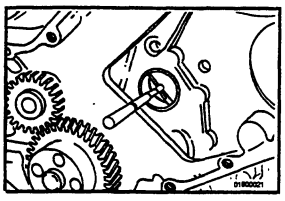
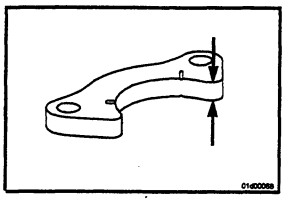
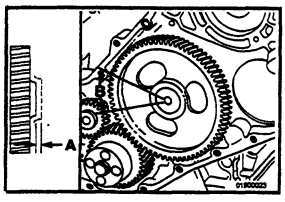
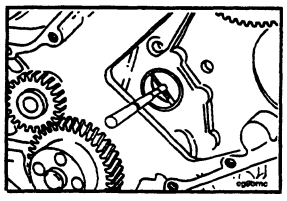
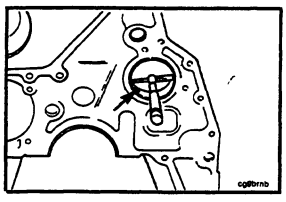
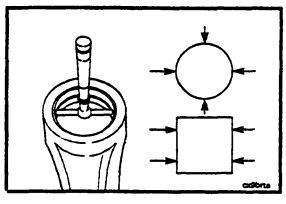
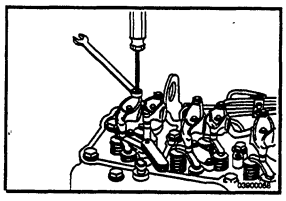
Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.
				
Camshaft Bore Diameter (Maximum)				
No. 1 only (without bushing)		59.248 mm	MAX	2.3326 in
No. 1 (with bushing)		54.147 mm	MAX	2.1318 in
No. 2 through 7		54.164 mm	MAX	2.1324 in
				
Camshaft Thrust Plate Thickness				
		9.34 mm	MIN	0.368 in
		9.6 mm	MAX	0.378 in
				
Camshaft End Play (A)				
		0.10 mm	MIN	0.004 in
		0.46 mm	MAX	0.018 in
Camshaft Gear Backlash Limits (B)				
		0.152 mm	MIN	0.006 in
		0.33 mm	MAX	0.013 in
				
Camshaft Bushings (001-010)				
Camshaft Bore Diameter (Maximum)				
No. 1 only (without bushing)		57.248 mm	MAX	2.3326 in
No. 1 with bushing		54.147 mm	MAX	2.1318 in
No. 2 through 7		54.164 mm	MAX	2.1324 in
				
Camshaft Bore (Bushing Installed)				
		54.083 mm	MIN	2.1293 in
		54.147 mm	MAX	2.1318 in
				
Connecting Rod (001-014)				
Connecting Rod Piston Pin Bushing Diameter				
		40.019 mm	MIN	1.5755 in
		40.042 mm	MAX	1.5765 in

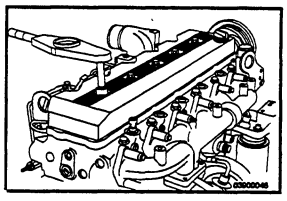
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.



Rocker Levers - Torque Values

Overhead Set (003-004)

Rocker Lever Locknut		24 N•m	18 ft-lb



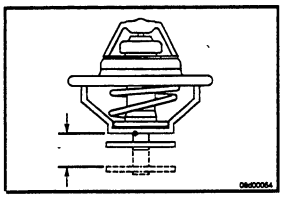
Rocker Lever Cover (003-011)

Rocker Lever Cover Capscrew Torque		12 N•m	9 ft-lb

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.

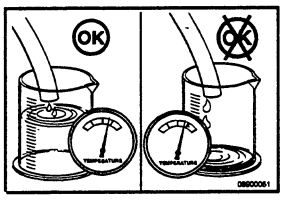
Cooling System - Specifications

Coolant Thermostat (008-013)



Thermostat Opening Temperatures

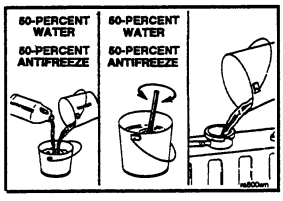
Initial Opening Temperature	81 °C	MIN	178 °F
	83 °C	MAX	182 °F
Fully Opened Temperature	94 °C	MAX	202 °F



Thermostat Initial Opening Temperature

81 °C	MIN	178 °F
83 °C	MAX	182 °F

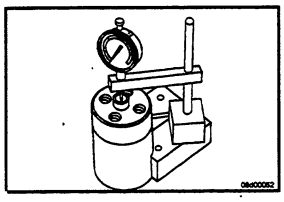
Cooling System (008-018)



Coolant Capacity (Engine Only)

ISB (Charge Air Cooler)	9 liters	MAX	2.38 U.S.gal

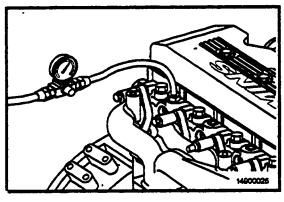
Fan Hub, Belt Driven (008-036)



Fan Hub End Play

0.15 mm	MAX	0.006 in

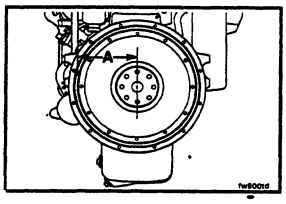
Water Pump (008-062)



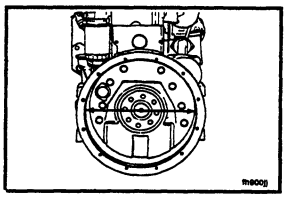
Minimum Gauge Capacity:	415 kPa	60 psi

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.

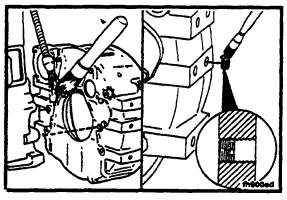
Mounting Adaptations - Specifications



Flywheel Radius (A)		Maximum of Flywheel Face	
mm	in	mm	in
203	8	0.203	0.008
254	10	0.254	0.010
305	12	0.305	0.012
356	14	0.356	0.014
406	16	0.406	0.016



SAE No.	Bore Diameter		TIR Max	
	mm	in	mm	in
2	447.68 to 47.80	17.625 to 17.30	0.20	0.008
3	409.58 to 409.70	16.125 to 16.130	0.20	0.008



Set Screw Installation Depth (Flywheel Housing)

3.00 mm MAX 0.118 in

Weights and Measures - Conversion Factors

Quantity	U.S. Customary		Metric		From U.S. Customary To Metric Multiply By	From Metric To U.S. Customary Multiply By
	Unit Name	Abbreviation	Unit Name	Abbreviation		
Area	sq. inch	in^2	sq. millimeters	mm^2	645.16	0.001550
			sq. centimeters	cm^2	6.452	0.155
	sq. foot	ft^2	sq. meter	m^2	0.0929	10.764
Fuel Consumption	pounds per horsepower hour	lb/hp-hr	grams per kilowatt hour	g/kW-hr	608.277	0.001645
Fuel Performance	miles per gallon	mpg	kilometers per liter	km/l	0.4251	2.352
	gallons per mile	gpm	liters per kilometer	l/km	2.352	0.4251
Force	pounds force	lbf	Newton	N	4.4482	0.224809
Length	inch	in	millimeters	mm	25.40	0.039370
	foot	ft	millimeters	mm	304.801	0.00328
Power	horsepower	hp	kilowatt	kW	0.746	1.341
Pressure	pounds force per sq. inch	psi	kilopascal	kPa	6.8948	0.145037
	inches of mercury	in Hg	kilopascal	kPa	3.3769	0.29613
	inches of water	in H_2O	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H_2O	millimeters of water	mm H_2O	25.40	0.039370
	bars	bars	kilopascals	kPa	100.001	0.00999
	bars	bars	millimeters of mercury	mm Hg	750.06	0.001333
Temperature	fahrenheit	°F	centigrade	°C	(°F-32) ÷1.8	(1.8 x °C) +32
Torque	pound force per foot	ft-lb	Newton-meter	N•m	1.35582	0.737562
	pound force per inch	in-lb	Newton-meter	N•m	0.113	8.850756
Velocity	miles/hour	mph	kilometers/hour	kph	1.6093	0.6214
Volume: liquid displacement	gallon (U.S.)	gal.	liter	l	3.7853	0.264179
	gallon (Imp*)	gal.	liter	l	4.546	0.219976
	cubic inch	in^3	liter	l	0.01639	61.02545
	cubic inch	in^3	cubic centimeter	cm^3	16.387	0.06102
Weight (mass)	pounds (avoir.)	lb	kilograms	kg	0.4536	2.204623
Work	British Thermal Unit	BTU	joules	J	1054.5	0.000948
	British Thermal Unit	BTU	kilowatt-hour	kW-hr	0.000293	3414
	horsepower hours	hp-hr	kilowatt-hour	kW-hr	0.746	1.341