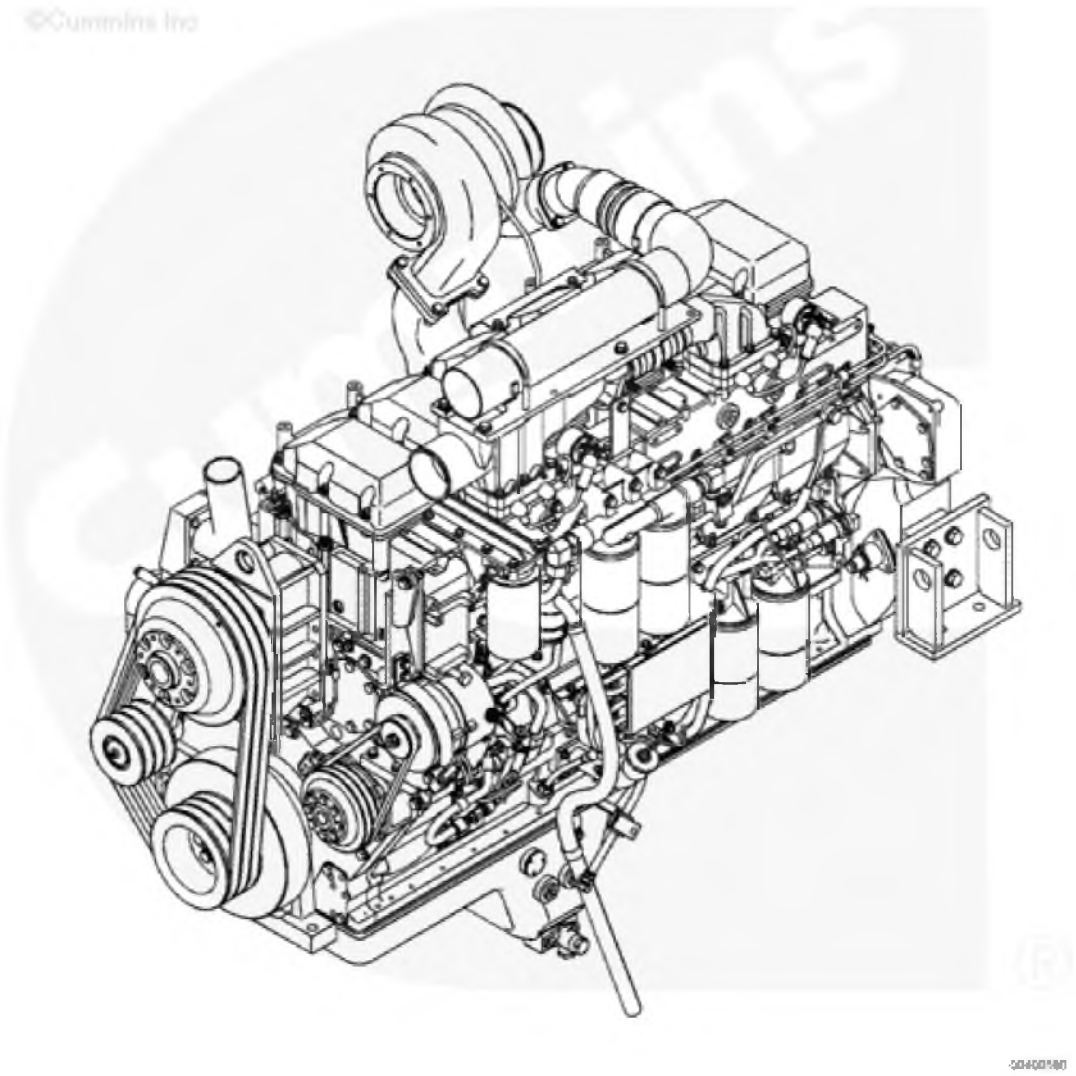
Troubleshooting and Repair Manual

QSK23 Series Engines



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Foreword

This manual provides instructions for troubleshooting and repairing this engine in the chassis. Component and assembly rebuild procedures are provided in the engine shop manual. Refer to Section i - Introduction for instructions on how to use this manual.

Read and follow all safety instructions. Refer to the WARNING in the General Safety Instructions in Section i - Introduction.

The manual is organized to guide a service technician through the logical steps of identifying and correcting problems related to the engine. This manual does not cover vehicle or equipment problems. Consult the vehicle or equipment manufacturer for repair procedures.

A series of specific service manuals (for example: Shop, Specifications, and Alternative Repair) are available and can be ordered by Contacting your local area Cummins Regional office. A Cummins Regional office listing is located in Service Literature (Section L).

The repair procedures used in this manual are recommended by Cummins Inc. Some service procedures require the use of special service tools. Use the correct tools as described.

Cummins Inc. encourages the user of this manual to report errors, omissions, and recommendations for improvement. Please use the postage paid, pre-addressed Literature Survey Form in the back of this manual for communicating your comments.

The specifications and rebuild information in this manual are based on the information in effect at the time of printing. Cummins Inc. reserves the right to make any changes at any time without obligation. If differences are found between your engine and the information in this manual, contact a Cummins Authorized Repair Location or call 1-800-DIESELS (1-800-343-7357) toll free in the U.S. and Canada.

The latest technology and the highest quality components are used to manufacture Cummins engines. When replacement parts are needed, we recommend using only genuine Cummins or ReCon® exchange parts.

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204-002 About the Manual

General Information

This Troubleshooting and Repair Manual is intended to aid in determining the cause of engine related problems and to provide recommended repair procedures.

The manual is divided into sections. Each section is equivalent to a group used in Cummins' filmcard system. Some sections contain **reference** numbers and **procedure** numbers. **Reference** numbers provide general information, specifications, diagrams, and service tools where applicable. **Procedure** numbers are used to identify and reference specific repair procedures for correcting the problem.

This manual **does not** contain fuel systems electronic troubleshooting. Use the troubleshooting trees in this manual, if there are no electronic fault codes.

This manual is designed so the troubleshooting trees are used to locate the cause of an engine problem. The troubleshooting trees then direct the user to the correct repair procedure. The repair procedures within a section are in numerical order. However, the repair steps within a given procedure are organized in the order the repair **must** be performed regardless of the numerical order of the steps. The user **must** use the contents pages or the index at the back of the manual to locate specific topics when **not** using the troubleshooting trees.

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204-003 How to Use the Manual

General Information

This manual is organized to provide an easy flow from problem identification to problem correction.

A list of troubleshooting symptoms containing the most common problems is in the Troubleshooting Symptoms, Section (TS). The manual is designed to use the Troubleshooting Symptoms as a guide to locating the problem and directing the end user to the correct procedure for making the repair. Complete the following steps to locate and correct the problem.

1. Locate the symptom on the Section Contents pages of Section TS.
    - Reference to the page number where the Troubleshooting Symptom Tree is found is made to the right of the symptom tree title.
2. The left column of boxes in the Troubleshooting Symptom Charts indicates a probable cause of the problem, starting at the top with the simplest and easiest to repair, and continuing downward to the most difficult.
    - The right column of boxes provides a brief description of the corrective action with a reference number to the correct procedure used to make the repair.
3. Locate the probable cause in the left column then turn to the procedure referenced in the right column.
4. The Troubleshooting Symptom Charts are based on the following assumptions:
    - The components have been installed according to the manufacturer's specifications.
    - The easiest repairs are done first.
    - All generic solutions are designed for the most common applications and Original Equipment Manufacturer (OEM).

Refer to the Original Equipment Manufacturer's service manual for their specifications.

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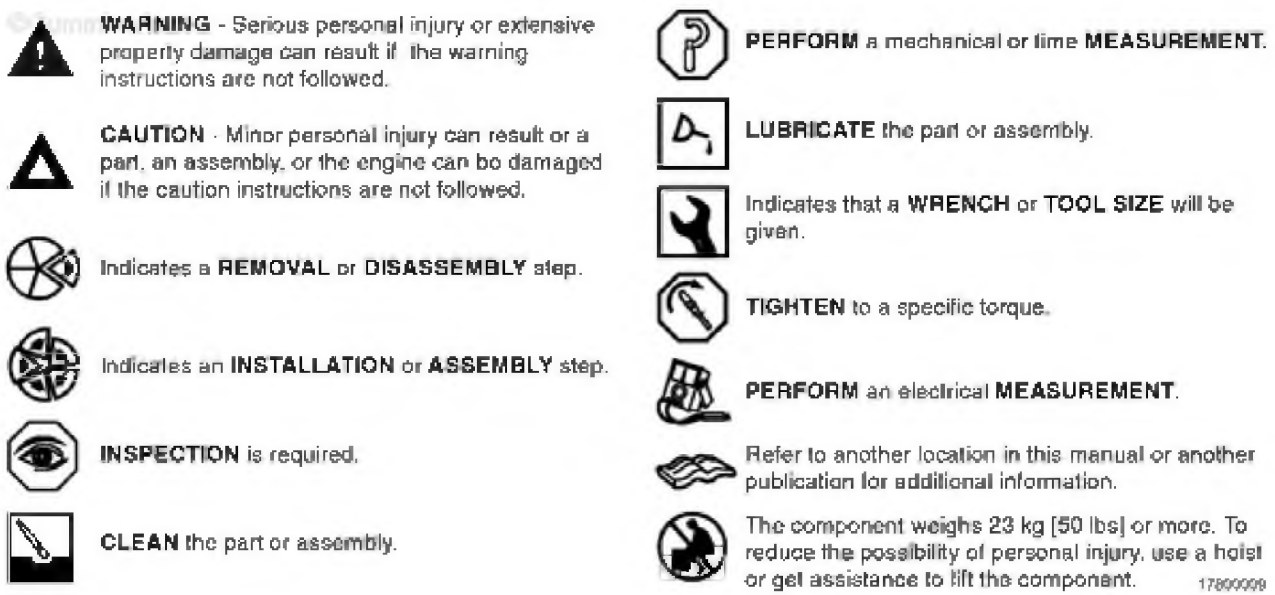
204-004 Symbols

General Information

The following symbols have been used in this manual to help communicate the intent of the instructions. When one of the symbols appears, it conveys the meaning defined below:



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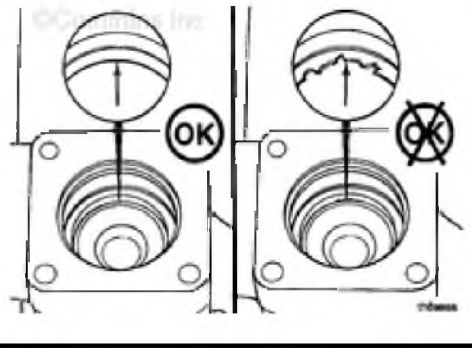
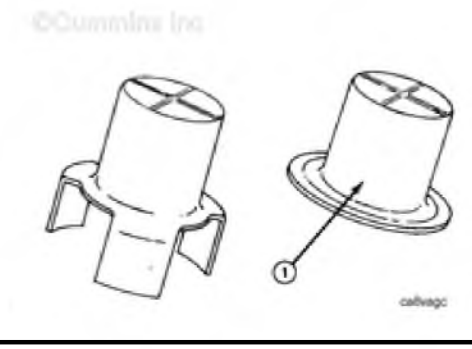
204-005 Illustrations

General Information

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.		

Last Modified: 12-Mar-2002

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204-006 General Safety Instructions

Important Safety Notice

WARNING

Improper practices, carelessness, or ignoring the warnings can cause burns, cuts, mutilation, asphyxiation or other personal injury or death.

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that **must** be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Work in an area surrounding the product that is dry, well lit, ventilated, free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do **Not** Operate" tag in the operator's compartment or on the controls.
- Use ONLY the proper engine barring techniques for manually rotating the engine. Do **not** attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before slowly loosening the filler cap to relieve the pressure from the cooling system.
- **Always** use blocks or proper stands to support the product before performing any service work. Do **not** work on anything that is supported ONLY by lifting jacks or a hoist.
- Relieve all pressure in the air, oil, fuel, and cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible

pressure when disconnecting any device from a system that utilizes pressure. Do **not** check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.

- To reduce the possibility of suffocation and frostbite, wear protective clothing and ONLY disconnect liquid refrigerant (Freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems **must** be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capturing and recycling refrigerant.
- To reduce the possibility of personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. **Always** use a spreader bar when necessary. The lifting hooks **must not** be side-loaded.
- Corrosion inhibitor, a component of SCA and lubricating oil, contains alkali. Do **not** get the substance in eyes. Avoid prolonged or repeated contact with skin. Do **not** swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and **must** be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- To reduce the possibility of burns, be alert for hot parts on products that have just been turned off, exhaust gas flow, and hot fluids in lines, tubes, and compartments.
- **Always** use tools that are in good condition. Make sure you understand how to use the tools before performing any service work. Use ONLY genuine Cummins® or Cummins ReCon® replacement parts.
- **Always** use the same fastener part number (or equivalent) when replacing fasteners. Do **not** use a fastener of lesser quality if replacements are necessary.
- When necessary, the removal and replacement of any guards covering rotating components, drives, and/or belts should only be carried out be a trained technician. Before removing any guards the engine **must** be turned off and any starting mechanisms **must** be isolated. All fasteners **must** be replaced on re-fitting the guards.
- Do **not** perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- 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.
- Do **not** connect the jumper starting or battery charging cables to any ignition or governor control wiring. This can cause electrical damage to the ignition or governor.
- **Always** torque fasteners and fuel connections to the required specifications. Overtightening or undertightening can allow leakage. This is critical to the natural gas and liquefied petroleum gas fuel and air systems.
- **Always** test for fuel leaks as instructed, as odorant can fade.
- Close the manual fuel valves prior to performing maintenance and repairs, and when storing the vehicle inside.

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- Coolant is toxic. If **not** reused, dispose of in accordance with local environmental regulations.
- The catalyst reagent contains urea. Do **not** get the substance in your eyes. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water. Do **not** swallow internally. In the event the catalyst reagent is ingested, contact a physician immediately.
- The catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. Always wear protective gloves and eye protection when handling the catalyst assembly. Do not get the catalyst material in your eyes. In Case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water.
- The Catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. In the event the catalyst is being replaced, dispose of in accordance with local regulations.
- California Proposition 65 Warning - Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

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204-007 General Repair Instructions

General Information

This system incorporates the latest technology at the time it was manufactured; yet, it is designed to be repaired using normal repair practices performed to quality standards.

WARNING

Cummins Inc. does not recommend or authorize any modifications or repairs to components except for those detailed in Cummins Service Information. In particular, unauthorized repair to safety-related components can cause personal injury or death. Below is a partial listing of components classified as safety-related:

1. Air Compressor
2. Air Controls
3. Air Shutoff Assemblies
4. Balance Weights
5. Cooling Fan
6. Fan Hub Assembly
7. Fan Mounting Bracket(s)
8. Fan Mounting Capscrews
9. Fan Hub Spindle
10. Flywheel
11. Flywheel Crankshaft Adapter
12. Flywheel Mounting Capscrews
13. Fuel Shutoff Assemblies
14. Fuel Supply Tubes
15. Lifting Brackets
16. Throttle Controls
17. Turbocharger Compressor Casing
18. Turbocharger Oil Drain Line(s)
19. Turbocharger Oil Supply Line(s)
20. Turbocharger Turbine Casing
21. Vibration Damper Mounting Capscrews
22. Manual Service Disconnect

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23. High Voltage Interlock Loop
24. High Voltage Connectors/Connections and Harnesses
25. High Voltage Battery System
26. Power Inverter
27. Generator Motor
28. Clutch Pressure Plate

- Follow all safety instructions noted in the procedures
- Follow the manufacturer's recommendations for cleaning solvents and other substances used during repairs. Some solvents have been identified by government agencies as toxic or carcinogenic. Avoid excessive breathing, ingestion and contact with such substances. **Always** use good safety practices with tools and equipment
- Provide a clean environment and follow the cleaning instructions specified in the procedures
- All components **must** be kept clean during any repair. Contamination of the components will cause premature wear.
- Perform the inspections specified in the procedures
- Replace all components or assemblies which are damaged or worn beyond the specifications
- Use genuine Cummins new or ReCon® service parts and assemblies
- The assembly instructions have been written to use again as many components and assemblies as possible. When it is necessary to replace a component or assembly, the procedure is based on the use of new Cummins or Cummins ReCon® components. All of the repair services described in this manual are available from all Cummins Distributors and most Dealer locations.
- Follow the specified disassembly and assembly procedures to reduce the possibility of damage to the components

Welding on a Vehicle with an Electronic Controlled Fuel System

CAUTION

Disconnect both the positive (+) and negative (-) battery cables from the battery before welding on the vehicle. Attach the welder ground cable no more than 0.61 meters [2 feet] from the part being welded. Do not connect the ground clamp of the welder to any of the sensors, wiring harness, electronic control units or the components. Direct welding of any electronic components must not be attempted. Sensors, wiring harness, and electronic control unit should be removed if nearby welding will expose these components to temperatures beyond normal operation.

Additionally, all electronic control unit connectors must be disconnected

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204-008 General Cleaning Instructions

Definition of Clean

Parts **must** be free of debris that can contaminate any engine system. This does **not** necessarily mean they have to appear as new.

Sanding gasket surfaces until the factory machining marks are disturbed adds no value and is often harmful to forming a seal. It is important to maintain surface finish and flatness tolerances to form a quality sealing surface. Gaskets are designed to fill small voids in the specified surface finish.

Sanding gasket surfaces where edge-molded gaskets are used is most often unnecessary. Edge-molded gaskets are those metal carriers with sealing material bonded to the edges of the gasket to seal while the metal portion forms a metal to metal joint for stability. Any of the small amounts of sealing material that can stick to the parts are better removed with a blunt-edged scraper on the spots rather than spending time polishing the whole surface with an air sander or disc.

For those gaskets that do **not** have the edge molding, nearly all have a material that contains release agents to prevent sticking. Certainly this is **not** to say that some gaskets are **not** difficult to remove because the gasket has been in place a long time, has been overheated or the purpose of the release agent has been defeated by the application of some sealant. The object however is just to remove the gasket without damaging the surfaces of the mating parts without contaminating the engine (don't let the little bits fall where they can not be removed).

Bead blasting piston crowns until the dark stain is removed is unnecessary. All that is required is to remove the carbon build-up above the top ring and in the ring grooves. There is more information on bead blasting and piston cleaning later in this document.

Cummins Inc. does **not** recommend sanding or grinding the carbon ring at the top of cylinder liners until clean metal is visible. The liner will be ruined and any signs of a problem at the top ring reversal point (like a dust-out) will be destroyed. It is necessary to remove the carbon ring to provide for easier removal of the piston assembly. A medium bristle, high quality, steel wire wheel that is rated above the rpm of the power tool being used will be just as quick and there will be less damage. Yes, one **must** look carefully for broken wires after the piston is removed but the wires are more visible and can be

attracted by a magnet.

Oil on parts that have been removed from the engine will attract dirt in the air. The dirt will adhere to the oil. If possible, leave the old oil on the part until it is ready to be cleaned, inspected and installed, and then clean it off along with any attracted dirt. If the part is cleaned then left exposed it can have to be cleaned again before installation. Make sure parts are lubricated with clean oil before installation. They do **not** need to be oiled all over but do need oil between moving parts (or a good lube system priming process conducted before cranking the engine).

Bead blasting parts to remove exterior paint is also usually unnecessary. The part will most likely be painted again so all that needs happen is remove any loose paint.

Abrasive Pads and Abrasive Paper

The keyword here is "abrasive". There is no part of an engine designed to withstand abrasion. That is they are all supposed to lock together or slide across each other. Abrasives and dirt particles will degrade both functions.

WARNING

Abrasive material must be kept out of or removed from oil passages and parts wear points. Abrasive material in oil passages can cause bearing and bushing failures that can progress to major component damage beyond reuse. This is particularly true of main and rod bearings.

Cummins Inc. does **not** recommend the use of emery cloth or sand paper on any part of an **assembled** engine or component including but **not** limited to removing the carbon ridge from cylinder liners or to clean block decks or counterbores.

Great care **must** be taken when using abrasive products to clean engine parts, particularly on partially assembled engines. Abrasive cleaning products come in many forms and sizes. All of them contain aluminum oxide particles, silicon carbide, or sand or some other similar hard material. These particles are harder than most of the parts in the engine. Since they are harder, if they are pressed against softer material they will either damage the material or become embedded in it. These materials fall off the holding media as the product is used. If the products are used with power equipment the particles are thrown about the engine. If the particles fall between two moving parts, damage to the moving parts is likely.

If particles that are smaller than the clearance between the parts while they are at rest

(engine stopped), but larger than the running clearance then damage will occur when the parts move relative to each other (engine started). While the engine is running and there is oil pressure, particles that are smaller than the bearing clearance are likely to pass between the parts without damage and be trapped in the oil filter. However, particles larger than the bearing clearance will remove material from one part and can become embedded in one of the parts. Once embedded in one part it will abrade the other part until contact is no longer being made between the two parts. If the damage sufficiently degrades the oil film, the two parts will come into contact resulting in early wear-out or failure from lack of effective lubrication.

Abrasive particles can fly about during cleaning it is **very** important to block these particles from entering the engine as much as possible. This is particularly true of lubricating oil ports and oil drilling holes, especially those located downstream of the lubricating oil filters. Plug the holes instead of trying to blow the abrasive particles and debris with compressed air because the debris is often simply blown further into the oil drilling.

All old gasket material **must** be removed from the parts gasket surfaces. However, it is **not** necessary to clean and polish the gasket surface until the machining marks are erased. Excessive sanding or buffing can damage the gasket surface. Many newer gaskets are of the edge molded type (a steel carrier with a sealing member bonded to the steel). What little sealing material that can adhere is best removed with a blunt-edged scraper or putty knife. Cleaning gasket surfaces where an edge-molded gasket is used with abrasive pads or paper is usually a waste of time.

WARNING

Excessive sanding or grinding the carbon ring from the top of the cylinder liners can damage the liner beyond reuse. The surface finish will be damaged and abrasive particles can be forced into the liner material which can cause early cylinder wear-out or piston ring failures.

Tape off or plug all openings to any component interior before using abrasive pads or wire brushes. If really necessary because of time to use a power tool with abrasive pads, tape the oil drillings closed or use plug and clean as much of the surface as possible with the tool but clean around the oil hole/opening by hand so as to prevent contamination of the drilling. Then remove the tape or plug and clean the remaining area carefully and without the tool. DO NOT use compressed air to blow the debris out of oil drilling on an assembled engine! More likely than **not**, the debris can be blown further into the drilling. Using compressed air is fine if both ends of the drilling are open but that is rarely the case when dealing with an assembled engine.

Gasket Surfaces

The object of cleaning gasket surfaces is to remove any gasket material, not refinish the gasket surface of the part.

Cummins Inc. does **not** recommend any specific brand of liquid gasket remover. If a liquid gasket remover is used, check the directions to make sure the material being cleaned will **not** be harmed.

Air powered gasket scrapers can save time but care must be taken to **not** damage the surface. The angled part of the scraper must be against the gasket surface to prevent the blade from digging into the surface. Using air powered gasket scrapers on parts made of soft materials takes skill and care to prevent damage.

Do **not** scrape or brush across the gasket surface if at all possible.

Solvent and Acid Cleaning

Several solvent and acid-type cleaners can be used to clean the disassembled engine parts (other than pistons. See Below). Experience has shown that the best results can be obtained using a cleaner that can be heated to 90° to 95° Celsius (180° to 200° Fahrenheit). Kerosene emulsion based cleaners have different temperature specifications, see below. A cleaning tank that provides a constant mixing and filtering of the cleaning solution will give the best results. Cummins Inc. does not recommend any specific cleaners. Always follow the cleaner manufacturer's instructions. Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful not to damage any gasket surfaces. When possible, steam clean the parts before putting them in the cleaning tank.

WARNING

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturers recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Experience has shown that kerosene emulsion based cleaners perform the best to clean pistons. These cleaners should **not** be heated to temperature in excess of 77°C (170°F). The solution begins to break down at temperatures in excess of 82°C (180°F) and will be less effective.

Do **not** use solutions composed mainly of chlorinated hydrocarbons with cresols, phenols and/or cresylic components. They often do **not** do a good job of removing deposits from the ring groove and are costly to dispose of properly.

Solutions with a pH above approximately 9.5 will cause aluminum to turn black; therefore do **not** use high alkaline solutions.

Chemicals with a pH above 7.0 are considered alkaline and those below 7.0 are acidic. As you move further away from the neutral 7.0, the chemicals become highly alkaline or highly acidic.

Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful to **not** damage any gasket surfaces. When possible use hot high pressure water or steam clean the parts before putting them in the cleaning tank. Removing the heaviest dirt before placing in the tank will allow the cleaner to work more effectively and the cleaning agent will last longer.

Rinse all the parts in hot water after cleaning. Dry completely with compressed air. Blow the rinse water from all the capscrew holes and the oil drillings.

If the parts are **not** to be used immediately after cleaning, dip them in a suitable rust proofing compound. The rust proofing compound **must** be removed from the parts before assembly or installation on the engine.

Steam Cleaning

Steam cleaning can be used to remove all types of dirt that can contaminate the cleaning tank. It is a good method for cleaning the oil drillings and coolant passages

WARNING

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

Do **not** steam clean the following components:

- Electrical Components
- Wiring Harnesses
- Injectors
- Fuel Pump
- Belts and Hoses
- Bearings (ball or taper roller)
- Electronic Control Module (ECM)
- ECM Connectors

- Dosing Control Unit
- NOx Sensor.

Plastic Bead Cleaning

Cummins Inc. does **not** recommend the use of glass bead blast or walnut shell media on **any** engine part. Cummins Inc. recommends using **only** plastic bead media, Part Number 3822735 or equivalent on any engine part. **Never** use sand as a blast media to clean engine parts. Glass and walnut shell media when **not** used to the media manufacturer's recommendations can cause excess dust and can embed in engine parts that can result in premature failure of components through abrasive wear.

Plastic bead cleaning can be used on many engine components to remove carbon deposits. The cleaning process is controlled by the use of plastic beads, the operating pressure and cleaning time.

CAUTION

Do not use bead blasting cleaning methods on aluminum pistons skirts or the pin bores in any piston, piston skirt or piston crown. Small particles of the media will embed in the aluminum or other soft metal and result in premature wear of the cylinder liner, piston rings, pins and pin bores. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.

CAUTION

Do not contaminate wash tanks and tank type solvent cleaners with the foreign material and plastic beads. Remove the foreign material and plastic beads with compressed air, hot high pressure water or steam before placing them in tanks or cleaners. The foreign material and plastic beads can contaminate the tank and any other engine parts cleaned in the tank. Contaminated parts may cause failures from abrasive wear.

Plastic bead blasting media, Part Number 3822735, can be used to clean all piston ring grooves. Do **not** sure any bead blasting media on piston pin bores or aluminum skirts.

Follow the equipment manufacturer's cleaning instructions. Make sure to adjust the air pressure in the blasting machine to the bead manufacturer's recommendations. Turning up the pressure can move material on the part and cause the plastic bead media to wear

out more quickly. The following guidelines can be used to adapt to manufacturer's instructions:

1. Bead size: U.S. size Number 16 — 20 for piston cleaning with plastic bead media, Part Number 3822735
2. Operating Pressure — 270 kPa (40 psi) for piston cleaning. Pressure should not cause beads to break.
3. Steam clean or wash the parts with solvent to remove all of the foreign material and plastic beads after cleaning. Rinse with hot water. Dry with compressed air.

CAUTION

The bead blasting operation must not disturb the metal surface. If the metal surface is disturbed the engine can be damaged due to increased parts clearance or inadequate surface finish on parts that move against other parts.

When cleaning pistons, it is **not** necessary to remove all the dark stain from the piston. All that is necessary is to remove the carbon on the rim and in the ring grooves. This is best done by directing the blast across the part as opposed to straight at the part. If the machining marks are disturbed by the blasting process, then the pressure is too high or the blast is being held on one spot too long. The blast operation **must not** disturb the metal surface.

Walnut shell bead blast material is sometimes used to clean ferrous metals (iron and steel). Walnut shell blasting produces a great amount of dust particularly when the pressure if the air pressure on the blasting machine is increased above media manufacturer's recommendation. Cummins Inc. recommends **not** using walnut shell media to clean engine parts due to the risk media embedment and subsequent contamination of the engine.

Cummins Inc. now recommends glass bead media **NOT** used to clean any engine parts. Glass media is too easily embedded into the material particularly in soft materials and when air pressures greater than media manufacturer's recommend are used. The glass is an abrasive so when it is in a moving part, that part is abrading all the parts in contact with it. When higher pressures are used the media is broken and forms a dust of a very small size that floats easily in the air. This dust is very hard to control in the shop, particularly if **only** compressed air (and not hot water) is used to blow the media after it is removed from the blasting cabinet (blowing the part off inside the cabinet may remove large accumulations but never removes all the media).

Bead blasting is best used on stubborn dirt/carbon build-up that has **not** been removed by first steam/higher pressure washing then washing in a heated wash tank. This is particularly true of pistons. Steam and soak the pistons first then use the plastic bead method to safely remove the carbon remaining in the grooves (instead of running the risk of damaging the surface finish of the groove with a wire wheel or end of a broken piston ring. Make sure the parts are dry and oil free before bead blasting to prevent clogging the return on the blasting machine.

Always direct the bead blaster nozzle "across" rather than directly at the part. This allows the bead to get under the unwanted material. Keep the nozzle moving rather than hold on one place. Keeping the nozzle directed at one-place too long causes the metal to heat up and be moved around. Remember that the spray is **not** just hitting the dirt or carbon. If the machining marks on the piston groove or rim have been disturbed then there has **not** been enough movement of the nozzle and/or the air pressure is too high.

Never bead blast valve stems. Tape or use a sleeve to protect the stems during bead blasting. Direct the nozzle across the seat surface and radius rather than straight at them. The object is to remove any carbon build up and continuing to blast to remove the stain is a waste of time.

Fuel System

When servicing any fuel system components, which can be exposed to potential contaminants, prior to disassembly, clean the fittings, mounting hardware, and the area around the component to be removed. If the surrounding areas are **not** cleaned, dirt or contaminants can be introduced into the fuel system.

The internal drillings of some injectors are extremely small and susceptible to plugging from contamination. Some fuel injection systems can operate at very high pressures. High pressure fuel can convert simple particles of dirt and rust into a highly abrasive contaminant that can damage the high pressure pumping components and fuel injectors.

Electrical contact cleaner can be used if steam cleaning tools are **not** available. Use electrical contact cleaner rather than compressed air, to wash dirt and debris away from fuel system fittings. Diesel fuel on exposed fuel system parts attracts airborne contaminants.

Choose lint free towels for fuel system work.

Cap and plug fuel lines, fittings, and ports whenever the fuel system is opened. Rust, dirt, and paint can enter the fuel system whenever a fuel line or other component is loosened or removed from the engine. In many instances, a good practice is to loosen a line or fitting to break the rust and paint loose, and then clean off the loosened material.

When removing fuel lines or fittings from a new or newly-painted engine, make sure to remove loose paint flakes/chips that can be created when a wrench contacts painted line nuts or fittings, or when quick disconnect fittings are removed.

Fuel filters are rated in microns. The word micron is the abbreviation for a micrometer, or one millionth of a meter. The micron rating is the size of the smallest particles that will be captured by the filter media. As a reference, a human hair is 76 microns [0.003 in] in

diameter. One micron measures 0.001 mm [0.00004 in.]. The contaminants being filtered out are smaller than can be seen with the human eye, a magnifying glass, or a low powered microscope.

The tools used for fuel system troubleshooting and repair are to be cleaned regularly to avoid contamination. Like fuel system parts, tools that are coated with oil or fuel attract airborne contaminants. Remember the following points regarding your fuel system tools:

- Fuel system tools are to be kept as clean as possible.
- Clean and dry the tools before returning them to the tool box.
- If possible, store fuel system tools in sealed containers.
- Make sure fuel system tools are clean before use.

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204-009 Acronyms and Abbreviations

General Information

The following list contains some of the acronyms and abbreviations used in this manual.

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
BTU	British Thermal Unit
BTDC	Before Top Dead Center
°C	Celsius
CO	Carbon Monoxide
CCA	Cold Cranking Amperes
CARB	California Air Resources Board
C.I.B.	Customer Interface Box
C.I.D.	Cubic Inch Displacement
CNG	Compressed Natural Gas
CPL	Control Parts List
cSt	Centistokes
DEF	Diesel Exhaust Fluid
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
ECM	Engine Control Module
EFC	Electronic Fuel Control
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency

°F	Fahrenheit
ft-lb	Foot-Pound Force
FMI	Failure Mode Indentifier
GVW	Gross Vehicle Weight
Hg	Mercury
hp	Horsepower
H_2O	Water
inHg	Inches of Mercury
in H_20	Inches of Water
ICM	Ignition Control Module
IEC	International Electrotechnical Commission
km/l	Kilometers per Liter
kPa	Kilopascal
LNG	Liquid Natural Gas
LPG	Liquified Petroleum Gas
LTA	Low Temperature Aftercooling
MIL	Malfunction Indicator Lamp
MPa	Megapascal
mph	Miles Per Hour
mpq	Miles Per Quart
N•m	Newton-meter
NOx	Mono-Nitrogen Oxides
NG	Natural Gas
O2	Oxygen
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PID	Parameter Identification Descriptions
ppm	Parts Per Million
psi	Pounds Per Square Inch
PTO	Power Takeoff
REPTO	Rear Power Take Off

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RGT	Rear Gear Train
rpm	Revolutions Per Minute
SAE	Society of Automotive Engineers
SCA	Supplemental Coolant Additive
SCR	Selective Catalytic Reduction
STC	Step Timing Control
SID	Subsystem Identification Descriptions
VDC	Volts of Direct Current
VS	Variable Speed
VSS	Vehicle Speed Sensor

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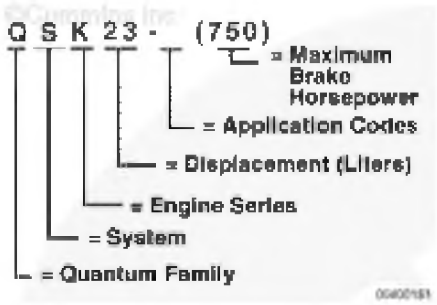
100-001 Engine Identification

Cummins Engine Nomenclature

The model name provides identification data for the engine. Refer to the illustration for the model name identification.

The applications codes are:

- A = Agricultural
- C = Construction
- D = Generator drive
- F = Fire pump
- G = Generator set
- L = Locomotive
- M = Marine
- P = Power unit
- R = Railcar
- T = Tactical military.

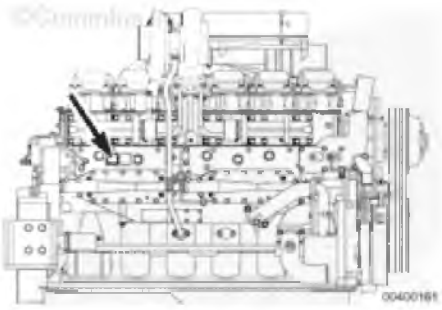


Engine Dataplate

The engine dataplate shows specific information about the engine. The engine serial number (ESN), Control Parts List (CPL), model, horsepower and rpm ratings , and Environmental Protection Agency

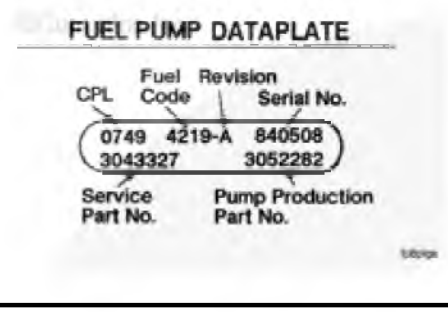
(EPA) information provide information for ordering parts and service needs.

The engine dataplate **must not** be changed unless approved by Cummins Inc.



Fuel Pump Dataplate

The fuel pump dataplate is located on the top of the fuel pump. It provides information for fuel pump calibration.

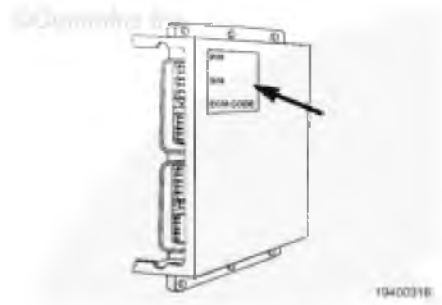


ECM Dataplate

The external ECM dataplate is located on top of the ECM.

The dataplate contains the following:

- ECM part number (P/N)
- ECM serial number (S/N)
- Manufacturer date code (D/C)



• Supplier identifier (S/I) • Input voltage rating of the ECM (V/R). The dataplate on the right contains engine and calibration information. This includes the engine serial number (ESN), ECM calibration date (Date), and ECM calibration code.		

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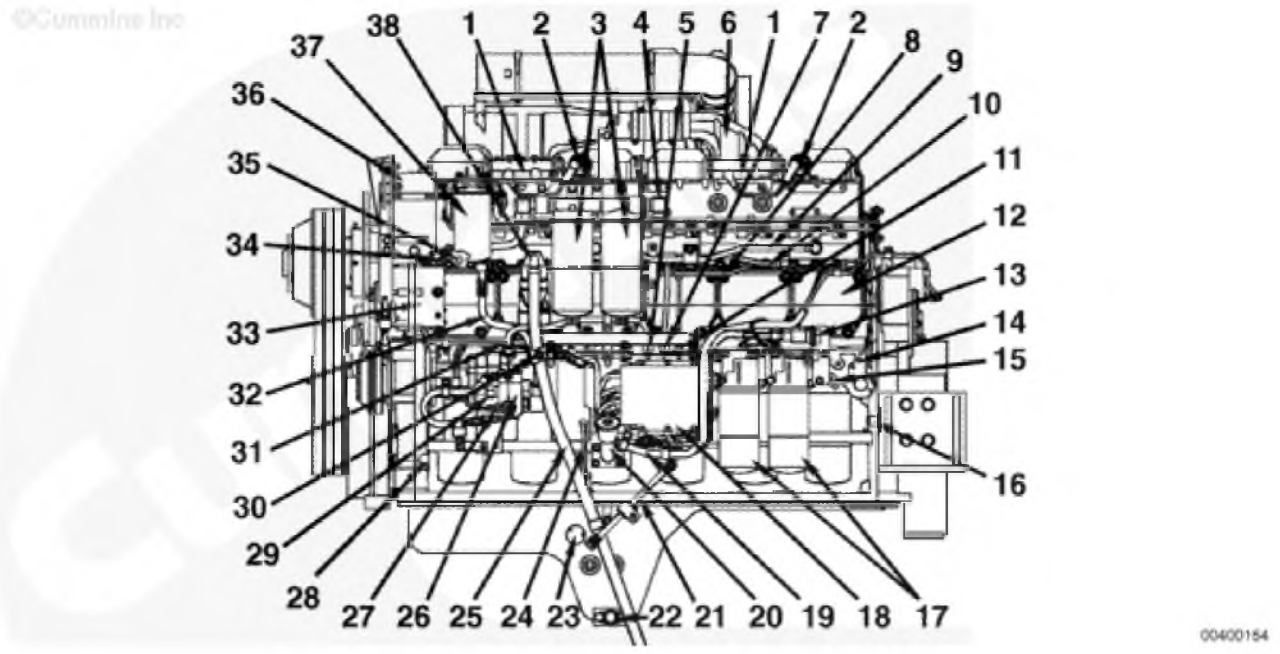
100-002 Engine Diagrams

Engine Views

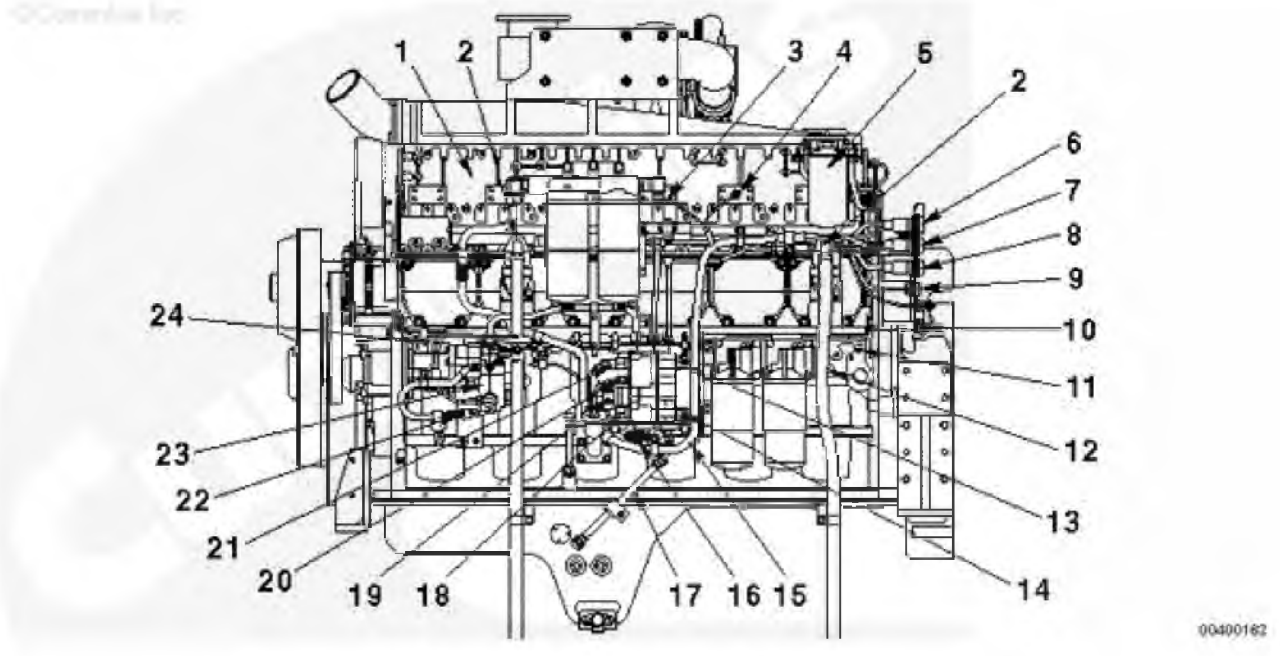
The illustrations show the locations of the major external engine components, filters, and other service and maintenance points. Some external components will be at different locations for different engine models.



Left Side - Industrial

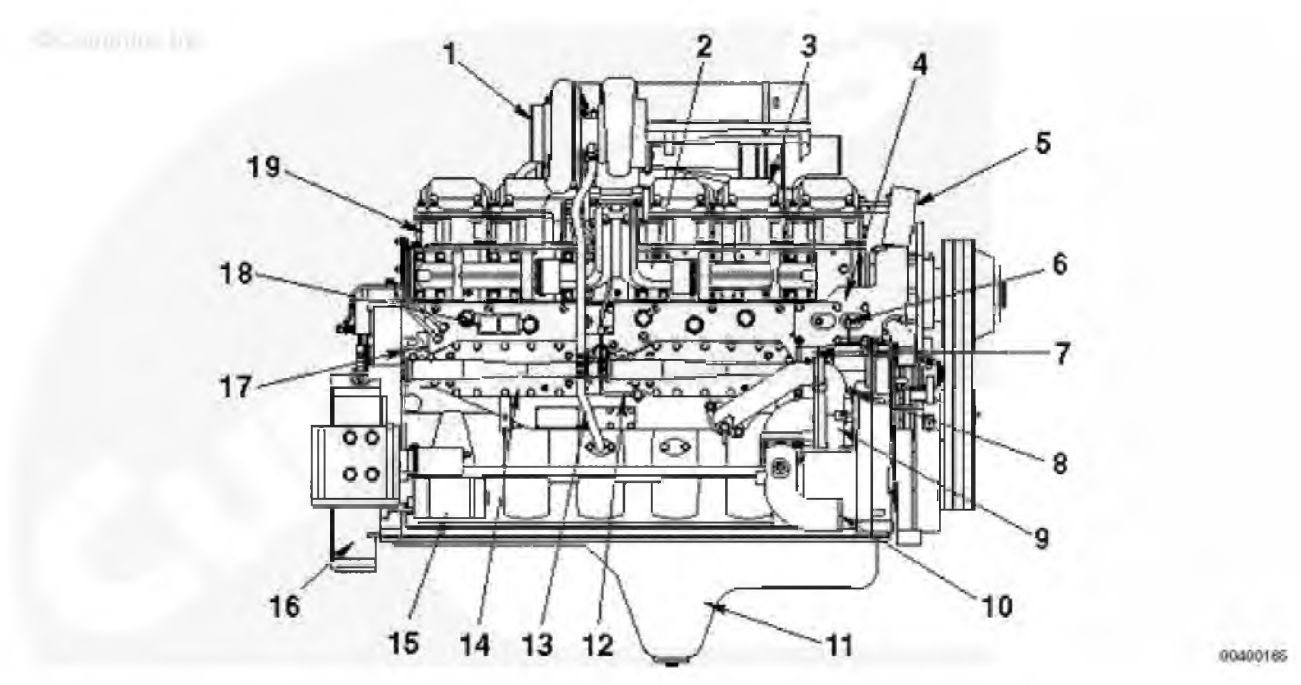
1. Grid heaters (Industrial **only**)
2. Grid heater relays (Industrial **only**)
3. Fuel filters
4. Fuel inlet (to filters)
5. Fuel inlet (to ECVA)
6. Air intake connection (Industrial **only**)

7. Fuel timing supply
8. Fuel pipe (to fuel rail)
9. Fuel pipe (return)
10. Fuel pipe (for injection timing)
11. Fuel rail supply
12. Cam follower cover
13. OEM electrical connections (Industrial **only**)
14. Oil pressure checkpoint (after filters)
15. Oil pressure checkpoint (before filters)
16. Engine barring device
17. Oil filters
18. ECVA/ECM
19. Wiring harness
20. Oil fill port
21. Fuel rail dampening hose
22. Engine oil drain valve
23. Oil level sensor (optional)
24. Dipstick
25. Blowby tube
26. Fuel pump
27. Fuel pump pressure sensor
28. Oil pressure check point (to front idler gears)
29. Fuel pump actuator
30. Oil pressure sensor
31. Fuel pipe (pump to ECVA)
32. Fuel pipe (filters to pump)
33. Alternator
34. Intake manifold pressure sensor (Industrial **only**)
35. Intake manifold temperature sensor (Industrial **only**)
36. Refrigerant compressor mounting location
37. Coolant filter (Industrial **only**)
38. Crankcase breather assembly.



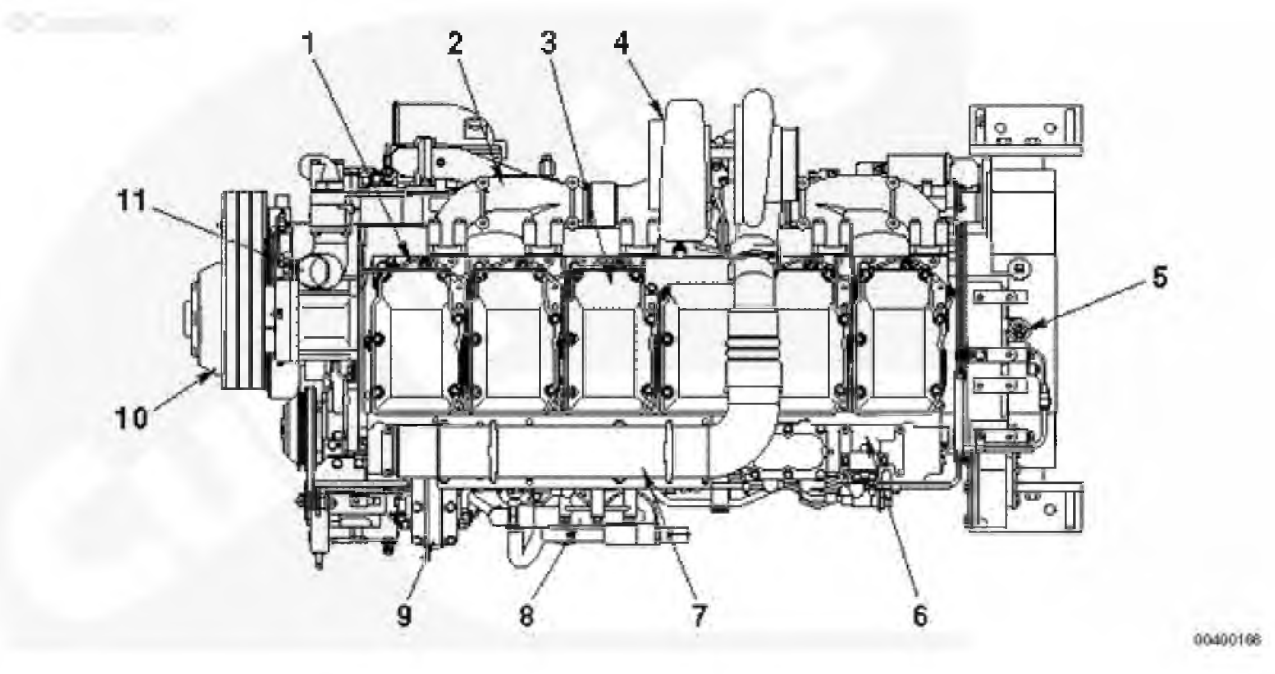
Left Side - Power Generation

1. Intake manifold (Power Generation **only**)
2. Crankcase breathers
3. Intake manifold pressure sensor (Power Generation **only**)
4. Intake manifold temperature sensor (Power Generation **only**)
5. Coolant filter (Power Generation **only**)
6. Inline B connector (Power Generation **only**)
7. Inline A connector (Power Generation **only**)
8. Inline C connector (Power Generation **only**)
9. Datalink connector (Power Generation **only**)
10. Engine speed sensor (Power Generation **only**)
11. Oil pressure checkpoint (after filters)
12. Oil pressure checkpoint (before filters)
13. Fuel timing pressure sensor
14. Fuel rail pressure sensor
15. Wiring harness
16. Barometric pressure sensor
17. Fuel rail dampening hose
18. Fuel rail actuator
19. Fuel shutoff valve
20. Fuel temperature sensor
21. Fuel timing actuator
22. Fuel pump pressure sensor
23. Fuel pump actuator
24. Oil pressure sensor.



Right Side - Industrial and Power Generation

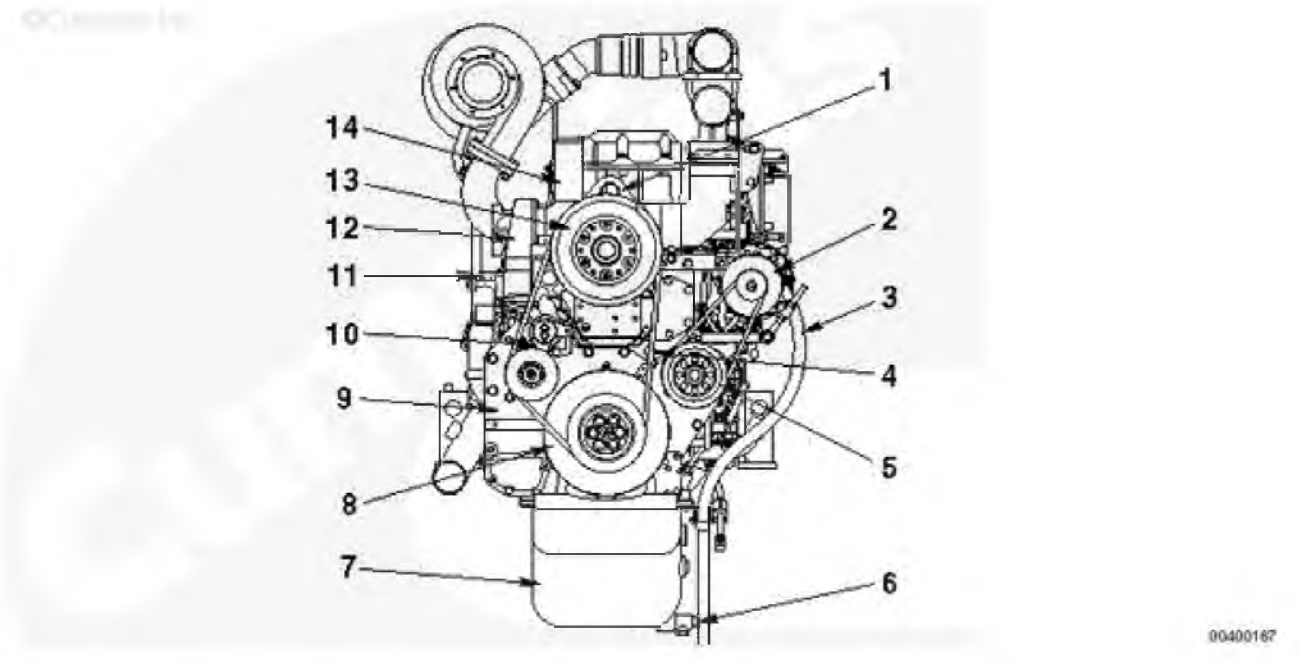
1. Turbocharger
2. Exhaust manifold (3-piece)
3. Rocker lever cover
4. Thermostat housing
5. Engine coolant outlet
6. Coolant temperature sensor
7. Coolant bypass tube
8. Oil pressure checkpoint (piston cooling nozzle gallery)
9. Water pump
10. Engine coolant inlet
11. Oil pan
12. Turbocharger oil supply line
13. Turbocharger oil drain line
14. Oil cooler housing
15. Starter
16. Flywheel housing
17. Oil pressure checkpoint (after oil coolers)
18. Engine dataplate
19. Rocker lever housing.



Top View - Industrial and Power Generation

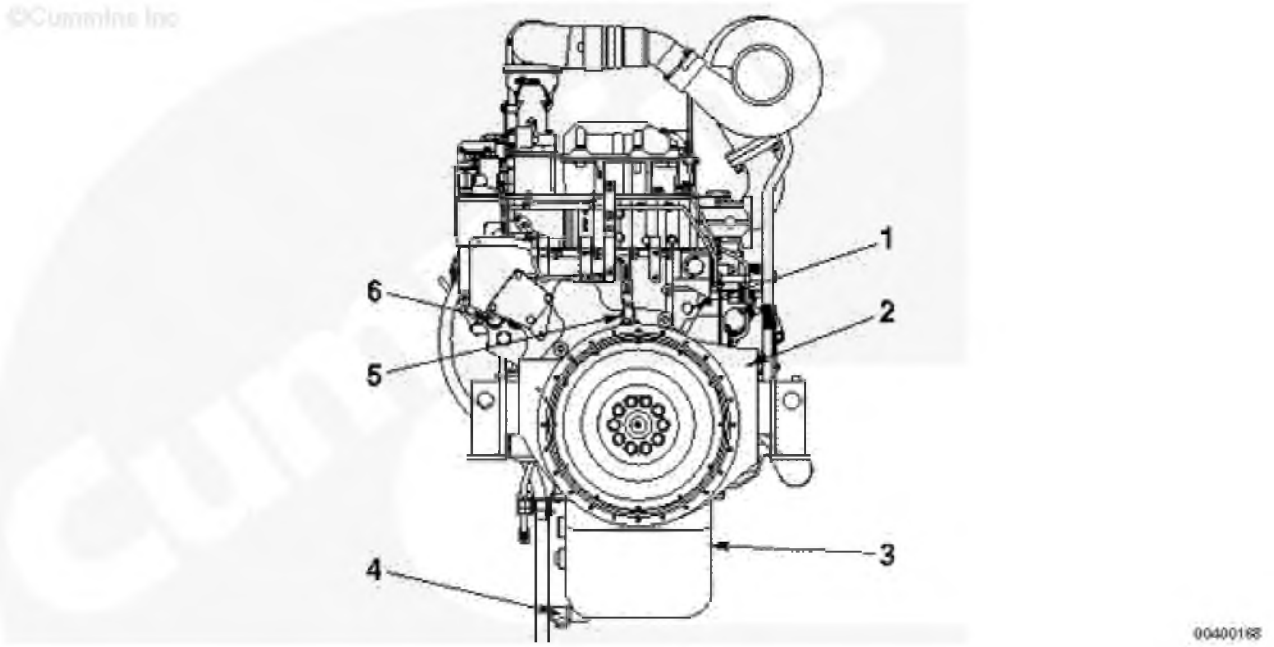
1. Coolant vent tube
2. Exhaust manifold
3. Rocker lever cover
4. Turbocharger
5. Engine speed sensor (Industrial **only**)
6. Intake manifold
7. Charge air piping (turbocharger to CAC)
8. Fuel filter head

9. Coolant filter head (Industrial **only**)
10. Fan hub assembly
11. Engine coolant outlet.



Front View - Industrial and Power Generation

1. Front engine lifting bracket
2. Alternator
3. Blowby tube
4. Cooling fan drive belt
5. Drive pulley (for alternator and refrigerant compressor)
6. Oil drain valve
7. Oil pan
8. Vibration damper
9. Front gear cover
10. Cooling fan belt tensioner (Industrial **only**)
11. Coolant temperature sensor
12. Thermostat housing
13. Fan hub assembly
14. Engine coolant outlet.



Rear View - Industrial and Power Generation

1. Oil pressure checkpoint (after oil coolers)
2. Flywheel housing
3. Oil pan
4. Engine oil drain valve
5. Engine speed sensor (Industrial **only**)
6. OEM electrical connections (Industrial **only**).

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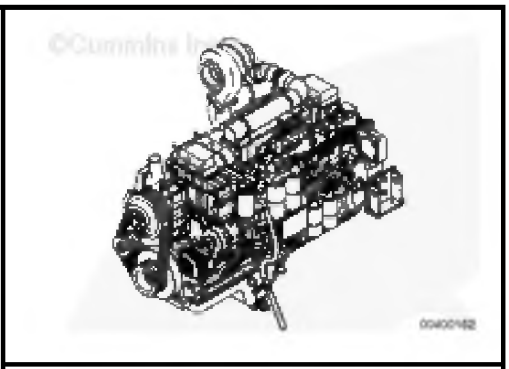
001-999 Cylinder Block - Overview

General Information

The QSK23 cylinder block is a robust design made of a one-piece iron casting. It has a solid and durable design to absorb internal forces and to enable resilient mounting. The one-piece iron block employs both front and rear gear housings. The oil pump housing and water jacket are also integrated into the cylinder block.



Crankshaft

The QSK23 crankshaft is made of forged high tensile steel.

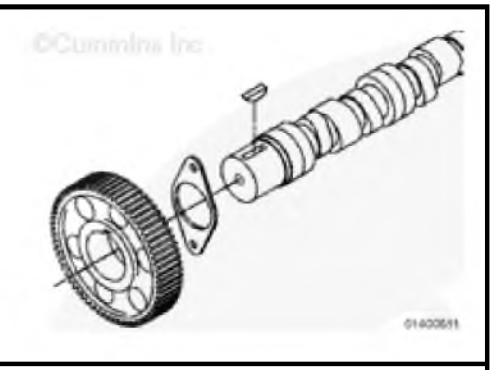
Vibration Damper

The QSK23 uses a viscous vibration damper mounted on the crankshaft nose. The vibration damper reduces the crankshaft torsional vibration and reduces gear train loading.

Cylinder Liner

The QSK23 uses a pressed-in, removable, cylinder liner. The liner has a 170 mm [6.69 in] bore and incorporates a top stop liner design. The top stop liner design features special honing for oil control and related piston ring wear. It also provides improved top ring cooling, improved

resistance to liner cavitation, and improvements to the cylinder head attachment joint due to low bending stress. Piston The QSK23 uses single piece ferrous cast ductile iron pistons. These pistons reduce piston-to-liner clearance for improvements in oil consumption, and optimize liner ovality and thereby the likelihood of liner “ringing”. Cast iron is used for its high strength and superior durability.		

Camshaft The QSK23 camshaft measures 105 mm [4.13 in] in diameter. A big cam diameter was incorporated to drive high pressure unit injectors. A special surface treatment was applied on cam follower roller surfaces to maintain adequate lubrication.		

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002-999 Cylinder Head - Overview

General Information

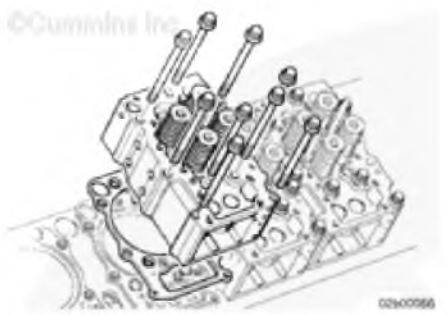
The QSK23 cylinder head is constructed from gray cast iron. The design features two intake and two exhaust valves per cylinder. The head incorporates efficient water cooling jackets for improved cooling of the thermally-loaded combustion deck.

The cylinder head is attached to the cylinder block using seven 16.5 mm x 230 mm capscrews and two 12 mm x 170 mm capscrews. The torque turn method is used to tighten these capscrews.

The intake and exhaust valve seat inserts are made of different materials and are **not** interchangeable between intake and exhaust positions.

The QSK23 cylinder head gasket has seals around all oil passages, coolant passages, and capscrew holes. The cylinder head is **not** interchangeable with the QSK78 cylinder head due to coolant drilling differences.

The QSK23 cylinder head uses a guided stem, adjustable crosshead design.



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003-999 Rocker Levers - Overview

General Information

Rocker Lever Covers

The QSK23 rocker lever covers are made of cast aluminum and utilize re-usable o-ring type valve cover gaskets.

Injector Levers

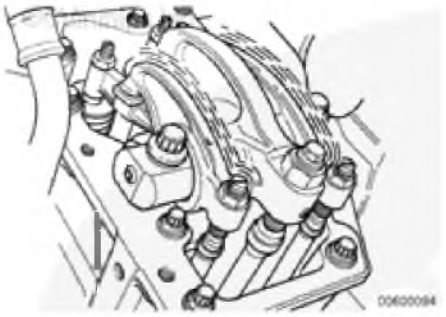
The QSK23 injector levers are made from forged steel.

Rocker Levers

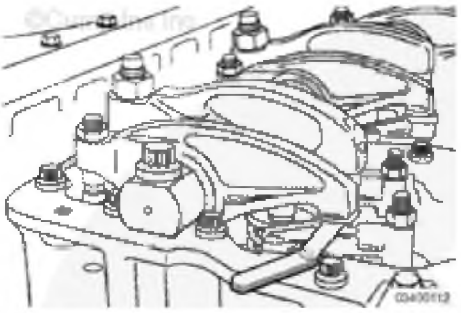
Each QSK23 rocker lever is a single piece, solid design with a precision-ground nose radius.

Rocker Lever Shaft

The QSK23 uses a large 45 mm [1.77 in] rocker lever shaft diameter due to high injector train loads.



The valves and injectors are adjusted using the outer base circle (OBC) feeler gauge, or screwdriver method.



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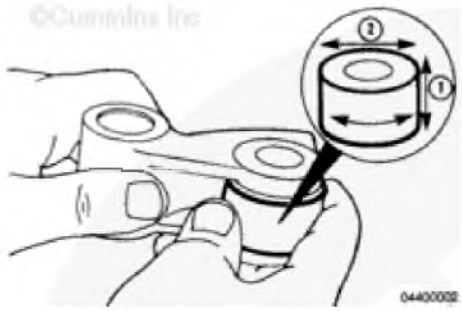
004-999 Cam Followers/Tappets - Overview

General Information

A special surface treatment is applied to the QSK23 cam follower roller surfaces to maintain adequate lubrication. The cam follower, push tube, and rocker lever are optimized to keep rigidity during injection pressures, to reduce weight, and reduce the possibility of drive system no follow conditions. Cam follower roller pins are assembled using liquid nitrogen. Replacement rollers and pins are **not** available for service. If the roller fails, the entire cam follower roller assembly **must** be replaced. The cam follower rollers are micro-finished and have a complex crown. The rollers **must not** be reground for service.



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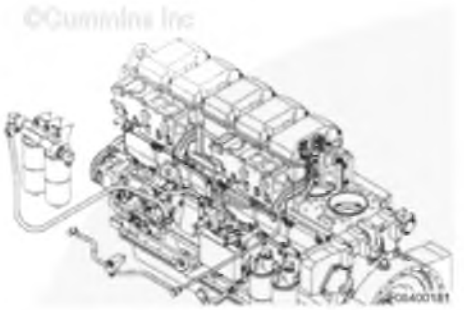
005-999 Fuel System - Overview

General Information

Fuel System

The QSK23 engine is equipped with the Quantum™ fuel system. The Quantum™ fuel system provides full electronic control of the engine with high-pressure fuel injection.



Operation

The QSK23 fuel pump supplies regulated pressure to the control valve assembly for the rail and timing as a function of speed. The fuel is supplied to both the rail and timing actuators. The actuators act as throttles to control the amount of fuel metered to the injector and timing supply lines. Timing and rail pressure sensors, after the actuators, measure the actual supplied pressures. The ECM compares the actual supplied pressures to the desired supply pressures. Desired supply pressure is based on throttle position and speed inputs. The ECM then communicates to the actuator to change spool plunger position which changes the flow orifice area until the desired pressures are obtained.

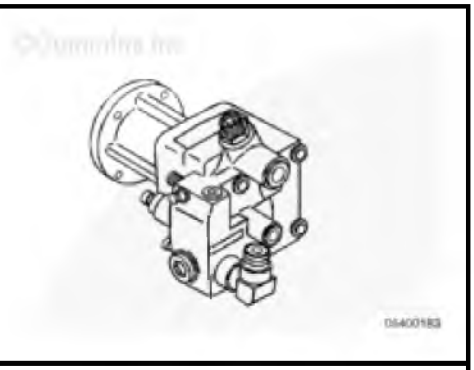
Fuel Filter

The QSK23 requires two 10-micron fuel filters with water separators, Fleetguard® Part Number FS1006, to provide injector and control valve protection.

Fuel Pump

The QSK23 has an electronically-controlled fuel pump that regulates output pressure to specific values based on a given engine speed. The pump has a fuel bypass regulator circuit controlled by an actuator. The actuator receives its command from the ECM based on the pump pressure sensor and the engine speed sensor.

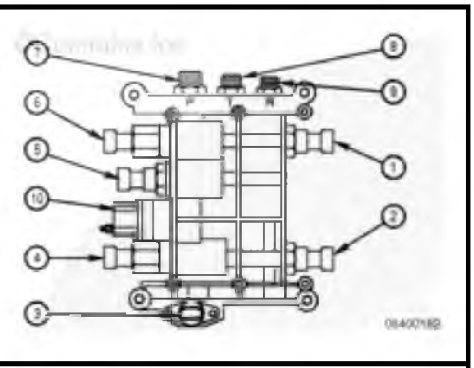
The QSK23 fuel pump is very similar to the pump used on QSK45, QSK60, and QSK78 series engines.



Electronic Control Valve Assembly (ECVA)

The electronic control valve assembly is located on the fuel pump side of the engine. The assembly contains the following actuators and sensors:

1. Timing rail pressure sensor
2. Fuel rail pressure sensor
3. Barometric pressure sensor
4. Fuel rail actuator
5. Fuel temperature sensor
6. Timing rail actuator
7. Fuel supply inlet
8. Timing rail outlet
9. Fuel rail outlet
10. Fuel shutoff valve.



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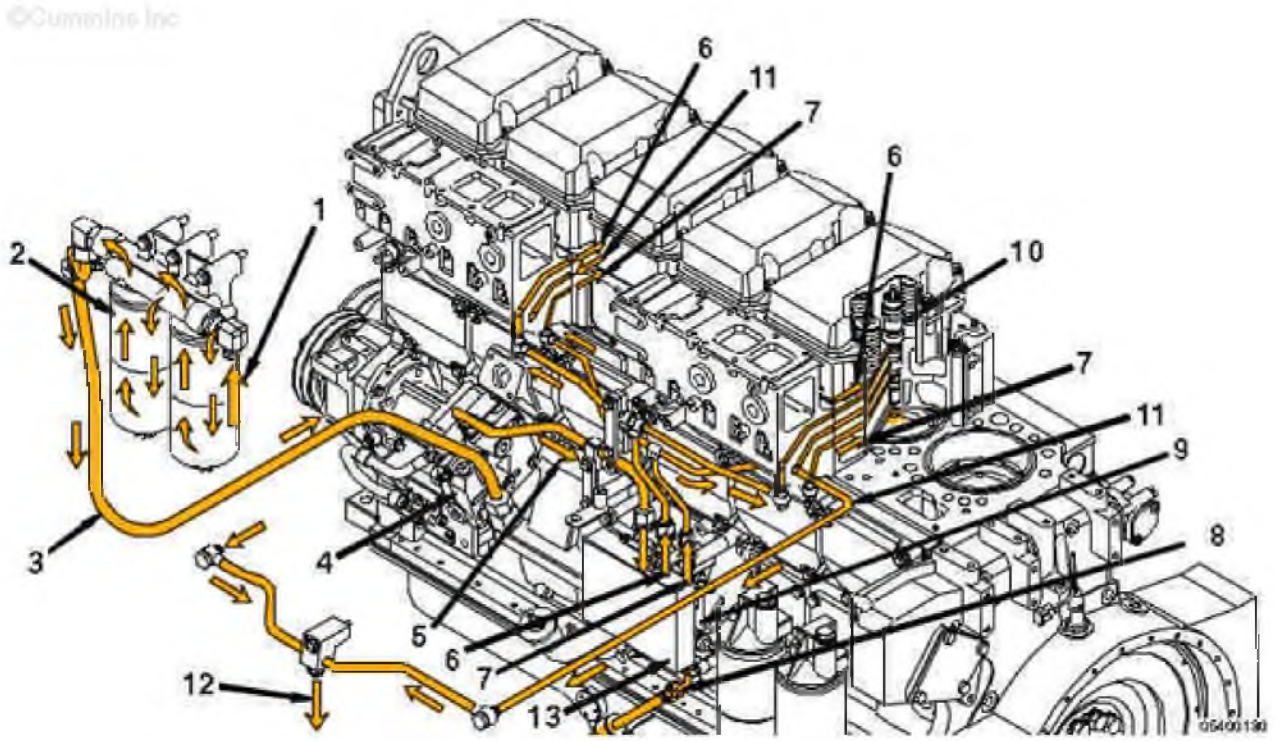
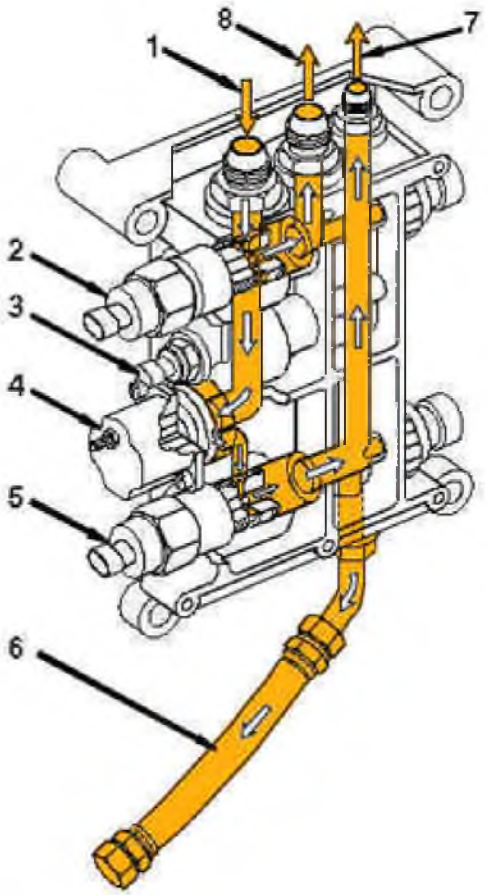
200-001 Flow Diagram, Fuel System

Fuel System



1. Fuel inlet from tank
2. Fuel filters with water separation
3. Fuel pump inlet tube
4. Fuel pump
5. Fuel control valve supply tube
6. Fuel timing supply tube
7. Fuel rail supply tube
8. Fuel rail dampening hose
9. Electronic fuel control valve assembly
10. Injector
11. Fuel return tube
12. Fuel drain (engine to fuel tank)

13. ECM.



1. Fuel inlet from pump
2. Fuel timing actuator
3. Fuel temperature sensor
4. Fuel shutoff valve
5. Fuel rail actuator
6. Fuel rail dampening hose
7. Fuel to fuel rail
8. Fuel to fuel timing.

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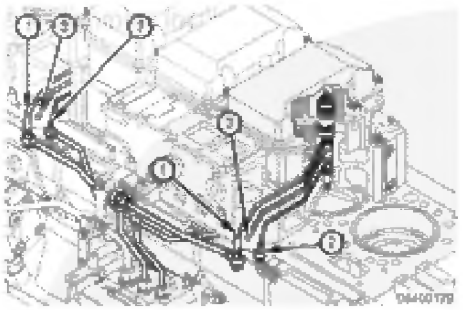
006-999 Injectors and Fuel Lines - Overview

General Information

Fuel Tubes

The QSK23 fuel rail supply (1), timing rail supply (2), and fuel drain (3) are integrated into the intake manifold housing.



Fuel supply and drain lines are sized to provide sufficient flow for injection and timing functions. Straight thread face o-ring fittings are used for superior leak prevention.

The recommended fuel pump inlet line size provides a maximum clean filter restriction of 102 mm Hg [4 in Hg] at high idle-no load.

The fuel drain fitting provides a maximum drain line restriction of 203 mm Hg [8 in Hg].

The fuel temperature at the fuel pump inlet **must not** exceed 71°C [160°F]. A fuel cooler in the fuel drain circuit will possibly be required. The fuel cooler is to be provided by the original equipment manufacturer (OEM).

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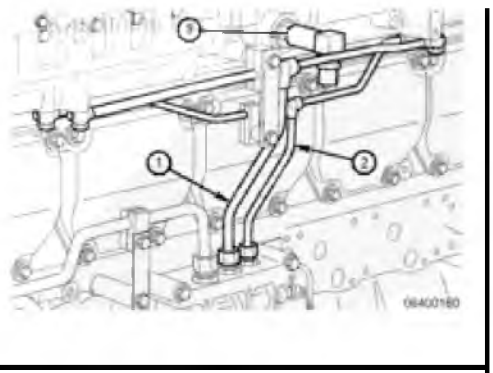
The fuel rails in the intake manifold receive fuel from the Electronic Control Valve Actuator (ECVA) through a fuel rail supply tube (1) and fuel timing supply tube (2). The fuel then passes through the fuel rails, through the cylinder head, and into the injectors. Unused fuel flows back through the cylinder head, into the fuel rail, and out through the fuel drain fitting (3) to return to the fuel tank.

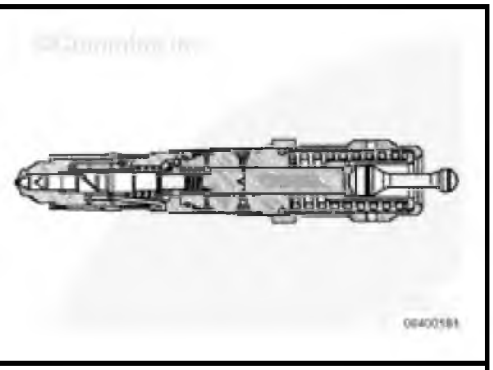
Industrial applications with dual intake manifolds will have a steel return line connecting the two manifolds to the fuel drain fitting.



Quantum™ Injector

The QSK23 Quantum™ injector begins operation with metering. The lower plunger retracts during the inner base circle portion of the camshaft profile, thus uncovering the rail feed port. The fuel is Pressure Time (PT) metered into the nozzle. The amount metered is a function of rail pressure and engine speed. This supply pressure will be as high as 1379 kPa [200 psi] at maximum fueling/speed and as low as 13.8 kPa [2 psi] at idle.

The timing fuel is also PT metered through a separate metering port into a chamber between the upper and timing plungers in the barrel. This also occurs during the inner base circle portion of the camshaft profile beginning when the upper plunger retracts and uncovers the timing feed port. Timing metering ends when the camshaft drives the upper plunger downward, covering the metering feed port and trapping the fuel between the upper and timing plungers. This trapped fuel acts as a solid hydraulic link. The lower plunger also moves downward, closing the rail feed port and ending injected fuel metering.



The amount of fuel metered into the timing chamber determines the amount of separation of the upper and timing plungers. This separation amount, called overtravel, varies from an approximate minimum of 2 mm [0.078 in] at torque peak fueling to a maximum of 9 mm [0.354 in] at high idle fueling. The amount of overtravel is changed to vary the start of injection for all speed and fueling conditions.		

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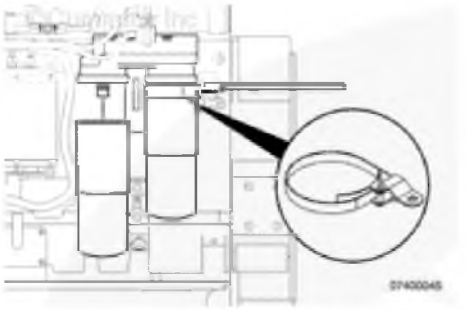
007-999 Lubricating Oil System - Overview

General Information

The QSK23 engine has two spin-on lubricating filter canisters. These filters can be replaced with Fleetguard® media with a wire mesh backing to obtain 10-micron filtering capability and long life.

The venturi combo filter design provides for both full-flow and bypass lubricating oil filtration in the same canister, eliminating the requirement for bypass filters. The filters are **only** mounted on the left side (fuel pump side) of the engine.

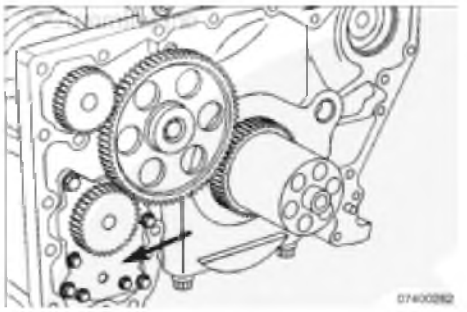
Cummins Inc. recommends using Fleetguard® venturi combo filters, Part Number LF9325, at each oil change interval.



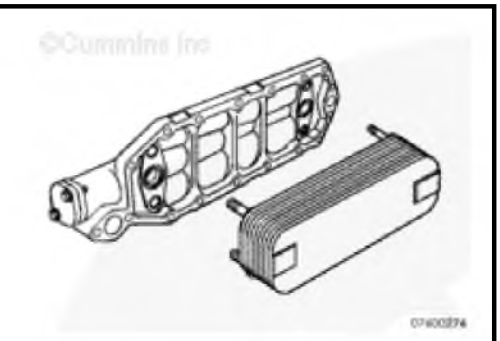
The QSK23 uses an oil pump idler gear which drives the lubricating oil pump at the front of the engine.

The QSK23 high-pressure relief valve is located internally in the lubricating oil pump. The relief pressure is 883 kPa [128 psi].

The high-pressure relief valve also serves



as the primary oil pressure regulator located internal to the lubricating oil pump. Regulated oil rifle pressure is 393 to 552 kPa [57 to 80 psi] at rated rpm.		

The QSK23 uses two oil coolers in parallel. Each cooler housing contains a thermostat which begin opening at 85°C [185°F] and fully open at 100°C [212°F]. Lubricating oil is routed from the oil pump through the oil coolers, across the rear of the engine, and to the oil filters. The oil then flows to the main oil gallery which supplies oil to the crankshaft, rod bearings, piston cooling nozzle gallery, camshaft, front and rear gear train, and turbocharger. There are multiple oil pressure ports for OEM usage.		

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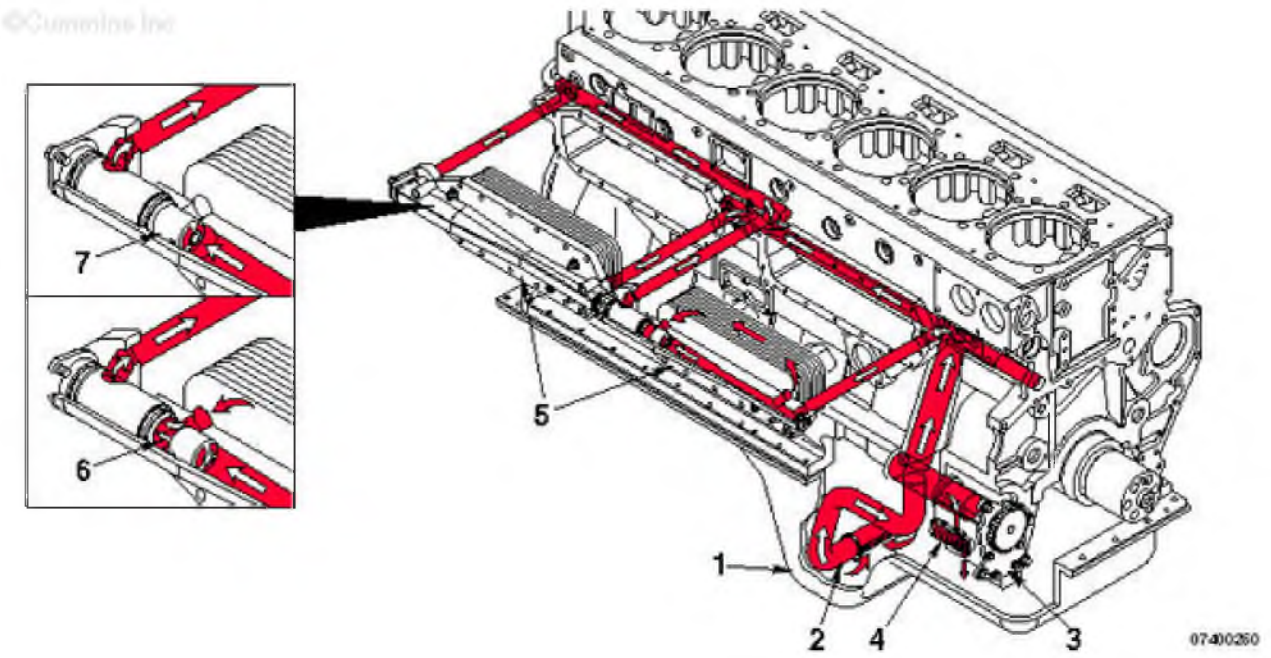
200-002 Flow Diagram, Lubricating Oil System

Flow Diagram



1. Lubricating oil pan
2. Lubricating oil suction tube
3. Lubricating oil pump
4. Lubricating oil pressure regulator valve
5. Lubricating oil coolers
6. Lubricating oil cooler thermostat (open)
7. Lubricating oil cooler thermostat (closed).

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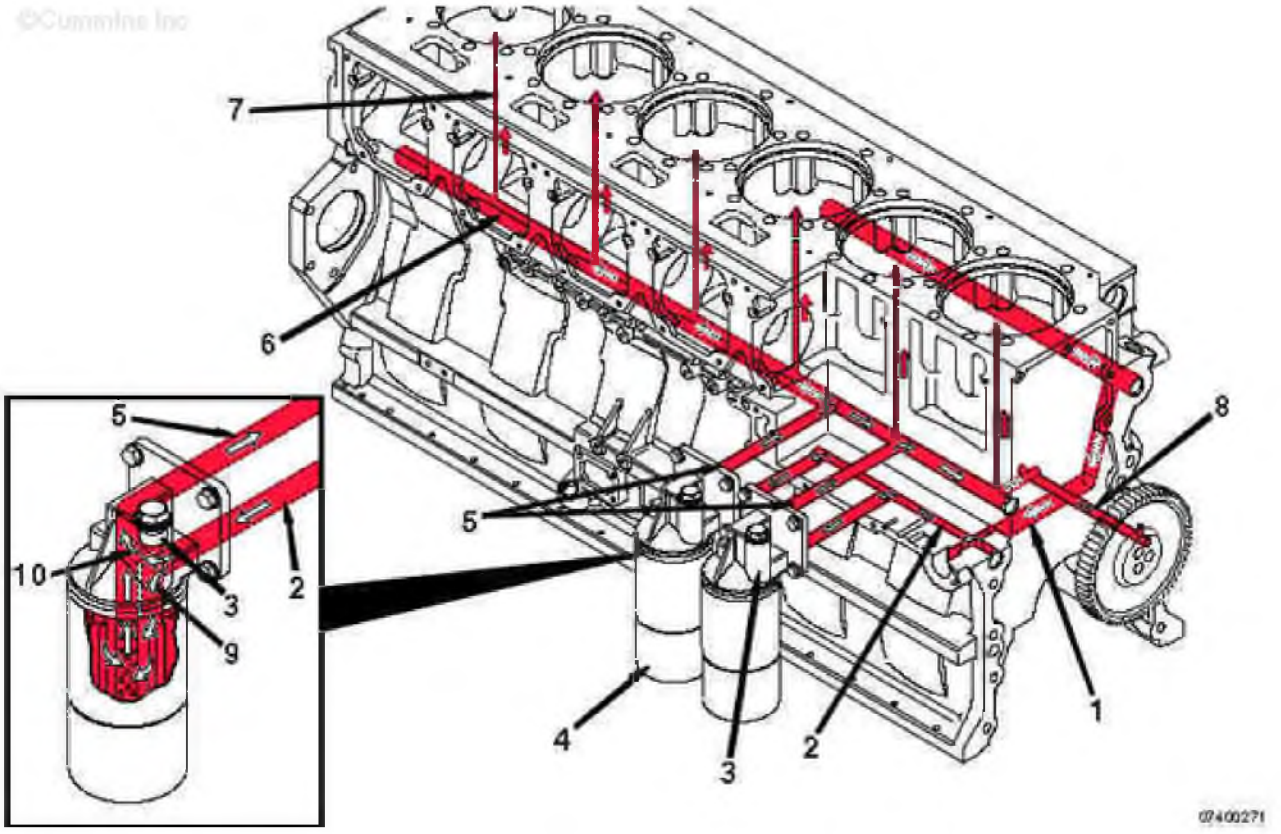
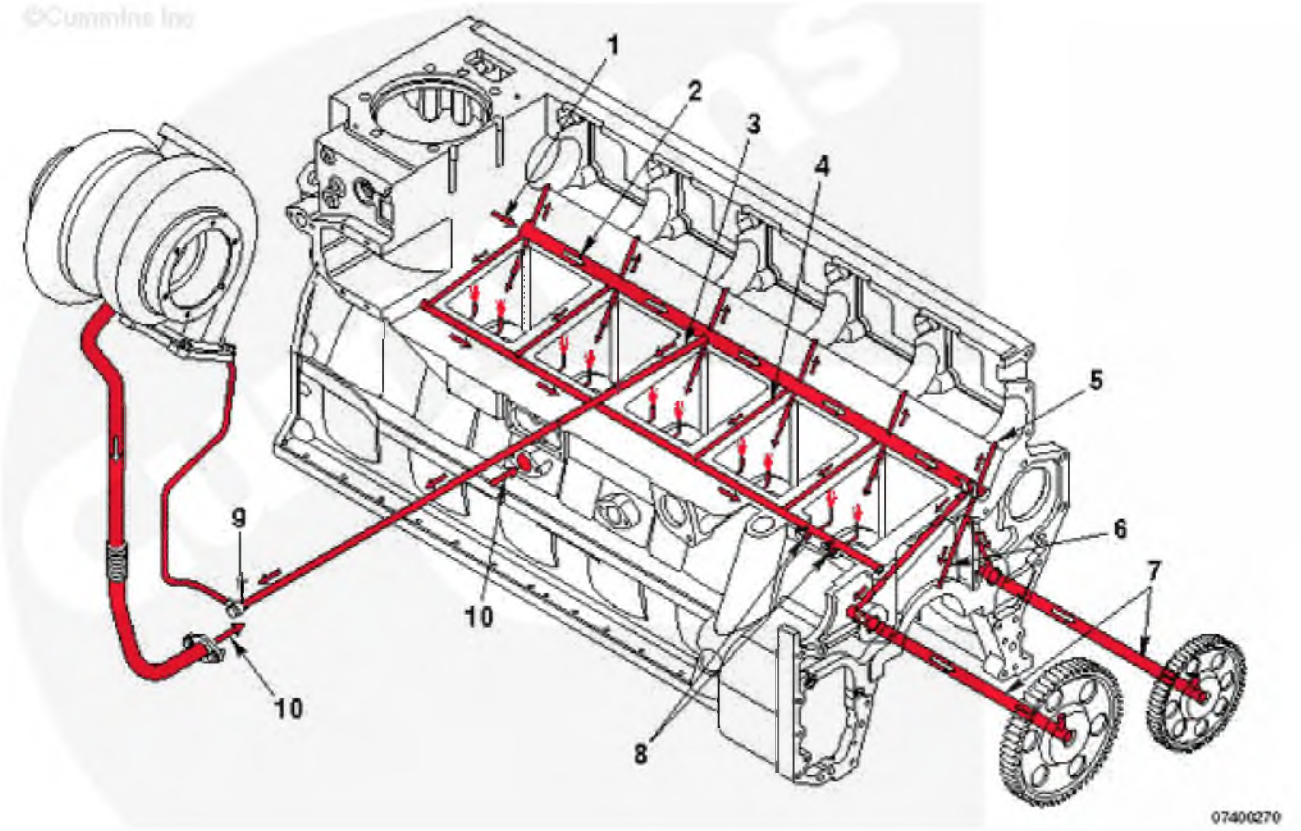
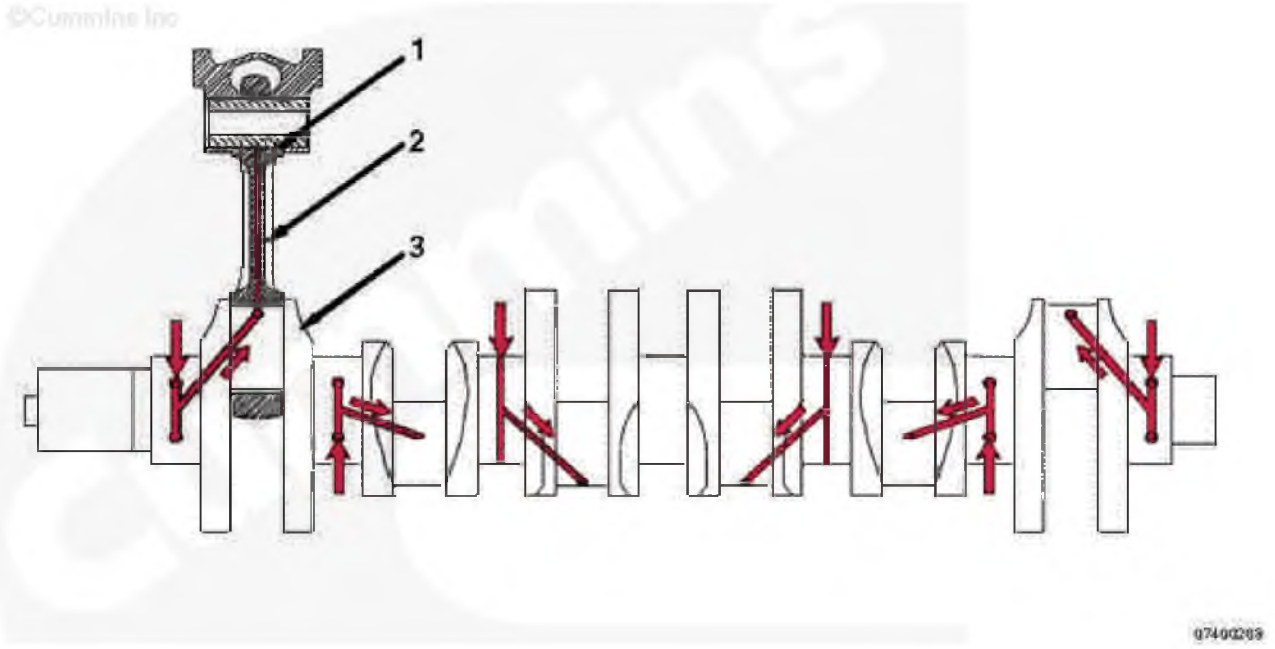


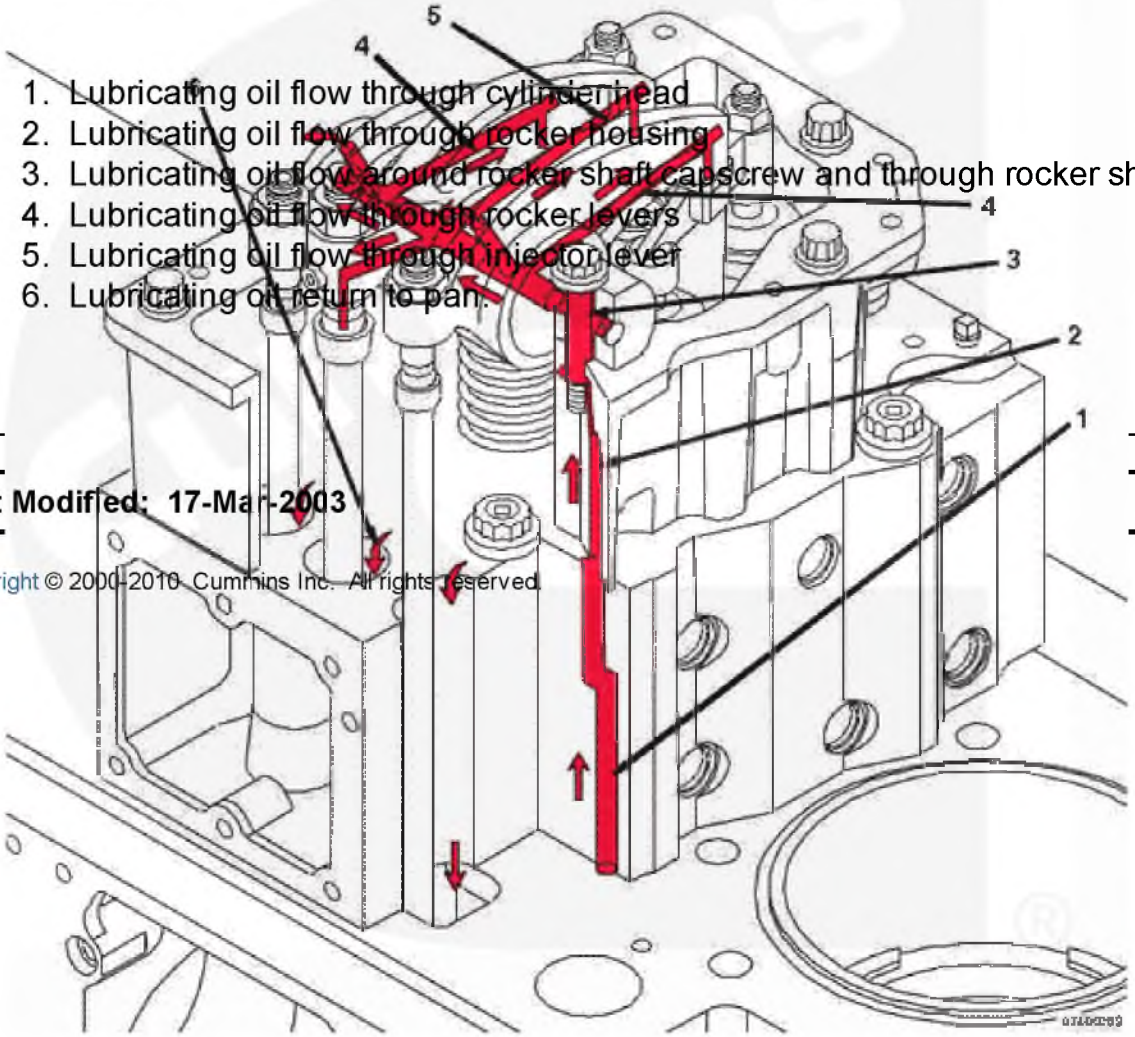
1. Lubricating oil flow from oil coolers
2. Lubricating oil flow to filters
3. Lubricating oil filter bypass valve(s)
4. Lubricating oil filter(s)
5. Lubricating oil from filters
6. Main lubricating oil rifle
7. Lubricating oil flow to cylinder head
8. Lubricating oil flow to rear idler gear
9. Normal lubricating oil flow through filter
10. Bypass lubricating oil flow.



1. Lubricating oil flow from filters
2. Main lubricating oil rifle
3. Lubricating oil drilling to turbocharger supply
4. Lubricating oil drilling to piston cooling nozzle oil rifle
5. Lubricating oil flow to camshaft bushings and cylinder head
6. Lubricating oil flow to main bearings and crankshaft
7. Lubricating oil flow to front idler gears
8. Lubricating oil flow to piston cooling nozzles
9. Turbocharger oil supply tube
10. Turbocharger oil drain to crankcase.



1. Piston pin bushing
2. Connecting rod
3. Crankshaft.



1. Lubricating oil flow through cylinder head
2. Lubricating oil flow through rocker housing
3. Lubricating oil flow around rocker shaft capscrew and through rocker shaft
4. Lubricating oil flow through rocker levers
5. Lubricating oil flow through injector lever
6. Lubricating oil return to pan.

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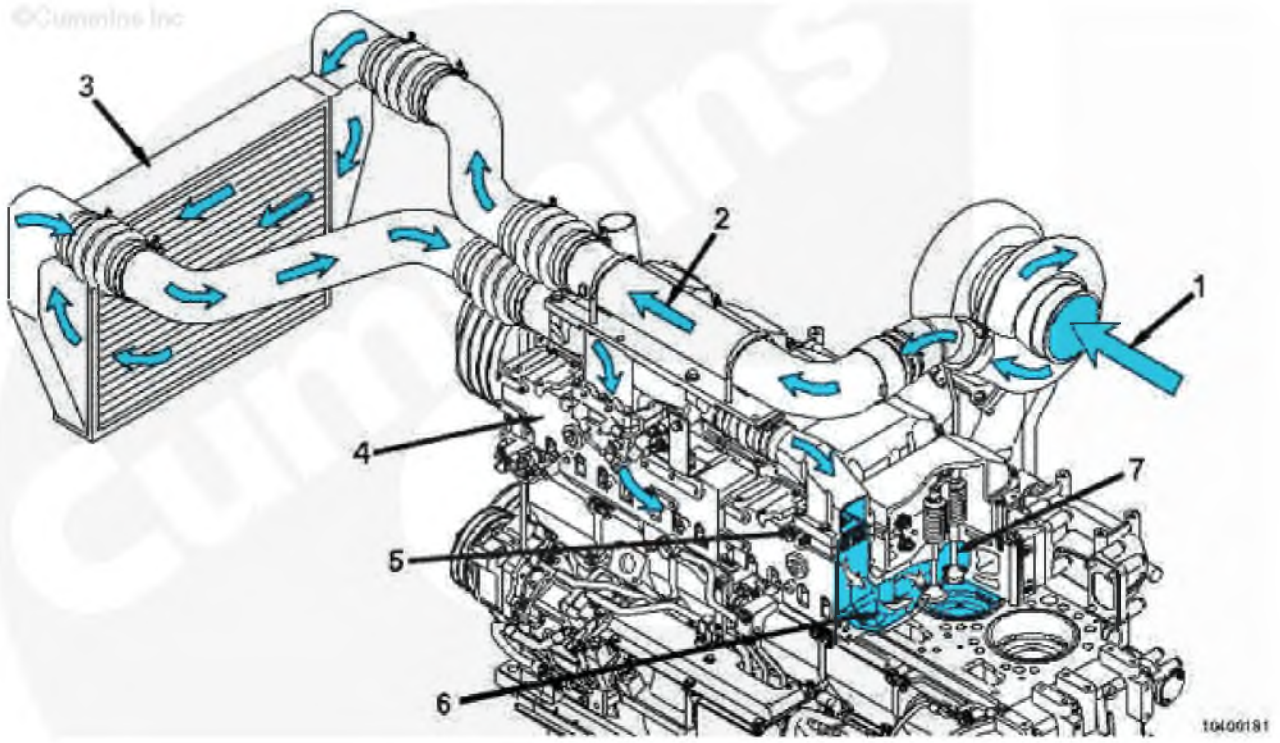
200-004 Flow Diagram, Air Intake System

Air Intake System



1. Intake air inlet to turbocharger
2. Turbocharged air to charge air cooler
3. Charge air cooler
4. Intake manifold
5. Grid heater (Industrial **only**)
6. Cylinder head intake air port
7. Intake valve.

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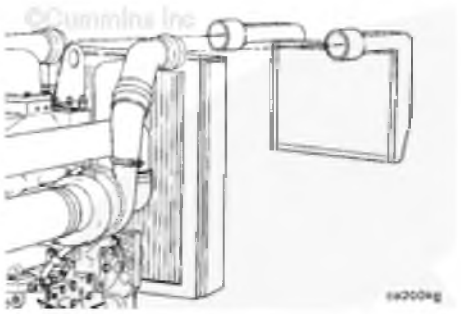
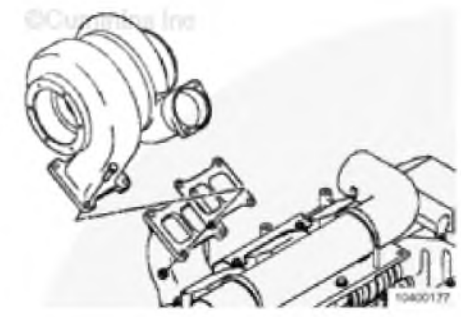
010-999 Air Intake System - Overview

General Information

The QSK23 air intake system uses a remote charge air cooler to reduce the air temperature into the intake manifold. The charge air from the engine turbocharger is routed to the intake manifold by means of a radiator mounted (air-to-air) cooler rather than through the conventional integral engine mounted aftercooler core (air-to-coolant) design. The advantage of cooling charge air directly by ambient air is that the lowest practical charge air temperature can be attained with the minimum cost penalty.



The QSK23 engine uses a single high-efficiency Holset® HX82 single-stage turbocharger on the power generator application and a Schwitzer S500 turbocharger on the industrial application. The QSK23 turbocharger is mounted on the right side of the engine.



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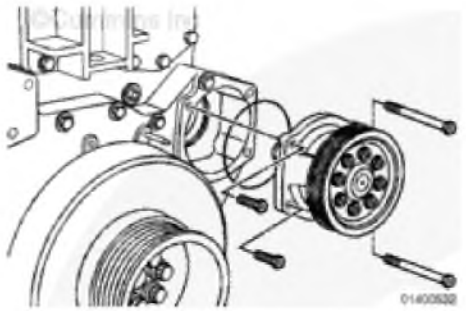
009-999 Drive Units - Overview

General Information

The Drive Units section consists of the removal, inspection, and installation of the alternator drive gear and shaft.

The alternator drive gear and shaft also drives the fuel pump and an OEM supplied refrigerant compressor on some industrial applications. The fuel pump engages the drive gear via a spider gear from the rear of the front cover and is mounted to the block.

The alternator drive gear and shaft revolves at a 1:1 ratio to the crankshaft and in the same direction. The drive contains 55 teeth and is driven by the crank gear through an idler gear and is splash lubricated.



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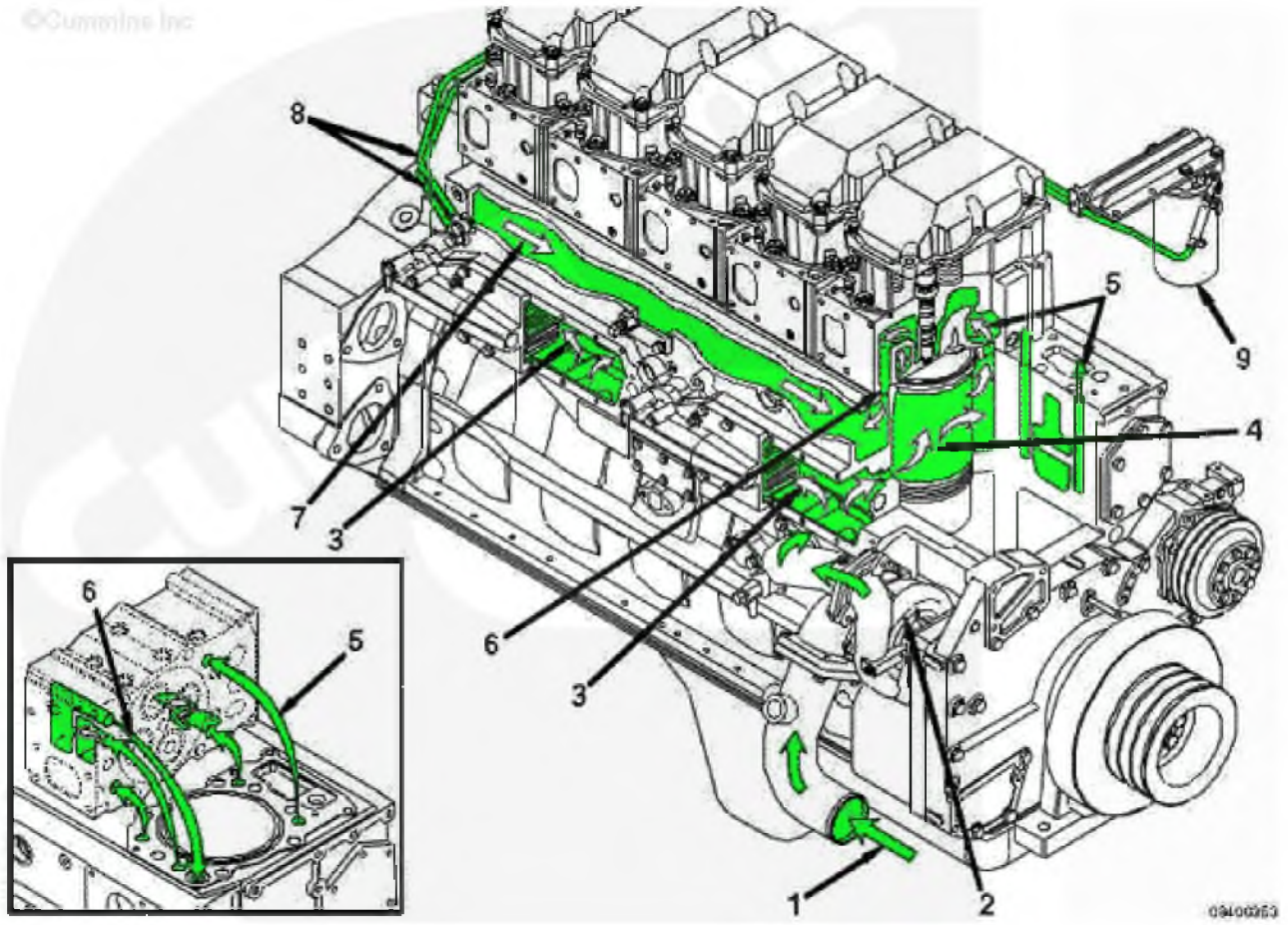
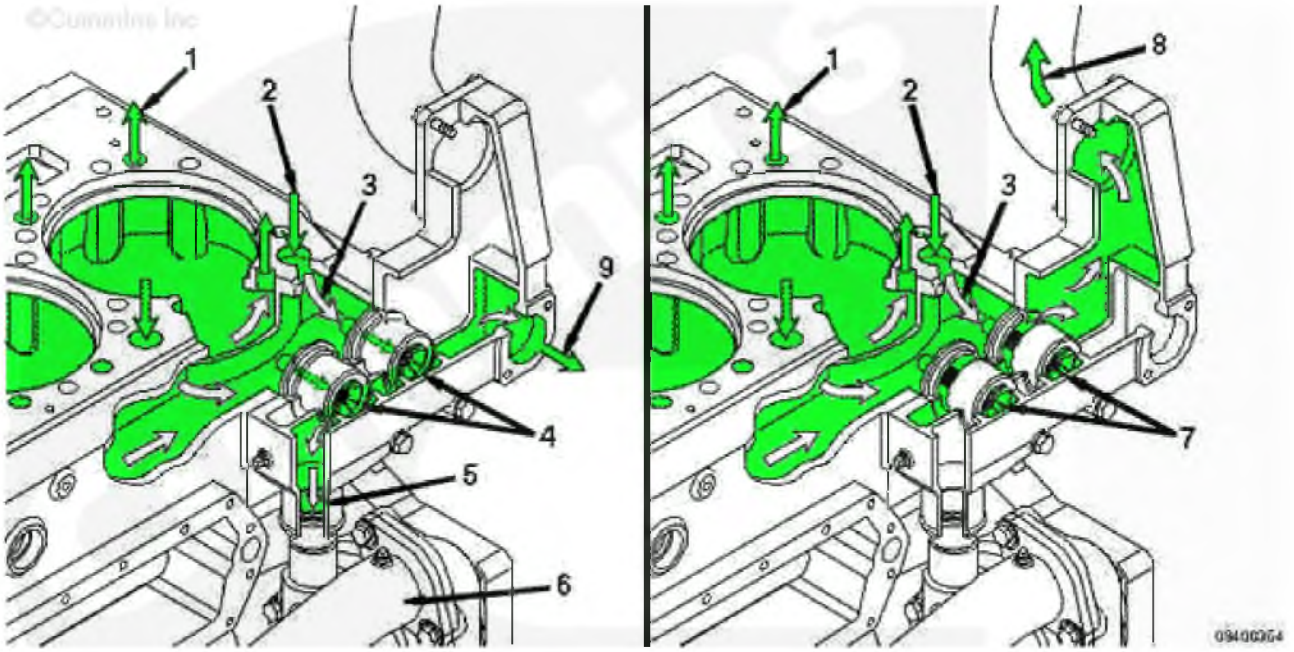
200-003 Flow Diagram, Cooling System

Cooling System



1. Coolant inlet from radiator
2. Water pump
3. Coolant flow through lubricating oil cooler
4. Coolant flow around cylinder liners
5. Coolant flow to cylinder head
6. Coolant flow from cylinder head to coolant manifold
7. Coolant manifold to thermostat housing
8. Coolant filter supply and return tubes

9. Coolant filter.



1. Coolant flow to cylinder head (four ports per cylinder head)
2. Coolant flow to water manifold (one port per cylinder head)
3. Coolant flow to thermostat housing
4. Radiator bypass open
5. Coolant flow to water pump
6. Coolant flow to oil coolers
7. Radiator bypass closed
8. Coolant flow to radiator
9. Coolant flow for optional torque converter (normally plugged)

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View Related Topic

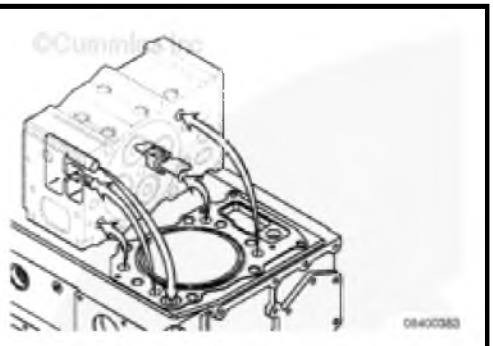
008-999 Cooling System - Overview

General Information

Cooling System

The QSK23 engine uses a standard jacket water cooling system for the engine. Each head has four coolant inlet ports and one coolant outlet port. There is also a coolant vent port at the top of each head on the exhaust side.

Coolant flow from the water pump runs through the oil cooler cavities, around the cylinder liners, then up through the four inlet passages in the cylinder heads. Coolant then exits the heads through a single outlet port, into the return manifold and to the thermostat housing.



Fan Drives

The power fan drive used on the QSK23 engine uses an adjustable fan belt tensioner for power generation applications or an automatic fan belt tensioner, as shown, on industrial applications.

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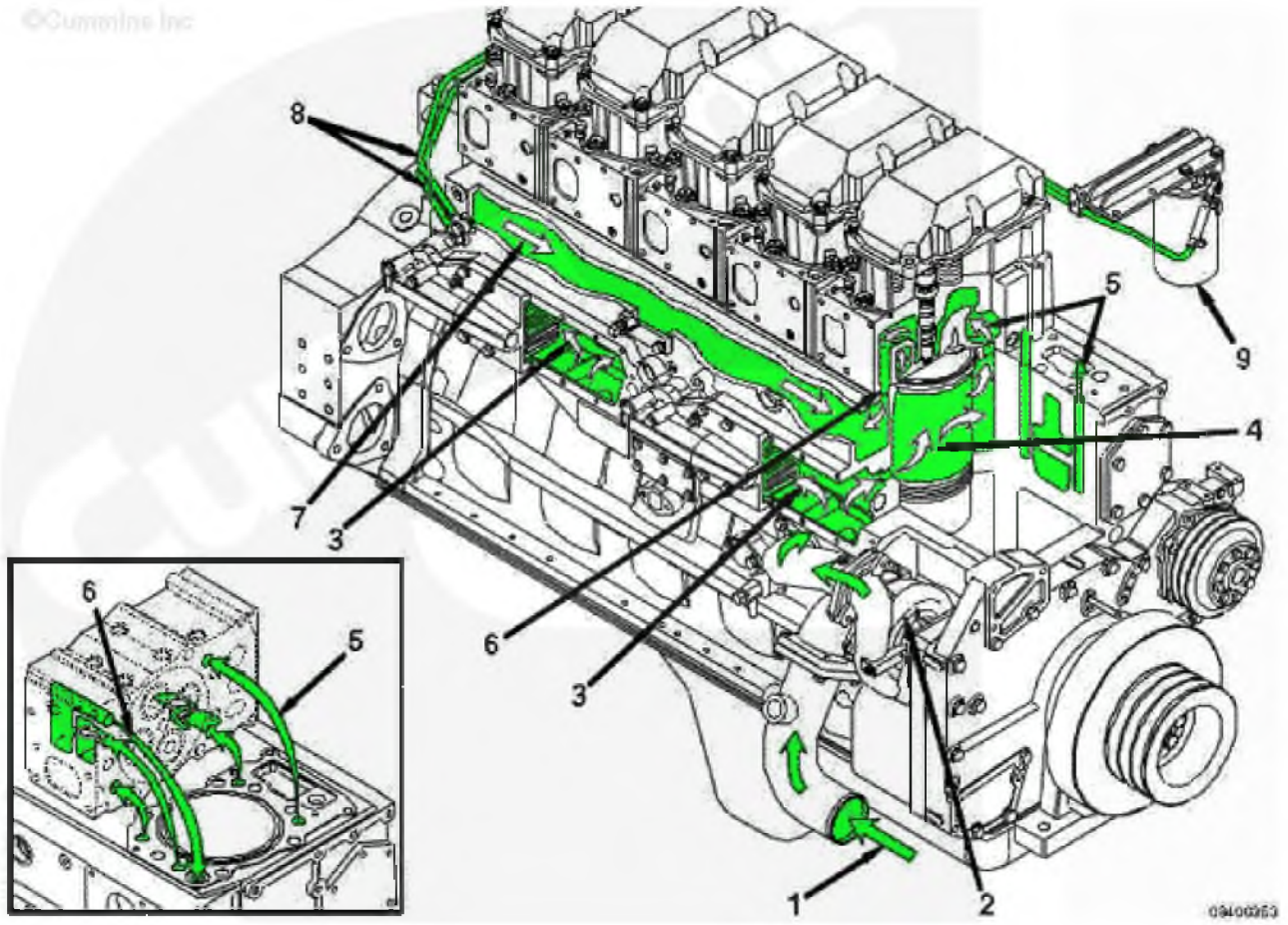
200-003 Flow Diagram, Cooling System

Cooling System



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4. Coolant flow around cylinder liners
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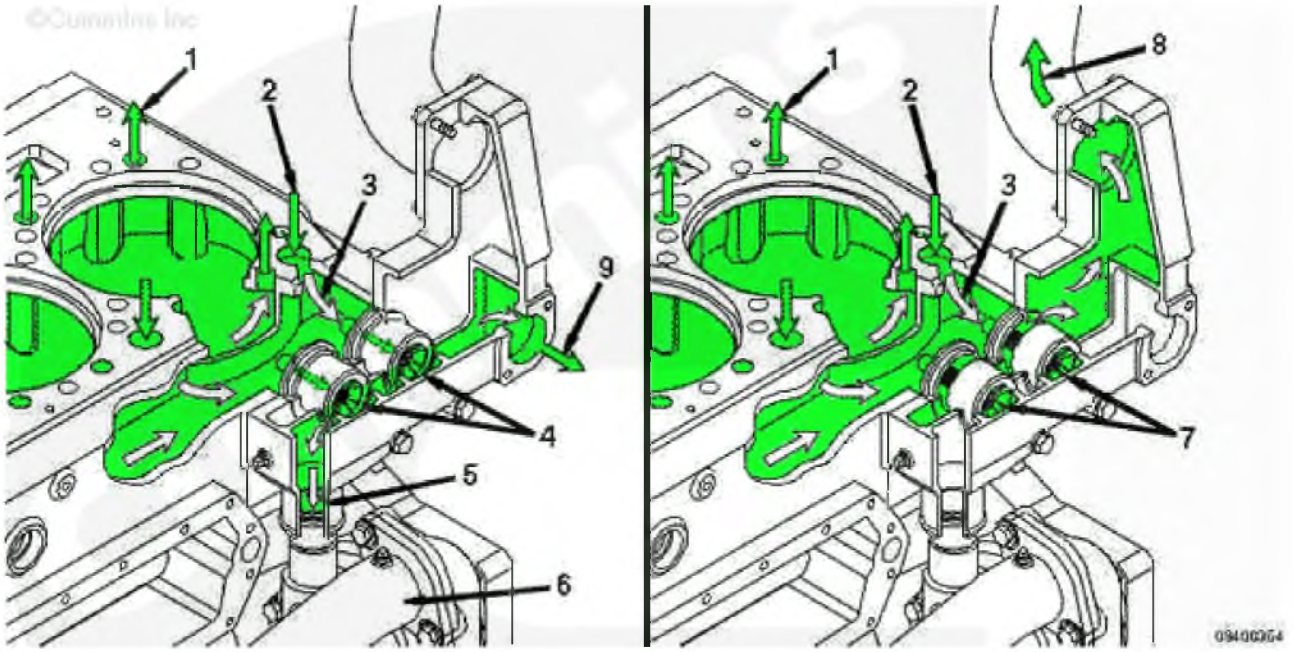
8. Coolant filter supply and return tubes

9. Coolant filter.



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009-999 Drive Units - Overview

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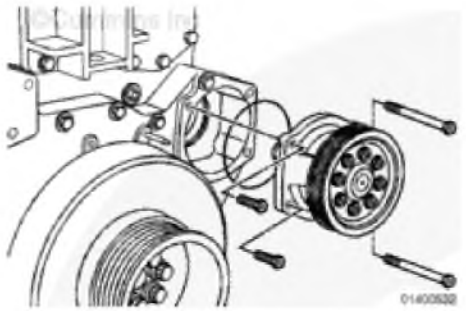

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010-999 Air Intake System - Overview

General Information

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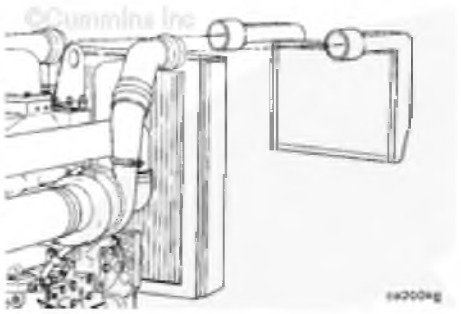
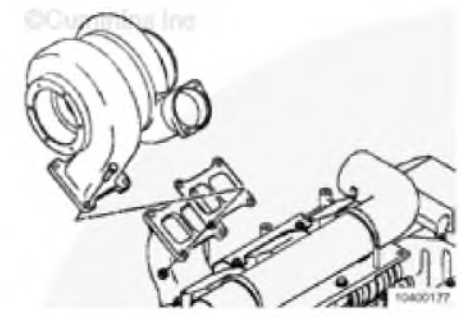


The QSK23 engine uses a single high-efficiency Holset® HX82 single-stage turbocharger on the power generator application and a Schwitzer S500 turbocharger on the industrial application. The QSK23 turbocharger is mounted on the right side of the engine.



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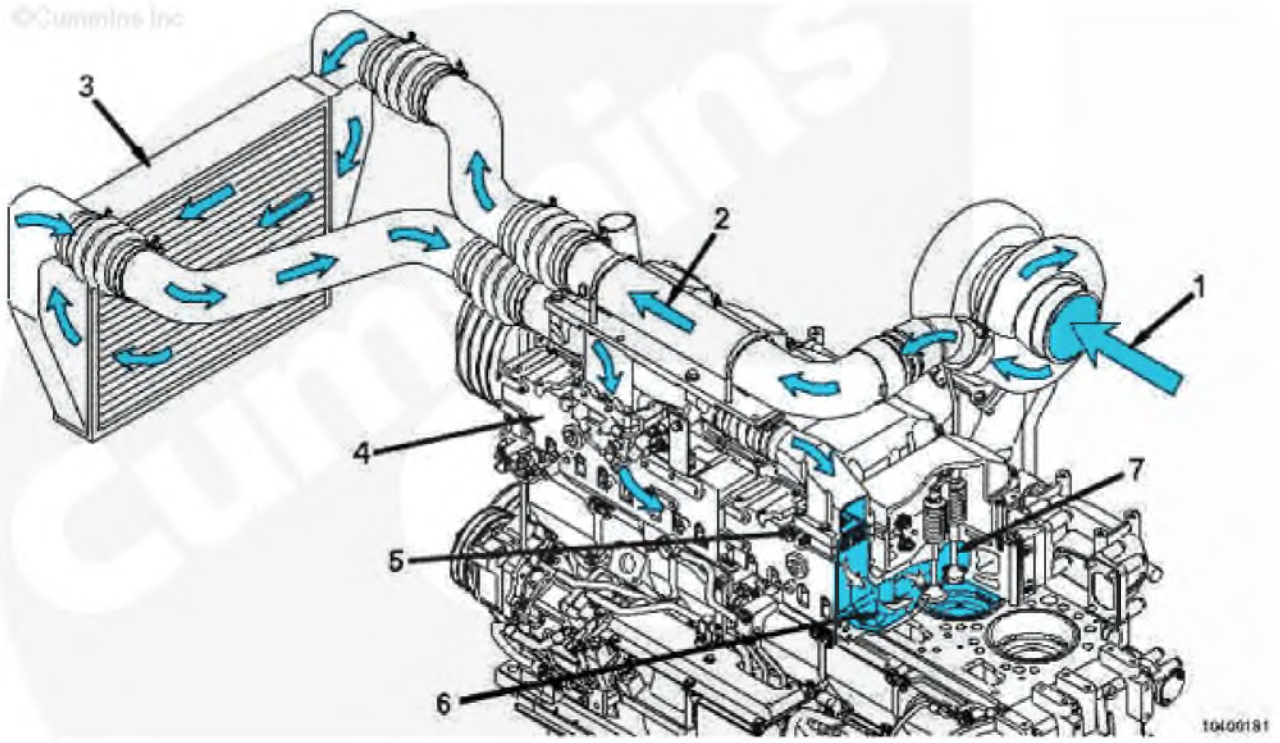
200-004 Flow Diagram, Air Intake System

Air Intake System



1. Intake air inlet to turbocharger
2. Turbocharged air to charge air cooler
3. Charge air cooler
4. Intake manifold
5. Grid heater (Industrial **only**)
6. Cylinder head intake air port
7. Intake valve.

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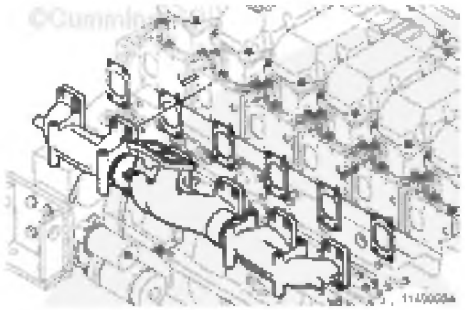
011-999 Exhaust System - Overview

General Information

The QSK23 exhaust manifold has been aerodynamically designed to reduce pumping losses and to enhance pulse flow. In addition, the manifold connection has been designed to allow for thermal expansion.

The maximum allowable exhaust system back pressure for the QSK23 engine is 76.2 mm Hg [3 in Hg].



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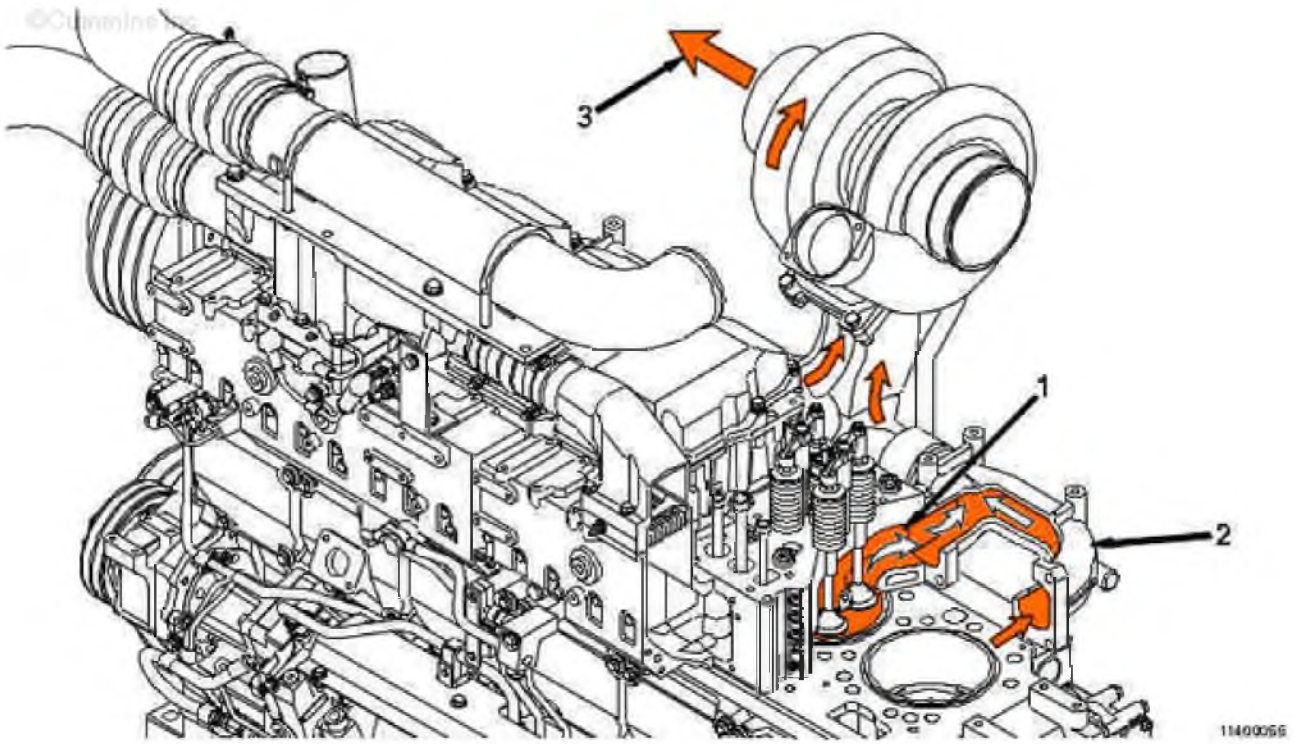
200-005 Flow Diagram, Exhaust System

Exhaust System



1. Cylinder head exhaust port
2. Exhaust manifold
3. Turbocharger exhaust outlet.

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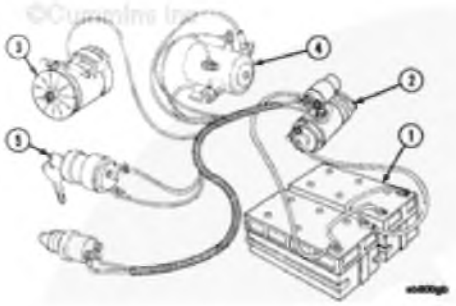
013-999 Electrical Equipment - Overview

General Information

The basic heavy-duty electrical system consists of:

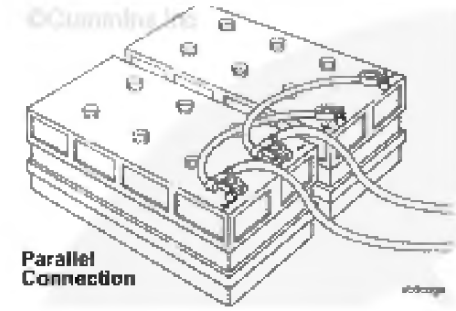
- Batteries (1)(Usually two or four connected in parallel)
- Starting motor (2)
- Alternator (3)
- Magnetic switch (4)
- Ignition switch (5)
- Necessary wiring (**not** shown)

All components **must** be carefully matched.

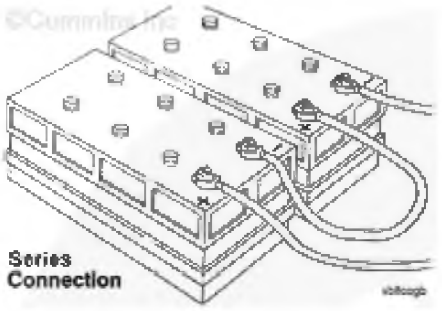


The accompanying illustrations show typical parallel and series battery connections.

- Parallel connection



- Series connection



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016-999 Mounting Adaptations - Overview

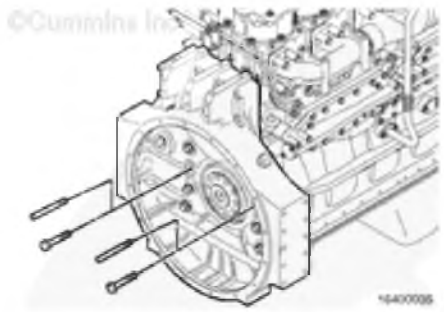
General Information

The QSK23 is available with a SAE 0 or SAE 1 flywheel/flywheel housing combination. The SAE 0 flywheel has a ring gear count of 138 teeth. The SAE 1 flywheel ring gear has 118 teeth.

Tapped holes for transmission mounting are:

- 24 - 7/16-14 UNC-2B for SAE number 1 flywheel housing
- 16 - M12 x 1.75 for SAE number 0 flywheel housing.

The flywheel housing has two magnetic pickup locations. A magnetic pickup hole is currently dedicated for use by the electronic engine control system. The magnetic pickup hole available for customer use is M22 x 1.5.



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t00-001 Troubleshooting Procedures and Techniques

General Information

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

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t00-002 Troubleshooting Symptoms Charts

General Information

Use the charts on the following pages of this section to aid in diagnosing specific engine symptoms. Read each row of blocks from top to bottom. Follow through the chart to identify the corrective action.

WARNING

Troubleshooting presents the risk of equipment damage, personal injury or death. Troubleshooting must be performed by trained, experienced technicians.

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t00-004

Engine Noise Diagnostic Procedures - General Information

When diagnosing engine noise problems, make sure that noises caused by accessories, such as the air compressor and power takeoff, are **not** mistaken for engine noises. Remove the accessory drive belts to eliminate noise caused by these units. Noise will also travel to other metal parts **not** related to the problem. The use of a stethoscope can help locate an engine noise.

Engine noises heard at the crankshaft speed, engine rpm, are noises related to the crankshaft, rods, pistons, and piston pins. Noises heard at the camshaft speed, one-half of the engine rpm, are related to the valve train. A hand-held digital tachometer can help to determine if the noise is related to components operating at the crankshaft or camshaft speed.

There is **not** a definite rule or test that will positively determine the source of a noise complaint.

Engine driven components and accessories, such as gear-driven fan clutches, hydraulic pumps, belt-driven alternators, air-conditioning compressors, and turbochargers can contribute to engine noise. Use the following information as a guide to diagnosing engine noise.

(Refer to Engine Noise Excessive - Main Bearing symptom tree)

The noise caused by a loose main bearing is a loud dull knock heard when the engine is pulling a load. If all main bearings are loose, a loud clatter will be heard. The knock is heard regularly every other revolution. The noise is the loudest when the engine is lugging or under heavy load. The knock is duller than a connecting rod noise. Low oil pressure can also accompany this condition.

If the bearing is **not** loose enough to produce a knock by itself, the bearing can knock if the oil is too thin, or if there is no oil at the bearing.

An irregular noise can indicate worn crankshaft thrust bearings.

An intermittent sharp knock indicates excessive crankshaft end clearance. Repeated clutch disengagements can cause a change in the noise.

(Refer to Engine Noise Excessive - Connecting Rod symptom tree)

Connecting rods with excessive clearance knock at all engine speeds, and under both idle and load conditions. When the bearings begin to become loose, the noise can be confused with piston slap or loose piston pins. The noise increases in volume with engine speed. Low oil pressure can also accompany this condition.

(Refer to Engine Noise Excessive - Piston symptom tree)

It is difficult to tell the difference between piston pin, connecting rod, and piston noise. A loose piston pin causes a loud double knock which is usually heard when the engine is idling. When the injector to this cylinder is cut out, a noticeable change will be heard in the sound of the knocking noise. However, on some engines the knock becomes more noticeable when the vehicle is operated on the road at steady speed condition.

Driveability/Low Power/Excessive Fuel Consumption - Checklist

Driveability is a term which in general describes vehicle performance on the road. Driveability problems for an engine can be caused by several different factors. Some of the factors are engine related and some are **not**.

Before troubleshooting, it is important to determine the exact complaint and whether the engine has a real driveability problem or if it simply does **not** meet driver expectations. The Driveability-Low Power Customer Complaint Form is a valuable list of questions that **must** be used to assist the service technician in determining what type of driveability problem the vehicle is experiencing. Complete the checklist before troubleshooting the problem. The form can be found at the end of this section. If an engine is performing to factory specifications but does **not** meet the customer's expectations, it **must** be explained to the customer that nothing is wrong with the vehicle and why.

The troubleshooting symptom charts have been set up to divide driveability problems into two different symptoms: Engine Power Output Low and Engine Acceleration or Response Poor.

Low power is a term that is used in the field to describe many different performance problems. However, in this manual low power is defined as the inability of the engine to produce the power necessary to move the vehicle at a speed that can be reasonably expected under the given conditions of load, grade, wind, and so on. Low power is usually caused by the lack of fuel flow which can be caused by any of the following factors:

- Lack of full travel of the throttle pedal
- Failed boost sensor
- Excessive fuel inlet, intake, exhaust, or drain line restriction
- Loose fuel pump suction lines.

Low power is **not** the inability of the vehicle to accelerate satisfactorily from a stop or the bottom of a grade. See the performance tree Engine Power Output Low for the proper procedures to locate and correct a low power problem. The chart starts off with basic items which can cause lower power.

Poor acceleration or response is described in this manual as the inability of the vehicle to accelerate satisfactorily from a stop or from the bottom of a grade. It can also be the lag in acceleration during an attempt to pass or overtake another vehicle at conditions less than rated speed and load. Poor acceleration or response is difficult to troubleshoot since it can be caused by factors such as:

- Engine or pump related factors
- Driver technique
- Improper gearing
- Improper engine application
- Worn clutch or clutch linkage.

Engine related poor acceleration or response can be caused by several different factors such as:

- Failed boost sensor
- Excessive drain line restriction
- Throttle dead band.

See the performance tree Engine Acceleration or Response Poor for the proper procedures to locate and correct a poor acceleration or response complaint.

Driveability/Low Power - Customer Complaint Form

Customer Name/Company _____ Date _____

1. How did the problem occur? Suddenly _____ Gradually _____
2. At what hour/mileage did the problem begin? Hours _____ Miles _____ Since New _____

- After engine repair? Yes _____ No _____
- After equipment repair? Yes _____ No _____
- After change in equipment use? Yes _____ No _____
- After change in selectable programmable parameters? Yes _____ No _____
- If so, what was repaired and when?_____
- Does the vehicle also experience poor fuel economy? Yes _____ No _____

Answer questions 4 through 8 using selections (A through F) listed below. Circle the letter or letters that best describes

A. Compared to fleet
B. Compared to competition
C. Compared to previous engine
D. Personal expectation
E. Will **not** pull on hill
F. Will **not** pull on flat.

A B C D E F

- Can the vehicle obtain the expected road speed? Yes _____ No _____
- What is desired speed? rpm/mph _____
- What is achieved speed? rpm/mph _____
- GVW _____

A B C D

- Is the vehicle able to pull the load? Yes _____ No _____

When?

- _____ In the hills
- _____ With a loaded trailer
- _____ On the flat
- _____ Other _____

If question 4 or 5 was answered no, fill out the Driveability/Low Power/Excessive Fuel Consumption Checklist and go t

- Is the vehicle slow to accelerate or respond? Yes _____ No _____
- From a stop? Yes _____ No _____
- After a shift? Yes _____ No _____ rpm _____
- Before a shift? Yes _____ No _____ rpm _____
- No shift? Yes _____ No _____ rpm _____

A B C D

- Does the vehicle hesitate after periods of long deceleration or coasting? Yes _____ No _____ rpm _____

If question 6 or 7 was answered Yes, fill out the Driveability/Low Power/ Excessive Fuel Consumption Checklist and go tree.

A B C D E F

Additional Comments:

_____

_____

_____

This form can be copied for convenience.

Driveability/Low Power/Excessive Fuel Consumption - Checklist

Vehicle/Equipment Specifications

Year, Type and Model: _____

Transmission (RT 14609, etc.): _____, Duty Cycle: _____

Rear Axle Ratio, No. of Axles: _____, Application: Industrial ____, Marine ____. Genset ____. Automotive ____

Typical GVW: _____, Engine Rating: _____

Trailer Type and Size: _____, Height: _____, Weight: _____

Tire Size (11R x 24.5, Low Profile, etc.) _____

Tire Type: Radial _____, Standard Tread _____, Extra Tread _____

Fan Type: Direct Drive _____, Viscous _____, Clutch _____

Power Steering: Yes _____ No _____
Air Conditioner: Yes _____ No _____
Air Shield: Yes _____ No _____
Freon Compressor: Yes _____ No _____

General Information:			
DO Number:			SC Number:
Fuel Pump Code:			Fuel Pump Serial Number:
Mileage:			Engine Serial Number:
Date in Service:			Engine Model and Rating:
Cruise Speed and rpm:			Rated Speed and rpm:
Road Speed Governor:	Yes	No	Type:
Engine Brake:	Yes	No	Type/Brand:

Chassis and Other Related Items			
Tank Vents:	OK	**Not** OK	Obvious Fuel Leaks:
Brake Drag:	OK	**Not** OK	Axel Alignment:
Altitude:	Ambient Temperature:		
Typical Terrian:	Flat	Hilly	Other
Fuel Heater:	Percent Asphalt:	Percent Concrete:	

Additional Comments:

This checklist can be copied for convenience.

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” 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 0.16 km [0.1 mpg] increase in fuel consumption. This means that increasing road speed from 50 to 60 mph will result in a loss of fuel mileage of 1.6 km [1 mpg].
3. Environmental and Seasonal Weather Changes: As a general rule, there can be as much as a 1.6 to 2.4 km [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 0.11 to 0.33 liters [0.5 to 1.5 gal] per hour depending on the engine idle speed.
5. Truck Route and Terrain: East/west routes experience almost continual cross winds and head winds. Less fuel can be used on north/south routes where parts of the trip are **not only** warmer, but see 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 a 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.

Fuel Consumption - Customer Complaint Form

Customer Name/Company _____ Date _____

Answer the following questions. Some questions require making an X next to the appropriate answer.

1. What fuel mileage is expected? _____ Expected mpg
2. What are the expectations based on? Original mileage _____, Other units in fleet _____, Competitive engines _____Previous engine owned _____, Expectations only _____, VE/VMS report _____
3. When did the problem occur? Since New _____, Suddenly _____, Gradually _____
4. Did the problem start after a repair? Yes _____ No _____ If so, what was repaired and when? _____
5. Is the vehicle also experiencing a Driveability problem (Low Power or Poor Acceleration/Response)? Yes _____ No _____

If answered Yes, fill out the Driveability/Low Power/Excessive Fuel Consumption Checklist and go to the Engine Power Output Low performance tree.

6. Is the problem seasonal? Yes _____ No _____
7. Weather conditions during fuel consumption check? Rain _____, Snow _____, Windy _____, Hot Temperatures _____, Cold Temperatures _____
8. How is the fuel mileage measured? Tank _____, Trip _____, Month _____, Year _____ Hubometer _____, Odometer _____
9. Are accurate records kept of fuel added on the road? Yes _____ No _____
10. Do routes vary between compared vehicles? Yes _____ No _____
11. Have routes changed for the engine being checked? Yes _____ No _____
12. What are the loads hauled, compared to comparison unit? GVW _____ Heavier _____, Lighter _____
13. What is the altitude during operation? Below 10,000 feet _____, Above 10,000 feet _____
14. How much of the time is the truck spent idling? Hours/day _____
15. Is the driver technique or operating practices affecting fuel economy?

- High road speed: mph _____
- Operate at rated speed or above: rpm _____
- Incorrect shift rpm: Shift rpm _____, Torque Peak _____
- Operate at a cruise speed: rpm _____
- Believe compensating for low power: Yes _____ No _____

If after filling out this form it appears that the problem is **not** caused by vehicle factors, environmental factors, or driver technique, fill out the Driveability/Low Power/Excessive Fuel Consumption Checklist and go to the Fuel Consumption Excessive performance tree.

This form can be copied for convenience.

Oil Consumption

In addition to the information that follows, a service publication is available entitled Technical Overview of Oil Consumption, Bulletin No. 3379214.

Cummins Inc. defines “Acceptable Oil Usage” as outlined in the following table.

Acceptable Oil Usage									
Any Time During Coverage Period									
Engine Family	Hours per Quart	Hours per Liter	Hours per Imperial Quart	Miles Per Quart	Miles per Liter	Miles per Imperial Quart	KM per Quart	KM per Liter	KM per Imperial Liter

A	10.0	10.6	12.0	400	425	475	650	675	775
4B	10.0	10.6	12.0	400	425	475	650	675	775
6B	10.0	10.6	12.0	400	425	475	650	675	775
6C	10.0	10.6	12.0	400	425	475	650	675	775
V/VT-378	4.0	4.3	5.0	–	–	–	–	–	–
V/VT-504	4.0	4.3	5.0	250	265	310	400	425	485
V/VT-555	4.0	4.3	5.0	250	265	310	400	425	485
L Series	4.0	4.3	5.0	250	265	310	400	425	485
M Series	4.0	4.3	5.0	250	265	310	400	425	485
N Series	4.0	4.3	5.0	250	265	310	400	425	485
V/VT/VTA-903	4.0	4.3	5.0	250	265	310	400	425	485
KT/KTA-19	3.0	3.2	3.75	200	210	250	320	340	390
QSK23	1.7	1.8	2.0	–	–	–	–	–	–
V/VT/VTA28	2.0	2.1	2.5	–	–	–	–	–	–
KT/KTA38	1.5	1.6	1.8	–	–	–	–	–	–
KTA50	1.1	1.2	1.3	–	–	–	–	–	–

Acceptable Oil Useage (Transit Bus, Shuttle Bus and School Bus)									
Any Time During Coverage Period									
Engine Family	Hours per Quart	Hours per Liter	Hours per Imperial Quart	Miles per Quart	Miles per Liter	Miles per Imperial Quart	KM per Quart	KM per Liter	KM per Imperial Liter
B	10.0	10.6	12.0	200	210	240	320	340	385
C	8.0	8.5	10.0	150	160	180	240	255	290
L, M, N	4.0	4.3	5.0	100	105	120	160	170	195

Cummins
Engine Company, Inc.
Box 3005
Columbus, IN, U.S.A.
47202-3005

15200020

Engine Lubricating Oil Consumption Report					
Owner's Name	Date of Delivery			Engine Serial Number	
	Month	Day	Year		
Address	Equipment Manufacturer			Engine Model & HP	
City	State/Province	Equipment Serial Number		Fuel Pump Serial Number	
Engine Application (Describe)	Oil and Filter Change Interval			Complaint Originally Registered	
	Oil	Filters		Date	Mile/Hours/KM
Lubricating Oil Added					
Date Added Oil	Engine Operation Miles/Hours/Kilometers	Quarts - Liters Oil Added		Brand and Viscosity of Oil Used	

Start Test			

Last Mileage/Hours/Kilometers _____ Minus Start Mileage/Hours/Kilometers _____

Equals Test Mileage/Hours/Kilometers _____ Divided By Oil Added _____

Equals _____ Usage Rate_____

Customer Signature	Cummins Dealer	Cummins Distributor

Cummins Inc. Form 4755

Cummins
Engine Company, Inc.
Box 3005
Columbus, IN, U.S.A.
47202-3005

15200020

Oil Consumption Report

Customer Name:	Dist/Dir:
Engine Model:	Mi/Km/Hr:
Engine Serial No.:	CPL No.:
Vehicle Make/Model:	Date:

Review of maintenance history:

List any previous failures that could have had a detrimental effect on cylinder component life. Failures could include fuel, coolant, and/or foreign abrasives in the oil, second ring groove beat-out, filter plugging, etc.

Lube Oil Used:

Brand

Viscosity

Change Interval (mi/km/hr)

Combination Oil Filter:

Model Element Change Interval (mi/km/hr)
Bypass Oil Filter: Model Element Change Interval (mi/km/hr)
Full Flow Oil Filter: Model Element Change Interval (mi/km/hr)
Air Cleaner: Make and Model Change Interval
List any external engine leaks.
Visually check for any internal leaks and list. Check turbocharger seals, valve guides, air compressor, etc.
Had the fuel pump been tampered with? _____ What is maximum rail pressure readings? _____ If yes, the pump must be reset to factory specifications and the customer sent out to re-evalute his oil consumption rate and the eligibility requirements must be met again.
Warning: Governmental agencies have determined that used engine oil is toxic and carcinogenic. Avoid breathing, injestion, and excessive contact. Drain and refill oil pan to check dipstick markings and notes findings.
Only after above checks are completed, leaks corrected and proper documentation is completed, disassemble engine to determine cause for the failure and repair as required.
State reason for oil consumption.
Signed: _____

Coolant Loss Pre-Troubleshooting Guide

Before troubleshooting, it is critical to know where the coolant is being lost. It is **not** always obvious where the missing coolant has gone.

Before troubleshooting, it is important to determine the exact complaint by interviewing the driver, looking at the service history and looking at the ECM information.

Driver Interview Questions

Driver's Name:

Engine Serial Number (ESN)

What is the complaint?

How is this engine used?

What are the load factors?

Where is the vehicle driven?

1. How is the radiator filled?
2. Is the radiator filled to the High or Low mark when the engine is cold (less than 60°C [140°F]?
3. What type of coolant is added?
4. Is threre any coolant on the ground under your vehicle or engine?
5. Is there green or white streaks on the engine or near the coolant overflow hose?
6. Is there any specific condition (weather, altitude, or load) when indications of coolant loss is evident?
7. Does the engine ever overheat?
8. Does the warning light flash?
9. Under what conditions?
10. What temperature does the coolant run at normally?
11. Does the cooling fan operate correctly (fan on a 99°C [210°F]?
12. Is there any white smoke at operating temperature, or has anyone told you that white smoke is coming out of the exhaust?
13. Is oil analysis performed as part of the maintenance?
14. Are there elevated levels of sodium or potassium?
15. Has any increase in moisture condensation on the dipstick or oil fill cap, or moisture in the blowby been noticed?
16. Has a milky appearance been noticed in the lube oil that might indicate coolant is present.
17. What other comments did the driver/operator have that might help Cummins Inc. make the right repair?

Service History Review

Repeat cylinder head or cylinder head gasket repairs can indicate the problem is likely **not** the cylinder head or cylinder head gasket. Repeat problems can indicate a deeper problem in the engine. Keep this information in mind while going through the troubleshooting procedure.

Look at this engine's warranty claims history: who worked on engine last and what did technician do? How many miles miles/kilometers are on the engine? Has a cylinder head or cylinder head gasket been replaced before? At what engine hours were these repairs made?

ECM Data Review

Print out an INSITE™ electronic service tool Image Report from the ECM. Look for high temperature alarms or low coolant level alarms. Either indication confirms a complaint of loosing coolant.

Are any fault codes logged in the Engine Protection Fault History?

ECM Fault Code 235 - Low Coolant (how may times)?

ECM Fault Code 151 - High Coolant Temperature (how many times)?

At this point, do you know where the coolant is going? If not and the coolant loss is not severe, suggest mounting a catch bottle on the radiator overflow tube to catch any overflow that can possibly be blowing out and becoming lost while at speed. Send the vehicle out to collect more data about where the coolant is or is not going. If the catch bottle has some coolant in it, refer back to the Coolant Loss External (out the overflow) interview questions.

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Air Compressor Air Pressure Rises Slowly

Symptom Tree t004

Printable Version

This is symptom tree

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, tanks, and valves. Refer to the manufacturer's instructions and specifications.

OK

Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to the manufacturer's instructions and specifications.

OK

Carbon buildup is excessive in the air discharge line, check valve, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line, if necessary. *Check the turbocharger for oil leaks. Check the intake tube for oil.* Refer to the manufacturer's instructions and

	specifications.

OK

Air system component is malfunctioning	Check the operation of check valves, alcohol evaporators, air dryers, and other OEM-installed air system components. Refer to the manufacturer's instructions and specifications.

OK

Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the manufacturer's instructions and specifications.

OK

Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to the manufacturer's instructions and specifications.

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Air Compressor Noise is Excessive

Symptom Tree t006

Printable Version

This is symptom tree

Cause	Correction
Carbon buildup is excessive in the air discharge line, check valve, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line, if necessary. *Check the turbocharger for oil leaks. Check the intake tube for oil.* Refer to the manufacturer's instructions and specifications.
OK	
Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the manufacturer's instructions and specifications.
OK	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to the manufacturer's instructions and specifications.

OK

Splined drive coupling or gear is excessively worn	Check the coupling for wear. Refer to the manufacturer's instructions and specifications.

OK

Pin bore wear is excessive	Check for pin bore wear. Refer to the manufacturer's instructions and specifications.

OK

Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to the manufacturer's instructions and specifications. Replace the desiccant element on the Turbo/CR 2000 air dryer (if equipped). Refer to the manufacturer's instructions.

OK

Air compressor drive gear or engine gear train is worn or damaged	Inspect the accessory drive gears and gear train. Refer to the OEM service manual.

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Air Compressor Pumping Excess Lubricating Oil into the Air System

Symptom Tree t007

Printable Version

This is symptom tree

Cause	Correction
Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Section 2 in the Operation and Maintenance Manual, QSK23 Series Engine, Bulletin 4021374.
OK	
Engine angularity during operation exceeds specification	Refer to the engine specification data sheet.
OK	
Air compressor pumping time is excessive	Replace the desiccant cartridge on the Turbo/CR 2000 air dryer. Refer to the OEM service manual. Check the air compressor duty cycle. Install a larger air compressor, if necessary. Refer to the manufacturer's instructions and specifications.

OK

Lubricating oil drain line is restricted	Remove the air compressor and check the oil drain holes in the air compressor and the accessory drive. Refer to the manufacturer's instructions and specifications.

OK

Turbocharger compressor oil seal is leaking	Check the compressor oil seal. Refer to the manufacturer's instructions and specifications.

OK

Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to the manufacturer's instructions and specifications. Replace the desiccant element on the Turbo/CR 2000 air dryer (if equipped). Refer to the manufacturer's instructions.

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Air Compressor Will Not Maintain Adequate Air Pressure (Not Pumping Continuously)

Symptom Tree t008

Printable Version

This is symptom tree

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, tanks, and valves. Refer to the OEM service manual.
OK	
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to the manufacturer's instructions and specifications.
OK	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to the manufacturer's instructions and specifications.

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Air Compressor Will Not Pump Air

Symptom Tree t009

Printable Version

This is symptom tree

Cause	Correction
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to the manufacturer's instructions and specifications.
OK	
Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the manufacturer's instructions and specifications.
OK	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to the manufacturer's instructions and specifications.
OK	

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Splined drive coupling or gear is excessively worn	Check the coupling for wear. Refer to the manufacturer's instructions and specifications.

Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to the manufacturer's instructions and specifications. Replace the desiccant element on the Turbo/CR 2000 air dryer (if equipped). Refer to the manufacturer's instructions.

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Air Compressor Will Not Stop Pumping

Symptom Tree t010

Printable Version

This is symptom tree

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, tanks, and valves. Refer to the OEM service manual.
OK	
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to the manufacturer's instructions and specifications.
OK	
Air governor signal line or actuator line is plugged	Inspect the signal line and actuator line. Refer to the manufacturer's instructions and specifications.

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OK

Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the manufacturer's instructions and specifications.

OK

Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to the manufacturer's instructions and specifications.

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Alternator Not Charging or Insufficient Charging

Symptom Tree t013

Printable Version

This is symptom tree

Cause	Correction
Alternator belt is loose	Check the alternator belt tension. Refer to Procedure 013-005.
OK	
Alternator pulley is loose on the shaft	Tighten the pulley. Refer to the manufacturer's instructions and specfications.
OK	
Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections. *Refer to Procedure 013-009 .*
OK	

Batteries have malfunctioned	Check the condition of the batteries. Replace the batteries, if necessary. Refer to Procedure 013-007 and the OEM service manual.

OK

Voltmeter is malfunctioning	Inspect the voltmeter. Replace as needed. Refer to the manufacturer's instructions and specifications.

OK

Alternator or voltage regulator is malfunctioning	Test the alternator output. Replace the alternator or voltage regulator if necessary. Refer to Procedure 013-001 and the OEM service manual.

OK

Electrical system is "open" (blown fuses, broken wires, or loose connections)	Check the fuses, wires, and connections. Refer to the OEM service manual and manufacturer's wiring diagram.

OK

Battery temperature is above specification	Position the batteries away from heat sources. Refer to the OEM service manual.

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OK

Alternator is overloaded, or alternator capacity is below specification	Install an alternator with a higher capacity. Refer to Procedure 013-001 and the OEM service manual.

OK

Battery isolator malfunctioned (if equipped)	Refer to boat manufacturer's specification and wiring diagram.

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Alternator Overcharging

Symptom Tree t014

Printable Version

This is symptom tree

Cause	Correction
Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections. *Refer to Procedure 013-009.*
OK	
Battery condition poor	Load-test the battery. If the battery charge is low, charge the battery. If battery fails the second load test, replace the battery. Refer to Procedure 013-007.
OK	
Voltage regulator is malfunctioning	Check the voltage regulator. Replace the voltage regulator, if necessary. Refer to the OEM service manual.
OK	

Battery isolator malfunctioned (if equipped)	Refer to boat manufacturer's specifications and wiring diagram.

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Coolant Loss - External

Symptom Tree t020

Printable Version

This is symptom tree

Cause	Correction
Coolant level is above specification	Check the coolant level. Refer to the OEM service manual.
OK	
External coolant leak	Inspect the engine for coolant leaking from hoses, draincocks, the water manifold, jumper tubes, the heat exchanger, expansion and pipe plugs, fittings, the turbocharger, cylinder head gaskets, the lubricating oil cooler, the water pump seal, and OEM-mounted components that have coolant flow. If necessary, pressure-test the cooling system. Refer to Procedure 008-018.
OK	
Pressure cap is **not** correct or is	Replace pressure cap with the correct rating for the cooling system. Refer to

malfunctioning	Procedure 008-047.

OK

Cooling system is contaminated with dirt, scale, or sludge	Clean the cooling system. Refer to Procedure 008-018.

OK

Fill line or vent lines are restricted, obstructed, or **not** routed correctly	Check the vent lines and the fill line for correct routing and for restriction. Refer to Procedure 008-017.

OK

Coolant is frozen due to incorrect antifreeze concentration	Check the antifreeze concentration. Refer to Cooling Recommendations and Specifications in Cummins Coolant Requirements and Maintenance, Bulletin 3666132.

OK

Air or combustion gases are entering the cooling system	Check for air or combustion gases in the cooling system. Refer to Procedure 008-019.

OK

Engine is overheating	Refer to the Coolant Temperature Above Normal - Gradual Overheat symptom tree.

OK

Cylinder block counterbore leak	Inspect the cylinder block for coolant leaking from the counterbore area. *Conduct a leak test. Refer to Procedure 001-026.*

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View Related Topic

Coolant Loss - Internal

Symptom Tree t021

Printable Version

This is symptom tree

Cause	Correction
Excessive internal or external engine coolant loss	Before troubleshooting, it is important to determine the exact complaint by interviewing the driver, looking at the service history, and looking at the ECM information. Refer to the Coolant Loss Pre-Troubleshooting Guide at the end of Section TS.

OK

Pressure test the cooling system	After verifying the above step, to pressure test the cooling system, refer to Procedure 008-018 (Cooling System) in Section 8. If this step was completed for the same complaint, within the last 30 days (as per history), skip to the next step. Use tracer dye, Part Number 3377438 (if required) to identify difficult leaks along with a black light lamp, Part Number 3824754.

OK

Fuel heater is malfunctioning (if equipped)	Check the fuel heater and replace, if necessary. Refer to the OEM service manual.

Heat exchanger (Marine) is leaking coolant	Pressure—test the heat exchanger element and check the sea water outlet. Refer to Procedure 008-018 (Cooling System) in Section 8.

Transmission oil cooler or torque converter cooler is leaking	Check the transmission oil cooler and torque converter cooler for coolant leaks. Refer to the manufacturer's instructions.

Water pump (engine/LTA) leaks	Inspect the water pump (engine/LTA) for plugged weep hole and for coolant leaks or tracer dye from the weep hole. Refer to Procedure 008-062 (Water Pump) in Section 8.

	Inspect the compressor air inlet and outlet tubes for signs of coolant or tracer dye.

Air compressor cylinder head is cracked or porous, or has a leaking gasket	Inspect the air compressor cylinder head and gasket. Refer to the manufacturer's instructions .

OK

Rocker housing cracked or the gasket damaged	Inspect the rocker lever housing. Remove the valve covers and check for signs of tracer dye for any coolant leak around the spring deck. Refer to Procedure 003-013 (Rocker Lever Housing) in Section 3.

OK

Turbocharger has damaged seals in bearing housing	Inspect the bearing housing seal for any damage by pressurizing the coolant system. Remove the oil drain line (and intake and exhaust piping — if required for access) to visually observe coolant leaking or **not**. **NOTE:** This procedure is applicable **only** if the bearing housing is cooled by coolant. Refer to Procedure 010-033 (Turbocharger) in Section 10.

OK

Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks. *Refer to Procedure 007-007 (Lubricating Oil Cooler Element) in Section 7.*

OK

OK

Cylinder liner is cracked or porous or crevice seal/sealing o-rings damaged	Perform the pressure test procedure (008-018) with tracer dye in the coolant. Inspect the cylinder liners. Refer to Procedure 001-028 (Cylinder Liner) in Section 1.

OK

Cylinder block is cracked or porous	Perform the pressure test procedure (008-018) with tracer dye in the coolant. Inspect the cylinder block. Refer to Procedure 001-026 (Cylinder Block) in Section 1.

OK

Cylinder block has cavitations or loose cup plug or liner o-ring area damaged	Inspect the cylinder block. Refer to Procedure 001-026 (Cylinder Block) in Section 1.

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Coolant Temperature Above Normal - Gradual Overheat

Symptom Tree t022

Printable Version

This is symptom tree

Cause	Correction
Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary. *Refer to the OEM service manual.*
OK	
Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 784 cm^2 [122 in^2] or approximately 28 x 28 cm [11 x 11 in] of opening at all times. Refer to the OEM service manual.
OK	
Coolant level is below specification	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to

	Procedure 008-018.

OK

Radiator fins or air conditioner condenser fins are damaged or obstructed with debris	Inspect the radiator fins and air conditioner condenser fins. Clean if necessary. Refer to Procedure 008-042.

OK

Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045.

OK

Fan drive belt is loose	Check the belt tension and tighten if necessary. *Refer to Procedure 008-002.*

OK

Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-025.

OK

Fan shroud is damaged or missing or the air recirculation baffles are damaged or missing	Inspect the shroud and the recirculation baffles. Repair, replace, or install, if necessary. Refer to Procedure 008-038.

Pressure cap is **not** correct or is malfunctioning	Replace pressure cap with the correct rating for the cooling system. Refer to Procedure 008-047.

Supplemental coolant additive (SCA) level is above specification or the coolant is overconcentrated with antifreeze	Check the SCA level. Verify the antifreeze concentration. Refer to Cooling Recommendations and Specifications in Cummins Coolant Requirements and Maintenance, Bulletin 3666132.

Fill line or vent lines are restricted, obstructed, or **not** routed correctly	Check the vent lines and the fill line for correct routing and for restriction. Refer to Procedure 008-017.

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 008-040.

OK

Thermostat is **not** correct or is malfunctioning	Check the thermostat for the correct part number and for correct operation. *Refer to Procedure 008-013.*

OK

Air or combustion gases are entering the cooling system	Check for air or combustion gases in the cooling system. Refer to Procedure 008-019.

OK

Cooling system component is malfunctioning	Perform the cooling system diagnostics test. Refer to Procedure 008-019.

OK

Water pump is malfunctioning	Check the water pump. Replace the water pump if necessary. Refer to Procedure 008-062.

Radiator core is internally obstructed or damaged, or the check valve or J-tube is malfunctioning	Inspect the radiator and clean if necessary. Refer to the OEM service manual.

Check valve is damaged (with remote-mounted engine coolant heater)	Inspect the check valve. Replace if necessary. Refer to the the manufacturer's instructions and specifications.

Engine is overfueled	Check the engine fuel rate. Refer to the Engine Testing - General Information in Section 14.

Torque converter is malfunctioning	Check the torque converter. Refer to the OEM service manual.

OK

Vehicle cooling system is **not** adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM service manual.

OK

Keel cooler or heat exchanger is malfunctioning or **not** adequately sized	Refer to the engine performance data sheet for heat rejection specification.

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Coolant Temperature Above Normal - Sudden Overheat

Symptom Tree t023

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Fan drive belt is broken	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002.
OK	
Coolant level is below specification	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to Procedure 008-018.

OK

External coolant leak	Inspect the engine for coolant leaking from hoses, draincocks, water manifold, jumper tubes, expansion and pipe plugs, fittings, radiator core, air compressor and cylinder head gaskets, lubricating oil cooler, water pump seal, cylinder block, and OEM-mounted components that have coolant flow. *If necessary, pressure-test the cooling system.* Refer to Procedure 008-018.

OK

Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Refer to Procedures 008-040.

OK

Radiator fins or air conditioner condenser fins are damaged or obstructed with debris	Inspect the radiator fins and air conditioner condenser fins. Clean if necessary. Refer to Procedure 008-042 and the OEM instructions and specifications.

OK

Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045.

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Pressure cap is **not** correct or is malfunctioning	Replace pressure cap with the correct rating for the cooling system. Refer to Procedure 008-047.

Fill line or vent lines are restricted, obstructed, or **not** routed correctly	Check the vent lines and the fill line for correct routing and for restriction. Refer to Procedure 008-017 and the OEM instructions and specifications.

Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to the manufacturer's instructions and specifications.

Cooling system component is malfunctioning	Perform the cooling system diagnostics test. Refer to Procedure 008-019.

	Check the thermostat for the correct part

Thermostat is **not** correct or is malfunctioning	number and for correct operation. *Refer to Procedure 008-013.*

OK

Water pump is malfunctioning	Check the water pump. Replace the water pump if necessary. Refer to Procedure 008-062.

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Coolant Temperature Below Normal

Symptom Tree t024

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Engine is operating at low ambient temperature	Check the winterfront, shutters, and under-the-hood air. Use under-the-hood intake air in cold weather. Refer to the Cold Weather Operation, Bulletin 3387266, and the Operation and Maintenance Manual, QSK23 Series Engine, Bulletin 4021374.
OK	
Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary. *Refer to the OEM service manual.*

Coolant temperature sensor is malfunctioning	Use an electronic service tool to check the coolant temperature sensor. Refer to Procedure 019-019 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Cooling system component is malfunctioning	Perform the cooling system diagnostics test. Refer to Procedure 008-019.

Thermostat seal is damaged, missing, or **not** installed correctly	Check the thermostat seal. Check the thermostat for correct seating. *Refer to Procedure 008-013 or 008-016.*

Thermostat is **not** correct or is malfunctioning	Check the thermostat for the correct part number and for correct operation. *Refer to Procedure 008-013.*

Coolant flow through the radiator is **not** correct	Check for correct coolant flow through the radiator. Refer to Procedure 008-042 and the OEM instructions and specifications.

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View Related Topic

Crankcase Gases (Blowby) Excessive

Symptom Tree t027

Printable Version

This is symptom tree

Cause	Correction
Excessive engine blowby	Before troubleshooting, it is important to determine the exact complaint by interviewing the operator, looking at the service history, oil consumption records, oil sampling information, and looking at the ECM information and fault codes.
OK	
Engine oil pan is overfilled	Inspect the oil level. Refer to Procedure 018-017 (Lubricating Oil System) in Section V.
OK	
Crankcase breather tube is plugged downstream of the blowby sensor	Inspect the breather tube for signs of debris or any other blockage or restriction. Refer to Procedure 003-001 (Crankcase

	Breather, External) in Section 3.

OK

Air intake system restriction	Check the air intake system for restriction. Refer to Procedure 010-031 (Air Intake Restriction) in Section 10.

OK

Engine blowby sensor has failed in range, or the electronic control module (ECM) calibration is incorrect	Connect the electronic control module (ECM) with INSITE™ electronic service tool and look for active, or recently active, Fault Codes 555, 719, or 729. If any are found active, perform the troubleshooting for the appropriate fault code. Inspect the blowby sensor and verify the blowby measurement. Refer to Procedure 019-043 (Engine Wiring Harness), Procedure 019-201 (Weather-Pack™ Connector Series), and Procedure 019-202 (Metri-Pack™ Connector Series) in Section 19 of the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Blowby sensor wiring harness connector	Connect to the electronic control module (ECM) with INSITE™ electronic service tool and look for active, or recently active, Fault Codes 555, 719, or 729. If any are found active, perform the troubleshooting for the appropriate fault code. Inspect the blowby sensor wiring harness connector for signs of corrosion or other damage.

is damaged	Refer to Procedure 019-043 (Engine Wiring Harness), Procedure 019-201 (Weather-Pack™ Connector Series), and Procedure 019-202 (Metri-Pack™ Connector Series) in Section 19 of the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Air compressor is malfunctioning	Isolate the air compressor by disconnecting the air inlet and outlet lines. Refer to Procedure 008-019 (Cooling System - Air or Combustion Gas Test) in Section 8. Check blowby. If blowby is within specifications, rebuild or replace the air compressor.

OK

One or more turbochargers are damaged	Isolate the turbocharger(s) one at a time by disconnecting the oil return lines. Check blowby and compare to data taken before disconnecting the oil return lines. Alternatively, check the turbocharger compressor and turbine seals. Refer to Procedure 010-033 (Turbocharger) in Section 10.

OK

	If equipped with a MCRS fuel system, use INSITE™ electronic service tool to shut off injectors/cylinders. First bank by bank, then cylinder by cylinder. Check blowby and compare to data taken before shutting

One or more power cylinders are damaged	off the back or cylinder. Alternatively, for all engines, perform a cylinder compression check. If a cylinder is found suspect, inspect the piston, piston rings, liner, and cylinder head for damage. Refer to Procedure 001-028 (Cylinder Liner), Procedure 001-043 (Piston), and Procedure 001-047 (Piston Rings) in Section 1, and Procedure 002-004 (Cylinder Head) in Section 2.

Cylinder head valve guides are excessively worn	Inspect the valve guides for wear and proper lubrication. Confirm the part number on the guide seal is correct. Refer to Procedure 002-004 (Cylinder Head) in Section 2.

Engine has incorrect size valve guides installed	Measure the valve guides and compare against the rebuild specifications for the cylinder head. Refer to Procedure 002-004 (Cylinder Head) in Section 2.

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Engine Acceleration or Response Poor

Symptom Tree t033

Printable Version

This is symptom tree

Cause	Correction
Verify the complaint	Test the engine operation while under load. Perform an engine acceleration test. Perform an engine load test. Observe the percent load with an electronic service tool. Refer to the Driveability/Low Power form.
OK	
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
	Check for accelerator pedal or lever restriction. Check the percent throttle reading on the electronic service tool or Cummins Digital Display. Check the

Accelerator pedal or lever position sensor or circuit is malfunctioning	position sensor and the circuit. Verify the accelerator position sensor provides 0- to 100-percent input to the ECM. Adjust as required. Refer to Procedure 019-086 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Programmable parameters or selected features are **not** correct or are **not** set the same as the values in comparable vehicles	Check the programmable parameters and the selected features with an electronic service tool. Make sure that gear-down protection road speeds are set to the same values as in comparable vehicles. Refer to the appropriate electronic service tool manual.

OK

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet on QuickServe™ Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021328. If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113, and the appropriate electronic service tool manual.

OK

Vehicle parasitics are excessive	Check the vehicle for brakes dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.

OK

Vessel is malfunctioning or parasitics are excessive	Check the vessel's bottom, propeller, transmission, and driven accessories. Refer to the OEM service manual.

OK

Drivetrain or propeller is damaged or is **not** correctly matched to the engine	Check for the correct gearing, drivetrain components, or propeller. Refer to the OEM service manual.

OK

Intake manifold air temperature is below specification	Refer to the Coolant Temperature Below Normal troubleshooting symptom tree in Section TS.

OK

Fuel inlet restriction	Check for fuel inlet restriction. Refer to Procedure 006-020 in Section 6.

OK

Gear pump is malfunctioning	Check the gear pump output pressure. Replace the gear pump, if necessary. Refer to Procedure 005-016 in Section 5.

OK

Air in the fuel system	Check for air in the fuel system. Refer to Procedure 006-003 in Section 6.

OK

Fuel drain line restriction	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary. Refer to Procedure 006-012 in Section 6.

OK

Engine is operating above recommended altitude	Engine power decreases above recommended altitude. Refer to the Engine Data Sheet for specifications.

OK

Air intake or exhaust leaks	Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024 in Section 10.

OK

Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031 in Section 10.

OK

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. Refer to Procedure 011-009 in Section 11.

OK

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of known high quality fuel. Refer to the Fuel Recommendations and Specifications in Fuel For Cummins Engines, Bulletin 3379001.

OK

Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 4021328. Replace the turbocharger, if necessary. Refer to

	Procedure 010-033 in Section 10.

OK

Fuel inlet temperature to pump is above specification	Fill the fuel tank, turn off or bypass the fuel heaters, and check the fuel cooler. Refer to the OEM service manual.

OK

Intake manifold pressure sensor is malfunctioning	Check the intake manifold pressure sensor. Refer to Procedure 019-061 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Ambient air temperature sensor is malfunctioning (if equipped)	Check the ambient air temperature sensor. Refer to Procedure 019-004 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-115 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78

	Engines, Bulletin 3666113.

OEM rail pressure lines are excessively long or trapped with air, which causes an accumulator effect (vehicles equipped with cab rail pressure gauges **only**)	Vent the air from the OEM devices. Refer to the OEM service manual.

Debris in the fuel passages	Check the fuel tubes and fuel manifold for debris. Refer to Procedure 006-024 in Section 6.

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006 in Section 3.

Static injection timing is **not** correct	Check the static injection timing. Refer to Procedure 006-025 in Section 6.

Crankcase pressure is excessive	Check for excessive blowby. Refer to the Crankcase Gases (Blowby) Excessive troubleshooting symptom tree in Section TS.

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Engine Decelerates Slowly

Symptom Tree t041

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for troubleshooting fault codes.
OK	
Accelerator pedal position sensor or circuit is malfunctioning	Check for accelerator pedal or lever restriction. Check the percent throttle reading on an electronic service tool. Check the accelerator pedal position sensor and the circuit. Refer to Procedure 019-086 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.
OK	
	Check the programmable parameters and

Programmable parameters or selected features are **not** correct	the selected features with an electronic service tool. Set the parameters and features again if necessary. Refer to the appropriate electronic service tool manual.

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to Procedure 019-032 and the appropriate electronic service tool manual.

Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*

OEM rail pressure lines are excessively long or trapped with air, which causes an accumulator effect (vehicles equipped with cab rail pressure gauges **only**)	Vent the air from the OEM devices. Refer to the OEM service manuals.

OK

Fueling rail actuator or timing rail actuator is malfunctioning	Check the fueling rail actuator and the timing rail actuator. Replace the actuators if necessary. Refer to Procedures 019-337 and 019-339 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Injector is malfunctioning	Replace the malfunctioning injector. Refer to Procedure 006-026.

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Engine Difficult to Start or Will Not Start (Exhaust Smoke)

Symptom Tree t043

Printable Version

This is symptom tree

Cause	Correction
Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK	
Vehicle parasitics are excessive	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.
OK	
Vessel is malfunctioning or parasitics are excessive	Check the vessel bottom, propeller, transmission, and driven accessories. Refer to the manufacturer's instructions and specifications.

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OK

Starting aid is necessary for cold weather or starting aid is malfunctioning	Check for the correct operation of the starting aid. Refer to the manufacturer's instructions. Refer to the Cold Weather Starting Aids in the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374.

OK

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113, for fault code troubleshooting.

OK

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 and the appropriate electronic service tool manual.

OK

Engine cranking speed is too slow	*Check the engine cranking speed with a handheld tachometer or electronic service tool.* If the cranking speed is slower than 150 rpm, refer to the Engine Will Not Crank or Cranks Slowly (Electric starter) symptom tree.

OK

Engine idle speed is set too low (electronically controlled fuel systems)	Verify the correct idle speed setting. Increase the idle speed with the idle increment switch or an electronic service tool. Refer to the appropriate electronic service tool manual.

OK

Engine speed sensor or circuit is malfunctioning	Check the engine speed sensor for correct adjustment and for debris on the sensor. Check the engine speed sensor circuit. Refer to Procedures 019-042 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*

OK

Gear pump is malfunctioning	Check the gear pump output pressure. Replace the gear pump if necessary. Refer to Procedure 005-016.

OK

Low or no rail pressure to the injectors	Check the rail pressure with an electronic service tool. Refer to the appropriate electronic service tool manual. If the pressure is low, check for fuel inlet restriction. Refer to Procedure 006-020 Procedure 005-016.

OK

Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003*.

OK

Actuator screen is restricted	Replace the actuator screen. Refer to Procedure 019-112 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fueling rail actuator or timing rail actuator is malfunctioning	Check the fueling rail actuator and the timing rail actuator. Replace the actuators if necessary. Refer to Procedures 019-337 and 019-339 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-115 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Low timing pressure to the injectors	Check the timing pressure with an electronic service tool. Refer to the appropriate electronic service tool manual. If the pressure is low, check for fuel inlet restriction. Refer to Procedure 006-020.

OK

Timing pressure sensor is malfunctioning	Check the timing pressure sensor. Replace the sensor if necessary. Refer to Procedure 019-113 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Fuel shutoff valve solenoid or circuit is malfunctioning (electronic controlled fuel systems)	Check the fuel shutoff valve solenoid and circuit. Refer to Procedures 019-049 and 019-050 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Fuel For Cummins Engines, Bulletin 3379001.

Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031.

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. *Refer to Procedure 011-009.*

Incorrect datalink adapter being used	Engines using multiple engine synchronization **must** communicate on J1587. The INLINE, INLINE I, or INLINE II adapter **must** be used to complete this task.

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

Injector o-rings are damaged or missing	Remove and check the injectors. Replace the injector o-rings. Refer to Procedure 006-026.

Debris in the fuel passages	Check the fuel tubes and fuel manifold for debris. Refer to Procedure 006-024.

	Check the engine for high crankcase pressure, low compression, static injection

Base engine problem	timing, damaged pistons, camshaft, and other parts. Refer to an Authorized Cummins Repair Facility

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

Symptom Tree t044

Printable Version

This is symptom tree

Cause	Correction
Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK	
NODE NOT FOUND	
OK	
Fuel shutoff valve solenoid or circuit is malfunctioning (electronic controlled fuel systems)	Check the fuel shutoff valve solenoid and circuit. Refer to Procedure 019-049 and Procedure 019-050 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.

OK

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet on QuickServe™ Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021328. If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to Procedure 013-009 in Section 13, Procedure 019-198, and Procedure 019-087 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fuel inlet restriction	Check for fuel inlet restriction. Refer to Procedure 006-020 in Section 6.

OK

Gear pump is malfunctioning	Check the gear pump output pressure. Replace the gear pump, if necessary. Refer to Procedure 005-016 in Section 5.

OK

Low or no rail pressure to the injectors	Check the rail pressure with an electronic service tool. Refer to the appropriate electronic service tool manual. If the pressure is low, check for fuel inlet restriction. Refer to Procedure 005-016 in Section 5.

OK

In-line check valve(s) is installed backward or has an incorrect part number	Check the in-line check valve(s) for the correct part number. Check the arrow on the check valve(s) for the correct orientation. Refer to the OEM service manual.

OK

Air in the fuel system	Check for air in the fuel system. Refer to Procedure 006-003 in Sectio 6.

OK

Engine speed sensor or circuit is malfunctioning	Check the engine speed sensor for correct adjustment and for debris on the sensor. Check the engine speed sensor circuit. Refer to Procedure 019-042 in Section 19 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Camshaft end clearance is excessive	Check the camshaft end clearance. Refer to Procedure 001-008 in Section 1.

OK

Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031 in Sectio 10.

OK

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. Refer to Procedure 011-009 in Section 11.

OK

Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-044 in Section 7.

OK

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Engine Noise Excessive

Symptom Tree t047

Printable Version

This is symptom tree

Cause	Correction

When troubleshooting engine noise complaints, make sure the engine accessories (air compressor, fan clutch, freon compressor, or hydraulic pump) are **not** the cause of the noise. Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Lubricating oil level is below specification	Check the oil level. *Verify the dipstick calibration and the oil pan capacity. Fill the system to the specified level.* Refer to Procedures 007-009 and 007-037.

OK

Lubricating oil pressure is below specification	Check the oil pressure. *Refer to Procedures 007-029 and 007-028.* If the pressure is low, refer to the Lubricating Oil Pressure Low symptom tree.

OK

Coolant temperature is above specification	Check the coolant level. Refer to Procedure 008-018.

OK

Lubricating oil is thin or diluted	Refer to Lubricating Oil Recommendations and Specifications in the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374. *If the oil pressure is low, refer to the Lubricating Oil Pressure Low symptom tree.*

OK

Fan drive belt is loose, tight, or **not** in alignment	Check the fan drive belt. Refer to *Procedure 008-002.*

OK

Fan is loose, damaged, or **not** balanced	Check the fan. Refer to Procedure 008-040.

OK

Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.

OK

Air intake or exhaust piping is contacting the chassis or cab	Inspect the air piping, chassis, and cab for contact points. Refer to the OEM service manual.

OK

Air intake or exhaust leaks	*Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024.*

OK

Turbocharger noise	Refer to the Engine Noise Excessive - Turbocharger symptom tree.

OK

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

OK

	Replace the malfunctioning injector. *Refer*

Injector is malfunctioning	*to Procedure 006-026.*

OK

Overhead components are damaged	Inspect the rocker levers, rocker shafts, cam followers or tappets, push rods, and valves for damage or excessive wear. Refer to Procedure 003-009, 004-001, 004-014, or 002-004.

OK

Accessory drive is worn (axial end play is out of specification)	Check the accessory drive axial end play. Inspect the shaft for wear. Refer to Procedure 009-009.

OK

Static injection timing is **not** correct	Check the static injection timing. *Refer to Procedure 006-025.*

OK

Vibration damper is damaged	Inspect the vibration damper. Refer to Procedure 001-052.

Air compressor noise is excessive	Refer to the Air Compressor Noise Excessive - Air Compressor symptom tree.

Fan clutch, hydraulic pump, or freon compressor noise is excessive	Isolate each component and check for noise. Refer to the OEM service manual.

Drivetrain noise is excessive	Disconnect the drivetrain. Check for engine noise. Refer to the OEM service manual.

Gear train backlash is excessive or the gear teeth are damaged	Check the gear backlash and the gear teeth. Refer to Procedures 001-036, 001-097, and 001-098.

Main bearing or connecting rod bearing noise	Refer to the Engine Noise Excessive - Main Bearing symptom tree.

OK

Flywheel or flexplate capscrews are loose or broken	Check the flywheel or flexplate and the mounting capscrews. Refer to Procedure 016-005.

OK

Piston, piston rings, or cylinder liner is worn or damaged	Refer to the Engine Noise Excessive - Piston symptom tree.

OK

Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-044.

OK

Rear engine power take-off (REPTO) noise is excessive	Disassemble and repair the REPTO as necessary. Refer to the OEM service manual.

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Engine Noise Excessive — Combustion Knocks

Symptom Tree t048

Printable Version

This is symptom tree

Cause	Correction

Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Intake manifold air temperature is below specification	Refer to the Coolant Temperature Below Normal symptom tree.

OK

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in the Operation and Maintenace Manual, QSK23 Series Engines, Bulletin 4021374.

OK

Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

Static injection timing is **not** correct	Check the static injection timing. *Refer to Procedure 006-025.*

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Engine Noise Excessive — Connecting Rod

Symptom Tree t049

Printable Version

This is symptom tree

Cause	Correction

Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Lubricating oil level is below specification	Check the oil level. *Verify the dipstick calibration and the oil pan capacity. Fill the system to the specified level.* Refer to Procedures 007-009 and 007-037.

OK

Lubricating oil pressure is below specification	Check the oil pressure. *Refer to Procedure 007-028.* If the pressure is low, refer to the Lubricating Oil Pressure Low symptom tree.

OK

Lubricating oil is thin or diluted	Refer to Lubricating Oil Recommendations and Specifications in the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374. *If the oil*

	pressure is low, refer to the Lubricating Oil Pressure Low symptom tree.

OK

Connecting rod capscrews are loose or **not** tightened correctly	Check the torque on the connecting rod capscrews. Refer to Procedure 001-014.

OK

Connecting rod is bent or out of alignment	Remove and inspect the connecting rods. Refer to Procedure 001-014.

OK

Connecting rod and bearings are damaged or worn, are **not** assembled correctly, or are the wrong bearings	Inspect the connecting rod and bearings. Refer to Procedure 001-005.

OK

Crankshaft journals are damaged or out of round	Inspect the crankshaft journals. Refer to Procedure 001-006.

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Engine Noise Excessive — Main Bearing

Symptom Tree t050

Printable Version

This is symptom tree

Cause	Correction

Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Main bearing capscrews are loose, worn or **not** tightened correctly	Check the torque on the main bearing capscrews. Inspect the capscrews for wear. Refer to Procedure 001-006.

OK

Main bearings are damaged or worn, or the wrong bearings are installed	Inspect the main bearings for damage, excessive wear, and the correct part number. Refer to Procedure 001-006.

OK

Crankshaft journals are damaged or out of round	Inspect the crankshaft journals. Refer to Procedure 001-006.

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Engine Noise Excessive — Piston

Symptom Tree t051

Printable Version

This is symptom tree

Cause	Correction

Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Listen to the engine before using this symptom tree. Listen for a light tapping noise, which is more noticeable with no load on the engine. Piston noise can usually be noticed when the engine is decelerating.

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in the Fuel For Cummins Engines, Bulletin 3379001.

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

OK

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

OK

Carbon deposits on the top of the pistons are contacting the cylinder head	Remove the cylinder head and check for carbon deposits on the pistons. If deposits are excessive, remove and clean the pistons. Check the piston rings for damage or wear. Refer to Procedures 002-004, 001-054, 001-043 and 001-047.

OK

Piston pin or bushing is loose, worn, or **not** installed correctly	Remove the pistons and inspect the piston pin and bushing for damage, wear, and correct installation. Refer to Procedure 001-043.

OK

Cylinder liner, pistons, or piston rings are worn or damaged	Check the pistons, piston rings, and cylinder liner. Refer to Procedures 001-043, 001-047 and 001-028.

OK

Connecting rod is bent or out of alignment	Remove and inspect the connecting rods. Refer to Procedure 001-014.

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

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Engine Noise Excessive — Turbocharger

Symptom Tree t052

Printable Version

This is symptom tree

Cause	Correction

Refer to Engine Noise Diagnostic Procedures - General Information at the end of Section TS before using this symptom tree.

Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 3379133 or 4021327. Replace the turbocharger if necessary. Refer to Procedure 010-033.

OK

Air intake or exhaust piping is contacting the chassis or cab	Inspect the air piping, chassis, and cab for contact points. Refer to the OEM service manual.

OK

Air intake or exhaust leaks	*Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024.*

Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031.

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. *Refer to Procedure 011-009.*

Turbocharger compressor wheel, turbine wheel, or nose cone is damaged	Check the compressor and turbine wheels for damage. Check the nose cone for damage. Refer to Procedure 010-033.

Turbocharger is worn or damaged	Check the turbocharger for damage. Measure the turbine and compressor wheel clearances. Refer to Procedure 010-033.

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Engine Runs Rough at Idle

Symptom Tree t061

Printable Version

This is symptom tree

Cause	Correction
Engine is cold	Allow the engine to warm to operating temperature. If the engine will **not** reach operating temperature, refer to the Coolant Temperature Below Normal symptom tree.

OK

Idle characteristics of the HPI system are different than characteristics of the PT system	Normal performance. No corrections are necessary.

OK

Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*

OK

Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*

OK

Fuel drain line restriction	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary. Refer to Procedure 006-012.

OK

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Fuels For Cummins Engines, Bulletin 3379001.

OK

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.

OK

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to the appropriate electronic service tool manual and Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Engine idle speed is set too low (electronically controlled fuel systems)	Verify the correct idle speed setting. Increase the idle speed with the idle increment switch or an electronic service tool. Refer to the appropriate electronic service tool manual.

OK

Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to Procedure 016-002.

OK

	Check the engine speed sensor for correct

Engine speed sensor or circuit is malfunctioning	adjustment and for debris on the sensor. Check the engine speed sensor circuit. Refer to Procedures 019-042 and 019-106 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fueling rail actuator or timing rail actuator is malfunctioning	Check the fueling rail actuator and the timing rail actuator. Replace the actuators if necessary. Refer to Procedures 019-337 and 019-339 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Actuator screen is restricted	Replace the actuator screen. Refer to Procedure 019-112 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Gear pump is malfunctioning	Check the gear pump output pressure. Replace the gear pump if necessary. Refer to Procedure 005-016.

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

Debris in the fuel passages	Check the fuel tubes and fuel manifold for debris. Refer to Procedure 006-024.

Camshaft end clearance is excessive	Check the camshaft end clearance. Refer to Procedure 001-008.

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 003-006

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Engine Runs Rough or Misfires

Symptom Tree t062

Printable Version

This is symptom tree

Cause	Correction
Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*
OK	
Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*
OK	
Fuel drain line restriction	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary. Refer to Procedure 006-012.
OK	

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Fuel For Cummins Engines, Bulletin 3379001.

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to the appropriate electronic service tool manual and Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Engine speed sensor or circuit is malfunctioning	Check the engine speed sensor for correct adjustment and for debris on the sensor. Check the engine speed sensor circuit. Refer to Procedures 019-042 and 019-106 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Fueling rail actuator or timing rail actuator is malfunctioning	Check the fueling rail actuator and the timing rail actuator. Replace the actuators if necessary. Refer to Procedures 019-337 and 019-339 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Electronic control module (ECM) is malfunctioning	Replace the ECM. Refer to Procedure 019-031 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 019-031 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113

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Engine Shuts Off Unexpectedly or Dies During Deceleration

Symptom Tree t064

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Engine will **not** restart	Refer to the Engine Difficult to Start or Will Not Start (exhaust smoke) symptom tree.
OK	
Keyswitch circuit is malfunctioning	Check the vehicle keyswitch circuit. Refer to Procedure 019-064 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78

	Engines, Bulletin 3666113.

OK

Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to Procedures 013-009 and 019-198 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fuel shutoff valve(s) closed (electronically controlled injection)	Check the fuel shutoff valve and circuit. *Refer to Procedures 019-049 and 019-050 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.*

OK

OEM engine protection system is malfunctioning	Isolate the OEM engine protection system. Follow the OEM service manuals to check for a malfunction.

OK

Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*

OK

Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

OK

Gear pump is malfunctioning	Check the gear pump output pressure. Replace the gear pump if necessary. Refer to Procedure 005-016.

OK

Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to Procedure 016-002.

OK

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

OK

Debris in the fuel passages	Check the fuel tubes and fuel manifold for debris. Refer to Procedure 006-024.

OK

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 006-024

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Engine Speed Surges at Low or High Idle

Symptom Tree t066

Printable Version

This is symptom tree

Cause	Correction
Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK	
Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*
OK	
Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*
OK	

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 and the appropriate electronic service tool manual.

Engine idle speed is set too low (electronically controlled fuel systems)	Verify the correct idle speed setting. Increase the idle speed with the idle increment switch or an electronic service tool. Refer to the appropriate electronic service tool manual.

OK

Accelerator pedal or lever position sensor or circuit is malfunctioning	Check for accelerator pedal or lever restriction. Check the percent throttle reading on the electronic service tool or Cummins Digital Display. Check the position sensor and the circuit. Verify the accelerator position sensor provides 0- to 100-percent input to the ECM. Adjust as required. Refer to Procedure 019-086 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Engine speed sensor or circuit is malfunctioning	Check the engine speed sensor for correct adjustment and for debris on the sensor. Check the engine speed sensor circuit. Refer to Procedures 019-042 and 019-106 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fuel drain line restriction	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary. Refer to Procedure 006-012.

OK

Actuator screen is restricted	Replace the actuator screen. Refer to Procedure 019-112 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Fueling rail actuator or timing rail actuator is malfunctioning	Check the fueling rail actuator and the timing rail actuator. Replace the actuators if necessary. Refer to Procedures 019-337 and 019-339 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Alternator is malfunctioning	Temporarily disconnect the alternator and run the engine. Replace the alternator if necessary. Refer to Procedure 013-001 and the OEM service manual.

Vehicle parasitics are excessive	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.

	Check the vessel bottom, propeller,

Vessel is malfunctioning or parasitics are excessive	transmission, and driven accessories. Refer to the manufacturer's instructions and specifications.

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

Camshaft end clearance is excessive	Check the camshaft end clearance. Refer to Procedure 001-008.

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Engine Starts But Will Not Keep Running

Symptom Tree t072

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Air in the fuel system	Check for air in the fuel system. *Refer to Procedure 006-003.*
OK	
Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.

Engine-driven units are engaged	Disengage engine-driven units.

Fuel is waxing due to cold weather	Check the fuel heater, if installed. Weather conditions sometimes require a fuel heater.

Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*

Fuel drain line is bent	Check the fuel drain line. Repair if necessary. *Refer to Procedure 006-013.*

	Check the fuel shutoff valve solenoid and circuit. Refer to Procedures 019-049 and

Fuel shutoff valve solenoid or circuit is malfunctioning (electronic controlled fuel systems)	019-050 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Fuels For Cummins Engines, Bulletin 3379001.

Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031.

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. *Refer to Procedure 011-009.*

Fuel pump is malfunctioning	Check the fuel pump output pressure, pulsation damper, and pressure regulator. Replace the fuel pump if necessary. Refer to Procedure 005-016 .

Static injection timing is **not** correct	Check the static injection timing. *Refer to Procedure 006-025.*

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Engine Will Not Crank or Cranks Slowly (Air Starter)

Symptom Tree t077

Printable Version

This is symptom tree

Cause	Correction
Air pressure is low in the air tanks	Increase air pressure with an external air source. Refer to the OEM service manual.
OK	
Engine-driven units are engaged	Disengage engine-driven units.
OK	
Lubricating oil temperature is below specification the OEM service manual	Install an oil pan heater, or drain the oil and fill the system with warm oil.

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

OK

Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-013 or the Lubricating Oil Recommendations and Specifications in the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374. *Use the oil type recommended in Section V of the operation and maintenance manual.*

OK

Crankshaft rotation is impaired	Check the crankshaft for ease of rotation. Refer to Procedure 001-016.

OK

Starting motor is malfunctioning or starting motor is **not** correct	Check the starting motor operation. Compare the starting motor with the engine and vehicle specifications. Refer to the manufacturer's instructions and specifications.

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 and specifications.*

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

Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-044.

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Engine Will Not Crank or Cranks Slowly (Electric Starter)

Symptom Tree t078

Printable Version

This is symptom tree

Cause	Correction
Neutral safety switch engaged or malfunctioning	Put gear lever in neutral or check for faulty switch. Refer to boat or component manufacturer.
OK	
Batteries have malfunctioned	Check the condition of the batteries. Replace the batteries, if necessary. Refer to the OEM service manual.
OK	
Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections. *Refer to Procedure 013-009.*

OK

Battery switch undersize or terminals are corroded	Replace the switch and/or clean the terminals. Refer to Procedure 013-009.

OK

Engine-driven units are engaged	Disengage engine-driven units.

OK

Battery temperature is below specification	Check the battery heater (if equipped) for correct operation. Refer to the manufacturer's instructions and specifications.

OK

Lubricating oil temperature is below specification the manufacturer's instructions and specifications	Install an oil pan heater, or drain the oil and fill the system with warm oil.

OK

	Change the oil and filters. Refer to Procedure 007-013 or the Lubricating Oil Recommendations and Specifications in

Lubricating oil does **not** meet specifications for operating conditions	the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374. *Use the oil type recommended in Section V of the operation and maintenance manual.*

Crankshaft rotation is impaired	Check the crankshaft for ease of rotation. Refer to Procedure 001-016.

Battery capacity is below specification	Refer to Section V in the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374. Replace the batteries if necessary.

Battery cables are **not** the correct gauge or length	Replace the battery cables with larger gauge or shorter length cables. Refer to Procedure 013-009.

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.*

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

Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-044.

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Engine Will Not Reach Rated Speed (RPM)

Symptom Tree t080

Printable Version

This is symptom tree

Cause	Correction
Tachometer is **not** calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.
OK	
Vehicle parasitics are excessive	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.
OK	
Vessel is malfunctioning or parasitics are excessive	Check the vessel bottom, propeller, transmission, and driven accessories. Refer to the manufacturer's instruction and specifications.

OK

Fuel inlet restriction	Check for fuel inlet restriction. *Refer to Procedure 006-020.*

OK

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.

OK

Accelerator pedal or lever position sensor or circuit is malfunctioning	Check for accelerator pedal or lever restriction. Check the percent throttle reading on the electronic service tool or Cummins Digital Display. Check the position sensor and the circuit. Verify the accelerator position sensor provides 0- to 100-percent input to the ECM. Adjust as required. Refer to Procedure 019-086 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

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

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Fuels For Cummins Engines, Bulletin 3379001.

OK

Drivetrain or propeller is damaged or is **not** correctly matched to the engine	Check for the correct gearing, drivetrain components, or propeller. Refer to the manufacturer's instructions and specifications.

OK

Injector o-rings are damaged or missing	Remove and check the injectors. Replace the injector o-rings. Refer to Procedure 006-026.

OK

Fueling rail actuator or timing rail actuator is malfunctioning	Check the fueling rail actuator and the timing rail actuator. Replace the actuators if necessary. Refer to Procedures 019-337 and 019-339 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

OK

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 003-006

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Engine Will Not Shut Off

Symptom Tree t081

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.
OK	
Keyswitch circuit is malfunctioning	Check the vehicle keyswitch circuit. Refer to Procedure 019-064 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.
OK	
Fuel shutoff valve (FSOV) or rail actuator is stuck open	Verify the solenoid is **not** being energized by a short in the wiring. Refer to Procedure 019-049. To replace the rail actuator, refer to Procedure 019-110 in the Troubleshooting and Repair Manual,

	Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Engine is running on fumes drawn into the air intake	Check the air intake ducts. Locate and isolate the source of the fumes. Repair as necessary. Refer to the OEM service manuals.

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

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Fuel Consumption Excessive

Symptom Tree t087

Printable Version

This is symptom tree

Cause	Correction
Interview the operator to verify the complaint	Refer to the Driveability - General Information, Driveability/Low Power Customer Complaint Form, and Driveability Checklist in Section TS. Follow the instructions on the forms before continuing with this tree.
OK	
Operator technique is **not** correct	Explain correct engine operation to the operator. Refer to the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374.
OK	
Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to Procedure 006-024 and the OEM service manual.

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 Procedures 007-009 and 007-037.

OK

Equipment and environmental factors are affecting fuel consumption	Consider ambient temperatures, wind, tire size, axle alignment, routes, and use of aerodynamic aids when evaluating fuel consumption.

OK

Tachometer is **not** calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.

OK

Vehicle parasitics are excessive	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.

OK

Vessel is malfunctioning or parasitics are excessive	Check the vessel bottom, propeller, transmission, and driven accessories. Refer to the manufacturer's instructions and specifications.

OK

Drivetrain or propeller is damaged or is **not** correctly matched to the engine	Check for the correct gearing, drivetrain components, or propeller. Refer to the manufacturer's instructions and specifications.

OK

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113, for fault code troubleshooting.

OK

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19,

	QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Programmable parameters or selected features are **not** correct or are **not** set the same as the values in comparable vehicles	Check the programmable parameters and the selected features with an electronic service tool. Make sure that gear-down protection road speeds are set to the same values as in comparable vehicles. Refer to the appropriate electronic service tool manual.

OK

Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-338 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Intake manifold pressure sensor is malfunctioning	Check the intake manifold pressure sensor. Refer to Procedure 019-061 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Air intake or exhaust leaks	*Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024.*

OK

Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031.

OK

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. *Refer to Procedure 011-009.*

OK

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 Fuel For Cummins Engines, Bulletin 3379001.

OK

Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 3379133 or 4021327. Replace the turbocharger if necessary. Refer to Procedure 010-033.

OK

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

OK

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 006-026

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Fuel in Coolant

Symptom Tree t091

Printable Version

This is symptom tree

Cause	Correction
Bulk coolant supply is contaminated	Check the bulk coolant supply. Drain the coolant and replace with noncontaminated coolant. Replace the coolant filters. *Refer to Procedure 008-018.*
OK	
Fuel heater is malfunctioning (if equipped)	Check the fuel heater and replace, if necessary. Refer to the manufacturer's instructions and specifications.
OK	
Air or combustion gases are entering the cooling system	Check for air or combustion gases in the cooling system. Refer to Procedure 008-019.

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Fuel in the Lubricating Oil

Symptom Tree t092

Printable Version

This is symptom tree

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 007-037.*
OK	
Engine idle time is excessive	Low oil and coolant temperatures can be caused by long idle time (greater than 10 minutes). Shut off the engine rather than idle for long periods. If idle time is necessary, raise the idle speed. Procedure 007-037
OK	
In-line check valve(s) is installed backward or has an incorrect part number	Check the in-line check valve(s) for the correct part number. Check the arrow on the check valve(s) for the correct

	orientation. Refer to the OEM service manual.

OK

Fuel pump seal is leaking	Perform the fluorescent dye tracer test to confirm fuel leak. Replace the fuel pump if necessary. Refer to Procedure 005-016.

OK

Top injector o-ring or injector timing plunger is damaged	Perform the fluorescent dye tracer test to find the bad injector. Replace the injector or o-ring. Refer to Procedure 006-026.

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

OK

Air or combustion gases are entering the cooling system	Check for air or combustion gases in the cooling system. Refer to Procedure 008-019.

OK

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 008-019

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Intake Manifold Air Temperature Above Specification

Symptom Tree t096

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	View and troubleshoot the fault codes with INSITE™. Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.

OK

Intake manifold temperature sensor is malfunctioning	Check the intake manifold temperature sensor. Refer to Procedure 019-059 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Vehicle speed is too low for adequate cooling with high engine load	Reduce the engine load. Increase the engine (fan) rpm by downshifting.

OK

Fan shroud is damaged or missing or the air recirculation baffles are damaged or missing	Inspect the shroud and the recirculation baffles. Repair, replace, or install, if necessary. Refer to Procedure 008-038.

OK

Fan drive belt is loose	Check the belt tension and tighten if necessary. *Refer to Procedure 008-002.*

OK

Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Refer to Procedures 008-040.

OK

Radiator shutters are **not** opening completely or the shutterstat setting is wrong	Inspect the radiator shutters. Repair or replace if necessary. Refer to the OEM service manual. Check the shutterstat setting.

OK

Check valve between the LTA and the engine radiator is installed backward	Check the installed direction of the check valve. Remove and install the check valve in the proper direction if necessary. Refer to the manufacturer's instructions and specifications.

OK

Coolant temperature is above specification	Refer to the Coolant Temperature Above Normal - Gradual Overheat symptom tree.

OK

Aftercooler element is restricted	Inspect the aftercooler element for restriction. Clean or replace the core if necessary. Refer to Procedure 010-031.

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Intake Manifold Pressure (Boost) is Below Normal

Symptom Tree t097

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	View and troubleshoot the fault codes with INSITE™. Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 3379133 or 4021327. Replace the turbocharger if necessary. Refer to Procedure 010-033.
OK	
Air intake or exhaust leaks	*Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024.*

OK

Air compressor connection is loose or damaged	Check the connection between the manifold and the air compressor. Repair or replace if necessary.

OK

Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031.

OK

Aftercooler element is restricted	Inspect the aftercooler element for restriction. Clean or replace the core if necessary. Refer to Procedure 010-031.

OK

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. *Refer to Procedure 011-009.*

OK

Turbocharger is worn or damaged	Check the turbocharger for damage. Measure the turbine and compressor wheel clearances. Refer to Procedure 010-033.

Fuel pump is malfunctioning	Check the fuel pump output pressure, pulsation damper, and pressure regulator. Replace the fuel pump if necessary. Refer to Procedures 005-016.

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Lubricating Oil Consumption Excessive

Symptom Tree t102

Printable Version

This is symptom tree

Cause	Correction
Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets if necessary. Refer to Procedure 007-024 in Section 7.
OK	
Verify the oil consumption rate	Check the amount of oil added versus the hours of operation.
OK	
Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to the Cummins® Engine Oil Recommendations, Bulletin 3810340.
OK	

Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-001 in Section 3.

OK

Crankcase pressure is excessive	Check for excessive blowby. Refer to Section 14. If blowby is excessive, check the piston rings for correct seating. Refer to Procedure 001-043 and Procedure 001-047 in Section 1.

OK

Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. Refer to Procedure 010-033 in Section 10.

OK

Air compressor is pumping lubricating oil into the air system	Check the air lines for carbon buildup and lubricating oil. Refer to the Air Compressor is Pumping Excessive Lubricating Oil into the Air System symptom tree.

OK

Lubricating oil cooler is leaking	Check for lubricating oil in the coolant. Refer to Lubricating or Transmission Oil in

	the Coolant symptom tree.

OK

Lubricating oil does **not** meet specifications	Use Cummins Inc. recommended lubricating oil type. Refer to Procedure 007-025 in Section 7or the Cummins® Engine Oil Recommendations, Bulletin 3810340.

OK

Lubricating oil dipstick calibration is **not** correct	Check the dipstick calibration. Refer to Procedure 007-009 in Section 7.

OK

Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-037 in Section 7.

OK

Lubricating oil is thin or diluted	Refer to the Cummins® Engine Oil Recommendations, Bulletin 3810340. Check the viscosity of the oil sample.

OK

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Lubricating Oil Pressure High

Symptom Tree t104

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113, for fault code troubleshooting.
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 007-028.
OK	
Coolant temperature is below specification	Refer to the Coolant Temperature Below Normal symptom tree.

OK

Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-013 and the Cummins Engine Oil Recommendations, Bulletin 3810340. *Use the oil type recommended in Section V of the operation and maintenance manual.*

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Lubricating Oil Pressure Low

Symptom Tree t105

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Lubricating oil level is below specification	Check the oil level. *Verify the dipstick calibration and the oil pan capacity. Fill the system to the specified level.* Refer to Procedures 007-009 and 007-037.
OK	
Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to Procedure 017-011 and Section V for torque specifications.

Engine angularity during operation exceeds specification	Refer to the engine specification data sheet.

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 007-028.

Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-013 and the Lubricating Oil Recommendations and Specifications in the Cummins Engine Oil Recommendations, Bulletin 3810340.

Lubricating oil is contaminated with coolant or fuel	*Refer to the Lubricating Oil Contaminated symptom tree.*

Lubricating oil filter is plugged	Change the oil and filter. Refer to Procedures 007-013.

OK

Piston cooling nozzles are damaged or are **not** installed correctly	Check the piston cooling nozzles for damage and correct installation. Refer to Procedure 001-046 Procedures 007-013.

OK

Lubricating oil pump is malfunctioning or the o-rings are damaged	Inspect the lubricating oil pump and o-rings. Refer to Procedure 007-031.

OK

Lubricating oil temperature is above specification	*Refer to the Lubricating Oil Temperature Above Specification symptom tree.*

OK

Lubricating oil suction or transfer tube is loose or broken, or the gasket or o-rings are leaking	Remove and inspect the oil pan or suction tube. Refer to Procedure 007-035.

OK

Lubricating oil cooler is plugged	Check the oil cooler. *Refer to Procedure 007-007.*

OK

Internal engine damage or internal lubricating oil leak	Analyze the lubricating oil. Inspect the oil filter. Check the main bearings, rod bearings, cam bushings, and rocker lever bushings for excessive wear. Refer to Procedures 001-006, 001-010, and 001-014.

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Lubricating Oil Sludge in the Crankcase Excessive

Symptom Tree t106

Printable Version

This is symptom tree

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 007-037 .*
OK	
Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-013 and Cummins Engine Oil Recommendations, Bulletin 3810340.
OK	
Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Section 2 in the Operation and Maintenance Manual, QSK23 Series Engines, Bulletin 4021374.

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

OK

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in the Fuel For Cummins Engines, Bulletin 3379001.

OK

Coolant temperature is below specification	Refer to the Coolant Temperature Below Normal symptom tree.

OK

Lubricating oil is contaminated with coolant or fuel	*Refer to the Lubricating Oil Contaminated symptom tree.*

OK

Crankcase pressure is excessive	Check for excessive blowby. Refer to the Crankcase Gases (Blowby) Excessive symptom tree.

OK

Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-

	001.

OK

Injector cup is damaged or is **not** correct	Check the injector cups for damage and for correct part numbers. Refer to Procedure 006-026.

OK

Static injection timing is **not** correct	Check the static injection timing. *Refer to Procedure 006-025 .*

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Lubricating Oil Temperature Above Specification

Symptom Tree t107

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
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 Procedures 007-009 and 007-037.
OK	
Coolant temperature is above specification	Refer to the Coolant Temperature is Above Normal - Sudden Overheat or the Coolant Temperature Above Normal - Gradual Overheat symptom tree.

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. Refer to the OEM installation manual.

OK

Lubricating oil cooler is leaking	Check for lubricating oil in the coolant. Refer to the Lubricating or Transmission Oil in the Coolant symptom tree.

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Lubricating or Transmission Oil in the Coolant

Symptom Tree t108

Printable Version

This is symptom tree

Cause	Correction
Bulk coolant supply is contaminated	Check the bulk coolant supply. Drain the coolant and replace with noncontaminated coolant. Replace the coolant filters. *Refer to Procedure 008-018.*
OK	
Lubricating oil cooler is leaking oil	Check the lubricating oil cooler for oil leaks. Refer to Procedure 007-007.
OK	
Torque converter cooler or hydraulic oil cooler is malfunctioning	Remove and inspect the cooler cores and o-rings. Refer to the OEM service manual.
OK	

Cylinder head is cracked or porous	Remove intake and exhaust manifolds. Check for evidence of coolant leak. If necessary, operate engine at low idle. Pressure-test the cylinder head. Refer to Procedure 002-004.

Cylinder block is cracked or porous	Inspect the cylinder block. Refer to Procedures 001-026.

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Smoke, Black — Excessive

Symptom Tree t116

Printable Version

This is symptom tree

Cause	Correction
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.
OK	
Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 and the OEM

	service manual.

OK

Intake manifold pressure (boost) sensor or circuit is malfunctioning	Check the boost sensor and circuit. Refer to Procedures 019-061 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fuel drain line restriction	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check valves, or tank vents as necessary. Refer to Procedure 006-012.

OK

Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-031.

OK

Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. *Refer to Procedure 011-009.*

OK

Air intake or exhaust leaks	*Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-024.*

OK

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Fuel For Cummins Engines, Bulletin 3379001.

OK

Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 3379133 or 4021327. Replace the turbocharger if necessary. Refer to Procedure 010-033 .

OK

Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. *Refer to Procedures 010-033.*

OK

	Measure and adjust the overhead settings.

Overhead adjustments are **not** correct	Refer to Procedure 003-006.

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

OK

Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-338 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 019-338 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113

Last Modified: 16-Jul-2003

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Smoke, White — Excessive

Symptom Tree t118

Printable Version

This is symptom tree

Cause	Correction
Starting aid is necessary for cold weather or starting aid is malfunctioning	Check for the correct operation of the starting aid. Refer to the manufacturer's instructions. Refer to the Cold Weather Starting Aid in the Cold Weather Operation, Bulletin 3382118.
OK	
Engine is cold	Allow the engine to warm to operating temperature. If the engine will **not** reach operating temperature, refer to the Coolant Temperature Below Normal symptom tree.
OK	
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113 for fault code troubleshooting.

Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet Click here to see ecm_calibration_rev_history.xls on QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to the appropriate electronic service tool manual and Procedure 019-032 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Coolant temperature sensor is malfunctioning	Use an electronic service tool to check the coolant temperature sensor. Refer to Procedure 019-019 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

Intake manifold air temperature is below specification	Refer to the Coolant Temperature Below Normal symptom tree.

OK

Intake manifold temperature sensor is malfunctioning	Check the intake manifold temperature sensor. Refer to Procedure 019-059 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Low timing pressure to the injectors	Check the timing pressure with an electronic service tool. Refer to the appropriate electronic service tool manual. If the pressure is low, check for fuel inlet restriction. Refer to Procedure 006-020.

OK

Timing pressure sensor is malfunctioning	Check the timing pressure sensor. Replace the sensor if necessary. Refer to Procedure 019-191 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

OK

Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to the Fuel Recommendations and Specifications in the Fuel For Cummins Engines, Bulletin 3379001.

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

OK

Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-006.

OK

Static injection timing is **not** correct	Check the static injection timing. *Refer to Procedure 006-025.*

OK

Injector is malfunctioning	Replace the malfunctioning injector. *Refer to Procedure 006-026.*

OK

Internal coolant leaks	Refer to the Coolant Loss - Internal symptom tree.

OK

Injector protrusion is **not** correct	Check the injector protrusion. Refer to

	Procedure 002-004.

Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 002-004

Last Modified: 16-Jul-2003

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Turbocharger Leaks Engine Oil or Fuel

Symptom Tree t122

Printable Version

This is symptom tree

Cause	Correction
Engine is operating for extended periods under light- or no-load conditions (slobbering)	Review the engine operating instructions in Section 1 in the Operation and Maintenance Manual, QSK23 Series Engine, Bulletin 4021374.
OK	
Turbocharger is **not** correct	Check the turbocharger part number and compare it to the Control Parts List (CPL), Bulletin 3379133 or 4021327. Replace the turbocharger if necessary. Refer to Procedure 010-033 .
OK	
Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. *Refer to Procedures 010-033.*

Turbocharger drain line is restricted	Remove the turbocharger drain line and check for restriction. Clean or replace the drain line. Refer to Procedure 010-033.

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Vibration Excessive

Printable Version

Symptoms

- Vibration excessive
- Cab noise due to vibration

How To Use This Tree

This symptom tree can be used to troubleshoot all vibration-based symptoms listed above. Start by performing Step 1 troubleshooting. Step 2 will ask a series of questions and will provide a list of troubleshooting steps to perform, depending on the symptoms. Perform the list of troubleshooting steps in the sequence shown in the Specifications/Repair section of the tree.

Shop Talk

Vibration Troubleshooting Documentation Information Questions

1) What is the OEM make/model?

2) What are the mileage/hours?

3) Has there been any recent repair and/or maintenance history?

- Any engine/clutch/transmission rebuild, removal, and installation?
- History of repeatedly broken brackets and/or capscrews (alternator, fan, exhaust, etc.)?
- Structural modifications to the vehicle from OEM built?

4) Description of vibration?

- What is shaking (mirror, seat, steering wheel, cab/dash, etc.)?
- Is there excessive noise in the cab during the vibration?

5) What are the conditions when the complaint occurs?

- Power take-off (PTO)?
- Power output (hard pull, during lug down, etc.)?
- During acceleration and/or deceleration?
- At idle?
- With or without a trailer?

- Does vibration increase with engine speed?
- Does vibration increase with road speed?
- Is the vibration at a certain engine RPM?

6) Has the vibration been present since new? (From new, recent repair, modification to equipment)

7) Can the vibration be easily duplicated?

8) Do you have another piece of equipment with the same specification which exhibits the same complaint? (If yes, get the engine serial number (ESN) and possibly test the vehicle)

9) Are you the **only** operator of the equipment? (If no, are the symptoms noticed by other operators)?

General Information

Vibration complaints can be very difficult to troubleshoot and understand the root cause. This troubleshooting document was designed to help guide you through the logical steps of identifying the source. Vibration acceptance is very subjective; what is objectionable to one person can possibly be acceptable to another.

Vibration complaints can be caused by many parts in the system (system includes the engine, driven component, mounts, and equipment). The cause can be transmitted or generated from a remote point that is **not** readily apparent.

Cummins Inc. experience has shown that the engine is rarely the cause of an operator complaint. The majority of the time, it is the engine mounts or design of the various components on the equipment. The engine is **only** at fault if there is a misfire or an engine component that is out of balance.

Vibration complaints that occur **only** at idle speed are most likely caused by the engine mounts. If the engine mount natural frequency is close to the engine firing frequency, the engine will cause the mounts to amplify the normal vibration on an engine idling and cause the adjacent components to vibrate excessively.

Natural Frequency

- Natural frequency, as the name implies, is the frequency at which an object wants to naturally vibrate. The frequency is primarily dependent on mass and elasticity.

Types of Vibration

1) Linear

a) Rotating components

b) Torque reaction

- Caused by unbalanced rotating components and cylinder firing impulses.
- Can be felt and observed visibly.

- When excessive, can cause operator discomfort and damage to components.

2) Torsional - twisting stresses

- Cyclic speeding and slowing of rotating components.
- Controlled by flywheel mass and vibration damper.
- Can **NOT** be felt by the operator.
- Can damage gears and splines.

3) Resonant - component excited at natural frequency

- Is actually linear vibration.
- Resonant vibration occurs when a system or component is excited by linear vibration at its natural frequency.
- Vibration will increase in amplitude as the system's natural frequency is approached. Amplitude will decrease as the exciting forces (engine firing frequency) increase in frequency beyond the system's natural frequency.
- Resonant vibration can be many times larger in amplitude than the exciting force.
- Vibration **must** be controlled by design of mounts (engine and cab) and components.

Engine and Cab Mounts

- The mounts **must** be designed to isolate or reduce the transmission of engine and equipment component vibrations.
- For maximum isolation, it is desired that the natural frequency of the mount be as low as possible.
- Good engine mounts will reduce the amount of engine vibration transmitted to the chassis frame by at least 50 percent at idle.
- Hard engine mounts will provide little or no isolation, and can actually magnify the vibration transmitted to the chassis.
- Stiffness (durometer) and size of the isolator, along with the weight of the engine or component applied are the determining factors when designing a mounting system. An isolator that is correct for one engine, can possibly **not** be right for another. Likewise, because of weight differential, a particular isolator designed for the rear of an engine, probably will **not** be ideal for the front.

Troubleshooting Steps

STEPS		SPECIFICATIONS
STEP 1.	Perform the basic troubleshooting procedures.	
	STEP 1A. Document the information questions in the Shop Talk section of this tree.	Documentation completed?
	STEP 1B. Check for active fault codes or high counts of inactive fault codes.	Active fault codes or high counts of inactive fault codes?

	STEP 1C. Perform the basic troubleshooting checks.	Are all steps verified to be correct?
	STEP 1D. Determine if the engine is running rough.	Is the engine running rough?
	STEP 1E. Perform a visual inspection of the engine mounts (without removal).	Is there visible engine mount damage?
	STEP 1F. Check for an engine mounted component contacting the frame or body.	Engine mounted components touching the frame or body?
	STEP 1G. Check for equipment structural modifications.	Are any structural modifications to the equipment present?
	STEP 1H. Complaint since new.	Has the problem been occurring since the equipment was new?
	STEP 1I. Marine application.	Is the engine installed in a marine application?
	STEP 1J. Do an engine RPM sweep.	Is the vibration present below 1050 RPM?
	STEP 1K. Do an engine RPM sweep.	Is the vibration present stationary above 1050 RPM?
	STEP 1L. Check the vibration engine speed range.	Is the vibration speed range greater than 300 to 400 RPM?
STEP 2.	Advance engine troubleshooting procedures.	
	STEP 2A. Check that the accessory load is not excessive for the idle speed setting.	Are all steps verified to be correct?
	STEP 2B. Inspect the engine mounts.	Are all steps verified to be correct?
	STEP 2C. Inspect the fan hub.	Does the fan hub meet specifications?
	STEP 2D. Check for malfunctioning belt driven accessories.	Did the vibration go away with the drive belts removed?
	STEP 2E. Check for a damaged vibration damper.	Is the vibration damper damaged or out of specification?
	STEP 2F. Check the overhead adjustments.	Are the overhead adjustments correct?
	STEP 2G. Check for malfunctioning gear driven components.	Did the vibration go away?
	STEP 2H. Check the drive train	Did disengaging the transmission

	components.	reduce the effect of the vibration?
	STEP 2I. Check for a loose or damaged flywheel or flex plate.	Does the flywheel meet specifications?
	STEP 2J. Check the flywheel housing for correct alignment.	Does the flywheel housing meet specifications?
	STEP 2K. Check for internal engine damage.	Is there internal engine damage?
STEP 3.	Marine applications.	
	STEP 3A. Check the gear ratio and propeller configuration.	Are the gear ratio and the propeller incorrectly matched to the engine power?
	STEP 3B. Check for the correct engine mounting isolators and for proper installation requirements.	Are the engine mount isolators correct and installed correctly?
	STEP 3C. Check for damaged engine mounts and isolators.	Are the engine mounts and isolators in good condition?
	STEP 3D. Check the exhaust system.	Is the exhaust system deficient?
	STEP 3E. Check the engine driven accessories.	Is an engine driven accessory malfunctioning?
	STEP 3F. Check the shaft coupling to gear coupling alignment.	Is the shaft coupling to gear coupling misaligned?
	STEP 3G. Check the propeller shaft for proper installation.	Is the propeller shaft installed correctly?
	STEP 3H. Check the propeller shaft for straightness.	Is the propeller shaft straightness within the OEM specification?
	STEP 3I. Isolate the engine.	Does the engine vibration persist?
	STEP 3J. Check for strut/cutlass bearing misalignment.	Is the strut/cutlass bearing misaligned or strut mounting not secure?
	STEP 3K. Check the propeller.	Is the propeller out of balance or not fitted properly to the shaft?
	STEP 3L. Check the V-angle on the V-strut.	Does the V-angle on the V-strut match the angle of the blade on the prop?
	STEP 3M. Check the propeller tunnels.	Does the entry and exit of the propeller tunnel match with the propeller blades?
	STEP 3N. Check the engine to transmission torsional coupling.	Is the torsional coupling incorrect or worn?
	STEP 3O. Check the rudder.	Does the rudder have excessive play in the rudder post?

STEP 3P. Check the engine flywheel housing to cylinder block alignment.	Is the flywheel housing alignment incorrect?

Guided Step 1 - Perform the basic troubleshooting procedures.

Guided Step 1A - Document the information questions in the Shop Talk section of this tree.

Conditions

- None

Action

Complete the basic troubleshooting questionnaire.

Complete the vibration troubleshooting documentation information questions contained in the Shop Talk section of this procedure.

Documentation completed?

YES	NO
No Repair	Complete the documentation.
Go to 1B	Go to 1A

Guided Step 1B - Check for active fault codes or high counts of inactive fault codes.

Conditions

- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action

Check the fault codes.

- Use INSITE™ electronic service tool to read the fault codes.

Active fault codes or high counts of inactive fault codes?

YES	NO
See the corresponding Electronic Control System Troubleshooting and Repair manual for the engine being serviced.	**No Repair**
Repair complete	Go to 1C

Guided Step 1C - Perform the basic troubleshooting checks.

Conditions

- As required.

Action

Check or verify the following items before continuing.

- Battery voltage is low (engine running)
- Lubricating oil level is above specification
- External fuel leak
- Engine idle speed is set too low
- Engine idle speed is set too high
- Throttle lever or pedal, return spring, or air throttle damaged or improperly adjusted (use INSITE™ electronic service tool for electronic engines)
- Air in the fuel
- Fuel pressure
- Inlet restriction.

Are all steps verified to be correct?

YES	NO

No Repair	No Repair
Go to 1D	Repair complete

Guided Step 1D - Determine if the engine is running rough.

Conditions

- Engine running at idle speed (less than 900 RPM).
- Accessories off (air conditioning, fan, PTO).
- Engine at operating temperature (greater than 77°C [170°F]).

Action

Determine if the engine is running rough at engine idle or misfiring.

Refer to the Engine Runs Rough symptom tree in Section TS or the Engine Performance Troubleshooting Tree in Section TT.

Is the engine running rough?

YES	NO
Refer to the Engine Runs Rough symptom tree.	**No Repair**
Complete Engine Runs Rough troubleshooting tree	Go to 1E

Guided Step 1E - Perform a visual inspection of the engine mounts (without removal).

Conditions

- Engine **not** running.
- Engine mounts installed.

Action

Perform a visual inspection of the engine mounts.

Look for obvious damage or something shorting against the mounts, preventing isolation.

Note: A more detailed inspection will be carried out later in the procedure.

Is there visible engine mount damage?

YES	NO
Repair or replace the engine mounts. Use Procedure 016-010 in Section 16 in the appropriate service manual.	**No Repair**
Repair complete	Go to 1F

Guided Step 1F - Check for an engine mounted component contacting the frame or body.

Conditions

- Engine **not** running.
- Engine mounts installed.

Action

Check for an engine mounted component touching the frame or body.

Inspect the engine and engine mounted components to make sure none of them are touching the frame and/or body.

Including but **not** limited to the following:

- Clamps
- Mounting hardware
- Exhaust system
- Air intake piping
- Cooling package support.

Engine mounted components touching the frame or body?

YES	NO
Correct the mounting of the engine mounted component.	**No Repair**
Repair complete	Go to 1G

Guided Step 1G - Check for equipment structural modifications.

Conditions

Visual inspection.

Action

Check for any structural modifications to the equipment.

Check for any structural modifications to the equipment in the engine area that were completed by the OEM after equipment manufacture.

Structural modifications can change the natural frequency of the frame and engine mounting system, which can result in a vibration complaint.

Are any structural modifications to the equipment present?

YES	NO
Contact the original equipment manufacturer (OEM). If possible, remove or isolate the structural modification.	**No Repair**
Repair complete	Go to 1H

Guided Step 1H - Complaint since new.

Conditions

- Record the odometer/hour meter.
- Review the troubleshooting documentation information questions.

Action

Check the equipment.

Check the equipment mileage/hours and compare to the vibration customer interview form completed in Step 1A.

- Low mileage/hours is an indication that the complaint has been present since the equipment was new.
- Complaints on new equipment are typically due to a manufacturing defect in the system or an inadequate engine mounting design.

Has the problem been occurring since the equipment was new?

YES	NO
The engine mounts are **not** the right specification for the application, or a structural resonance exists.	**No Repair**
Contact a Cummins® Technical Support Specialist or the OEM.	Go to 1I

Guided Step 1I - Marine application.

Conditions

None

Action

Is this engine in a marine application?

Is the engine installed in a marine application?

YES	NO
No Repair	**No Repair**
Go to 3A	Go to 1J

Guided Step 1J - Do an engine RPM sweep.

Conditions

- Engine running.
- INSITE™ electronic service tool connected.
- Vehicle stationary.

Action

Perform a slow (at 4 RPM per second) RPM sweep and note where the vibration occurs.

Record the engine speed at which any unusual vibration related noise occurs (mirrors, panels, doors, seat, etc.). Record the speed points or ranges with excessive vibration.

If a resonance is passed through quickly and is getting up to the operating speed range, and doesn't exist in the idle speed or peak operating range, it represents no major problem.

Is the vibration present below 1050 RPM?

YES	NO
No Repair	**No Repair**
Go to 1L	Go to 1K

Guided Step 1D - Do an engine RPM sweep.

Conditions

- Engine running.
- INSITE™ electronic service tool connected.
- Vehicle stationary.

Action

Perform a slow (at 4 RPM per second) RPM sweep and note where the vibration occurs.

If the vibration increases progressively from idle to maximum speed, rotating or reciprocating unbalance is the source. This can be caused by any rotating components or engine mount isolation.

Is the vibration present above 1050 RPM?

YES	NO
No Repair	**No Repair**
Go to 1L	**Repair complete**

Guided Step 1K - Check the vibration engine speed range.

Conditions

- Engine running.
- INSITE™ electronic service tool connected.
- Vehicle stationary.

Action

Perform a slow (at 4 RPM per second) RPM sweep and note where the vibration occurs.

This step is to identify if the vibration progressively increases with engine speed or if it starts and stops within a slow engine RPM band. If the vibration progressively increases with engine speed and has a peak band greater than 300 RPM, this can indicate a rotating component that is out of balance.

If the vibration peak is in a tight band of approximately 300 to 400 RPM or less, this indicates that a structural component of the engine or equipment is going into resonance because its natural frequency is close to or the same as the engine firing frequency.

Is the vibration speed range greater than 300 to 400 RPM?

YES	NO
No Repair	**No Repair**
Go to 2A	Go to 2A

Guided Step 2 - Advanced engine troubleshooting procedures.

Guided Step 2A - Check that the accessory load is not excessive for the idle speed setting.

Conditions

- Engine running at idle speed (less than 900 RPM).
- Accessories off (air conditioning, fan, and PTO).
- Engine at operating temperature (greater than 77°C [170°F]).

Action

Disable all engine driven accessories and PTOs to make sure they are not applying excessive load to the engine.

Are all steps verified to be correct?

YES	NO
No Repair	Repair as required.
Go to 2B	**Repair complete**

Guided Step 2B - Inspect the engine mounts.

Conditions

- Engine **not** running.
- Remove engine mount isolators.
- Install engine mount isolators.

Action

Inspect the engine mount brackets, isolators, and mounting hardware.

- Check the engine mount isolators for installation damage.
- Check the alignment of the engine mount brackets.
- Check for premature wear on the engine mount isolators and mounting hardware.

Are all steps verified to be correct?	
YES	NO
No Repair	Repair or replace the damaged components. Use Procedure 016-010 in Section 16 or the appropriate service manual.
Go to 2C	**Repair complete**

Guided Step 2C - Inspect the fan hub.

Conditions

- Engine not running.

Action

Inspect the fan hub to see if it is loose, damaged, or has excessive hub bearing end play.

Use Procedure 008-040 in the appropriate service manual for fan hub specifications.

Does the fan hub meet specifications?	
YES	NO
No Repair	Repair or replace the fan hub as required. Use Procedure 008-040 in the appropriate service manual.
Go to 2D	**Repair complete**

Guided Step 2D - Check for malfunctioning belt driven accessories.

Conditions

- Remove the drive belts.

Action

Check the belt driven accessories.

Remove the drive belts and operate the engine under the condition where vibration occurs.

Did the vibration go away with the drive belts removed?

YES	NO
Repair or replace the malfunctioning belt driven accessory. Refer to the OEM service manual.	**No Repair**
Go to 2D	Go to 2E

Guided Step 2E - Check for a damaged vibration damper.

Conditions

- Engine not running.

Action

Remove and visually inspect the vibration damper.

Use Procedure 001-052 in the appropriate service manual for vibration damper inspection specifications.

Is the vibration damper damaged or out of specification?

YES	NO
Replace the vibration damper. Use Procedure 001-052 in the appropriate service manual for replacement instructions.	**No Repair**
Repair complete	Go to 2F

Guided Step 2F - Check the overhead adjustments.

Conditions

- Engine not running.
- Rocker lever cover removed.

Action

Measure and adjust the overhead settings.

- Check the overhead components for damages.

Use Procedure 003-004 in the appropriate service manual.

Are the overhead adjustments correct?

YES	NO
No Repair	Repair or adjust the overhead. Use Procedure 003-004 in the appropriate service manual.
Go to 2G	**Repair complete**

Guided Step 2G - Check for malfunctioning gear driven accessories.

Conditions

None

Action

Check the gear driven accessories for any damage or signs of wear.

If possible, isolate any gear-driven accessories and check for vibration.

Did the vibration go away?

YES	NO
Repair or replace the damaged gear driven component. Use the appropriate procedure in the appropriate service manual.	**No Repair**
Repair complete	Go to 2H

Guided Step 2H - Check the drive train components.

Conditions

- Isolate the engine from the transmission.
- Engine running.

Action

With the transmission disengaged from the engine, operate the engine in the condition where the vibration occurs.

If there is a signification vibration reduction, the transmission is the source of the vibration.

Did disengaging the transmission reduce the effect of the vibration?

YES	NO
Repair or replace the transmission. Refer to the OEM service manual.	**No Repair**
Repair complete	Go to 2I

Guided Step 2I - Check for a loose or damaged flywheel or flex plate.

Conditions

- Transmission removed.

Action

Check the flywheel.

- Check the flywheel bore and face runout.
- Check the flywheel for damage.

Use Procedure 016-005 in the appropriate service manual.

Does the flywheel meet specifications.

YES	NO
No Repair	Repair or replace the flywheel or flexplate. Use Procedure 016-005 in the appropriate service manual.
Go to 2J	**Repair complete**

Guided Step 2J - Check the flywheel housing for correct alignment.

Conditions

- Transmission removed.
- Flywheel/flexplate removed.

Action

Check the flywheel housing bore and face alignment.

Use Procedure 016-006 in the appropriate service manual.

Does the flywheel housing meet specifications?

YES	NO
No Repair	Repair or replace the flywheel housing. Use Procedure 016-006 in the appropriate service manual.
Go to 2K	**Repair complete**

Guided Step 2K - Check for internal engine damage.

Conditions

- None

Action

Contact a support specialist.

At this point, a significant amount of labor has been invested in the repair. Before disassembly the engine, seek troubleshooting assistance. Contact the appropriate Technical Support Channel for your facility. They will provide the necessary guidance and schedule on-site support, if deemed necessary.

- Camshaft journals and number 1 camshaft busing are severely damaged.
- Gear train backlash is excessive or the gear teeth are damaged.
- Idler gear bushing damaged or worn.
- Main or connecting rod bearings damaged.
- Gears out of balance or gear bushing damage.
- Connecting rod damage.

Is there internal engine damage?

YES	NO
No Repair	**No Repair**
Contact Cummins® Technical Support Go to	**Contact Cummins® Technical Support**

Guided Step 3 - Marine applications.

Guided Step 3A - Check the gear ratio and propeller configuration.

Conditions

- Turn keyswitch OFF.

Action

Check for an incorrect matching of the gear ratio and propeller to the engine power.

Are the gear ratio and the propeller incorrectly matched to the engine power?

YES	NO
Contact a Cummins® Distributor or a Marine District Field Service Manager.	**No Repair**
Repair complete	Go to 3B

Guided Step 3B - Check for the correct engine mounting isolators and for proper installation requirements.

Conditions

- None.

Action

Check for the correct engine mount isolators and for propeller installation requirements.

Are the engine mount isolators correct and installed correctly?

YES	NO
No Repair	Check for proper isolator installation requirements. Replace and repair vibration isolators as needed. Use Procedure 016-026 in the appropriate service manual and Engine Mounting/Drive Systems section in the Marine Commercial Installation Directions, Bulletin 3884744. If the isolators are **not** manufactured by Cummins Inc., refer to the OEM service manual.

Go to 3C	**Repair complete**

Guided Step 3C - Check for damaged engine mounts and isolators.

Conditions

- None.

Action

Inspect the engine mount and isolators for damage.

Are the engine mounts and isolators in good condition?

YES	NO
No Repair	Remove and replace the engine mount isolators. Use Procedure 016-026 in the appropriate service manual and Engine Mounting/Drive Systems section in the Marine Commercial Installation Directions, Bulletin 3884744. If the isolators are **not** manufactured by Cummins Inc., refer to the OEM service manual.
Go to 3D	**Repair complete**

Guided Step 3D - Check the exhaust system.

Conditions

- None.

Action

Check for exhaust system deficiencies.

Is the exhaust system deficient?

YES	NO
Repair or replace as needed. See the Exhaust System section in the Marine Commercial Installation Directions, Bulletin 3884744, and the OEM service manual.	**No Repair**
Repair complete	Go to 3E

Guided Step 3E - Check the engine driven accessories.

Conditions

- Turn keyswitch ON.
- Turn keyswitch OFF.

Action

Check for engine driven accessory malfunctions.

- Isolate or disconnect the accessories and check for vibration.
- Do **not** operate the engine if the sea water pump is disconnected.

Is an engine driven accessory malfunctioning?

YES	NO
Determine the cause of the malfunctioning accessories and correct the problem. See the Exhaust System section in the Marine Commercial Installation Directions, Bulletin 3884744, and the OEM service manual.	**No Repair**
Repair complete	Go to 3F

Guided Step 3F - Check the shaft coupling to gear coupling alignment.

Conditions

- Turn keyswitch OFF.

Action

Check the shaft coupling to gear coupling alignment.

Is the shaft coupling to gear coupling misaligned?

YES	NO
Repair or replace as needed. Use Procedure 016-025 in the appropriate service manual and the Engine Mounting/Drive Systems section in the Marine Commercial Installation Directions, Bulletin 3884744, and the gear manufacturer's recommendations.	**No Repair**
Repair complete	Go to 3G

Guided Step 3G - Check the propeller shaft for proper installation.

Conditions

- None.

Action

Check the propeller shaft for proper installation.

Is the propeller shaft installed correctly?

YES	NO
No Repair	Repair or replace as needed. Use Procedure 016-025 in the appropriate service manual and the Engine Mounting/Drive Systems section in the Marine Commercial Installation Directions, Bulletin 3884744, and the gear manufacturer's recommendations.

Go to 3H	**Repair complete**

Guided Step 3H - Check the propeller shaft for straightness.

Conditions

- None.

Action

Check the propeller shaft for straightness.

Is the propeller shaft straightness within the OEM specification?

YES	NO
No Repair	Repair or replace the propeller shaft as needed. Refer to an Authorized OEM Service Location.
Go to 3I	**Repair complete**

Guided Step 3I - Isolate the engine.

Conditions

- Disconnect the drive shaft.

Action

Run the engine without the drive shaft attached at the coupler.

Does the engine vibration persist?

YES	NO

Check the engine vibration damper for damage. Repair or replace as needed. Use Procedure 001-052 in the appropriate service manual.	**No Repair**
Repair complete	Go to 3J

Guided Step 3J - Check for strut/cutlass bearing misalignment.

Conditions

- Turn keyswitch OFF.

Action

Check for strut/cutlass bearing wear or damage.

Check for strut/cutlass bearing misaligned or strut mounting is not secure.

Is the strut/cutlass bearing damaged, misaligned, or strut mounting not secure?

YES	NO
Check the strut for mounting stiffness. Repair or replace as necessary. Refer to an Authorized OEM Service Location.	**No Repair**
Repair complete	Go to 3K

Guided Step 3K - Propeller checks.

Conditions

- None.

Action

Check for propeller out-of-balance or propeller not fitted properly to shaft.

Check for any propeller damage.

Check for excessive propeller cavitation. Refer to the OEM service manual for propeller cavitation specifications.

Does the propeller meet specifications?

YES	NO
No Repair	Repair or replace the propeller. Refer to the OEM service manual.
Go to 3L	**Repair complete**

Guided Step 3L - Check the V-angle on the V-strut.

Conditions

- None.

Action

Check to see if the V-angle on the V-strut does not match the angle of the blade on the propeller.

Does the V-angle on the V-strut match the angle of the blade on the prop?

YES	NO
No Repair	Contact the OEM as a possible re-design of the V-angle on the V-strut may be required.
Go to 3M	**Repair complete**

Guided Step 3M - Check the propeller tunnels.

Conditions

- None.

Action

Check if the propeller tunnels are properly matched with the propellers.

Does the entry and exit of the propeller tunnel match with the propeller blades?

YES	NO
No Repair	Repair or replace as needed. Refer to an Authorized OEM Service Location.
Go to 3N	**Repair complete**

Guided Step 3N - Check the engine to transmission torsional coupling.

Conditions

- None.

Action

Check the engine to transmission torsional coupling.

Is the torsional coupling incorrect or worn?

YES	NO
Replace the coupling. Refer to an Authorized OEM Service Location.	**No Repair**
Repair complete	Go to 3O

Guided Step 3O - Check the rudder.

Conditions

None.

Action

Check the rudder for excessive play in the rudder post.

Does the rudder have excessive play in the rudder post?

YES	NO
Repair or replace as needed. Refer to an Authorized OEM Service Location.	**No Repair**
Repair complete	Go to 3P

Guided Step 3P - Check the engine flywheel housing to cylinder block alignment.

Conditions

- None.

Action

Check the engine flywheel housing to cylinder block alignment.

Is the flywheel housing alignment incorrect?

YES	NO
Align the flywheel housing to cylinder block. Use Procedure 016-006 in the appropriate service manual.	The engine can possibly have internal damage that has **not** been detected. Analyze the oil and inspect the filters to locate an area of probable damage. Use Procedure 007-083 in the appropriate service manual. The engine can possibly need to be rebuilt. Use Procedure 000-001 and the engine rebuild specifications in the appropriate

	service manual. If the engine is **not** damaged, the problem can possibly be the vessel design. Refer to an Authorized OEM Service Location.
Repair complete	**Repair complete**

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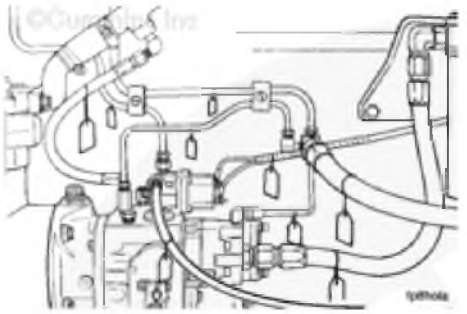
000-001 Engine Removal

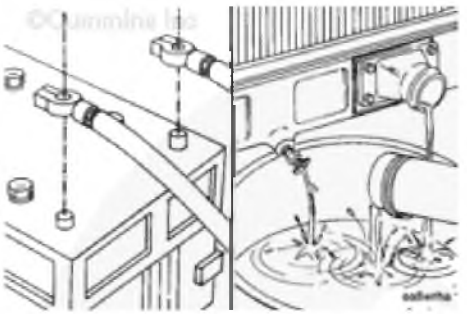
Remove

Tag all hoses, lines, linkage, and electrical connections as removed to identify location and aid in the installation process.



WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



WARNING

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

Disconnect the battery cables. Refer to

Procedure 013-009.

Drain the cooling system. Refer to Procedure 008-018.

WARNING

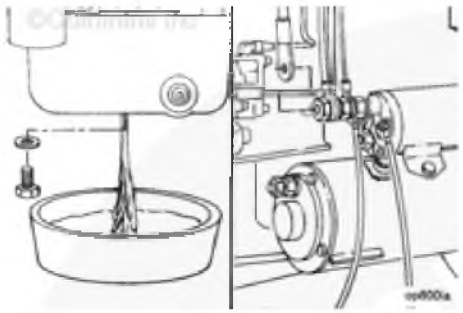
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

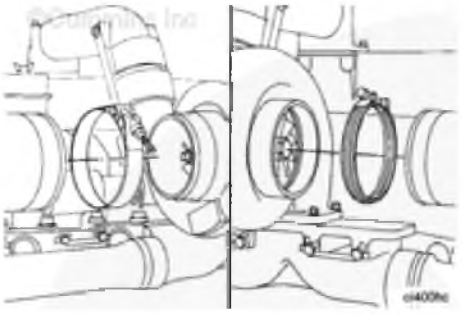
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Drain the lubricating oil from the oil pan. Refer to Procedure 007-037.

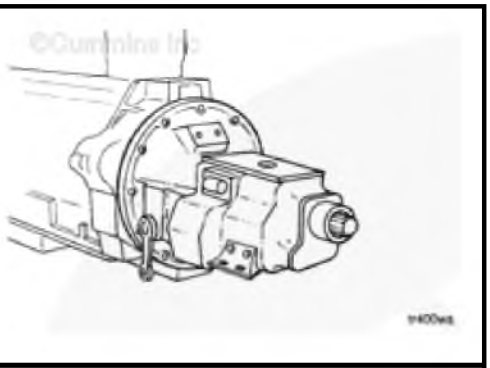
Disconnect the starter cable, engine ground straps, cab or chassis to engine hoses, tubing, electrical wiring and hydraulic lines. Refer to the OEM service manual.



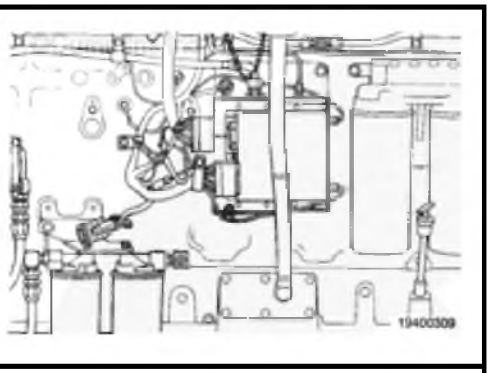
Disconnect the intake and exhaust system piping. Refer to Procedures 010-023 and 011-007.



Disconnect the drive units from the flywheel housing and flywheel. Refer to manufacturer's instructions.



Disconnect the OEM wiring harness from the electronic control module (ECM). Refer to Procedure 019-072 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.

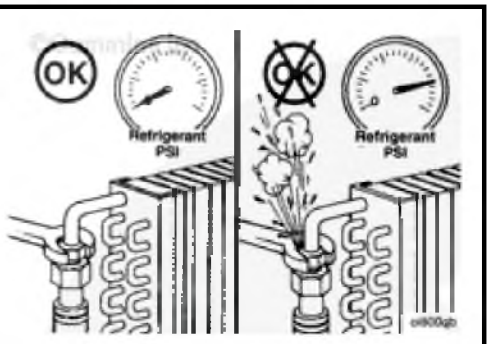


WARNING

If a liquid refrigerant system (air conditioning) is used, wear eye and face protection, and wrap a cloth around the fitting before removing. Liquid refrigerant can cause serious eye and skin injuries.

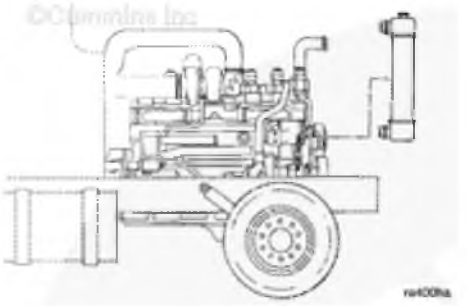
WARNING

To protect the environment, liquid refrigerant systems must be properly emptied and filled using equipment that prevents the release of refrigerant gas into the atmosphere. Federal law requires capturing and recycling the refrigerant.



Disconnect the refrigerant lines from the engine. Refer to the manufacturer's instructions.

Remove all chassis components necessary to remove the engine from the equipment. Refer to the OEM service manual.

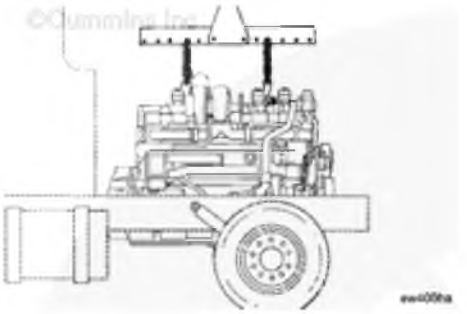


WARNING

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.



On applications where the rear engine mounts are attached to the drive unit, it is sometimes necessary to remove the engine and drive unit as an assembly.

Inspect the engine lifting brackets for damage or cracks. Do **not** attempt to lift engine if cracks or damage is visible.

Use engine lifting fixture, Part Number 3163264, or equivalent, for removal of engine. The fixture **must** be designed to lift a maximum of 3175 kg [7000 lb]. Refer

to the manufacturer's instructions.

Use a properly rated hoist and engine lifting fixture to support the weight of the engine. Remove the front and rear engine support capscrews.

Use a properly rated hoist, engine lifting fixture, Part Number 3163264, or equivalent, to remove the engine from the chassis.

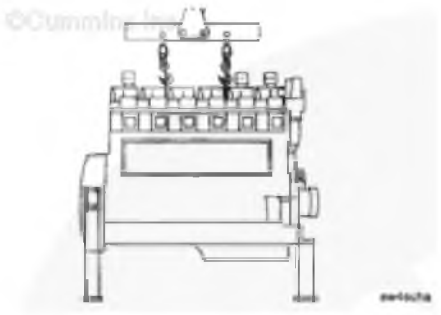
If the drive unit is **not** removed, place a support under the drive unit to prevent it from falling.

CAUTION

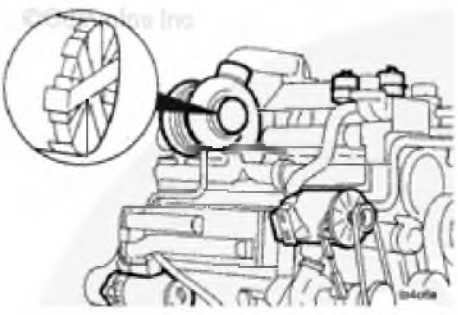
The oil sump or cover plate will not support the weight of the engine. The engine will fall and damage to the engine will occur.

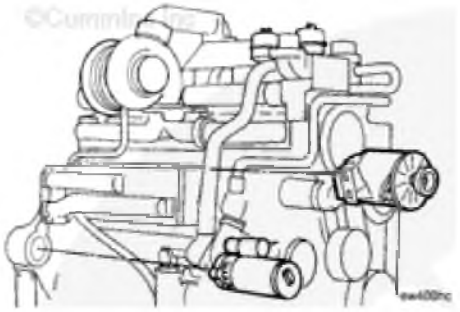
Use a engine stand or skid that contacts the engine mounts. The stand **must** hold the weight of the engine and provide permanent support to prevent the engine from falling.

Place the engine on an engine stand.



Cover all engine openings to prevent dirt and debris from entering the engine.



Remove all remaining accessories and brackets that will be used on the replacement engine.		

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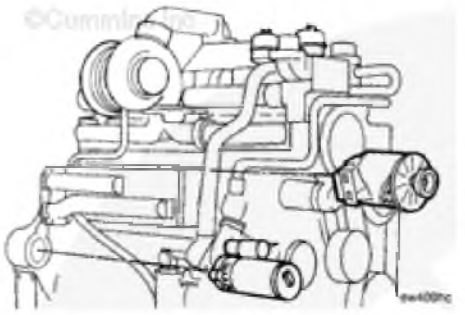
000-002 Engine Installation

Install

Install all accessories and brackets that were removed from the engine.

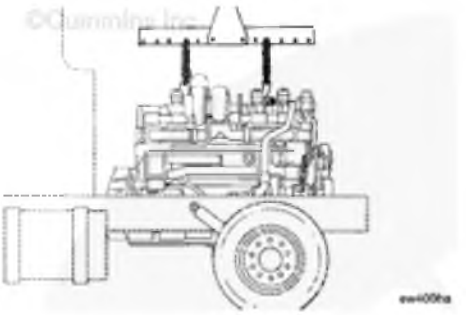


WARNING

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.



Inspect the engine lifting brackets for damage or cracks. Do **not** attempt to lift engine if cracks or damage is visible.

Use engine lifting fixture, Part Number 3163264, or equivalent, for installation of engine. The fixture **must** be designed to lift a maximum 3175 kg [7000 lb]. Refer to manufacturer's instructions. Refer to Section V for wet and dry weight of engine.

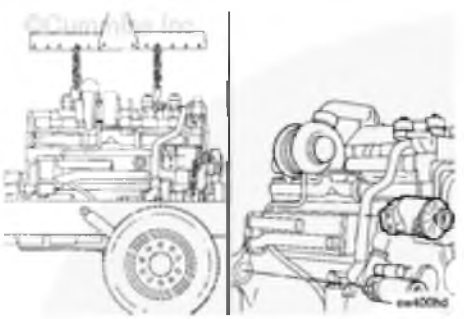
Use a properly rated hoist and engine lifting fixture to support the weight of the engine. Install the front and rear engine support capscrews.

Use a properly rated hoist, engine lifting fixture, Part Number 3163264, or equivalent, to install the engine into the chassis.

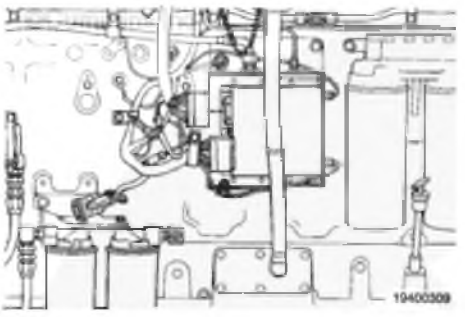
Align the engine in the chassis and tighten the engine mounting capscrews. Refer to the equipment manufacturer's torque specifications.

Connect all engine and chassis mounted accessories that were removed.

Make sure all lines, hoses, and tubes are in good condition, properly routed, and fastened to prevent damage.



Connect the OEM wiring harness to the electronic control module (ECM). Refer to Procedure 019-072 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.



CAUTION

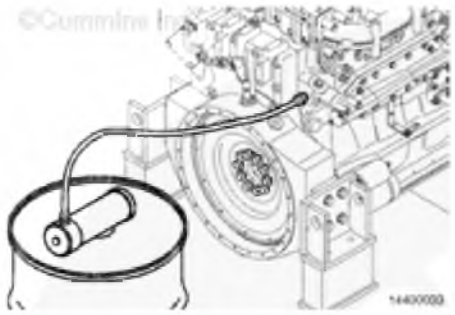
The lubricating system must be primed before operating the engine after rebuild to reduce the possibility of internal engine damage. Do not prime the system from the bypass filter as the filter will be damaged.

Remove the large plug [1-1/4 inch pipe thread] from the oil cooler housing.

Use a pump capable of supplying 207 kPa [30 psi] continuous pressure. Connect the pump to the block at the rear of the engine oil cooler as shown.

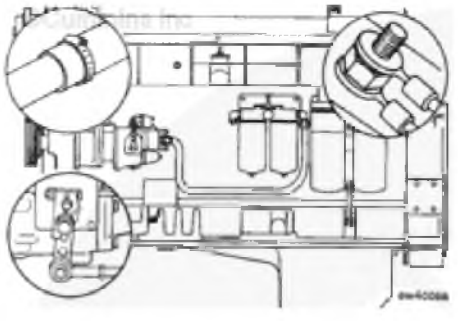
Use a supply of clean 15W-40 engine oil. Turn the pump to the ON position.

Check the engine oil pressure gauge. When the gauge indicates oil pressure, begin monitoring the oil level in the oil pan.



Fill the cooling system with fully formulated coolant. Refer to Procedure 008-018 and the Operation and Maintenance Manual, QSK23 Engine, Bulletin 4021374 for coolant specifications.

Complete a final inspection to be sure that all hoses, wires, linkages, and components have been properly installed and tightened.

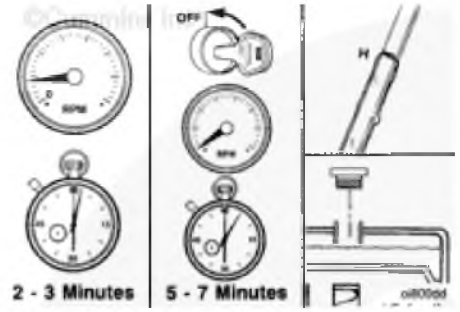


WARNING

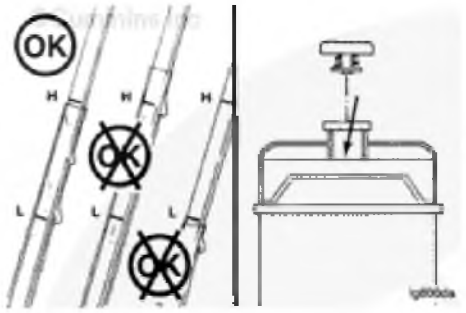
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Operate the engine at low idle for 2 to 3 minutes.

Turn the keyswitch to the OFF position and wait 5 to 7 minutes for the oil to drain to the oil pan and check the oil and coolant levels again.

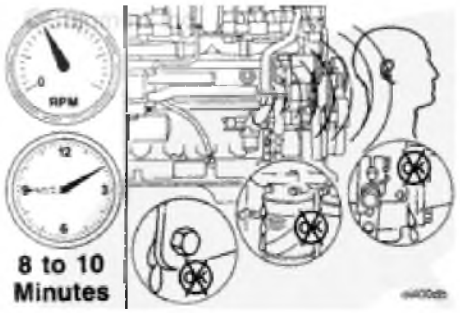


Add oil or coolant to obtain the correct level if necessary. Refer to Section V for oil specifications.



Operate the engine for 8 to 10 minutes to check for proper operation, unusual noises, coolant, fuel, and lubricating oil leaks.

Repair all leaks and component problems. Refer to the appropriate procedures.



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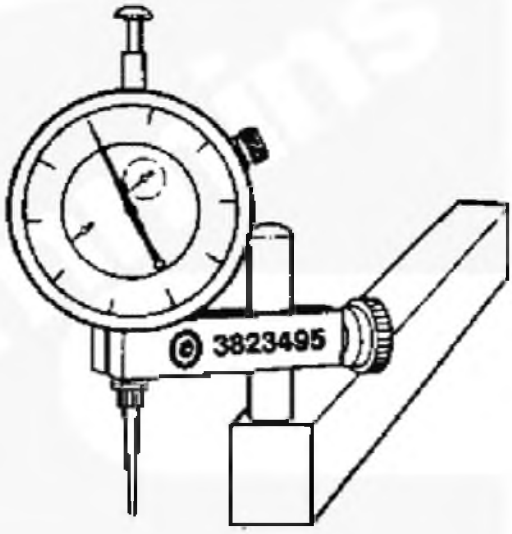
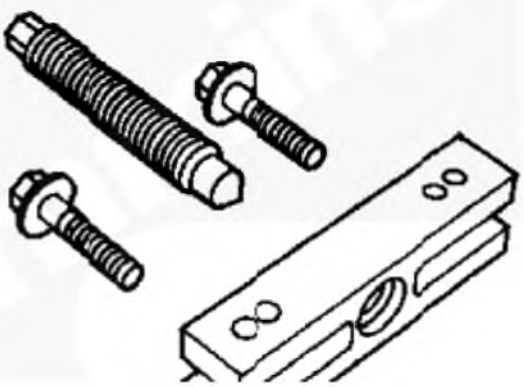
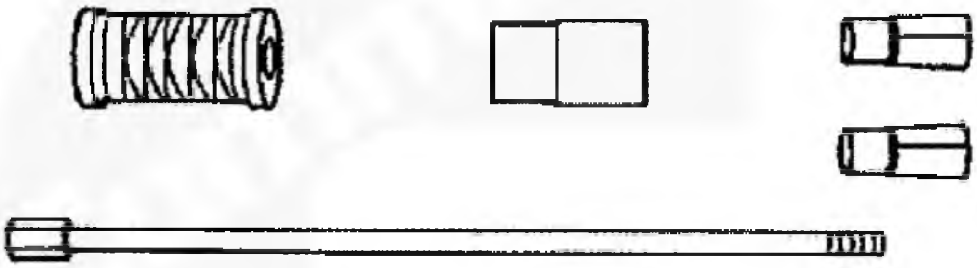
022-001 Service Tools

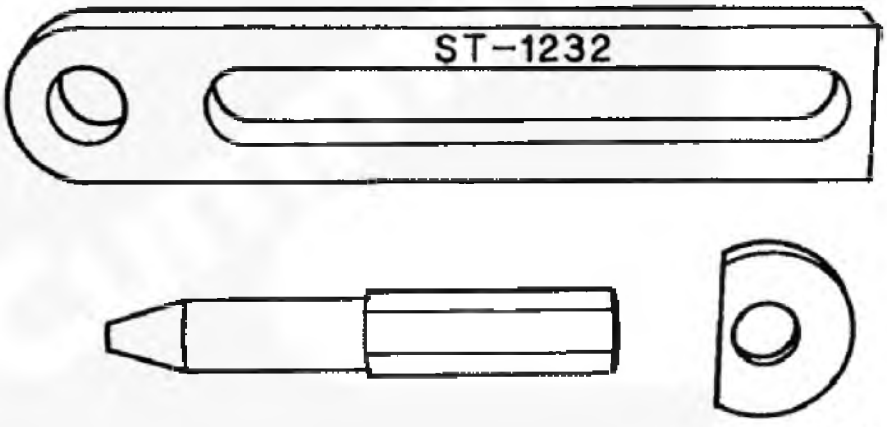
Cylinder Block

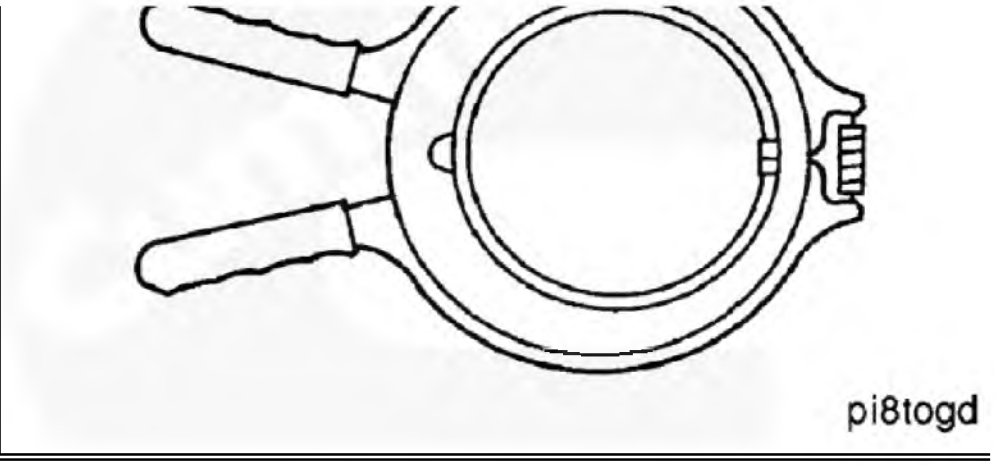
Tool Number 3164438	**Depth Gauge Assembly** Used to measure cylinder liner protrusion and cylinder liner counterbore ledge angle.	 3823495

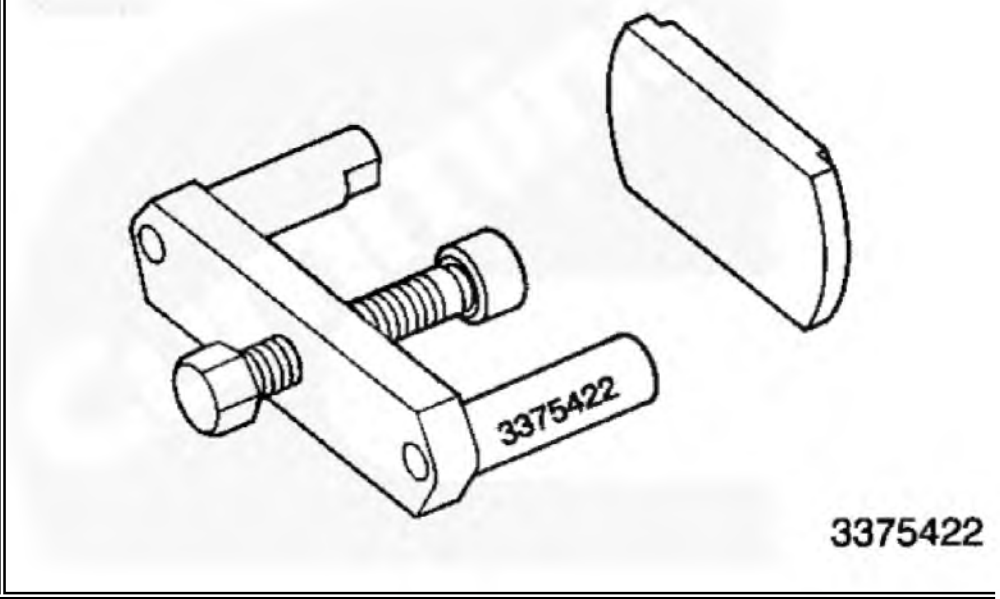
Tool Number ST-647	**Puller** Used to remove the alternator and accessory drive pulleys.	

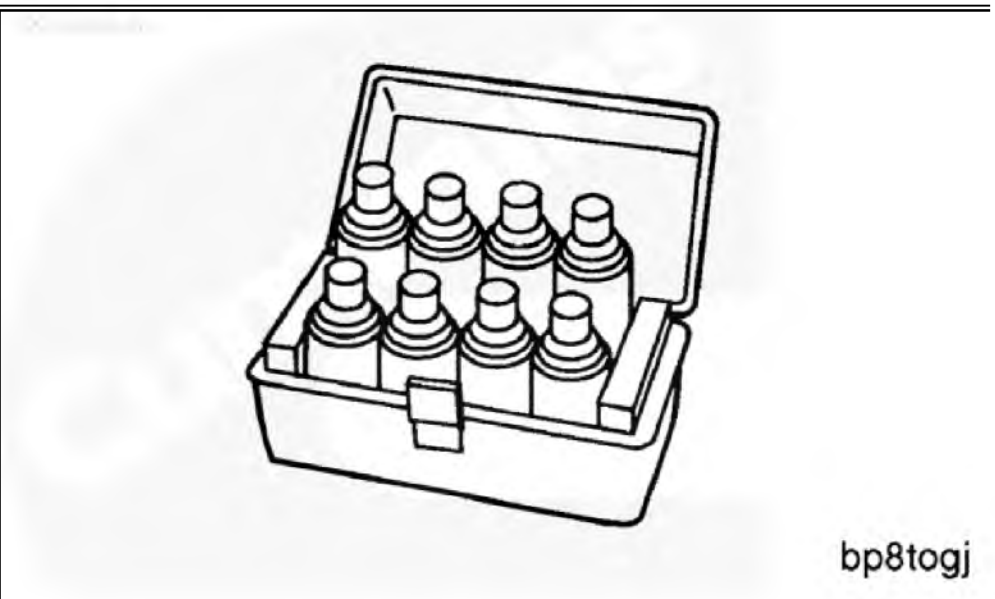
ad8toga

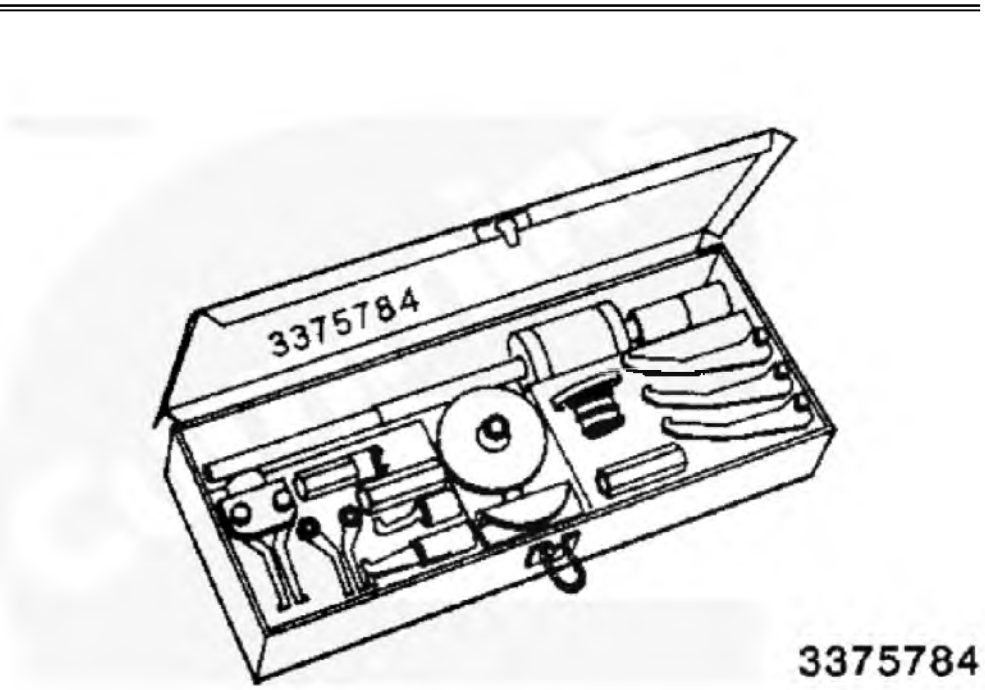
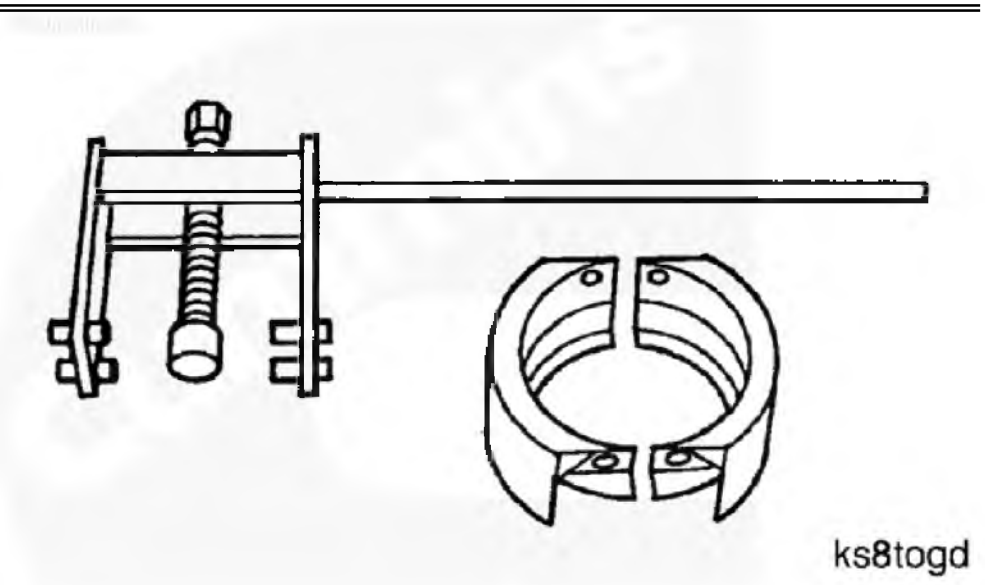
Tool Number 3163720	**Dowel Pin Extractor** Used to remove dowel pins and crosshead guides.	 ck8toge

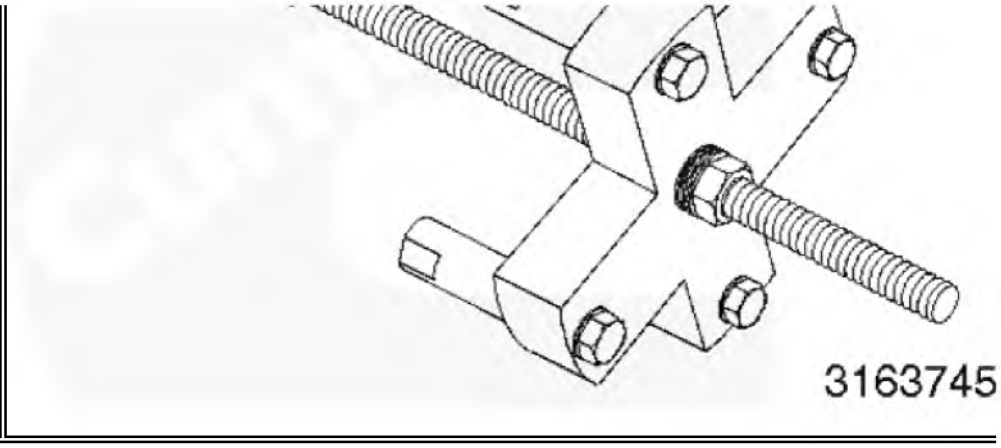
Tool Number ST-1232	**Drill Ream Fixture** Machine dowel hole used to install oversize dowels in cylinder block and flywheel housing. Use with a drill, reamer, and the appropriate drill/ream bushing set.	 st-1232

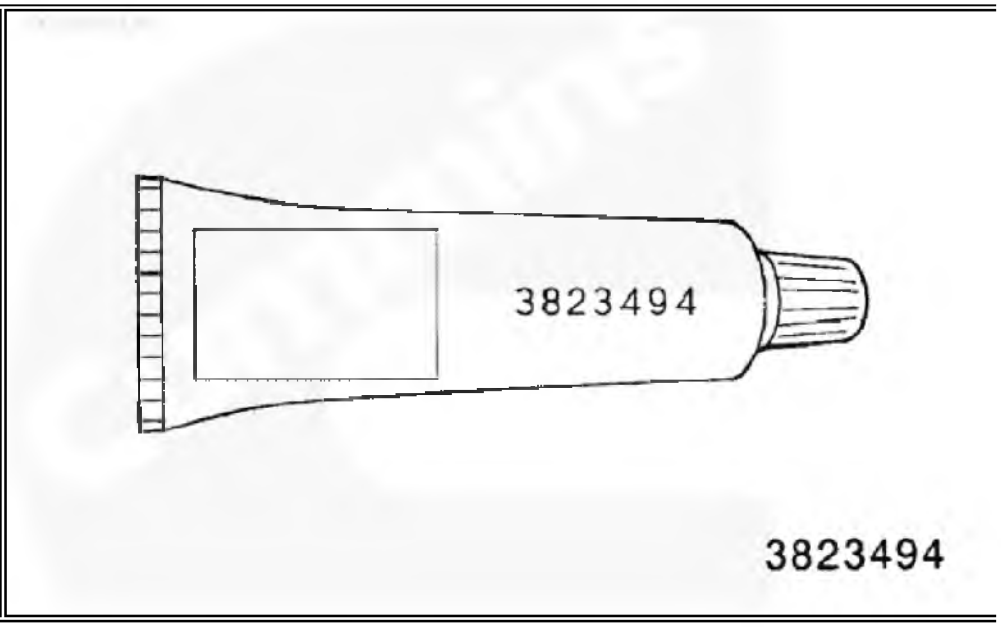
Tool Number 3164401	**Piston Ring Expander** Used to install piston rings on the piston without damaging or distorting the rings.	

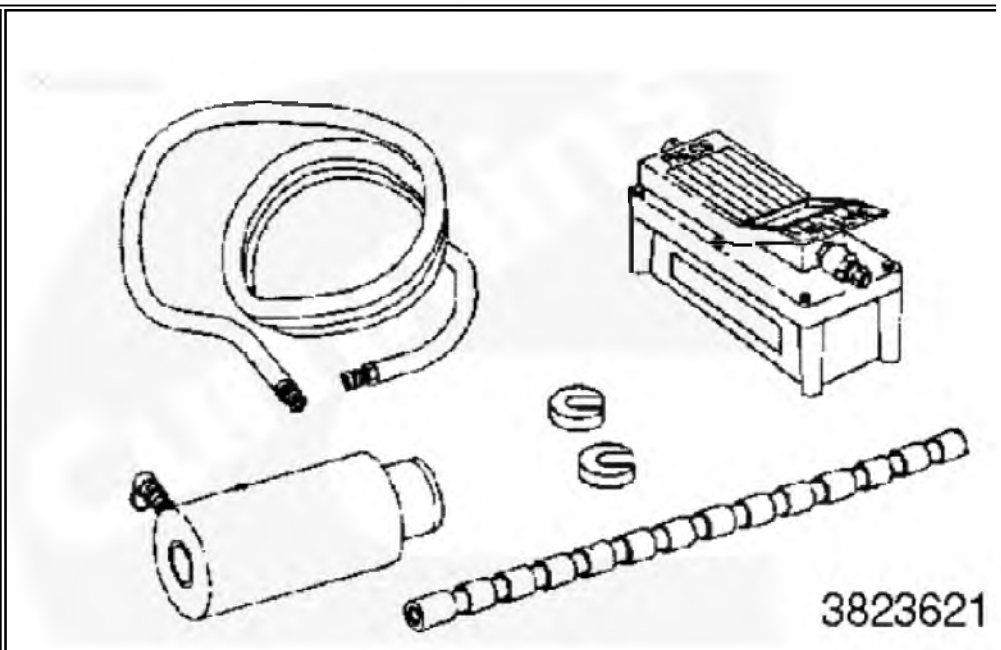
Tool Number 3164207	**Liner Installation Tool** Used to install cylinder liner in the engine.	

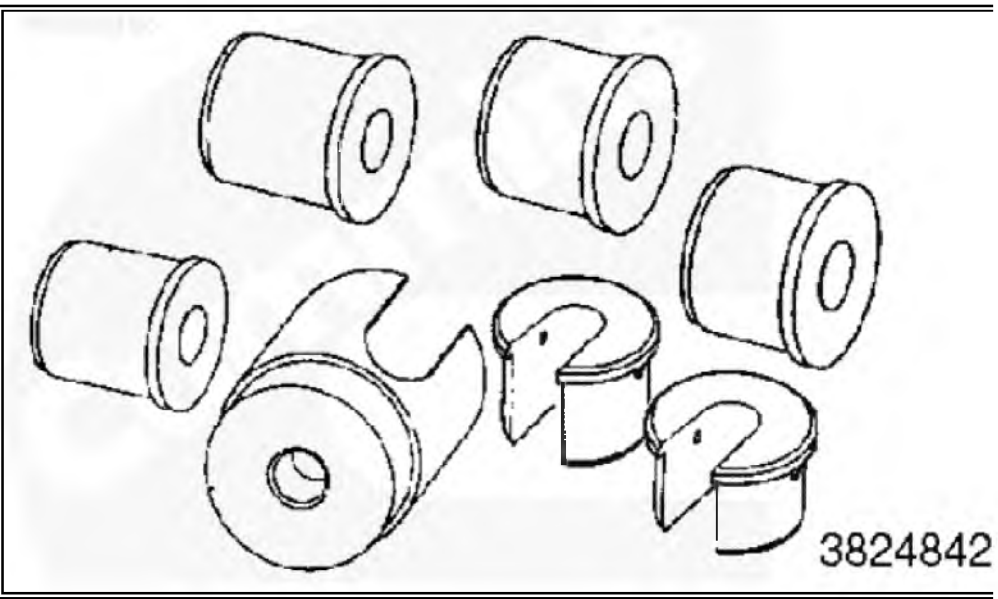
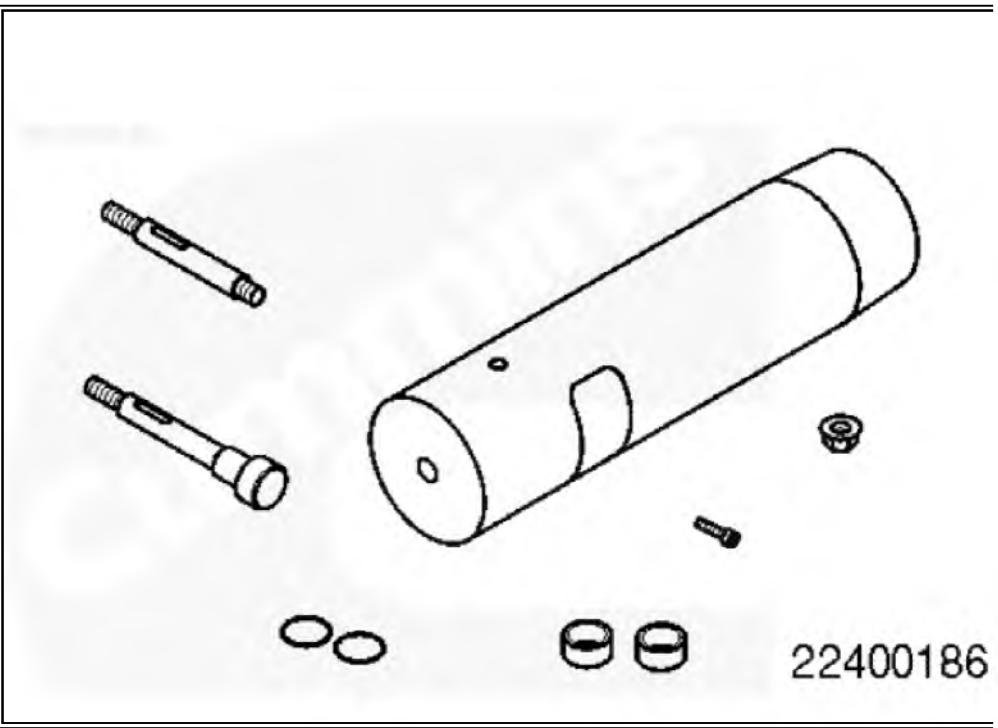
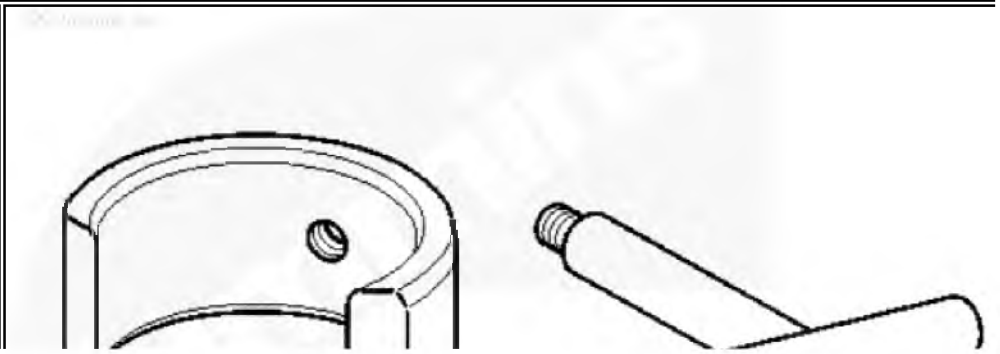
Tool Number 3375432	**Crack Detection Kit** Used to check for cracks in any engine component. Contains cleaner, developer, and penetrant.	

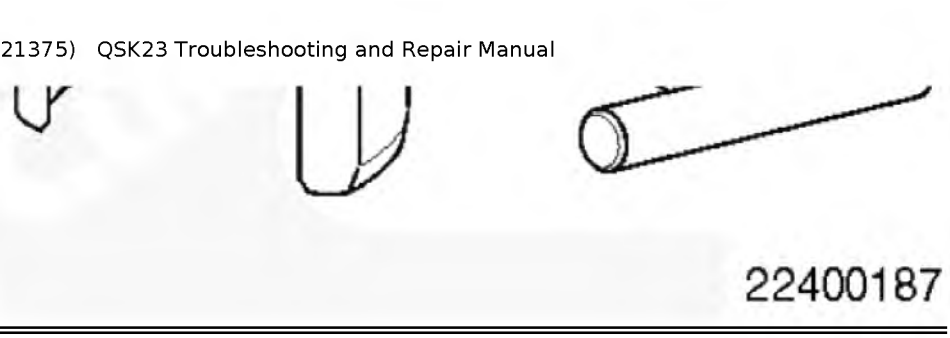
Tool Number 3375784	**Light Duty Puller Kit** Used to remove small bushings, oil seals, and bearings.	
Tool Number 3165049	**Puller Assembly** Used to remove the front crankshaft gear from the crankshaft. Use with the puller jaw, Part Number 3375835.	
	Cylinder Liner Puller	

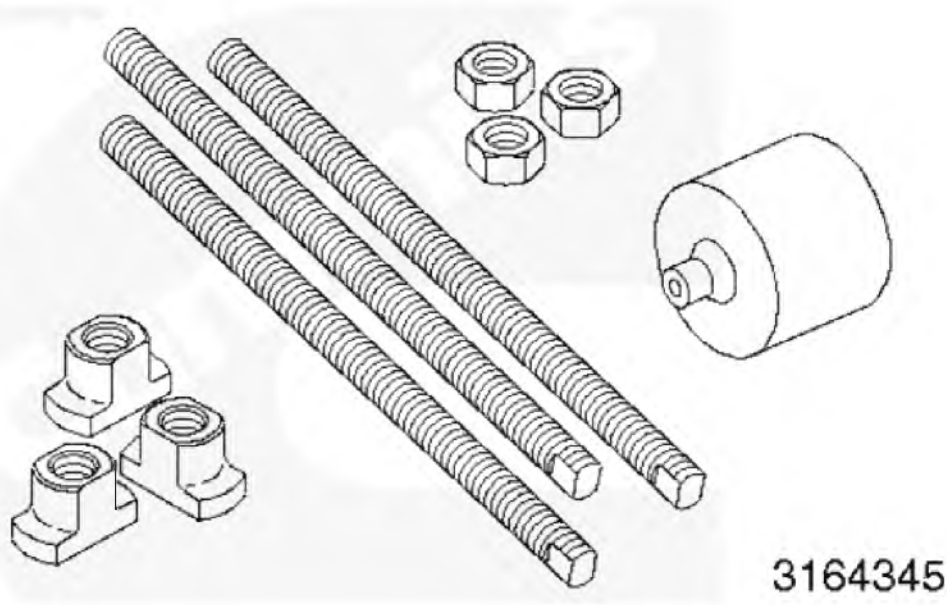
Tool Number 3163745	Used to remove cylinder liner from engine. Use with puller plate, Part Number 3163751.	

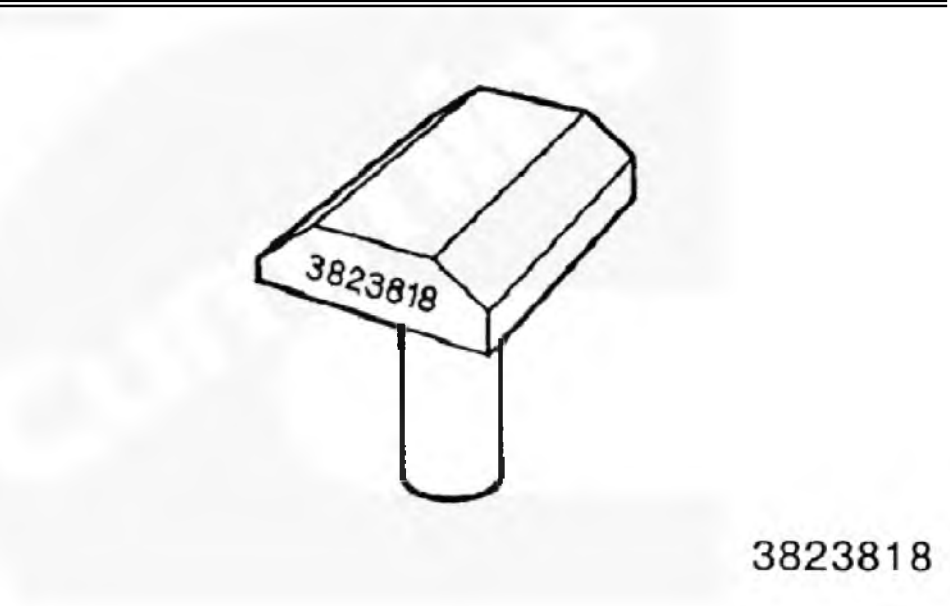
Tool Number 3823494	**Cummins Sealant** Used to prevent coolant or oil leaks. This is one part room temperature vulcanizing (RTV) silicone rubber, adhesive, and sealant material having high heat and oil resistance, and low compression rate.	

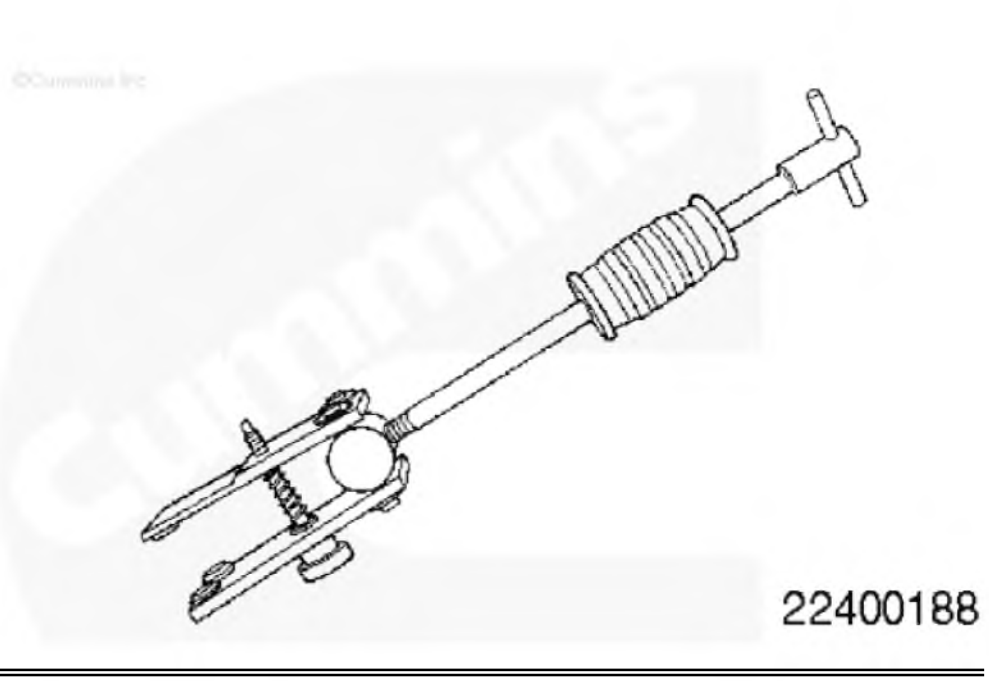
Tool Number 3823621	**Camshaft Bushing Tool Hydraulic Actuator Kit** Used with hydraulic ram force to install/remove cam bushings when used with installation/removal kit.	

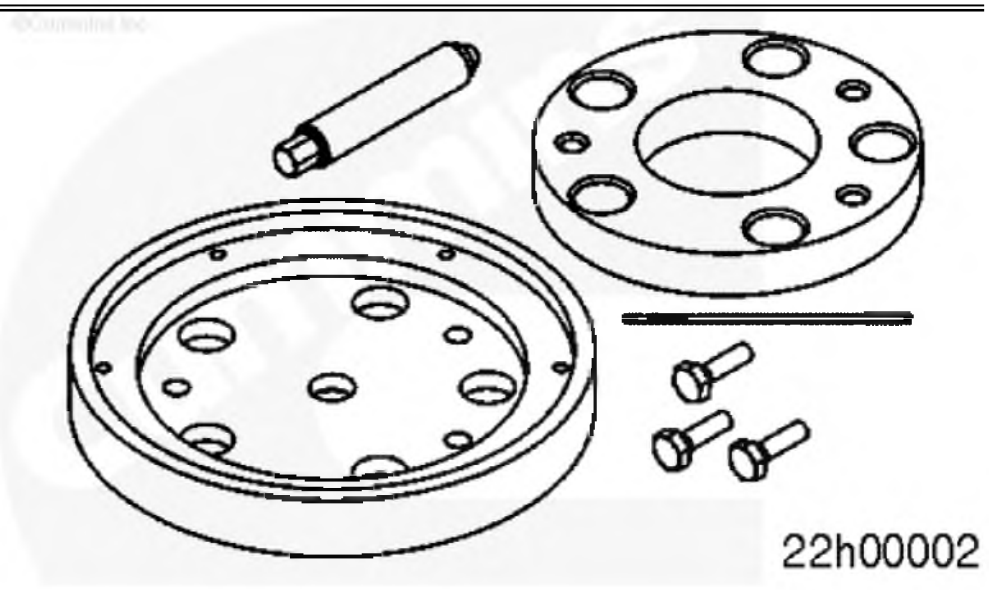
Tool Number 3163015	**Camshaft Bushing Installation/Removal Kit** Used with the Camshaft Bushing Hydraulic Actuator Kit, Part Number 3823621, to remove the camshaft bushing.	
Tool Number 3164845	**Camshaft Pilot Kit** Used to install the camshaft without damaging the camshaft bushings or camshaft. Use with the Camshaft Removal and Installation Kit, Part Number 3164610.	
Tool Number 3164610	**Camshaft Removal and Installation Kit** Used to install the camshaft without damaging the camshaft bushings	

	camshaft bushings or camshaft. Use with the Camshaft Pilot Kit, Part Number 3164845.	 22400187

Tool Number 3164345	**Hydraulic Gear Remover Kit** Used to remove the camshaft gear and rear crankshaft gear from the engine. Use with gear remover kits, Part Numbers 3164925, 3164948, and 3164378.	 3164345

Tool Number 3823818	**Main Bearing Roll-out Tool** Used to remove upper main bearing shell.	 3823818

Tool Number ST-1116	**Main Bearing Cap Puller** Used to remove the main bearing caps.	

Tool Number 5298540	**Crankshaft Seal Replacer Kit** Used to remove/install the rear crankshaft seal.	

Last Modified: 21-Mar-2012

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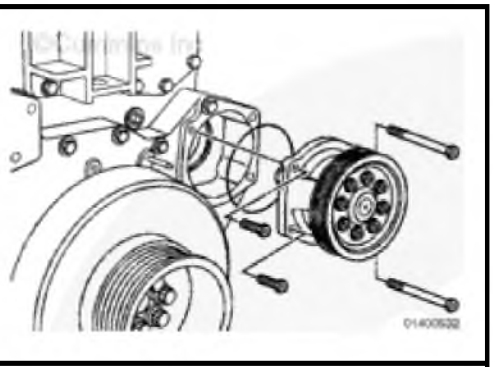
001-001 Alternator Drive Seal

Preparatory Steps

Remove the alternator drive belt. Refer to Procedure 013-005.		

Remove

NOTE: Some components shown removed from engine for clarity. Loosen the four alternator drive housing capscrews and remove the alternator drive housing. Remove the o-ring seal from the alternator drive housing.		

Install

Lubricate the o-ring seal with clean engine oil.

Install the o-ring seal into the alternator drive housing.

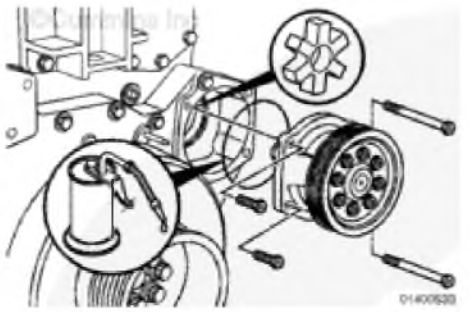
Verify that the fuel pump coupling is in place.

Install the alternator drive housing and four capscrews into the front gear housing.

Bar the engine, if necessary, to align the drive gear with the idler gear and the drive coupling with the fuel pump coupling.

Tighten the four capscrews alternately and evenly.

Torque Value: 113 n.m [83 ft-lb]



Finishing Steps

Install the alternator drive belt. Refer to Procedure 013-005.

Last Modified: 04-Aug-2003

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001-005 Bearings, Connecting Rod

Preparatory Steps

WARNING

To reduce the possibly of personal injury, avoid direct contact of hot oil with your skin.

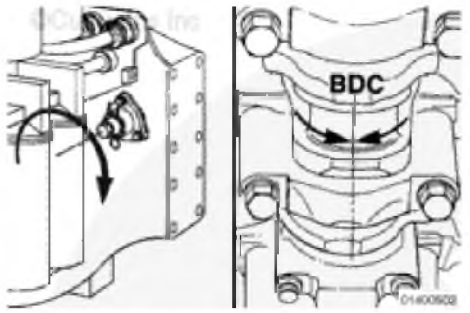
WARNING

Some state and federal agencies 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. If not reused, dispose of in accordance with local environmental regulations.

- Drain the oil and remove the lubricating oil pan. Refer to Procedure 007-025.
- Remove the oil suction tube and block stiffener plate. Refer to Procedure 001-089.
- Remove the piston cooling nozzles. Refer to Procedure 001-046.

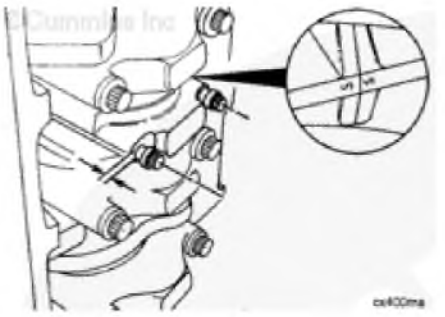
Remove

Use the barring mechanism to rotate the engine. Rotate the crankshaft to position a connecting rod at bottom dead center (BDC).



CAUTION

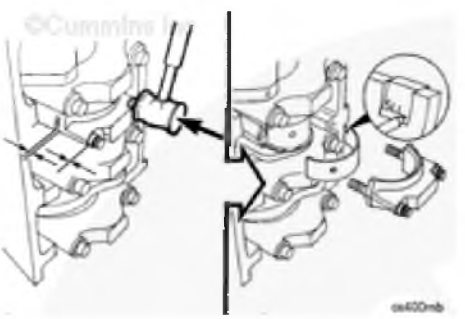
Remove the piston cooling nozzles prior to piston removal. Damage to the piston nozzles can result causing engine failure.



The connecting rods **must** have the cylinder number marked on both the rod and the cap on the side positioned toward the camshaft. Check the rods for correct markings. Use a steel stamp to mark any rod that is **not** correctly marked.

Loosen the capscrews until there is a 6 mm [¼ in] clearance between the rod cap and capscrew head.

Use a mallet to tap the connecting rod capscrews until the connecting rod cap and rod separate.



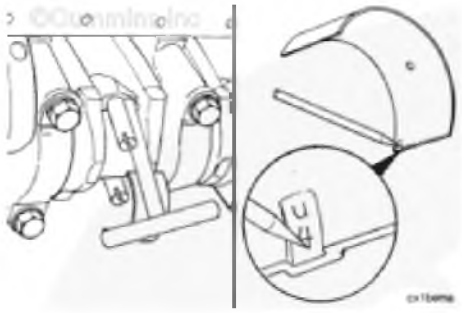
Remove the capscrews and the cap.

Remove the lower rod bearing. Use an awl to mark the bearing position in the tang area.

Mark the cylinder number and the letter “L” in the flat surface of the bearing tangs.

Use a T-handle piston pusher to push the rod away from the crankshaft. Push the rod up far enough to allow the upper bearing shell to be removed.

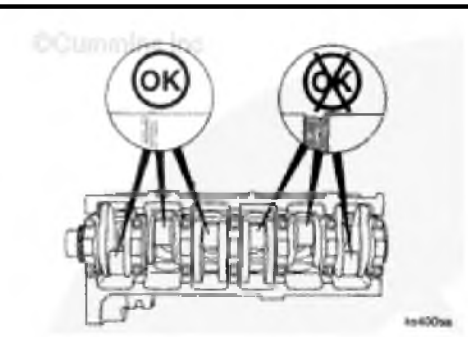
Remove the bearing shell and mark the cylinder number and the letter “U” in the flat surface of the bearing tangs.



Install

Use a clean, lint free paper towel to clean the rod bore, the cap, and the crankshaft rod journal.

Inspect the crankshaft rod journals for damage.



CAUTION

Do not lubricate the back of the bearing shells. Engine damage can occur.

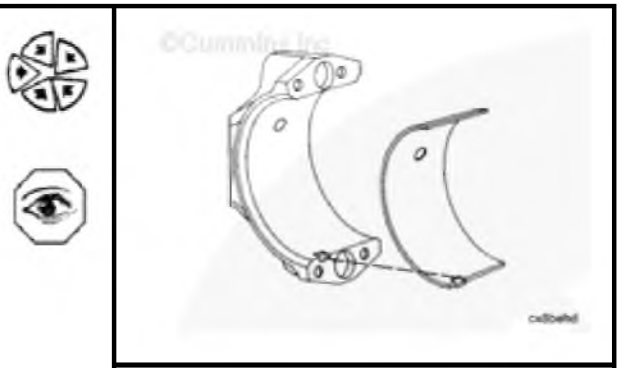
NOTE: The illustration shows the piston and connecting rod removed from the block for better clarity.

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

Lubricate the bearing shell with clean engine oil. Install the upper bearing shell in the connecting rod with the tang of the bearing in the slot of the rod.

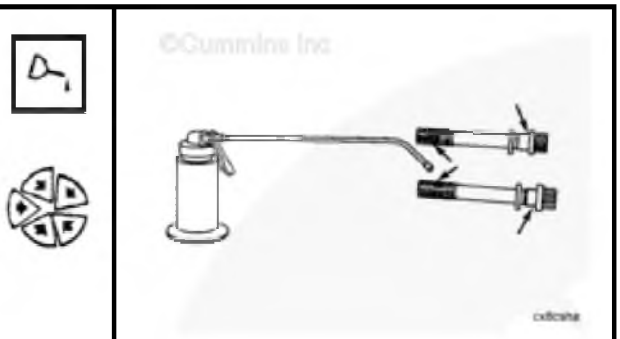
Pull the connecting rod down against the crankshaft journal.

Install the lower bearing shell in the rod cap. Be sure the tang of the bearing shell is in the slot of the rod cap and the end of the bearing is even with the surface of the rod cap.



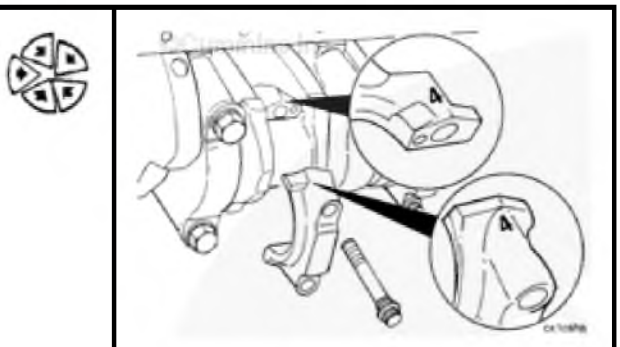
Use clean 15W-40 engine oil to lubricate the connecting rod capscrews and washers, as shown.

Install the washers and capscrews in the rod caps.



CAUTION

The connecting rods and caps are not interchangeable. The rods and caps are machined as an assembly. Failure will result if the parts are mixed.



CAUTION

The cylinder number on the rod and cap must be the same. Failure will result if the parts are mixed.

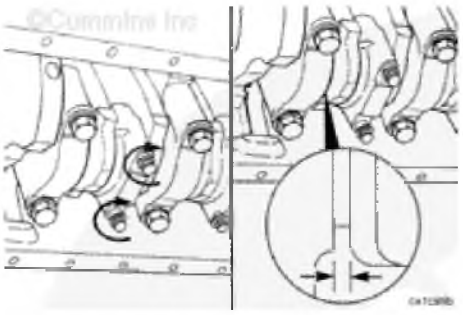
CAUTION

The side of the cap with the cylinder number marking (bearing tang side) must be toward the camshaft. Failure will result if the parts are not installed correctly.

Install the connecting rod cap.

Tighten the capscrews alternately and evenly to pull the cap over the dowel pins. Use the following steps to tighten the capscrews.

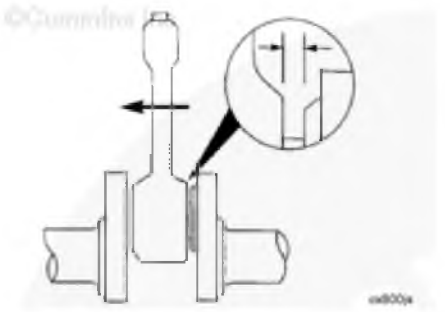
Torque Value:	Step 1	60 n.m [44 ft-lb]
	Step 2	117 n.m [86 ft-lb]
	Step 3	196 n.m [145 ft-lb]
	Step 4	Loosen
	Step 5	60 n.m [44 ft-lb]
	Step 6	117 n.m [88 ft-lb]
	Step 7	196 n.m [145 ft-lb]
	Step 8	Tighten 90 degrees



Check the side clearance between the rod and the crankshaft.

Connecting Rod Side Clearance		
mm		in
0.20	MIN	0.008
0.37	MAX	0.015

The rod **must** move freely from side-to-side.



Finishing Steps

CAUTION

Do not pry or bend the suction tube to get the support bracket capscrew holes to align. Improper oil flow can cause engine damage.

- Install the piston cooling nozzles. Refer to Procedure 001-046.
- Install the oil suction tube and the block stiffener plate. Refer to Procedure 001-089.
- Install the oil pan and related components. Refer to Procedure 007-025.
- Use clean, 15W-40 engine oil to fill the engine. Refer to Procedure 007-037 for engine oil capacity.
- Operate the engine to 70°C [160°F] coolant temperature and check for leaks.

Last Modified: 20-Jun-2003

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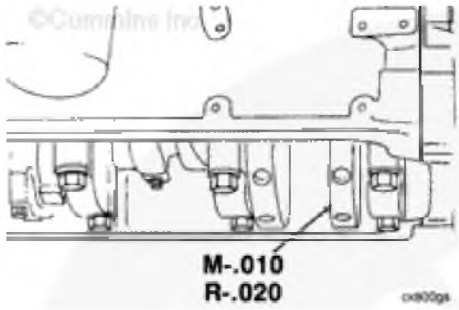
001-006 Bearings, Main

General Information

The crankshaft will be stamped on the end of the number 1 counterweight to indicate whether it has been ground undersize. The amount of material removed from the main journals and the rod journals are both stamped at this location. Thrust bearing size is stamped on a crankshaft counterweight adjacent to the thrust location.



Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be

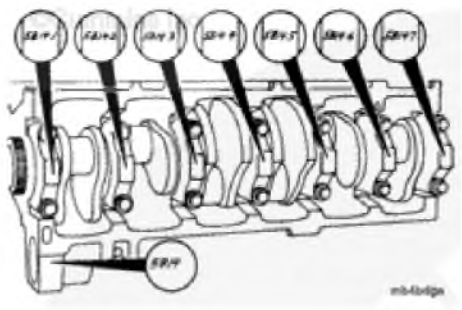
carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Drain the oil from the lubricating oil pan. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the oil suction tube and o-ring. Refer to Procedure 001-089 in Section 1.
- Remove the block stiffener plate. Refer to Procedure 001-089 in Section 1.

Remove

WARNING

Remove the bearings one set at a time. Personal injury and damage to the crankshaft can result if the crankshaft falls.



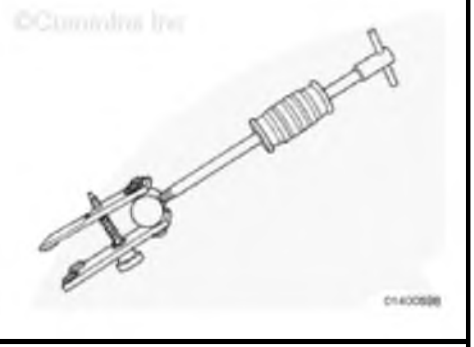
The main bearings caps **must** be marked for position. The last number on each bearing cap identifies the cap location position in the block.

The block and main bearing cap identification numbers **must** be identical.

Use a steel stamp and mark any cap that is **not** marked correctly.

Loosen the main bearing cap capscrews until there is approximately 25 mm [1 in] between the capscrew head and the cap. Use a main bearing replacer, Part Number ST1116, to loosen the cap.

Remove the cap and capscrews.



Remove the lower bearing. Use an awl to mark the bearing position in the tang area.

Mark the bearing position for future identification or for possible failure analysis.

Use the following procedure for instructions on removal of the thrust bearing. Refer to Procedure 001-007 in Section 1.

Remove the upper main bearing shells.

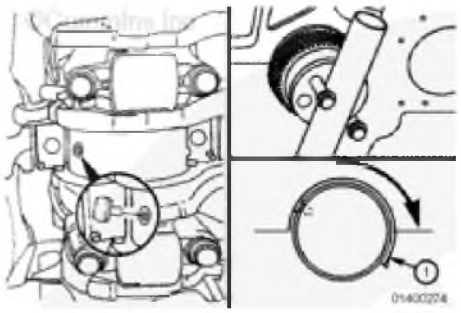
Insert the main bearing roll-out tool, Part Number 3823818, into the crankshaft oil drilling.

Rotate the crankshaft so the tang (1) of the main bearing shell rolls out of the block.

Use the crankshaft adapter mounting bolts and slowly turn the crankshaft until the bearing shell is out of the block.

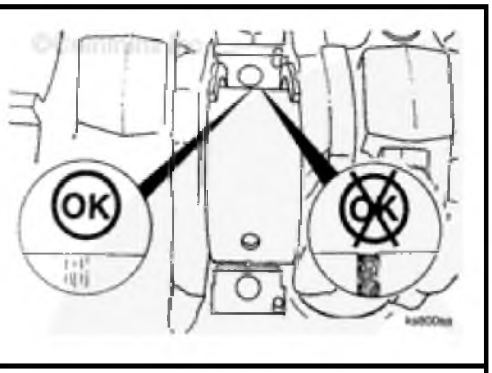
NOTE: Crankshaft journal number 4 has no oil drilling.

For removing upper bearing number 4, use a flat piece of bar stock (approximately



3.175 x 38.1 mm [0.125 x 1.5 in]) to press the non-tang side of the bearing. It can be necessary to turn the crankshaft at the same time. Once the bearing starts to turn out of the block, use a pry bar to gently pry between the block and the back side of the bearing. While applying pressure to the back side of the bearing, turn the crank until the bearing is free from the cylinder block.		

Clean

Use a lint-free cloth. Clean the crankshaft journals, connecting rods, and main bearings. Check the crankshaft journal for damage.		

Install

CAUTION Used bearings must be installed in their original location. Engine damage can result if bearings are not installed in the		

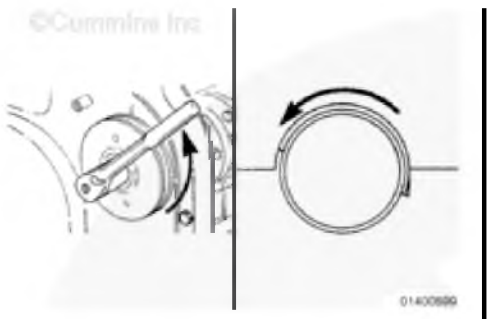
original position.

CAUTION

Do not use the bearing roll-out tool to install the upper bearings. The tool can slide under the bearing and engine damage can result.

Install the upper main bearing shells as far as possible by hand. The bearing will want to spring away from the crank. Use a use a flat piece of bar stock (approximately 3.175 x 38.1 mm [0.125 x 1.5 in]) to press the bearing against the crank while turning the crankshaft in the direction to rotate the bearing into place.

The bearing tang **must** fit into the slot in the bearing saddle to assure proper location of the bearing.

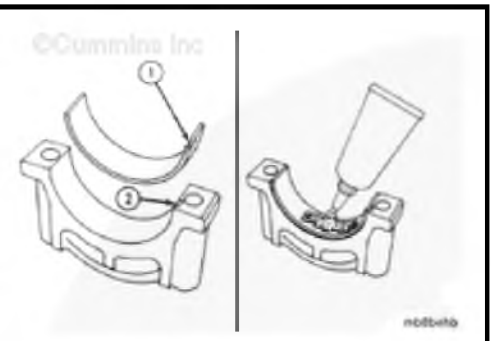


Use a lint-free cloth. Clean the lower main bearings, the lower thrust bearings, and the mounting surfaces.

Do **not** lubricate the back of the main bearings.

Align the tang (1) in the bearing with the slot (2) in the main bearing cap. Install the bearing. The end of the bearing **must** be even with the main bearing cap mounting surface.

Lubricate the bearing surface with clean engine oil.



CAUTION

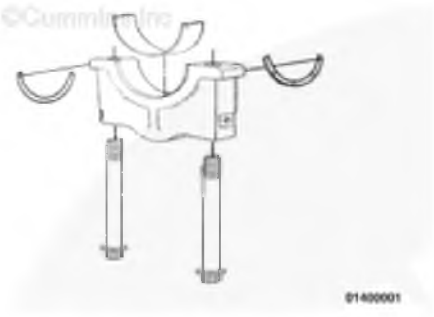
The grooves in the thrust bearings must

point toward the crankshaft. The dowels that secure the bearings must not protrude above the bearing. Engine damage can result.

Lubricate the capscrew head and threads with clean 15W-40 engine oil. Allow the excess oil to drip off of the capscrews before installing in the block.

Install the capscrews in the cap.

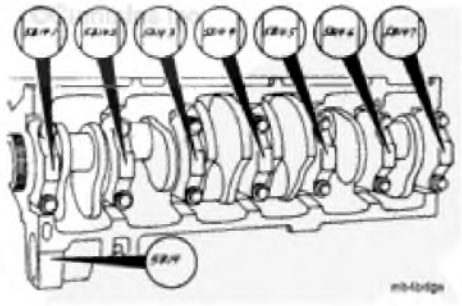
Install the two thrust bearings on the number 6 main bearing cap. Use the following procedure for removal of the thrust bearing. Refer to Procedure 001-007 in Section 1.



CAUTION

The numbers on the main bearing caps must be the same as the numbers on the block. If the main bearing caps are not installed in the same location, engine damage can result.

Match the number on the main bearing caps with the correct location in the block. The side of the cap marked “F” should face the front of the engine.



CAUTION

Make sure the side of the cap and bearing with the bearing locating tang is toward the tang in the block. If the main bearing caps are not positioned correctly, engine damage can result.

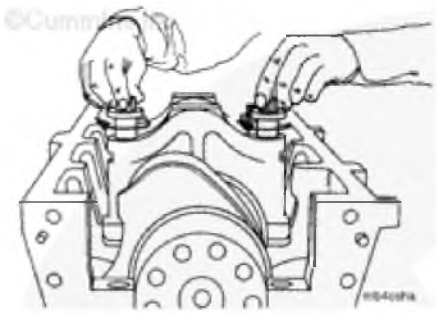
CAUTION

Do not hit the main bearing caps with a hammer. The bearing shells can fall out.

Lubricate the bearing surface with engine oil. The bearing shells **must** be firmly seated in the cap and the correct capscrew and washer combination in position. Install the main bearing caps.

CAUTION

Do not rotate the crankshaft until all of the main bearing caps are pulled to the block. Damage will result if the bearings move out-of-location.

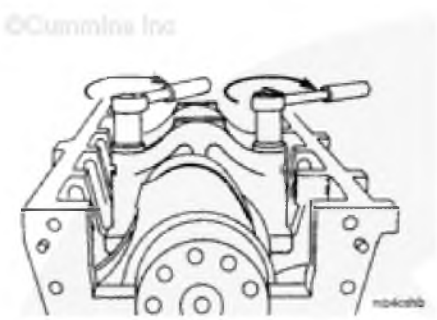


Install the capscrews.

Turn each capscrew until it touches the main bearing cap.

CAUTION

Do not use an impact wrench. The main bearing shells can fall out.



Use both of the capscrews to pull the main bearing cap into position.

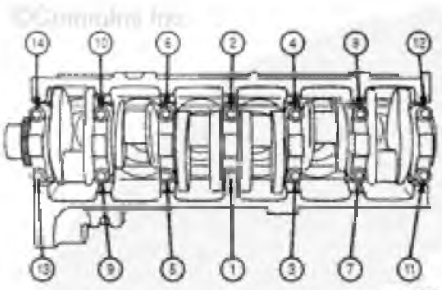
Use two wrenches and tighten both capscrews at the same time.

Check to be sure the number 7 cap is even with the back of the block and that the thrust bearings are still in place.

Use the following steps to tighten the capscrews in the sequence shown.

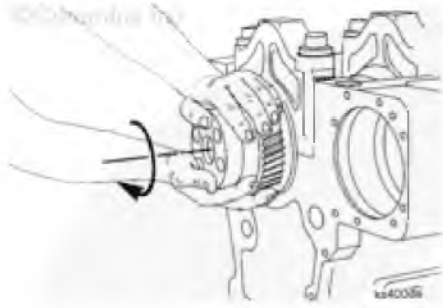
Torque Value:

1. 285 n.m [210 ft-lb]
2. 580 n.m [428 ft-lb]
3. Tighten 90°



Turn the crankshaft by hand. If the pistons have **not** been removed, use the barring mechanism.

The crankshaft will turn freely if the main bearings are installed correctly.

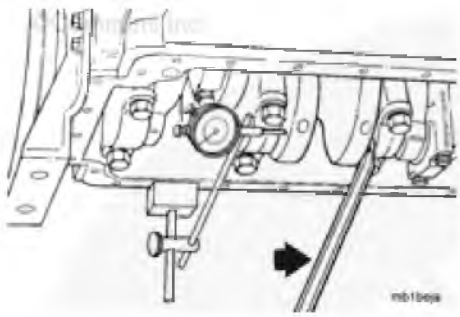


Use a dial indicator to measure the crankshaft end clearance.

Crankshaft End Clearance		
New Minimum	**New Maximum**	**Worn Limit**
0.14 mm [0.0055 in]	0.32 mm [0.0125 in]	0.60 mm [0.0236 in]

If the clearance is **not** within specifications, check for foreign material. Oversize thrust bearings are available to adjust the end clearance.

The upper and lower thrust bearing on the same side of the main caps **must** be the same thickness.



Finishing Steps

CAUTION

Do not pry or bend the suction tube to get the support bracket capscrew holes to align. A bent suction tube can cause improper oil flow and cause engine damage.

- Install the block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Install the suction tube. Refer to Procedure 001-089 in Section 1.
- Install the oil pan and related components. Refer to Procedure 007-025 in Section 7.
- Fill the engine with clean 15W-40 lubricating oil. Use the following procedure for engine oil capacity specifications. Refer to Procedure 007-037 in Section 7.
- Operate the engine to 70°C [160°F] coolant temperature and check for leaks.

Last Modified: 10-Dec-2010

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001-007 Bearings, Thrust

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

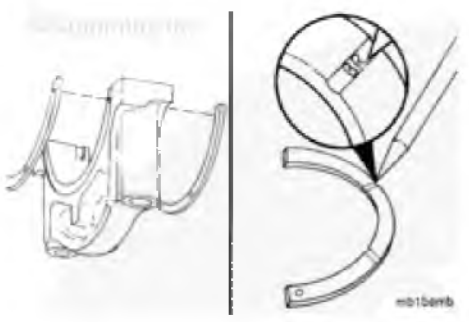
Some state and federal agencies have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Drain the oil and remove the oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the oil suction tube and block stiffener plate. Refer to Procedure 001-089 in Section 1.

Remove

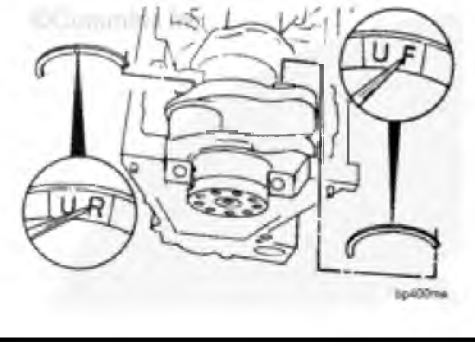
The number 6 main bearing cap contains two thrust bearings.

Remove and mark them in the notched area for position.



Remove the two upper thrust bearings from the block at the number 6 location. Mark them for position.

If necessary, slide the crankshaft to the front or to the rear to allow the thrust bearings to be removed.



Inspect for Reuse

Thrust bearing sets are available in five sizes. The upper and lower thrust bearings **must** be the same size. The front and rear can be different sizes.

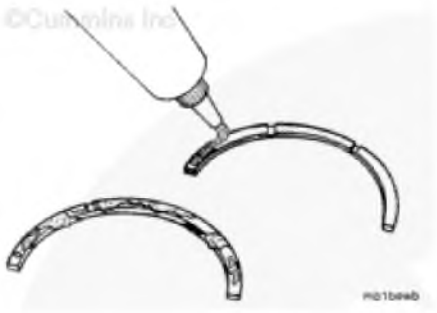
Bearing Set Size	Set Contents
STD	**Four (4) STD Bearings**
0.25	

mm [0.010 in]	Two (2) STD and two (2) 0.25 mm [0.010 in] oversize bearings
0.50 mm [0.020 in]	Four (4) 0.25 mm [0.010 in] oversize bearings
0.75 mm [0.030 in]	Two (2) 0.25 mm [0.010 in] oversize and two (2) 0.50 mm [0.020 in] oversize bearings
1.00 mm [0.040 in]	Four (4) 0.50 mm [0.020 in] oversize bearings

Use the same size as those removed. The crankshaft will be marked on a counterweight adjacent to the thrust location if the thrust flange has been machined for oversize thrust bearings.

Install

Use clean engine oil to lubricate the thrust bearings.



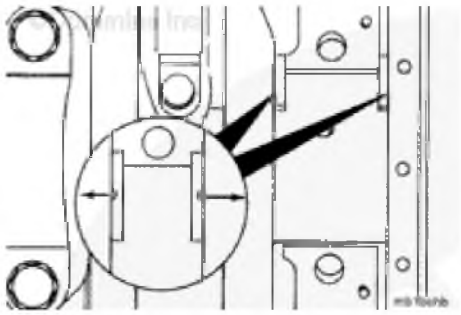
CAUTION

The grooves in the thrust bearings must point toward the crankshaft. Engine damage can occur if the thrust bearing is not orientated correctly.

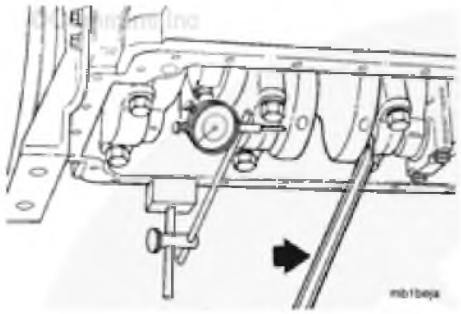
Install the bearings in the number 6 location.

Move the crankshaft to the front or to the rear so the second thrust bearing can be installed.

The upper and lower thrust bearings on the same side of the main cap **must** be the same thickness.



Install the main caps and measure the crankshaft end clearance. Refer to Procedure 001-006 in Section 1.



Finishing Steps

CAUTION

Do not pry or bend the suction tube to get the support bracket capscrew holes to align. A bent suction tube can cause improper oil flow and cause engine damage.

• Install the block stiffener plate and suction tube. Refer to Procedure 001-089 in Section 1. • Install the oil pan and related components. Refer to Procedure 007-025 in Section 7. • Fill the engine with clean lubricating oil. Use the following procedure for engine oil capacity specifications. Refer to Procedure 007-037 in Section 7. • Operate the engine to 70°C [160°F] coolant temperature and check for leaks.		

Last Modified: 30-Nov-2010

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001-008 Camshaft

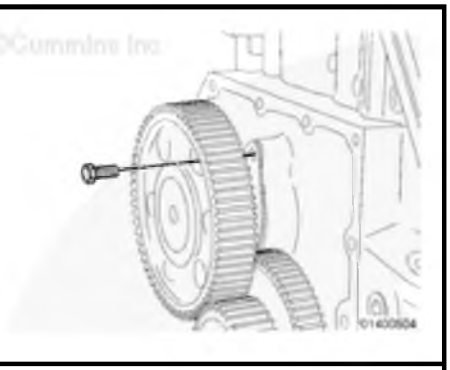
Preparatory Steps

- Engage and turn the engine barring device **counterclockwise** until the “I-6TC” mark on the damper is aligned with the pointer attached to the front of the block.
- Remove all of the rocker covers. Refer to Procedure 003-011 in Section 3.
- For cylinders 2 and 5, identify the injector push rod which is higher in relation to the top of the rocker lever housing. If the injector push rod is higher on cylinder number 2, cylinder number 1 is on its compression stroke. If **not**, rotate the crankshaft one full revolution to place the number 1 cylinder on its compression stroke.
- Remove all of the rocker assemblies. Refer to Procedure 003-009 in Section 3.
- Remove all of the push rods. Refer to Procedure 004-014 in Section 4.
- Remove all of the cam follower covers and assemblies. Refer to Procedure 004-001 in Section 4.
- Drain the lubricating oil from the oil pan. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the oil suction tube and

cylinder block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Remove the camshaft cover plate. Refer to Procedure 001-011 in Section 1.
- Remove the flywheel housing and all related components. Refer to Procedure 016-006 in Section 16.

Remove

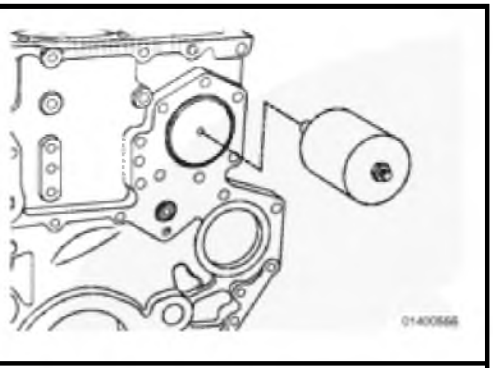
Remove the two camshaft thrust bearing mounting capscrews.



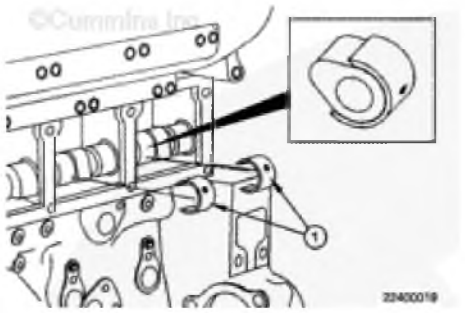
CAUTION

Pilots must be used to reduce the possibility of damage to the camshaft and the bushings.

Install the camshaft installation and removal pilot, Part Number 3164845.

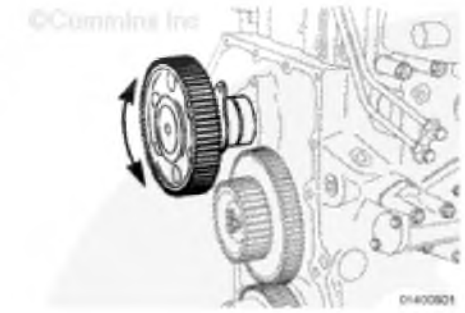


Install the camshaft guide kit (1), Part Number 3164610.



WARNING

This component weighs more than 23 kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.



CAUTION

Do not damage the camshaft or bushings during disassembly. Turn the camshaft gently clockwise and counterclockwise slightly while pulling the component out.

CAUTION

Rotating the camshaft too far in one direction will cause the cam lobe guides to lock up in the bushing bores.

CAUTION

Do not change the crankshaft position while the camshaft is removed.

Make sure the gear teeth with the “B” marks on the cam gear and the smaller idler gear are in mesh and the keyway in

the camshaft is at 6 o'clock.

Slightly rotate the camshaft back and forth during removal, if necessary.

Once the camshaft extends approximately 1/2 the length out of the block, use a sling to support the camshaft and complete the removal.

Clean

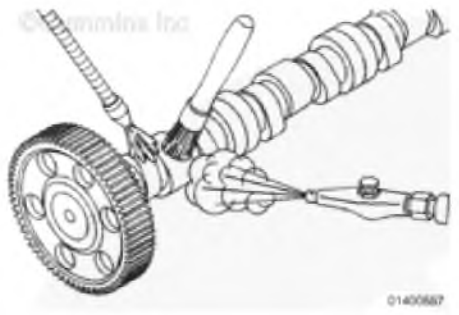
WARNING

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

WARNING

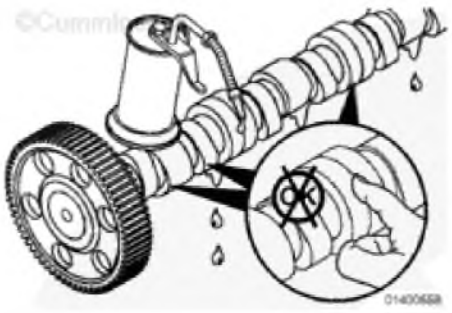
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent and compressed air to clean the camshaft.



After the camshaft has been cleaned, do **not** touch the machined surfaces with bare hands. This will cause rust to form. Lubricate the camshaft with clean 15W-40

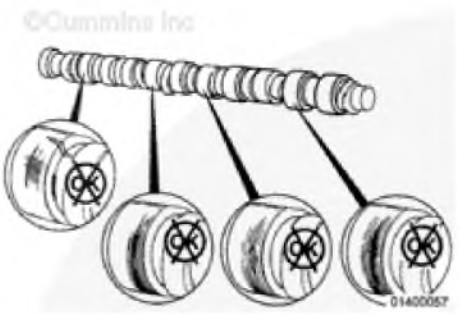
engine oil before handling.



Inspect for Reuse

CAUTION

Do not repair the camshaft by grinding the valve or the injector lobes.



Inspect the camshaft.

Check the valve and the injector lobes for damage.

If the camshaft is damaged, it **must** be replaced.

Measure each of the seven bushing journals.

Measure the outside diameter.

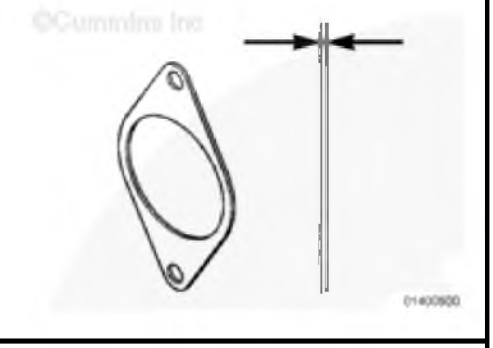
Camshaft Bushing Journal Outside Diameter

mm		in
104.88	MIN	4.129
104.96	MAX	4.132

If the outside diameter is **not** within specifications, the camshaft **must** be

replaced.

Inspect the camshaft thrust bearing. Refer to Procedure 001-056 in Section 1.



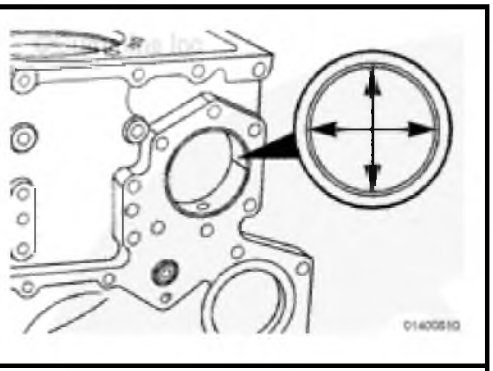
Inspect the camshaft bushings.

Measure the inside diameter.

Camshaft Bushing Inside Diameter

mm		in
105.01	MIN	4.134
105.10	MAX	4.138

If the bushing is **not** within specifications, the bushing **must** be replaced.

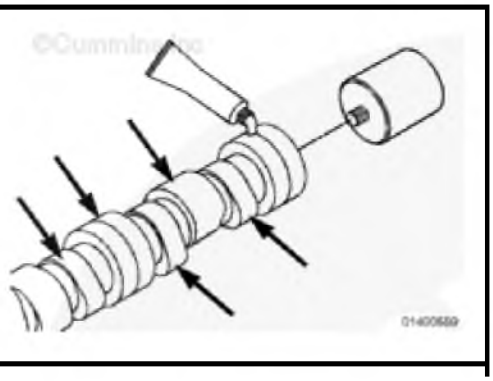


Install

Install the camshaft installation pilot, Part Number 3164835, or equivalent, on the end of the camshaft.

Install the camshaft guide kit, Part Number 3164610, or equivalent.

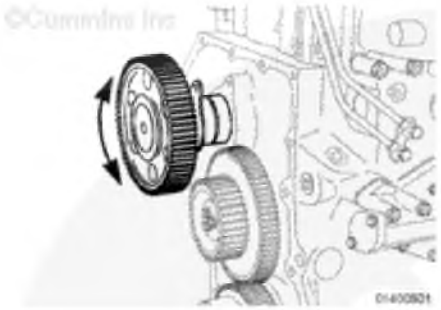
Use Lubriplate™ 105, or equivalent, to



lubricate the camshaft and camshaft bushings.

WARNING

This component weighs more than 23 kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.



CAUTION

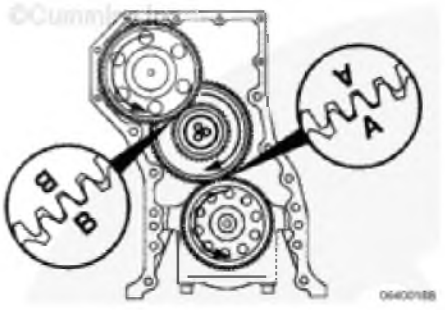
Be careful when installing the camshaft to reduce the possibility of the camshaft lobes damaging the bushings.

Turn the keyway in the camshaft to the 6 o'clock position.

Install the camshaft. Turn the camshaft backward and forward as it is being installed, if necessary.

Align the “B” marks on the cam gear and the smaller idler gear.

After installing the gear and camshaft, double check that the "A" and "B" marks are lined up on the camshaft compound idler gear.



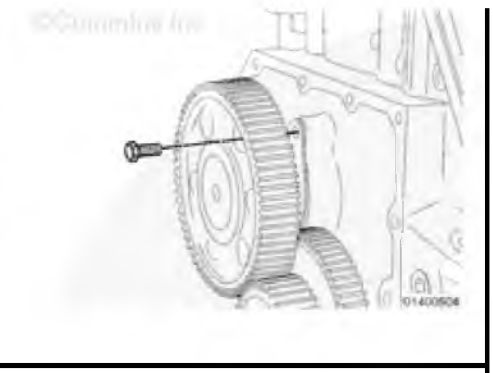
Install the two camshaft thrust bearing

mounting capscrews.

Tighten the capscrews

Torque Value: 64 n.m [47 ft-lb]

Remove the camshaft installation pilot and guide kit.

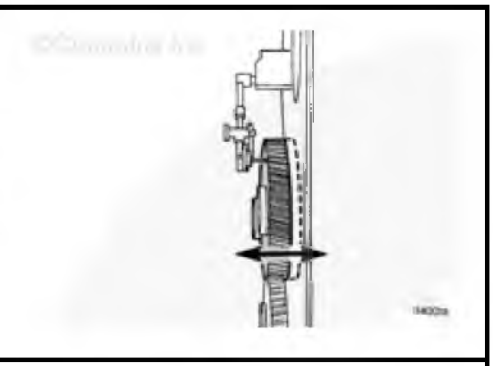


Use a dial indicator to measure the camshaft end clearance.

Camshaft End Clearance

mm		in
0.05	MIN	0.002
0.20	MAX	0.008

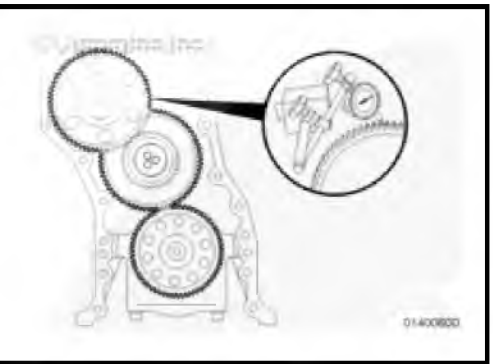
If the clearance is **not** within specifications, check for foreign material or a piece of gasket between the thrust plate and the block.



Use a dial indicator to measure the camshaft gear backlash.

Camshaft Gear Backlash

mm		in
0.145	MIN	0.006
0.380	MAX	0.015



Finishing Steps

- Install the flywheel housing and all related components. Refer to Procedure 001-020 in Section 1.
- Install all of the cam follower covers and assemblies. Refer to Procedure 004-001 in Section 4.
- Install the camshaft cover plate. Refer to Procedure 001-011 in Section 1.
- Install the oil suction tube and cylinder block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Install the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Fill the lubricating oil pan. Refer to Procedure 007-037 in Section 7.
- Install all of the push rods. Refer to Procedure 004-014 in Section 4.
- Install all of the rocker assemblies. Refer to Procedure 003-009 in Section 3.
- Adjust the overhead setting. Refer to Procedure 003-006 in Section 3.
- Install all of the rocker covers. Refer to Procedure 003-011 in Section 3.

Last Modified: 07-Jan-2011

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001-010 Camshaft Bushings

Preparatory Steps

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

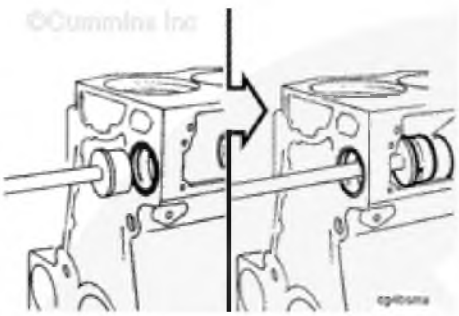
WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

- Push the barring device shaft in and turn **counterclockwise** until the “I-6TC” mark on the damper is aligned with the pointer attached to the front of the block.
- Drain the oil from the lubricating oil pan. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the cylinder block stiffener plate. Refer to Procedure 001-089 in

Section 1. • Remove the flywheel housing and all related components. Refer to Procedure 001-020 in Section 1. • Remove all of the rocker covers. Refer to Procedure 003-011 in Section 3. • Remove all of the rocker assemblies. Refer to Procedure 003-009 in Section 3. • Remove all of the push rods. Refer to Procedure 004-014 in Section 4. • Remove all of the cam follower assemblies. Refer to Procedure 004-001 in Section 4. • Remove the camshaft. Refer to Procedure 001-008 in Section 1.		

Remove

Remove the camshaft bushings using the camshaft bushing installation and removal kit, Part Number 3163015.		

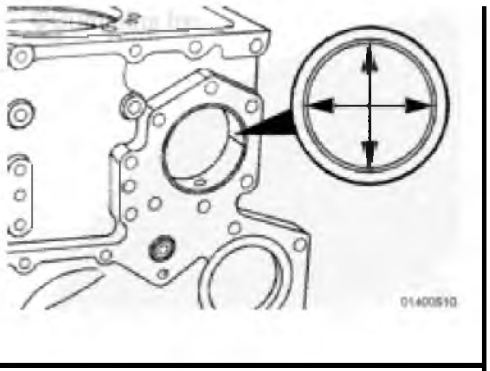
Inspect for Reuse

Measure the inside diameter of the camshaft bushings.

Camshaft Bushing Inside Diameter

mm		in
105.01	MIN	4.134
105.10	MAX	4.138

If the bushing is **not** within specifications, the bushing **must** be replaced.

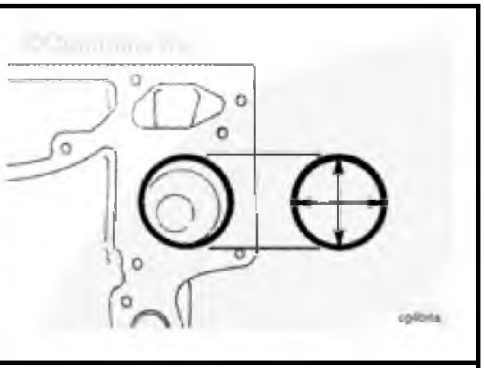


Clean and inspect the camshaft bores.

Camshaft Bushing Bore in the Block

mm		in
111.966	MIN	4.408
111.988	MAX	4.409

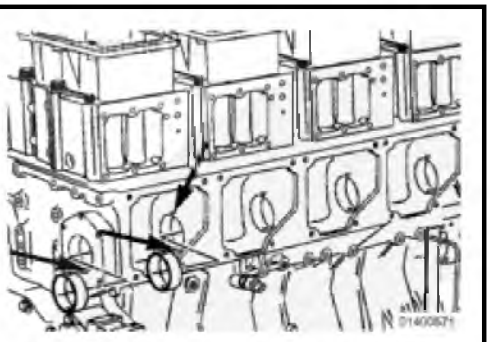
If the bore is damaged and can **not** be repaired, the cylinder block **must** be replaced.



Install

Align the oil holes in the bushing with the oil drilling in the block.

Position the notch in the bushing toward the front of the block.



CAUTION

Clean the oil groove in the back of the camshaft bushing to prevent contamination of the lubrication system.

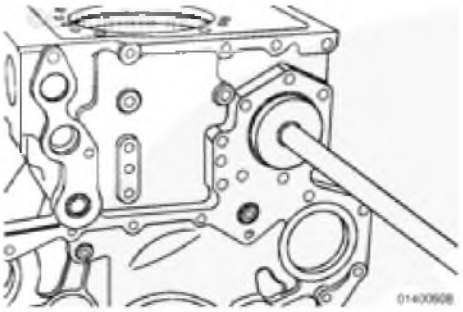
Install the bushing until the edge of the groove on the back (outside diameter) is even with the edge of the block.

Clean the bushing outside diameter. Remove any metal shavings from the oil groove.

CAUTION

Be sure the front bushing is below the surface of the block. Engine damage can result.

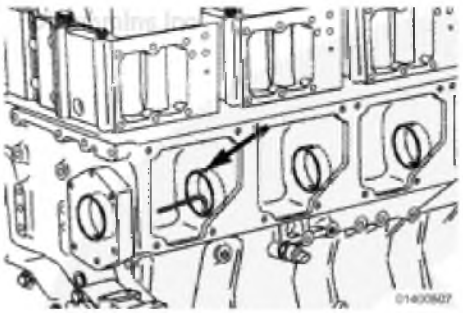
Install the bushing until the oil holes are aligned.



Use a 7-mm [¼-in] Allen wrench. Check the alignment of the bushing oil holes.

All holes **must** be aligned. The front bushing bore has **only** one drilling in the bottom of the bore, all other bores have two drillings, one in the top and one in the bottom.

There is no drilling to align with the upper hole on the front bushing.



Finishing Steps

- Install the camshaft. Refer to Procedure 001-008.
- Install the camshaft cover plate. Refer to Procedure 001-011 in Section 1.
- Install all of the cam follower assemblies. Refer to Procedure 004-001 in Section 4.
- Install the push rods. Refer to Procedure 004-014 in Section 4.
- Install the rocker assemblies. Refer to Procedure 003-009 in Section 3.
- Adjust the overhead setting. Refer to Procedure 003-006 in Section 3.
- Install the rocker cover. Refer to Procedure 003-011 in Section 3.
- Install the cylinder block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Install the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Fill the engine with lubricating oil. Refer to Procedure 007-037 in Section 7.
- Install the flywheel housing and all related components. Refer to Procedure 001-020 in Section 1.

Last Modified: 28-Sep-2011

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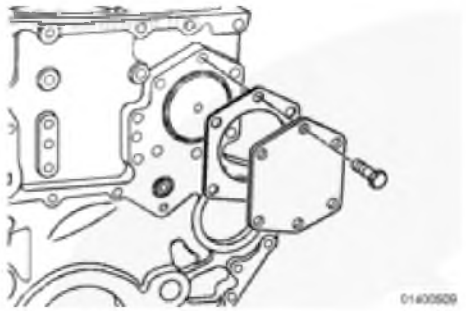
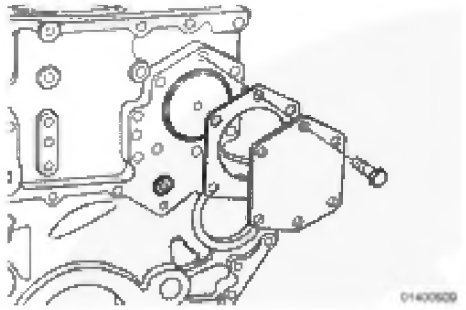
001-011 Camshaft Cover Plate

Remove

Remove the six capscrews. Remove the camshaft cover. Remove and discard the gasket.		

Install

Install the camshaft cover gasket and the cover. Install the capscrews. Tighten the capscrews. **Torque Value:** 66 n.m [50 ft-lb]		

Last Modified: 20-Jun-2003

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001-012 Camshaft Gear (Camshaft Installed)

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Remove rocker lever covers from cylinder 2 and 5. Refer to Procedure 003-011 in Section 3.
- Push the barring device shaft in and turn **counterclockwise** until the “I-6TC” mark on the damper is aligned with the pointer attached to the front of the block.
- For cylinders 2 and 5, identify the injector push rod which is higher in relation to the top of the rocker lever housing. If the injector push rod is higher on cylinder number 2,

cylinder number 1 is on its compression stroke. If **not**, rotate the crankshaft one full revolution to place number 1 cylinder on its compression stroke.

- Drain the oil from the lubricating oil pan. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the cylinder block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Remove the flywheel housing and all related components. Refer to Procedure 016-006 in Section 16.

Remove

CAUTION

Do not change crankshaft position while the camshaft is removed.

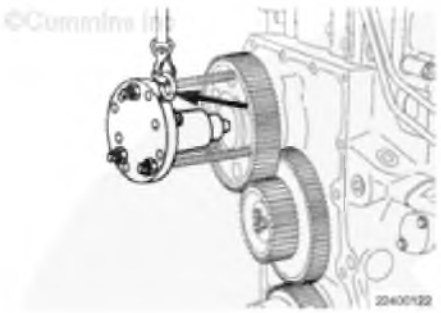
Make sure the gear teeth with the “B” marks on the cam gear and the smaller idler gear are in mesh and the keyway in the crankshaft is at 6 o'clock.

Use the Camshaft Gear Puller Kit, Part Number 3164345, or equivalent, to remove the camshaft gear.

Attach the puller to the camshaft gear.

Remove the camshaft gear.

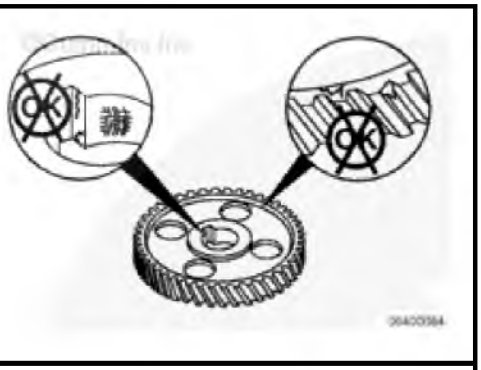
Remove the puller.



Inspect for Reuse

Inspect the camshaft gear for cracks or chipped or broken teeth.

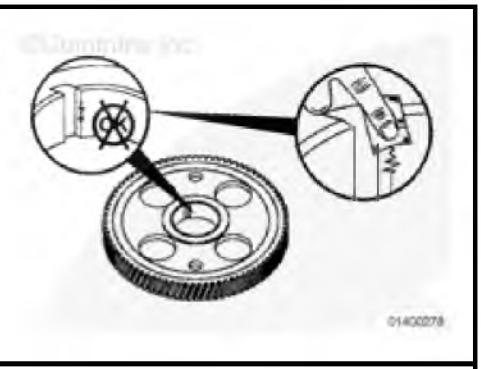
Inspect the bore of the gear for fretting or burrs.



Inspect the gear keyway for burrs.

Remove any burrs with fine crocus cloth.

If the keyway is damaged or it is **not** possible to remove the burrs with fine crocus cloth, the gear **must** be replaced.

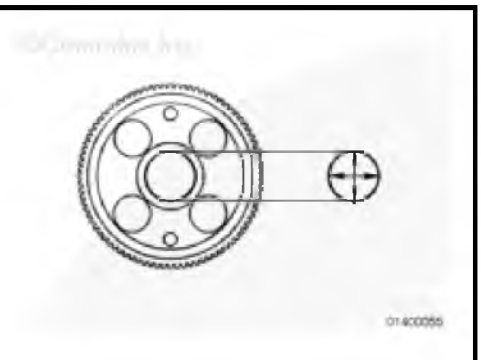


Measure the inside diameter of the camshaft gear.

Camshaft Gear Inside Diameter

mm		in
80.00	MIN	3.150
80.02	MAX	3.150

The gear **must** be replaced if the inside diameter is **not** within specifications.



Install

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

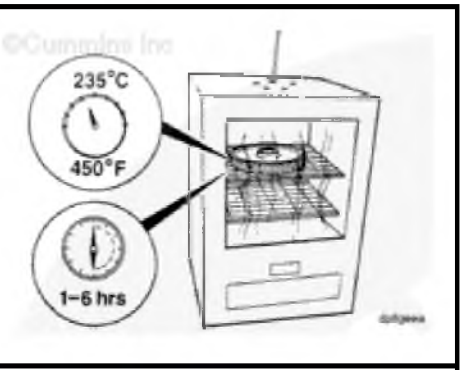
CAUTION

Do not exceed the specified time or the temperature. Damage to the gear and the gear teeth will result.

CAUTION

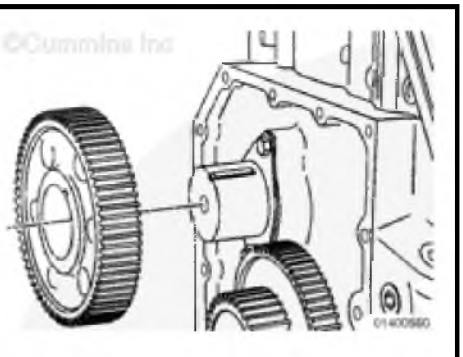
Do not attempt to install the gear without using heat. Damage to the camshaft and camshaft gear can result.

Use an oven and adjust the heat to 235°C [450°F]. Heat the gear for a minimum of 1 hour, but no more than a maximum of 6 hours. The inside diameter of the gear will become larger and will simplify installation.



CAUTION

Allow the gear to cool slowly. Do not use water or oil to reduce the cooling time. This will cause the gear to crack.



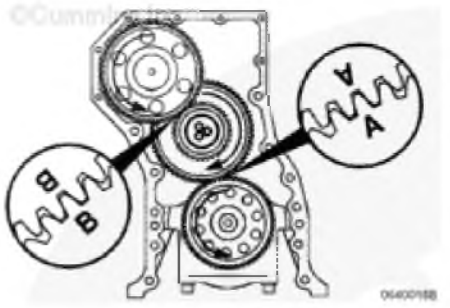
If removed, install the camshaft key into the slot on the camshaft.

NOTE: There is only a straight key option. It is not necessary to check/adjust static injection timing on the QSK23 engine.

The timing mark on the camshaft gear **must** be visible from the front of the gear after it is installed on the camshaft.

Remove the gear from the oven and install it on the camshaft. The keyway in the gear **must** be aligned with the key in the camshaft and the “B” marks on the cam gear and the smaller idler gear **must** also be aligned.

After installing the gear and camshaft, double check that the "A" and "B" marks are lined up on the camshaft compound idler gear.



Use a dial indicator and measure the camshaft end clearance.

Camshaft End Clearance

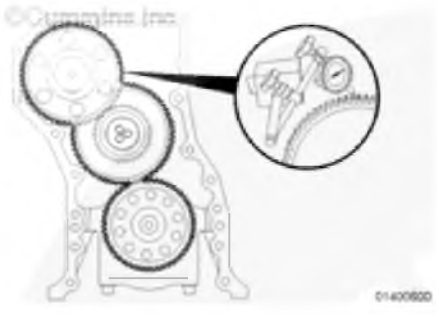
mm		in
0.05	MIN	0.002
0.20	MAX	0.008

If the clearance is too small, check for foreign material or a piece of gasket between the thrust plate and the block.

Use a dial indicator to measure the camshaft gear backlash.

Camshaft Gear Backlash

mm		in
0.145	MIN	0.006
0.380	MAX	0.015



Finishing Steps

- Install the flywheel housing and all related components. Refer to Procedure 016-006 in Section 16.
- Install the cylinder block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Install the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Install the rocker lever covers for cylinders 2 and 5. Refer to Procedure 003-011 in Section 3.
- Fill the engine with lubricating oil. Refer to Procedure 007-037 in Section 7.

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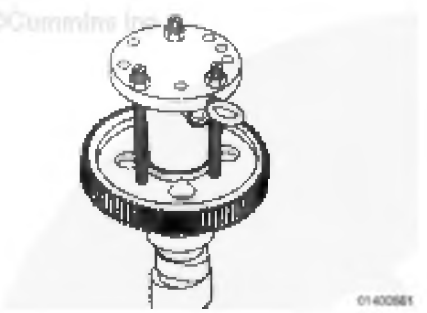
001-013 Camshaft Gear (Camshaft Removed)

Remove

Use the camshaft gear puller kit, Part Number 3164345, to remove camshaft gear.

Attach the puller to the camshaft gear. Remove the gear.

Remove the puller.



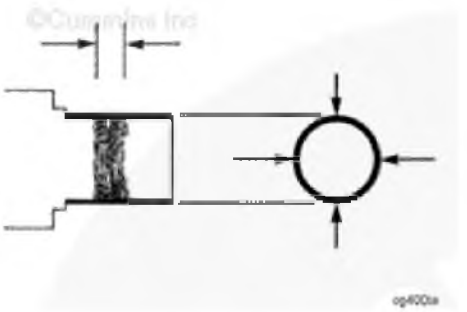
Inspect for Reuse

Inspect the camshaft and camshaft gear for reuse. Check for fretting damage. The camshaft **must** be replaced if the fretting damage is more than 3 mm [1/8 in] wide.

Measure the outside diameter of the camshaft.

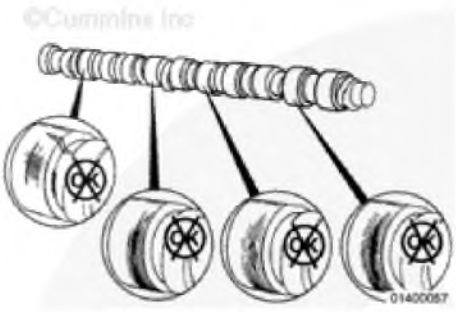
Camshaft Outside Diameter (Gear Location)

mm	in



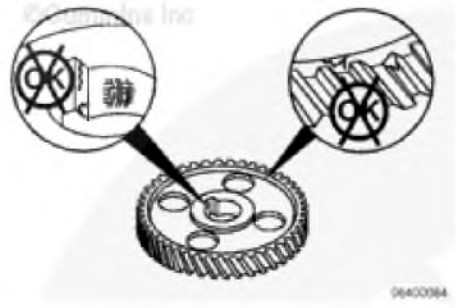
80.10	MIN	3.154
80.12	MAX	3.154

Inspect the camshaft. Refer to Procedure 001-008 in Section 1.



Inspect the camshaft gear for cracks or chipped or broken teeth.

Inspect the bore of the gear for fretting or burrs. Refer to Procedure 001-012 in Section 1.

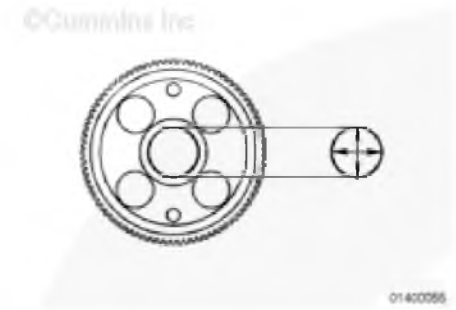


Measure the inside diameter of the camshaft gear.

Camshaft Gear Inside Diameter

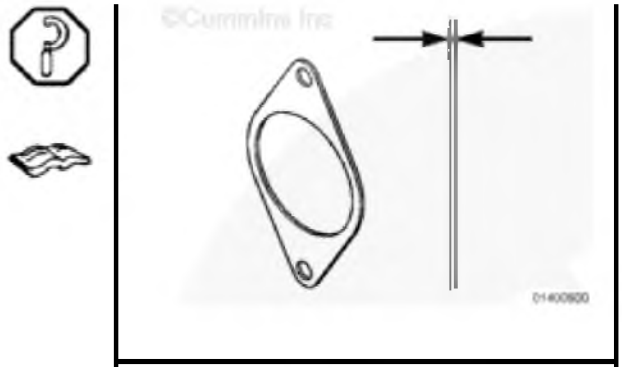
mm		in
80.00	MIN	3.150
80.02	MAX	3.150

The gear **must** be replaced if the inside diameter is **not** within specification.



Inspect the thrust bearing for damage.

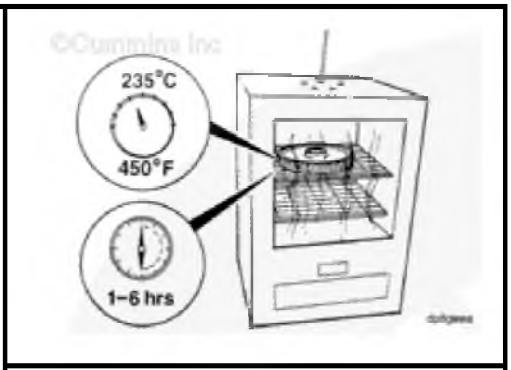
Measure the thickness. Refer to Procedure 001-056 in Section 1.



Install

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.



CAUTION

Do not exceed the specified time or the temperature. Damage to the gear and the gear teeth will result.

CAUTION

Do not attempt to install the gear without using heat. Damage to the camshaft and camshaft gear can result.

Use an oven with the temperature adjusted to 235°C [450°F]. Heat the gear in the oven for a minimum of one hour but **not** more than a maximum of six hours. The inside diameter of the gear will

become larger and will simplify the installation.

CAUTION

Allow the gear to air cool. Do not use water or oil to reduce the cooling time. It will cause the gear to crack.

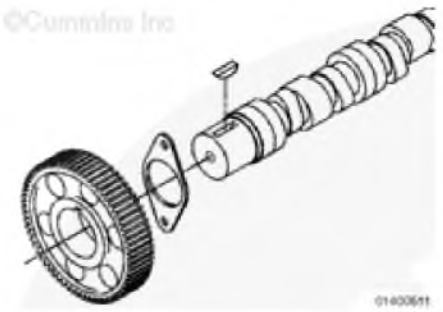
Install the thrust bearing onto the camshaft.

If removed, install the camshaft key into the slot on the camshaft.

NOTE: There is only a straight key option. It is not necessary to check/adjust static injection timing on the QSK23 engine.

The timing mark on the camshaft gear **must** be visible from the front of the gear after it is installed on the camshaft.

Remove the gear from the oven and install it on the camshaft. The keyway in the gear **must** be aligned with the key in the camshaft.



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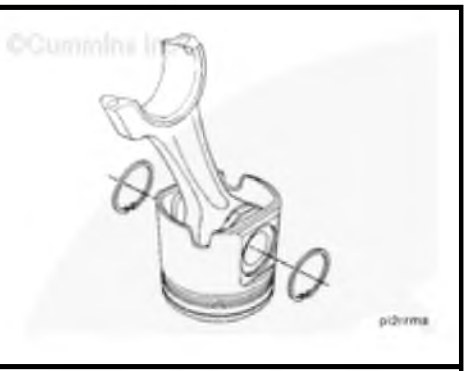
View Related Topic

001-014 Connecting Rod

Remove

Remove the piston from the connecting rod. Refer to Procedure 001-054.		

Clean

CAUTION The number on the connecting rod must be the same as the number on the cap. NEVER assemble a new cap to an old rod or an old cap to a new rod. Remove the capscrews and the cap from the connecting rod.		

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. 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 and protective clothing to reduce the possibility of personal injury.

WARNING

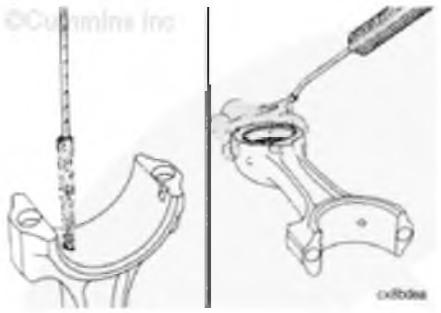
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent or steam to clean the parts.

Dry with compressed air.

Use a soft bristle brush to clean the oil drilling.

Dry the rod with compressed air.



Inspect for Reuse

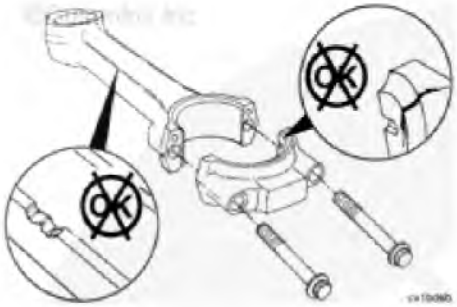
Visually check the rod and the cap for fretting damage.

The rod and cap **must** be replaced as an assembly if fretting damage is visible on either piece.

Inspect for cracks and damage around the capscrew holes.

Inspect the rods and caps for damage.

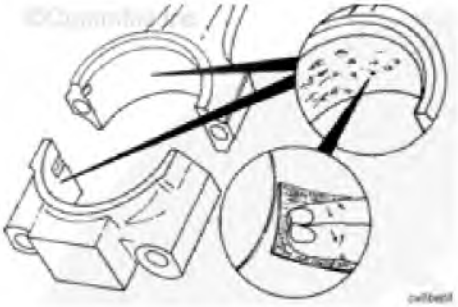
Replace the rod and cap if either the I beam or cap is nicked or damaged.



Visually inspect the rod pin bore bushing for damage or misalignment of the oil hole passage and bushing.

If the bushing is damaged the rod **must** be replaced.

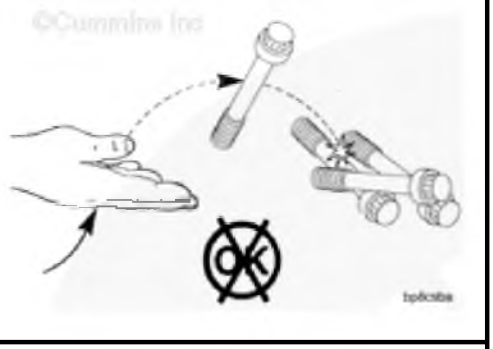
Visually inspect the bearing surface for nicks or burrs. If it is **not** possible to remove any nicks or burrs with a fine crocus cloth, the rod **must** be replaced.



BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

CAUTION

Prevent damage to the capscrews. Nicks in the body of the capscrew can cause an area of stress that can fail during engine operation. Damage to the threads will cause torque values to be incorrect and will damage the mating parts.



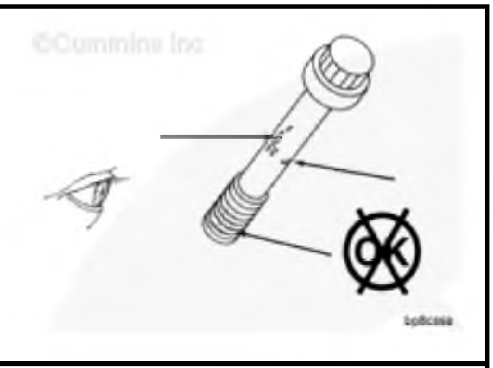
Visually inspect the capscrew.

The capscrew **must** be replaced if:

- The threads are damaged
- Rust or corrosion has caused pitting in the body
- The body is nicked, galled, bent or stretched.

NOTE: Repair of rolled threads by the use of a thread die is not recommended. The thread die can create a sharp corner on the minor diameter (root) of the threads. This sharp corner can cause an area of increased stress.

Magnetic crack inspect the connecting rod capscrews. Connecting rod capscrews **must** be magnetic crack inspected. Refer to Procedure 017-001.

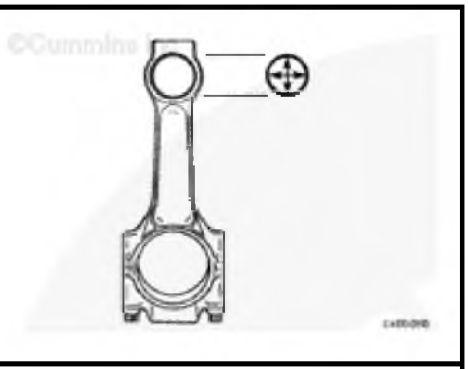


Measure

Measure the connecting rod bushing inside diameter.

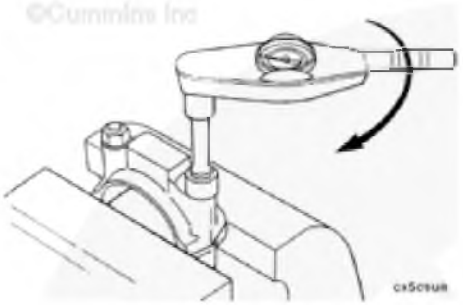
Connecting Rod Bushing I.D.		
mm		in
68.030	MIN	2.678
68.049	MAX	2.679

NOTE: The bushing is not replaceable without remanufacturing. If the bushing is not within specification the connecting rod must be replaced.



CAUTION

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



CAUTION

The number on the connecting rod **must** be the same number as the number on the rod cap.
NEVER assemble a new cap to an old rod or an old cap to a new rod.

NOTE: Check the number of punch marks on the head of the mounting capscrews. If there already 4 punch marks, do not reuse the capscrew, replace it with a new part.

Use clean engine oil. Lubricate the connecting rod capscrews.

Assemble the connecting rod, the cap and the capscrews.

NOTE: Always use the torque-turn method to tighten the connecting rod capscrews when access permits.

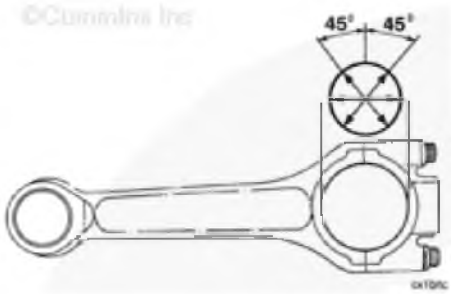
Tighten the capscrews alternately and evenly to pull the cap over the dowel pins. Use the following steps and sequence to tighten the capscrews:

Torque Value:	Step 1	196 n.m [145 ft-lb]
	Step 2	Turn 90 degrees

NOTE: After tightening the capscrews make 1 punch mark on the head of each capscrew. Do not make a punch mark when using a new capscrew.

Use a dial bore indicator. Measure the I.D. using the measuring positions shown.

Connecting Rod Bearing Bore I.D.		
mm		in
115.000	MIN	4.5276
115.026	MAX	4.5286



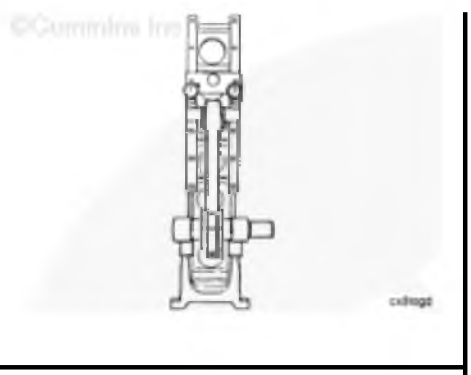
NOTE: If the measurements are not within specification the rod must be replaced or repaired.

Bend and Twist Inspect

Required tools:

- Part No. ST-561 Connecting Rod Checking Fixture
- Part No. ST—1331 Connecting Rod Location Mandrel (for crank pin end of rod)
- Part No. 3165106 Connecting Rod locating mandrel (for piston rod end with bushing **installed**)

Bulletin No. 3377541, Service Tool Instructions - Connecting Rod Checking, is also available.



Calibration Procedure

CAUTION

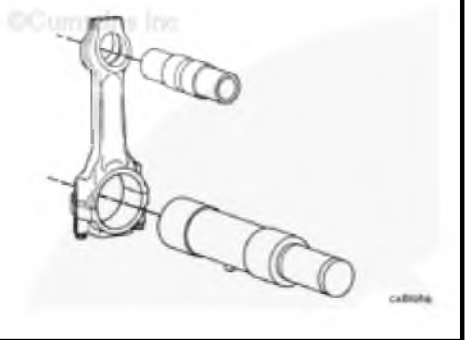
The rod **must** be installed and torqued to specification or the measurement will be incorrect.

A connecting rod of known length, bend and twist, called a **reference** rod, is required to calibrate the fixture. A **new** connecting rod with a known distance from centre of the crank pin to the centre of the piston pin end (rod length), can also be used.

Install the appropriate connecting rod mandrel into the reference connecting rod piston pin bore and center the mandrel.

Install the appropriate connecting rod mandrel into the reference connecting rod crankshaft bore.

NOTE: Make sure that the locating pin on the mandrel is down and centered in the connecting rod.



Lock the mandrel in position by rotating the end of the mandrel.

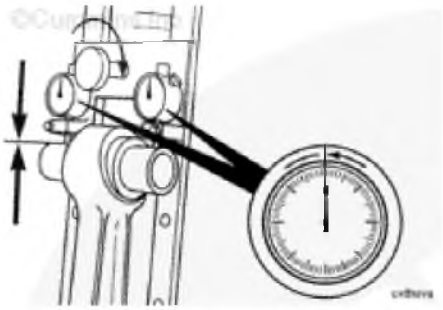
Install the **reference** connecting rod in the cranking fixture.

Loosen the knob and move the indicator bracket until both indicators touch the top of the piston pin end mandrel.

Move the bracket toward the mandrel until the indicator needles have moved approximately 0.25 mm (0.010 in].

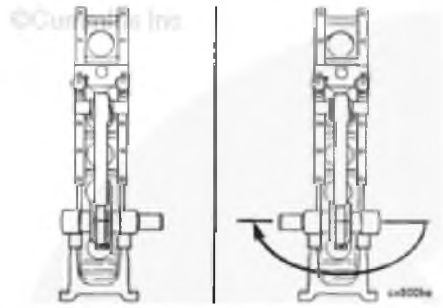
Turn the knob to tighten the bracket.

Adjust the indicator needles to "0". Move the connecting rod **in** and **out** to confirm the "0" setting.



Remove the **reference** connecting rod from the fixture.

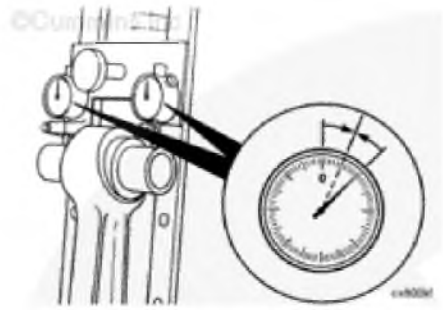
Rotate the connecting rod 180 degrees **horizontally** and install it in the checking fixture.



Be sure the indicators are "0" setting.

If the indicator needles do **not** return to the "0", adjust the indicator so that the "0" moves ½ of the indicated difference from the needle to the "0" established during the previous step.

NOTE: If the needle is more than 0.10 mm [0.004 in] from the "0" established during the previous step, check for dirt or burrs on the mandrels and fixture. If



the "0" is still not within specification, check to be sure that the reference connecting rod is not damaged.

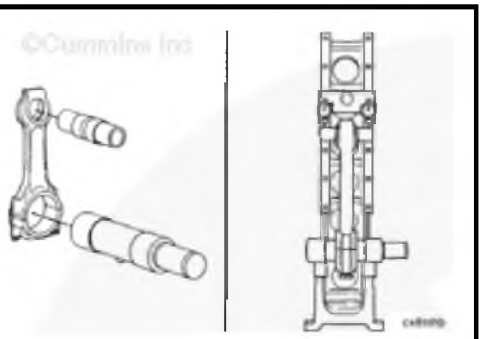
CAUTION

Do **not** adjust the indicators during this step of the procedure or the measurement will be incorrect.

After completing the calibration of the fixture, remove the **reference** connecting rod.

Repeat the same steps to install the mandrels in the connecting rod to be measured, as you did for the **reference** rod.

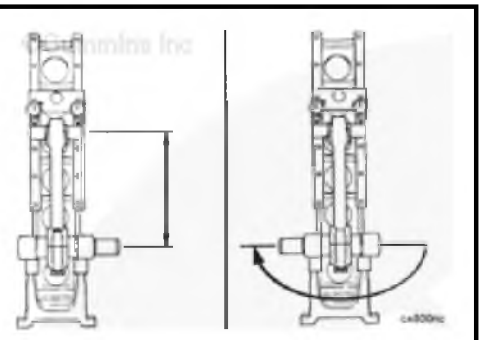
Install the rod to be measured into the fixture.



Record the indicator reading. The difference of the calibrated "0" of the indicator **must** be added or subtracted from the known length of the **reference** rod to determine the length of the connecting rod being measured.

Connecting Rod Length		
mm		in
304.950	MIN	12.006
305.000	MAX	12.008

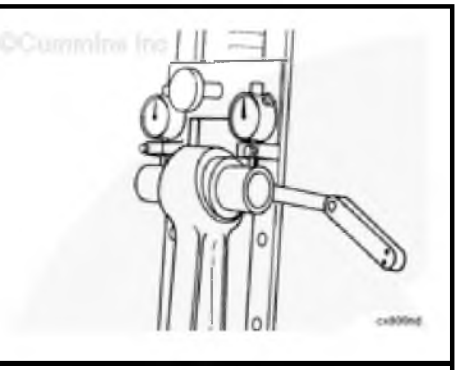
If the connecting rod length is **not** within specification, the connecting rod **must** be replaced.



Make a note of the indicator readings.

Remove the rod from the fixture. Turn the rod 180 degrees horizontally.

Compare the indicator readings with those noted in the previous step. The difference between the indicator readings is the amount of **bend** in the connecting rod.



Maximum Connecting Rod Bend (Bushing Installed)		
mm		in
0.10	MAX	0.004

If the connecting rod bend is **not** within specification, the connecting rod **must** be replaced.

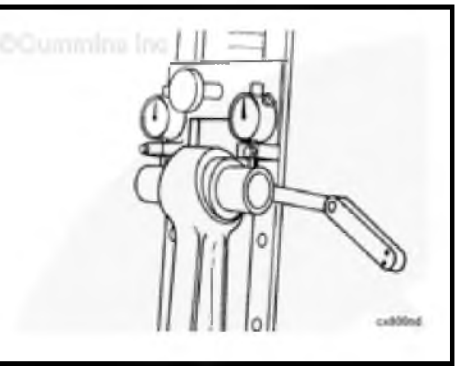
CAUTION

Never attempt to straighten a connecting rod with the use of heat or force. The connecting rod could eventually break and cause extensive engine damage.

Check the fixture and mandrel in the piston pin end for a gap between the two. If there is any twist in the connecting rod, the mandrel will **only** touch one side of the fixture.

Hold the end of the mandrel that is touching the fixture **firmly** against the fixture.

Use a feeler gauge to measure the gap between the mandrel and the fixture. the amount of gap between the mandrel and



the fixture is the amount of connection rod twist.

Maximum Connecting Rod Twist (Bushing Installed)		
mm		in
0.25	MAX	0.010

If the connecting rod twist is **not** within specification, the connecting rod **must** be replaced.

CAUTION

Never attempt to straighten a connecting rod with the use of heat or force. The connecting rod could eventually break and cause extensive engine damage.

Magnetic Crack Inspect

Use a magnetic particle testing machine.

The connecting rod and cap **must** be assembled during this check.

Use the residual method. Apply head shot amperage. Adjust the amperage to 1500 ampere D.C. or rectified A.C.

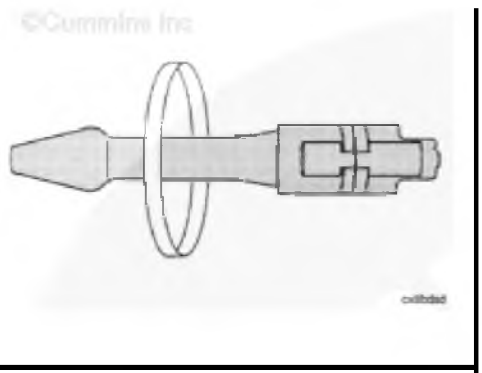
Check for cracks.

Use the residual method. Apply coil shot

amperage. Check for cracks.

Amperage (Ampere Turns)	
MIN	2600 D.C. or Rectified A.C.
MAX	2800 D.C. or Rectified A.C.

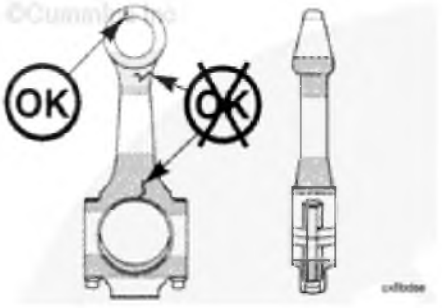
NOTE: Ampere turn is an electrical current of one ampere flowing through the coil, multiplied by the number of turns in the coil.



The connecting rod **must** be replaced if any indications are visible in the **critical** (shaded) areas.

CAUTION

The rod **must** be demagnetized completely and cleaned thoroughly. Any small metal particles will cause engine damage.



Demagnetize the connecting rod.

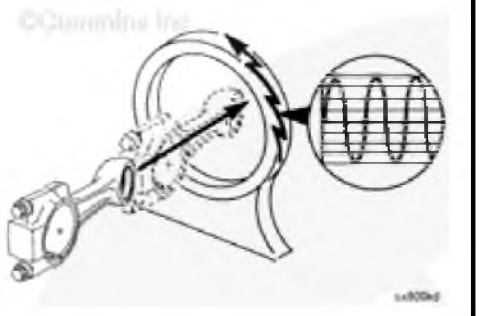
Use solvent or steam. Clean the part.

WARNING

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. 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 and protective clothing to reduce the possibility of personal injury.

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001-016 Crankshaft

Preparatory Steps

WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Drain the engine lubricating oil. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Remove the engine and place on an engine stand. Refer to Procedure 000-001 in Section 0.
- Remove the flywheel. Refer to Procedure 016-005 in Section 16.
- Remove the flywheel housing. Refer to Procedure 016-006 in Section 16.
- Remove the front gear cover. Refer to Procedure 001-031 in Section 1.
- Remove the connecting rod bearing caps. Refer to Procedure 001-054 in

Section 1.

- Remove the main bearing caps. Refer to Procedure 001-006 in Section 1.
- Remove the thrust bearings. Refer to Procedure 001-007 in Section 1.

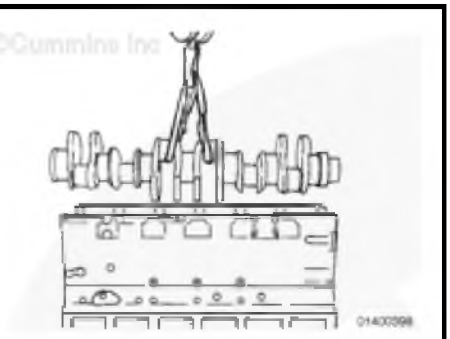
Remove

WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Support the weight of the crankshaft with a hoist or lifting device.

Remove the crankshaft.



Clean and Inspect for Reuse

WARNING

When using solvents, acids or alkaline materials for cleaning, follow the

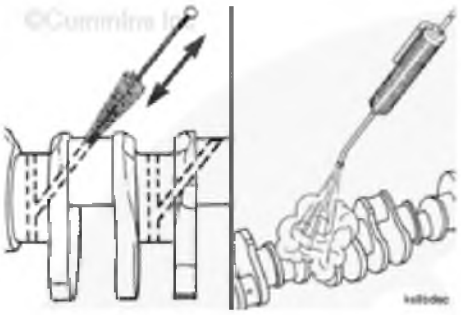
manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

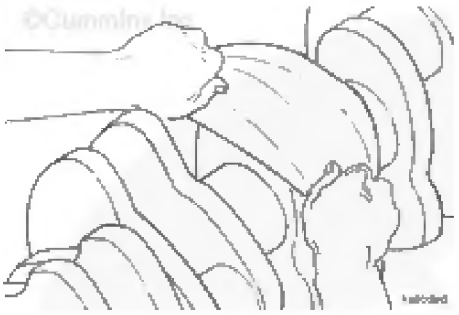
Clean the crankshaft with solvent and dry with compressed air.

Inspect the crankshaft for nicks or scratches. If a mark can **not** be felt with the fingernail, there is no value in polishing the crankshaft.



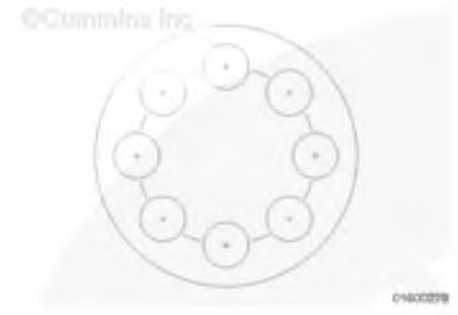
Use a Scotch-Brite™ 7448 abrasive pad, Part Number 3823258, or equivalent, to remove discoloration or light scratches from the machined surfaces.

The crankshaft **must** be cleaned again if this polishing is performed.



WARNING

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



WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Do not use a thread chaser to clean the capscrew threads in the crankshaft. Severe engine damage can result.

The QSK23 uses rolled capscrew threads in the bolt holes in the nose of the crankshaft.

To clean the ROLLED threads, flush with solvent, and dry with compressed air.

If additional cleaning is required, brush with a nylon bristle brush.

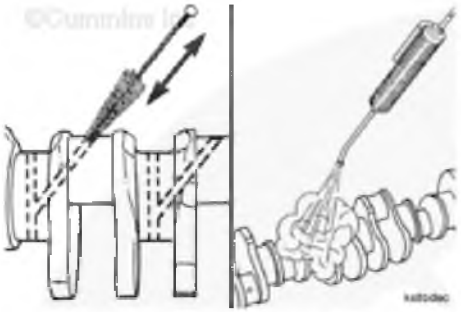
Place tape over the threaded capscrew holes.

WARNING

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

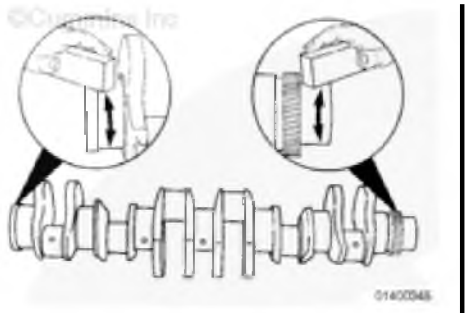
Use a bristle brush and solvent to clean all of the crankshaft oil drillings.

Use a light preservative oil to lubricate the crankshaft to prevent the formation of rust.



WARNING

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

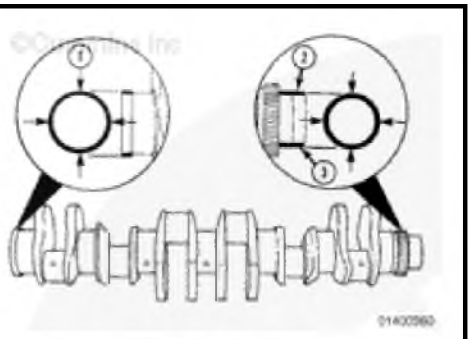


NOTE: New crankshafts are coated with a heavy preservative. Use solvent to thoroughly remove the coating. Brush or flush the packing debris from the oil drillings before installing the crankshaft into the engine.

Use a honing stone to polish the outside diameter of the front and rear oil seal locations, the flywheel mounting location, and the vibration damper location. Remove all small scratches and grooves.

NOTE: Use a light preservative oil to prevent rust during engine rebuild. If the crankshaft is not going to be installed immediately, use a heavy preservative oil.

Measure the outside diameter at the locations shown



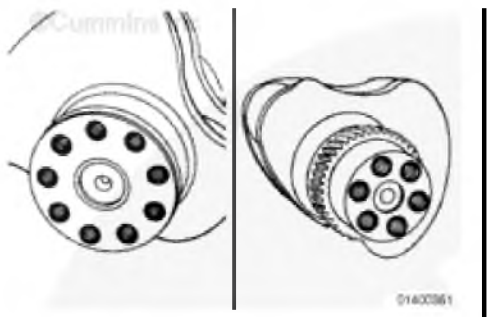
Crankshaft Outside Diameter

	mm		in
Location (1)	111.075	MIN	4.3730
	111.125	MAX	4.3750
Location (2)	170.481	MIN	6.7119
	170.519	MAX	6.7133
Location (3)	169.981	MIN	6.6922
	170.019	MAX	6.6937

CAUTION

Do not chase threads on the crankshaft. Severe engine damage can occur.

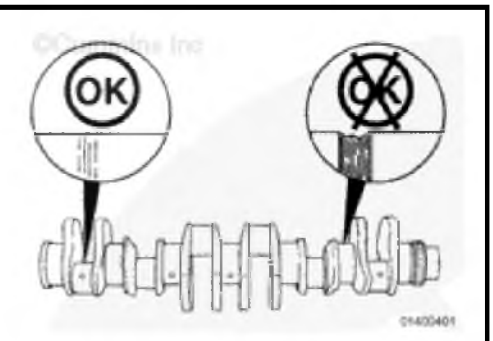
Check the threads for damage at both ends of the crankshaft.



Check the main bearing journals and rod bearing journals for damage or excessive wear. Minor scratches are acceptable.

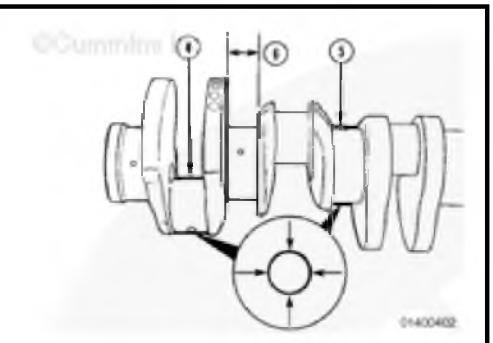
If a fingernail is caught in the scratch, the crankshaft **must** be replaced or machined.

If the main or rod journals are machined, mark the number 1 counterweight with the amount of material removed. If the crankshaft thrust flanges are machined, mark the adjacent counterweight with the amount of material removed.



Measure the outside diameter.

Rod Bearing Journal Outside Diameter (4)			
	mm		**in**
Standard	107.910	MIN	4.2484
	108.000	MAX	4.2520
Undersize 0.25 mm [0.010 in]	107.660	MIN	4.2384
	107.750	MAX	4.2420
Undersize 0.50 mm [0.020 in]	107.410	MIN	4.2284
	107.500	MAX	4.2320
Undersize 0.75 mm [0.030	107.160	MIN	4.2184



in]	107.250	MAX	4.2220
Undersize 1.00 mm [0.040 in]	106.910	MIN	4.2084
	107.000	MAX	4.2120

Main Bearing Journal Outside Diameter (5)			
	mm		**in**
Standard	139.910	MIN	5.5083
	140.000	MAX	5.5118
Undersize 0.25 mm [0.010 in]	139.660	MIN	5.4984
	139.750	MAX	5.5020
Undersize 0.50 mm [0.020 in]	139.410	MIN	5.4886
	139.500	MAX	5.4921
Undersize 0.75 mm [0.030 in]	139.160	MIN	5.4787
	139.250	MAX	5.4823
Undersize 1.00 mm [0.040 in]	138.910	MIN	5.4689
	139.000	MAX	5.4724

Measure the thrust distance between the thrust faces on the number 6 main bearing journal.

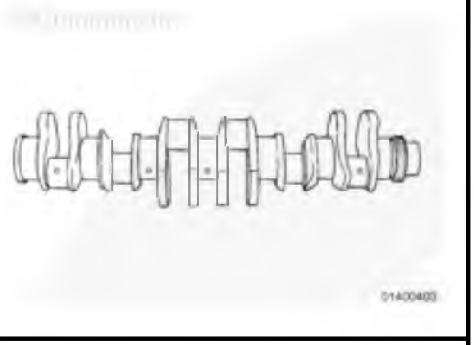
Thrust Distance (6)			
	mm		**in**
Standard	64.000	MIN	2.5197
	64.050	MAX	2.5217
Undersize 0.25 mm [0.010 in]	64.250	MIN	2.5297
	64.300	MAX	2.5317
Undersize 0.50 mm [0.020 in]	64.500	MIN	2.5397
	64.550	MAX	2.5417
Undersize 0.75 mm [0.030	64.750	MIN	2.5497
	64.800	MAX	2.5517

in]			
Undersize 1.00 mm [0.040 in]	65.000	MIN	2.5597
	65.050	MAX	2.5617

The crankshaft can be machined undersize if the outside diameter is **not** within specifications. If one of the main journals is ground undersize, **always** grind all of the main journals when one is **not** within specifications. If one of the rod journals is ground undersize **always** grind all of the rod journals when one is **not** within specifications.

Oversize main, rod, and thrust bearings are available if the crankshaft is machined undersize. Bearings that are 0.25 mm [0.010 in], 0.50 mm [0.020 in], 0.75 mm [0.030 in], and 1.00 mm [0.040 in] oversize are available.

Use a light preservative oil. Lubricate the crankshaft to prevent rust. If the crankshaft is **not** going to be used immediately, use a heavy preservative oil.



Magnetic Crack Inspect

Use a magnetic particle testing machine.

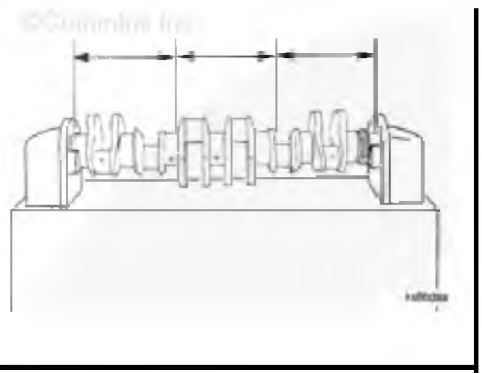
Perform the head shot and inspection method, then perform the coil shot and

inspection method.

Adjust the testing machine to 1800 ampere direct current or rectified alternating current.

Use the continuous method. Wet **only** 1/3 of the crankshaft at a time.

Check the crankshaft for cracks.



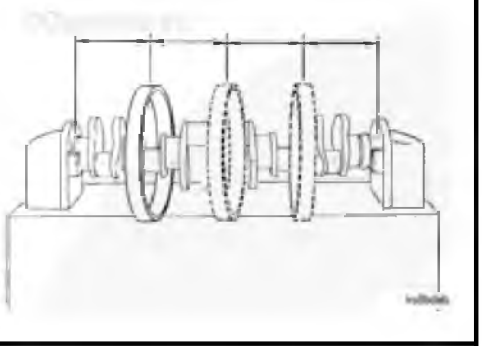
Use the coil shot method. Use a coil that is a minimum of 514 mm [20.250 in] diameter.

Use the continuous method. Apply coil shot.

Amperage (Ampere Turns)	
Minimum	Maximum
4500 direct current or rectified alternating current	5000 direct current or rectified alternating current

Ampere turns is an electrical current of one ampere flowing through the coil, multiplied by the number of turns in the coil.

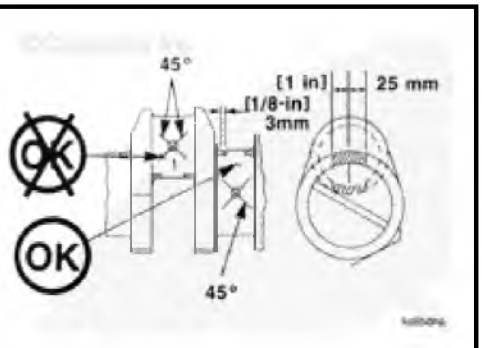
Check the crankshaft for cracks.



An open indication is visible after the wetting operation has been completed. An indication below the surface is **not** visible after the wetting operation has been completed. An indication below the surface can be seen with the use of the ultraviolet light.

Limits of Acceptance - Open Indications

Do **not** use the crankshaft if:

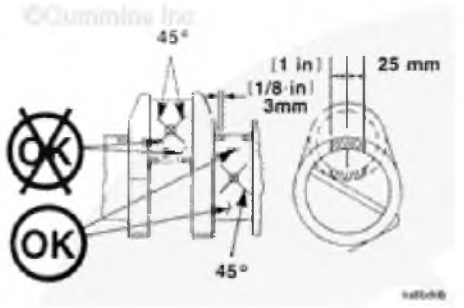


- There is an indication in the fillet or in the shaded area.
- There is an indication that passes through the 45 degree diagonal from the oil hole or goes into the oil hole chamfer.
- There is an indication that is longer than 6 mm [0.250 in].
- There are more than four indications on one journal.

Do **not** use the crankshaft if:

Limits of Acceptance - Indications Below the Surface

- There is an indication in the fillet or in the shaded area that is in a circumferential direction.
- There is an indication in a circumferential direction that is longer than 25.4 mm [1.0 in].
- There is an indication in an axial direction that is longer than 9.5 mm [0.375 in].
- There is an indication that is closer than 1.5 mm [0.063 in] to an oil hole chamfer.
- There is an indication that passes through the 45 degree diagonal from the oil hole.

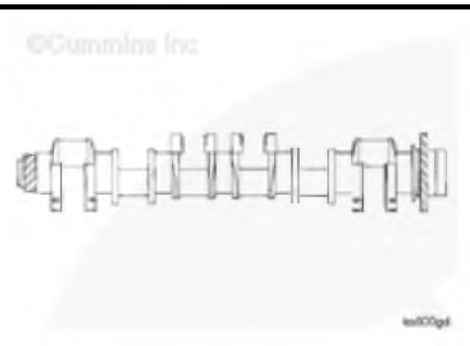


WARNING

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

CAUTION

The crankshaft must be demagnetized



completely and cleaned thoroughly. Small metal particles will cause engine damage.

Use steam to clean the crankshaft and oil drillings.

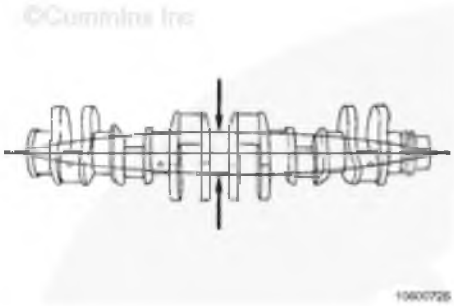
Use a light preservative oil to lubricate the crankshaft to prevent the formation of rust.

Use a heavy preservative oil if the crankshaft is **not** going to be installed immediately. Protect the part with a cover to prevent dirt from sticking to the oil.

Bend and Twist Inspect

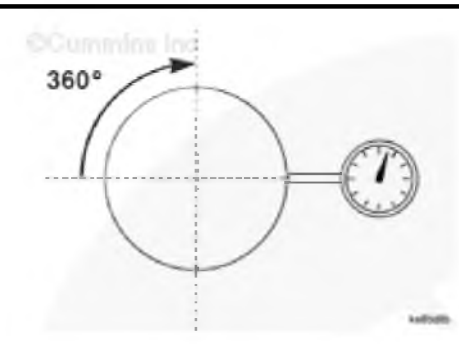
The crankshaft straightness is determined by the amount of total runout and the adjacent journal runout.

Total runout is defined as the total indicator runout measured at the middle bearing journal, when the crankshaft is supported on the two end journals. Total runout is often referred to as the bend or full length alignment.



Journal runout is defined as the total indicator runout (total sweep of the needle) of the main bearing journals, when the crankshaft is rotated one complete revolution (360 degrees).

Adjacent journal runout is defined as the relationship of the total indicator runout of a main bearing journal, as it is rotated on a

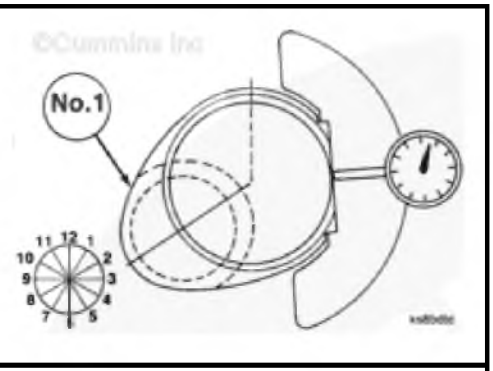


common axis, to the total indicator runout of an adjacent journal.

Adjacent runout is often referred to as step runout, bearing-to-bearing runout, or journal-to-journal runout.

The clock position is defined as the location of the journal at the highest total indicator runout point. Compare its angular relationship with the number one crankshaft pin as viewed from the front of the crankshaft.

In the illustration, the crankshaft pin is at the 8 o'clock position. This is the clock position of the journal being measured.

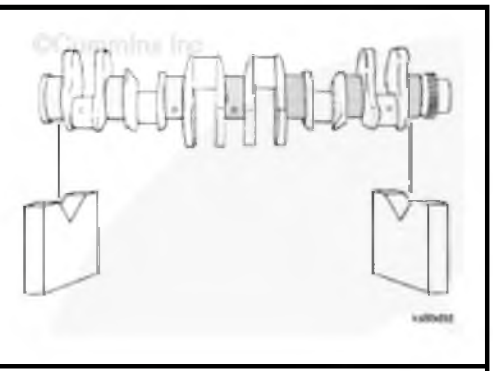


WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

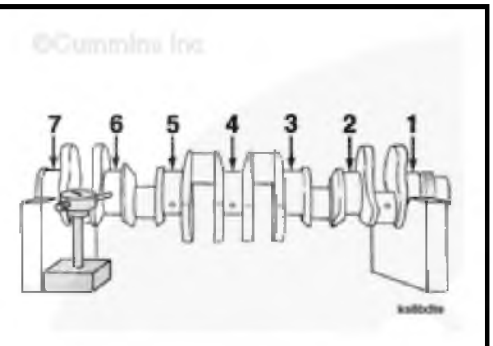
Place two v-blocks on a flat surface.

Support the crankshaft on the v-blocks at the two end bearing journals.

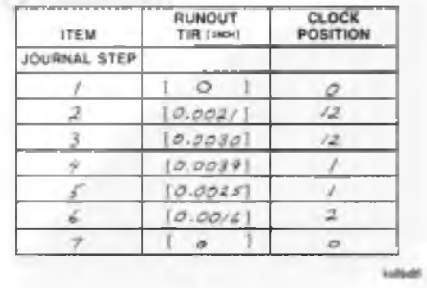


Position a dial indicator so the stem touches the center line of the main bearing journal.

The dial indicator **must** be positioned at the centerline of any journal that is measured (1) through (7).



Rotate the crankshaft and measure the total indicator run out at each bearing journal. Record the value and the clock position for each location.



ITEM	RUNOUT TIR (INCH)	CLOCK POSITION
JOURNAL STEP		
1	[0]	0
2	[0.0021]	12
3	[0.0030]	12
4	[0.0039]	1
5	[0.0025]	1
6	[0.0016]	2
7	[0]	0

A fully fillet hardened crankshaft **must** be discarded if the total runout is **not** within specifications.

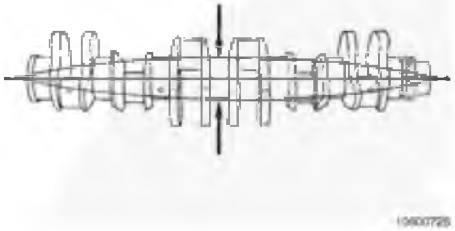
Position the dial indicator stem to the center main bearing journal.

Rotate the crankshaft a complete revolution.

Crankshaft Total Runout

mm		in
0.150	MAX	0.006

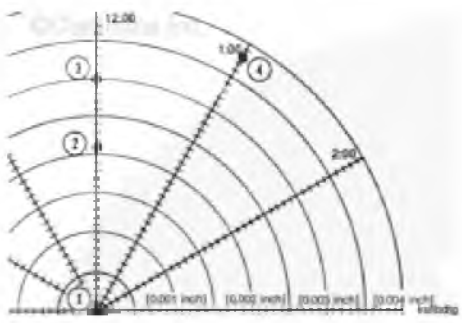
If the crankshaft is **not** within specifications. The crankshaft **must** be replaced.



For each journal, plot the total indicator runout value at its clock position illustrated on the polar chart.

The end journals, supported by v-blocks, **must** be plotted at the center of the chart.

The graphic illustrates the plot points.



Journal	Total Indicator Run Out	Clock Position

(1)	0	0
(2)	0.002	12
(3)	0.003	12
(4)	0.004	1

Draw a straight line between the plotted points. From journal number one to journal number two from journal number two to journal number three until all journals are plotted on the chart.

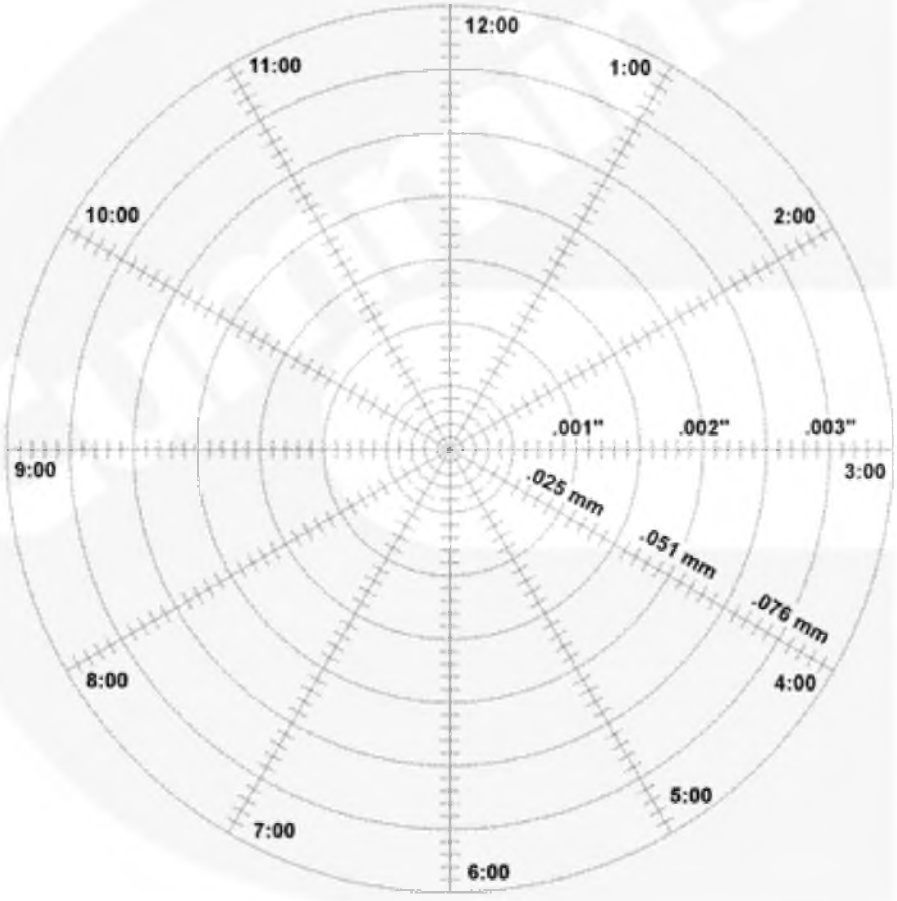
To determine the adjacent journal runout, measure the length of the line from each journal to its corresponding journal point.

In the above table journal number three and number four are 5.1 mm [2 in]. This represents a runout of 0.051 mm [0.002 in].

Record the adjacent journal runout for each main bearing journal.

The maximum adjacent journal runout is 0.070 mm [0.0028 in].

If the crankshaft is **not** within specifications, the crankshaft **must** be replaced.



Polar Chart

Install

WARNING

This component or assembly weighs

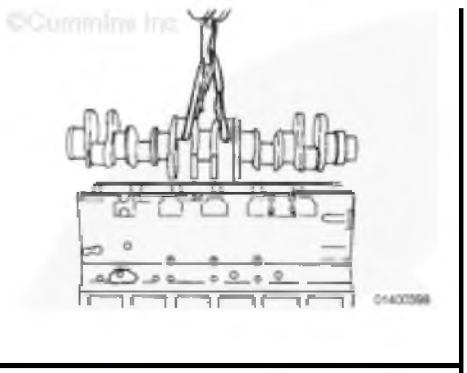
greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

CAUTION

Use a lifting strap that will not damage the crankshaft. Do not drop the crankshaft on the bearings.

Use a lint-free cloth to clean the crankshaft bearing journals.

The end of the crankshaft with the smallest diameter **must** point toward the front of the block. Install the crankshaft.



Finishing Steps

WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To

reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

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

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Install the thrust bearings. Refer to Procedure 001-007 in Section 1.
- Install the main bearing caps. Refer to Procedure 001-006 in Section 1.
- Install the connecting rod bearing caps. Refer to Procedure 001-054 in Section 1.
- Install the front gear cover. Refer to Procedure 001-031 in Section 1.
- Install the flywheel housing. Refer to Procedure 016-006 in Section 16.
- Install the flywheel. Refer to Procedure 016-005 in Section 16.
- Install the engine. Refer to Procedure 000-001 in Section 0.
- Install the block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Install the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Fill the engine with coolant. Refer to Procedure 008-018 in Section 8.
- Fill the engine with lubricating oil. Refer to Procedure 007-037 in Section 7.
- Connect the batteries. Refer to

Procedure 013-009 in Section 13.

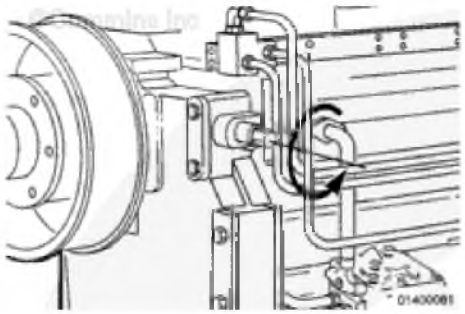
Start the engine and check for leaks.

Rotation Check

To rotate the engine crankshaft, push in on the engine barring device and rotate **counterclockwise**.

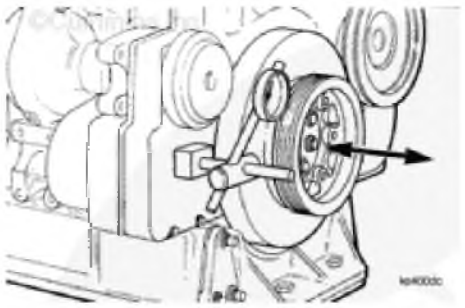
Rotate the crankshaft through two complete revolutions.

If the engine does **not** turn freely, the equipment can have a malfunction. Refer to the equipment manufacturer's instructions. The engine can have internal problems. Refer to the relevant procedure for inspection and replacement of internal engine components.



CAUTION

Extreme care must be used in prying against the viscous vibration damper. Sharp pry bars can damage the damper casing, resulting in a leak of the viscous vibration damper fluid and ultimate failure of the vibration damper.



Measure the crankshaft end clearance with a dial indicator.

Measure the end clearance. Refer to Procedure 001-006 in Section 1.

The check can be made by attaching a dial indicator resting against the vibration damper or pulley while prying against the front cover and inner part of the pulley or vibration damper. End clearance **must** be in specification with the engine mounted in the unit and assembled to the transmission or converter. If the clearance is **not** within specifications, oversize bearings or machining the crankshaft thrust flanges may be required..		

Last Modified: 19-Dec-2011

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001-018 Crankshaft Gear, Front (Crankshaft Installed)

Preparatory Steps

- Remove the alternator drive belt. Refer to Procedure 013-005.
- Remove the alternator. Refer to Procedure 013-001.
- Remove the alternator drive gear and shaft. Refer to Procedure 009-009.
- Remove the cooling fan drive belt. Refer to Procedure 008-002.
- Remove the fan hub idler arm assembly. Refer to Procedure 008-002.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the gear cover and all related components. Refer to Procedure 001-031.
- Remove both front idler gears. Refer to Procedures 001-097 and 001-098.

Remove

CAUTION

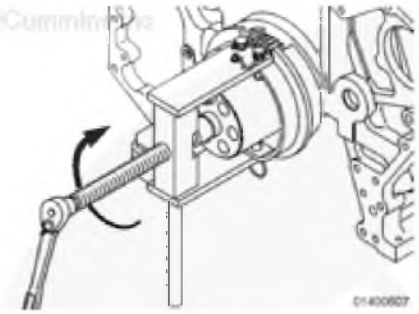
Heat can be used to aid the removal of the gear. Do not use a cutting torch. The high temperature of a torch will damage the teeth of the gear.

CAUTION

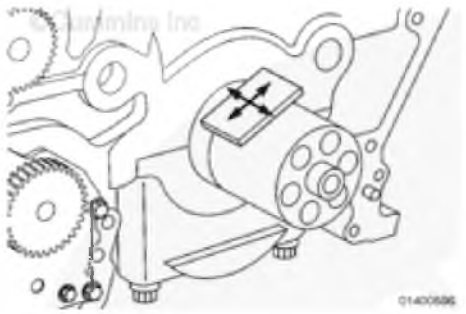
Do not exceed 475 N•m [350 ft-lb] of torque when turning the jackscrew.

Only remove the gear when the crankshaft or the gear is damaged.

Use a puller jaw, Part Number 3375835, and bridge assembly, Part Number 3165049, or equivalent, to remove the gear.



Use a hone stone to polish the shaft outside diameter. Remove all of the small scratches, burrs, and small grooves.

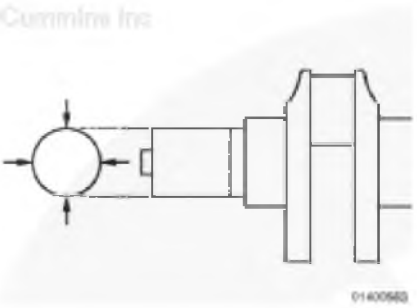


Inspect for Reuse

Clean and inspect the crankshaft for reuse. Measure the outside diameter.

Crankshaft Outside Diameter (Gear Location) Front

mm		in
112.15	MIN	4.416
112.13	MAX	4.415



Install

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

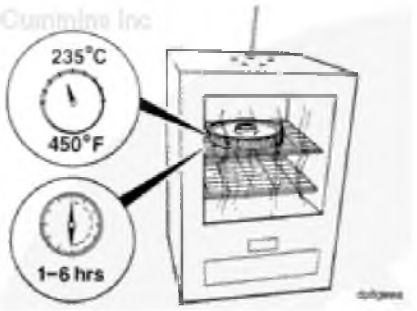
CAUTION

Do not exceed the specified time or the temperature. Damage to the gear and the gear teeth will result.

CAUTION

Do not attempt to install the gear without using heat.

Use an oven and adjust the heat to 235°C [450°F]. Heat the gear for a minimum of one hour, but **not** more than six hours. The inside diameter of the gear will become larger and will simplify installation.



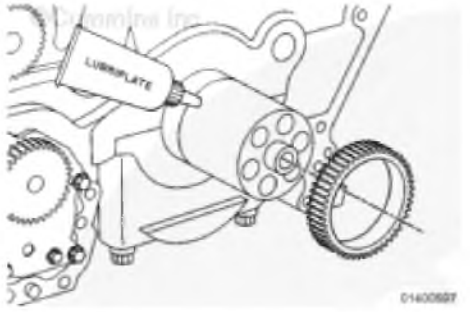
WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

CAUTION

Allow the gear to air cool slowly. Do not use water or oil to reduce the cooling time. This will cause the gear to crack.

Lubricate the outside diameter of the crankshaft with Lubriplate™ 105, or equivalent. Remove the gear from the oven and install it on the crankshaft.



Finishing Steps

- Install both front idler gears. Refer to Procedures 001-097 and 001-098.
- Install the gear cover and all related components. Refer to Procedure 001-031.
- Install the alternator drive gear and shaft. Refer to Procedure 009-009.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator drive belt. Refer to Procedure 013-005.
- Install the fan hub idler arm assembly. Refer to Procedure 008-002.
- Install the vibration damper. Refer to Procedure 001-052.

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

Last Modified: 28-Jul-2003

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001-020 Crankshaft Gear, Rear (Crankshaft Installed)

Preparatory Steps

WARNING

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

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

- Remove the transmission, clutch, and all related components. Refer to the equipment manufacturer's

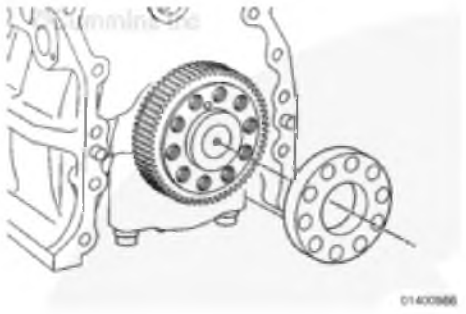
instructions.

- Remove the starter motor. Refer to Procedure 013-020.
- Drain the lubricating oil. Refer to Procedure 007-037.
- Remove the lubricating oil pan. Refer to Procedure 007-025.
- Remove the block stiffener plate. Refer to Procedure 001-089.
- Remove the flywheel. Refer to Procedure 016-005.
- Remove the flywheel housing. Refer to Procedure 016-006.
- Remove the camshaft idler gear. Refer to Procedure 001-036.

Remove

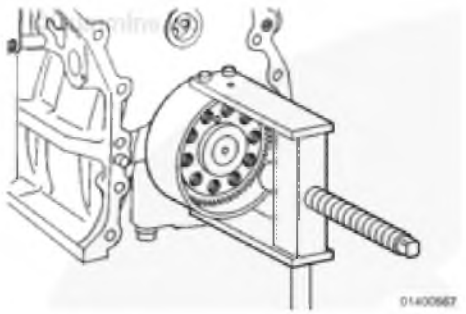
Remove the spacer from the rear of the crankshaft.

NOTE: If spacer can not be removed easily, proceed to removing the gear. The spacer should come off when pulling the gear.



Only remove the gear when the crankshaft or gear is damaged.

Use a puller jaw, Part Number 3375835, and bridge assembly, Part Number 3165049, to remove the gear.



CAUTION

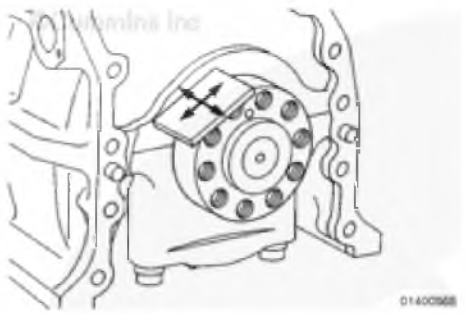
Heat can be used to aid the removal of the gear. Do not use a cutting torch. The high temperature of a torch will damage the teeth of the gear.

CAUTION

Do not exceed 475 N•m [350 ft-lb] of torque when turning the jackscrew.

Use a hone stone and polish the crankshaft outside diameter. Remove all of the small scratches, burrs, and small grooves.

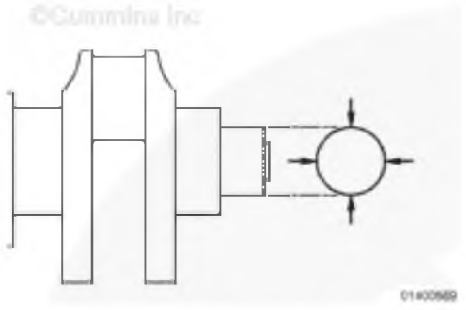
Use care **not** to damage the crankshaft keyway.



Inspect for Reuse

Clean and inspect the crankshaft for reuse. Measure the outside diameter.

Crankshaft Outside Diameter (Gear Location)		
mm		in
169.98	MIN	6.692
170.02	MAX	6.694



Install

WARNING

Wear protective clothing to reduce the possibility of personal injury from burns.

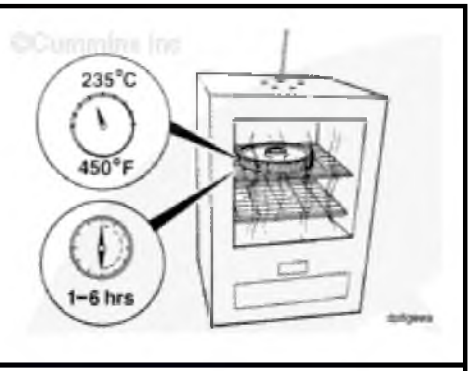
CAUTION

Do not exceed the specified time or the temperature. Damage to the gear and gear teeth will result.

CAUTION

Do not attempt to install the gear without using heat.

Use an oven and adjust the heat to 235°C [450°F]. Heat the gear for a minimum of 1 hour, but **not** more than a maximum of 6 hours. The inside diameter of the gear will become larger and simplify installation.

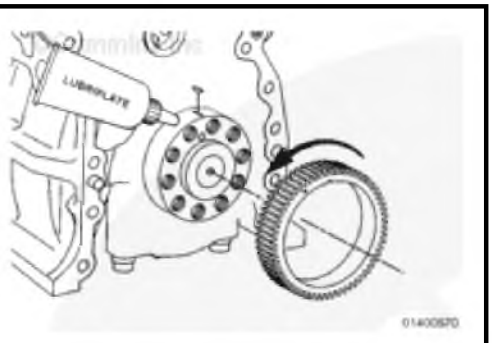


WARNING

Wear protective clothing to reduce the possibility of personal injury from burns.

CAUTION

Allow the gear to cool slowly. Do not use water or oil to reduce the cooling time. This will cause the gear to crack.



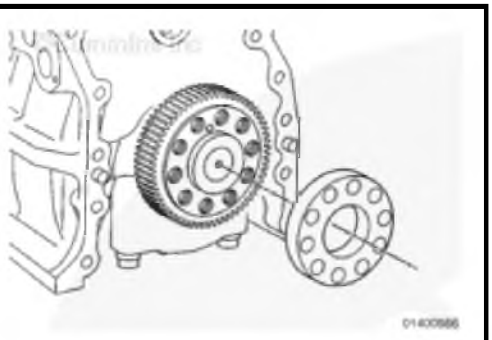
The timing mark on the crankshaft gear **must** be visible from the front of the gear after it is installed on the crankshaft.

Install a new key into the crankshaft.

Lubricate the outside diameter of the crankshaft with Lubriplate™ Number 105, or equivalent. Remove the gear from the oven and install it on the crankshaft.

Install the crankshaft spacer onto the rear of the crankshaft.

Use two flywheel bolts and washers to pull the spacer onto the crankshaft nose.



Finishing Steps

WARNING

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

- Install the flywheel housing. Refer to Procedure 016-006.
- Install the flywheel. Refer to Procedure 016-005.
- Install the block stiffener plate. Refer to Procedure 001-089.
- Install the lubricating oil pan. Refer

to Procedure 007-025. • Fill the lubricating oil system. Refer to Procedure 007-037 for engine oil capacity. • Install the starter motor. Refer to Procedure 013-020. • Install the camshaft idler gear. Refer to Procedure 001-036. • Install the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.		

Last Modified: 20-Jun-2003

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001-022 Crankshaft Pulley

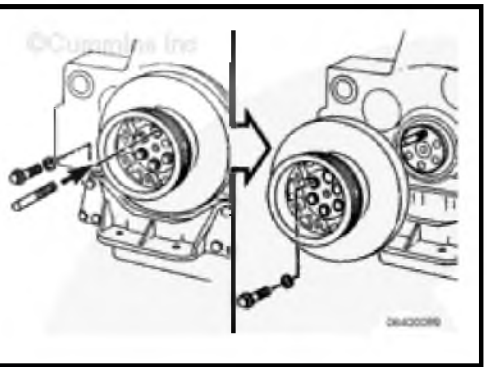
Preparatory Steps

- Remove the fan drive belt. Refer to Procedure 008-002 in Section 8.

Remove

WARNING

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



CAUTION

Do not pry or hammer on the vibration

damper or damage can occur.

Remove one capscrew and install a M22 x 1.5 guide stud.

Remove the remaining capscrews, damper, and pulley.

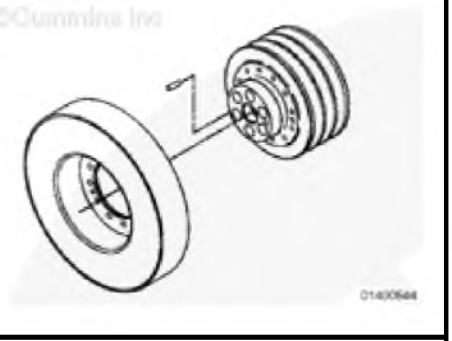
Remove the M22 x 1.5 guide stud.

Disassemble

Remove the twelve crankshaft pulley mounting capscrews.

Remove the crankshaft pulley from the vibration damper.

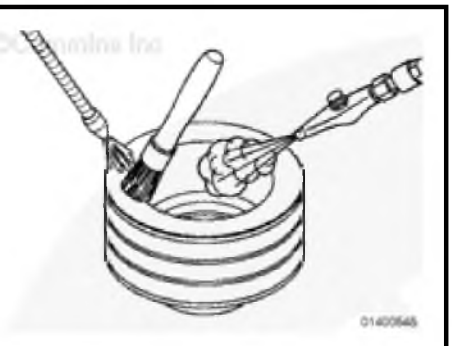
Do **not** use a hammer or a screwdriver to remove the viscous damper. These tools can damage the damper.



Clean and Inspect for Reuse

WARNING

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



personal injury.

WARNING

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

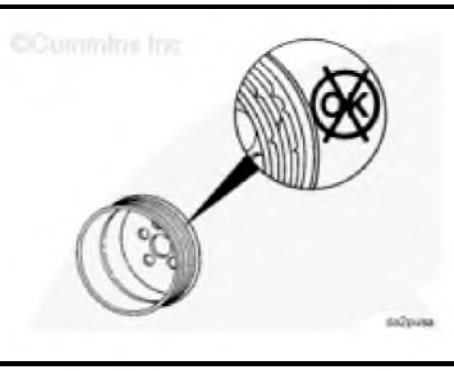
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent or steam to clean the crankshaft pulley.

Dry with compressed air.

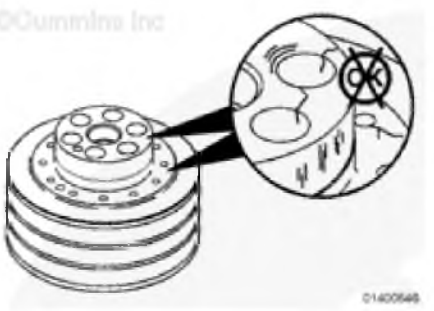
Inspect the pulley for cracks, excessive wear in the belt grooves, or other damage.



CAUTION

The mounting pilots and surfaces control the center and spacing of the pulleys. Do not repair the part by machining. It can cause an out-of-balance condition or a crankshaft failure.

Check all mounting pilots and surfaces for

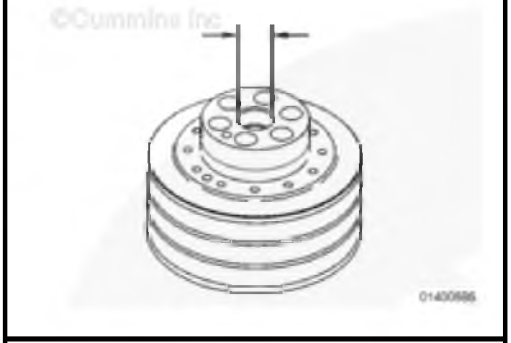


damage from fretting. If it is **not** possible to remove the damage with a 240-grit abrasive cloth, the part **must** be replaced.

Measure the inside diameter.

Pulley Inside Diameter

mm		in
36.000	MIN	4.417
36.025	MAX	4.418



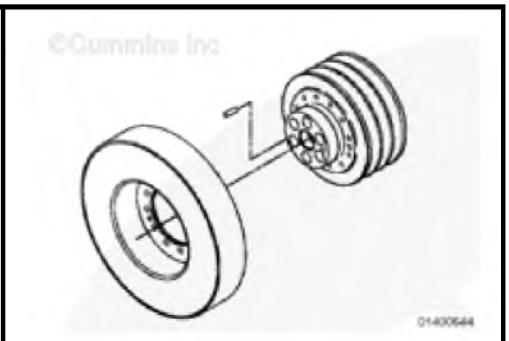
Assemble

Make sure the mating surfaces of the vibration damper and the crankshaft pulley are clean, dry, and free of burrs.

Align the dowel pin and install the crankshaft pulley onto the vibration damper.

Install the twelve capscrews that fasten the crankshaft pulley to the vibration damper.

Tighten the capscrews. Use the following procedure for crankshaft pulley mounting capscrew torque values. Refer to Procedure 001-052 in Section 1.



Install

Make sure the mounting surfaces of the crankshaft and the crankshaft pulley and vibration damper assembly are clean, dry, and free of burrs.

Install a M22 x 1.5 guide stud into the crankshaft.

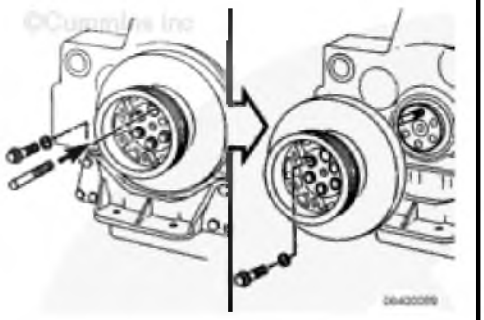
Align the dowel pin and install the crankshaft pulley and vibration damper assembly on the crankshaft.

Use clean 15W-40 oil to lubricate the capscrew threads.

Install five of the six capscrews.

Remove the M22 x 1.5 guide stud and install the sixth capscrew.

Tighten the capscrews. Use the following procedure for crankshaft pulley mounting capscrew torque values. Refer to Procedure 001-052 in Section 1.



Finishing Steps

- Install and adjust the fan drive belt. Refer to Procedure 008-002 in Section 8.

Last Modified: 28-Nov-2011

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001-023 Crankshaft Seal, Front

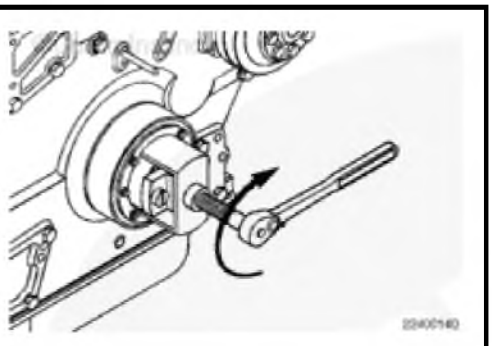
Preparatory Steps

- Remove the fan and fan spacer(s). Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the fan belt tensioner on Generator-Drive applications. Refer to Procedure 008-087.
- Remove the vibration damper and fan drive pulley. Refer to Procedure 001-052.

Remove

Use the front crankshaft seal removal tool, Part Number 3164926, or equivalent, to remove the front crankshaft seal.

NOTE: The front crankshaft seal is covered by a dust seal, drill through this dust seal and remove it with the oil seal. Discard the old dust seal and oil seal.



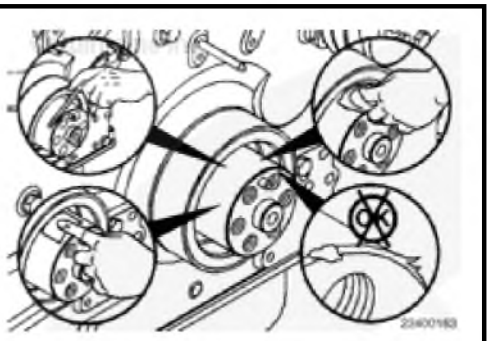
Clean and Inspect for Reuse

Use a magnet to remove any metal chips from the crankshaft and crankshaft seal bore in the front cover.

Use a crocus cloth to polish and remove deposits from the crankshaft. Visible scratches on the sealing surface can result in seal leakage.

Use a clean, lint-free cloth to clean the crankshaft and remove all traces of oil film.

Check the crankshaft end for nicks, burrs, and grooves.

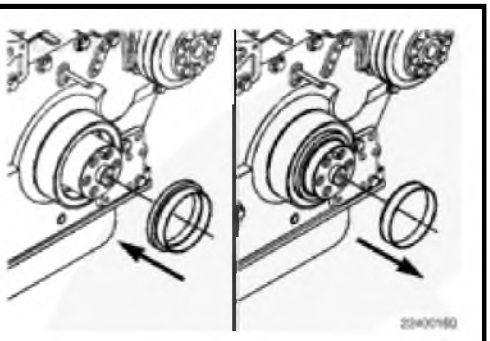


Install

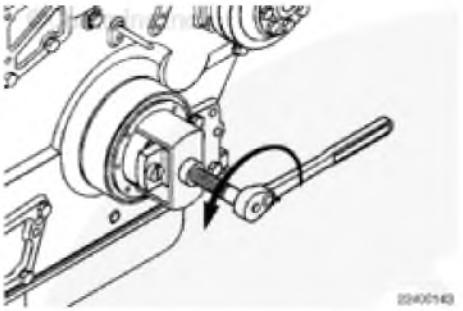
CAUTION

Do not allow oil to come in contact with other areas of the seal to reduce the possibility of damage to sealing surfaces.

Using the plastic installation sleeve, place the new seal and sleeve assembly over the crankshaft nose and slide the seal toward the front cover. Make sure the seal is positioned squarely on the crankshaft.



Remove the plastic installation sleeve.		

Use the front crankshaft seal installation tool, Part Number 3164926, or equivalent, to complete the crankshaft seal installation. Use hands or a flat piece of metal to install a new dust seal over the crankshaft seal. Push the dust seal onto the crankshaft until it just touches the crankshaft seal. Do **not** use excessive force to seat the dust seal against the crankshaft seal.		

Finishing Steps

• Install the vibration damper and fan drive pulley. Refer to Procedure 001-052. • Install the fan belt tensioner on Generator-Drive applications. Refer to Procedure 008-087. • Install the fan belt. Refer to Procedure 008-002. • Install the fan spacer(s) and fan. Refer to Procedure 008-040.		

Last Modified: 20-Jun-2003

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001-024 Crankshaft Seal, Rear

Preparatory Steps

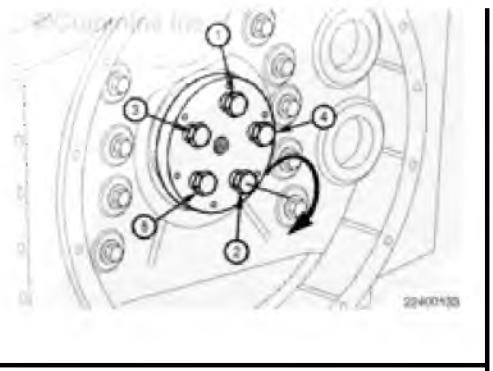
WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

- Remove the transmission, clutch, and all related components. Refer to the OEM service manual.
- Remove the engine speed sensor. Use the following procedure in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113. Refer to Procedure 019-042 in Section 19.
- Remove the flywheel. Refer to Procedure 016-005 in Section 16.

Remove

Use the flywheel mounting capscrews to install the rear crankshaft seal replacer tool, Part Number 5298540, onto the crankshaft.



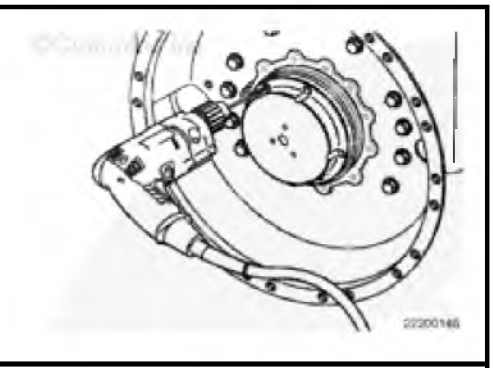
Apply grease to the drill to catch the chips.

Drill one hole through the oil seal casing, using the installer plate as a location guide.

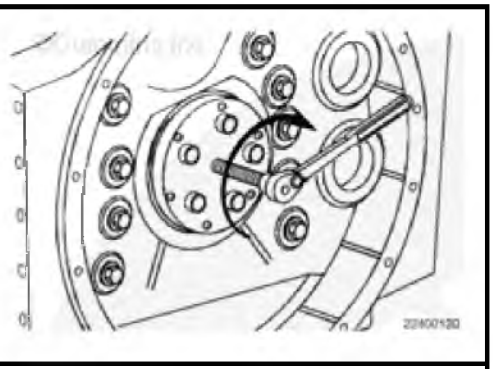
Install a self tapping metal screw and hand tighten.

Repeat the process of drilling and installing the sheet metal screws.

Six screws **must** be used in this process to make sure the seal will come out evenly.



Use the rear crankshaft seal replacer tool, Part Number 5298540, to remove the rear crankshaft seal.



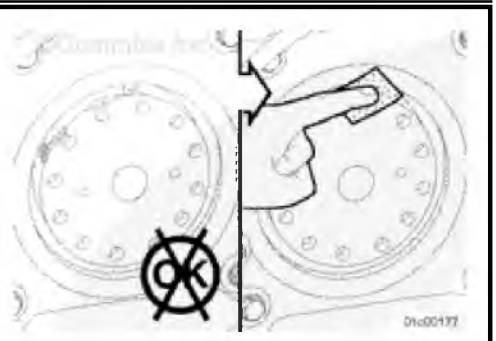
Clean and Inspect for Reuse

Use a magnet to remove any metal chips from the crankshaft and crankshaft seal bore.

Clean the crankshaft and seal mounting area.

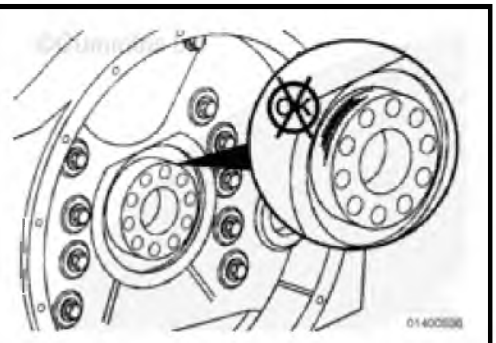
Use a crocus cloth to polish and remove deposits from the crankshaft. Visible scratches on the sealing surface can result in seal leakage.

Use a clean, lint-free cloth to clean the sealing surface of the crankshaft and remove all traces of oil film from the crankshaft.



Inspect the crankshaft end for nicks, burrs, and grooves.

If grooves on the crankshaft sealing surface exceed 10µm in depth, a wear sleeve **must** be used.



Install

If a seal/wear sleeve assembly is to be installed, attach the spacer (1) to the main tool (2) with the three provided capscrews.

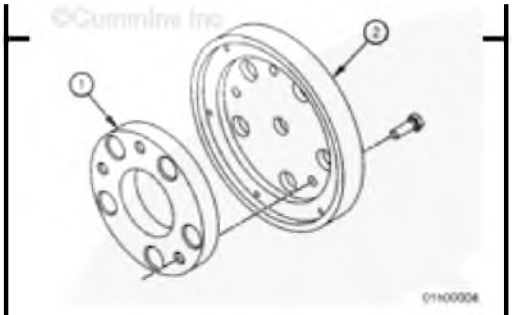
Place the seal/wear sleeve assembly on the tool and install it onto the crankshaft

with five 85 mm M22 x 1.5 capscrews.

Tighten the capscrews evenly until the wear sleeve is installed.

Remove the tool from the crankshaft and remove the spacer (1) from the main tool (2).

NOTE: Only the wear sleeve has been seated. Proceed to the next step to install the seal.

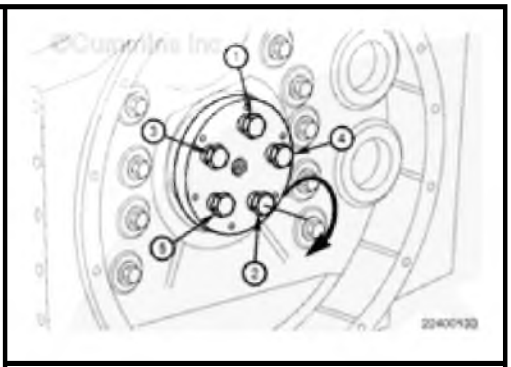


If the seal/wear sleeve assembly is already on the crankshaft, install the tool onto the crankshaft.

If the seal is **not** on the crankshaft, place the seal on the tool and install it onto the crankshaft.

Install five flywheel mounting capscrews and tighten the capscrews evenly until the tool is against the crankshaft.

Remove the tool.



Finishing Steps

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

- Install the flywheel. Refer to Procedure 016-005 in Section 16.

• Install the engine speed sensor. Use the following procedure in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113. Refer to Procedure 019-042 in Section 19. • Install the transmission, clutch, and all related components. Refer to the OEM service manual.		

Last Modified: 21-Mar-2012

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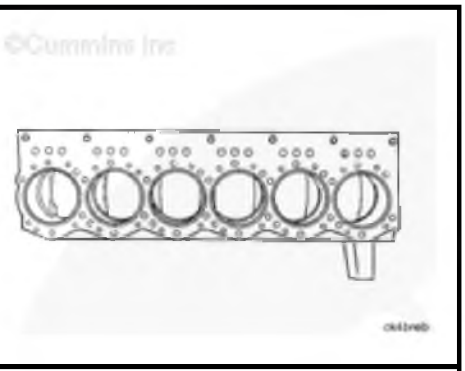
001-026 Cylinder Block

Clean

WARNING

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

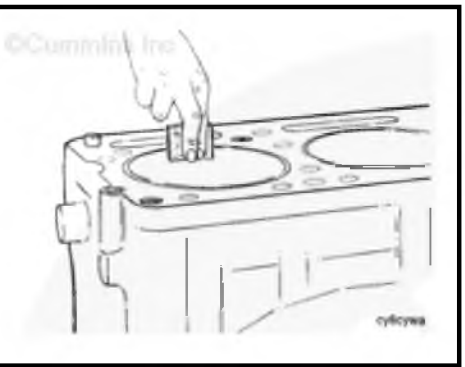
Clean the counterbore area with safety solvent.



Use a scraper or a fibrous abrasive pad such as Scotch-Brite™ 7477, or equivalent, and solvent. Clean the top deck surface of the block. Do **not** allow any dirt to get into the cylinder. The surface **must** be free of dirt, oil, and gasket material, but it does **not** have to look like new metal.

Check the top surface of the block for wear. If fretting damage is present in an area where a head gasket seal ring or a grommet makes contact, the surface **must** be repaired.

Fretting damage in any other area is acceptable **only** if it does **not** change the

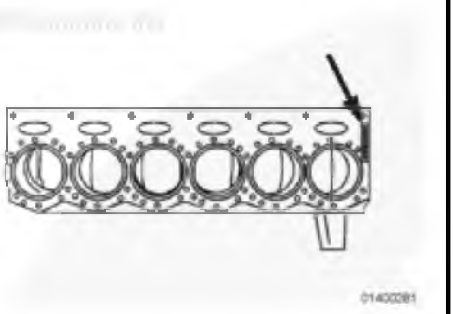


protrusion measurement of the counterbore or liner.

Inspect for Reuse

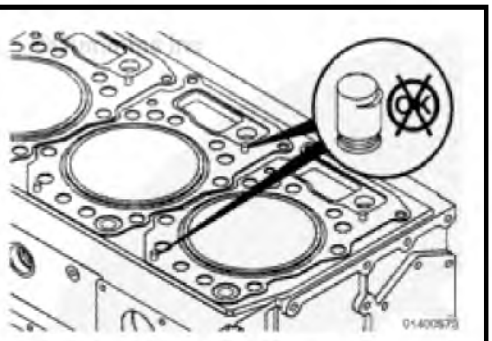
Inspect the cylinder block to determine if an oversize or standard size head gasket is required.

An oversize head gasket can be required on cylinder blocks that have had material removed from the top surface of the cylinder block. Check the cylinder block for markings indicating an oversize gasket is required.

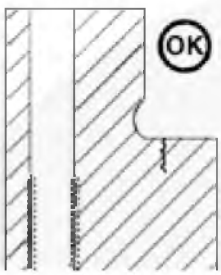


Inspect the groove pins for damage.

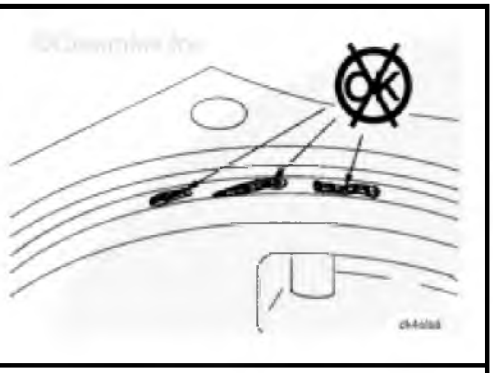
Replace damaged pins using a dowel pin extractor, Part Number 3163720.



Metallurgical analysis of cross sections of counterbores having circumferential cracks has revealed that the cracks are surface initiated on the top of the counterbore ledge, and normally do **not** propagate vertically through the counterbore ledge into the coolant passage around the cylinder liner.



Pitting on the liner seat is **not** acceptable. The graphic illustrates an example of pitting on the liner seat. Contact a Cummins® Authorized Repair Location if the block requires counterbore machining before it can be reused.



Measure

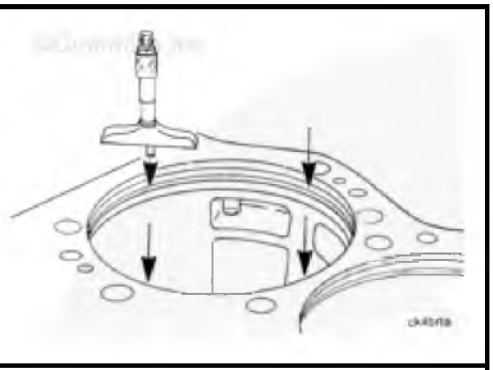
Make sure the micrometer contacts the flat surface of the ledge. It **must not** touch the radius.

Use a depth micrometer to measure the counterbore depth at the four locations illustrated in the graphic.

Counterbore Depth

mm		in
14.00	MIN	0.551
14.05	MAX	0.553

The four measurements **must not** vary by more than 0.25 mm [0.001 in]. If the measurements exceed specifications, the counterbore **must** be machined. Contact a Cummins® Authorized Repair Location.

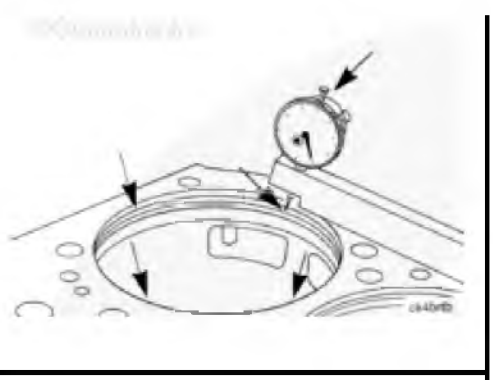


Make sure the indicator does **not** contact the counterbore radius on a block that

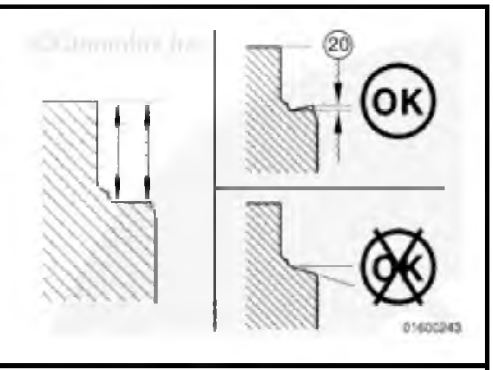
does **not** have a double undercut.

Use depth gauge assembly, Part Number 3164438, to measure the angle of the counterbore ledge at four locations on the counterbore circumference.

The measurement of the ledge depth **must** be as near to the counterbore radius as possible, and as near to the counterbore edge as possible.



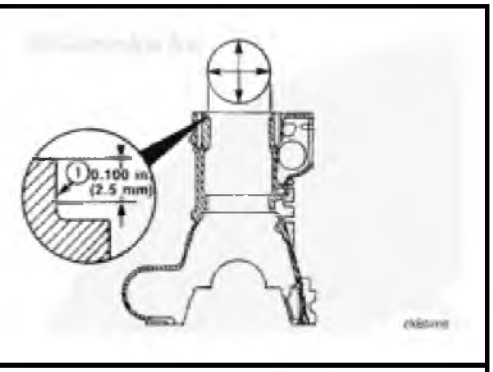
The angle (reference callout number 20 in the illustration) of the counterbore ledge is acceptable if the measurement that is near the counterbore edge is the same or **not** more than 0.036 mm [0.001 in] shorter than the measurement near the counterbore radius. If the measurement near the counterbore ledge is longer than the measurement near the counterbore radius, the ledge **must** be machined.



Measure the inside diameter of the upper counterbore (1). The point of measurement **must** be within 2.54 mm [0.100 in] from the top of the block.

Counterbore Diameter - Upper Press Fit Diameter

mm		in
205.93	MIN	8.107
205.99	MAX	8.110



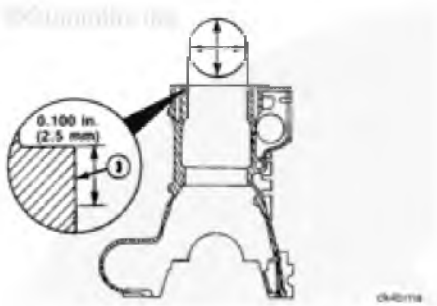
The inside diameter of the upper counterbore **must** be completely round within 0.050 mm [0.002 in]. If the measurement is **not** within specifications, check to see if the block can be machined to use oversize liners.

The upper counterbore **must not** be more

than 0.076 mm [0.003 in] larger than the cylinder liner flange.

If the counterbore does **not** meet specifications, an oversize liner has possibly been used in a previous machining bore process. Measure and record the measurement so the proper press fit liner can be determined.

Measure the inside diameter of the lower counterbore (3) . The point of measurement **must** be within 2.54 mm [0.100 in] from the top of the counterbore ledge.



Counterbore Diameter - Lower Press Fit Diameter

mm		in
194.48	MIN	7.657
194.54	MAX	7.659

The inside diameter of the lower counterbore **must** be completely round within 0.050 mm [0.002 in].

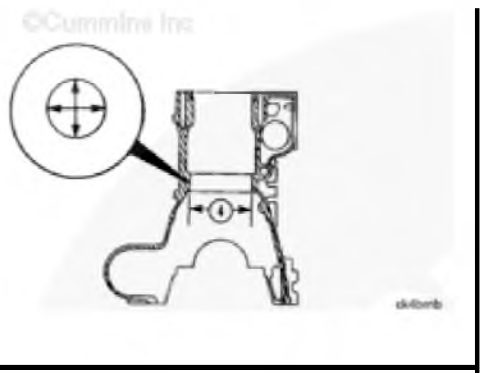
If the counterbore does **not** meet specifications, an oversize liner has possibly been used in a previous machining bore process. Measure and record the measurement so the proper press fit liner can be determined.

If the block is **not** within specifications, do **not** use the block.

Check the chamfer at the top of the packing ring bore (4) . Excessive pitting **must** be repaired.

Packing Ring Bore

mm		in
190.34	MIN	7.494
190.40	MAX	7.496

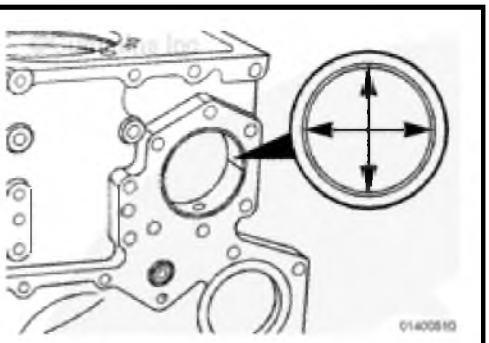


Measure the inside diameter.

Camshaft Bushing Inside Diameter

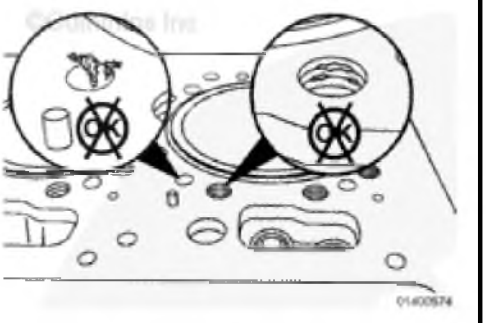
mm		in
105.01	MIN	4.134
105.10	MAX	4.138

If the bushing is **not** within specifications, the bushing **must** be replaced. Refer to Procedure 001-010 in Section 1.



Check the coolant holes. If erosion or pitting is more than 0.08 mm [0.003 in] deep, or extends more than 2.41 mm [0.095 in] from the edge of the hole, the coolant hole **must** be repaired.

Check the threads of the capscrew holes for damage. Use a thread insert if a damaged capscrew hole **must** be repaired. Contact an Cummins® Authorized Repair Location for proper thread inserts.



Install the main bearing caps. Refer to Procedure 001-006 in Section 1.

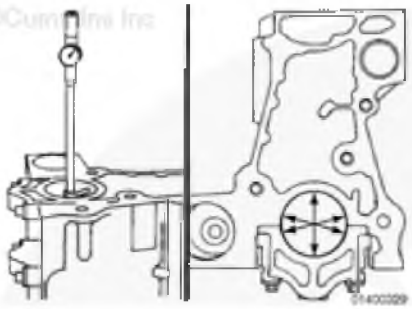
Use a dial bore indicator to measure the

inside diameter of each bearing bore in three positions, as shown in the illustration.

Main Bearing Bore Diameter

mm		in
147.999	MIN	5.8267
148-025	MAX	5.8277

If the main bearing bore is **not** within specification, the block **must not** be reused.



Last Modified: 23-Nov-2010

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001-028 Cylinder Liner

Preparatory Steps

WARNING

Batteries can emit explosive gasses. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

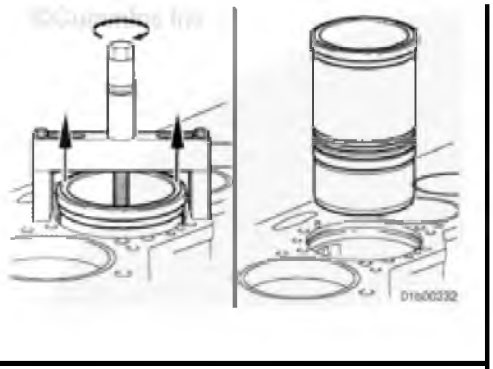
WARNING

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

- Disconnect the batteries or air supply to the air starter to prevent accidental engine starting.
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Drain the lubricating oil system and remove the oil pan. Refer to Procedure 007-037 in Section 7.
- Remove the oil suction tube and the block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Remove the exhaust manifold. Refer to Procedure 011-007 in Section 11.
- Remove the air intake manifold. Refer to Procedure 010-023 in Section 10.
- Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Remove the rocker levers. Refer to Procedure 003-009 in Section 3.
- Remove the crossheads.
- Remove the push rods. Refer to Procedure 004-014 in Section 4.
- Remove the rocker lever housing. Refer to Procedure 003-013 in Section 3.
- Remove the cylinder head. Refer to Procedure 002-004 in Section 2.
- Remove the connecting rod and piston assembly. Refer to Procedure 001-054 in Section 1.

Remove

Use a liner puller, Part Number 3163745, and puller plate, Part Number 3163751, to remove the cylinder liner.

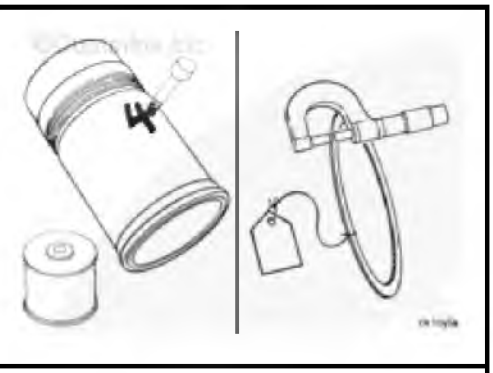


Use a liquid metal marker to mark the cylinder number and bank on each liner. Mark the cylinder liner on the camshaft side of the cylinder liner.

If sealing rings were used:

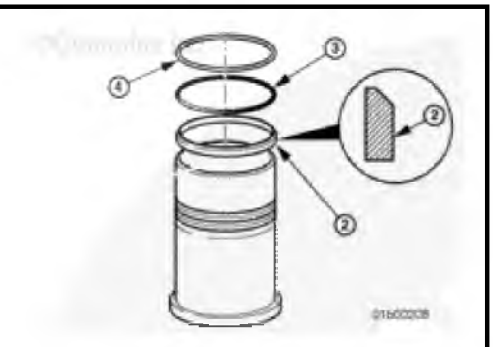
- Use a tag to mark the cylinder number.
- Measure in several places, and record the thickness of the sealing rings used in each cylinder.

The thickness of the sealing ring is one factor in determining liner protrusion. This information **must** be know when the liners are installed in the engine.



Remove the two D-rings (3) and (4).

Remove the crevice seal (2).



BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

Clean

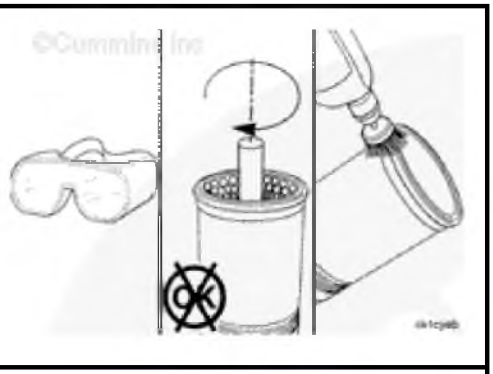
WARNING

Wear eye protection. Make sure the wire brush is rated for the RPM being used if the brush is motor driven. Flying debris and dirt can cause personal injury.

CAUTION

Do not use a hone, aluminum oxide cloth, sandpaper, deglazing, or pre-brushing to clean the cylinder liners. Abrasives can damage the finish and the crosshatch pattern and can contaminate the liner.

Use a high quality steel wire brush to clean the liner flange seating area and the secondary press fit below the liner flange.



WARNING

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

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

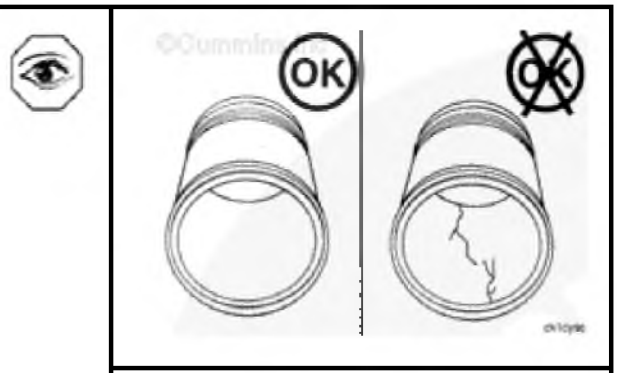
Do not contaminate the wash tank solution with bead blast materials. Use a kerosene emulsion-based solvent. Do not use a solvent that contains chlorinated hydrocarbons with cresol, phenols, or cresylic components. Engine damage can result.

Use a nonmetallic bristle brush, detergent soap, and warm water to clean the inside of the liner.

Use a steam cleaner or solvent tank to clean the liners.

Dry with compressed air.

Inspect the liners for cracks on the inside and the outside diameters.

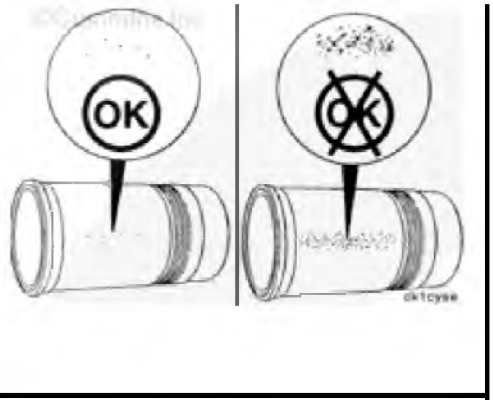


Inspect for cracks under the flange.

Cracks can also be detected by using either magnetic inspection or the dye method.

Inspect the outside diameter for excessive corrosion or pitting. Pits **must not** be more than 1.6 mm [0.063 in] deep.

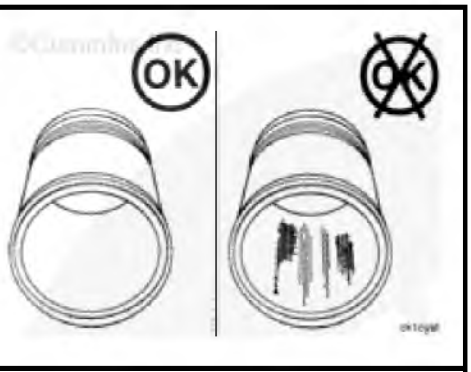
Replace the liner if the pits are too deep or if the corrosion can **not** be removed with a fine emery cloth.



Inspect the inside diameters for vertical scratches deep enough to be felt with a fingernail.

If a fingernail catches in the scratch, the liner **must** be replaced.

Inspect the inside diameter for scuffing or scoring.

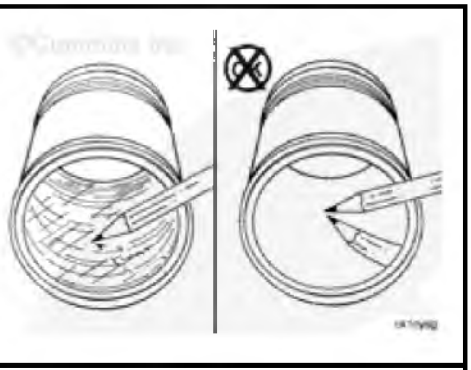


Inspect the inside diameter for liner bore polishing.

A moderate polish produces a bright mirror finish in the worn area with traces of the original hone marks or an indication of an etch pattern.

A heavy polish produces a bright mirror finish in the worn area with no traces of hone marks or an etch pattern.

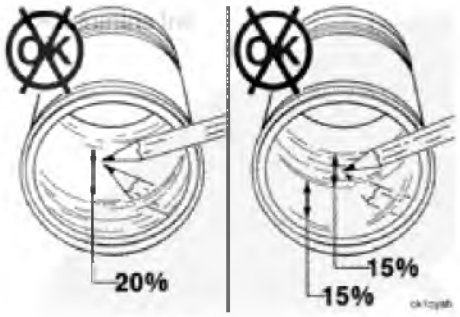
Refer to Parts Reuse Guidelines, Bulletin 3810303, for further information on liner bore polishing.



Replace the liner if:

- A heavy polish is present over

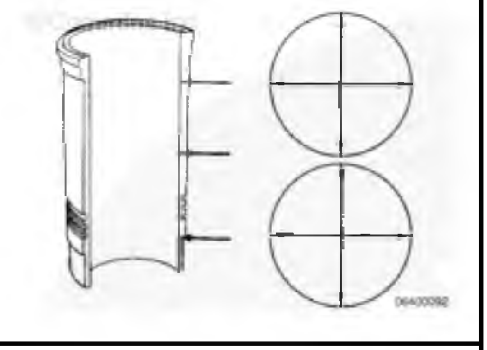
twenty percent of the piston ring travel area.
- Thirty percent of the piston ring travel area has both moderate and heavy polish, with one-half of the 30 percent consisting of heavy polish.



Use a dial bore gauge to measure the inside diameter of the liner at the top, the bottom, and the middle of the piston ring travel area. Perform two measurements at each location. The measurements **must** be 90 degrees apart.

Cylinder Liner Inside Diameter

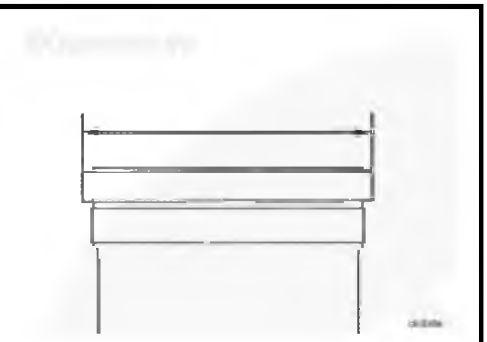
mm		in
170.040	MIN	6.694
170.240	MAX	6.702



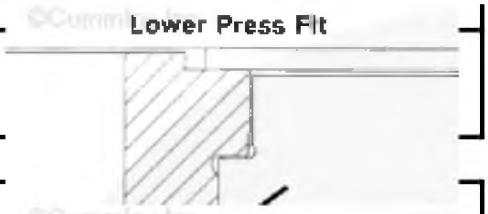
Measure the liner flange outside diameter.

Upper Press Fit Liner Flange Diameter

mm		in
205.965	MIN	8.109
206.015	MAX	8.111



The liner design incorporates a press fit between the upper liner bore and the area of the liner directly below the liner flange. This is referred to as the Lower Press Fit design.



Measure the lower press fit diameter.

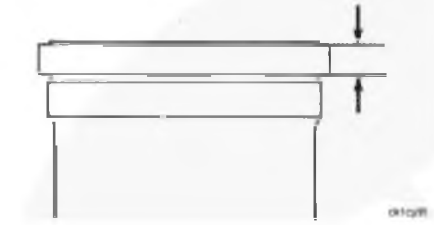
Lower Press Fit Area Outside Diameter

mm		in
194.565	MIN	7.660
194.615	MAX	7.662

Measure the liner flange thickness.

Liner Flange Thickness

mm		in
14.12	MIN	0.556
14.15	MAX	0.557

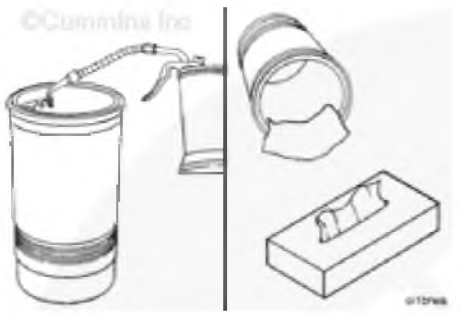


CAUTION

Do not place the liners in an area where dirty air flow can contaminate the liners. Engine damage can result.

Apply a thick film of clean 15W-40 engine oil to the bores of the liners for final cleaning. Leave the oil on for 5 to 10 minutes.

Use a clean, lint-free paper towel to wipe the oil from the bores until the black and gray deposits are removed.

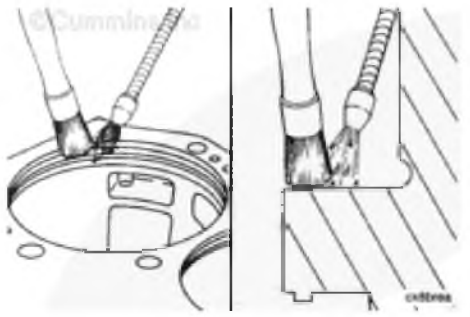


Install

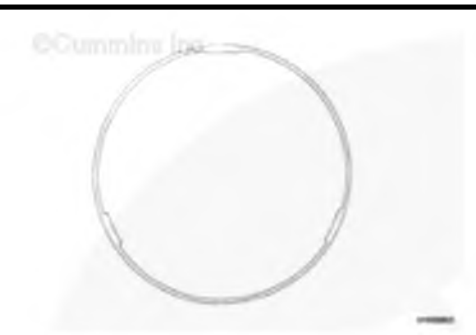
WARNING

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

Clean the bottom of the cylinder liner flange and the cylinder block upper and lower liner bore area with safety solvent.



NOTE: Cylinder liner seal rings for the QSK23 are not installed at the factory. They are to be used at rebuild, after the machining process, to adjust liner protrusion.



The seal rings have three locating tabs on the inner diameter. The tabs have an interference fit to the liner lower press-fit diameter to hold the seal ring in place during liner installation.

Install the seal rings.

The seal ring **must** be straight on the liner upon installation. Use finger pressure to push the seal ring near the tabs to fit the seal ring down and over the lower press fit diameter during installation.

This practice during installation of the seal ring will prevent deformation that will result in the seal ring **not** fitting squarely on the bottom of the liner flange.

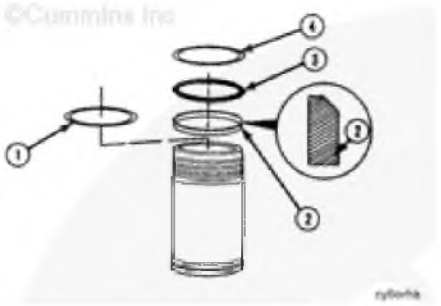
Cylinder Liner Seal Rings	
Thickness	Number of Notches
0.457 mm [0.0180 in]	Two
0.521 mm [0.0205 in]	Two
0.559 mm [0.0220 in]	Two
0.610 mm [0.0240 in]	Two
0.787 mm [0.0310 in]	Two

Install the crevice seal. The beveled-edge of the crevice seal (2) **must** be positioned as shown.

Some o-rings have a “D” shape cross section. This type of o-ring **must** be installed with the flat side against the cylinder liner.

Install the o-rings in the position shown. Use the mold mark on the o-ring to check whether the o-ring is twisted.

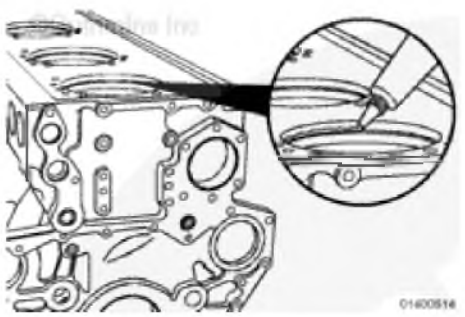
1. Liner, counterbore sealing ring
2. Crevice seal
3. Black o-ring
4. Red o-ring.



CAUTION

If more than a 2 to 3 mm [0.078 to 0.118 in] bead of gasket sealant is applied to the cylinder block counter bore surface engine damage can occur.

Install a bead of gasket sealant, Part Number 3165150 or equivalent, 2.0 to 3.0 mm [0.078 to 0.118 in] wide onto the cylinder block counter bore surface. The



sealant bead **must** be a continuous loop and **must not** contain any breaks or voids from start to finish.

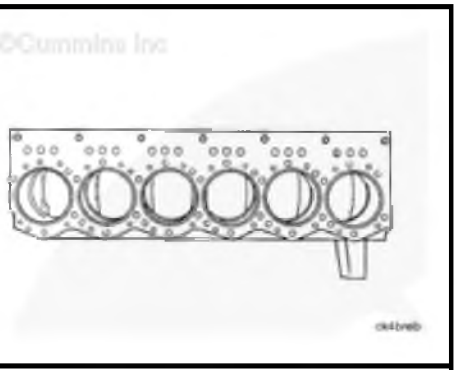
The assembly of the cylinder liner **must** be complete within 30 minutes of applying the gasket sealant.

CAUTION

Do not use petroleum-based oil. This will cause swelling of the packing ring.

Use vegetable oil to lubricate the inside diameter of the packing ring bores.

Use your hands to push the cylinder liners into the block.



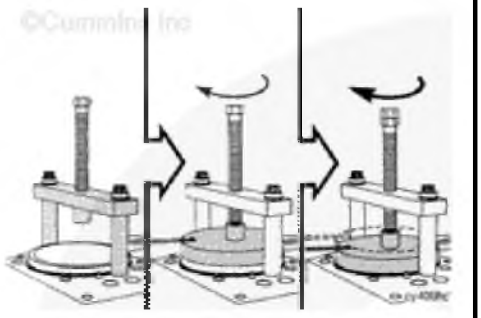
Use liner installation tool, Part Number 3164207, or equivalent, to install the liner. Install the bridge assembly and two cylinder head capscrews. Tighten the capscrews.

Torque Value: 68 n.m [50 ft-lb]

Install the pusher plate in the liner. Be sure it is aligned correctly in the liner. Turn the pusher screw until it touches the plate. Turn the pusher screw until the liner flange touches the counterbore ledge.

Tighten pusher screw.

Torque Value: 90 n.m [67 ft-lb]



Use a dial bore gauge and measure the inside diameter of the liner at the top, bottom, and middle of the liner.

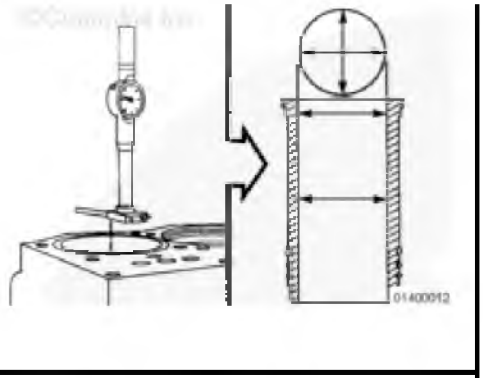
Perform two measurements at each location. The measurements **must** be 90 degrees apart.

New Cylinder Liner Inside Diameter

mm		in
170.000	MIN	6.693
170.040	MAX	6.694

The inside diameter **must not** be more than 0.076 mm [0.003 in] out-of-round at the top two measurements.

If the inside diameter is more than 0.04 mm [0.002 in] out-of-round in the bottom measurement location, the liner **must** be removed. Check for a twisted o-ring.



Measure

Use liner installation tool, Part Number 3164207, or equivalent, and two cylinder head capscrews.

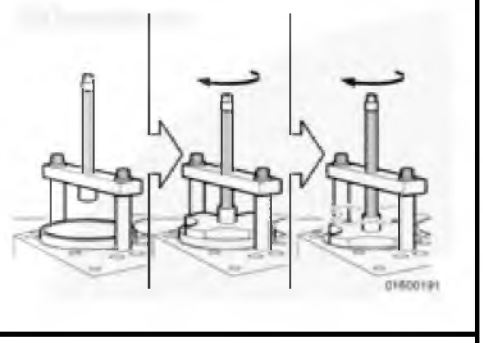
Tighten the capscrews.

Torque Value: 68 n.m [50 ft-lb]

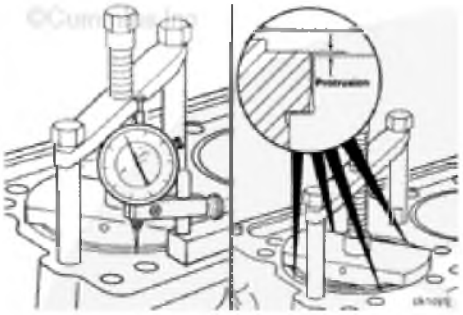
Install the pusher plate in the liner. Make sure it is aligned correctly in the liner. Turn the pusher screw until it touches the plate. Turn the pusher screw until the liner flange touches the counterbore ledge.

Tighten the pusher screw.

Torque Value: 90 n.m [67 ft-lb]



Use a depth gauge block. Position the depth gauge block so the indicator needle will contact the liner flange on the outside of the sealing bead as shown.



Gently push the indicator needle down until it touches the liner. Turn the gauge until the zero is aligned with the head of the dial. Repeat this step several times to be sure the gauge is set to zero.

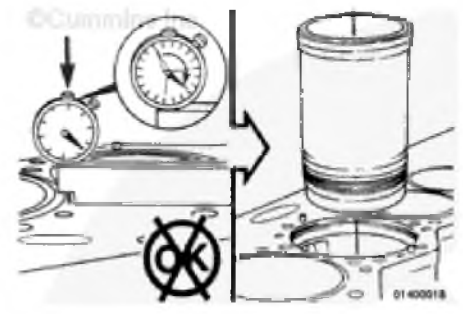
Raise the indicator and move the gauge block until the indicator will touch the block surface. Gently push the indicator down until it touches the block. Read the indicator.

Cylinder Liner Protrusion

mm		in
0.07	MIN	0.003
0.15	MAX	0.006

Read the liner protrusion in four places equally spaced on the liner outside diameter. The measurements on each liner **must not** vary more than 0.05 mm [0.002 in].

If the liner protrusion is **not** correct, the liner **must** be removed. The protrusion can be adjusted using seal rings and/or machining the counterbore ledge. Contact an Authorized Cummins® Repair Facility if machining is required.



NOTE: Use seal rings to increase protrusion. Machine counterbore ledge to decrease protrusion.

Finishing Steps

- Install the connecting rod and piston assembly. Refer to Procedure 001-054 in Section 1.
- Install the cylinder head. Refer to Procedure 002-004 in Section 2.
- Install the rocker lever housing. Refer to Procedure 003-013 in Section 3.
- Install the push rods. Refer to Procedure 004-014 in Section 4.
- Install the crossheads. Refer to Procedure 002-001 in Section 2.
- Install the rocker levers. Refer to Procedure 003-009 in Section 3.
- Adjust the overhead set. Refer to Procedure 003-006 in Section 3.
- Install the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Install the air intake manifold. Refer to Procedure 010-023 in Section 10.
- Install the exhaust manifold. Refer to Procedure 011-007 in Section 11.
- Install the oil suction tube and the block stiffener plate. Refer to Procedure 001-089 in Section 1.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Fill the engine with clean lubricating oil. Refer to Procedure 007-037 in Section 7.
- Connect the batteries or air supply to the starter.

Last Modified: 07-Jun-2011

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001-031 Gear Cover, Front

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative Refer to (-) battery cable first and attach the negative Refer to (-) battery last.

WARNING

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

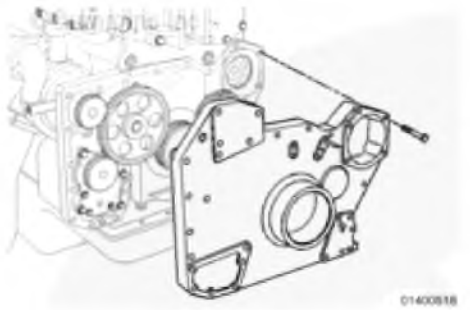
- Disconnect the batteries and air starter to prevent accidental starting.
- Drain the cooling system. Refer to Procedure 008-018.
- Remove the fan and fan spacer. Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the alternator. Refer to Procedure 013-001.
- Remove the fan belt tensioner. Refer to Procedure 008-087.

- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the front crankshaft seal. Refer to Procedure 001-023.
- Remove the alternator drive gear and shaft. Refer to Procedure 009-009.
- Drain the lubricating oil from the oil pan. Refer to Procedure 007-037.
- Remove the lubricating oil pan. Refer to Procedure 007-025.
- Remove the block stiffener plate. Refer to Procedure 001-089.
- Remove the front engine support bracket. Refer to Procedure 016-002.

Remove

WARNING

This component weighs more than 53 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

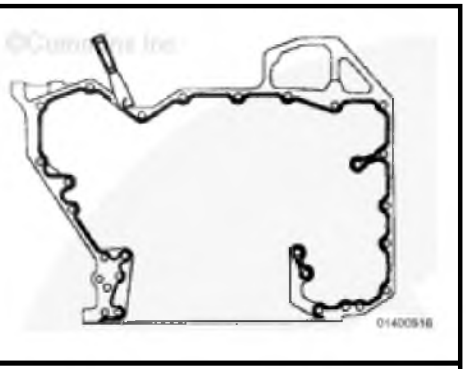


NOTE: One capscrew must be removed from the backside of the cover, located in the bottom of the fuel pump support plate.

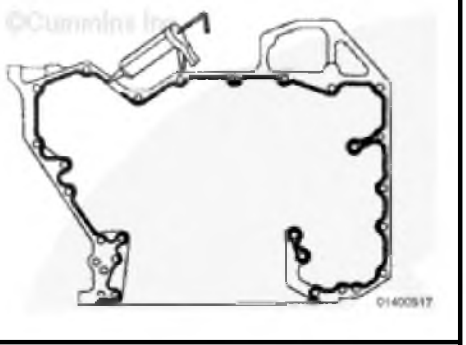
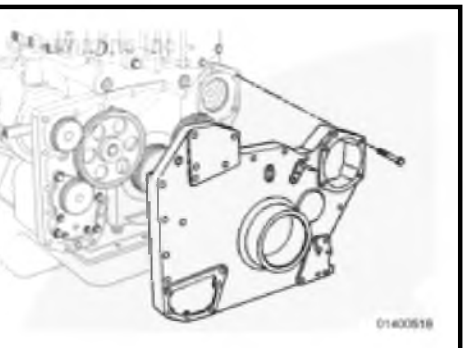
Remove the front gear cover capscrews.

Remove the front gear cover.

Clean

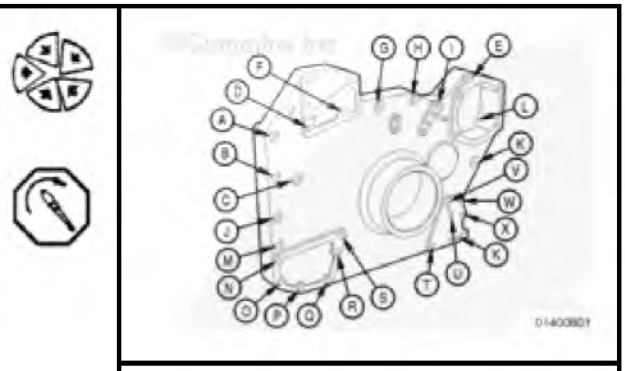
Clean the gasket sealant from the front gear cover and the block.		

Install

Apply a bead of gasket sealant 2 to 3 mm [0.079 to 0.118 in] wide to the front cover.		
WARNING This component weighs more than 53 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component. Install the front gear cover.		

Install the front cover capscrews.

Several different lengths of capscrews are used to mount the front cover, refer to the illustration to find the appropriate capscrew length for each location. Some of the capscrews mount other components in addition to the front cover.



Capscrew Location	Length (Industrial)	Length (Power-Generation)
A, B, C, D, E	115 mm [4.5 in]	115 mm [4.5 in]
F, G, H, I, J, K	75 mm [2.95 in]	75 mm [2.95 in]
L, M	65 mm [2.6 in]	65 mm [2.6 in]
N	Location **not** used	40 mm [1.6 in]
O	75 mm [2.95 in]	100 mm [3.9 in]
P	75 mm [2.95 in]	100 mm [3.9 in]
Q	75 mm [2.95 in]	100 mm [3.9 in]
R	Location **not** used	100 mm [3.9 in]
S	75 mm [2.95 in]	100 mm [3.9 in]
T	Location **not** used	40 mm [1.6 in]
U	Location **not** used	100 mm [3.9 in]
V	75 mm [2.95 in]	100 mm [3.9 in]
W	75 mm [2.95 in]	100 mm [3.9 in]

X	75 mm [2.95 in]	100 mm [3.9 in]
Y	75 mm [2.95 in]	100 mm [3.9 in]

Tighten the capscrews.

Torque Value: 113 n.m [83 ft-lb]

Finishing Steps

- Instai the alternator drive gear and shaft. Refer to Procedure 009-009
- Install the front crankshaft seal. Refer to Procedure 001-023.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the fan belt tensioner assembly. Refer to Procedure 008-087.
- Install the alternator drive idler gear. Refer to Procedure 001-097.
- Install the alternator. Refer to Procedure 013-001.
- Install the fan belt. Refer to Procedure 008-002.
- Install the fan spacer(s) and fan. Refer to Procedure 008-040.
- Install the front engine support bracket. Refer to Procedure 016-002.
- Install the lubricating oil pan. Refer to Procedure 007-025.
- Install the block stiffener plate. Refer to Procedure 001-089.
- Fill the engine with clean lubricating oil. Refer to Procedure 007-037.
- Fill the cooling system. Refer to Procedure 008-018.
- Connect the batteries.
- Operate the engine to normal

operating temperature. Check for leaks.		

Last Modified: 28-Jul-2003

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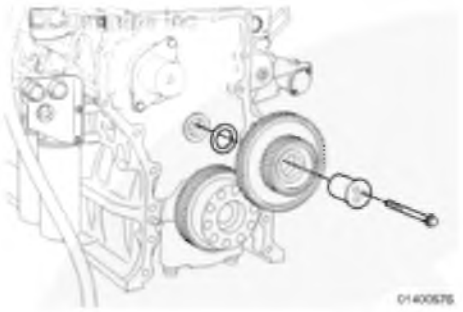
001-036 Idler Gear, Camshaft

Preparatory Steps

- Remove the oil pan and associated components. Refer to Procedure 007-025.
- Remove the flywheel housing. Refer to Procedure 016-006.
- Remove the camshaft gear. Refer to Procedure 001-008.

Remove

Remove the three capscrews, the shaft, the camshaft idler gear assembly, and the rear thrust bearing.



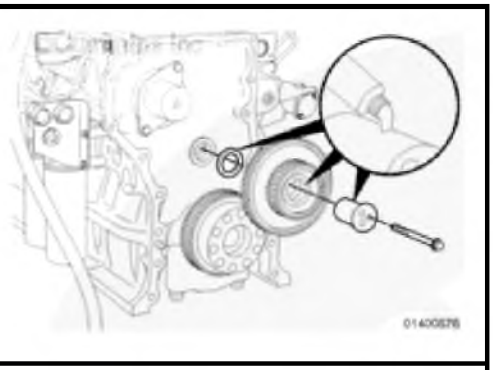
Install

CAUTION

The chamfer in the thrust washers must be positioned toward the gear. Improper installation of thrust washer can cause engine damage.

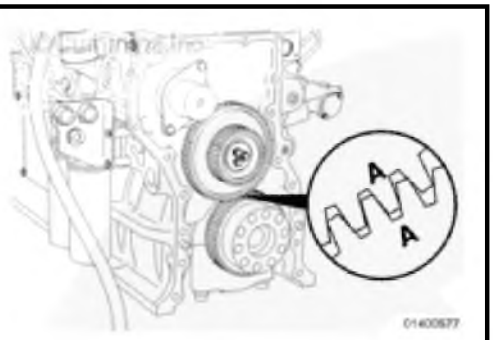
The timing marks on the camshaft gear **must** be visible when the gear is installed.

Use Lubriplate™ 105, or equivalent to lubricate the gear bushing, shaft, and the rear thrust bearing.



The camshaft idler gear is the **only** idler gear that has timing marks.

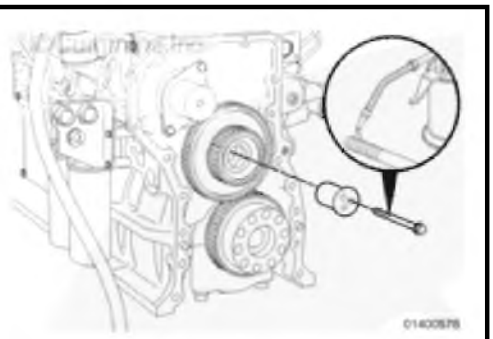
Align the "A" on the larger idler gear with the "A" on the crankshaft gear.



CAUTION

The outer face of the idler gear shaft is stamped with the word “UP”. This stamp must be positioned toward the cylinder heads. Improper installation of the idler gear shaft can cause engine damage.

Use clean engine oil to lubricate the



capscrews.

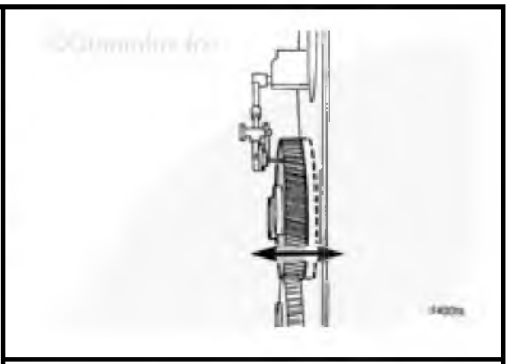
Use the capscrew to pull the shaft into the bore.

Use the following steps to tighten the capscrews in the sequence shown.

Torque Value:	Step 1	45 n.m	[35 ft-lb]
	Step 2	60 n.m	[44 ft-lb]
	Step 3	90°	

Use a dial indicator to measure the idler gear end clearance.

Camshaft Idler Gear - End Clearance		
mm		in
0.04	MIN	0.002
0.18	MAX	0.007



If the clearance is **not** within specifications, check for foreign material between the parts, or check for proper location of the thrust washers. Oversize thrust washers are available.

Camshaft Idler Gear Lash		
mm		in
0.145	MIN	0.006
0.380	MAX	0.015

Finishing Steps

- Install the camshaft gear. Refer to

Procedure 001-012.

- Install the flywheel and flywheel housing. Refer to Procedure 001-008.
- Install the oil pan and related components. Refer to Procedure 007-025.

Last Modified: 20-Jun-2003

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001-043 Piston

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery first and connect the negative (-) battery last.

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

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

- Disconnect the battery or supply air to the starter.
- Drain the coolant. Refer to Procedure 008-018.
- Drain the lubricating oil and remove the oil pan. Refer to Procedure 007-025.
- Remove the oil suction tube and block stiffener plate. Refer to Procedure 001-089.
- Remove the intake manifold. Refer to Procedure 010-023.
- Remove the exhaust manifold. Refer to Procedure 011-007.
- Remove the rocker lever cover. Refer to Procedure 003-011.
- Remove the rocker lever assembly. Refer to Procedure 003-009.
- Remove the push rods and crossheads.
- Remove the rocker lever housing. Refer to Procedure 003-013.
- Remove the cylinder head. Refer to Procedure 002-004.

- Remove the piston cooling nozzles. Refer to Procedure 001-046.
- Remove the piston and connecting rod assembly and disassemble. Refer to Procedure 001-054.

Clean and Inspect for Reuse

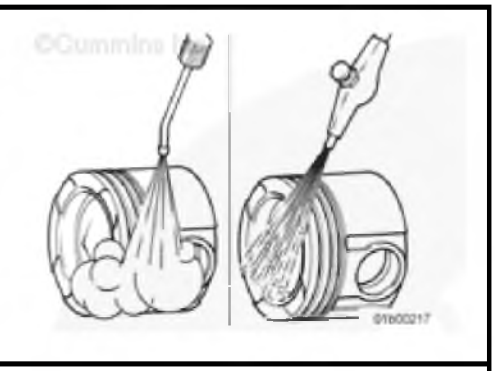
WARNING

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

Use steam to clean the outer layers of carbon from the piston surface. The bead-blast method can be used to clean the top of the piston. If this method is used, cover the ring grooves.

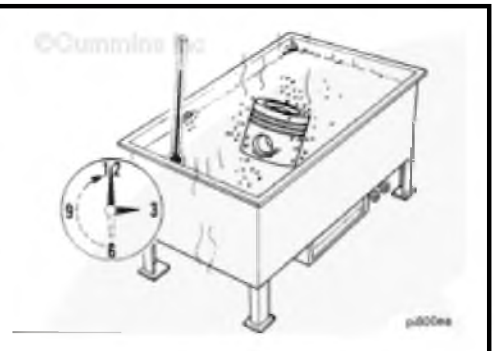
The oil gallery holes **must** be covered before using the bead blast method.

It is **only** necessary to remove the carbon buildup. It is **not** necessary to make the piston crown appear new.



WARNING

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



personal injury.

CAUTION

Do not contaminate the wash tank solution with bead-blast materials. Use a kerosene emulsion-based solvent. Do not use a solvent that is higher than 9.5 pH. Do not use a solvent that contains chlorinated hydrocarbons with cresol, phenols, or cresylic components. Engine damage can result.

For best results, soak the pistons several hours or overnight. Use a solvent that can be heated from 90 to 95°C [194 to 203°F]. Use a cleaning tank that will circulate and filter the solvent.

Allow the pistons to soak in solvent for a minimum of 30 minutes.

CAUTION

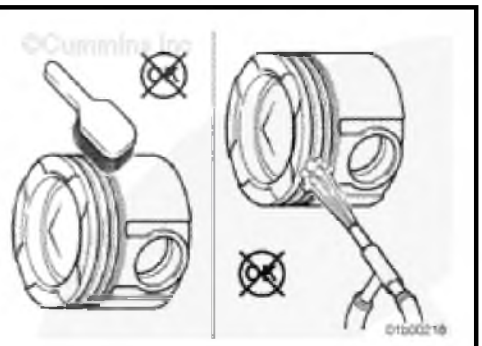
Do not use the bead-blast method to clean the skirt. The piston skirt will be damaged by the bead-blast method.

CAUTION

Do not use a metal bristle brush to clean the pistons. Damage to the ring grooves will result.

Use a brush to clean the ring grooves. Walnut shell blasting can be used on the piston crown.

Repeat the soaking and scrubbing process until the piston is thoroughly cleaned.



WARNING

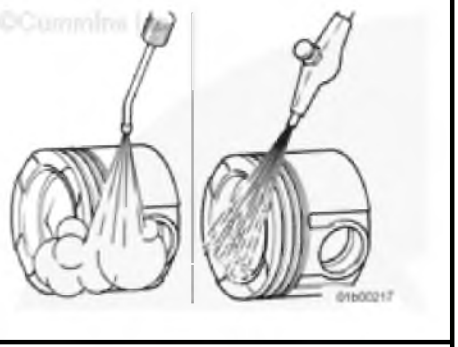
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use steam to rinse the solvent from the pistons.

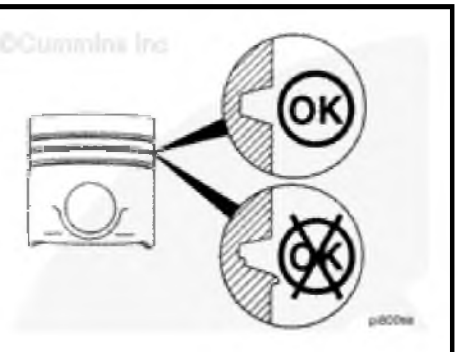
Dry the pistons with compressed air.



Use crack detection kit, Part Number 3375432, or equivalent, to inspect the bowl, crown and piston pin bore.

Remove any cover plugs in the oil gallery holes.

Inspect the ring grooves. The pistons **must** be replaced if there is a visible ridge in the back of the groove, or if a lip has formed on the outer diameter of the groove.



Measure

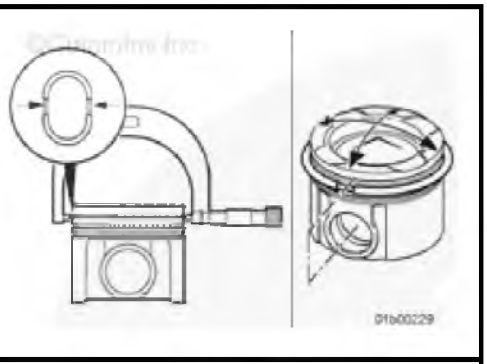
Use piston ring groove wear gauge, Part Number 3824846, and a 152- to 177-mm [6- to 7-in] micrometer to inspect the top ring groove (compression ring).

Measure the top and second ring grooves (diameter over pins) when the piston temperature is at 21°C [70°F] in two areas 90 degrees apart as illustrated.

Ring Groove Wear Limits (Diameter Over Pins)

	mm		in
Top Ring	158.1	MIN	6.224
Second Ring	154.3	MIN	6.075

The piston **must** be replaced if measured dimensions are less than those in the table.

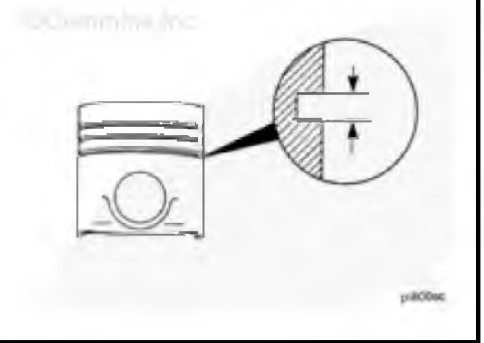


Measure the oil ring groove height.

Piston Oil Ring Groove Height

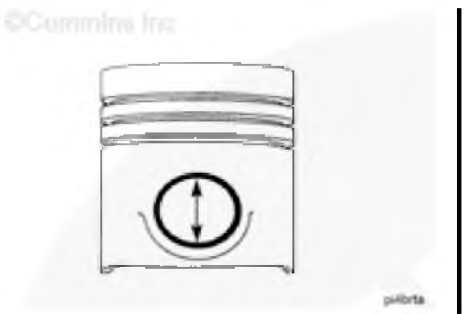
mm		in
4.01	MIN	0.158
4.03	MAX	0.159

The piston **must** be replaced if it is **not** within specifications.

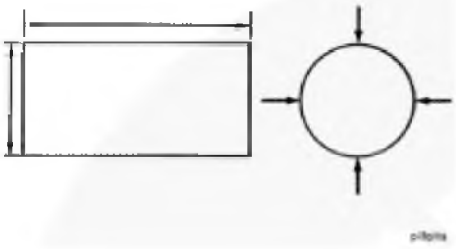


Measure the piston pin bore inside diameter.

Piston Pin Bore Inside Diameter		
mm		in
68.034	MIN	2.678
68.044	MAX	2.679



Measure the piston pin outside diameter and length.



Piston Pin Outside Diameter		
mm		in
67.994	MIN	2.677
68.000	MAX	2.678
Piston Pin Length		
mm		in
125.80	MIN	4.953
126.00	MAX	4.961

Finishing Steps

- Assemble and install the piston and connecting rod. Refer to Procedure 001-054.
- Install the piston cooling nozzles. Refer to Procedure 001-046.
- Install the cylinder head. Refer to Procedure 002-004.
- Install the rocker lever housing. 003-013.
- Install the push rods and crossheads.
- Install the rocker lever assembly.

003-009. • Adjust the overhead set. Refer to Procedure 003-006. • Install the rocker lever cover. Refer to Procedure 003-011. • Install the exhaust manifold. Refer to Procedure 011-007. • Install the intake manifold. Refer to Procedure 010-023. • Install the oil suction tube and block stiffener plate. Refer to Procedure 001-089. • Install the lubricating oil pan. Refer to Procedure 007-025. • Fill the engine with clean 15W-40 lubricating oil. Refer to Procedure 007-037 for engine oil capacity. • Fill the cooling system. Refer to Procedure 008-018. • Connect the battery or supply air to the starter. • Operate the engine to normal operating temperature. Check for leaks.		

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001-046 Piston Cooling Nozzle

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a lift or get assistance to lift this component.

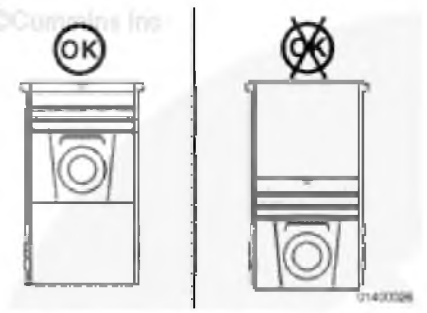
- Drain the lubricating oil and remove the lubricating oil pan. Refer to Procedure 007-037.
- Remove the suction tube and block stiffener. Refer to Procedure 001-

089.

Remove

CAUTION

Do not attempt to remove the piston cooling nozzle when the piston is at bottom dead center. The nozzle will be damaged and can result in piston damage.

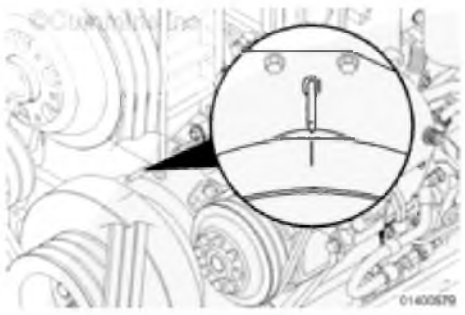


To reduce the possibility of damage to the piston cooling nozzles during removal, use the valve set marks and the sequence chart to identify those nozzles that can be removed at each index mark on the damper.

One complete crankshaft revolution is required to remove all of the nozzles.

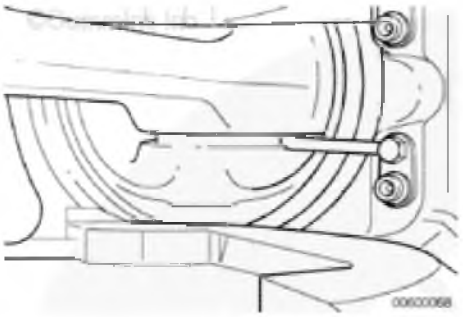
Piston / Position	Remove Nozzles
Number 1 TDC	1 and 6
Number 2 TDC	2 and 5
Number 3 TDC	3 and 4

Rotate the engine barring device until the “1,6” mark on the damper is aligned with the front cover pointer.

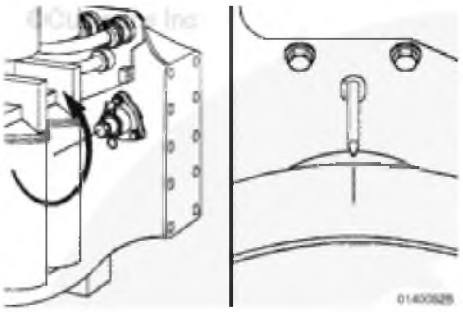


Remove the piston cooling nozzle capscrew.

Remove the front and rear piston cooling nozzles on cylinders number 1 and 6.



After removing the nozzles from cylinders 1 and 6, rotate the engine barring device and align the next valve set mark on the damper with the pointer on the front cover.



Use the chart in the illustration to determine the appropriate cooling nozzles to be removed.

Repeat the process to remove the remaining piston cooling nozzles.

Piston / Position	Remove Nozzles
Number 1 TDC	1 and 6
Number 2 TDC	2 and 5
Number 3 TDC	3 and 4

Clean

WARNING

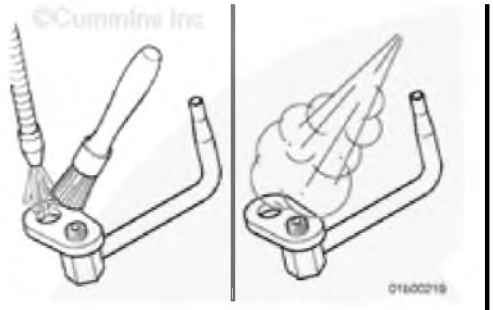
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent to clean the piston cooling nozzles. Dry with compressed air.

Blow out the oil passages with compressed air.



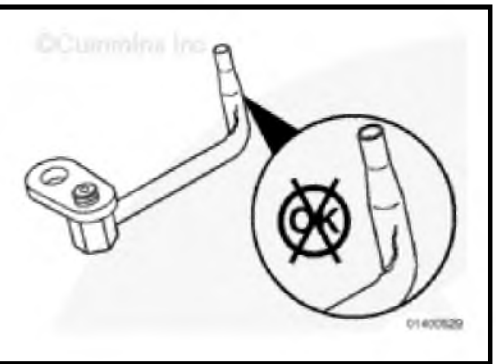
Inspect for Reuse

CAUTION

Any damage to the piston cooling nozzle can result in major engine damage.

Check the nozzle for cracks, bends, or other damage. Check the spray hole for burrs.

The piston cooling nozzle **must** be replaced if it is damaged.



Install

CAUTION

Do not attempt to install the piston cooling nozzle when the piston is at bottom dead center. The nozzle will be damaged and can result in piston failure.

Rotate the engine barring device to position the cylinders for best access to the piston cooling nozzle mounting pad.

Refer to the sequence chart in the illustration to identify the four piston cooling nozzles that can be installed at each timing mark.

Piston / Position	Remove Nozzles
Number 1 TDC	1 and 6
Number 2 TDC	2 and 5
Number 3 TDC	3 and 4

Install the piston cooling nozzles stamped with an “F” at the front of the two cylinders selected.

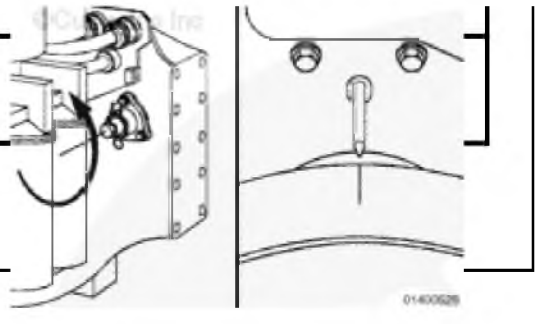
Install the piston cooling nozzles stamped with an “R” at the rear of the two cylinders selected.

Tighten the capscrews.

Torque Value: 30 n.m [22 ft-lb]

Rotate the barring device and align the next valve set mark on the damper with the pointer on the front cover.

Repeat the process to install the remaining piston cooling nozzles.



Finishing Steps

- Install the suction tube and block stiffener. Refer to Procedure 001-089.
- Install the lubricating oil pan. Refer to Procedure 007-025.
- Fill the engine with clean 15W-40 lubricating oil. Refer to Procedure 007-037 for engine oil capacity.

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001-047 Piston Rings

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery first and connect the negative (-) battery last.

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

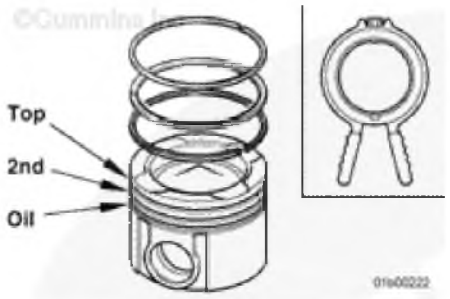
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

- Disconnect the battery or supply air to the starter.
- Drain the coolant. Refer to Procedure 008-018.
- Drain the lubricating oil and remove the oil pan. Refer to Procedure 007-025.
- Remove the oil suction tube and block stiffener plate. Refer to Procedure 001-089.
- Remove the intake manifold. Refer to Procedure 010-023.
- Remove the exhaust manifold. Refer to Procedure 011-007.
- Remove the rocker lever cover. Refer to Procedure 003-011.
- Remove the rocker lever assembly. Refer to Procedure 003-009.
- Remove the push rods and crossheads.
- Remove the rocker lever housing. Refer to Procedure 003-013.
- Remove the cylinder head. Refer to Procedure 002-004.

- Remove the piston cooling nozzles. Refer to Procedure 001-046.
- Remove the piston and connecting rod assembly and disassemble. Refer to Procedure 001-054.

Remove

Use piston ring expander, Part Number 3164401, or equivalent, to remove the piston rings.



Measure

To check the ring gap, install the piston ring in the cylinder liner to be used. Use the top part of the piston to position the ring in the liner correctly.

Use a feeler gauge to check the ring gap. The ring **must** be replaced if it does **not** meet specifications.

Piston Ring Gap			
	mm		in
Top	0.50	MIN	0.020
	0.65	MAX	0.026
Intermediate	0.70	MIN	0.028
	0.85	MAX	0.033
Oil	0.50	MIN	0.020
	0.70	MAX	0.028

Finishing Steps

- Assemble and install the piston and connecting rod. Refer to Procedure 001-054.
- Install the piston cooling nozzles. Refer to Procedure 001-046.
- Install the cylinder head. Refer to Procedure 002-004.
- Install the rocker lever housing. 003-013.
- Install the push rods and crossheads.
- Install the rocker lever assembly. 003-009.
- Adjust the overhead set. Refer to Procedure 003-006.
- Install the rocker lever cover. Refer to Procedure 003-011.
- Install the exhaust manifold. Refer to Procedure 011-007.
- Install the intake manifold. Refer to Procedure 010-023.
- Install the oil suction tube and block stiffener plate. Refer to Procedure 001-089.
- Install the lubricating oil pan. Refer

to Procedure 007-025. • Fill the engine with clean 15W-40 lubricating oil. Refer to Procedure 007-037 for engine oil capacity. • Fill the cooling system. Refer to Procedure 008-018. • Connect the battery or supply air to the starter.		

Last Modified: 30-May-2003

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001-052 Vibration Damper, Viscous

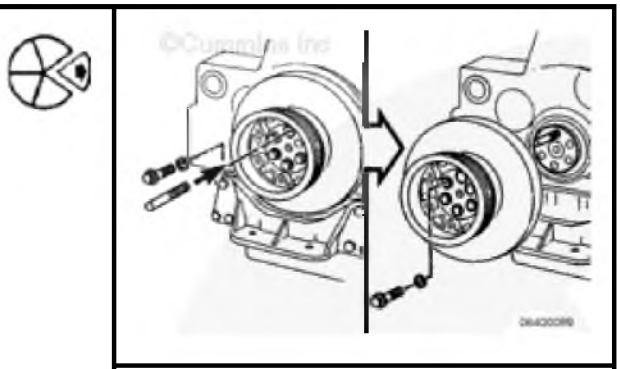
Preparatory Steps

- Remove the fan belt. Refer to Procedure 008-002 in Section 8.

Remove

WARNING

This assembly weighs more than 23 kg [50 lb]. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.



CAUTION

Do not pry or hammer on the vibration

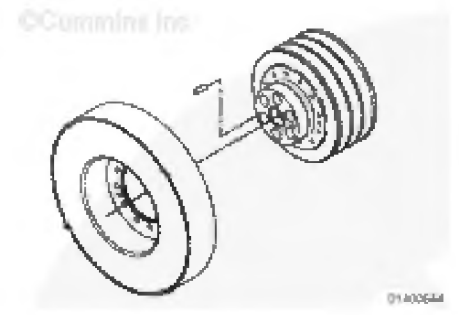
damper. Damage will result.

Remove one capscrew and install a M22 x 1.5 guide stud.

Remove the remaining capscrews, damper, and pulley.

Remove the guide stud.

Remove the pulley from the damper.



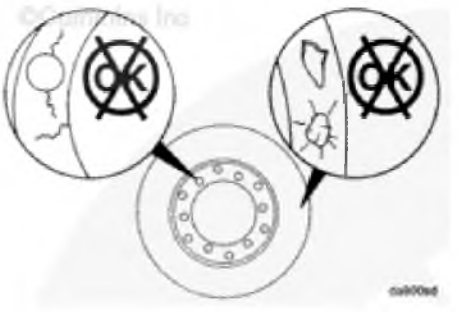
Inspect for Reuse

Vibration dampers have a limited service life. The damper **must** be replaced after 576,000 km [360,000 mi] or 15,000 hours of service.

Do **not** repair or balance a viscous damper in the field.

Inspect the damper for reuse. Inspect for cracks on the mounting flange. Inspect for dents or bulges on the housing.

If the damper is damaged, it **must** be replaced.



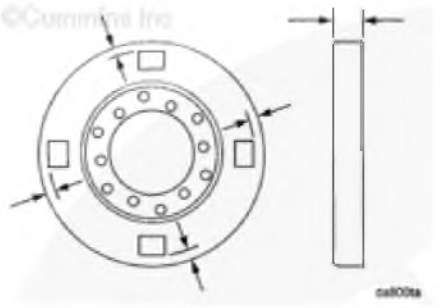
WARNING

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

Use a paint solvent and fine crocus cloth. Remove the paint from the front and back of the housing at the four areas shown.

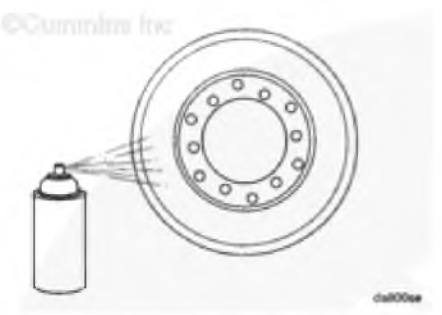
Measure **no** less than 3 mm [1/8 in] from the O.D. to be sure that the measurement is on a flat surface.

Measure the thickness at four places. If the measurements vary more than 0.25 mm [0.010 in], or if the thickness exceeds 68.05 mm [2.679 in], the damper **must** be replaced.



Use the crack detection kit, Part Number 3375432, or equivalent, and spray the rolled lip of the damper.

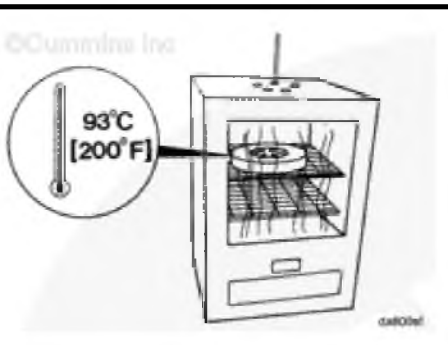
The crack detection kit, Part Number 3375432, contains the necessary cleaner, penetrant, and developer to check for cracks using the dye penetrant method.



WARNING

Wear protective clothing to reduce the possibility of personal injury from burns.

Use an oven with the temperature adjusted to 93°C [200°F].

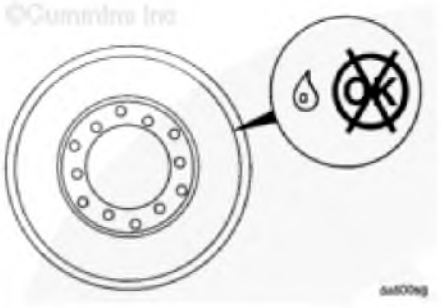


Put the damper in the oven with the rolled lip down. Heat the damper for two hours.

WARNING

Wear protective clothing to reduce the possibility of personal injury from burns.

Remove the damper and check for leakage around the lip. If there is any leakage the damper **must** be replaced.



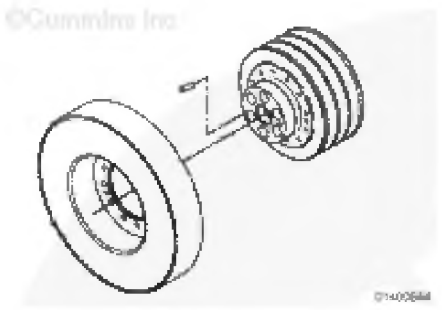
Install

Align the dowel pin and install the vibration damper on the crankshaft pulley.

Install the twelve washers and capscrews.

Tighten the capscrews.

Torque Value: 68 n.m [50 ft-lb]

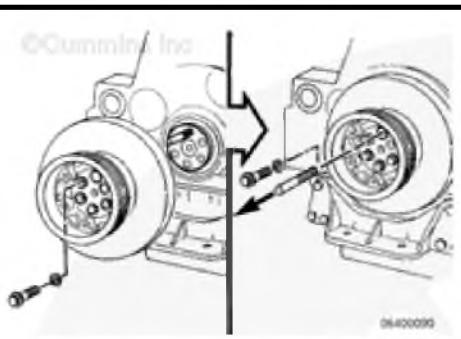


Install the M22 x 1.5 guide stud in the crankshaft.

Align dowel pin and install the crankshaft pulley and vibration damper assembly on the crankshaft.

Use clean 15W-40 oil to lubricate the capscrew threads.

Install five of the six capscrews.



Remove the M22 x 1.5 guide stud and install the sixth capscrew.

Tighten the capscrews to the values indicated below.

Torque Value:

1. 74 n.m [55 ft-lb]
2. 240 n.m [177 ft-lb]
3. 637 n.m [470 ft-lb]

Finishing Steps

- Install the fan belt and related components. Refer to Procedure 008-002 in Section 8.

Last Modified: 28-Nov-2011

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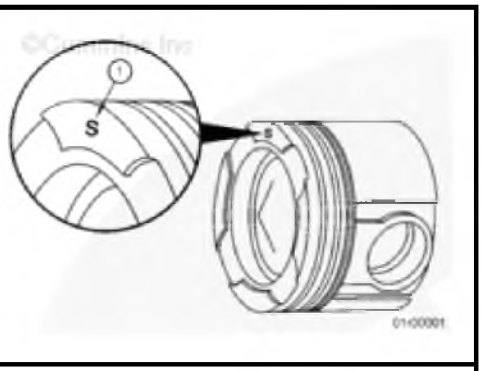
001-054 Piston and Connecting Rod Assembly

General Information

Two different piston part numbers are used in production on the QSK23 engine. The two different piston part numbers can be indentified by an "L" or and "S" on the head of the piston (1). Pistons marked with a "S" are used for service **only**.

These service pistons can be used to replace a "L" or "S" marked piston. Piston "L" and "S" can be mixed in the same engine.

NOTE: Tier 1 and Tier 2 pistons have different part numbers and are not interchangeable.



Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment

before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery first and connect the negative (-) battery last.

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

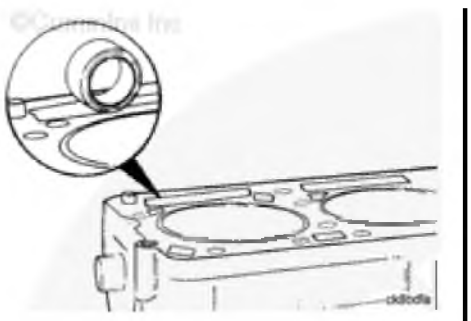
WARNING

This component weighs 23 kg [50 lb] or more. To reduce the possibility of

personal injury, use a hoist or get assistance to lift this component. • Disconnect the battery or supply air to the starter. • Drain the coolant. Refer to Procedure 008-018. • Drain the lubricating oil and remove the oil pan. Refer to Procedure 007-025 in Section 7. • Remove the oil suction tube and block stiffener plate. Refer to Procedure 001-089 in Section 1. • Remove the intake manifold. Refer to Procedure 010-023 in Section 10. • Remove the exhaust manifold. Refer to Procedure 011-007 in Section 11. • Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3. • Remove the rocker lever assembly. Refer to Procedure 003-009 in Section 3. • Remove the push rods and crossheads. • Remove the rocker lever housing. Refer to Procedure 003-013 in Section 3. • Remove the cylinder head. Refer to Procedure 002-004. • Remove the piston cooling nozzles. Refer to Procedure 001-046 in Section 1.		

Remove

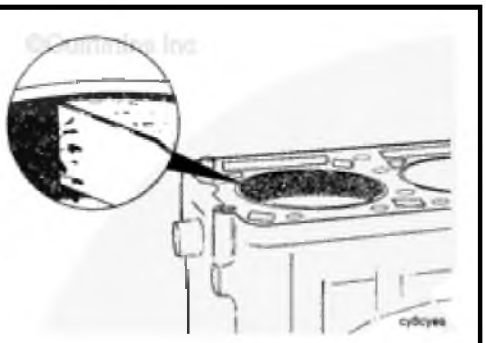
Use tape to protect the push rod galleys, coolant passages, and oil passages from contamination.		



CAUTION

Do not use abrasive paper to remove the carbon deposits. Small particles of abrasive paper will cause severe damage.

Use a scraper or similar blunt-edged tool to loosen the carbon deposits.



WARNING

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

CAUTION

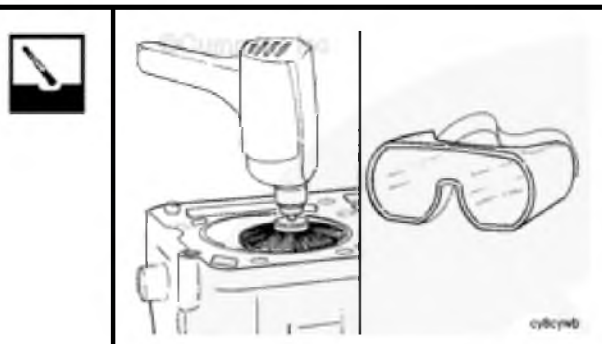
Make sure that no abrasive cleaners or materials are used in the piston ring travel area.

Remove the remaining carbon with an abrasive nylon pad, such as Scotch-Brite™ 7448, and solvent. The carbon

must be removed, but the surface does **not** have to look like new metal.

WARNING

Wear eye protection to prevent serious eye damage during this operation.

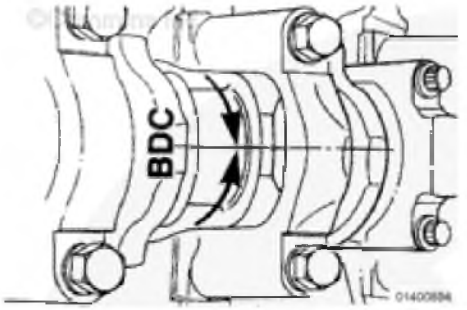


An alternate method to remove the carbon ridge is to use a high-quality steel wire wheel installed in a drill.

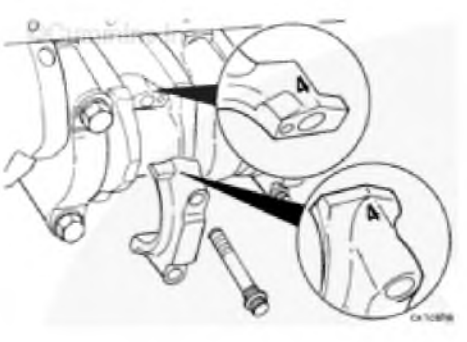
Do **not** use a steel wire wheel of inferior quality because it will lose steel bristles during operation and cause additional contamination.

Do **not** use a steel wire wheel in the piston ring travel area. Operate the wire wheel in a circular motion to remove the deposits.

Use the barring mechanism to rotate the engine. Rotate the crankshaft to position the connecting rod at bottom dead center (BDC).



The connecting rods **must** have the cylinder number marked on both the rod and the cap on the side positioned toward the camshaft. Check the rods for correct markings. Use a steel stamp to mark any connecting rod that is **not** correctly marked.

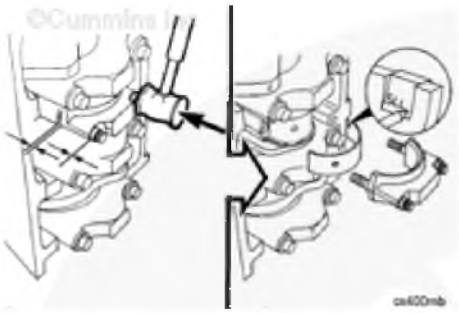


Loosen the capscrews until there is 6 mm

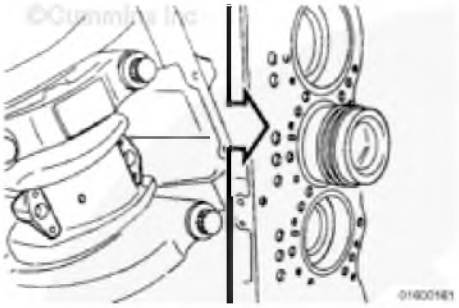
[0.236 in] of clearance between the rod cap and capscrew head.

Use a mallet to tap the connecting rod capscrews until the connecting rod cap and connecting rod separate. Remove the capscrews and the connecting rod cap.

Remove the lower rod bearing. Use an awl to mark the bearing position in the tang area for future identification or possible failure analysis.



Push the piston and connecting rod up until the piston rings are above the cylinder.



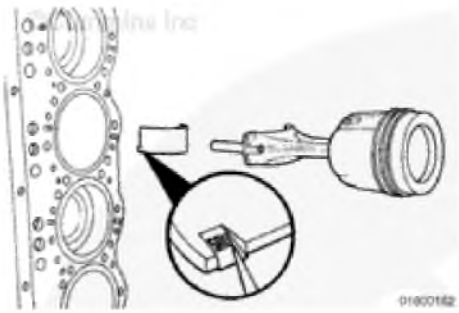
CAUTION

Put the piston and connecting rod assembly in a rack to prevent damage to the piston and connecting rod assembly.

Remove the piston and connecting rod assembly.

Remove the upper connecting rod bearing and place the piston and connecting rod assembly in a rack.

Use an awl to mark the bearing position in the tang area.



Disassemble

Remove the piston rings. Refer to Procedure 001-047 in Section 1.

Use snap ring pliers to remove the snap rings from both sides of the piston.

Mark or tag the rings from each cylinder with the cylinder number for analysis, if desired.

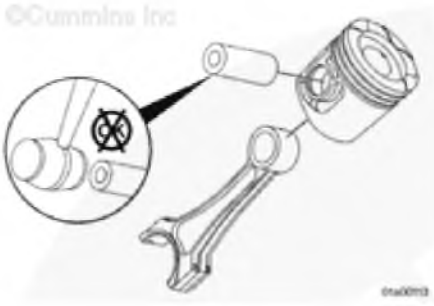
WARNING

To reduce the possibility of personal injury, and damage to the piston, do not drop the piston while removing the piston pin.

Remove the piston pin from the piston assembly.

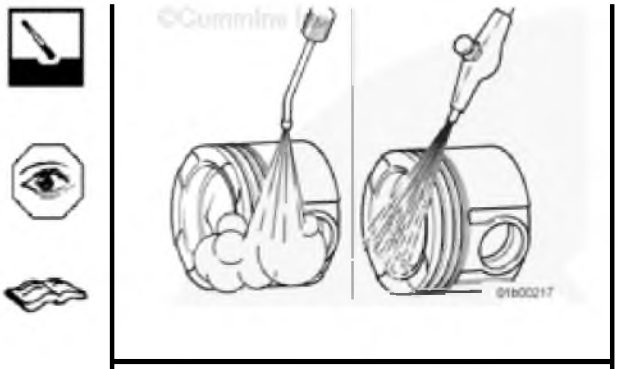
Separate the piston and connecting rod.

It is recommended that the piston and connecting rod be kept together for future analysis.



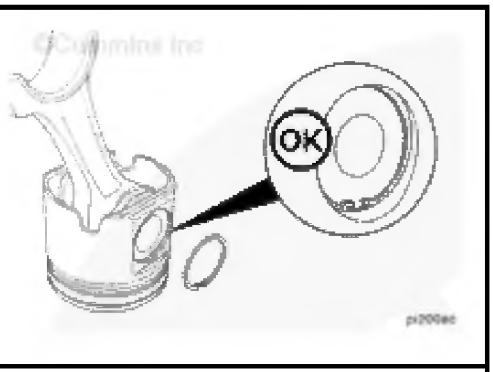
Assemble

Clean and inspect the pistons for reuse. Refer to Procedure 001-043 in Section 1.



Install a new snap ring in one piston pin bore of each piston.

It is **not** necessary to heat the pistons before assembly. The piston pin is a slip fit.



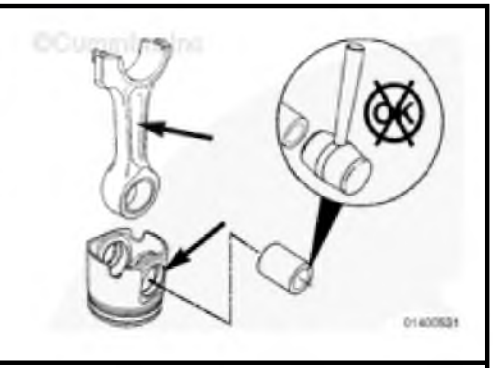
CAUTION

Do not use a hammer to install the piston pin. The piston can distort, causing it to seize in the liner.

Lubricate the piston pin and connecting rod bushing with clean 15W-40 engine oil.

Align the “EX”, stamped on the piston skirt, with the part number cast into the connecting rod and insert the rod into the piston.

Align the pin bore of the connecting rod with the pin bore of the piston and install the piston pin.

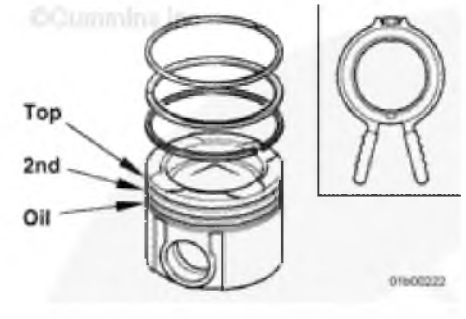


CAUTION

The snap ring must be seated completely in the piston groove to reduce the possibility engine damage during operation.

Install a new snap ring in the piston pin bore.

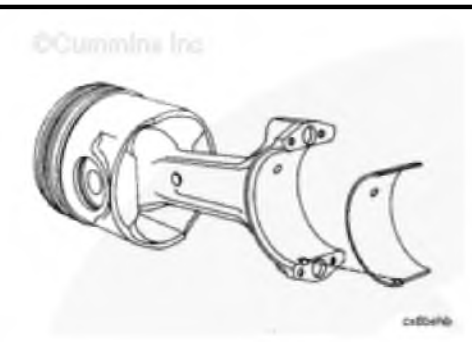
Install the piston rings. Refer to Procedure 001-047.



Install

Use a lint-free cloth to clean the connecting rod and bearing shells.

Install the connecting rod bearing. Make sure the tang is positioned in the machined slot as shown in the illustration. The end of the bearing shell **must** be even with the connecting rod cap mounting surface.



CAUTION

Do not lubricate the back side of the bearing shells. Engine damage can result.

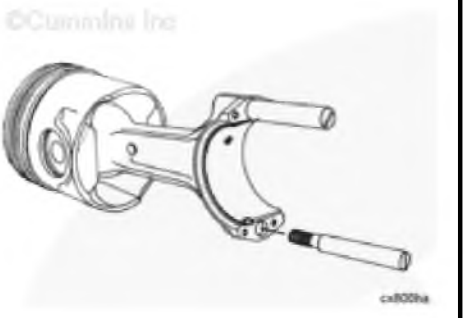
Lubricate the bearing surface with clean 15W-40 engine oil.

The bearings **must** be installed in their original location if new bearings are **not** used.

All of the connecting rod bearing shells are identical.

Install two connecting rod guides, or equivalent, in the connecting rod.

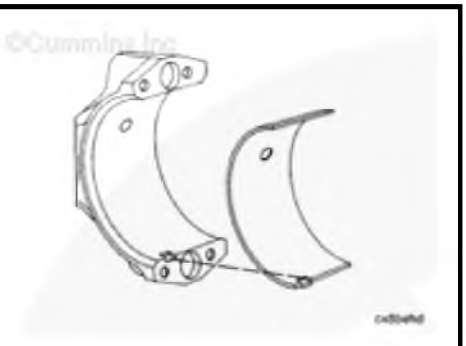
The guide will aid in assembly and protect the crankshaft.

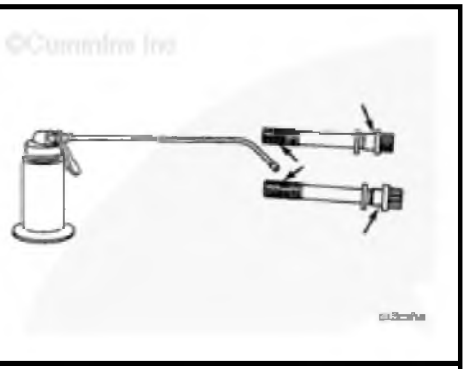
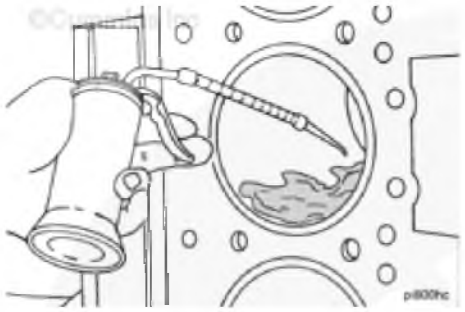
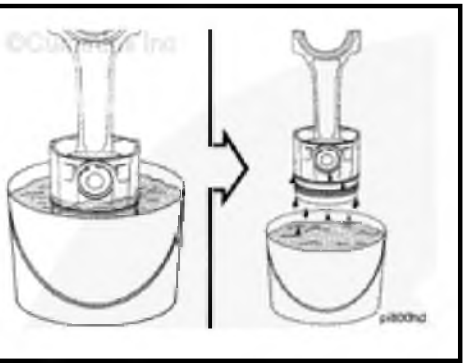
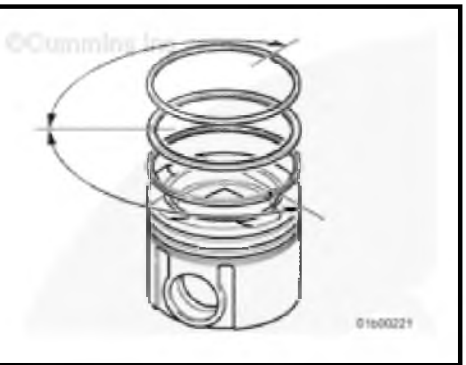


CAUTION

The connecting rods and connecting rod caps are not interchangeable. The connecting rods and connecting rod caps are machined as an assembly. Engine failure will result if they are mixed.

Install the lower bearing shell in the connecting rod cap. Make sure the tang of the bearing shell is in the slot of the connecting rod cap and the end of the bearing is even with the surface of the connecting rod cap.

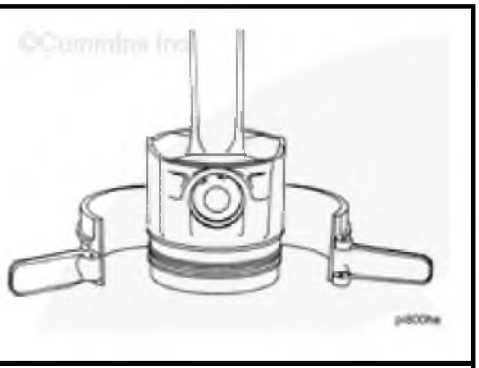


Lubricate the connecting rod capscrews and washers with clean 15W-40 engine oil. Install the washers and capscrews in the connecting rod cap.		
Lubricate the cylinder liner with clean engine oil. The entire liner bore **must** be lubricated.		
Immerse the piston in clean engine oil until the piston rings are covered. Allow the excess oil to drip off the assembly.		
Make sure the ring gap position is still correct. Refer to Procedure 001-047 in Section 1.		

CAUTION

Make sure the rings fit correctly in the piston ring grooves or engine damage can result.

Use piston ring compressor, Part Number 3164459 or equivalent, to install the ring compressor on the piston.



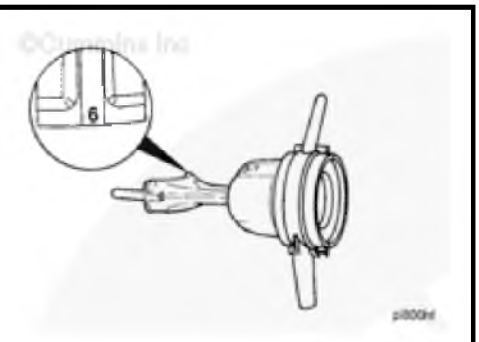
CAUTION

The connecting rod and connecting rod cap are matched set. The cylinder number on the connecting rod and connecting rod cap must be the same, damage to the engine can occur if the connecting rods and connecting rod caps are mismatched.

CAUTION

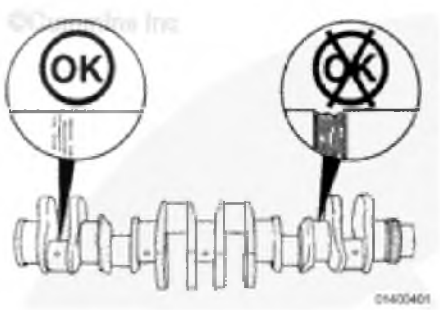
The “EX” stamped on the piston skirt and the part number, cast into the connecting rod, **must** be facing the front of the engine. If the connecting rods are installed backwards engine damage can occur.

Rotate the crankshaft until the journal for the connecting rod to be installed is at top dead center (TDC) and centered in the cylinder bore.



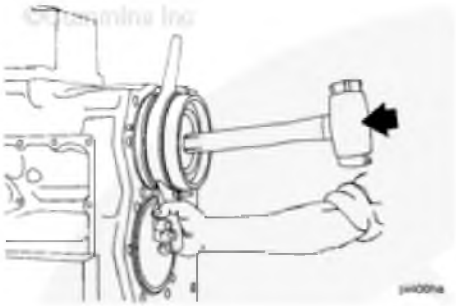
NOTE: The crankshaft is illustrated out of engine for clarity.

Inspect the crankshaft rod journals for damage.



CAUTION

The “EX” stamped on the piston skirt and the part number, cast into the connecting rod, **must** be facing the front of the engine. If the connecting rods are installed backwards engine damage can occur.

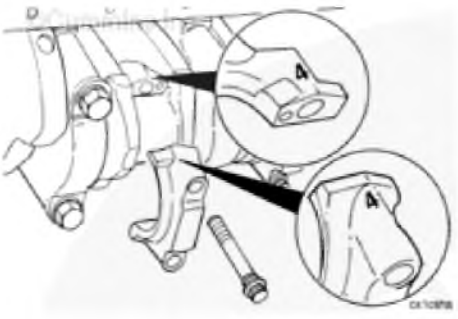


Align the part number, cast into the connecting rod, toward the front of the engine. Install the connecting rod and piston into the cylinder bore until the ring compressor touches the cylinder block. Align the rod with the crankshaft journal.

Hold the ring compressor firmly against the block. Use a wooden hammer handle to push the piston into the liner.

CAUTION

The connecting rod and connecting rod cap are matched set. The cylinder number on the connecting rod and connecting rod cap must be the same, damage to the engine can occur if the connecting rods and connecting rod caps are mismatched.



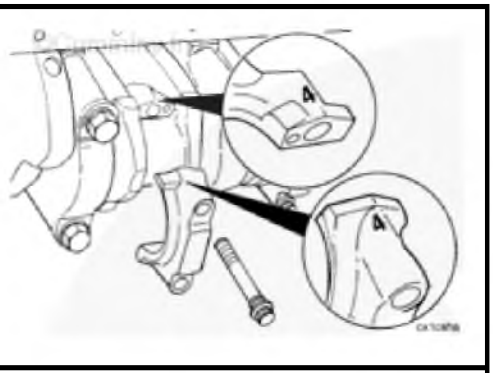
Remove the guide pins and install the connecting rod cap.

Always use the torque-turn method to tighten the connecting rod capscrews.

Use the following steps to tighten the capscrews alternately and evenly.

Torque Value:

1. 196 n.m [145 ft-lb]
2. Tighten 90°

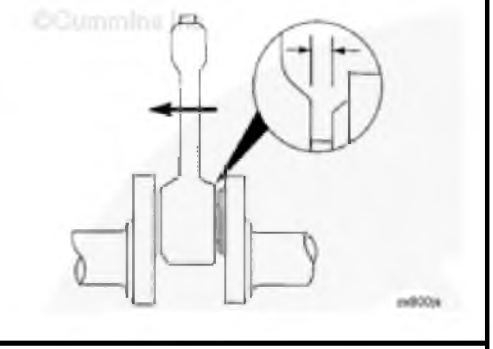


Check the side clearance between the connecting rod and the crankshaft.

The connecting rod **must** move freely from side to side.

Connecting Rod and Crankshaft Side Clearance New or Remanufactured Parts

mm		in
0.200	MIN	0.008
0.374	MAX	0.015



Finishing Steps

- Install the piston cooling nozzles. Refer to Procedure 001-046 in Section 1.
- Install the cylinder head. Refer to Procedure 002-004.
- Install the rocker lever housing. Refer to Procedure 003-013 in

Section 3. • Install the push rods and crossheads. • Install the rocker lever assembly. Refer to Procedure 003-009 in Section 3. • Adjust the overhead set. Refer to Procedure 003-006. • Install the rocker lever cover. Refer to Procedure 003-011 in Section 3. • Install the exhaust manifold. Refer to Procedure 011-007 in Section 11. • Install the intake manifold. Refer to Procedure 010-023. • Install the oil suction tube and block stiffener plate. Refer to Procedure 001-089 in Section 1. • Install the lubricating oil pan. Refer to Procedure 007-025 in Section 7. • Fill the engine with clean 15W-40 lubricating oil. Refer to Procedure 007-037 in Section 7 for engine oil capacity. • Fill the cooling system. Refer to Procedure 008-018 in Section 8. • Connect the battery or supply air to the starter.		

Last Modified: 24-Aug-2010

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001-055 Gear Train Backlash, Front

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery last.

WARNING

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

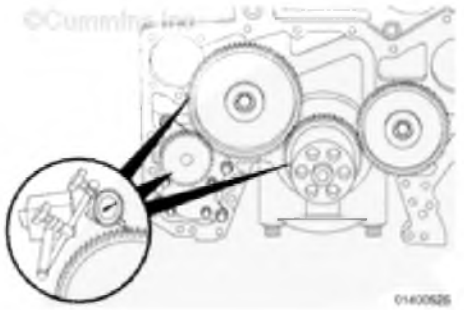
- Disconnect the batteries and air starter to prevent accidental starting.
- Drain the cooling system. Refer to Procedure 008-018.
- Remove the fan and fan spacer(s). Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the alternator belt and alternator. Refer to Procedure 013-001.
- Remove the fan belt tensioner. Refer to Procedure 008-036.

- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the front crankshaft seal. Refer to Procedure 001-023.
- Remove the alternator drive gear and shaft. Refer to Procedure 009-009.
- Remove the front engine mount. Refer to Procedure 016-010.
- Remove the front gear cover. Refer to Procedure 001-031.

Measure

CAUTION

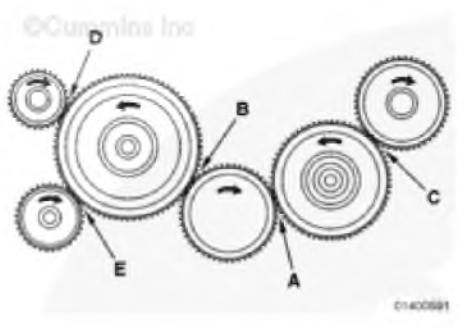
The adjacent (engaging) gear must not turn as the gear being measured is turned.



Position a dial indicator so the tip is contacting the surface of the gear tooth as shown. Do **not** allow the mating gear to turn.

Rotate the gear being measured **clockwise**. Position the indicator to zero, rotate the gear **counterclockwise**, and read the indicator.

Measure the gear backlash.



Gear Train Backlash		
	MIN	MAX
A	0.144 mm [0.006	0.320 mm [0.013

	in]	in]
B	0.134 mm [0.005 in]	0.362 mm [0.014 in]
C	0.114 mm [0.004 in]	0.320 mm [0.013 in]
D	0.121 mm [0.005 in]	0.333 mm [0.013 in]
E	0.121 mm [0.005 in]	0.333 mm [0.013 in]

Finishing Steps

- Install the front cover. Refer to Procedure 001-031.
- Install the front engine mount. Refer to Procedure 016-010.
- Install the alternator drive gear and shaft. Refer to 009-009.
- Install the front crankshaft seal. Refer to Procedure 001-023.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the fan belt tensioner. Refer to Procedure 008-036.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator belt. Refer to Procedure 013-005.
- Install the fan belt. Refer to Procedure 008-002.
- Install the fan spacer(s) and fan. Refer to Procedure 008-040.
- Install new oil filters. Refer to Procedure 007-013.
- Install the front gear cover. Refer to Procedure 001-031.
- Connect the batteries.
- Fill the cooling system. Refer to Procedure 008-018.

• Operate the engine to normal operating temperature. Check for leaks.		

Last Modified: 28-Jul-2003

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001-056 Camshaft Thrust Bearing

Preparatory Steps

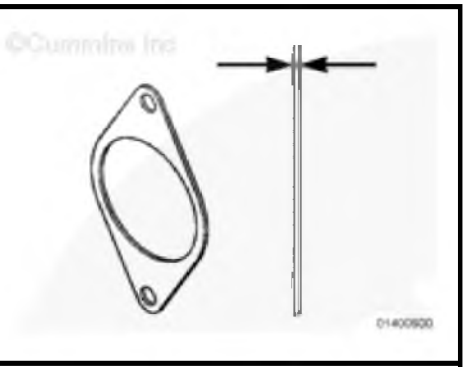
- Remove the flywheel housing and all related components. Refer to Procedure 016-006 in Section 16.
- Remove the camshaft gear. Refer to Procedure 001-008 in Section 1.

Inspect for Reuse

Inspect the thrust bearing for damage. Measure the thickness.

Camshaft Thrust Bearing Thickness

mm		in
3.20	MIN	0.126
5.00	MAX	0.197



Finishing Steps

- Install the camshaft gear. Refer to Procedure 001-008 in Section 1.
- Measure the gear train backlash. Refer to Procedure 001-055 in Section 1.
- Install the flywheel housing and all related components. Refer to Procedure 016-006 in Section 16.

Last Modified: 07-Jan-2011

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001-089 Block Stiffener Plate

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Drain the lubricating oil and remove the oil pan. Refer to Procedure 007-025.

Remove

WARNING

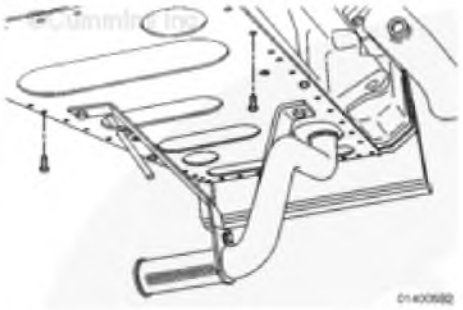
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

WARNING

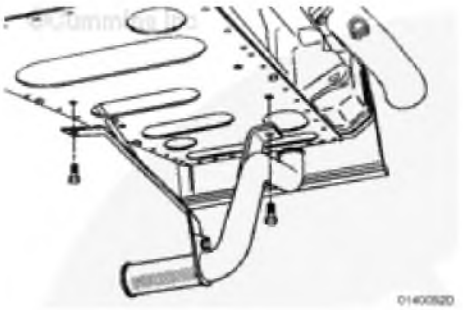
The block stiffener plate is attached by the suction tube capscrews. Removing these screws prior to securing the stiffener plate can cause the plate to drop and cause personal injury.

Install the four oil pan capscrews in the stiffener plate at the location in the illustration.

Remove the oil suction tube brackets and oil suction tube. Refer to Procedure 007-035 for clean and inspect of the lubricating oil suction tube.

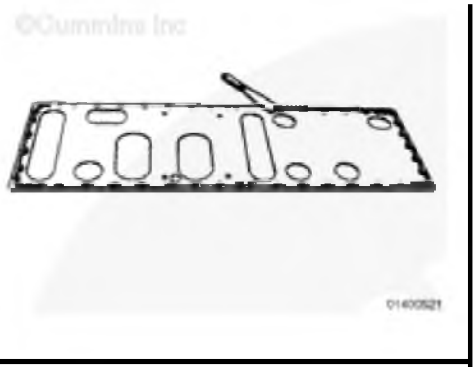


Remove the stiffener plate capscrews and remove the stiffener plate.



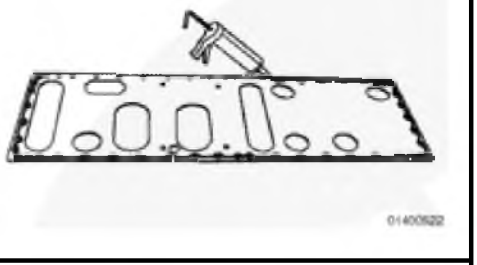
Clean

Clean the gasket sealant from the block stiffener plate, oil pan, and block.



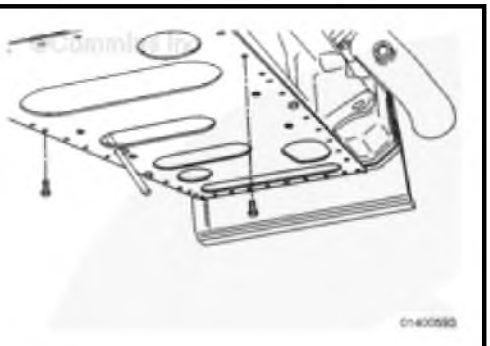
Install

Place a bead of gasket sealer 2 to 3 mm [0.08 to 0.12 in] on the stiffener plate.



WARNING

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



CAUTION

The lubricating oil pan must be installed within 30 minutes of gasket sealant application. Improper sealing

and engine damage can result.

Place the stiffener plate on the block and install the four capscrews.

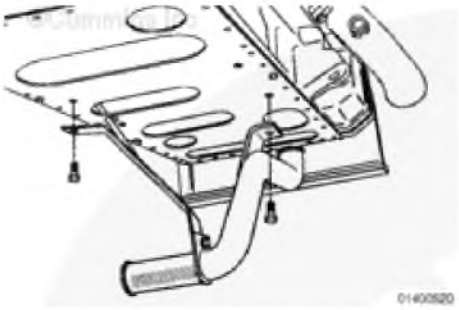
Place an o-ring on the suction tube.

Install the suction tube.

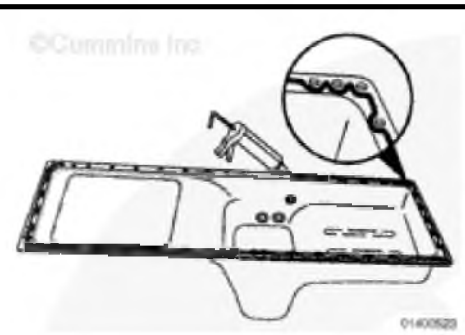
Tighten the capscrews.

Torque Value: 66 n.m [48 ft-lb]

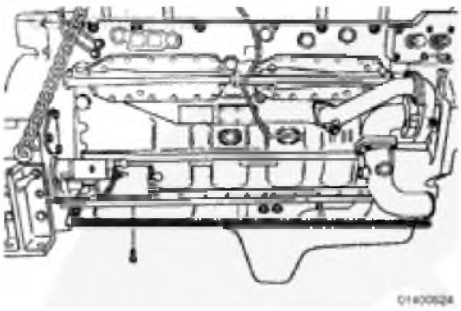
Remove the temporary mounting capscrews.



Place a bead of gasket sealer 2 to 3 mm [0.08 to 0.12 in] wide on the oil pan.



Install the oil pan. Refer to Procedure 007-025 for capscrew torque sequence.



Finishing Steps

• Fill the oil pan with clean 15W-40 lubricating oil. Refer to Procedure 007-037. • Operate the engine until the engine is at 70°C [160°F] coolant temperature and check for leaks.		

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001-097 Idler Gear, Alternator Drive

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery last.

WARNING

A small amount of coolant can leak when servicing the coolant filter with the shutoff valve in the OFF position. To reduce the possibility of personal injury, avoid contact with hot coolant.

WARNING

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

- Disconnect the batteries and air starter to prevent accidental starting.
- Remove the fan and fan spacer(s). Refer to Procedure 008-040.

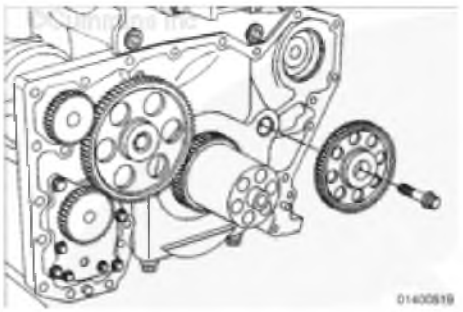
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the alternator belt and alternator. Refer to Procedure 013-001.
- Remove the fan belt tensioner assembly. Refer to Procedure 008-029.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the alternator drive gear and shaft. Refer to Procedure 009-009.
- Remove the front crankshaft seal. Refer to Procedure 001-023.
- Remove the oil pan and related components. Refer to Procedure 007-025.
- Remove the block stiffener plate. Refer to Procedure 001-089.
- Remove the front gear cover. Refer to Procedure 001-031.

Remove

The bolt-in idler shafts have a flange that require the shaft, the idler gear, and the thrust washer to be removed as an assembly.

Remove the mounting capscrew from the idler gear.

Remove the gear assembly using two pry bars to gently pry the gear and the shaft from the block.



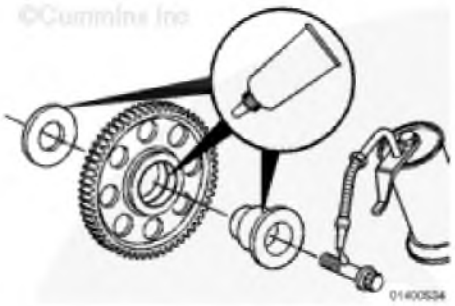
Install

CAUTION

The chamfer on the thrust washer must be turned toward the gear.

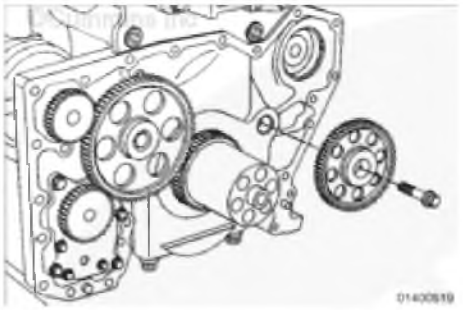
Use Lubriplate™ 105, or equivalent. Lubricate the gear bushing, shaft, and the thrust washer.

Use engine oil to lubricate the capscrew. Assemble the parts as shown.



Use the capscrew to pull the shaft into the bore. Tighten the capscrew.

Torque Value: 277 n.m [204 ft-lb]



Use a dial indicator to measure the idler gear end clearance.

Idler Gear, Lubricating - Idler Gear End Clearance		
mm		in
0.05	MIN	0.002
0.17	MAX	0.006

If the clearance is **not** within specifications, check for foreign material between the parts or check for proper location of the thrust washer. Oversize

washers are available. Check the idler gear backlash. Refer to Procedure 001-055.		

Finishing Steps

• Install the front gear cover. Refer to Procedure 001-031. • Install the alternator drive gear and shaft. Refer to Procedure 009-009. • Install the front crankshaft seal. Refer to Procedure 001-023. • Install the block stiffener plate. Refer to Procedure 001-089. • Install the vibration damper. Refer to Procedure 001-052. • Install the fan belt tensioner assembly. Refer to Procedure 008-029. • Install the alternator. Refer to Procedure 013-001. • Install the alternator belt. Refer to Procedure 013-005. • Install the fan belt. Refer to Procedure 008-002. • Install the fan spacer(s) and fan. Refer to Procedure 008-040. • Install the oil pan and related components. Refer to Procedure 007-025. • Install new oil filters. Refer to Procedure 007-013. • Connect the batteries. • Operate the engine to normal operating temperature. Check for leaks.	 	

Last Modified: 30-May-2003

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001-098 Idler Gear Oil Pump and Water Pump

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery last.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

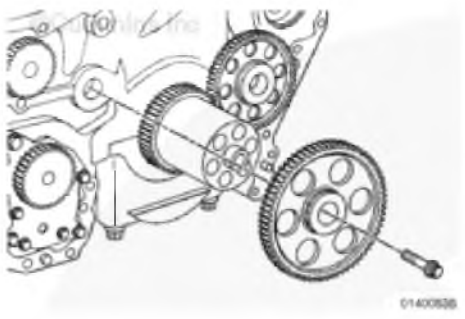
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

- Disconnect the batteries and air starter to prevent accidental starting.
- Drain the lubricating oil system. Refer to Procedure 007-025.
- Remove the oil pan. Refer to Procedure 007-025.
- Remove the block stiffener plate. Refer to Procedure 001-089.
- Remove the fan and fan spacer(s). Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the alternator belt and alternator. Refer to Procedure 013-001.
- Remove the fan belt tensioner assembly. Refer to Procedure 008-087.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the front crankshaft seal. Refer to Procedure 001-023.
- Remove the front gear cover. Refer to Procedure 001-031.

Remove

The bolt-in idler shafts have a flange that require the shaft, the idler gear, and the thrust washer to be removed as an assembly.

Remove the mounting capscrew from the idler gear.



Remove the gear assembly using two pry bars to gently pry the gear and the shaft from the block.

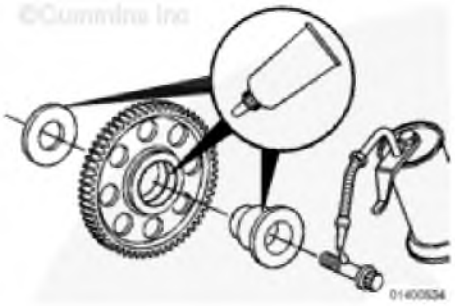
Install

CAUTION

The chamfer on the thrust washer must be turned toward the gear.

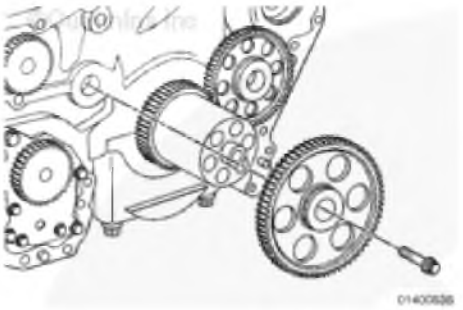
Use Lubriplate™ 105, or equivalent. Lubricate the gear bushing, shaft, and the thrust washer.

Use clean 15W-40 engine oil to lubricate the capscrew. Assemble the parts as shown.



Use the capscrew to pull the shaft into the bore. Tighten the capscrew.

Torque Value: 277 n.m [204 ft-lb]



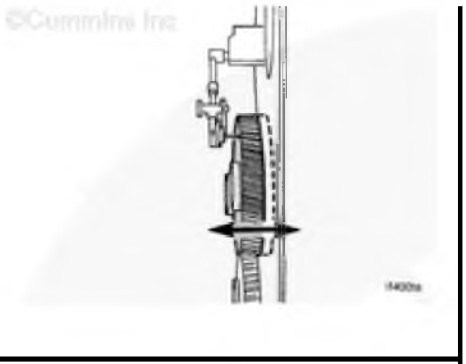
Use a dial indicator to measure the idler gear end clearance.

Water Pump - Idler Gear End

mm	Clearance	in
0.05	MIN	0.002
0.17	MAX	0.006

If the clearance is **not** within specifications, check for foreign material between the parts or check for proper location of the thrust washers. Oversize washers are available.

Check the idler gear backlash. Refer to Procedure 001-055.



Finishing Steps

- Install the front gear cover. Refer to Procedure 001-031.
- Install the front crankshaft seal. Refer to Procedure 001-023.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the fan belt tensioner assembly. Refer to Procedure 008-087.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator belt. Refer to Procedure 013-005.
- Install the fan belt. Refer to Procedure 008-002.
- Install the fan spacer(s) and fan. Refer to Procedure 008-040.
- Install new oil filters. Refer to Procedure 007-013.
- Install the block stiffener plate. Refer to Procedure 001-089.
- Install the oil pan. Refer to Procedure 007-025.
- Fill the lubricating oil system. Refer to Procedure 001-037).

• Connect the batteries. • Operate the engine to normal operating temperature. Check for leaks.		

Last Modified: 30-May-2003

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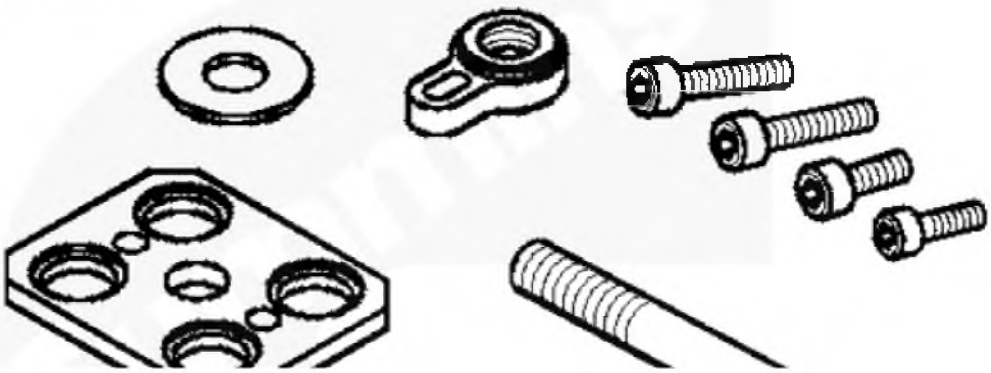
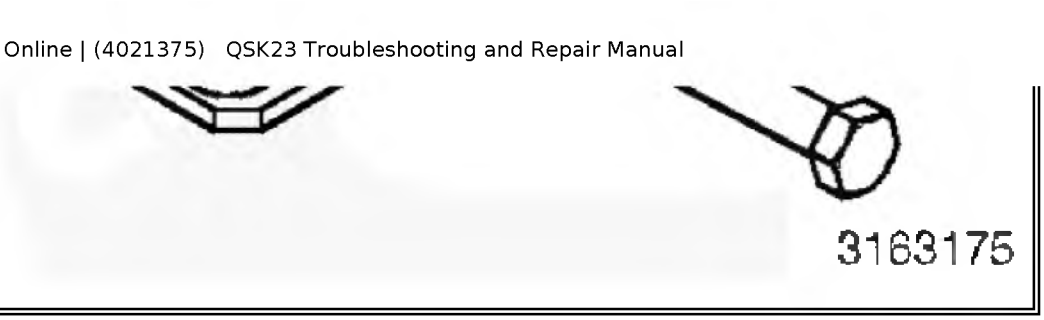
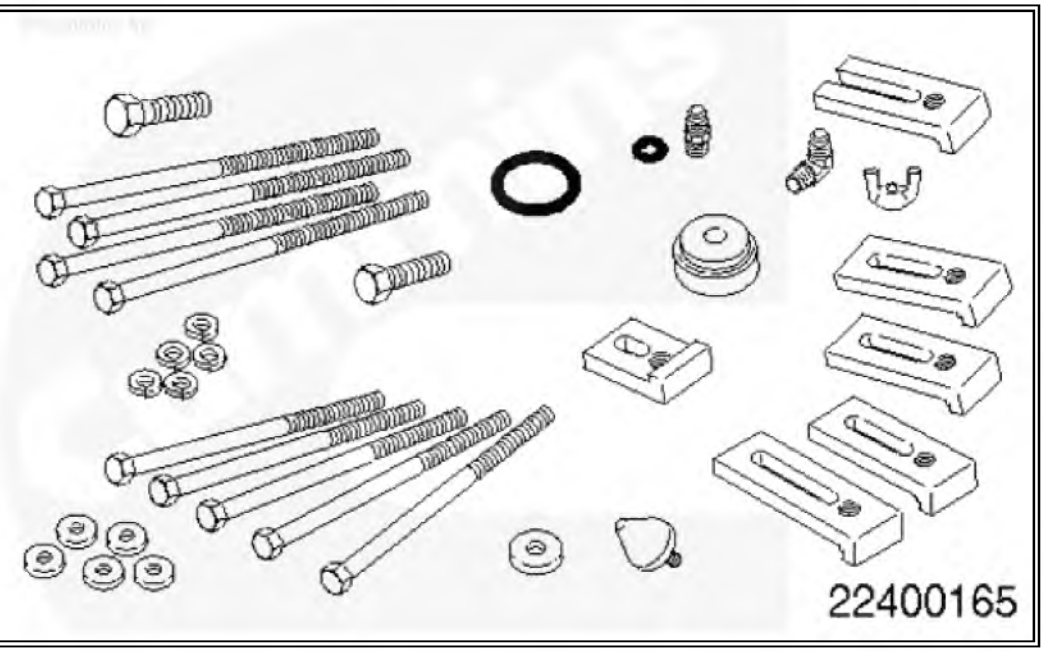
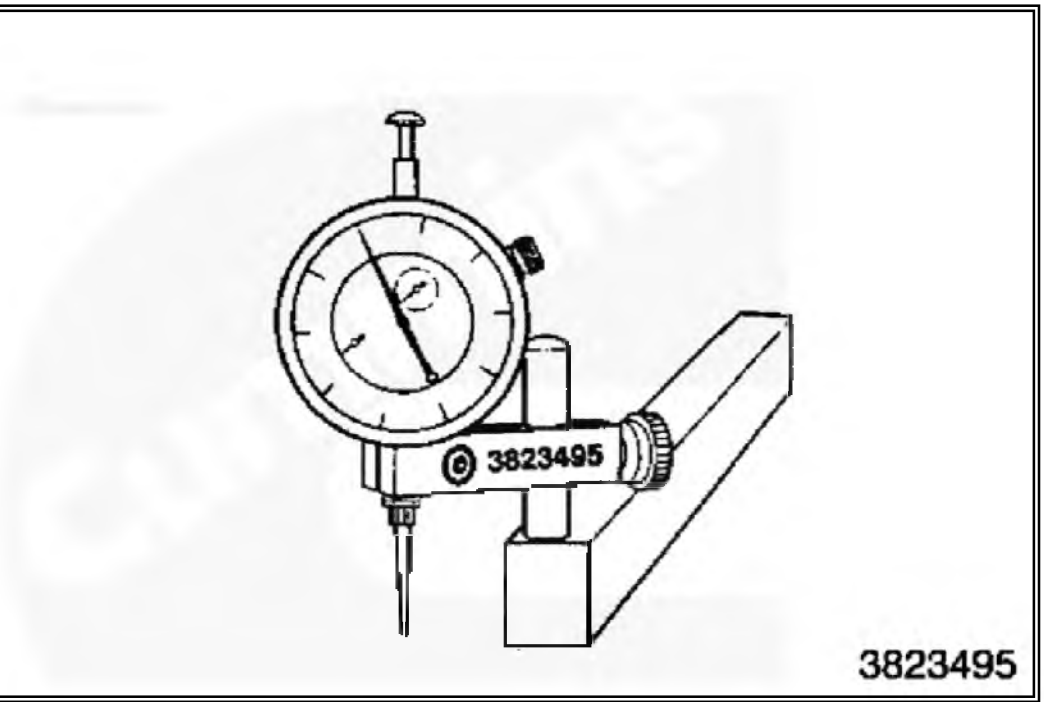
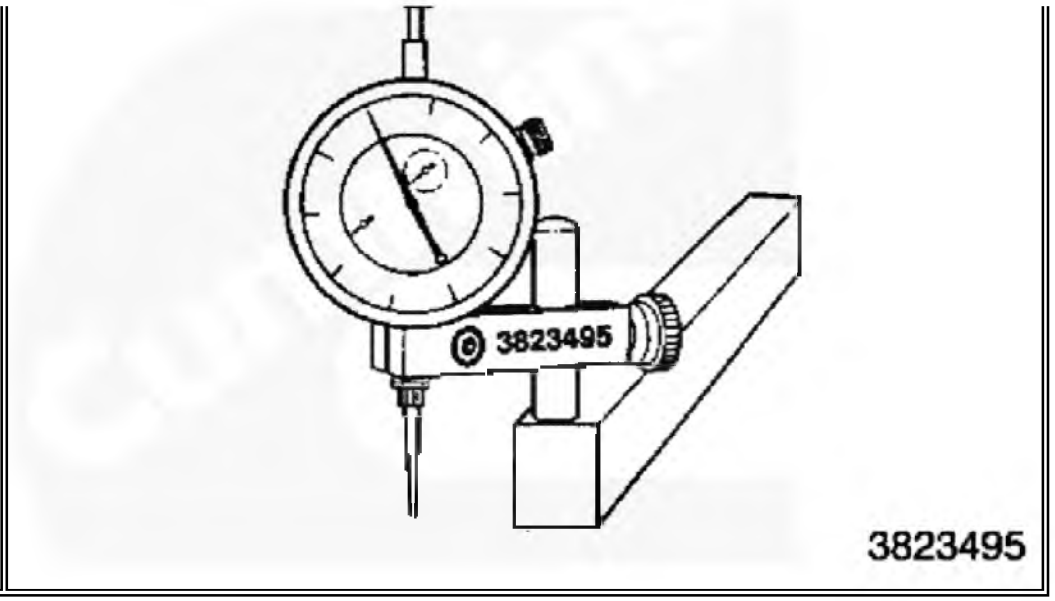
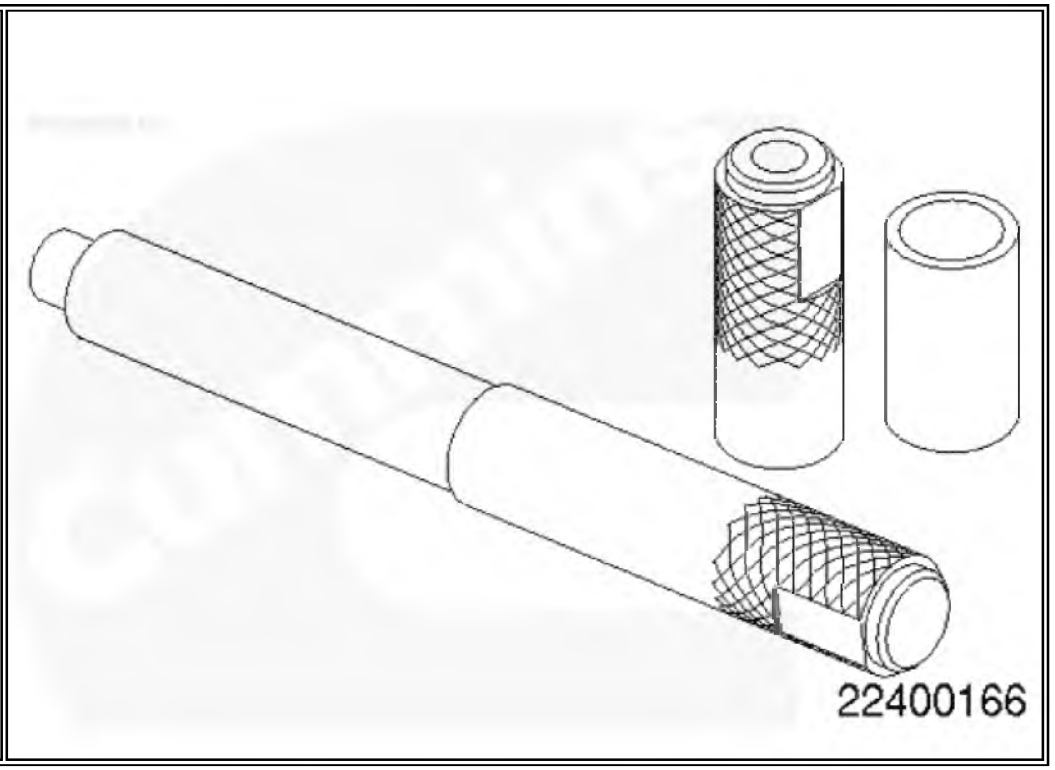
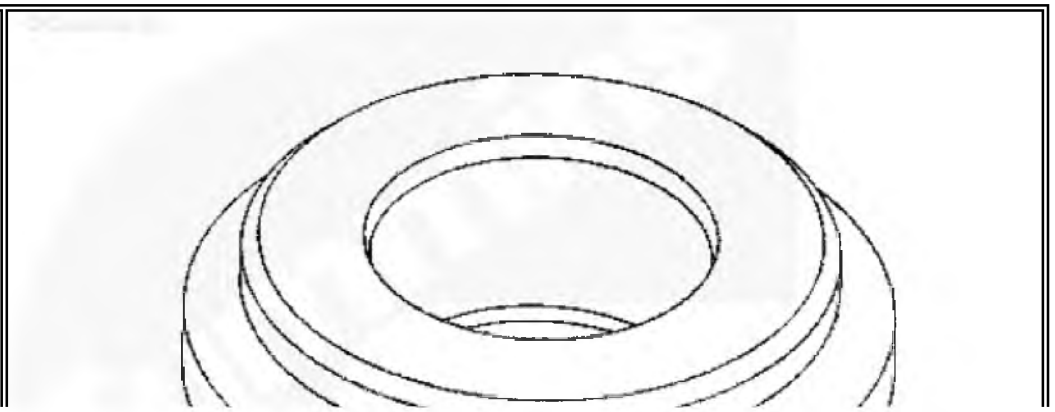
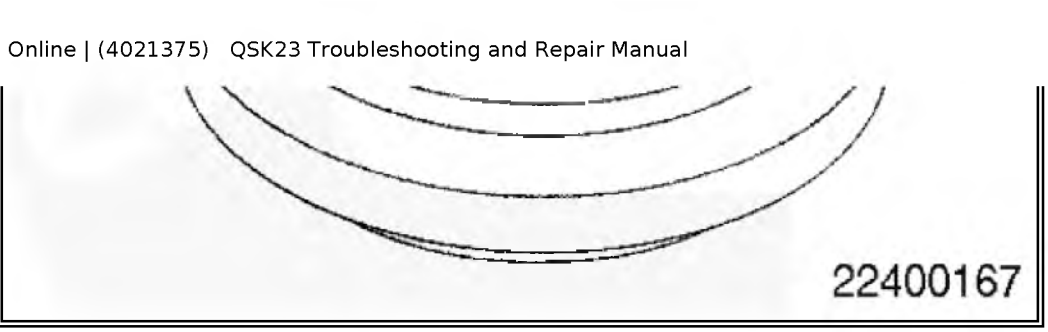
022-001 Service Tools

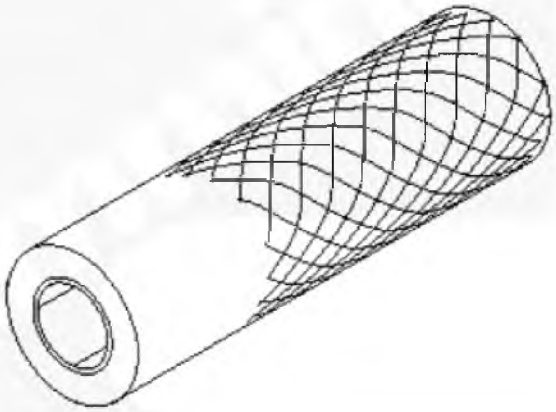
Cylinder Head

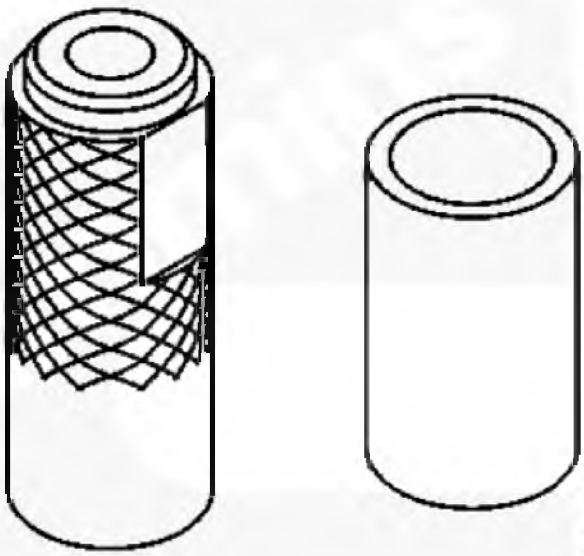
Tool Number 3164435	**Cylinder Head Capscrew Length Gauge** Use to check the length of the cylinder capscrews.	
Tool Number 3163606	**Valve Spring Compressor** Use to compress the valve spring to allow the valve to be removed or installed. Use with Plate, Part Number 3164594 (M10 x 1.5	

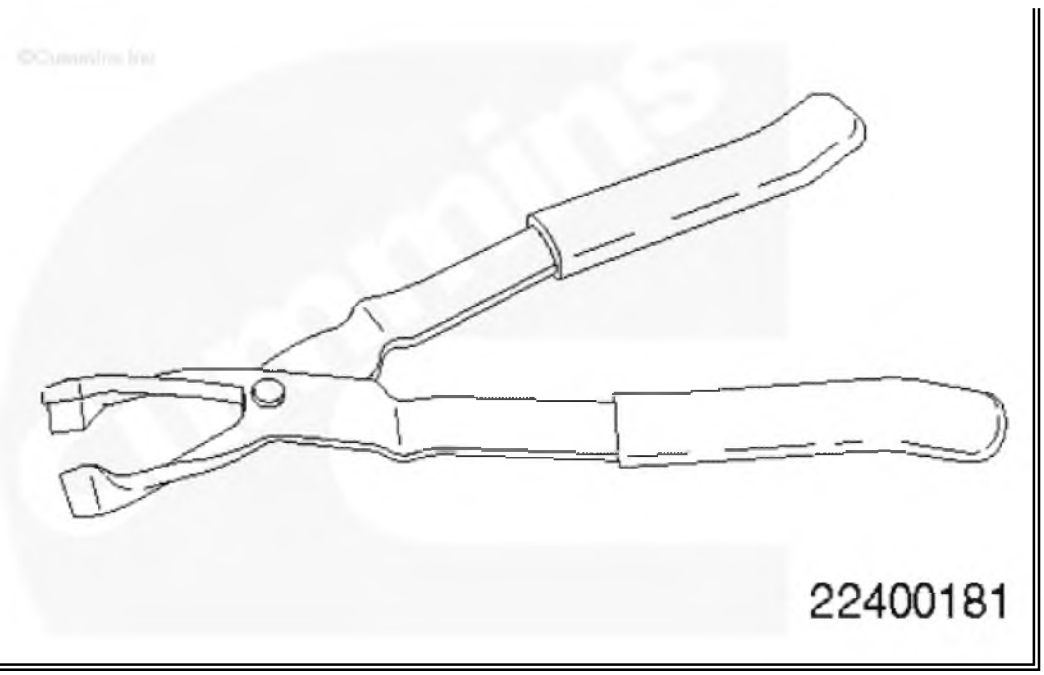
	thread).	
Tool Number 3164341	**Cylinder Head Leak Test Kit** Use to check for coolant leaks in the cylinder head. Use with pressure regulator assembly, Part Number 3164231.	
Tool Number 3164438	**Depth Gauge Assembly** Use to measure cylinder liner counterbore ledge angle, injector protrusion, liner protrusion, counterbore depths, and valve intrusion and/or protrusion.	
	Depth	

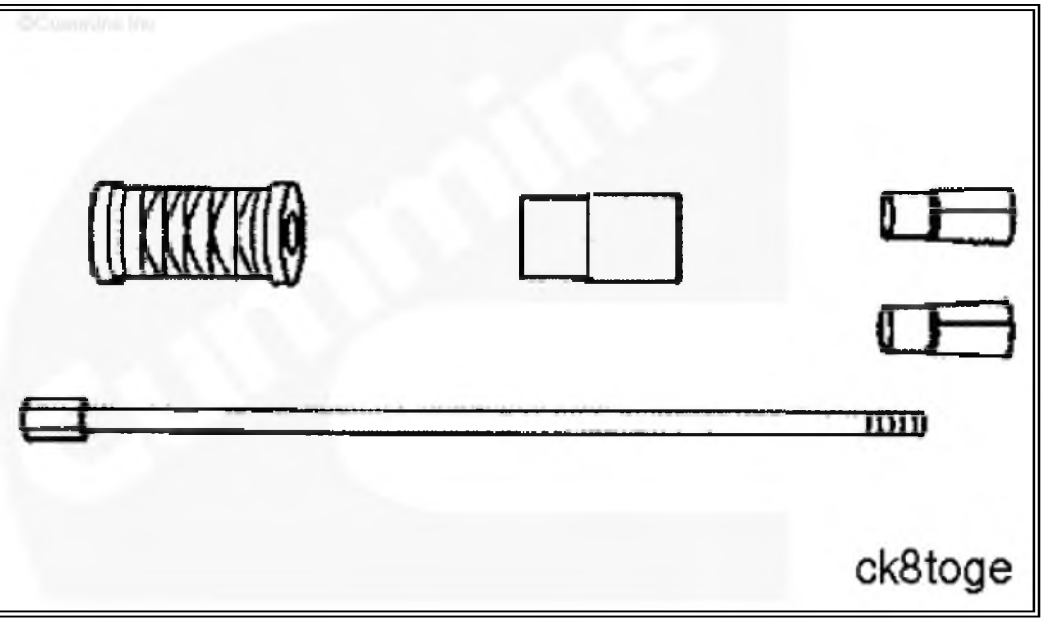
Tool Number 3823495	**Gauge Assembly** Use to measure cylinder liner counterbore ledge angle, injector protrusion, liner protrusion, counterbore depths, and valve intrusion and/or protrusion.	
Tool Number 3164427	**Valve Guide Replacer** Use to remove and install valve guides.	
Tool Number 3164790	**Valve Seat Installer** Use to install valve seats. Use with valve seat installer	

	Installer, Part Number 3164978.	 22400167

Tool Number 3164373	**Crosshead Guide Installer** Use to install crosshead guides.	 22400183

Tool Number 3164430	**Valve Stem Seal Installer** Use to install valve stem seals.	 22400182

Tool Number 3163293	**Boot Pliers** Use to remove valve stem seals.	

Tool Number 3163720	**Dowel Pin Extractor** Use to remove dowel pins and crosshead guides.	

Last Modified: 23-Sep-2003

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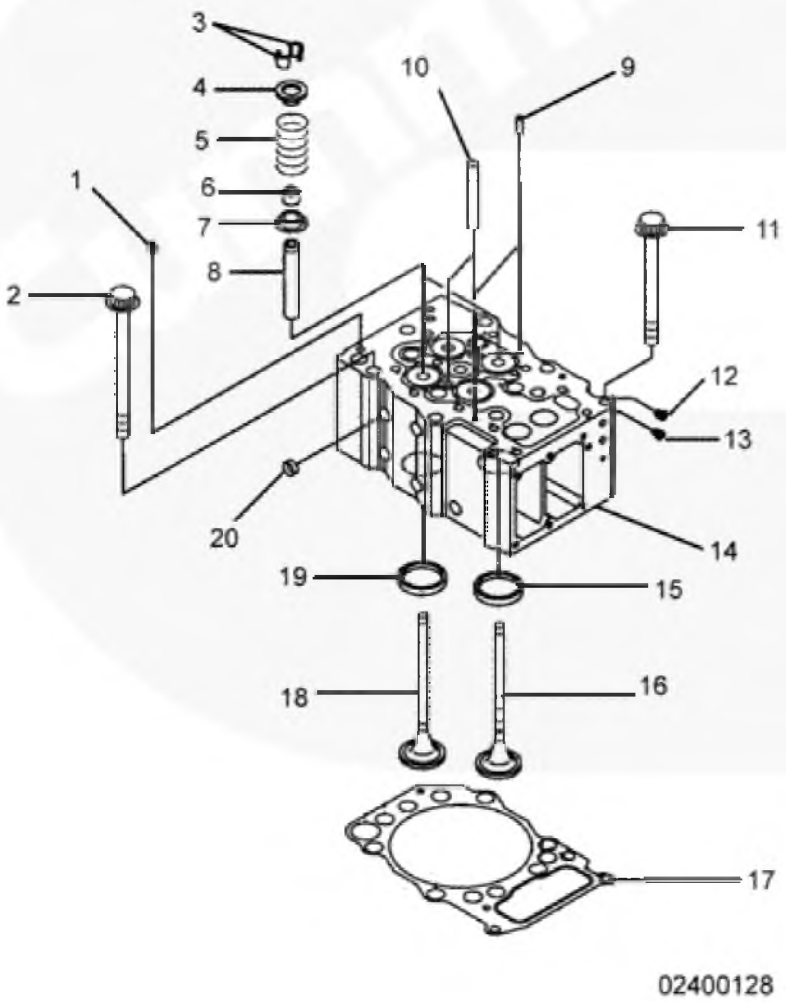
002-004 Cylinder Head

Exploded View



1. Pipe plug
2. Capscrew, 12-point (7 large)
3. Valve collet
4. Valve spring retainer, upper
5. Valve spring
6. Valve spring seal
7. Valve spring retainer, lower
8. Valve guide
9. Dowel pin
10. Crosshead guide
11. Capscrew, 12-point (2 small)
12. Pipe plug
13. Pipe plug
14. Cylinder head
15. Exhaust valve seat
16. Exhaust valve
17. Cylinder head gasket
18. Intake valve
19. Intake valve seat
20. Expansion plug.

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap.

Heated coolant spray or steam can cause personal injury.

WARNING

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

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

- Disconnect the batteries or air supply to the air starter to reduce the possibility of accidental starting of the engine.
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Remove the crankcase breather, if necessary. Refer to Procedure 003-001 in Section 3.
- Remove the exhaust manifold. Refer to Procedure 011-007 in Section 11.
- Remove the intake manifold. Refer to Procedure 010-023 in Section 10.
- Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Remove the rocker levers. Refer to Procedure 003-009 in Section 3.
- Remove the push rods. Refer to Procedure 004-014 in Section 4.
- Remove the rocker lever housing. Refer to ProcedureRefer to Procedure 003-013 in Section 3.
- Remove the injector. Refer to Procedure 006-026 in Section 6.

Remove

WARNING

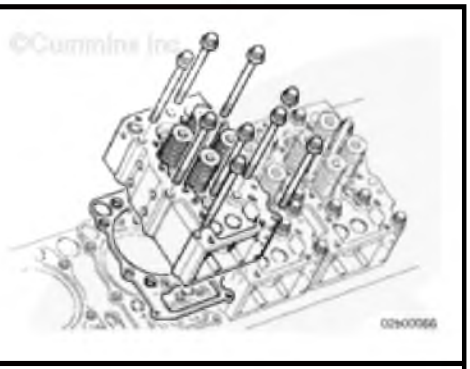
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Remove the coolant vent line from top of the cylinder heads.

Remove the nine cylinder head mounting capscrews.

Remove the cylinder head.

Remove and discard the cylinder head gasket.

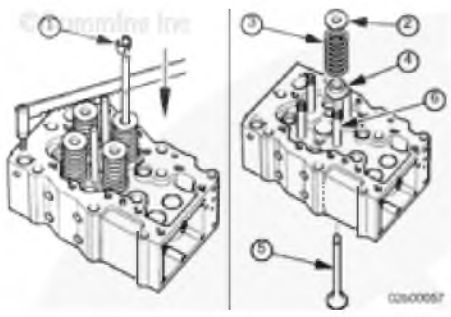


Disassemble

WARNING

The valve springs are under compression. Be cautious when using the valve spring compressor to reduce the possibility of personal injury.

Use a valve spring compressor, Part Number 3163606 or the equivalent) or a valve spring compressor stand, Part Number ST-1022 (or the equivalent). A



valve spring compressor plate, Part Number 3164594 can be used with 3163606 and ST-1022 to compress all four valve springs at the same time. An air operated valve spring compressor, Part Number 3375960 (or the equivalent) can also be used.

Mark the valve for location prior to removal. The intake and exhaust valves are different. This practice will aid the assembly procedure.

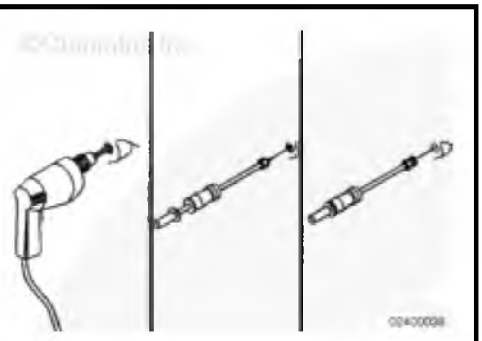
Remove the following parts:

1. Valve collet
2. Valve spring retainer
3. Valve spring
4. Wear plate
5. Valve
6. Valve stem seal.

Discard the valve collets and valve stem seals.

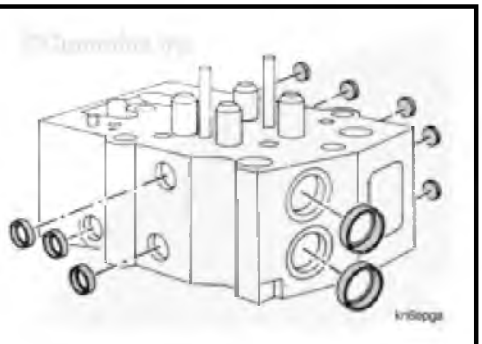
Use a drill, sheet metal screw, and the following parts from the light-duty puller kit, Part Number 3375784, to remove the cup plugs.

- Slide hammer
- Hook.



Remove and discard the 17 cup plugs.

Cup plugs **must** be removed from the head casting for cleaning purposes.

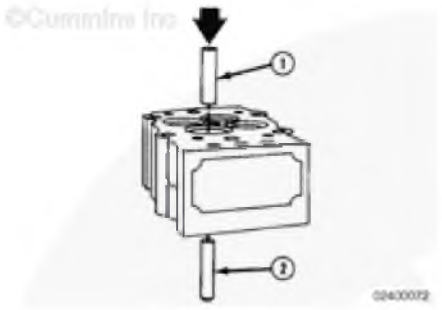


CAUTION

If a valve guide is replaced, the valve seat insert for the valve guide must be ground or severe engine damage can result.

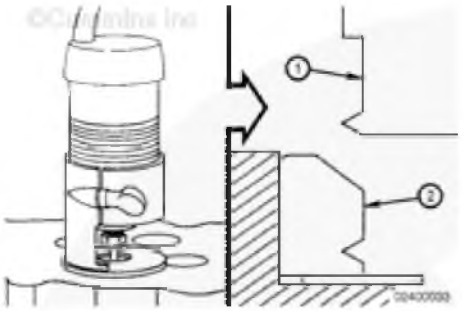
Only replace the valve guide if it is **not** within specifications.

Use an arbor press and valve guide replacer (1), Part Number 3164427, to remove the worn valve guide (2).

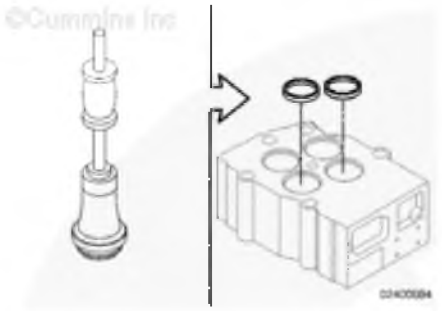


Use a valve seat cutter kit, Part Number 3376405, or equivalent.

Machine a groove in the seat (2) as close to the bottom of the bore as possible. This will allow the valve seat extractor (1) to be used.



Use a slide hammer remover, Part Number 3376617, and seat extractor, Part Number ST-1323-1 to remove the valve seats.



Clean and Inspect for Reuse

WARNING

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

Clean the cylinder heads, capscrews, valve spring retainers, and valves with solvent.

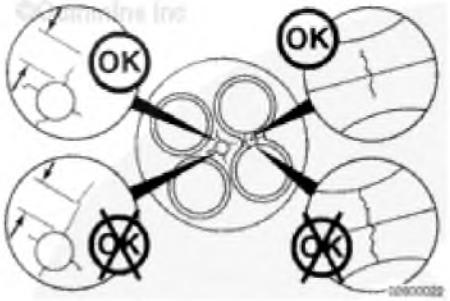
Check for cracks on the combustion surface.

If a crack around the injector bore exceeds the maximum length, the cylinder head **must** be replaced.

Injector Bore Allowable Crack Length

mm		in
6.4	MAX	0.250

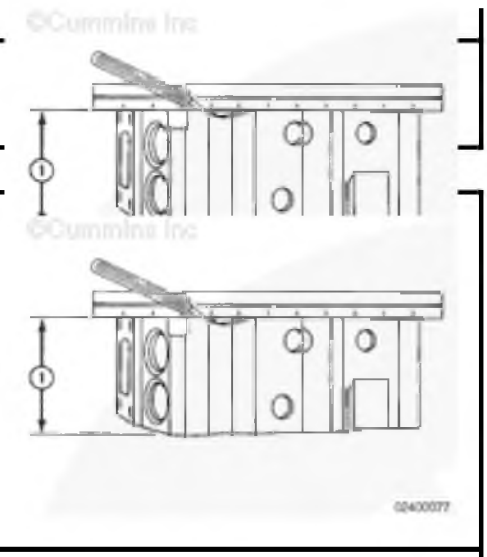
Both ends of a crack between the valve **must** be visible. If one crack extends into the valve seat bore (behind the valve seat), the condition of the cylinder head is questionable.



Use a straightedge to measure the flatness of the head gasket surface.

The head **must** be resurfaced, or replaced if a feeler gauge larger than 0.10 mm [0.004 in] will fit between the straightedge

and the cylinder head.



The head can be resurfaced as long as the head thickness (1) measurement is within specifications.

Minimum Head Thickness (1)

mm		in
150.65	MIN	5.93

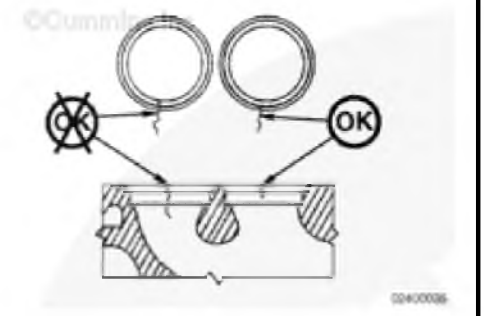
If the head is resurfaced, make certain the injector protrusion and valve depth in the head are adjusted properly.

Clean the valve seat insert bore.

Check the length of any cracks extending into the valve seat insert bore.

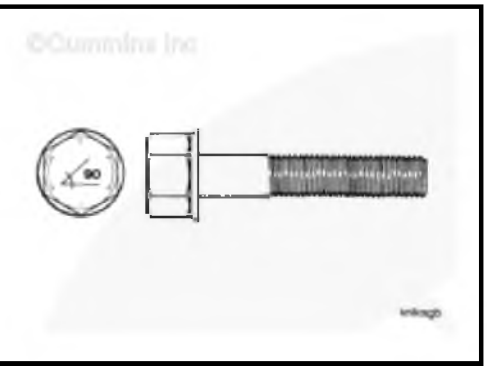
The cylinder head **must** be replaced if a crack extends into the bottom of the bore.

Sometimes it is possible to remove the crack by machining the head to use an oversize valve seat insert.



NOTE: The torque plus angle method is used only on the seven larger 233 mm [9.173 in] cylinder head capscrews.

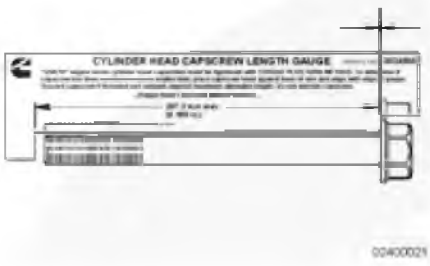
The torque plus angle method of installation places the cylinder head capscrew beyond the yield point and permanently stretches the capscrew. These capscrews can be reused throughout the life of the engine unless the capscrew exceeds the specified free length.



The free length **must** be checked to avoid bottoming in the block during installation and to make sure the capscrew still has the proper strength.

A cylinder head capscrew length gauge has been developed to check the capscrew free length.

Use capscrew length gauge, Part Number 3164435, to check the capscrew free length. Place the head of the capscrew in the slot with the flange against the base of the slot.



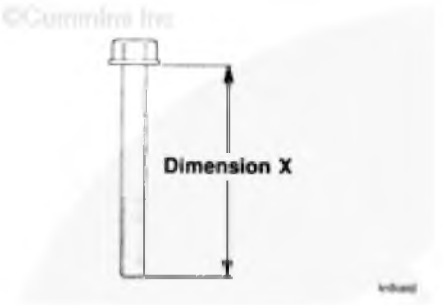
If the end of the capscrew touches the foot of the gauge, the capscrew is too long and **must** be discarded.

If there is clearance between the end of the capscrew and the bottom base of the tool, the capscrew is acceptable for reuse.

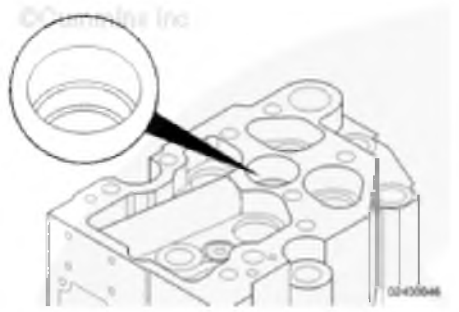
The capscrew can also be checked using a set of calipers. The maximum allowable free length is measured from the bottom of the flange to the end of the capscrew (dimension X).

Cylinder Head Capscrew Free Length

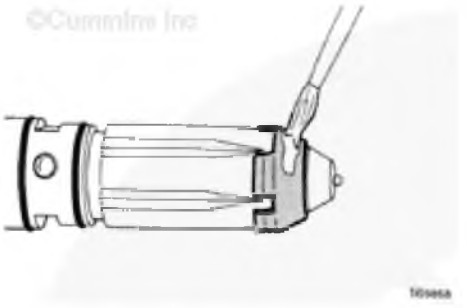
mm		in
233	MAX	9.173



Inspect the injector bore for cracks or other damage.



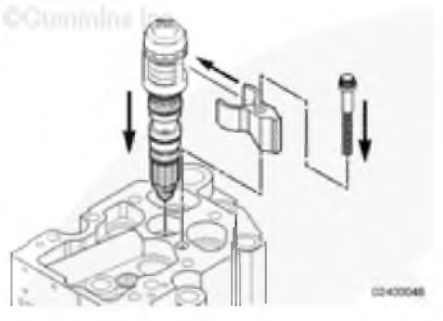
Apply a thin coating of Prussian blue on the sealing ring.



CAUTION

Support the cylinder head to reduce the risk of damage to the injector tip that protrudes from the combustion face.

Install the injector and injector hold-down clamp.



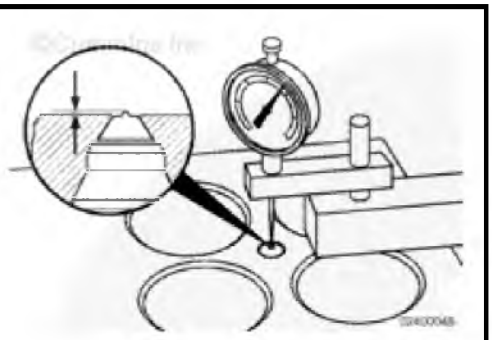
Tighten the hold-down capscrew.

Torque Value:

1. 34 n.m [25 ft-lb]
2. Tighten 90 degrees.

Use a gauge block, Part Number 3164438, or equivalent, to measure the injector protrusion.

Measure as shown in the illustration.



Injector Protrusion

mm		in
2.42	MIN	0.095
2.92	MAX	0.115

If the protrusion is **not** within specifications, use an oversize sealing ring. Sealing rings are available in various sizes.

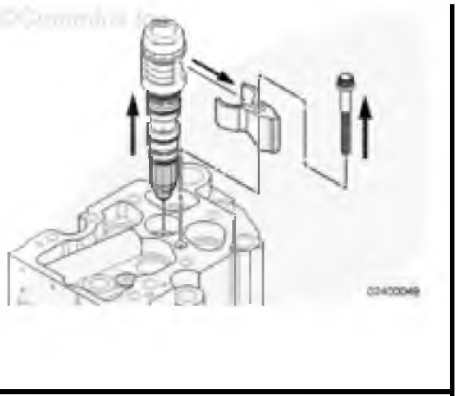
Injector Sealing Rings

	mm		in
Wall thickness	0.343	MIN	0.0135
	0.419	MAX	0.0165
Protrusion change	0.00	NOM	0.000
Wall thickness	0.470	MIN	0.0185
	0.546	MAX	0.0215
Protrusion change	0.25	NOM	0.010
Wall thickness	0.597	MIN	0.0235
	0.673	MAX	0.0265
Protrusion change	0.51	NOM	0.020
Wall thickness	0.724	MIN	0.0285
	0.800	MAX	0.0315
Protrusion change	0.76	NOM	0.030

The 0.343/0.419 mm [0.0135/0.0165 in] is the standard sealing ring.

Remove the injector hold-down clamp capscrew.

Remove the injector and injector hold-down clamp.



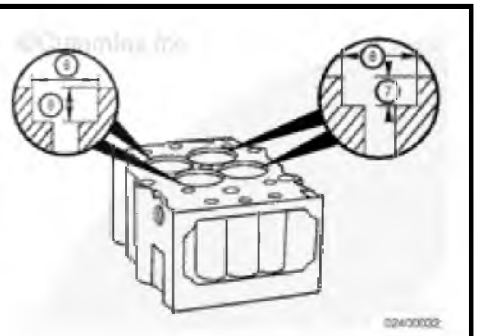
Inspect the contact pattern in the injector bore. A blue band 1.52 mm [0.060 in] wide and 360 degrees full circumference minimum **must** be visible.

If the pattern does **not** meet the specification, clean the injector bore with a tapered brush and inspect the seating pattern again. The cylinder head **must** be replaced or repaired if it is **not** within specifications.

If the valve seat inserts have been removed, measure the inside diameter and the depth of the insert bore in the head.

Valve Seat Bore Measurements

	mm		in
Intake Diameter	64.00	MIN	2.519
	64.019	MAX	2.520
Intake Depth	11.30	MIN	0.445
	11.50	MAX	0.452
Exhaust Diameter	63.60	MIN	2.504
	63.619	MAX	2.505
Exhaust Depth	12.20	MIN	0.480
	12.40	MAX	0.448



If the inside diameter is **not** within specifications, use an oversize seat.

Oversize valve seat inserts are available in the following sizes. Machine the valve insert bore in the head. A press fit within 0.064 to 0.114 mm [0.0025 to 0.0045 in] between the valve seat insert and the valve seat insert bore **must** be maintained.

Outside Diameter Oversize	Depth (Thickness) Oversize
0.25 mm [0.010 in]	Standard
0.50 mm [0.020 in]	0.12 mm [0.005 in]
0.75 mm [0.030 in]	0.25 mm [0.010 in]
1.00 mm [0.040 in]	0.38 mm [0.015 in]

Inspect the valve collet grooves for wear.

Measure the outside diameter of the valve stem.

Valve Stem Outside Diameter — Intake

mm		in
11.920	MIN	0.469
11.940	MAX	0.470

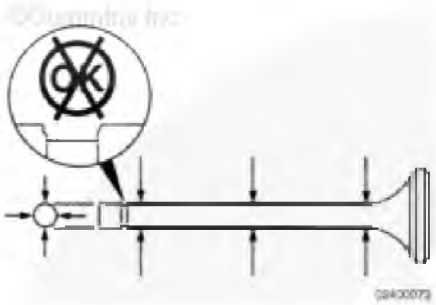
Valve Stem Outside Diameter — Exhaust

mm		in
11.893	MIN	0.468
11.908	MAX	0.469

Inspect the valve springs for notches or cracks.

If the notches or cracks are present do **not** reuse the valve springs.

Test the spring force of the valve springs with service tool, Part Number 3375182.



Measurements	mm	in
Approximate Free Length	99.6	3.92

Compress the valve spring to 87.4 mm [3.44 in].

Valve Spring Force

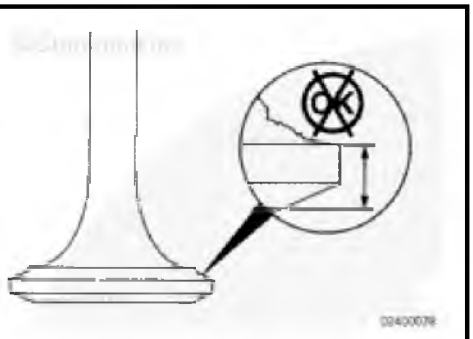
n		lbf
582.6	MIN	130.97
712.0	MAX	160.06

To measure the head thickness of the valve, put the valve on a flat surface. Check the height of the outside diameter.

Valve Head Thickness (At the Outside Diameter)

	mm		in
Intake	2.91	MIN	0.114
Exhaust	3.01	MIN	0.118

If the valve is **not** within specification, it **must** be replaced.

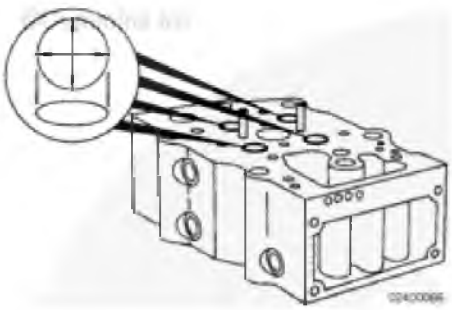


If the valve guides have been removed, measure the inside of the valve guide bore.

If the bore is **not** within specifications, the head **must** be replaced.

Valve Guide Bore Inside Diameter

mm		in
19.00	MIN	0.748
19.021	MAX	0.749



Magnetic Crack Inspect

CAUTION

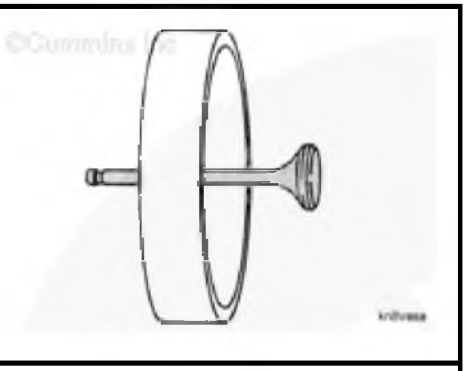
Always demagnetize and clean the parts thoroughly after a magnetic particle inspection. The iron fragments can damage the internal engine components.

Use the magnetic particle residual method.

Check the valves for cracks.

Check the intake valves with the coil and head shot methods (the coil shot first). Check the exhaust valves with the coil shot method.

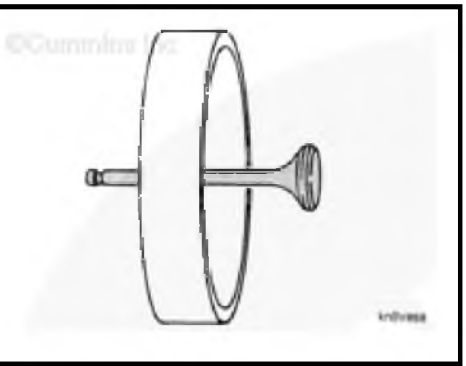
Use a 305-mm [12-in] minimum diameter coil.



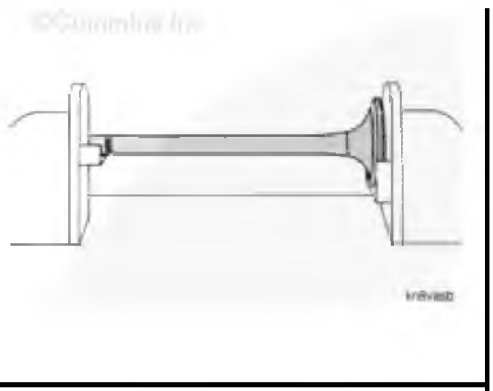
Coil Shot Amperage (Ampere Turns)	
Minimum	Maximum
400 VDC	800 VDC

An ampere turn is an electrical current of one ampere flowing through the coil, multiplied by the number of turns in the coil.

A broad, fuzzy pattern will appear at the welded joint on the exhaust valves. This is normal. If there is a distinct line in the broad, fuzzy pattern, the valve **must** be replaced.

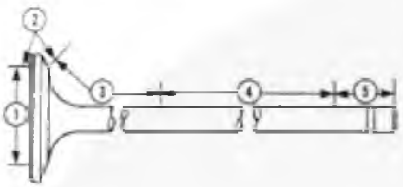


Head Shot Amperage (Ampere)	
Minimum	Maximum
500 VDC	700 VDC



Acceptance criteria (intake and exhaust valves):

1. Indications less than 38.1 mm [1.5 in] in length are acceptable. More than five indications, spaced closer than 3 mm [0.118 in], are **not** acceptable.
2. No indications are acceptable.
3. **Only** longitudinal indications are acceptable.
4. No indications are acceptable.
5. No indications are acceptable.



Grind

Valves

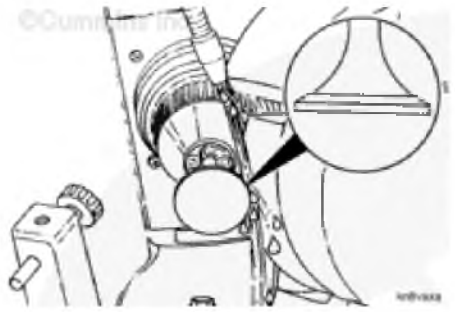
Do **not** use aluminum oxide cloth or sandpaper to clean the valves.

Use Scotch-Brite™, Part Number 3823258, to clean the valve stems. Clean the carbon deposits from the valve face and the head.

The valves **must** be clean and free of carbon deposits before they are ground. Valves can be cleaned by the bead blasting method in the head area **only**. If the stems are bead blasted, the valve **must not** be reused because surface finish will be damaged.

Use a valve facing machine, Part Number 3376256 or equivalent, to grind the face of the valve.

Follow the instructions supplied with the valve facing machine for the correct setup before grinding the valves.



WARNING

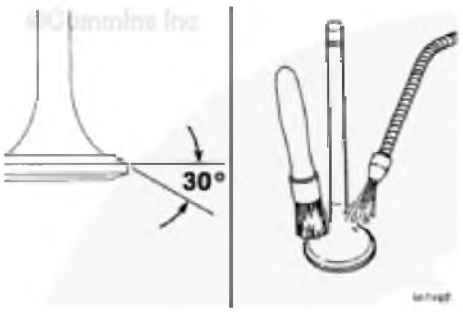
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent to clean the metal particles from the valve.

Dry with compressed air.

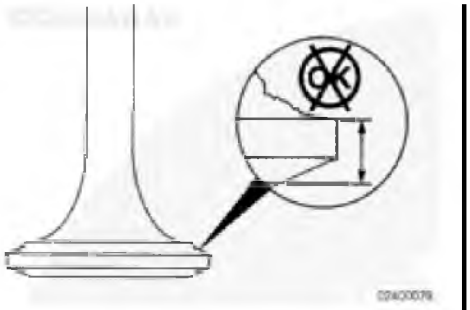


To measure the head thickness of the valve, put the valve on a flat surface. Check the height if the outside diameter.

Valve Head Thickness (At the Outside Diameter)

	mm		in
Intake	2.91	MIN	0.114
Exhaust	3.01	MIN	0.118

If the valve is **not** within specification, it **must** be replaced.

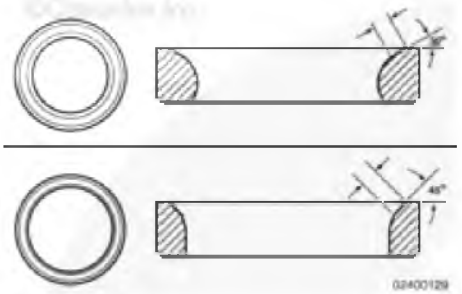


Valve Seat

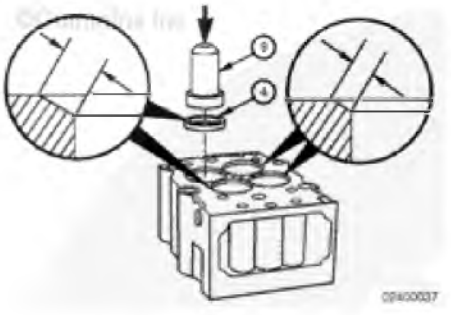
Identify the correct valve seat insert.

- Top illustration: Intake port seat.
- Bottom illustration: Exhaust port seat.

Both the intake and the exhaust port seats **must** be installed with the angle positioned as shown.



Use an arbor press with valve seat adapter insert installer, Part Number 3164790 and valve seat installer, Part Number 3164978 (9) to install the insert (4) into the head.



Use the valve seat grinding machine, Part Number ST-685-A or ST-685-C or equivalent, and the valve guide arbor set,

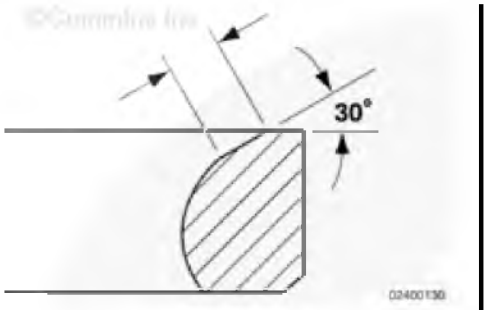
Part Number 3164734 or equivalent, to grind the valve seats.

Grind the valve seat insert to the angle shown.

Measure the width.

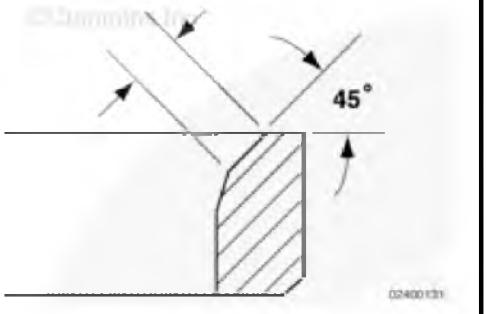
Valve Seat Width

	mm		in
Intake	3.5	MIN	0.138
	4.2	MAX	0.165
Exhaust	4.0	MIN	0.157
	4.3	MAX	0.169



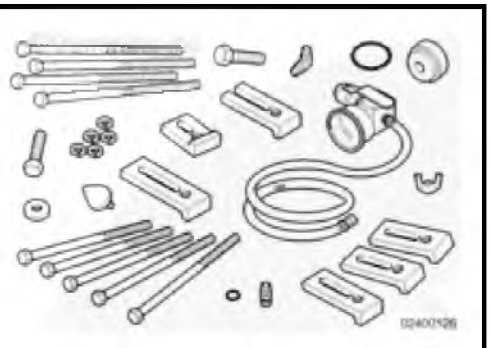
If the width of the valve seat is **not** within specifications, remove the surface material on the inside diameter and the outside diameter to decrease the width of the seat.

If the valve seat specifications are **not** obtained by grinding, the insert **must** be replaced.

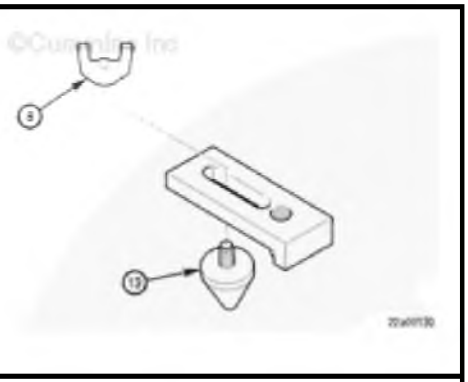


Leak Test

Use cylinder head leak test kit, Part Number 3164341, with regulator Part Number 3164231, to test the cylinder head.



Assemble the wing nut (8), clamp and plug (13) as necessary.



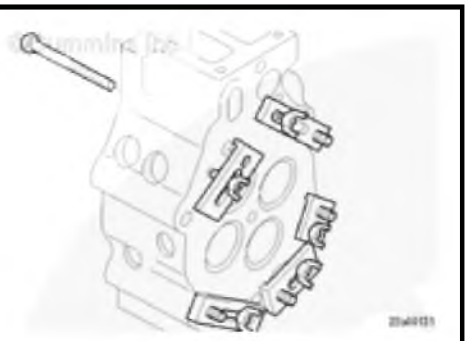
NOTE: The cylinder head as shown uses five clamps and plug assemblies; the QSK23 cylinder heads use only four longer assemblies.

Install the clamp and plug assembly into the cylinder head, blocking the coolant passages.

Insert the appropriate capscrew through the valve guide side of the cylinder head, and thread it into the clamp.

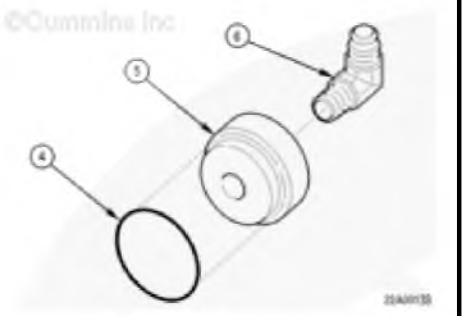
Tighten the capscrew.

Torque Value: 20 n.m [177 in-lb]



Install the o-ring (4) into the o-ring groove of the test adapter (5).

Thread the adapter elbow (6) into adapter (5).



Place the test adapter assembly into the cylinder head.

Install the clamp (7) over the test adapter assembly secure it with the appropriate capscrew and washer.

Torque Value: 54 n.m [40 ft-lb]

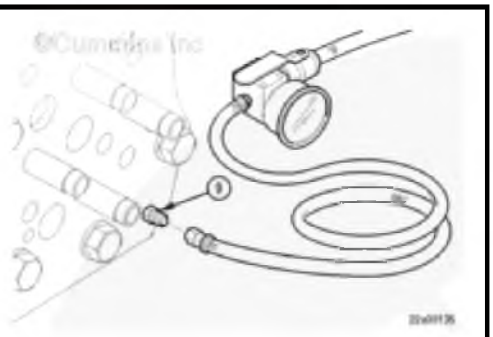
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Connect the pressure regulator valve kit to the pipe nipple (9).

Connect the pressure regulator valve kit to shop air and adjust air pressure.

Measurements		
	kpa	psi
Air Pressure	345	50

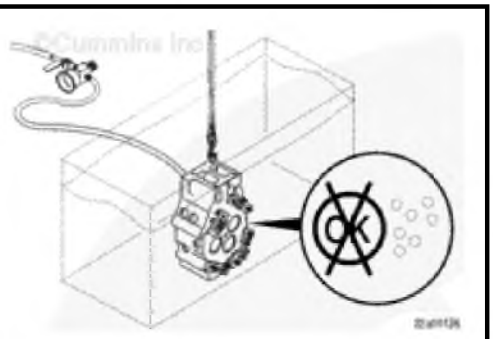


WARNING

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

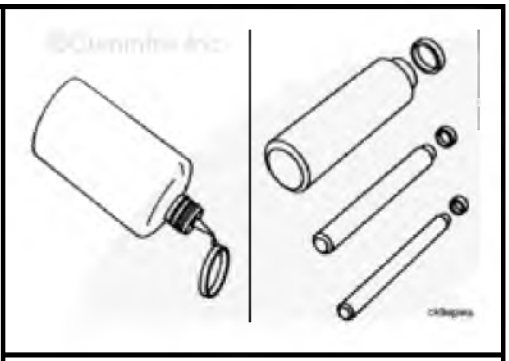
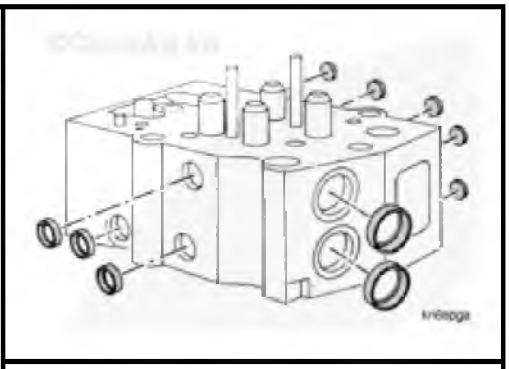
Attach an eyebolt to the cylinder head.

Use a suitable lifting device to lift the cylinder head.

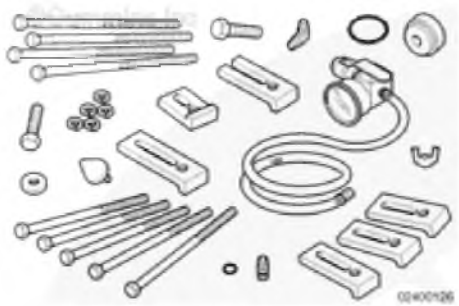


Immerse the cylinder head into a tank of water. Check for bubbles. Bubbles indicate an air leak. If the cylinder head leaks, it **must** be repaired or replaced.		

Assemble

Use cup plug Loctite™ sealant, Part Number 3375068, or equivalent.		
Plug O.D. 22.63 mm [0.891 in], I.D. 21.18 mm [0.834 in]. Use the correct expansion cup plug installer (driver) to make sure the expansion cup plugs are installed to the correct depth in the cylinder head. Drive the plug until the shoulder of the installer (driver) contacts the cylinder head. Expansion (cup) plug installer handle, Part Number 3376795 or 3164085 **must** be used with expansion (cup) plug installer (driver), Part Number 3376813. Install 17 new cup plugs.		

Use cylinder head leak test kit, Part Number 3164341, with regulator, Part Number 3164231, to test the cylinder head.

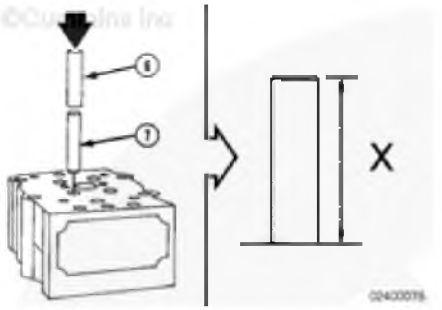


CAUTION

Make certain the mandrel does not damage the top of the valve guide. If the guide is damaged, the valves may stick, causing severe engine damage.

If valve guides were removed, use an arbor press and a suitable mandrel, Part Number 3164427, to install the new valve guides.

Install the valve guide (7) to the specified height (X).

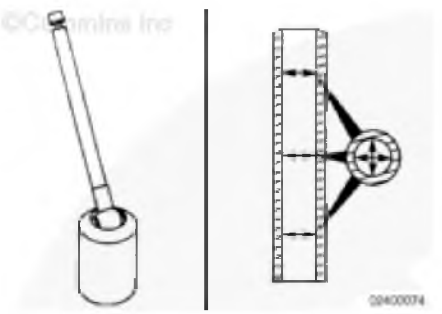


Valve Guide Height

	mm		in
To top of head	42.50	MIN	1.673
	43.50	MAX	1.713

Inspect the valve guides for chips and cracks.

Use a ball gauge or a dial bore indicator to measure the inside diameter of the valve guides.



Measure the inside diameter.

Valve Guide Inside Diameter

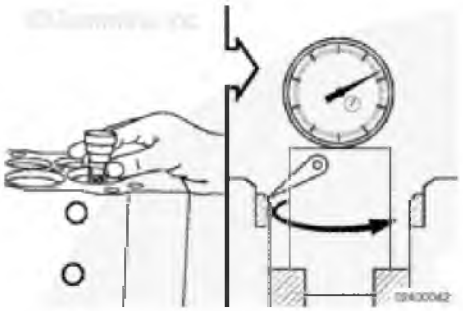
mm		in
11.981	MIN	0.471
11.999	MAX	0.472

Measure the valve seat to the valve guide concentricity.

The seat and guide be concentric.

Valve Seat to Guide Concentricity

mm		in
0.05	MAX	0.002



Use a lead pencil or Prussian blue to mark across the valve face. Install the valve in the valve guide.

Hold the valve against the valve seat and rotate the valve backward and forward three or four times.

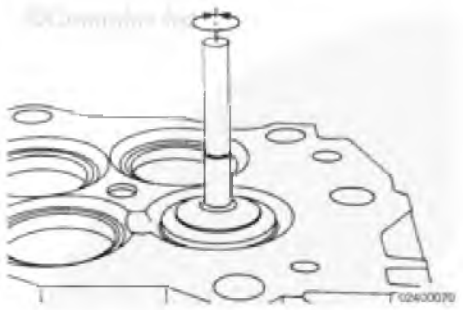
Correct contact against the valve seat will break the marks on the valve face.

Valves and valve seats that are correctly machined do **not** require the use of lapping compound to make an airtight seal. If lapping compound is required, inspect the adjustments of the facing machine and the condition of the grinding stone.

Use a fine lapping compound, Part Number 3375805, or equivalent. Apply a thin and even coating on the valve.

Use a power or a hand suction lapping tool to provide pressure in the center of the valve.

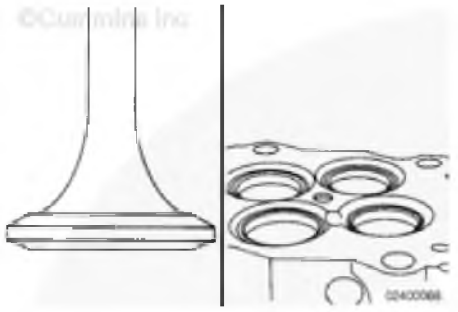
Turn the valve backward and forward. Continue lapping until the compound shows a continuous contact pattern on both the valve seat insert and the valve.



CAUTION

Lapping compound is an abrasive material. Failure will result if the cylinder head, valves, and valve seats are not cleaned thoroughly.

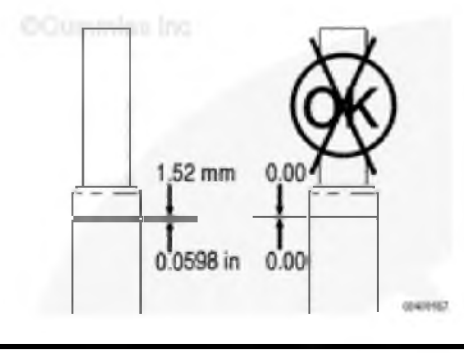
Clean the lapping compound from the parts.



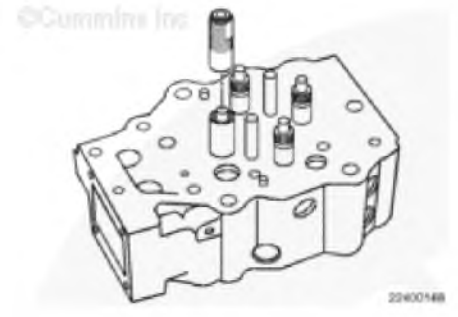
CAUTION

To avoid the valve seal fitting loosely on the valve guide, do not lubricate the valve seal. The seal must be installed dry.

If the valve stem seal is installed too far on the guide, the seal will fail prematurely, causing excessive oil consumption. The gauge allows correct positioning of the seal.



Use valve stem seal installer, Part Number 3164430, to install the valve stem seals.



CAUTION

The valve springs are under compression. Use caution when using the valve spring compressor. Personal injury can result.

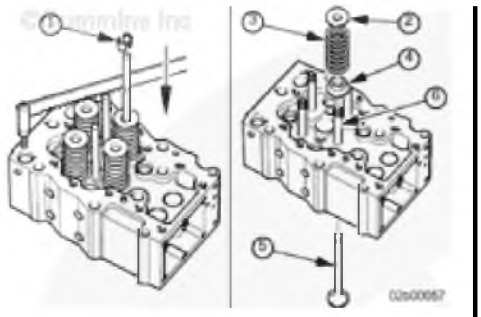
Use a valve spring compressor, Part Number 3163606 (or equivalent), or a valve spring compressor stand, Part Number ST-1022 (or the equivalent). A valve spring compressor plate, Part Number 3164594 can be used with 3163606 and ST-1022 to compress all four valve springs at the same time. An air operated valve spring compressor, Part Number 3375960 (or the equivalent) can also be used.

Assemble the parts in the following order:

- Valve (5)
- Wear plate (4)
- Valve spring (3)
- Valve spring retainer (2).

Compress the valve spring and install the following parts:

- New valve collets.

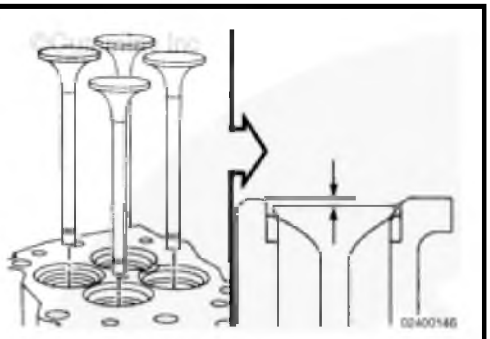


Install the valve into the valve guide.

Measure the depth of the valve with a depth gauge, Part Number 3164438, or equivalent.

The valve head **must** be even with or **not** more than 0.80 mm [0.031 in] below the surface of the cylinder head.

If the valve depth is **not** within specifications, the valve or the valve seat **must** be replaced.



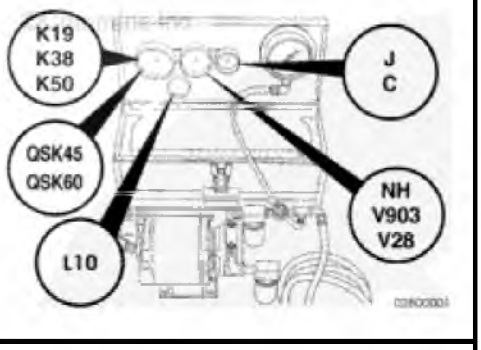
Vacuum Test

The valve vacuum tester, Part Number 3824277 (115-VAC, 50/60 hz) or 3824278 (220-VAC, 50/60 hz), can be used to test all Cummins® engine models.

Before using the tester, test the leakage shutoff valve. If the valve is dirty or worn, it will produce a false leakage measurement on the gauge.

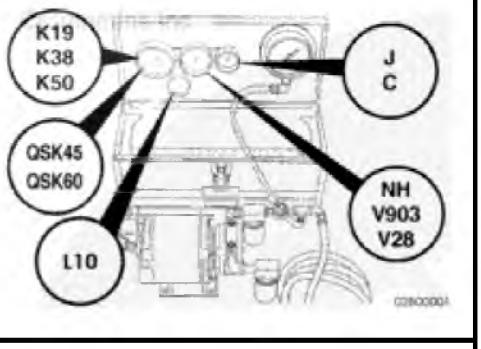
Check the valve:

- Open the shutoff valve
- Turn on the vacuum pump
- Place the cup against a smooth surface
- Close the shutoff valve
- Turn off the vacuum pump
- Wait approximately 10 seconds
- The gauge **must not** drop more than 7 kPa [2 in Hg].

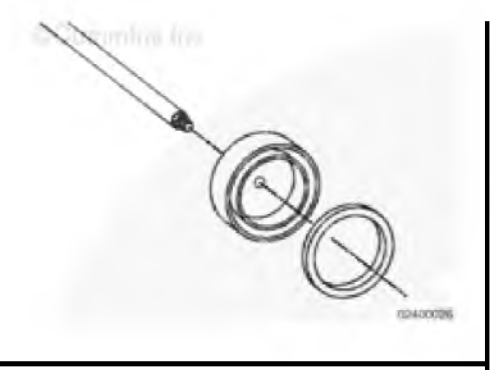


The valve and the valve seats **must** be clean and dry.

Choose the correct cup and the correct seal from the service tool kit for the engine model that is to be tested.

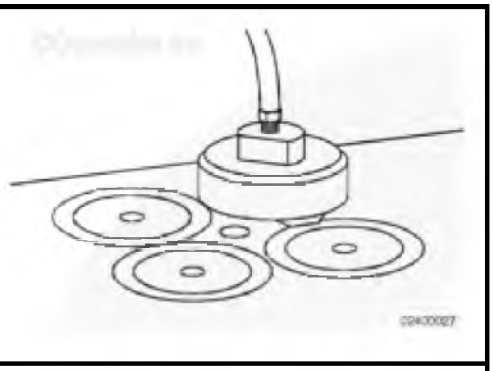


Install the seal and the cup to the vacuum line (hose).



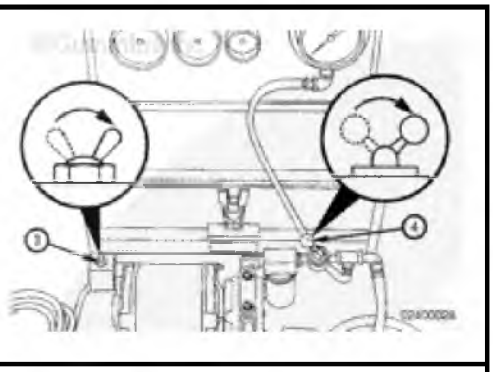
Cover the valve with the cup and the seal. The seal **must** have a tight contact on the cylinder head around the valve.

To check the exhaust valves, the seal **must** completely fill the milled area between the exhaust valves.



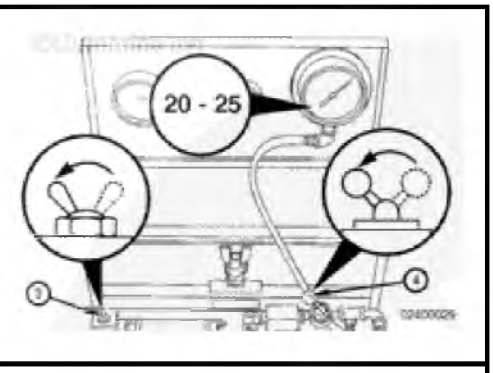
Move the toggle switch (3) to the ON position.

Turn the vacuum control valve (4) to the OPEN position.



When the gauge indicates between 34 to 85 kPa [10 to 25 in Hg], turn the vacuum control valve (4) to the CLOSED or OFF position.

Turn the toggle switch (3) to the OFF position.



CAUTION

The cylinder head must be disassembled and cleaned after any grinding or cutting procedures to reduce the possibility of engine damage.

Use a stopwatch. As the vacuum gauge needle moves **counterclockwise**, start timing when the needle on the gauge points to 61 kPa [18 in Hg].

Stop timing when the needle on the gauge points to 27 kPa [8 in Hg].

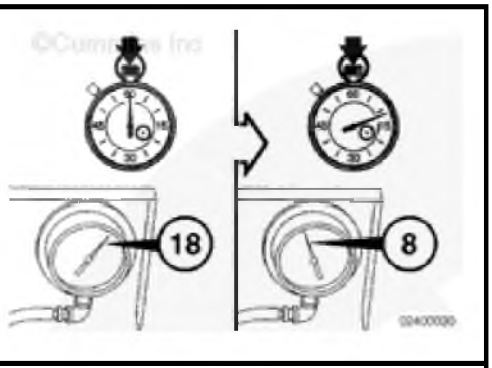
The elapsed time for the gauge to move between the specified readings **must** be 10 seconds or more.

If the elapsed time is less than 10 seconds, perform the following checks:

- Repeat the test to be certain the equipment is functioning properly.
- Use a mallet to lightly hit the valve stem to be certain the valve is sealed. Repeat the test.
- Apply a thin coating of grease on the outside diameter of the insert and the valve head. Repeat the vacuum test. The grease pattern will show the point of leakage.
- If the leakage is between the valve insert and the head, the insert **must** be replaced.

If the leakage is between the valve and the valve insert seat, one of the following procedures **must** be performed:

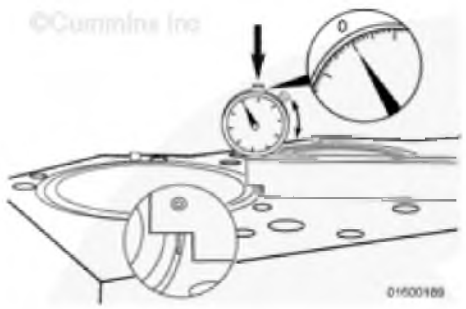
- Lap valve to insert seat
- Grind the valves
- Grind the valve insert seat.



Install

Measure the liner protrusion. Refer to Procedure 001-028 in Section 1.

If the liner protrusion is **not** correct, it **must** be adjusted before installing the cylinder head.



An oversize cylinder head gasket is often required on cylinder blocks that have had material removed from the top surface of the cylinder block.

Inspect the cylinder block for markings to determine if a oversize or a standard size cylinder head gasket is required.

Install the cylinder head gasket, using dowel pins for alignment.

WARNING

This component weighs 23 kg [50 lb] or more. To reduce the possibility of

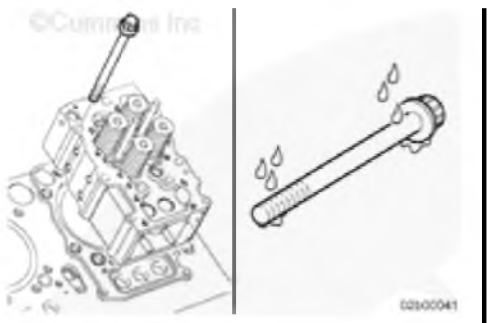
personal injury, use a hoist or get assistance to lift this component.

Install the cylinder head. It **must** slide easily over the dowel pins.

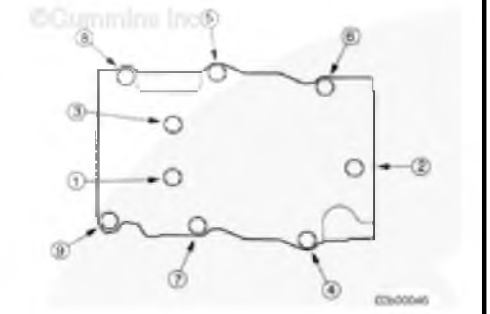
Lubricate the capscrew cylinder head flange with clean engine oil.

Lubricate the capscrew threads with clean engine oil. Allow excess oil to drip off the capscrews before installing them into the block.

Install the capscrews.



When using torque plus angle, the tolerance on the 90 degree angle of rotation is 90 degrees ± 5 degrees. If the capscrew is rotated beyond two flats, do **not** loosen the capscrew. The clamp load is still acceptable; however, rotating the capscrew beyond two flats causes additional stretch and reduces the life of the capscrew. With proper tightening, the capscrew can typically be reused for the life of the engine.



Tighten the capscrews 1 through 7 in sequence.

Torque Value:

1. 100 n.m [74 ft-lb]
2. 245 n.m [181 ft-lb]
3. 380 n.m [280 ft-lb]
4. Rotate 90 degrees

Tighten capscrews 8 and 9 in sequence.

Torque Value:

1. 50 n.m [37 ft-lb]
2. 100 n.m [74 ft-lb]

Replace the coolant vent line.

Torque Value: 12 n.m [106 in-lb]		

Finishing Steps

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Install the rocker lever housing. Refer to Procedure 003-013 in Section 3.
- Install the injector. Refer to Procedure 006-026 in Section 6.
- Install the push rods. Refer to Procedure 004-014 in Section 4.
- Install the rocker levers. Refer to Procedure 003-009 in Section 3.
- Adjust the valves and injectors. Refer to Procedure 003-006 in Section 3.
- Install the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Install the intake manifold and crossover. Refer to Procedure 010-023 in Section 10.

• Install the exhaust manifold. Refer to Procedure 011-007 in Section 11. • Connect the batteries or air starter supply line. • Fill the cooling system. Refer to Procedure 008-018 in Section 8. • Operate the engine to 70°C [158°F] minimum coolant temperature and check for leaks.		

Last Modified: 08-Nov-2010

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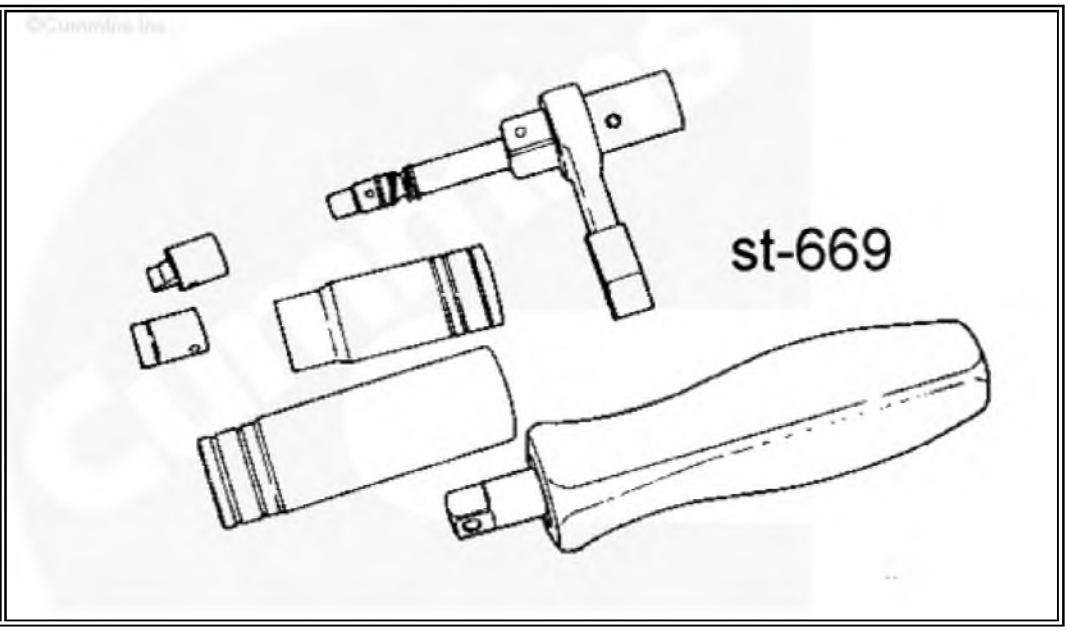
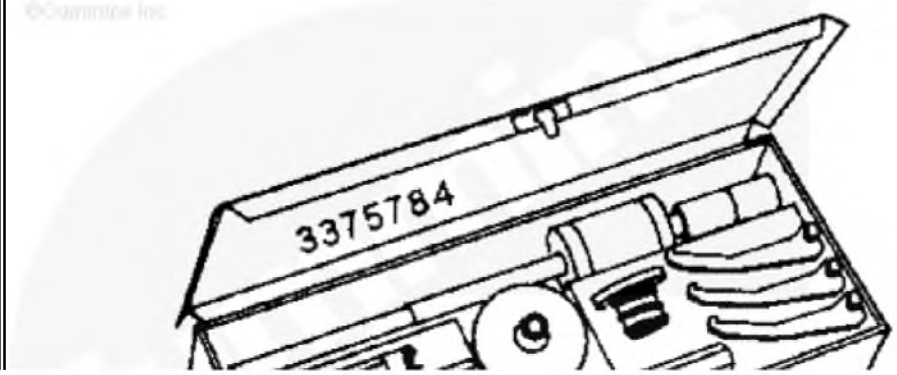
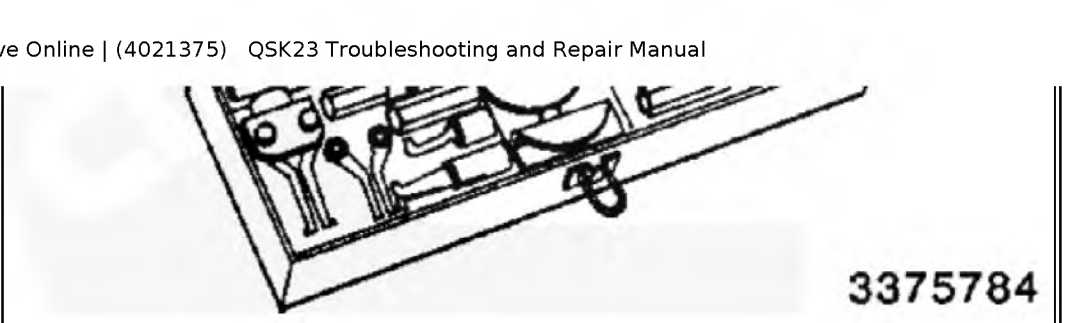
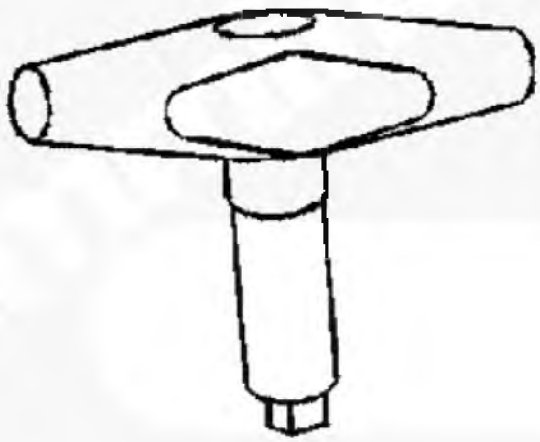
022-001 Service Tools

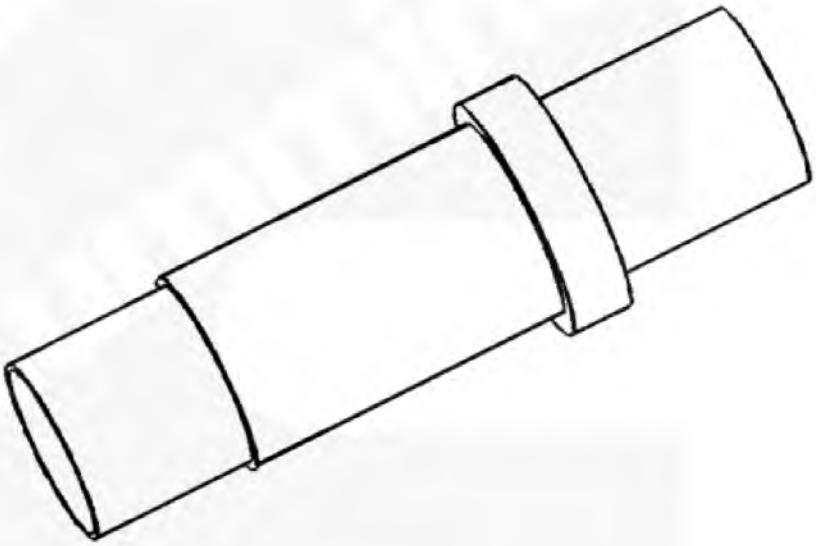
Rocker Levers

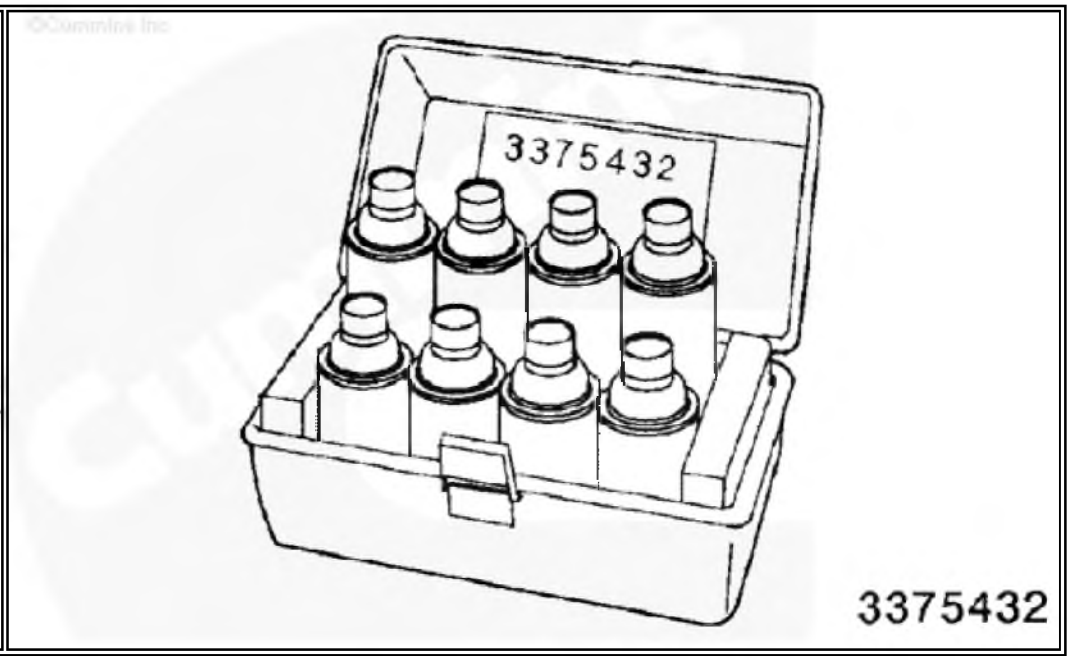
Tool Number 3163196	**Torque Wrench Adapter** Use to secure the rocker lever adjusting screw while tightening the locknut.	

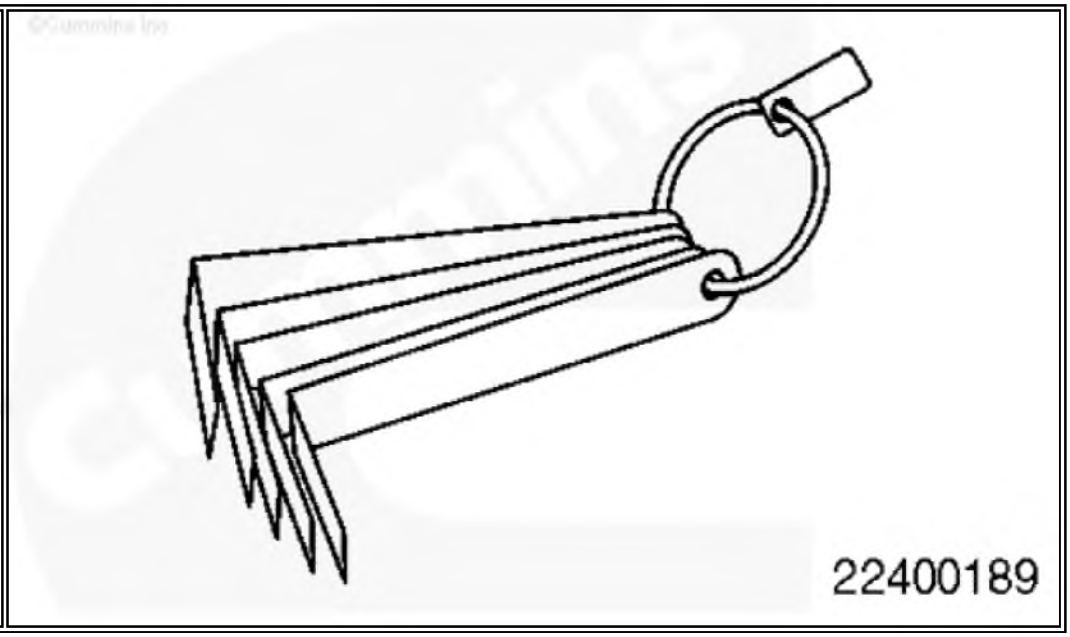
Tool Number 3375784	**Light Duty Puller** Use to remove small bushings, oil seals, and bearings.	

		 3375784

Tool Number 3376592	**Torque Wrench** Use this Inch-pound torque wrench to tighten the valve lever adjusting screw. This torque wrench does not require a screwdriver attachment.	 3376592

Tool Number 3162458	**Rocker Lever Bushing Mandrel** Use to install and/or remove rocker lever bushings.	 03400049

Tool Number 3375432	**Crack Detection Kit** Use to inspect the housing for cracks.	

Tool Number 3823557	**Feeler Gauge Set** Used to set valves.	

Last Modified: 15-Sep-2003

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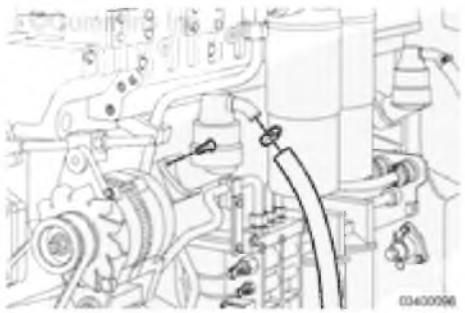
003-001 Crankcase Breather (External)

Remove

Do **not** damage hoses when removing.

Loosen the hose clamps connecting the hose assembly to the crankcase breather and remove the hose.

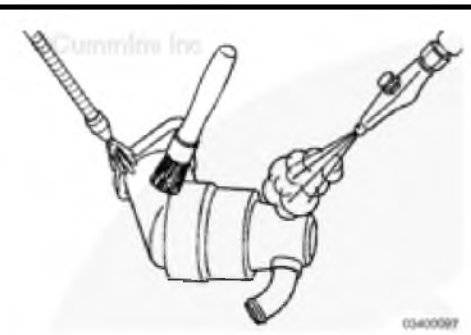
Remove the two capscrews connecting the crankcase breather assembly to the cam follower cover.



Clean

WARNING

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



WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

WARNING

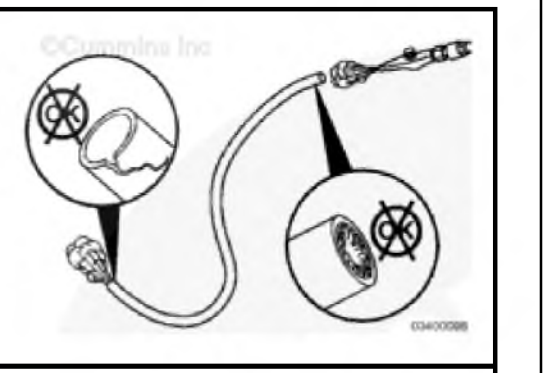
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

Soak the breather in solvent or clean with steam.

Dry the breather assembly with compressed air.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

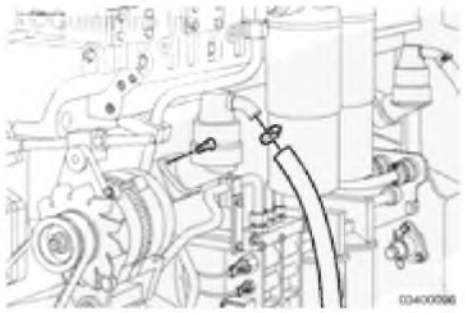


Inspect hoses for cracks or other damage. Replace if necessary.

Use compressed air to blow through the hose.

Replace the hose if it has obstructions or sludge buildup.

Install

Place the o-ring into the breather o-ring groove.		
Install the breather onto cam follower cover with two capscrews. Tighten the capscrews. **Torque Value:** 66 n.m [48 ft-lb] Install the hose assembly and clamp the hose onto the breather assembly. Tighten the hose clamp. **Torque Value:** 5 n.m [44 in-lb]		

Last Modified: 30-May-2003

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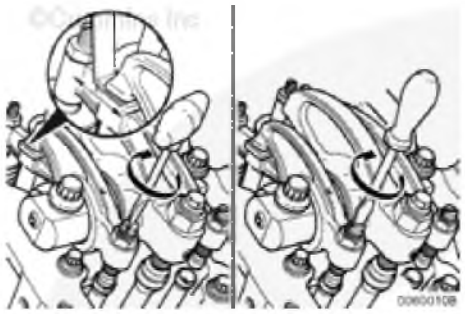
View Related Topic

003-006 Overhead Set (OBC)

General Information

Cummins Inc. has found that engines in most applications will **not** experience significant valve/injector train wear. It is recommended that the valve and injector adjustment be performed **only** when the injectors are removed or when other repairs disturb the valve train.

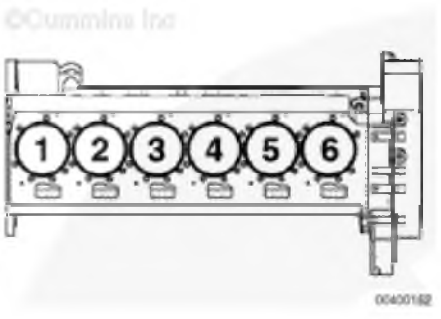
Valves and injectors **must** be correctly adjusted for the engine to operate efficiently. Valves and injector adjustment **must** be performed using the values listed in this section.



The cylinders are numbered from the front of the engine.

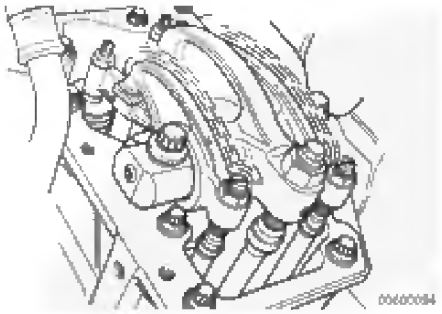
Firing order for the QSK23 engine is 1-5-3-6-2-4.

The crankshaft rotation is **clockwise** when viewed from the front of the engine.



Each cylinder has three rocker levers.

When facing the cylinder head from the intake side of the engine, the lever on the left is the intake rocker lever, and the lever on the right is the exhaust rocker lever. The center rocker lever is for the injector.

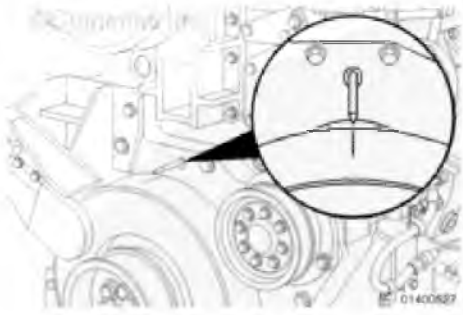


The engine has valve and injector adjustment marks on the vibration damper.

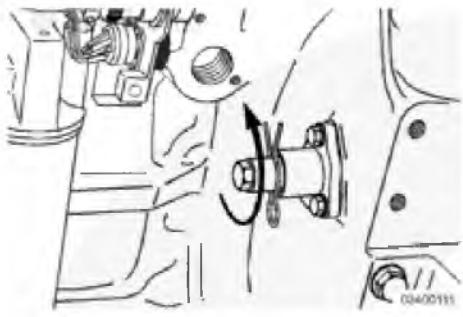
Valve and injector marks **must** be aligned with the pointer, or a false adjustment can occur.

One pair of valves and one injector are adjusted at each vibration damper index mark.

Two crankshaft revolutions are required to adjust all of the valves and injectors.

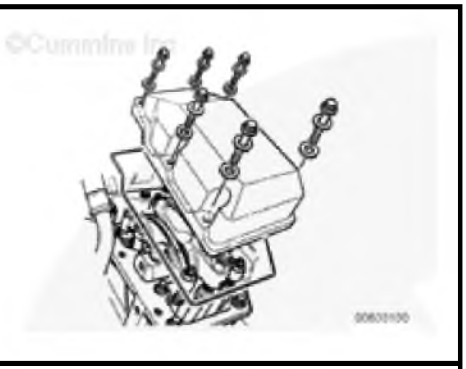


This illustration shows the engine barring device. To use the device, remove the clip and push the device towards the flywheel. The barring device **must** be rotated **counterclockwise** to turn the flywheel and crankshaft in the direction of normal rotation.



Preparatory Steps

- Remove the rocker lever cover. Refer to Procedure 003-011 (Rocker Lever Cover) in Section 3.



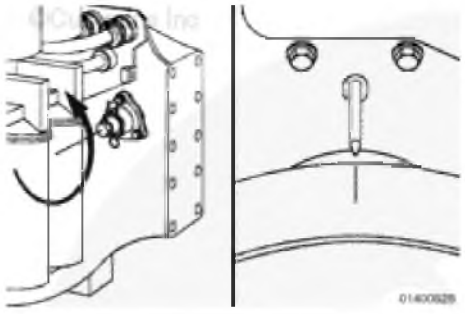
Adjust

If the rocker lever assemblies were removed for this repair, use this step to determine the correct cylinder to set.

Lubricate the adjusting screw threads with clean engine oil prior to making valve and injector adjustments.

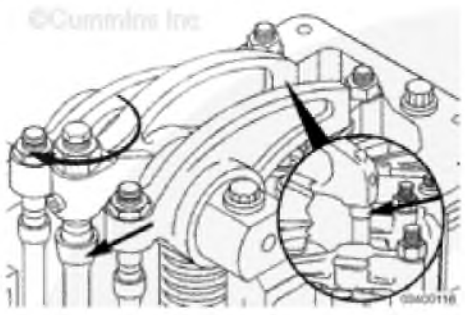
All adjusting screws **must** be loose on all cylinders and the push rods **must** remain in alignment.

Bar the engine to the next valve set mark on the damper. Setting can begin on any valve set mark.



To determine which cylinder is ready for setting, identify the cylinders that would be in position for injector setting, refer to the chart in this procedure. For example, if the engine was barred to the “1.6 TOP” mark, cylinder 2 or 5 would be in position for injector setting.

For these two cylinders, turn the injector



adjusting screws and locknuts down until the injector rocker is in contact with the push rod and injector link. Perform the injector setting on the cylinder which has the most visible threads above the locknut on the injector adjusting screw.

Prior to barring the engine, the injector which had less visible threads and was **not** set in the previous step **must** have the injector adjusting screw backed out until there are at least as many threads above the adjusting nut as for the injector that was set.

To determine which cylinder is ready for valve setting, refer to the chart in this section and identify the cylinder which corresponds to the injector set cylinder from the previous step. For example, if cylinder 2 injector was set, then cylinder 1 would be ready for valve setting.

NOTE: The engine must be cold to perform the overhead set procedure.

Crosshead adjustment **must always** be made before attempting to adjust the valves.

Adjust the crossheads on the cylinder that is ready for valve setting.

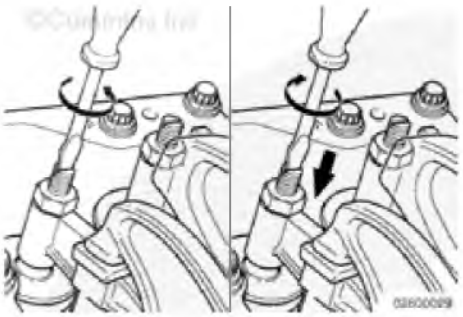
Loosen the crosshead adjusting screw locknuts on the intake and exhaust valve crossheads.

Use the following procedure to adjust both the intake and exhaust crossheads.

Turn the adjusting screw **counterclockwise** at least one turn.

Hold the crosshead down against the guide.

Turn the adjusting screw **clockwise** until it touches the top of the valve stem, but does **not** raise the crosshead.

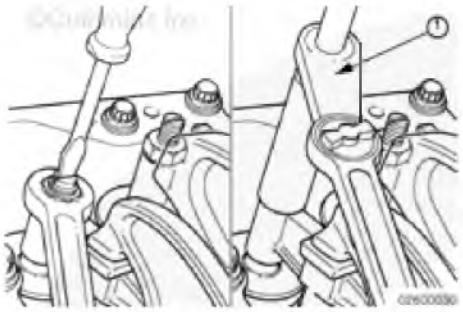


Hold the adjusting screw in this position. The adjusting screw **must not** turn when the locknut is tightened to its torque value.

Tighten the locknut.

The following torque values are given with and without a torque wrench adapter, Part Number 3163196.

With adapter	60 n.m	[44 ft-lb]
Without adapter	65 n.m	[48 ft-lb]

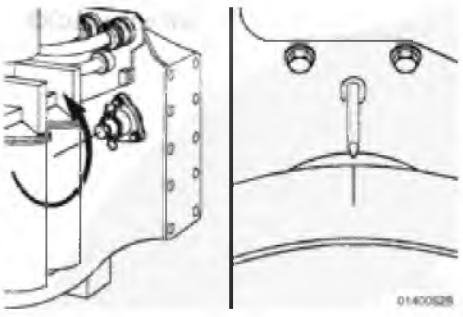


Bar the engine to the next damper timing mark and (refer to the chart in this procedure) to determine the next injector cylinder and valve cylinder to set.

If the rocker lever assemblies were **not** removed, identify the cylinders that are in position for injector setting.

On these two cylinders, identify the injector push rod which is higher in relation to the top of the rocker lever housing. This is the cylinder ready for injector setting.

Refer to the chart in this section to determine the corresponding valve set cylinder.



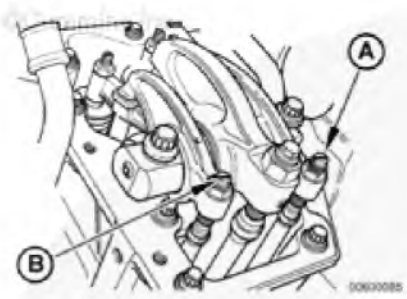
Valve and Injector Adjustment Determination		
Vibration Damper Mark	Valve Adjustment on Cylinder Number	Injector Adjustment on Cylinder Number
1.6 TOP	1	2
2.5 TOP	5	4
3.4 TOP	3	1
1.6 TOP	6	5
2.5 TOP	2	3
3.4 TOP	4	6

Valve Adjustment

Valve Clearances - Initial Set			
	mm		in
Exhaust valves (A)	0.62	MAX	0.024
Intake valves (B)	0.32	MAX	0.013

Valve Clearances - Check			
	mm		in
Exhaust valves (A)	0.60	MIN	0.023
	0.64	MAX	0.025
Intake valves (B)	0.30	MIN	0.012
	0.34	MAX	0.013

The Torque Wrench Method and Screwdriver Method are used to set valve lash clearance. Both are described below. Either method can be used; however, the Torque Wrench Method has proven to be the most consistent.

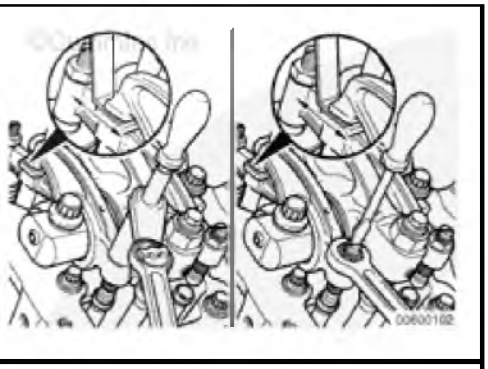


Make sure the crossheads have been adjusted and are firmly in place on the valve stems.

Make sure the feeler gauge is under the center of the rocker lever or incorrect adjustment can result.

The adjustment screws **must** turn freely or a false reading or setting can occur.

Select the proper feeler gauge for the valves being set. Use feeler gauge set, Part Number 3823557, or equivalent.



Valve Adjustment - Torque Wrench Method

Make sure parts are aligned and squeeze the oil out of the valve train by tightening the adjusting screw.

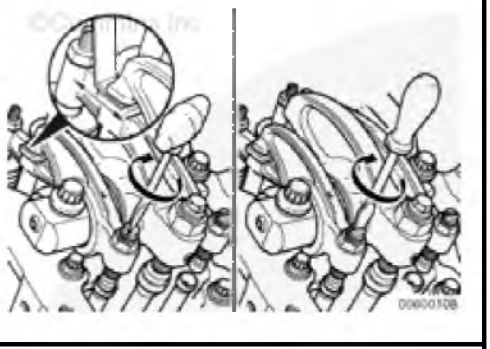
Loosen the adjusting screw at least one revolution.

Insert the feeler gauge between the rocker lever and the crosshead.

Use torque wrench, Part Number 3376592, to tighten the adjusting screw.

Torque Value: 0.68 n.m [6 in-lb]

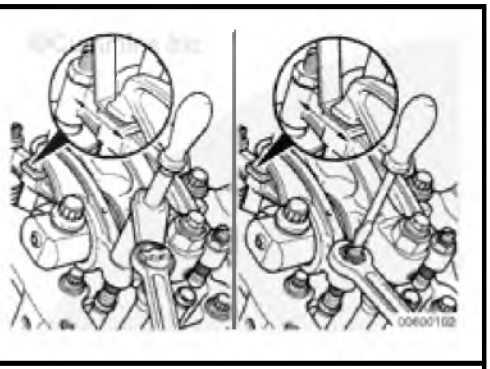
Remove the feeler gauge.



The adjusting screw **must not** turn when the locknut is tightened. Locknut torque can be applied with or without the torque wrench adapter, Part Number 3163196.

Tighten the locknut.

With adapter 48 n.m [35 ft-lb]



Without adapter	68 n.m	[50 ft-lb]

Attempt to insert a feeler gauge that is 0.03 mm [0.001 in] thicker. The valve lash is **not** correct if the thicker feeler gauge will fit.

Repeat the adjustment process until the proper lash is obtained.

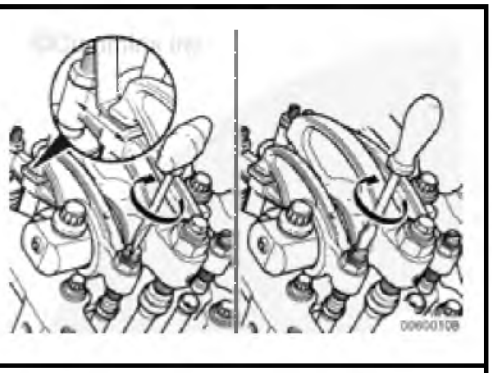
Valve Adjustment - Screwdriver Method

Make sure the parts are aligned and squeeze the oil out of the valve train by tightening the adjusting screw.

Loosen the adjusting screw at least one revolution.

Insert the feeler gauge between the rocker lever and the crosshead.

Tighten the adjusting screw until the rocker lever touches the feeler gauge.



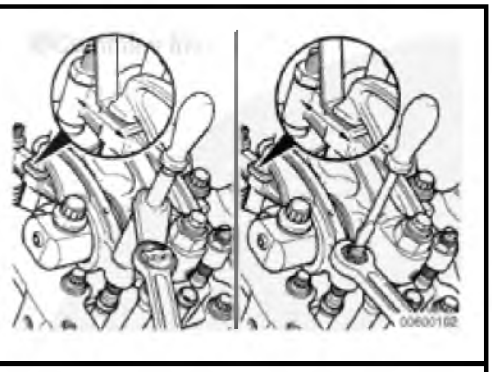
The adjusting screw **must not** turn when the locknut is tightened. Locknut torque can be applied with or without a torque wrench adapter, Part Number 3163196.

Tighten the locknut.

With Adapter	48 n.m	[35 ft-lb]
Without Adapter	68 n.m	[50 ft-lb]

Attempt to insert a feeler gauge that is 0.03 mm [0.001 in] thicker. The valve lash is **not** correct if the thicker feeler gauge will fit.

Repeat the adjustment process until the proper lash is obtained.



Injector Lever Adjustment

Either a click type or a dial type torque wrench can be used to tighten the injector rocker lever adjusting screw. The specified adjusting screw torque **must** fall near the center of the operating range for the torque wrench used. If the screw chatters during setting, repair the screw and lever as required.

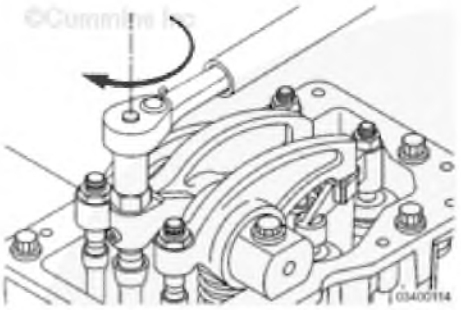
Tighten the adjusting screw.

Torque Value: 32 n.m [24 ft-lb]

Loosen the adjusting screw at least one revolution.

Tighten the adjusting screw again.

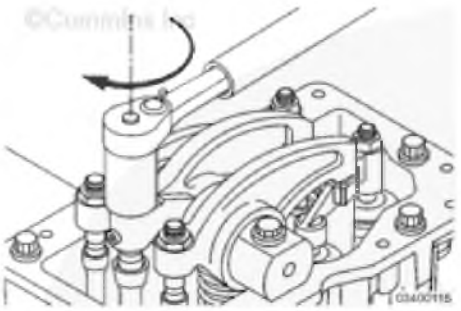
Torque Value: 32 n.m [24 ft-lb]



When tightening the adjusting screw locknut, do **not** hold the adjusting screw in position.

Tighten the injector adjusting screw locknut.

Torque Value: 225 n.m [166 ft-lb]

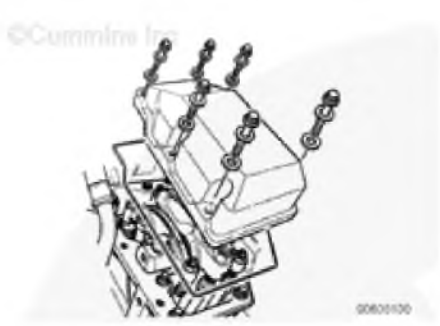


Finishing Steps

- Install the rocker lever cover. Refer to Procedure 003-011 (Rocker Lever

Cover) in Section 3.

- Operate the engine and check for leaks.



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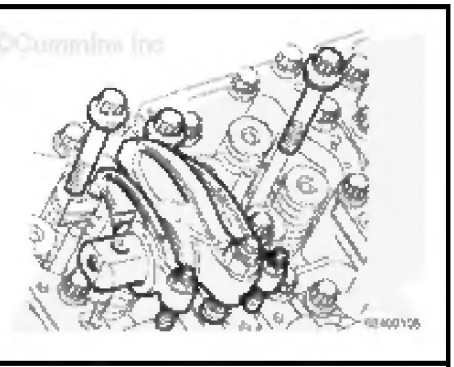
003-009 Rocker Lever Assembly

Preparatory Steps

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

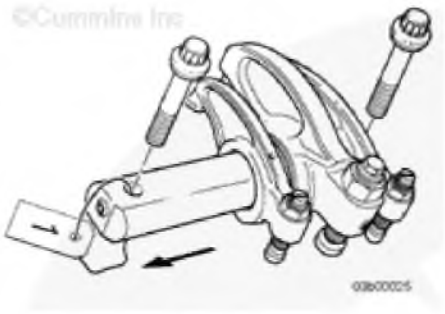
Remove

Do **not** allow the rocker levers to fall off the shaft during removal. Remove the two rocker lever assembly mounting capscrews. Remove the rocker lever assembly.		

Remove the mounting capscrews from the rocker lever shaft.

Remove the rocker levers from the rocker lever shaft.

NOTE: If more than one rocker lever assembly is being removed, tag each assembly with the cylinder number it was removed from.

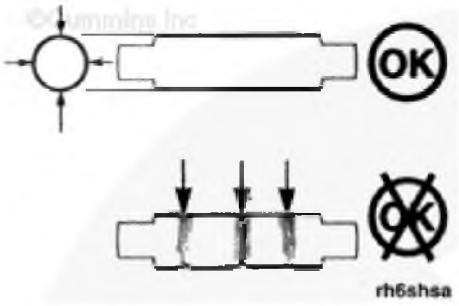


Inspect for Reuse

Inspect the rocker lever shaft for damage or roughness.

Measure the outside diameter of the rocker lever shaft.

Rocker Lever Shaft Outside Diameter		
mm		in
44.97	MIN	1.770
44.99	MAX	1.771



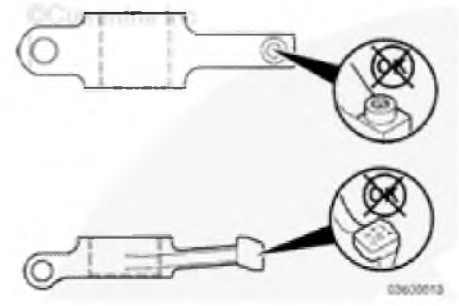
Inspect the pad for wear on the valve actuator rocker lever.

Inspect the socket for wear on the injector actuating rocker levers.

Inspect the adjusting screw ends.

Inspect the crosshead pad for wear.

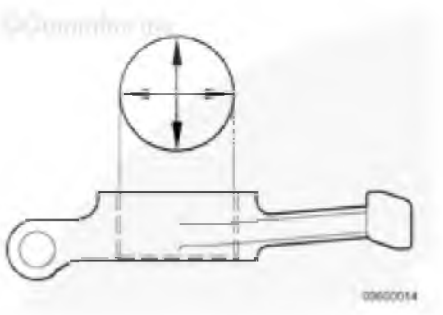
If there is damage that can be felt with a fingernail, the parts **must** be replaced.



Inspect the valve and injector actuating rocker lever bushings for wear.

Measure the inside diameter of the valve and injector actuating rocker lever bushings.

Valve Actuating Rocker Lever Bushing Inside Diameter		
mm		in
45.024	MIN	1.773
45.099	MAX	1.776
Injector Actuating Rocker Lever Bushing Inside Diameter		
mm		in
45.021	MIN	1.773
45.097	MAX	1.776



Install

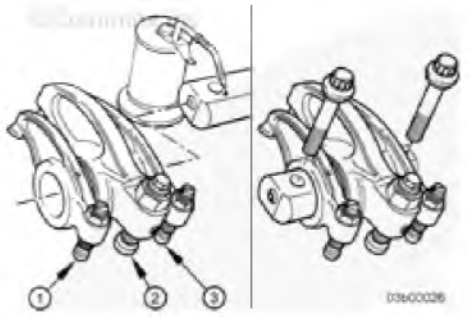
Lubricate the rocker lever shaft with clean 15W-40 engine oil.

To align the oil drillings in the shaft with the oil drillings in the rocker levers, the rivited end of the shaft **must** face the front of the engine and larger diameter capscrew holes **must** face downward.

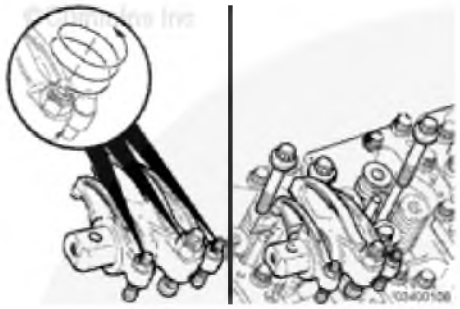
Slide the rocker levers on the shaft in the following sequence:

1. Intake rocker lever
2. Injector rocker lever
3. Exhaust rocker lever.

Lubricate the capscrew threads, rocker lever sockets, and crosshead pads with clean 15W-40 engine oil.



Place the capscrews into the rocker lever shaft.		

Make sure the adjusting screws are loose. Make sure the rocker lever orientation is correct. Position the rocker lever assembly on the housing. Install the capscrews and finger-tighten two or three revolutions. Align the push rod sockets with the adjusting screws. Tighten the capscrews. **Torque Value:** 245 n.m [180 ft-lb]		

Finishing Steps

• Adjust the valves and injectors. Refer to Procedure 003-006. • Install the rocker lever covers. Refer to Procedure 003-011.		

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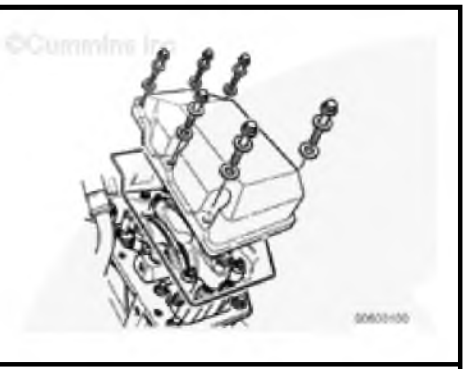
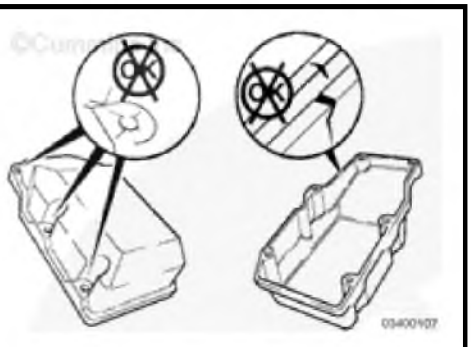
BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

003-011 Rocker Lever Cover

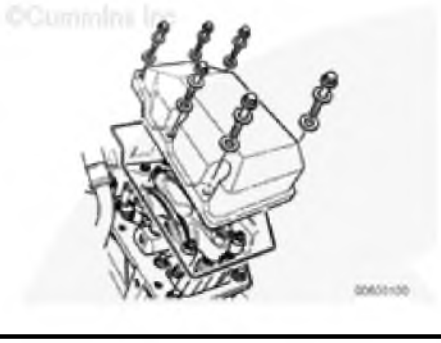
Remove

Remove the six capscrews, washers, and seal washers from the rocker lever cover. Remove the rocker lever cover.		

Inspect for Reuse

Inspect the cover for cracks. Inspect the seal groove for damage.		

Install

The rocker lever cover is fitted with a seal, a gasket is **not** required. Each capscrew **must** be used in conjunction with a washer and sealing washer. Install the rocker lever cover onto the rocker lever housing. Install the six capscrews. Tighten the capscrews. **Torque Value:** 10 n.m [89 in-lb]	 	

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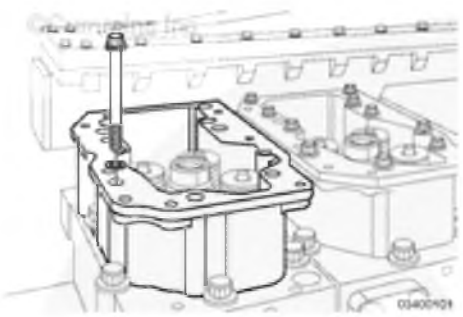
003-013 Rocker Lever Housing

Preparatory Steps

- Remove the rocker lever covers. Refer to Procedure 003-011.
- Remove the rocker lever assembly. Refer to Procedure 003-009.
- Remove the push rods and crossheads. Refer to Procedure 004-014.

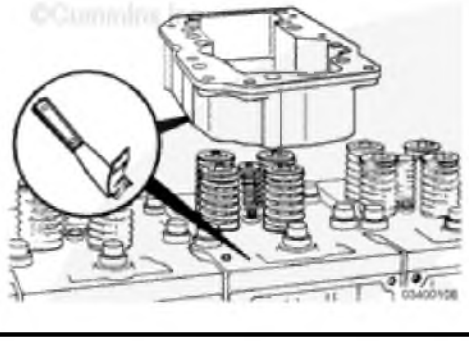
Remove

Remove the ten rocker lever housing mounting capscrews and remove the rocker lever housing.



Clean and Inspect for Reuse

Remove and discard the liquid gasket material from rocker housing and cylinder head mating surfaces.



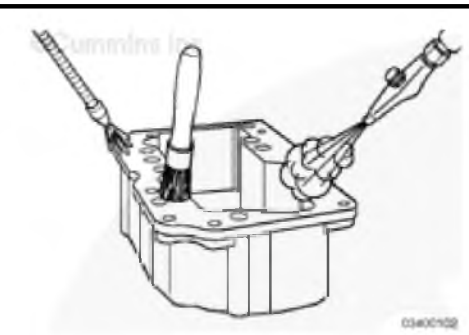
WARNING

Wear safety glasses or a face shield, as well as protective clothing, to reduce the possibility of personal injury when using a steam cleaner or high pressure water.

WARNING

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

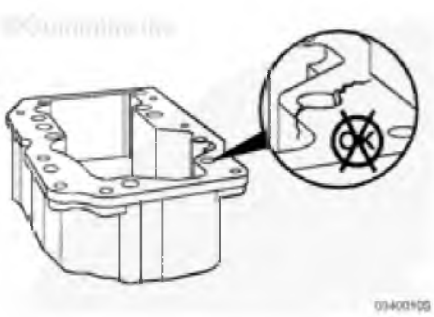
Use steam or solvent to clean the rocker lever housing.



Inspect the rocker lever housing for damage.

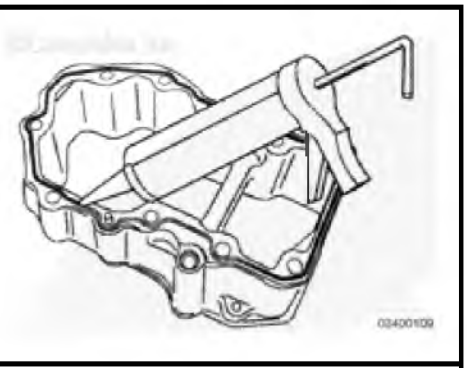
Use the crack detection kit, Part Number

3375432, to inspect the housing for cracks. If the housing is cracked, it **must** be replaced.



Install

Apply an even amount of gasket sealant into the groove on the bottom of the rocker housing.



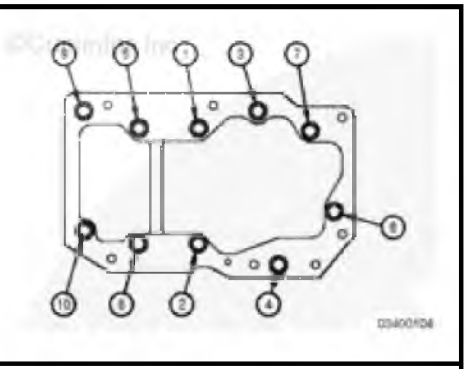
The housing **must** be aligned correctly with the dowel pins.

Install the rocker lever housing.

Install the ten rocker lever housing mounting capscrews.

Use the sequence illustrated in the graphic to tighten the capscrews.

Torque Value: 86 n.m [64 ft-lb]



Finishing Steps

- Install the push rods and crossheads. Refer to Procedure 004-014.
- Install the rocker levers. Refer to Procedure 003-009.
- Adjust the valves and injectors. Refer to Procedure 003-006.
- Install the rocker lever cover. 003-011.

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004-001 Cam Follower Assembly

Preparatory Steps

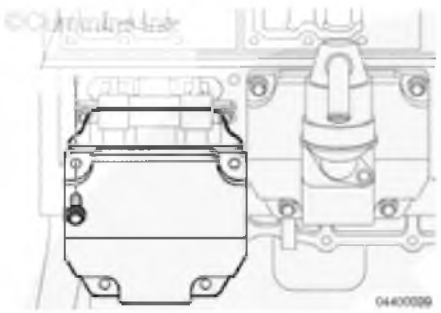
- Remove the rocker lever cover. Refer to Procedure 003-011.
- Remove the rocker levers. Refer to Procedure 003-009.
- Remove the push rods. Refer to Procedure 004-014.
- Remove the crankcase breather assembly, if necessary. Refer to Procedure 003-001.
- Remove the fuel supply lines, if necessary. Refer to Procedure 006-024.
- Remove the fuel drain lines, if necessary. Refer to Procedure 006-013.
- Remove the fuel filters, if necessary. Refer to Procedure 006-015.
- Remove the alternator, if necessary. Refer to Procedure 013-001.

Remove

Remove the cam follower cover.

Remove and inspect the gasket.

Discard the gasket if it is damaged.

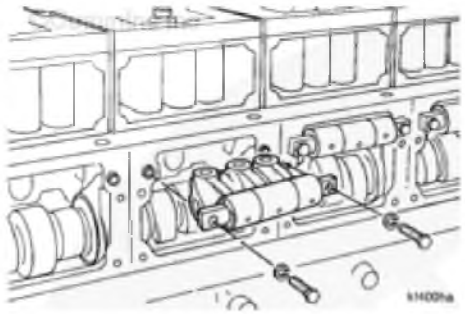


Mark the location of the cam follower assemblies as they are removed, so they can be installed in the original location.

Remove the cam follower assembly capscrews.

Pull the cam follower assembly out until the shaft is off the ring dowels.

NOTE: If one of the followers is in the raised position on the cam lobe, it may be necessary to bar the engine over in order to remove the assembly from the block.



Clean and Inspect for Reuse

WARNING

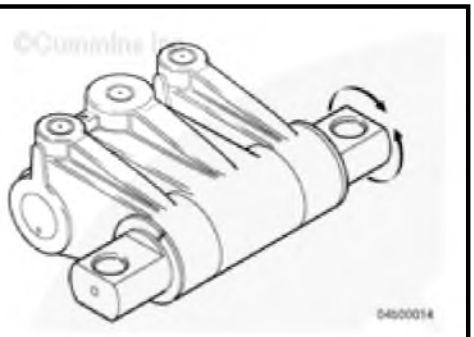
When using solvents, acids or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of

personal injury.

Use solvent and clean the cam follower assembly.

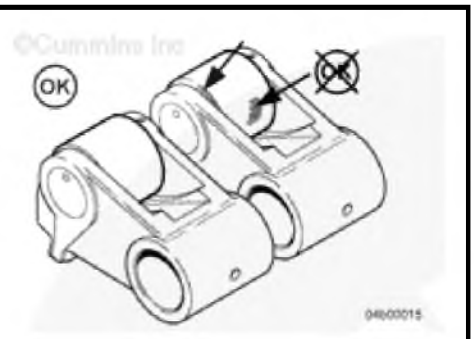
Do **not** touch the machined surfaces of the cam follower roller with bare hands, use rubber gloves or a similar covering.

The shaft **must** rotate easily. If resistance is apparent, disassemble and check for burrs on the shaft.



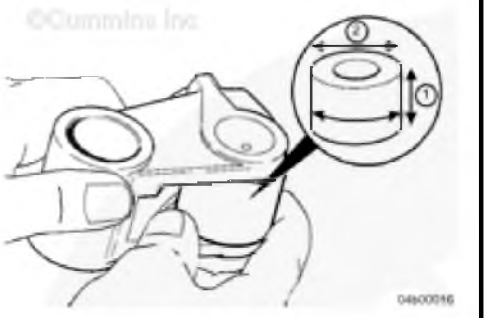
Inspect the cam follower lever and roller for damage.

The cam follower lever assembly **must** be replaced if damaged.



The roller **must** rotate freely.

Measure the side clearance of the roller.

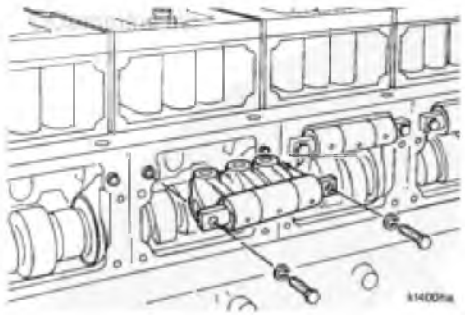
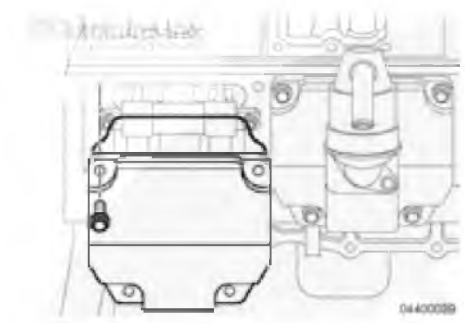


Cam Follower Roller Side Clearance			
	mm		in
1	0.075	MIN	0.003
	0.305	MAX	0.012
2	0.082	MIN	0.003
	0.114	MAX	0.005

If the clearances do **not** meet

specifications, the cam follower **must** be replaced.		

Install

Do **not** touch the machined surfaces of the cam follower roller, that have been cleaned, with bare hands. This can cause rust to form. Use clean 15W-40 engine oil to lubricate the camshaft cam follower rollers and cam follower shaft. Install the cam follower assembly. The shaft **must** fit on ring dowels. Install and tighten the mounting screws. **Torque Value:** Step 1 35 n.m [26 ft-lb] Step 2 60 n.m [44 ft-lb] Step 3 100 n.m [74 ft-lb]		
Install the cam follower gasket and cover. Install the cam follower cover capscrews. **Torque Value:** 10 n.m [90 in-lb]		

Finishing Steps

- Install the fuel drain lines. Refer to Procedure 006-013.
- Install the fuel supply lines. Refer to Procedure 006-021.
- Install the crankcase breather assembly. Refer to Procedure 003-001.
- Install the fuel filters. Refer to Procedure 006-015.
- Install the alternator. Refer to Procedure 013-001.
- Install the pushrods. Refer to Procedure 004-014
- Install the rocker levers. Refer to Procedure 003-009.
- Adjust the overhead. Refer to Procedure 003-006.
- Install the rocker lever cover. Refer to Procedure 003-011.

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004-014 Push Rods or Tubes

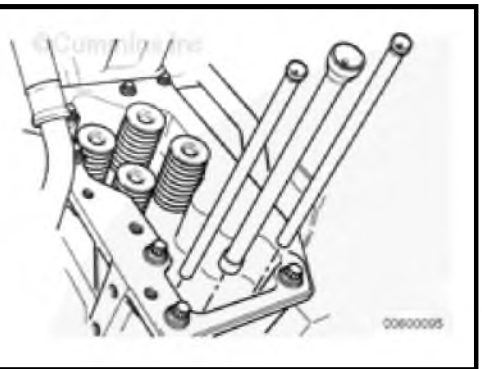
Preparatory Steps

- Remove the rocker lever cover. Refer to Procedure 003-011.
- Remove the rocker levers. Refer to Procedure 003-009.

Remove

It is a recommended service practice to mark the push rods so they can be reinstalled in their original position.

Remove the push rods.



Clean and Inspect for Reuse

WARNING

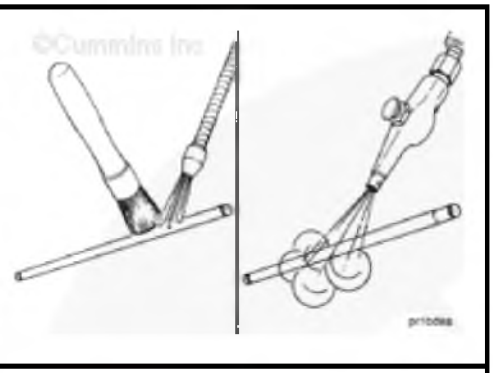
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying dirt and debris can cause personal injury.

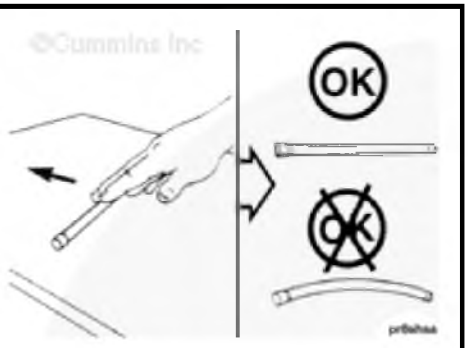
Use solvent to clean the push rods.

Dry the push rods with compressed air.



Inspect the straightness of the push rod by rolling it on a level surface. Replace the push rod if it is bent.

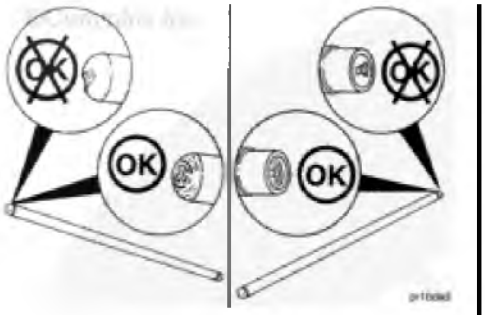
Do **not** use or try to straighten a bent pushrod.



Inspect both ends of the push rods for wear or damage.

The cam follower lever assembly **must** be

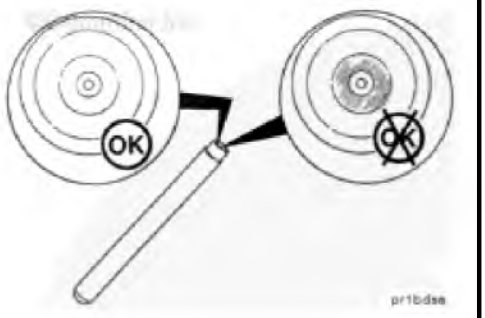
replaced if a push rod is worn or damaged in the area where it contacts the socket. Replace both the rocker lever adjusting screw and the push rod if the socket surface in the rod or the adjusting screw is damaged.



Inspect the socket end of the push rod for uneven wear or scratches.

When parallel scratches are found in the contact area, the push rod **must** be replaced.

If a worn socket is found, the matching adjusting screw in the rocker lever **must** also be replaced.

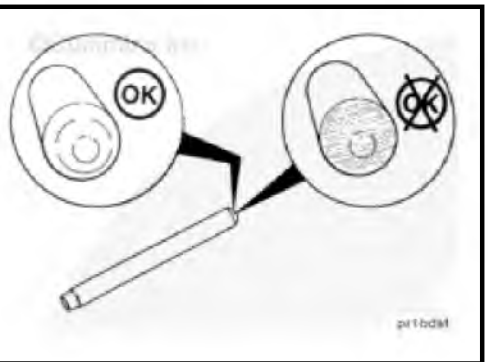


Inspect the ball end of the push rod.

The contact area **must** show a smooth seating area.

If the ball end of the push rod has parallel grooves and scratches with a raised center, the push rod **must** be replaced.

If a worn push rod is found, the mating cam follower lever assembly **must** be replaced.



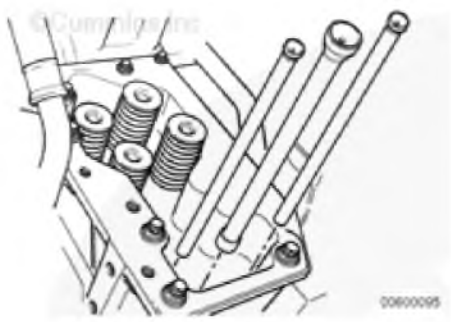
Install

The injector push rods are thicker in the middle than the valve push rods. The intake and the exhaust valve push rods are both the same.

The push rods **must** be seated correctly in the cam followers.

Use clean 15W-40 engine oil to lubricate the sockets in the cam followers.

Install the push rods back into their original position.



Finishing Steps

- Install the rocker levers. Refer to Procedure 003-009.
- Adjust the overhead. Refer to Procedure 003-006.
- Install the rocker lever covers. Refer to Procedure 003-011.

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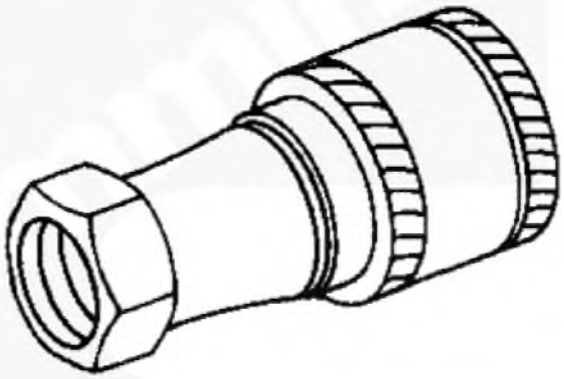
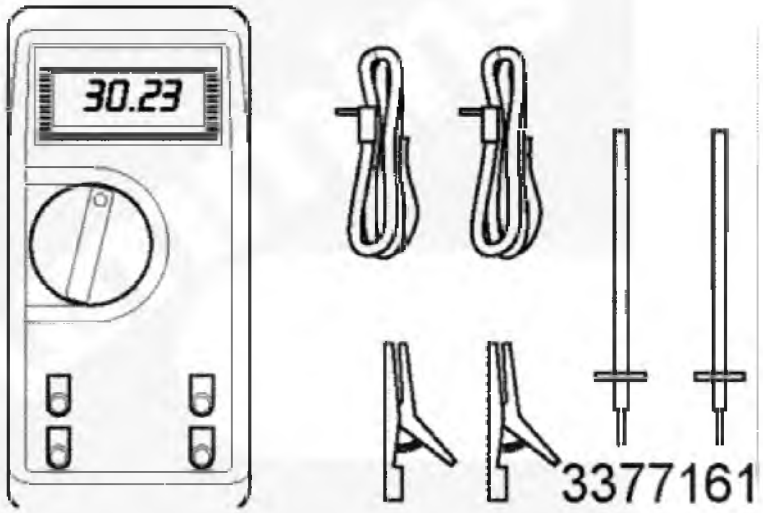
022-001 Service Tools

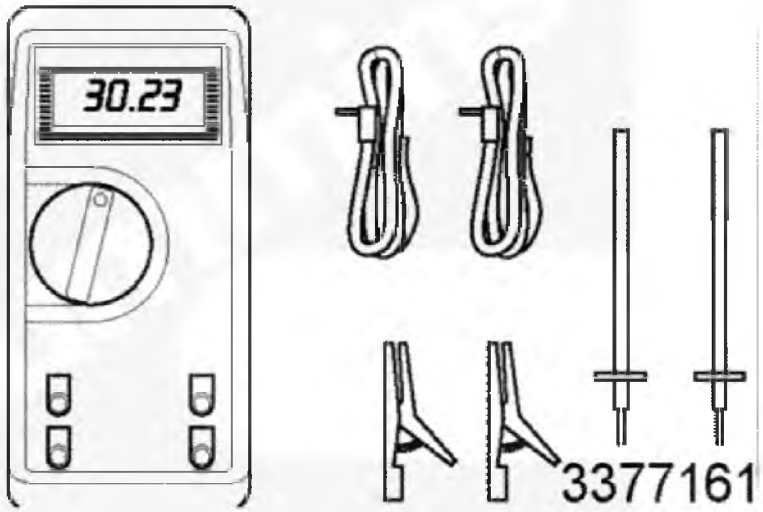
Fuel System

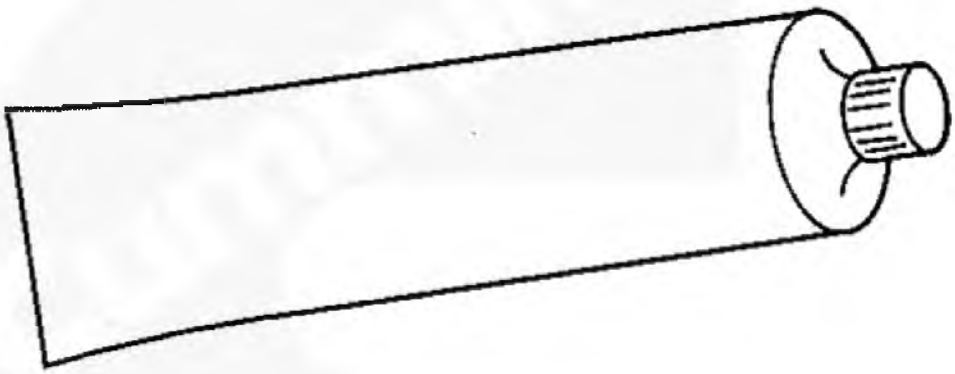
Tool Number ST-435-7	**Fitting** Connects gauges when measuring various fuel pressures.	 st-435-7

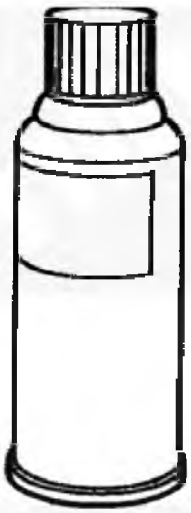
Tool Number 3824877	**Gauge** Used to measure the fuel pump pressure from 0 to 2758 kPa [0 to 400 psi]. Includes necessary hoses and hardware to attach to a fuel pump.	

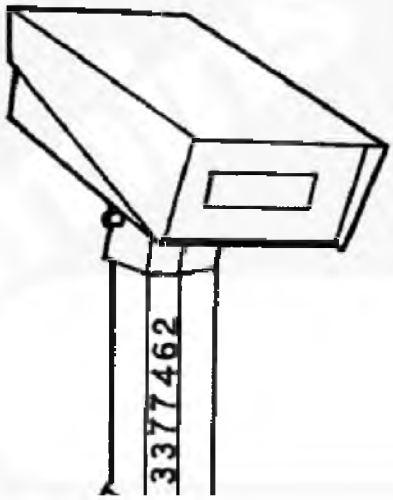
		eg8togh

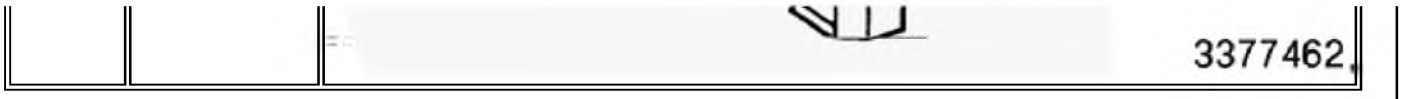
Tool Number 3377161	**Digital Multimeter** Used to check the resistance of the fuel shut-off solenoid.	

Tool Number 3164488	**Digital Multimeter** Used to check the resistance of the fuel shut-off solenoid.	

Tool Number 3822934	**Lubricant DS-ES** Dielectric lithium grease used to lubricate the pins in the electrical connectors.	 3377132

Tool Number 3824510	**QD Contact Cleaner** A nonpetroleum cleaner used to clean electrical connections.	 oi8togt

Tool Number 3377462	**Optical Tachometer** Measure engine rpm.	



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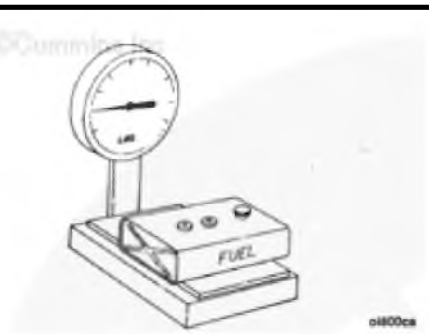
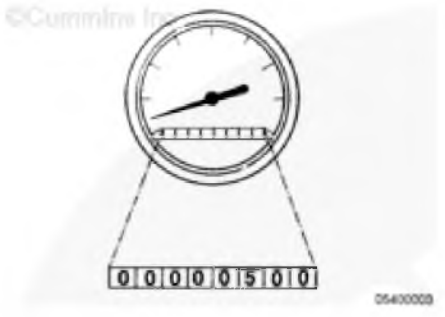
005-010 Fuel Consumption

Initial Check

Refer to the fuel consumption check list sheets in the back of this section. The most accurate method to check the fuel consumption is to weigh the fuel used during a specific time interval.		
Use a scale capable of measuring within 0.045 kg [0.1 lb] to weigh the fuel tank. Fill the fuel tank. Weigh the tank and the fuel. The weight of Number 2 diesel fuel is 0.844 kg per liter [7.03 lb per gallon]. Install a remote fuel tank (1) with enough capacity to run 80 km [50 mi] or 1 hour.		

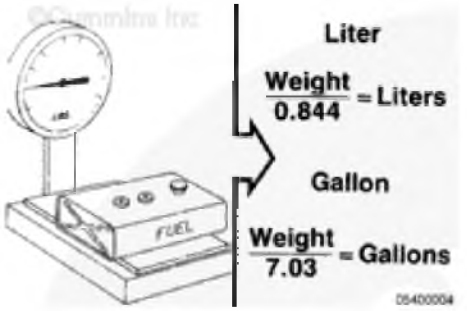
Test

For off-highway applications, measure the time with a stop watch.



After one hour of operation, weigh the fuel remaining, and compute the fuel used in liters [gallons] as required.

Compute the fuel consumption. Fuel used divided by the time equals the fuel consumption rate.



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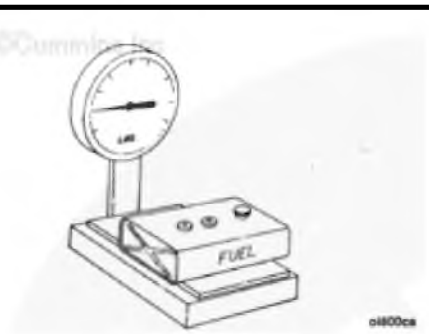
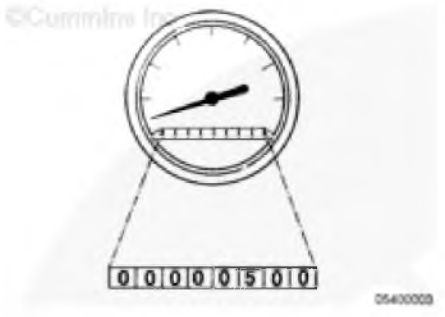
005-010 Fuel Consumption

Initial Check

Refer to the fuel consumption check list sheets in the back of this section. The most accurate method to check the fuel consumption is to weigh the fuel used during a specific time interval.		
Use a scale capable of measuring within 0.045 kg [0.1 lb] to weigh the fuel tank. Fill the fuel tank. Weigh the tank and the fuel. The weight of Number 2 diesel fuel is 0.844 kg per liter [7.03 lb per gallon]. Install a remote fuel tank (1) with enough capacity to run 80 km [50 mi] or 1 hour.		

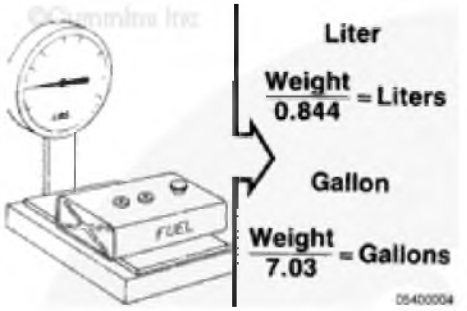
Test

For off-highway applications, measure the time with a stop watch.



After one hour of operation, weigh the fuel remaining, and compute the fuel used in liters [gallons] as required.

Compute the fuel consumption. Fuel used divided by the time equals the fuel consumption rate.



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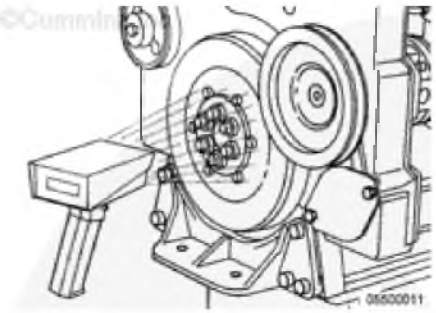
005-016 Fuel Pump

Pressure Test

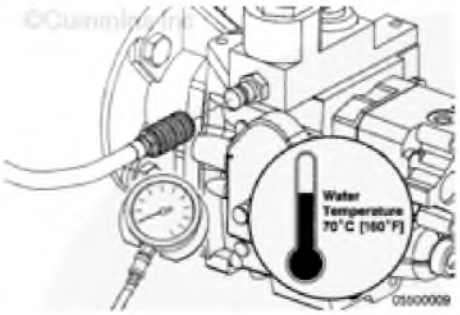
Use the INSITE™ tool, the vehicle tachometer, or an optical tachometer, Part Number 3377462, to check the fuel pump pressure at a specified rpm. See fuel pressure specifications in this section.



Use pressure gauge and hose assembly capable of 2800 kPa [400 psi] with quick disconnect fitting, Part Number ST-435-7.

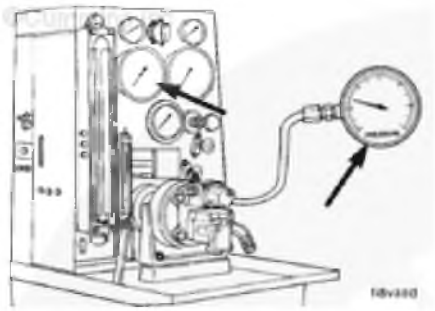
Crank the engine at 150 rpm and measure the fuel pressure. The minimum fuel pressure **must** be 241 kPa [35 psi].

Start the engine and operate at high idle speed. Refer to the table below for specifications.

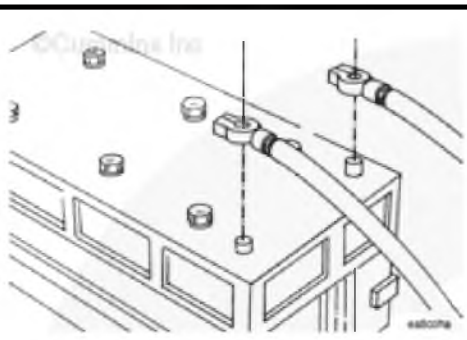


Minimum Fuel Pressure		
Engine High Idle Speed	kPa	psi
1500 rpm	1779	258
1800 rpm	2117	307
2100 rpm	2344	340

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

The fuel pressure will **not** change significantly with engine load.		
If the fuel pump pressure is **not** within specifications, check the fuel pump on a fuel pump test stand.		
If the fuel pump pressure is within specifications when checked on a fuel pump test stand, check the injector o-rings for damage. Refer to Procedure 006-026.		

Remove

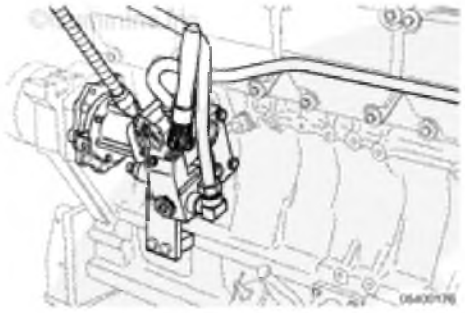
WARNING Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery last.		

Disconnect the battery cables.

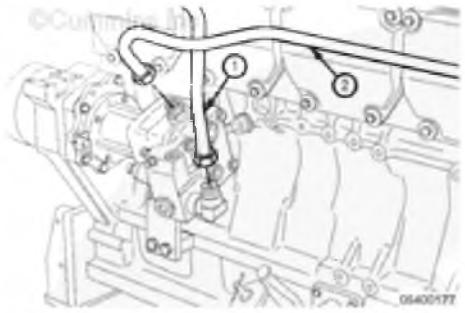
WARNING

Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.

Clean the fuel pump and surrounding area.



Disconnect the fuel pump inlet hose (1). Disconnect the electronic fuel control valve supply hose (2).

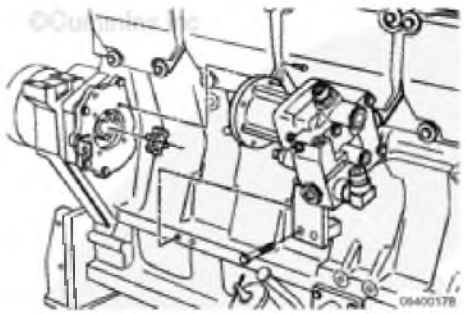


Remove the four mounting capscrews.

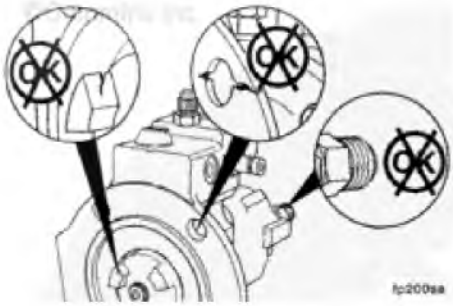
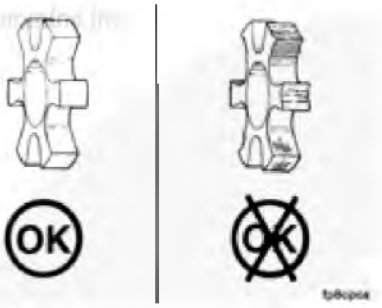
Remove the lower mounting bracket capscrews and remove the fuel pump.

Remove the jaw coupling spider.

Remove and discard the gasket.



Clean and Inspect for Reuse

Clean the fuel pump mounting surface.		
Inspect the fuel pump body and front support for cracks and other damage. Inspect the fuel pump assembly for damaged or loose capscrews and fittings. Inspect the drive coupling lugs for excessive wear or damage.		
Inspect the spider coupling for cracks or damage.		

Install

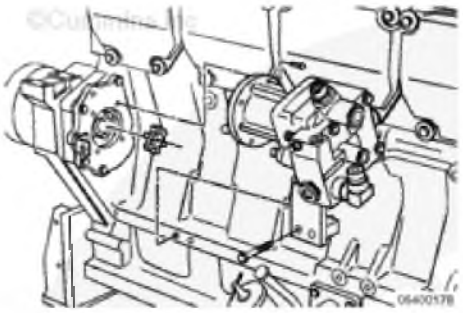
Install the fuel pump drive coupling, fuel pump gasket, and fuel pump.

Completely install the fuel pump mounting capscrews but do **not** tighten them.

Install the fuel pump support bracket.

Tighten the capscrews.

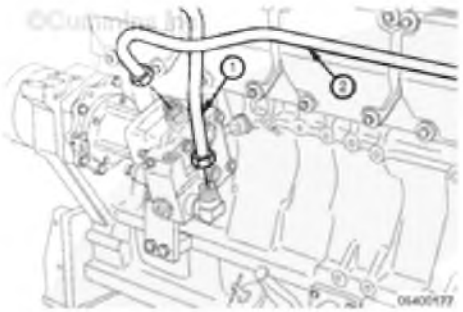
Bracket to Fuel Pump	100 n.m	[75 ft-lb]
Fuel Pump Mounting	70 n.m	[52 ft-lb]
Bracket to Block	70 n.m	[52 ft-lb]



Install the fuel pump inlet hose (1) and the electronic fuel control valve supply hose (2).

Tighten the hoses.

Fuel Pump Inlet Hose (1)	65 n.m	[48 ft-lb]
Fuel Supply Hose (2)	90 n.m	[66 ft-lb]



Prime

WARNING

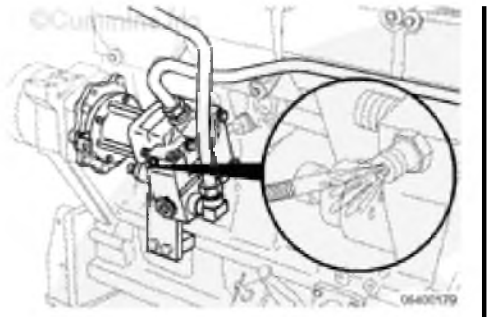
Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and

areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.

NOTE: This procedure is normally only required when the fuel pump has been changed, the fuel filters are dry, or the fuel system has been drained.

If the fuel supply pump is dirty, clean the outside of the pump near the fuel inlet and outlet.

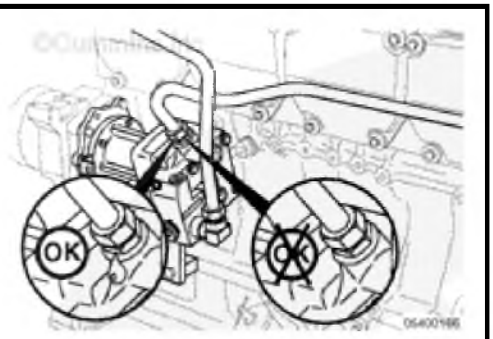
To reduce engine cranking time, depress the quick-disconnect fitting at the fuel pump outlet while cranking the engine until fuel is present.



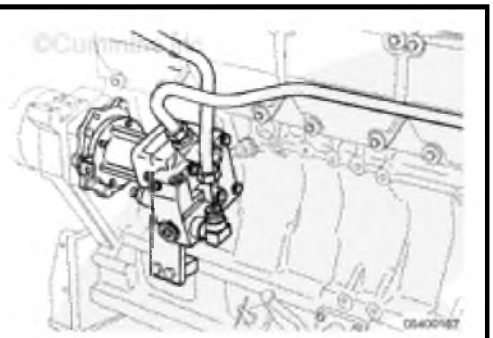
While the engine is cranking, loosen the electronic fuel control valve supply line at the top of the fuel pump. If fuel does **not** come out of the connection, the pump **must** be primed.

Tighten the fuel supply line.

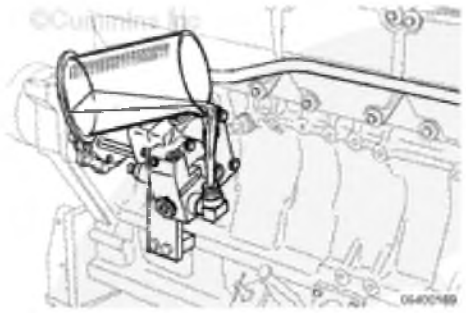
Torque Value: 90 n.m [66 ft-lb]



Remove the fuel pump inlet hose.



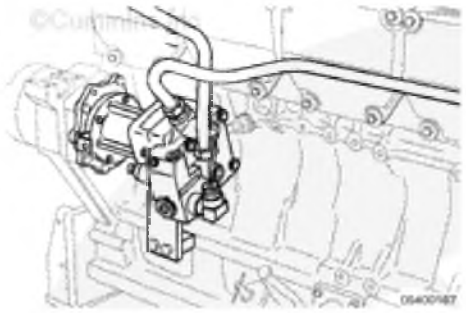
Use clean fuel and fill the fuel pump.



Install the fuel pump inlet hose to the fuel pump.

Tighten fuel supply hose.

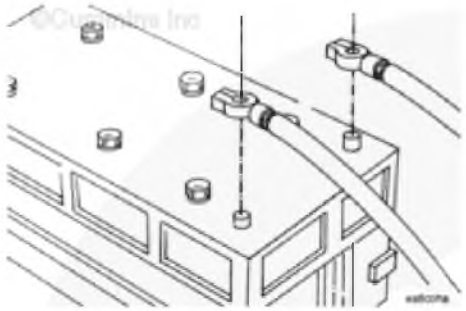
Torque Value: 90 n.m [66 ft-lb]



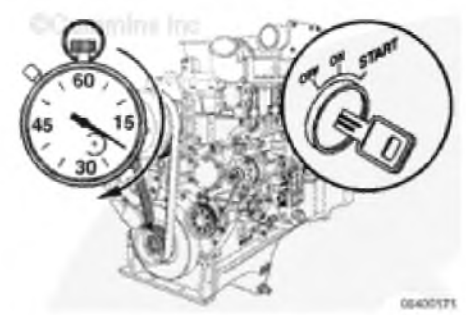
WARNING

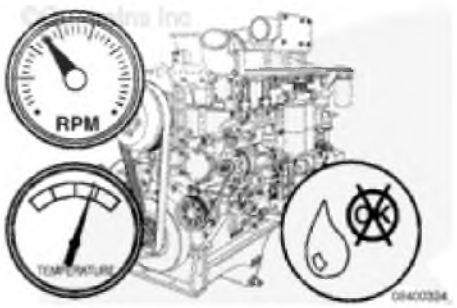
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery last.

Connect the battery cables.



Crank the engine for 20 seconds. If the engine does **not** start within 20 seconds, wait two minutes and repeat cranking procedure until the engine starts. The engine may run rough until the air is out of the system.



Operate the engine to normal operating temperature and check for leaks.		

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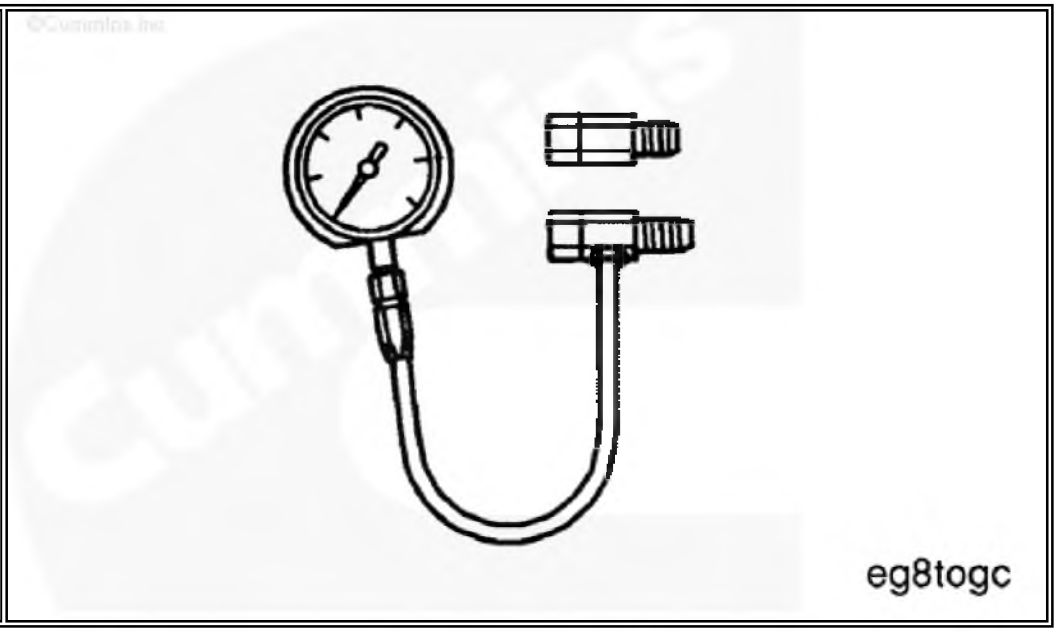
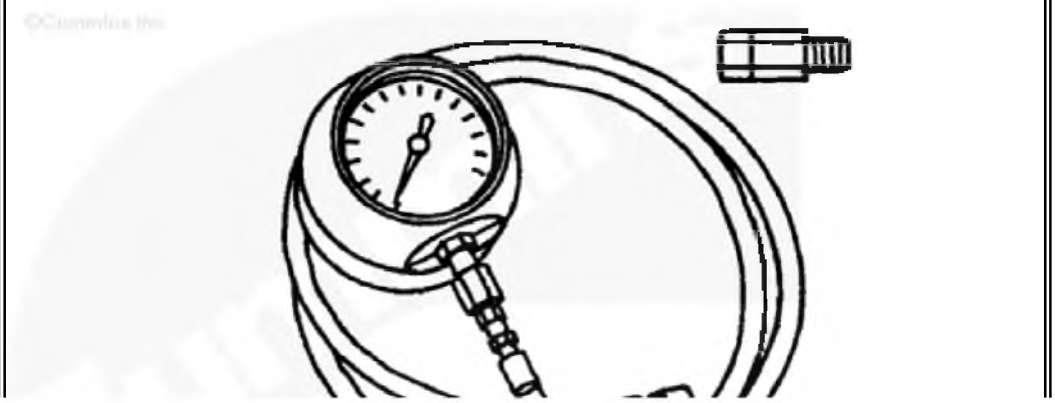
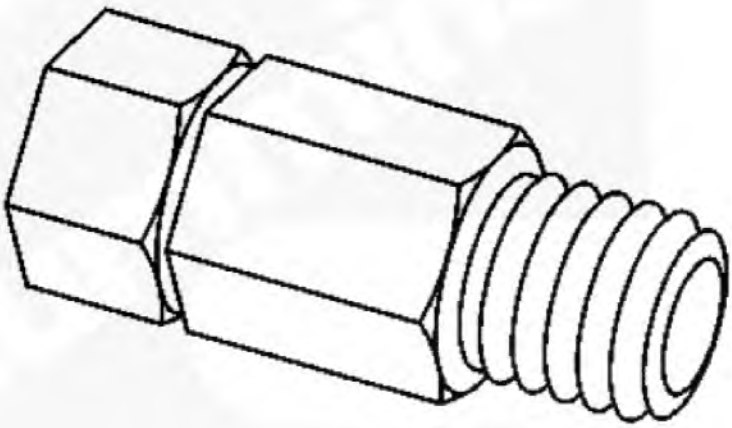
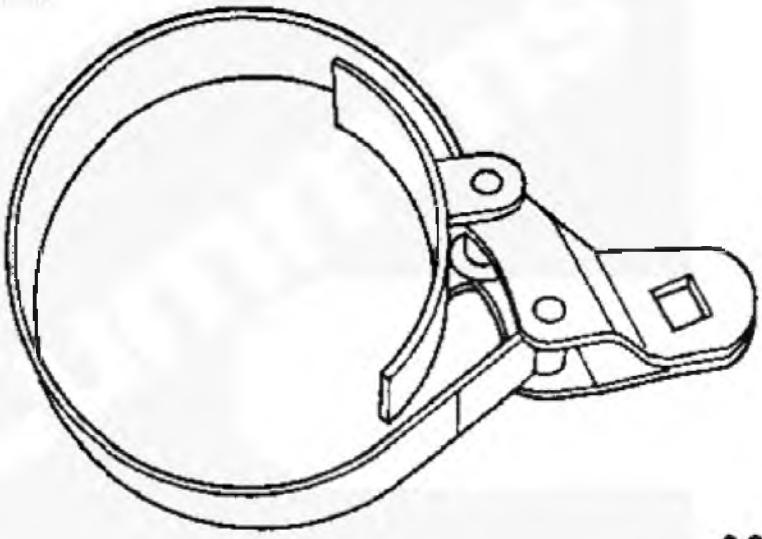
022-001 Service Tools

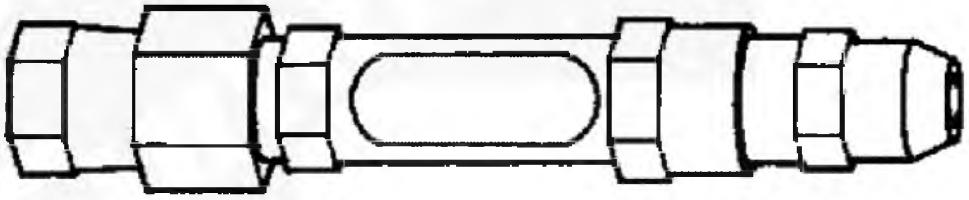
Injectors and Fuel Lines

Tool Number ST-434	**Vacuum Gauge** Measure fuel pump inlet restriction. Includes hose adapter (number 12 hose), and hose adapter (number 10 hose).	
Tool Number ST-1273	**Pressure Gauge** Measure injector drain line restriction when used with drain adapter, Part Number 3376719.	

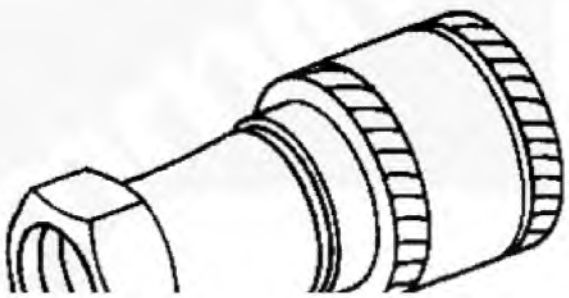
		eg8togi

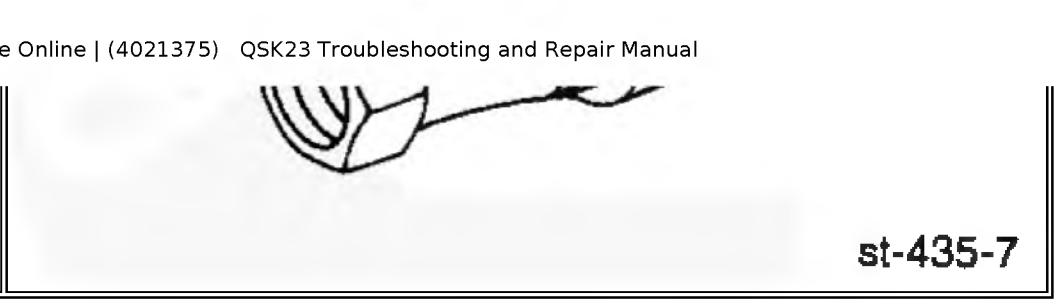
Tool Number 3376719	**Adapter** Use with pressure gauge, Part Number ST-1273 to measure restriction.	 22400191

Tool Number 3375049	**Filter Wrench** Remove fuel filter.	 3375049

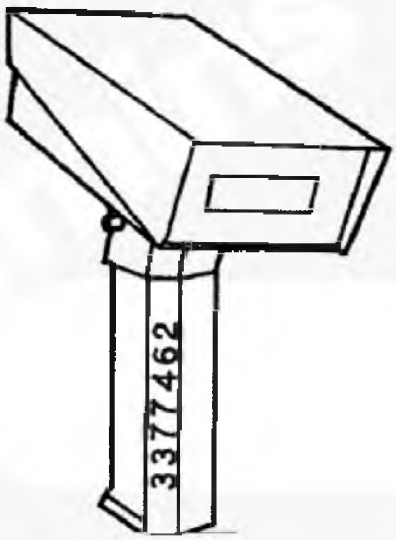
Tool Number 3164387	**Fuel Sight Glass** Used to check for air in the fuel suction line. Use with adapter hose, Part Number 3165146.	 22800570

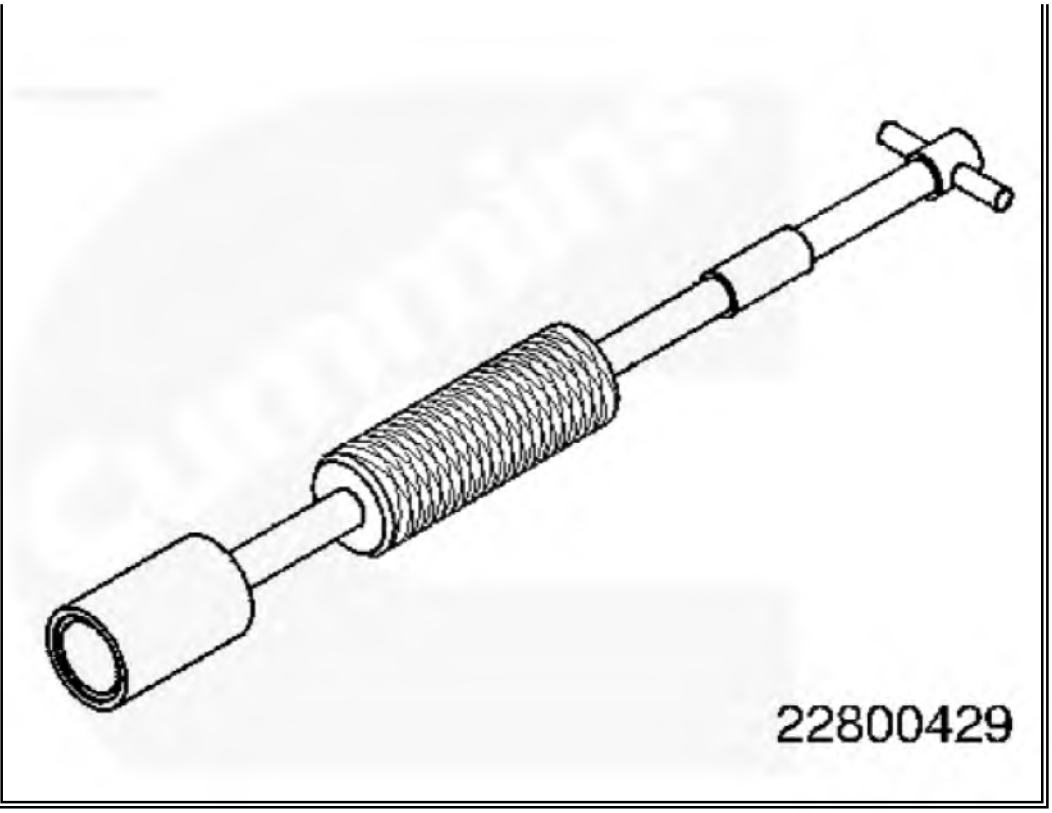
Tool Number 3165146	**Adapter Hose** Check for air in fuel suction line. Use with fuel sight glass, Part Number 3164387.	 22400190

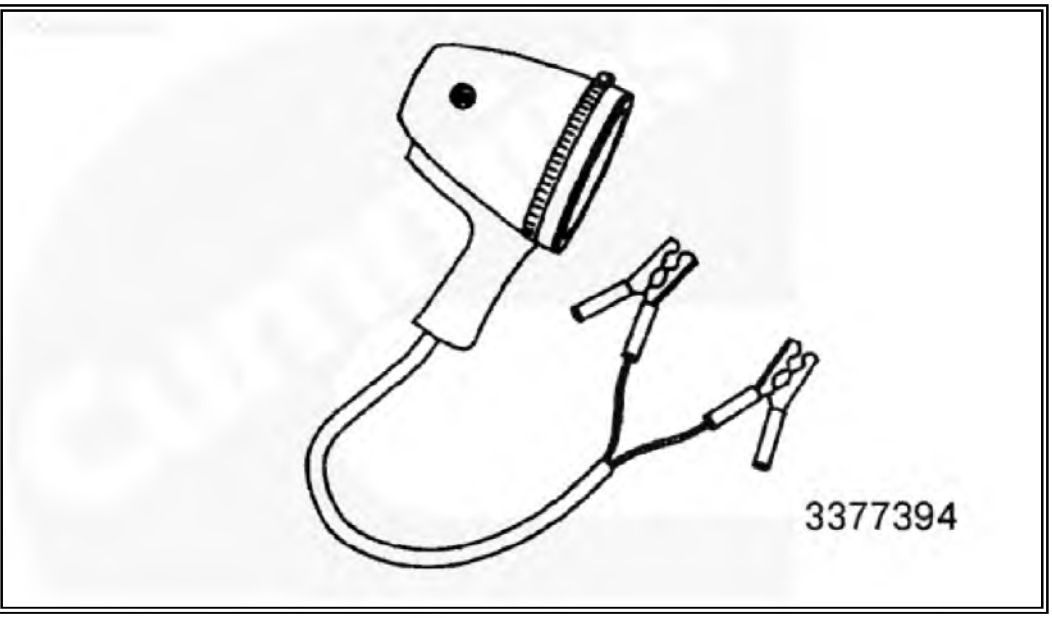
Tool Number ST-435-7	**Fitting** Connects gauges when measuring various fuel	

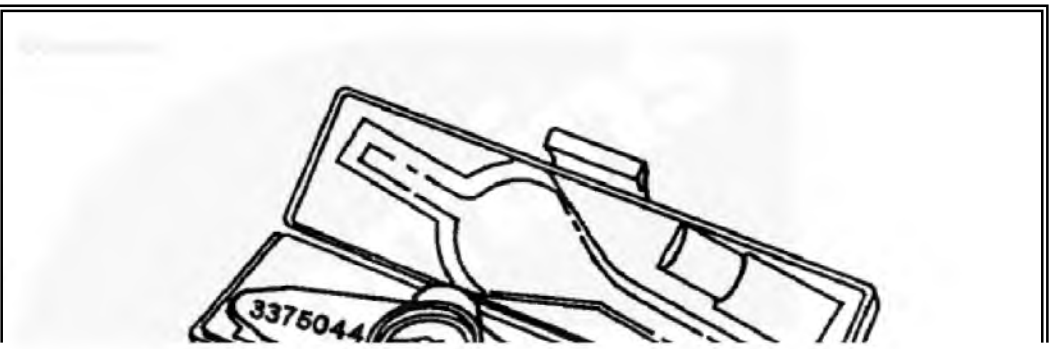
	pressures.	 st-435-7

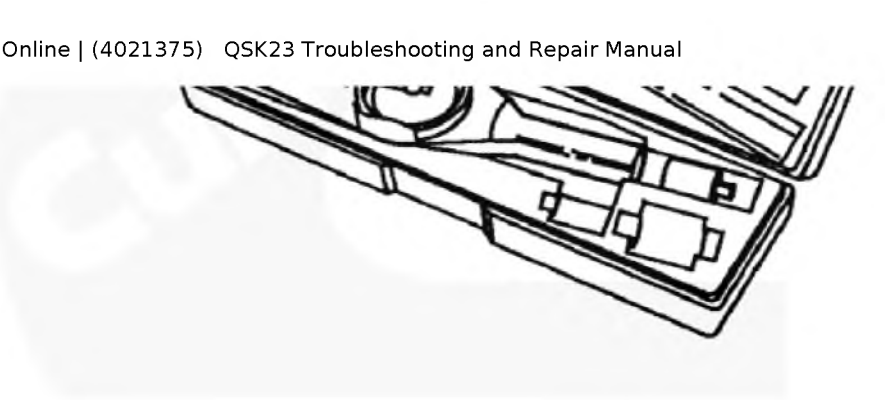
Tool Number 3376891	**Fluorescent Tracer** Put in engine oil or fuel. Use black light to read oil or fuel leaks.	3376891

Tool Number 3377462	**Optical Tachometer** Measure engine RPM.	 3377462

Tool Number 3824830	**Injector Removal and Installation Tool** Used to remove and install the QSK injector.	

Tool Number 3163337	**Black Light** Locate fuel, oil, or coolant leaks.	

Tool Number	**Torque Wrench** This is a [3/8 inch] drive,	

3164794	torque wrench used to set injector preload adjustments.	

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006-003 Air in Fuel

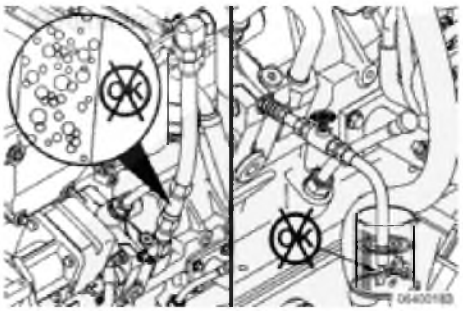
General Information

CAUTION

Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.

There are two good methods to check for air in the fuel.

- Sight glass method
- Gear pump drain method.



Test

Sight Glass Method

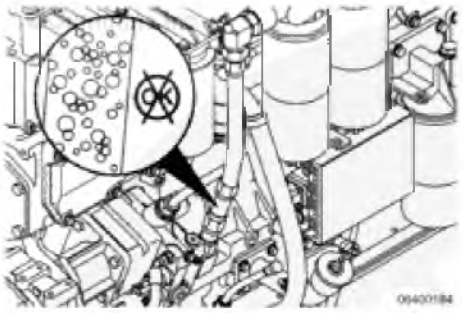
Remove the fuel inlet line connecting the fuel filter head to the fuel pump.

Replace the fuel line with the fuel sight glass, Part Number 3164387, and adapter hose, Part Number 3165146, or equivalent.

Operate the engine at high idle with no load.

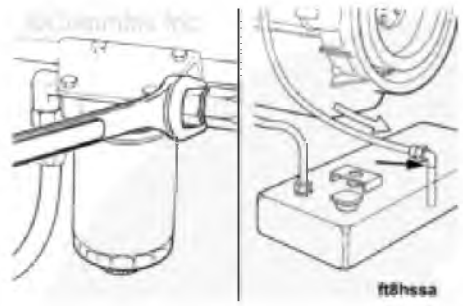
A small air leak will have a “milky” appearance.

A large air leak will look like bubbles in the fuel.



If an air leak is found, perform the following:

- Tighten the hose connections and the fuel filter.
- Check the drop tube in the fuel tank for damage.
- Check the fuel fitting supply o-rings for damage.

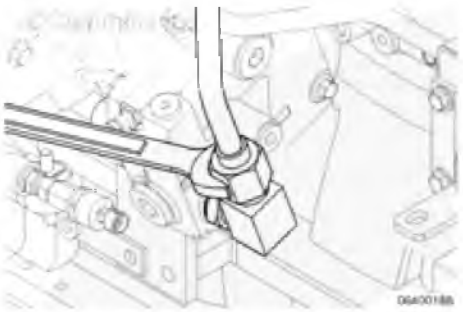


Continue to test and look for a source of air until no air bubbles are visible.

Remove the sight glass.

Tighten the fuel inlet hose.

Torque Value: 88 n.m [65 ft-lb]

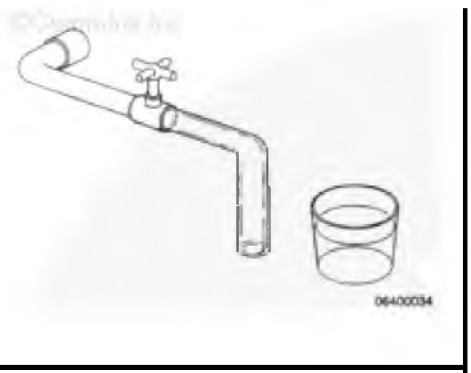


Gear Pump Drain Method

To perform a pressure side air in fuel test, use the following items:

- Quick disconnect fitting, Part Number

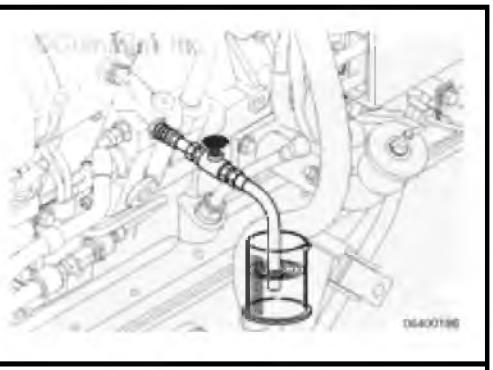
3376859
- High pressure hose
- Pressure valve (capable of 2758 kPa [400 psi])
- Clean tubing
- Clean container.



Connect the equipment to the quick-connect fitting at the fuel pump outlet.

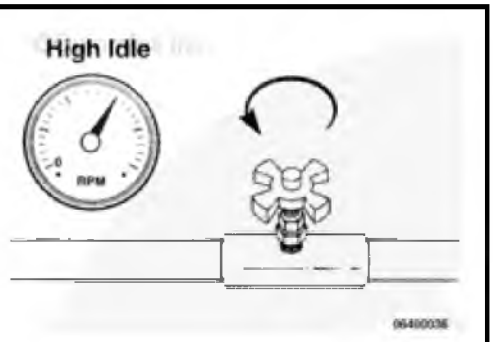
Put the end of the clear hose in the clean container.

Close the pressure valve.



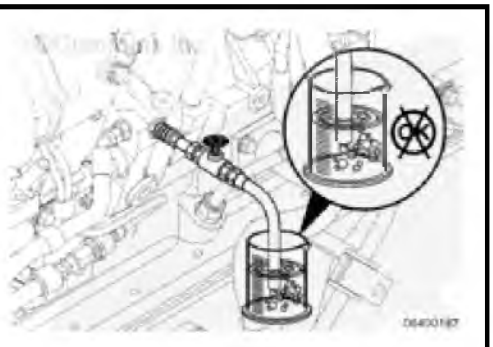
Operate the engine at high idle with no load.

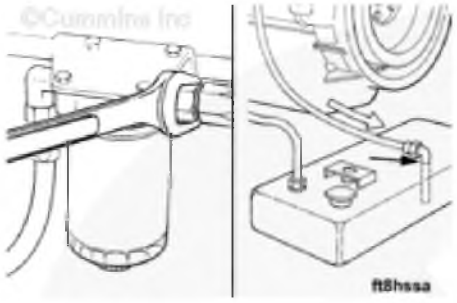
Slowly open the valve until a steady stream of fuel is visible.



Put the end of the hose below the surface of the fuel.

If there is an air leak, bubbles will be visible.



If an air leak is found, perform the following: • Tighten the hose connections on the fuel filter. • Check the drop tube in the fuel tank for damage. • Check the fuel supply fitting o-rings for damage.		
Continue to test and look for air leaks until there are no bubbles visible. Remove the test equipment.		

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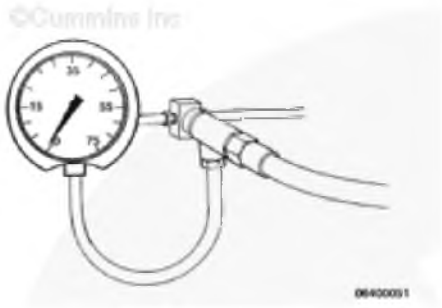
006-012 Fuel Drain Line Restriction

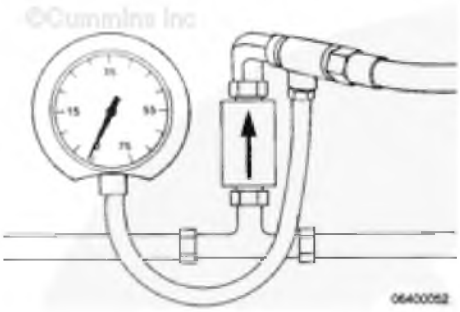
Measure

Remove the fuel drain hose.

Install the adapter, Part Number 3376719, and pressure gauge, Part Number ST-1273, between the engine fuel drain fitting and the fuel drain hose.



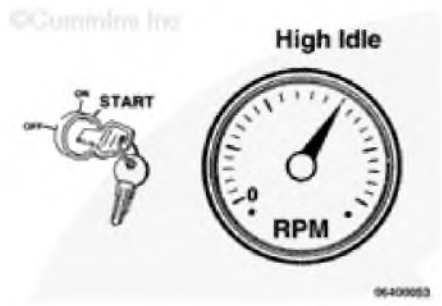
If the engine has a drain side check valve, install the adapter and pressure gauge between the check valve outlet and fuel drain hose.



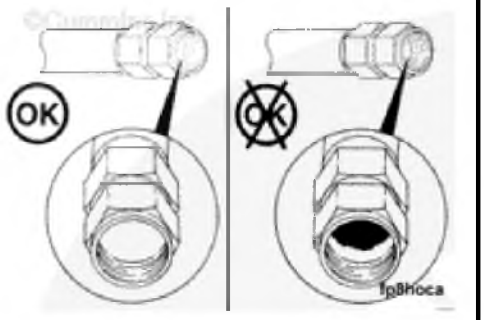
Start and operate the engine at high idle, no load.

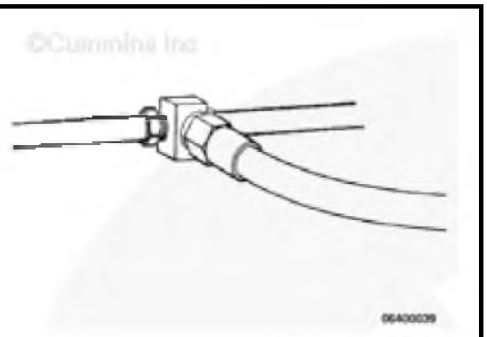
Fuel Drain Line Restriction

	kpa	psi
With check valve	21 MAX	3
Without check valve	30 MAX	5



All QSK23 engines are built without check valves.		

If the fuel drain line restriction is above specifications, inspect the fuel drain line. Refer to Procedure 006-013.		

Remove the pressure gauge. Install the fuel drain line. Tighten the fuel line. **Torque Value:** 95 n.m [70 ft-lb]		

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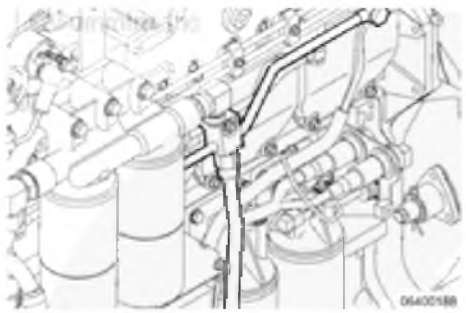
006-013 Fuel Drain Lines

Remove

Remove the engine-to-fuel tank fuel drain hose from the engine.

Remove the steel fuel drain line connecting the duel intake manifolds.

NOTE: Power generation engines use a one piece intake manifold and do not have this steel line.

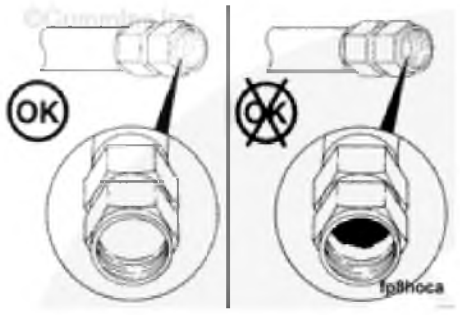


Clean and Inspect for Reuse

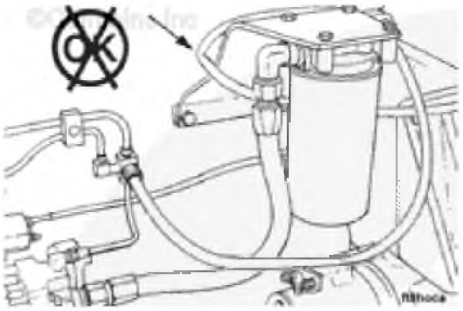
Inspect the inside of the engine-to-fuel tank fuel drain hose.

- The inner lining of the hose can separate from the center hose section.
- A separation of the inner lining can cause a restriction in the fuel flow.

Inspect for any pinches in the hose that would obstruct the flow.



Make sure the engine-to-fuel tank hose and the steel fuel manifold line are free of pinches or loops that would obstruct the flow.

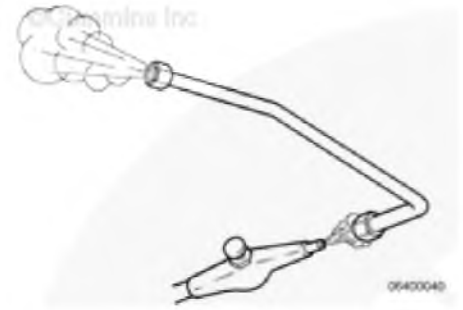


WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean and inspect the steel fuel manifold drain line.

Use compressed air to flush the line and remove any loose dirt or particles.



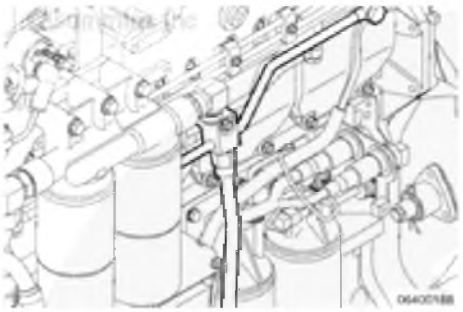
Install

Install and tighten the steel fuel manifold drain line.

Torque Value: 44 n.m [33 ft-lb]

Install and tighten the engine-to-fuel tank drain hose.

Torque Value: 95 n.m [70 ft-lb]



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006-015 Fuel Filter (Spin-On Type)

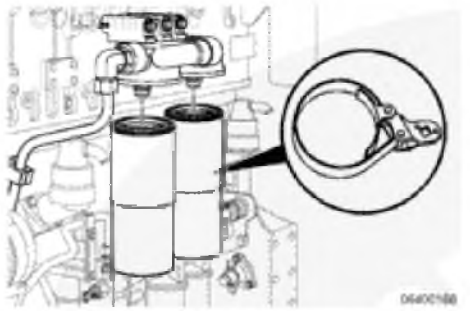
Remove

WARNING

Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.

Close the fuel line shutoff valve before changing the fuel filters. The overhead tank can drain, causing a fuel leak.

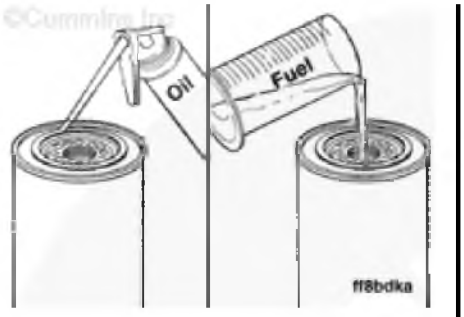
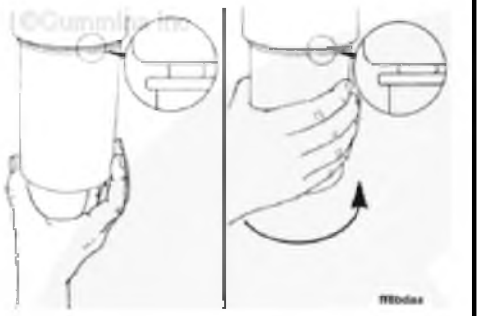
Remove the fuel filter with a filter wrench, Part Number 3376807, or equivalent.



Install

Use a clean lint-free towel to clean the sealing surface on the filter head.

A fuel-water separator or fuel filter and water separator combination filter **must** be

installed. Refer to Section V for fuel filter specifications. Apply a light coating of clean engine oil to the surface of the filter gasket. Fill the filter with clean fuel.		
Install the filter on the filter head. Turn the filter until the gasket touches the surface of the filter head. Tighten the filter an additional ½ to ¾ of a turn after the gasket touches the filter head surface. Open the fuel line shutoff valve and check for leaks.		

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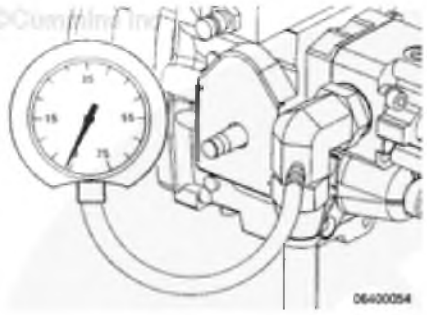
006-020 Fuel Inlet Restriction

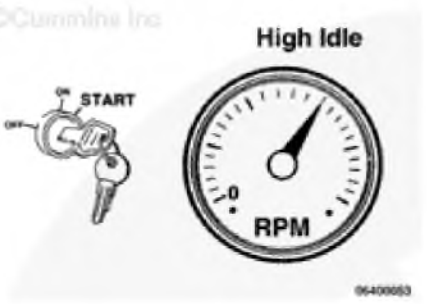
Measure

Use a Compuchek® fitting and a vacuum gauge, Part Number ST-434-12. Connect the gauge to the Compuchek® fitting on the fuel pump inlet fitting.



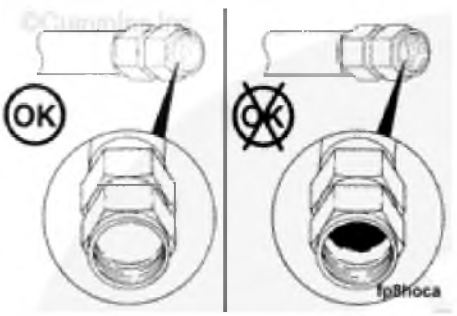
Start and operate the engine at high idle, no load.

Fuel Inlet Restriction	mm-hg	in-hg
With clean filters	102 MAX	4
With dirty filters	229 MAX	9



If the restriction is above specifications,

- Change the fuel filters. Refer to Procedure 006-015.
- Inspect the fuel lines. Refer to Procedure 006-024.



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006-024 Fuel Supply Lines

Preparatory Steps

- Remove as much of the engine wiring harness and brackets as necessary to gain access to the fuel tubes. Refer to Procedure 019-043 in the Fuel System Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, and QSK60 Engines, Bulletin 3666113.

Remove

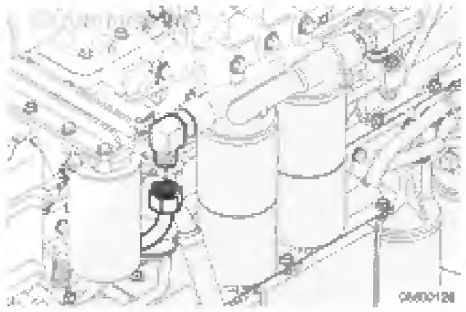
Use two wrenches to remove the fuel tubes and hoses.

Support the mating fittings with a wrench. Loosen the fuel tube nuts with the other wrench.

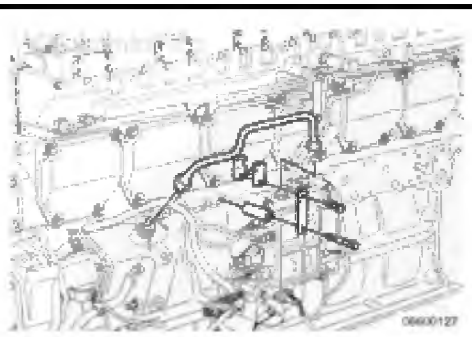
Tank to Fuel Filter

Remove the fuel filter inlet hose and related clamps.		

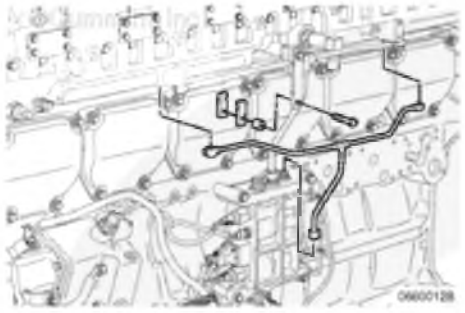
Fuel Pump Inlet Line

Remove the fuel pump inlet line and line clamp. Discard the o-rings.		

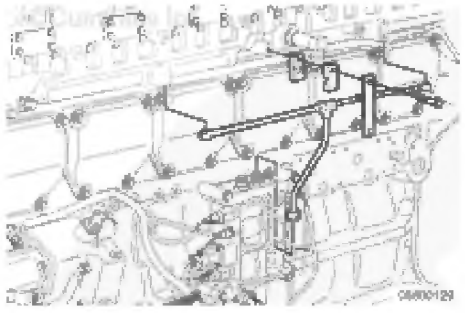
Control Supply Line

Remove the fuel control supply line and line clamp. Discard the o-rings.		

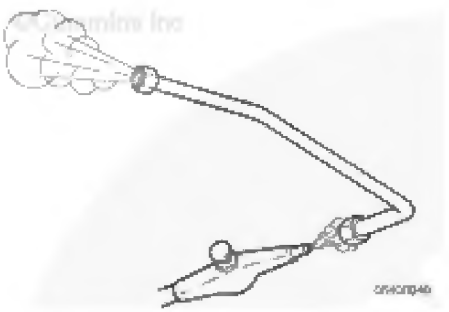
Timing Supply Line

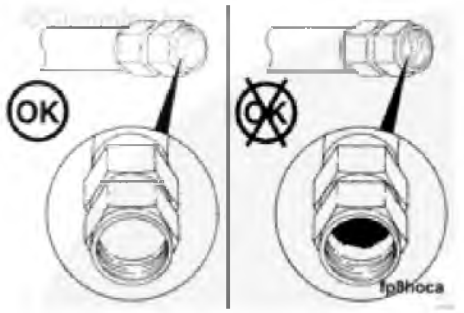
Remove the fuel timing supply line and line clamp. Discard the o-rings and banjo fitting washers.		

Rail Supply Line

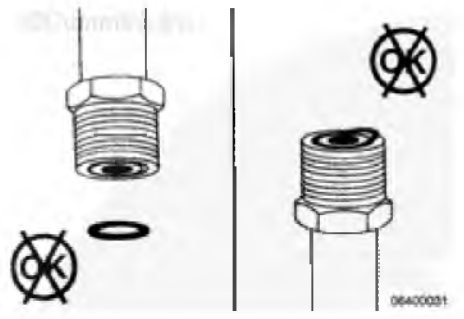
Remove the fuel rail supply line and line clamp. Discard the o-rings and banjo fitting washers.		

Clean and Inspect for Reuse

WARNING Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury. Use compressed air to flush the lines and remove any loose dirt particles.		

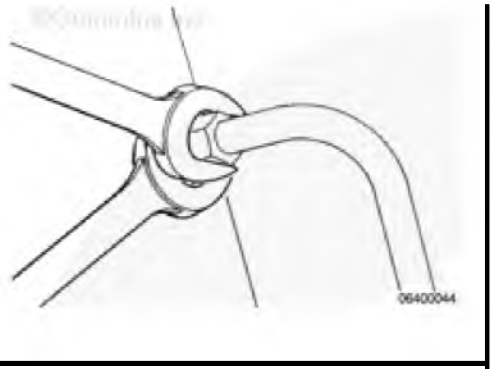
Inspect the inside of the hose. • The inner lining of the hose can separate from the center hose section. • A separation of the inner lining can cause a restriction in the fuel flow. Inspect for bends in the line that can restrict fuel flow.		
Inspect the line for cracks that can cause a pressure loss. Inspect the metal fuel lines for sharp bends that can cause a pressure restriction.		

Install

Install the new o-rings in the fittings. The fuel filter outlet, fuel pump inlet, fuel pump outlet, and fuel control module fittings use face seal o-rings. Make sure the o-rings are properly seated during installation.		

Use two wrenches to install the fuel tubes and hoses.

Support the mating fittings with a wrench. Tighten the fuel tube nuts with the other wrench.

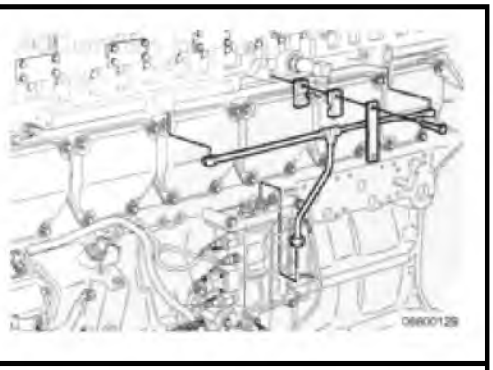


Rail Supply Line

Install a new o-ring in the rail supply line fitting and new washers on the banjo fittings.

Install the rail supply line.

Sleeve nut	27 mm	[20 ft-lb]
Banjo fitting	34 mm	[25 ft-lb]

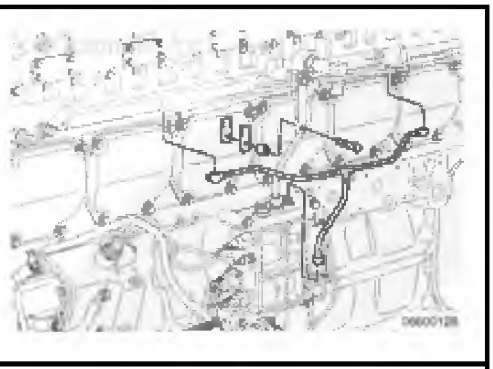


Timing Supply Line

Install a new o-ring in the timing supply line fitting and new washers on the banjo fittings.

Install the timing supply line and line clamp.

Sleeve nut	47 mm	[35 ft-lb]
Banjo fitting	44 mm	[32 ft-lb]

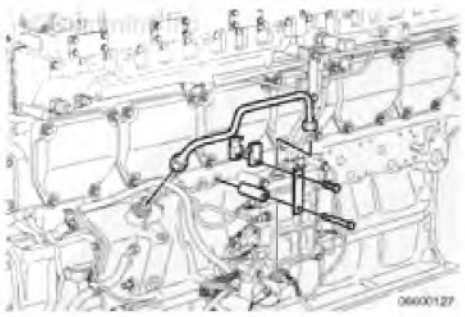


Control Supply Line

Install new o-rings in the fuel pump outlet and fuel control module inlet fittings.

Install the fuel control module supply line.

Torque Value: 68 n.m [50 ft-lb]



Fuel Pump Inlet Line

Install new o-rings in the fuel pump inlet and fuel control module outlet fittings.

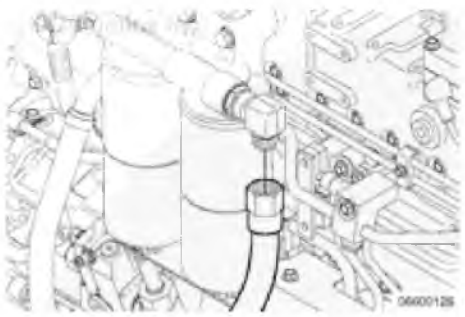
Install the fuel pump inlet line and line clamp.

Torque Value: 95 n.m [70 ft-lb]

Tank to Fuel Filter

Install the fuel filter inlet line.

Torque Value: 95 n.m [70 ft-lb]



Finishing Steps

• Install the engine wiring harness and brackets, as necessary. Refer to Procedure 019-043 in the Fuel System Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, and QSK60 Engines, Bulletin 3666113.		

Last Modified: 17-Mar-2003

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View Related Topic

006-026 Injector

Initial Check

Misfire Using Heat Indicator Marker

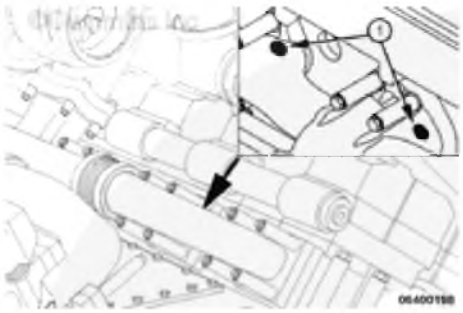
NOTE: This procedure may not be effective when the symptoms occur only at low idle or when the engine is cold.

WARNING

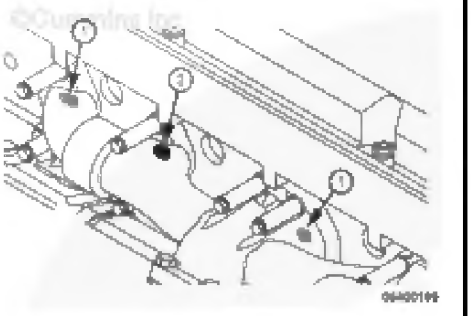
The engine temperature, when performing in-chassis exhaust temperature testing, can be excessive. To reduce the possibility of serious injury wait until the engine coolant temperature is below 50°C [122°F].

If the engine exhibits symptoms of a possible injector **not** firing, perform the following check:

Operate the engine to normal operating coolant temperature of 80°C [180°F].

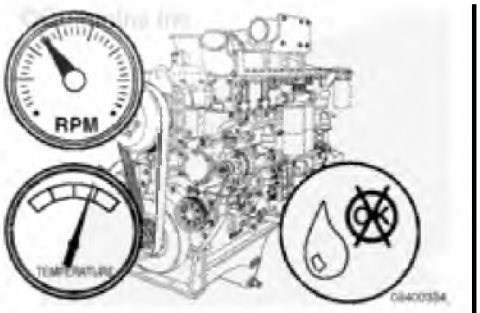


Stop the engine and allow the exhaust manifold to cool for 10 minutes. Apply a mark (1) using a 204°C [400°F] temperature indicator marker, (Part Number 3165163), on the surface of all exhaust manifold ports. The mark should be as close to the cylinder head as possible, but **not** directly on the exhaust manifold mounting flange. Start the engine and operate under light load for a short time. Do **not** operate the engine under heavy load or for an extended period of time as this may cause inaccurate results.		

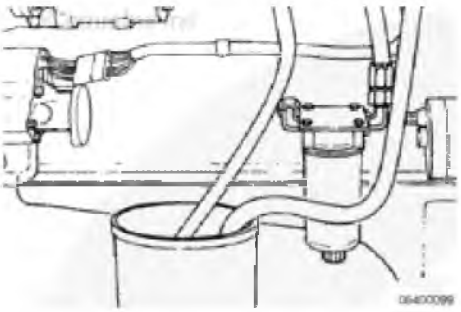
If the 204°C [400°F] mark melts (1) the color will disappear and leave **only** a transparent glazed appearance where the mark was. This indicates that the cylinder is operating to a temperature above 204°C [400°F] . If the 204°C [400°F] mark does **not** melt (2) the mark color remains present. This indicates that the cylinder is **not** operating to temperature of 204°C [400°F], indicating a possible injector malfunction. Refer to the trouble shooting tree t062 for additional troubleshooting information. **NOTE: It is not recommended to use the temperature indicator markers to troubleshoot for cylinders that are operating too hot.**		

Flourescent Tracer Dye Test

Run the engine until the water temperature is above 80°C [180°F].		



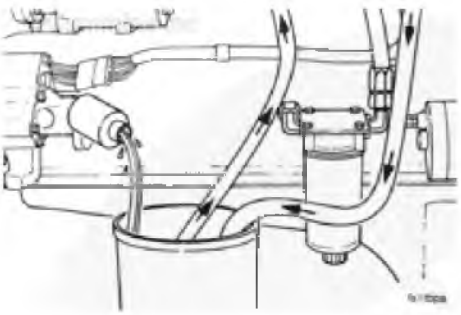
Remove the fuel pump return and supply lines and install a 50 litre [15 gallon] isolated fuel supply tank.



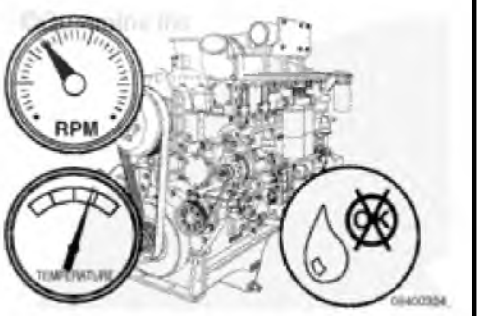
Add one unit of fluorescent tracer, Part Number 3376891, to each 38 litres [10 gallons] of fuel.

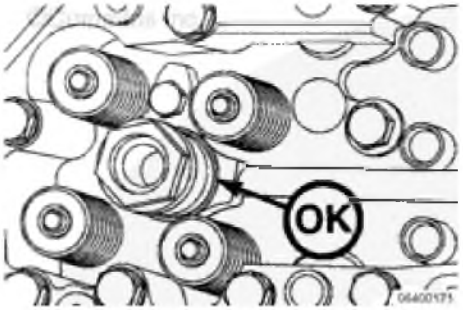
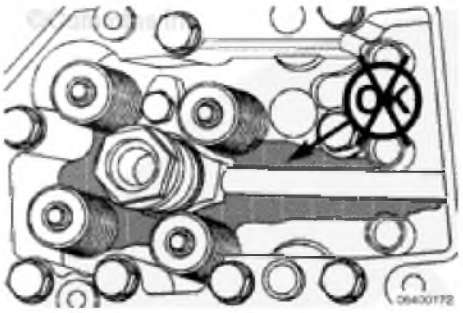
Preheat the black light.

Remove the rocker lever cover mounting hardware, but do **not** remove the rocker lever covers.



Idle the engine for 5 to 10 minutes or until normal operating temperature is reached to allow the dye to circulate through the fuel system.



Shut the engine off. Immediately remove the rocker lever covers and inspect each cylinder head using the black light. Some leakage around the injector is normal.		
Replace the injector or injector o-rings if an abnormal amount of leakage is detected.		

Preparatory Steps

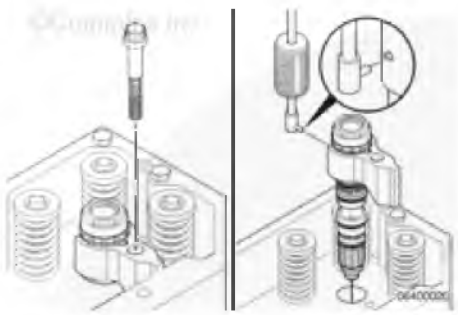
• Remove the rocker lever assembly. Refer to Procedure 003-009.		

Remove

Remove the injector hold-down capscrew. Remove the injector and clamp.

Use injector removal/installation tool, Part Number 3824830, to remove the injectors. Insert the pin of the tool in the hole provided in the body of the injector. The hole faces the front of the engine.

If the injector removal/installation tool mentioned above is **not** available, carefully use a pry bar. Pry upward on the injector against the cylinder head.



Inspect for Reuse

Remove the sealing ring (1) and note the cylinder location.

Sealing rings are available in different thickness sizes to adjust the injector protrusion.

The four new o-rings **must** be installed and oriented correctly on the injector. Identify the o-rings to install them in the correct grooves.

Remove the o-rings (2, 3, 4, and 5).

Use a lint-free cloth to clean the exterior of the injector.

Carefully check the area where the

sealing ring touches the injector.

Inspect the o-ring grooves for damage.

Inspect the injector body and cup retainer for cracks or other damage.

Inspect the injector links for damage, excessive wear, and pitting or scoring on the ball ends.

If the link is damaged or pitting/scoring can be seen or felt, the link **must** be replaced.

O-ring (2) is brown and is smaller in diameter than the other three.

O-ring (3) is black.

O-ring (4) is brown and is larger in diameter than (2), but has a smaller cross section than o-ring (5).

O-ring (5) is brown and is the largest in diameter and cross section.

Do **not** lubricate the o-rings until the injector is ready for installation in the cylinder head.

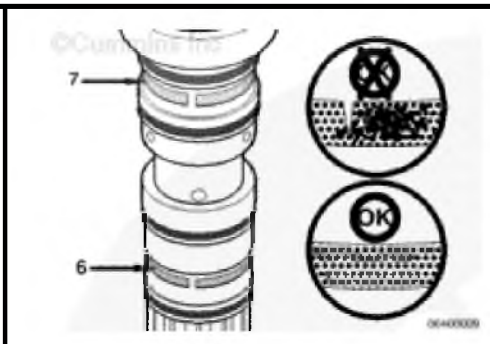
Install four new o-rings on the injector. Do **not** twist the o-rings.

Install the proper size sealing ring (1).

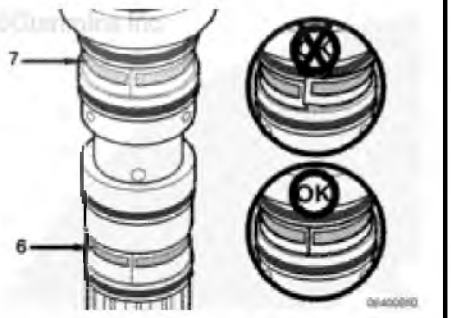
WARNING

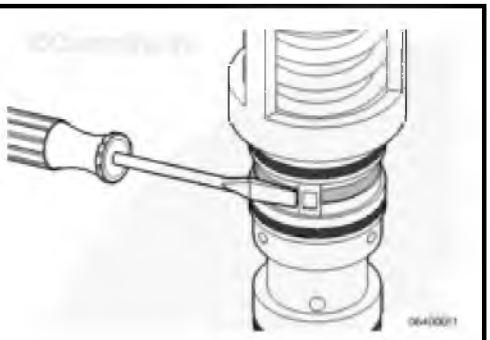
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

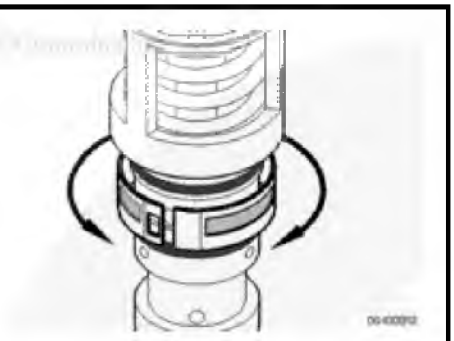
Use solvent when cleaning the filters. The screens **must** be thoroughly dry prior to installation.



Check the rail (6) and timing (7) filter screens for debris, tears, or punctures. Replace the filter screens if damaged or dirty.		

Check the rail (6) and timing (7) filter for proper installation. Screens **must** be securely snapped into the correct position.		

Use a small screwdriver to remove the filter screen by gently prying up on the connector clip.		

Wrap the filter screen around the inlet groove.		

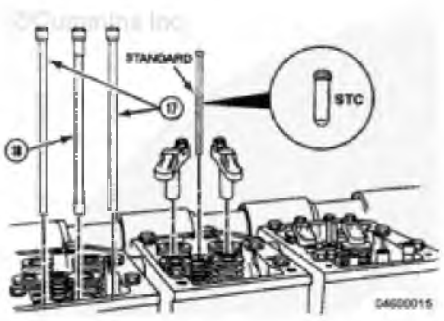
Apply pressure on the filter screen connector clip. A properly secured connector will create a		

single, snapping sound.

Install

Use clean 15W-40 engine oil to lubricate the o-rings.

Install the hold-down clamp on the side of the injector.

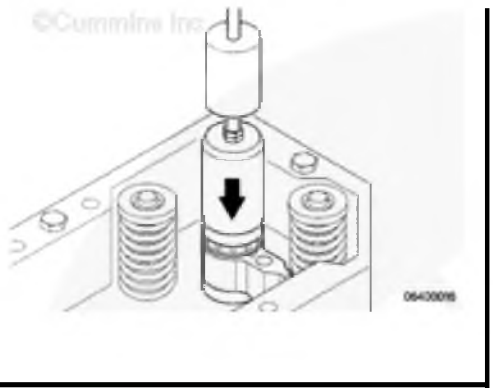


Install the injector and hold-down clamp in the cylinder head.

Use the injector removal/installation tool, Part Number 3824830, to set the injector in the bore.

The slide hammer will make a dull sound when the injector is seated properly.

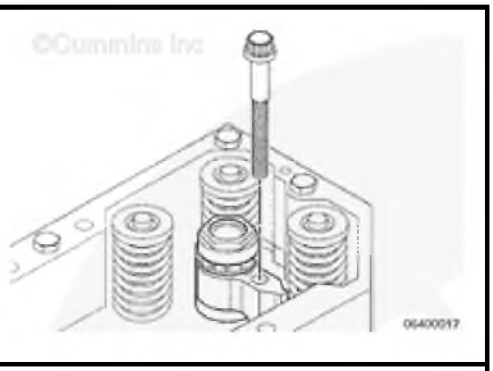
NOTE: If the injector removal/installation tool, Part Number 3824830, is not available, use a 40 mm [19/16 in] socket with an extension and a rubber mallet to install the injector.



Use clean 15W-40 engine oil to lubricate the injector hold-down capscrew.

Install the injector hold-down capscrew.

Torque Value:	Step 1	34 n.m [25 ft-lb]
	Step 2	Tighten 90°



Finishing Steps

- Install the rocker lever assembly. Refer to Procedure 003-009.
- Adjust the valves and injectors. Refer to Procedure 003-006.
- Install the rocker lever cover. Refer to Procedure 003-011.

Last Modified: 13-Nov-2003

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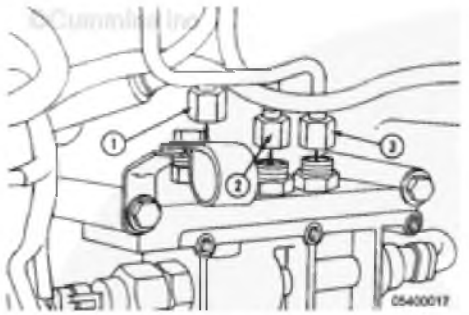
006-049 Fuel Control Valve Body Assembly

Preparatory Steps

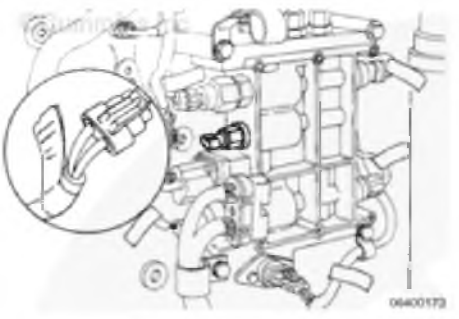
- Remove the electronic control module (ECM). Refer to Procedure 019-031 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.
- Clean the control valve body and the surrounding area.

Disconnect the fuel supply hose (1), timing pressure line (2), and rail pressure line (3), at the control valve body.



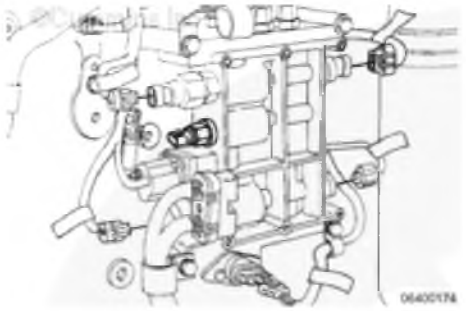
It is a good service practice to label parts during removal. Identification of the connections at time of removal with a label will aid the installation process.

Label the electrical connections to the actuators, fuel pressure sensors, and

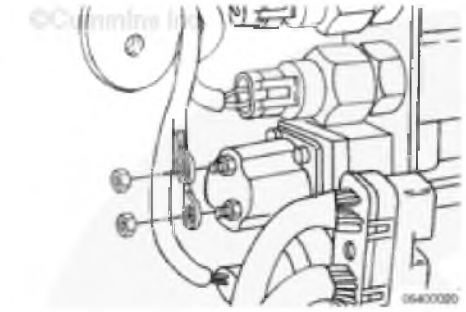


ambient air pressure sensor.

Disconnect the actuator and pressure sensor connections.



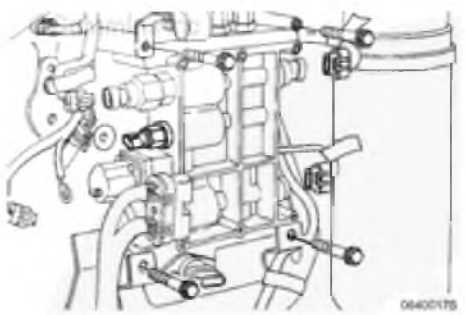
Remove the nuts holding the electrical connections of the fuel shutoff valve coil. Refer to Procedure 019-050 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.



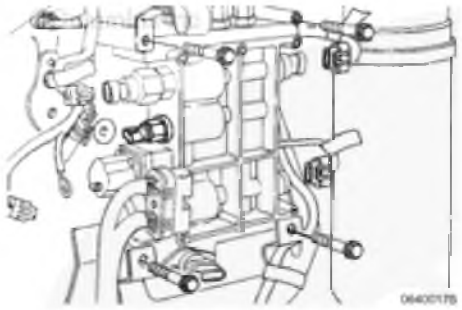
Remove

Remove the four capscrews. Move the wire harness and brackets away from the control valve body to gain access.

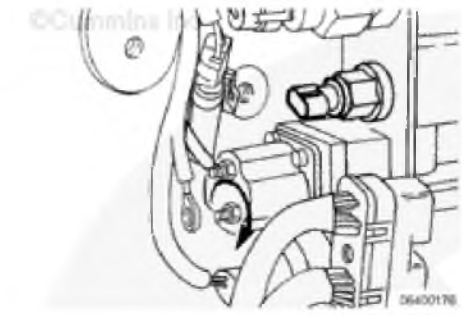
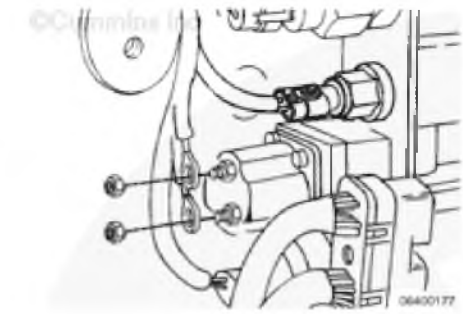
Remove the control valve body assembly.



Install

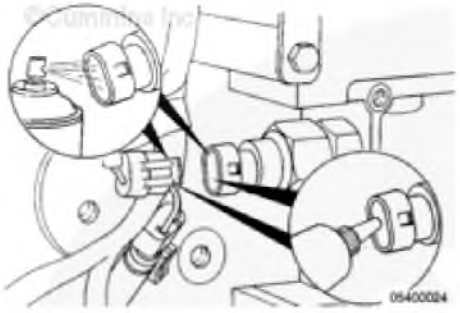
Install the four capscrews to secure the control valve body assembly and the wire harness and brackets. **Torque Value:** 45 n.m [35 ft-lb]		

Finishing Steps

Install the nut that holds the electrical connection post on the fuel shutoff valve coil. Refer to Procedure 019-050 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.		
Install the electrical connection on the fuel shutoff valve. Refer to Procedure 019-050 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.		

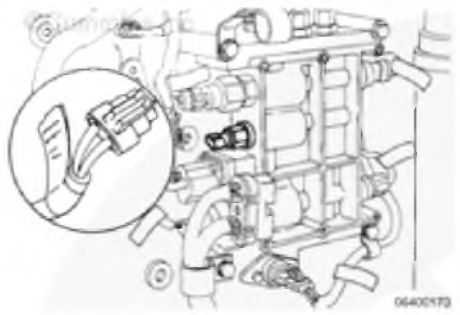
Inspect the actuator and pressure sensor connections for dirt and debris.

Use QD contact cleaner, Part Number 3824510, to clean the connections and actuator, if cleaning is required.



NOTE: If the electrical connections were not labeled for identification purposes during disassembly, verify the types of connections on the wiring diagram.

Connect the actuator and pressure sensor connections.

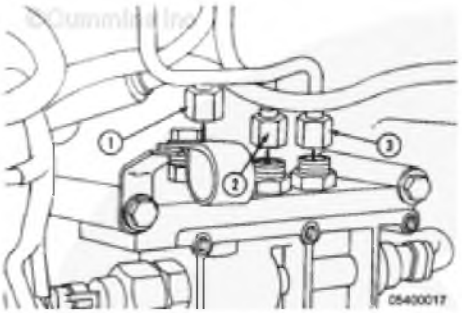


Connect the fuel supply hose (1), the timing rail pressure line (2), and the metering rail pressure lines (3) to the control valve body.

Tighten the fuel supply hose (1).

Tighten the timing pressure (2) and rail pressure lines (3).

Fuel Supply Hose (1)	68 n.m	[50 ft-lb]
Timing Pressure Line (2)	47 n.m	[35 ft-lb]
Rail Pressure Line (3)	27 n.m	[20 ft-lb]



• Install the ECM. Refer to Procedure 019-031 in the Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines, Bulletin 3666113.		

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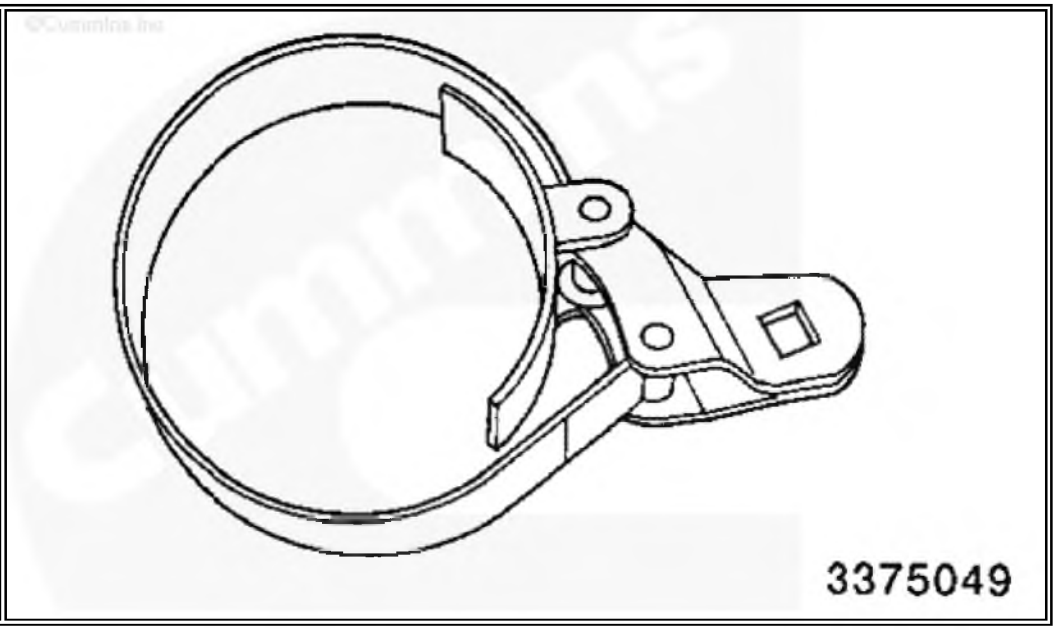
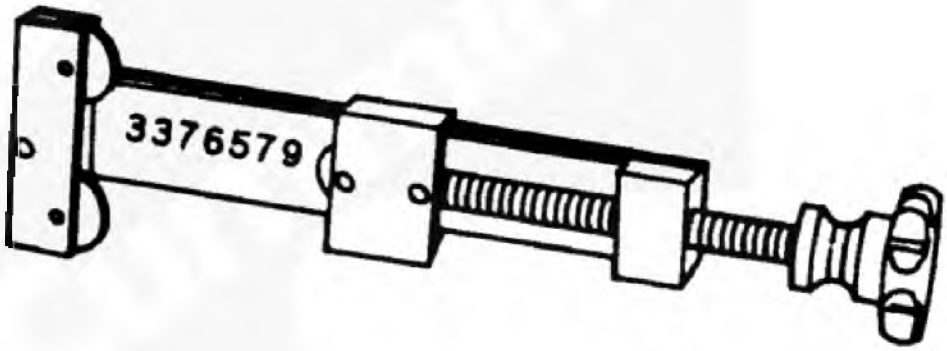
022-001 Service Tools

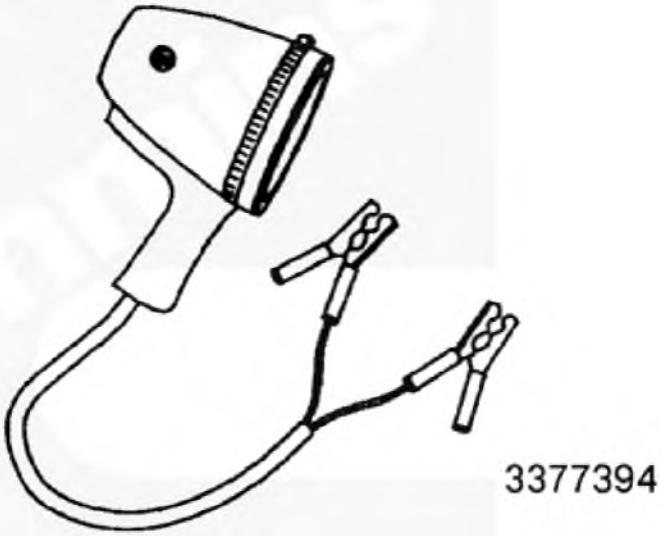
Lubricating Oil System

Tool Number 3375049	**Oil Filter Wrench** Remove spin-on oil filter.	

Tool Number 3375182	**Valve Spring Tester** Measure spring force at a given spring height.	

Tool Number 3376579	**Filter Cutter** Open spin-on full-flow filter for inspection.	 lf8togd

Tool Number 3376891	**Fluorescent Tracer** Add to oil. Use with black light to find oil leaks.	 3376891

Tool Number		
3163337	**Black Light** Used to locate oil or coolant leaks.	

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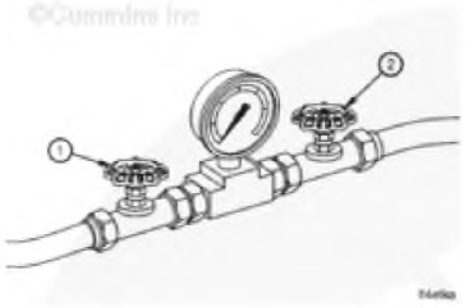
007-007 Lubricating Oil Cooler Element

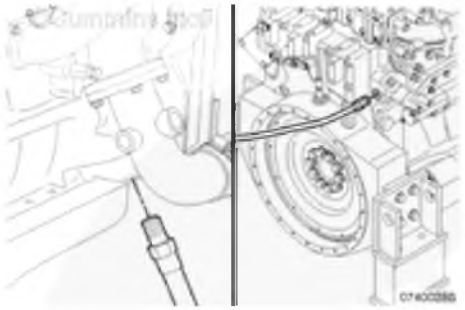
Pressure Differential Test

Use a differential pressure gauge or one pressure gauge with two oil hoses and two valves to eliminate gauge error. Use a gauge with a minimum pressure capacity of 517 kPa [75 psi].

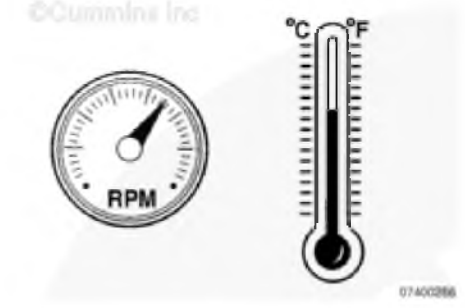


Install a hose into the oil port located on the exhaust side of the engine, under the water pump inlet. This port indicates oil pressure entering the oil coolers.

Install a hose in the oil port located on the right rear of the engine. See illustration for detail. This port indicates oil pressure leaving the oil coolers.



Operate the engine at rated rpm until the oil temperature is at least 112°C [234°F].



Close valve number 1 and open valve number 2.

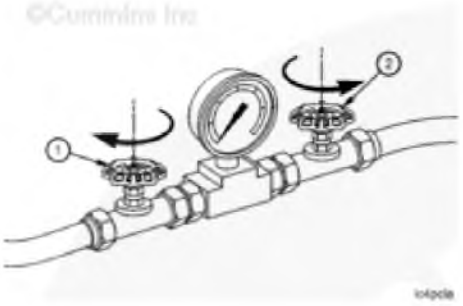
Read the oil pressure after the oil has passed through the oil coolers.

Open valve number 1 and close valve number 2.

Read the pressure of the oil being supplied to the oil coolers.

Compare the difference between the two pressures. If the difference is more than the maximum limit specified below, replace the oil cooler elements.

Lubricating Oil Cooler Differential		
	kpa	psi
Industrial Applications (2100 rpm)	352 MAX	51
Power-Generation (1500 rpm)	248 MAX	36
Power-Generation (1800 rpm)	283 MAX	41



Preparatory Steps

WARNING

Some state and federal agencies 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

Use engine oil must be disposed of in accordance with local environmental regulations.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

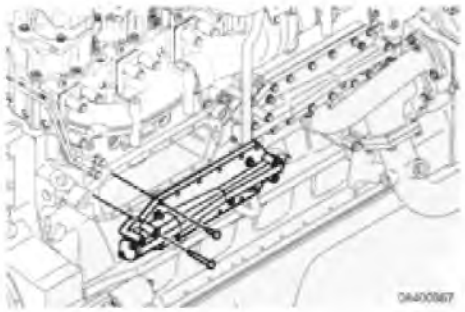
- Drain the cooling system. Refer to Procedure 008-018.
- Remove the water pump supply tube, if necessary. Refer to Procedure 008-062.
- Remove the turbocharger oil supply and drain lines, if necessary. Refer to Procedure 010-033.

Remove

Remove the oil cooler cover and element

assembly.

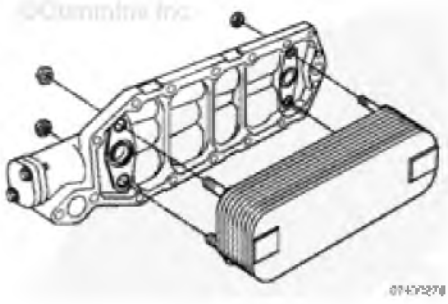
Discard the old gasket.



Disassemble

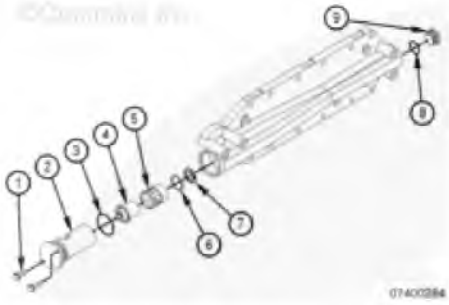
Remove the four nuts and the oil cooler element from each oil cooler assembly.

Remove and discard the six o-rings and two gaskets for each oil cooler assembly.



Remove the following components from the oil cooler cover:

- Capscrews (1)
- Cover (2)
- O-ring (3)
- Thermostat (4)
- Seal housing (5)
- Thermostat seal (6)
- Disk valve (7)
- O-ring (8)
- Plug (9)



Clean and Inspect for Reuse

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

WARNING

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

WARNING

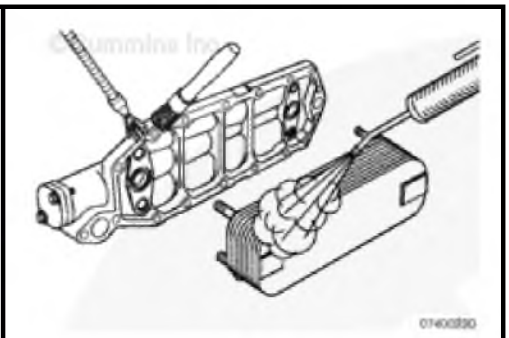
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

CAUTION

Use a solvent that is not harmful to copper.

Replace the oil cooler elements, engine oil, and lubricating oil filters, if any debris is found or the engine has a debris-causing failure.

Remove gasket material from the oil cooler cover, oil cooler element, and engine block mating surface.



Use steam or hot, high-pressure water. Clean the exterior of the element. Flush the interior of the element until all engine oil is removed.

Dry the element with compressed air.

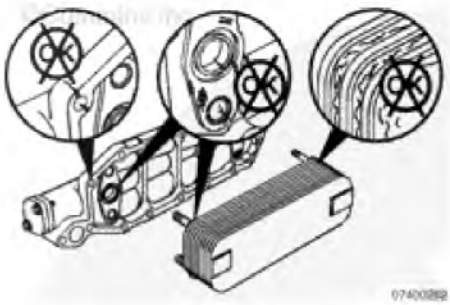
Use solvent to clean the oil cooler cover.

Dry the oil cooler cover with compressed air.

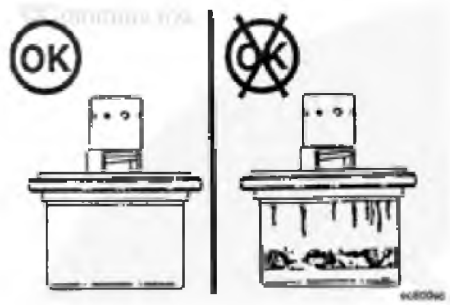
Check the cover and housing for cracks. If leaks are suspected, use the dye-penetrant method to locate them.

Check the cover and housing for corrosion.

Check the exterior of the element for scale-formed minerals in the cooling water. If there is evidence of scale, clean the exterior of the element using cleaning methods for the interior of the radiator.

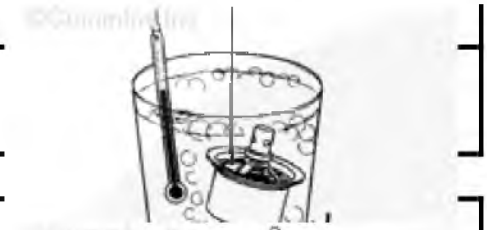


Inspect the thermostat for wear or damage. If the barrel of the thermostat is worn or fretted, the thermostat **must** be replaced.



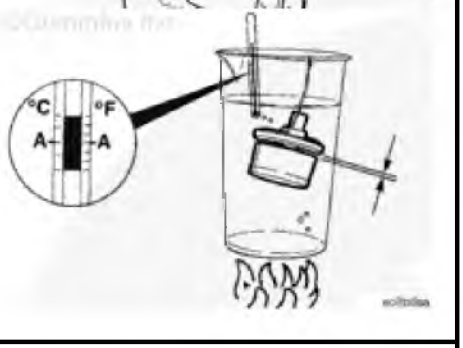
Suspend the thermostat and a 100°C [212°F] thermometer in a container of water and heat the water to 100°C [212°F]. Do **not** let the thermostat or thermometer touch the sides of the container.

Allow the thermostat to soak in the 100°C [212°F] for 4 to 5 minutes.



Continue to apply heat and check that the thermostat is fully open and the water is at the “full open” temperature.

Thermostat Opening Distance			
	mm		in
100°C [212°F]	8	MIN	0.31



Remove the heat and check to see that the thermostat fully closes as the water cools to 85°C [185°F].

Measurements		
	celsius	fahrenheit
Fully Closed Thermostat	85	185

If the thermostat does **not** perform to specifications, it **must** be replaced.

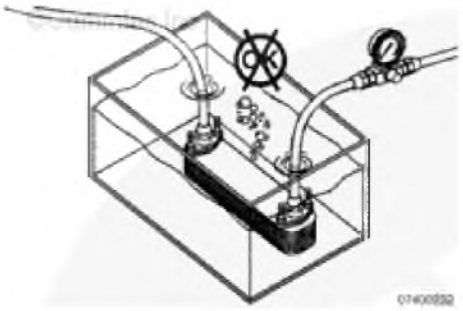
Completely dry water from the thermostat prior to assembly.

Pressure Test

Apply air pressure of 415 kPa [60 psi] to the oil cooler element and check for leaks. Heat the water in the tank to 50°C [120°F]

for more accurate test results.

Discard element if leaks are present.



Assemble

CAUTION

The convex surface on the disk valve (7) must be positioned so that if faces the inside of the oil cooler housing and away from the thermostat. Engine damage can result if this is not installed properly.

Install the following components on the oil cooler cover:

- Plug (9)
- O-ring (8)
- Disk valve (7)
- Thermostat seal (6)
- Seal housing (5)
- Thermostat (4)
- O-ring (3)
- Cover (2)
- Capscrews (1)

Tighten the cover (2) capscrews.

Torque Value: 31 n.m [23 ft-lb]

Tighten the oil cooler plug (9).

Torque Value: 17 n.m [151 in-lb]

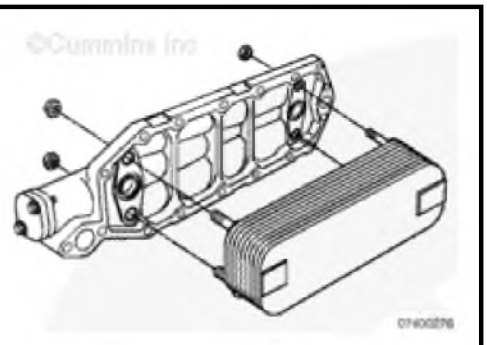
CAUTION

If present, plastic shipping plugs must be removed from new oil cooler elements.

Install the oil cooler element to the oil cooler cover using new gaskets and o-rings.

Tighten the nuts.

Torque Value: 18 n.m [159 in-lb]

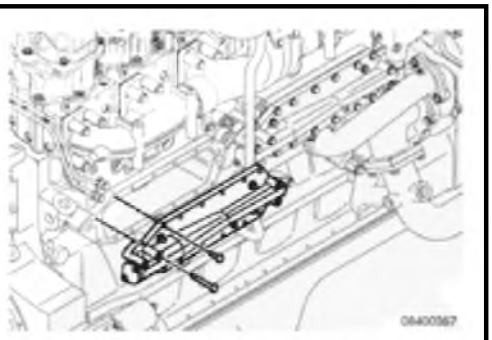


Install

Install the new gasket, oil cooler assembly, and capscrews.

Tighten the capscrews.

Torque Value: 32 n.m [24 ft-lb]



Finishing Steps

- Install the turbocharger oil supply and drain lines, if necessary. Refer to Procedure 010-033.
- Install the water pump supply tube, if necessary. Refer to Procedure 008-062.
- Fill the cooling system. Refer to Procedure 008-018.
- Check the level of the lubricating oil system. Add lubricating oil, if necessary. Refer to Procedure 007-037.
- Operate the engine and check for leaks.

Last Modified: 15-Sep-2003

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007-009 Lubricating Oil Dipstick

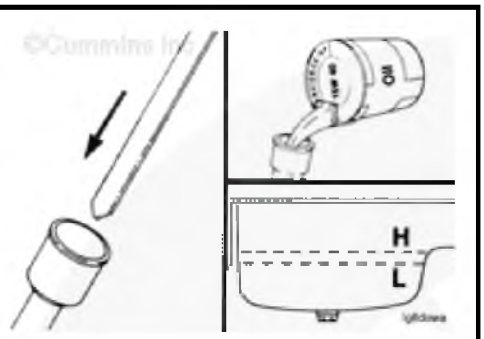
Calibrate

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not used, dispose of in accordance with local environmental regulations.



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

The vehicle **must** be on a level surface.

Install the dipstick into the dipstick tube housing.

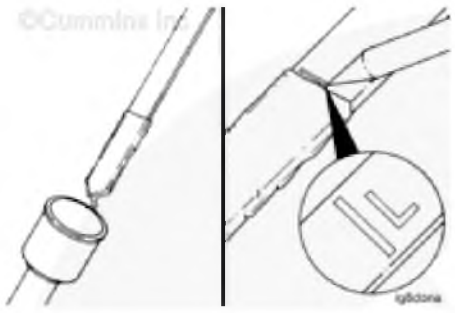
Use the correct volume of clean 15W-40 oil to fill the oil pan to the specified LOW oil level. Refer to Lubricating Oil System - Specifications in Section V for the correct engine oil capacity for your application.

CAUTION

Use care when marking the dipstick, or the dipstick will break if the scribe mark is too deep.

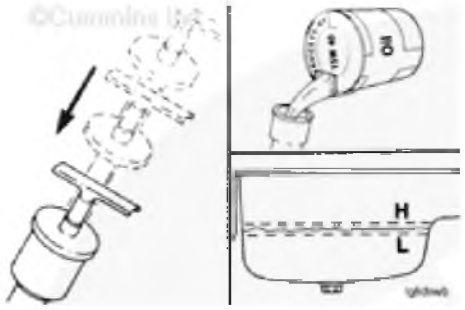
Remove the dipstick, and scribe a mark across the dipstick at the oil level. Label the mark with an L to indicate the LOW oil level.

If a new blank dipstick is being used, cut the dipstick off approximately 38 mm [1.5 in] below the LOW oil level mark.

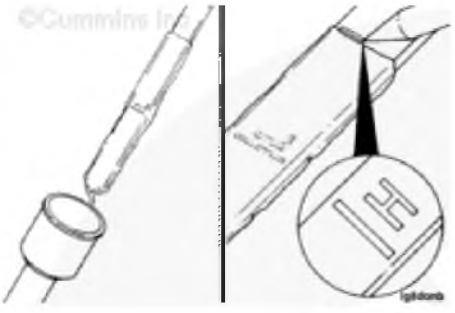


Wipe the excess oil from the dipstick, and install it into the dipstick tube housing.

Use the correct volume of oil to fill the oil pan to the specified high or H oil level. Refer to Lubricating Oil System - Specifications in Section V for engine oil capacity.



Remove the dipstick and scribe a mark across the stick at the oil level. Label the mark with an H to indicate the high oil level.



Last Modified: 30-May-2003

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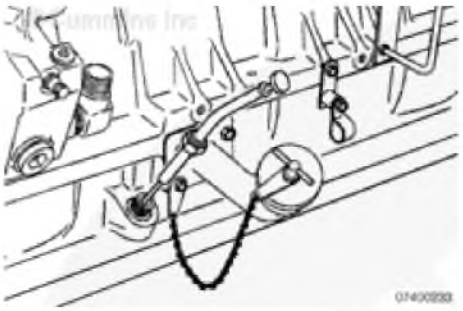
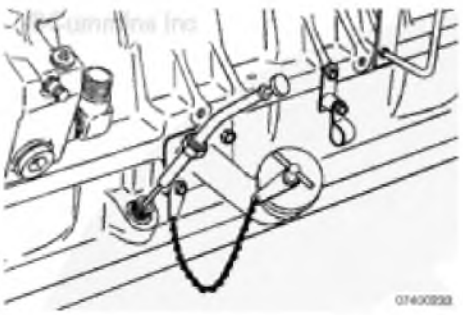
007-011 Lubricating Oil Dipstick Tube

Remove

Remove the dipstick and dipstick tube.		

Install

NOTE: The dipstick tube mounting location varies depending on the engine application. Install the dipstick tube. Tighten the nut ¾ to 1 turn after contact with the ferrule.		

Last Modified: 30-May-2003

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007-013 Lubricating Oil Filter (Spin-On)

Remove

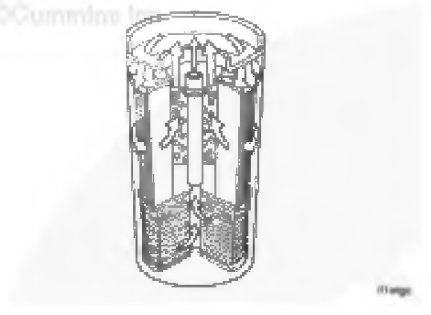
CAUTION

The bypass and combination filters have the same threads. Verify the correct filter is used for replacement to avoid damage to the engine.

The external appearance of the full-flow (1), the bypass (2), and the combination (3) filters are the same. The accompanying picture identifies the differences among the three filters.

The full-flow, bypass, and combination filters contain 1 ½ 12-inch threads.

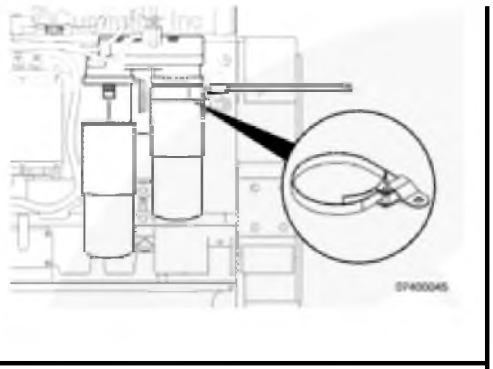
A combination oil filter is used on most engines. The upper section of the filter contains the full-flow filter element while the lower section contains the bypass element.



NOTE: The following illustrations show the combination oil filter. Use the same procedure when changing the remote bypass oil filters.

Use an oil filter wrench, Part Number 3375049, or equivalent to remove the oil filters.

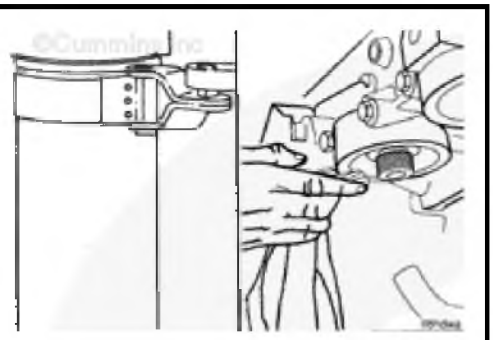
Discard the filters if they are **not** needed for a failure analysis.



Install

Clean the filter head sealing surface with a lint free cloth.

Use clean engine oil to lubricate the gasket surface of the filters.

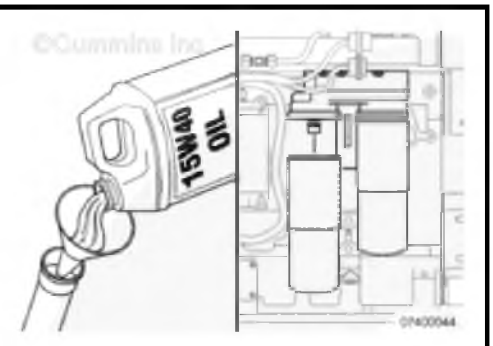


Fill the filters with clean, 15W-40 engine oil.

Install the filters on the oil filter head.

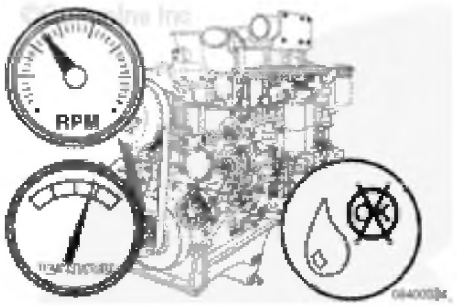
Mechanical overtightening can distort the threads or damage the filter element seal.

Turn the filter until the seal contacts the head. Turn an additional ¾-turn to 1 turn.



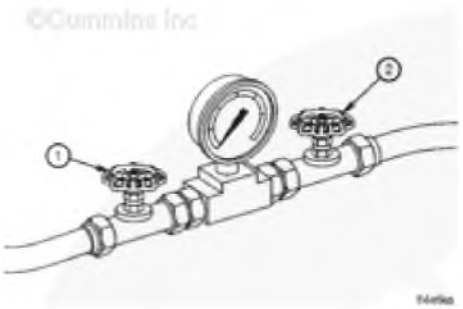
Operate the engine until the oil

temperature is at least 65°C [150°F] and check for leaks.



Pressure Differential Test

Use a differential pressure gauge, or one pressure gauge with two oil hoses and two valves to eliminate gauge error. Use a gauge with a minimum pressure capacity of 517 kPa [75 psi].

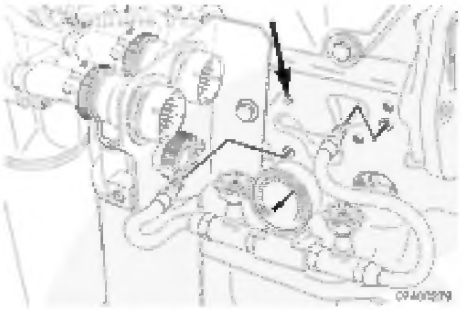


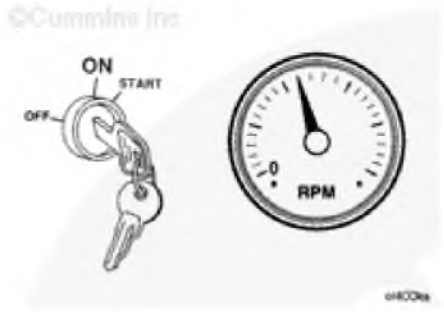
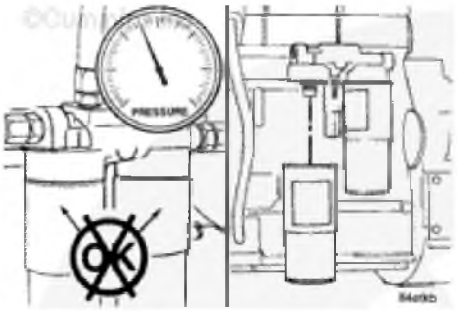
Install hoses into the before-filter and after-filter oil pressure ports. The ports are located between the oil filter heads and the flywheel housing.

The after-filter oil pressure port is closest to the flywheel housing.

The before-filter oil pressure port is slightly lower and left of the after-filter port.

NOTE: Applications with air compressors will use the port directly above the before-filter port for after-filter pressure.



Operate the engine at rated rpm and normal operating temperature. Open the valve to read the pressure after the filter first. Close the valve and open the other valve to read the oil pressure before the filter.		
If the difference in pressure is more than 103 kPa [15 psi], replace the filters. If the difference in pressure using clean oil filters is more than 69 kPa [10 psi], an oil filter with excessive restriction is being used. Replace the oil filters. Oil Filter Pressure Differential (new filters) kpa MAX psi 69 MAX 10		

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007-015 Lubricating Oil Filter Head

Remove

WARNING

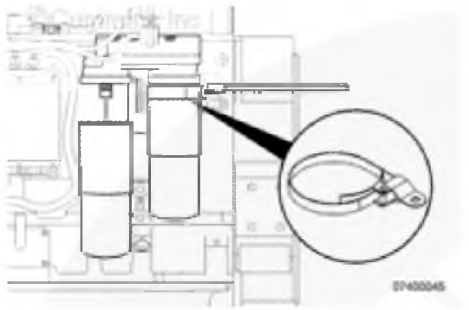
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

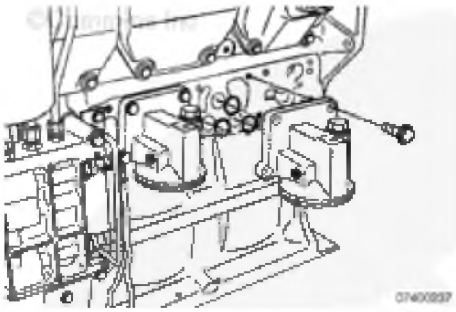
To reduce the possibility of personal injury, avoid contact with hot oil with your skin.

Use an oil filter wrench, Part Number 3375049, or equivalent, to remove the combination oil filters.

Discard the filters if they are **not** needed for failure analysis.



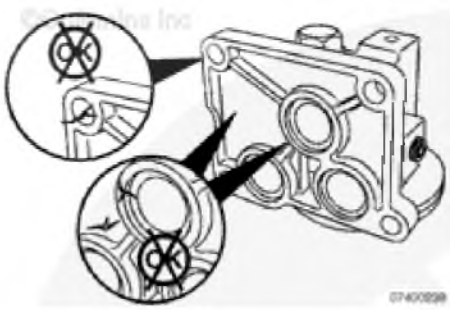
Remove the four capscrews and the filter head assembly.



Clean and Inspect for Reuse

WARNING

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



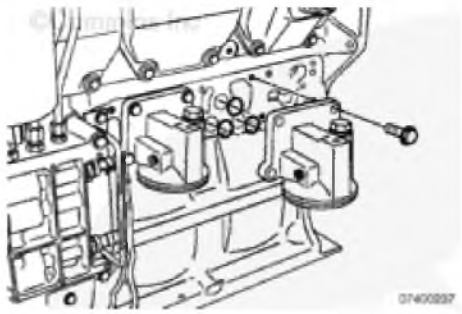
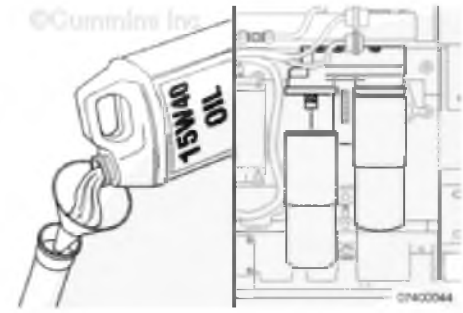
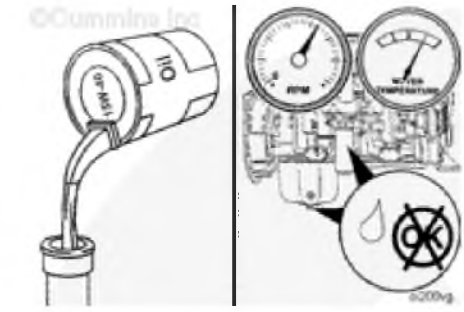
Use solvent to clean the filter head.

Inspect the o-ring seals for nicks or cuts, replace if necessary.

Inspect the filter head for cracks or other damage.

Replace the oil filter head if cracks or damage are found.

Install

Install the filter head, and four capscrews. Tighten the capscrews. **Torque Value:** 65 n.m [50 ft-lb]		
Install the new combination oil filters. Refer to Procedure 007-013.		
Fill the engine with clean, 15W-40 oil. Refer to Section V for engine oil capacity. Operate the engine to normal operating temperature and check for leaks.		

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007-024 Lubricating Oil Leaks

Preparatory Steps

WARNING

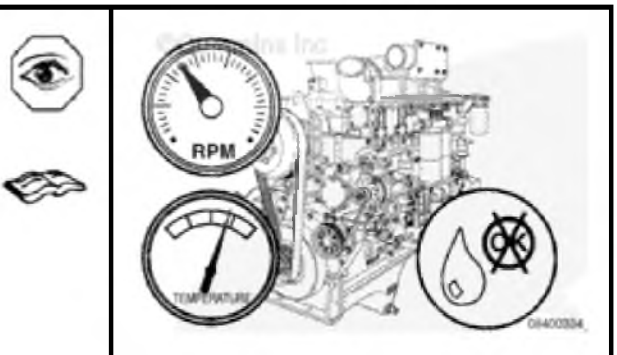
Wear safety glasses or a face shield, as well as protective clothing, to prevent personal injury when using a steam cleaner or high-pressure water.

- Use a steam cleaner or a high-pressure washer to clean the engine.

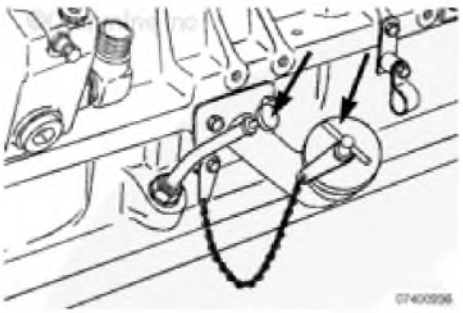
Inspect

Operate the engine until the coolant temperature reaches 80°C [180°F]. Inspect the exterior of the engine for leaking gaskets, seals, o-rings, pipe plugs, or fittings.

Before replacing any gaskets, check that the capscrews are tightened to the correct torque values. Refer to Specifications in Section V for capscrew torque listings.

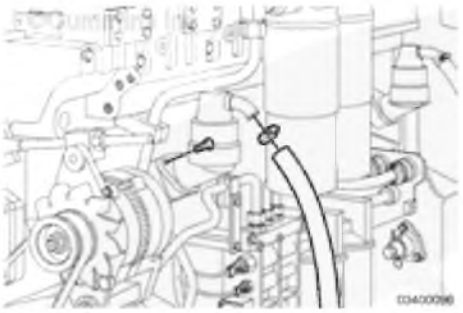


Check for a loose, broken, or missing oil dipstick tube, dipstick, or oil filter cap.



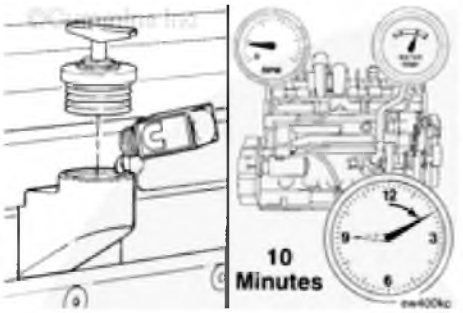
Check the engine crankcase breather elements and breather hose for restriction.

If **not** restricted, check the blowby. Refer to Procedure 014-005. High blowby can cause gasket and seal leakage.

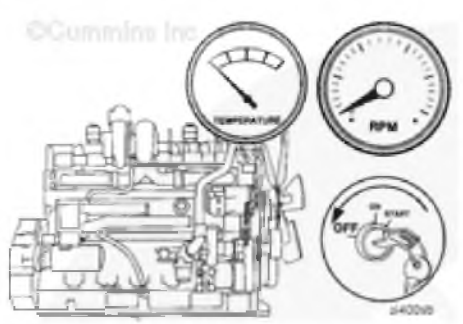


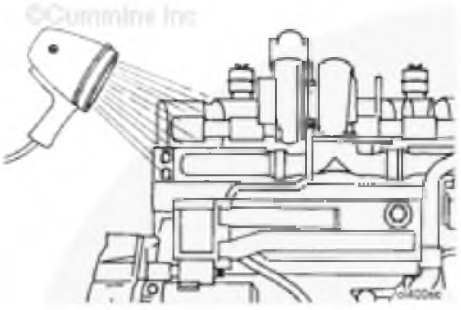
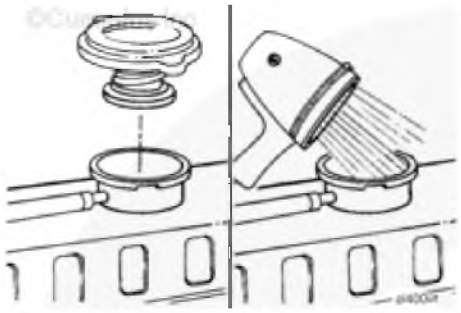
Add one unit of Fluorescent Tracer, Part Number 3376891, to each 38 liters [10 gal] of engine lubricating oil. Refer to Section V for oil pan capacity.

Operate the engine for 10 minutes.



Shut the engine off.



Use a high intensity black light to inspect for oil leakage. Oil will glow a dark blue color.		
If an oil leak into the coolant is suspected, check the coolant.		

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007-025 Lubricating Oil Pan

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

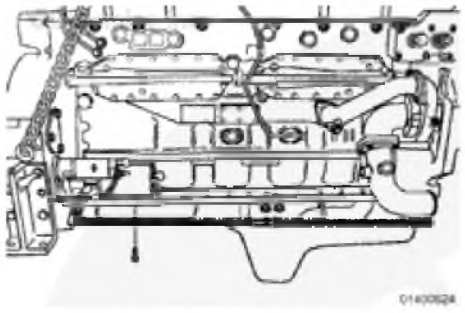
- Drain the lubricating engine oil from the oil pan. Refer to Procedure 007-037.

Remove

Remove the 51 capscrews.

Remove the oil pan.

Clean and discard the liquid gasket material from the block, stiffener plate, and oil pan.



Clean and Inspect for Reuse

WARNING

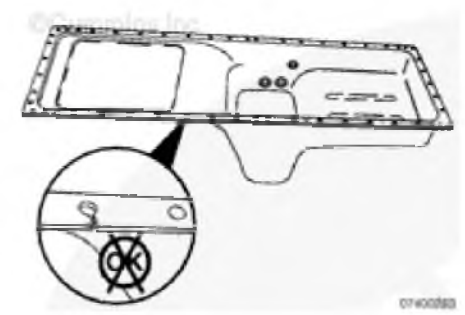
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

CAUTION

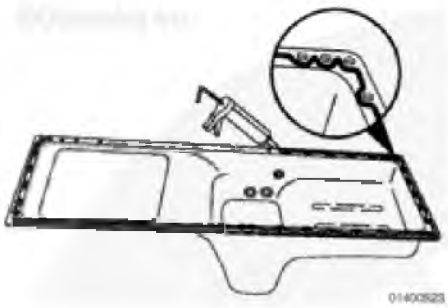
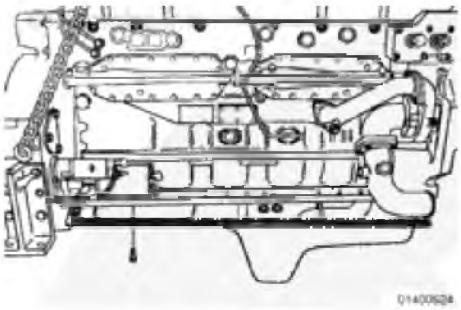
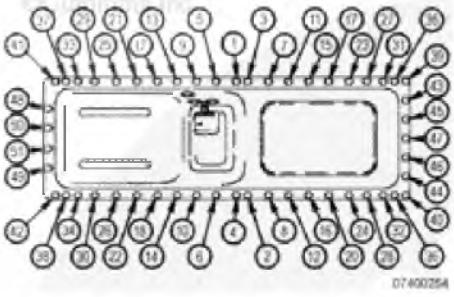
If oil pan is cast aluminum, use solvent that will not harm aluminum. Failure to do so will damage oil pan.

Clean the oil pan.

Inspect for cracks or other damage.



Install

Apply liquid gasket to oil pan.		
Install the gaskets and oil pan.		
Use the sequence shown to torque the capscrews. Tighten the capscrews. **Torque Value:** 66 n.m [50 ft-lb]		

Finishing Steps

- Fill the oil pan with clean 15W-40 engine oil. Refer to Procedure 007-037.
- Operate the engine and check for leaks.

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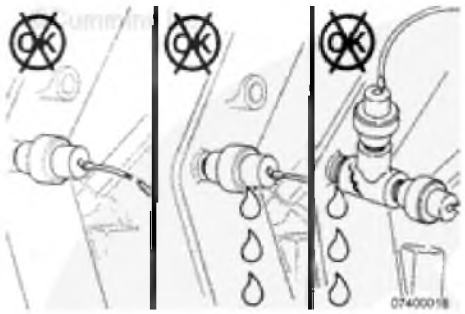
007-028 Lubricating Oil Pressure Gauge

Inspect for Reuse

Inspect for the following defects:

- Broken electrical wiring
- Sending unit malfunction
- Loose or broken plumbing.



Use a reference gauge of known accuracy to verify the reading of the suspect gauge.

Connect the line from the master gauge at location (1) or (2) as shown, to the rear of the oil filters.

1. 3.175 mm [1/8 in] pipe thread.
2. 6.35 mm [1/4 in] pipe thread.

Measurements

	kpa	psi
Minimum Gauge Capacity	830	120

Operate the engine. Compare the pressure reading of the master gauge and the suspect gauge.

The sending unit **must** be replaced if it is defective.		

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007-031 Lubricating Oil Pump

Preparatory Steps

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery last.

- Disconnect the batteries or air starter to prevent accidental starting.
- Drain the lubricating oil. Refer to Procedure 007-037.
- Remove the oil pan. Refer to Procedure 007-025.
- Remove the block stiffener plate. Refer to Procedure 001-089.
- Remove the fan and fan spacer(s).

Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the alternator belt. Refer to Procedure 013-005.
- Remove the alternator. Refer to Procedure 013-001.
- Remove the fan hub. Refer to Procedure 008-036.
- Remove the fan belt tensioner. Refer to Procedure 008-036.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the front crankshaft seal. Refer to Procedure 001-023.
- Remove the alternator drive gear and shaft. Refer to Procedure 009-009.
- Remove the front gear cover. Refer to Procedure 001-031.
- Remove the oil pump idler gear. Refer to Procedure 001-098.

Remove

Remove the four capscrews from the oil pump mounting flange.

Use a pry bar to gently pry the oil pump out of the engine block.

Remove and discard the two o-rings and the seal ring from the pump.

Clean and Inspect for Reuse

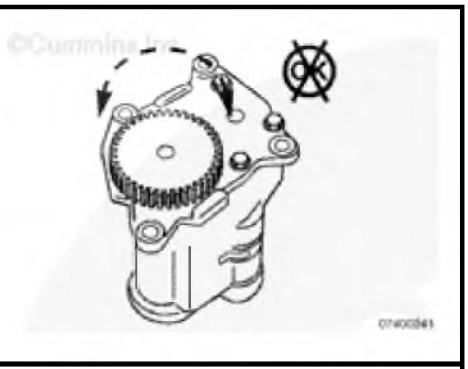
WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

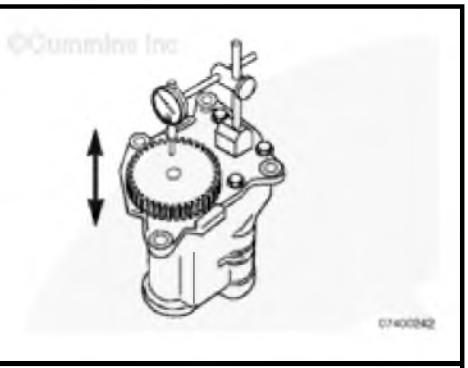
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Clean and inspect the oil pump for reuse. Rotate the drive gear slowly and check the pump gears for damage.



Measure the oil pump end clearance.

Oil Pump End Clearance		
mm		in
0.04	MIN	0.002
0.097	MAX	0.004

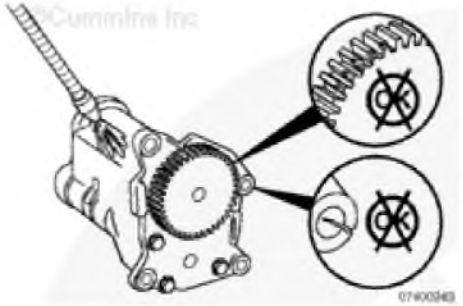


WARNING

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

Use solvent to flush the lubricating oil pump.

Inspect the gears of the oil pump for damage. If the part is damaged, it **must** be rebuilt or replaced.



Install

Apply a light coating of grease to the seal rings to hold them in place during assembly.

Install the seal rings on the pump.

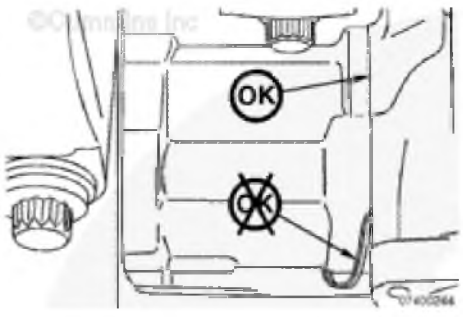
Use vegetable oil to lubricate the seal rings and the bore in the block.

Install the pump and the capscrews. Tighten the capscrews.

Torque Value: 66 n.m [50 ft-lb]

Be sure the seal rings at the back of the pump are positioned correctly.

Look up into the block between the number 1 and number 2 main bearing caps. The seal **must not** protrude from the space between the rear of the pump and the block.



Install the oil pump idler gear. Refer to Procedure 001-098.

Check the oil pump gear backlash. Refer to Procedure 001-055. Adjust the backlash, if necessary, by loosening the mounting capscrews and rotating the pump.

Lubricating Oil Pump Gear Backlash		
mm		in
0.121	MIN	0.004
0.333	MAX	0.013

Finishing Steps

- Install the front gear cover. Refer to Procedure 001-031.
- Install the front crankshaft seal. Refer to Procedure 001-023.
- Install the alternator drive gear and shaft. Refer to Procedure 009-009.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the fan belt tensioner. Refer to Procedure 008-036.
- Install the fan hub. Refer to Procedure 008-036.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator belt. Refer to Procedure 013-005.
- Install the fan belt. Refer to Procedure 008-002.
- Install the fan and fan spacer(s). Refer to Procedure 008-040.
- Install the block stiffener plate. Refer

to Procedure 001-089. • Install the oil pan. Refer to Procedure 007-025. • Fill the engine with clean, 15W-40 oil. Refer to Procedure 007-037 and Section V for engine oil capacity. • Connect the batteries or air starter. • Operate the engine and check for leaks.		

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007-037 Lubricating Oil System

Drain

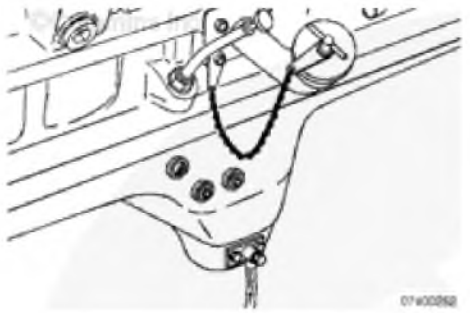
WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Remove the oil drain plug from the bottom of the drain valve.
- Open the drain valve.
- Drain the oil.



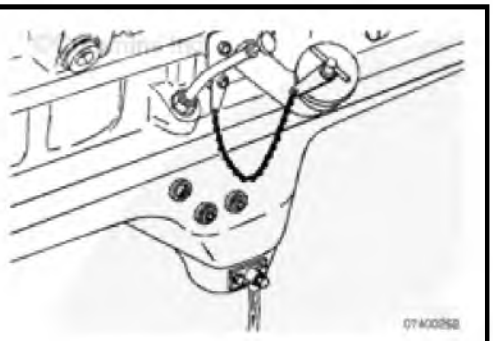
Fill

Install the oil pan drain plug and close the drain valve.

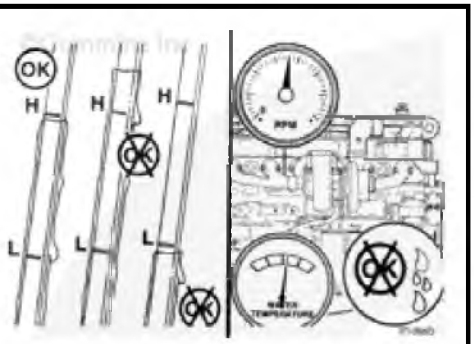
Tighten the drain plug.

Torque Value: 68 n.m [50 ft-lb]

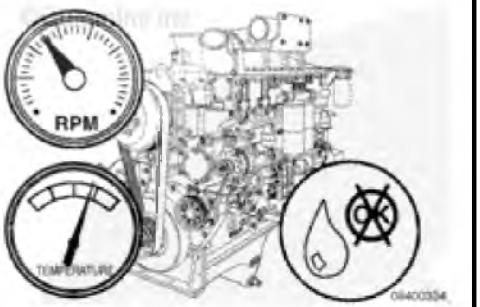
Add the specified amount of clean, 15W-40 oil to fill the oil pan.



Check the oil level on the dipstick.

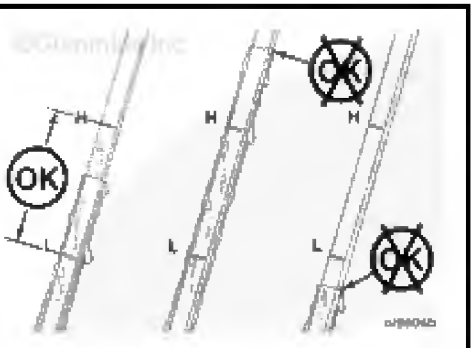


Operate the engine to normal operating temperature and check for oil leaks.



Shut the engine off and wait 10 minutes for the oil to drain back into the pan.

Check the oil level. Add oil as necessary to raise the oil level to the HIGH or H mark on the dipstick.



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007-038 Lubricating Oil Temperature Gauge

Preparatory Steps

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

- Drain the oil from the oil pan. Refer to Procedure 007-037.
- Remove one of the pipe plugs from the left side of the oil pan.
- Install a reference gauge of known accuracy to verify the reading of the suspect gauge. Use a gauge with a minimum temperature capacity of 150°C [300°F].
- Fill the engine with oil. Refer to Procedure 007-037.

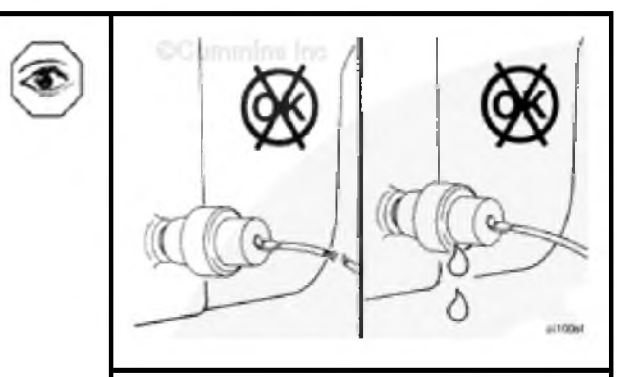
Inspect for Reuse

Operate the engine. Compare the temperature reading of the master gauge and the suspect gauge.

If the suspect gauge does **not** read the same temperature as the reference gauge, check the following for defects:

- Electrical wiring
- Sending unit.

Replace the defective parts.



Finishing Steps

- Drain the oil from the oil pan. Refer to Procedure 007-037.
- Remove the reference gauge. Tighten the plug to specification. Refer to Section V for torque specifications.
- Fill the engine with oil. Refer to Procedure 007-037 for engine oil capacity.
- Operate the engine to normal operating temperature. Check for leaks.

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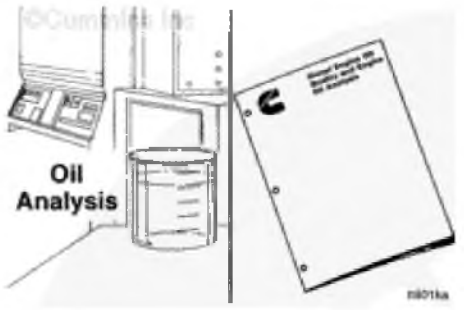
007-044 Lubricating Oil Contamination

General Information

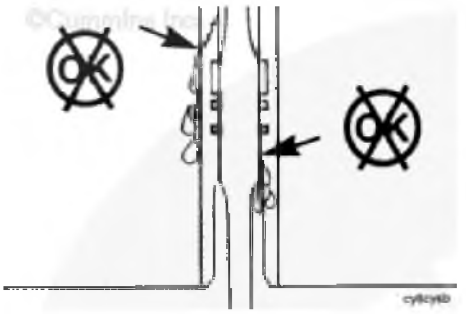
An used oil analysis can help diagnose internal damage and determine if it was caused by one of the following:

- Oil diluted with coolant
- Oil diluted with fuel.



Pressure Test

For oil diluted with coolant. Refer to Procedure 008-018.

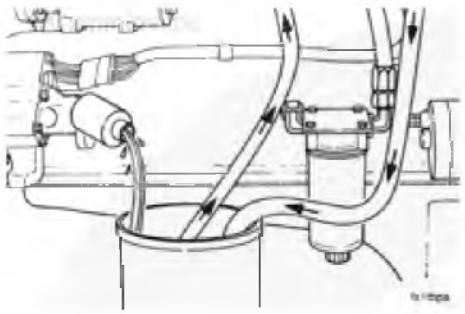


Fluorescent Dye Tracer

The following is the procedure for oil diluted with fuel.

This test is **not** effective on a cold engine, less than 21°C [70°F] coolant temperature, or with a loose overhead setting.

Install an isolated fuel supply tank to the inlet and drain lines. Add fluorescent tracer, Part Number 3376891, to the fuel supply tank.

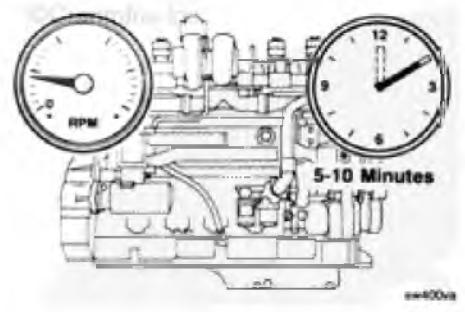


Remove the rocker lever cover mounting capscrews, but do **not** remove the rocker lever covers.

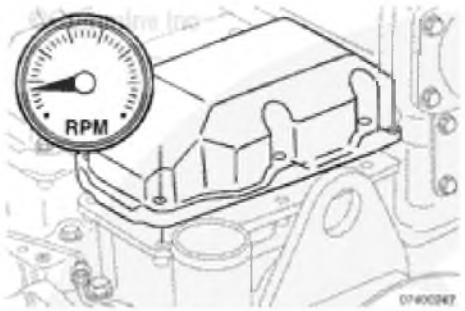
Start the engine and operate it at high idle for 30 seconds.

Let the engine go to low idle.

Complete the next step within 5 minutes.



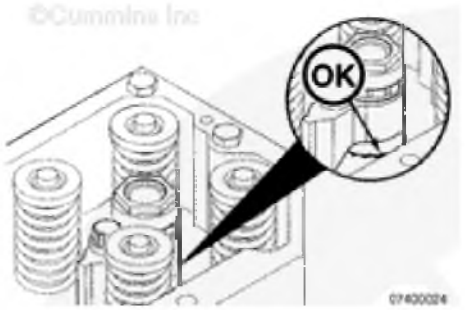
While the engine is operating at low idle, remove the rocker lever covers.



Use a black light to find fuel leaks from inside or around the injector. Refer to the black light manufacturer's operating instructions.

Injectors normally have a small amount of fuel leakage. Fuel will be a yellow color.

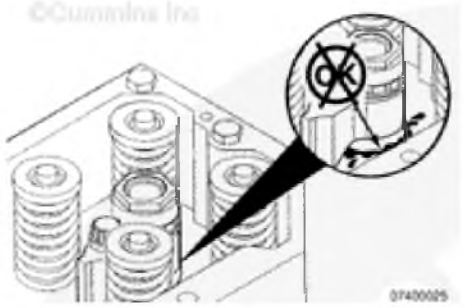
NOTE: Some components shown removed for clarity.



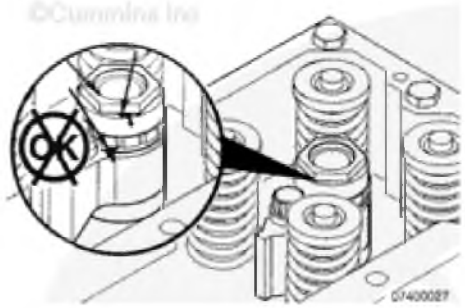
If there is excess leakage around the outside of the injector, check the top o-ring for damage.

Remove the injector and replace all three o-rings. Refer to Procedure 006-026.

NOTE: Some components shown removed for clarity.



If there is excess leakage from inside the injector, replace the injector. Refer to Procedure 006-026.



Install the rocker lever covers. **Torque Value:** 10 n.m [89 in-lb]		

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007-050 Cylinder Smokes (Blue Smoke)

Preparatory Steps

CAUTION

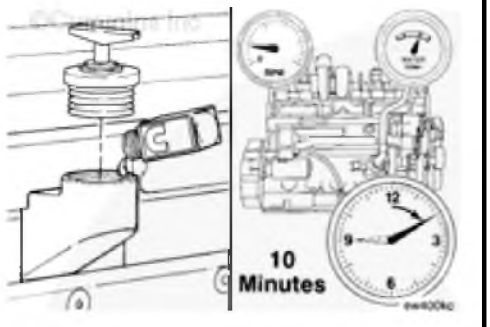
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

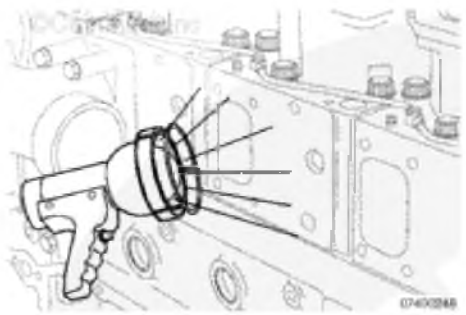
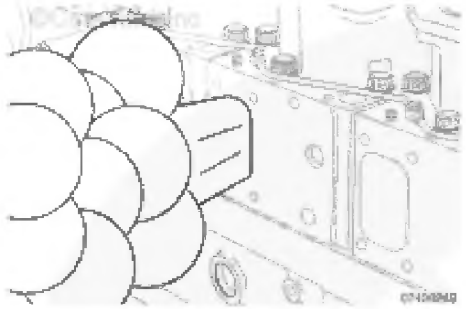
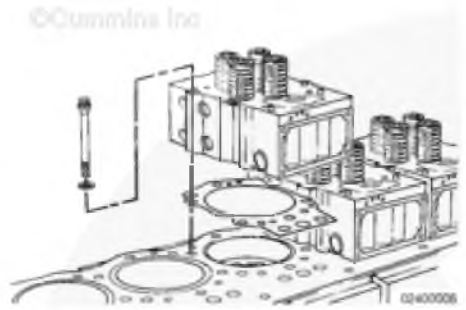
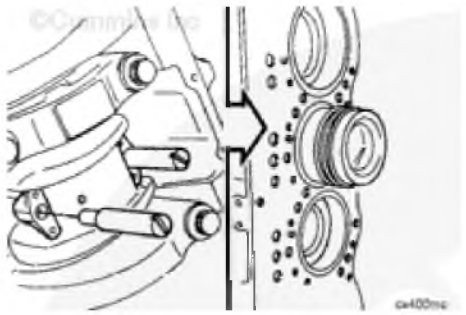
- Check for single cylinder oil consumption, remove the exhaust manifold. Refer to Procedure 011-007.

Fluorescent Dye Tracer

Add one unit of fluorescent tracer, Part Number 3376891, to each 38 liters [10 U.S. gallons] of engine oil.

Idle the engine for 5 to 10 minutes or until normal operating temperature is reached to allow the dye to circulate through the lubricating system.



Use a high intensity black light, Part Number 3163337, or equivalent, to inspect the exhaust ports. A yellow glow indicates a fuel leak. A dark blue glow indicates an oil leak.		
Start the engine for a brief time and look for excessive blue smoke coming out of the faulty cylinder. Shut off engine.		
Check the cylinder heads. Refer to Procedure 002-004.		
Check the pistons and rings. Refer to Procedure 001-054.		

Finishing Steps

- Install the exhaust manifold. Refer to Procedure 011-007.

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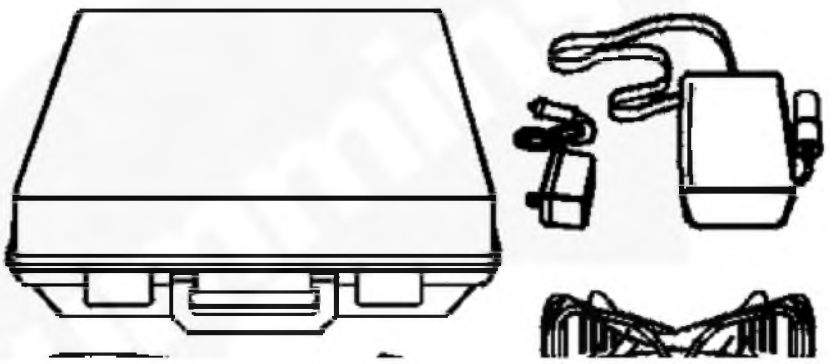
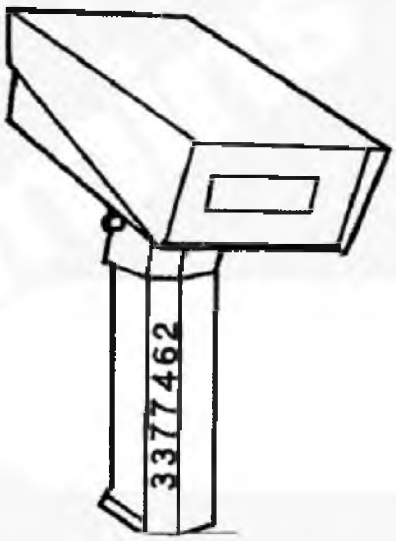
View Related Topic

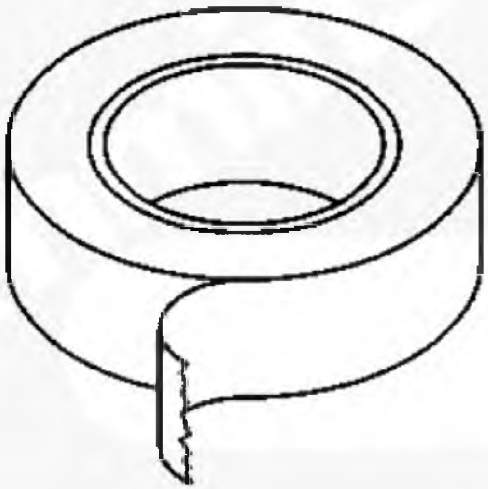
022-001 Service Tools

Cooling System

Tool Number 3377438	**Fluorescent Tracer Dye** Used with black light, Part Number 3163337, to find coolant leaks.	 3376891
Tool Number 3163337	**Black Light Lamp Kit** Used in conjunction with fluorescent tracer dye, Part Number 3376891, to check for oil or Part Number	

	3377438, to check for coolant leaks.	3163337

Tool Number 3377462	**Digital Optical Tachometer** Used to measure revolutions per minute (rpm).	 3377462

Tool Number 3377464	**Reflective Tape** Used to mark a spot on rotating object to measure speed (rpm).	 22400180

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008-002 Drive Belt, Cooling Fan

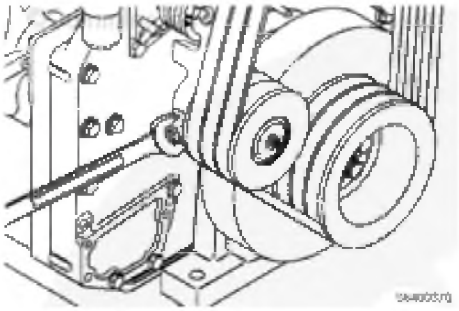
Remove

Industrial Applications

WARNING

The belt tensioner is under pressure. Relieve and restore belt tension slowly to reduce the possibility of personal injury.

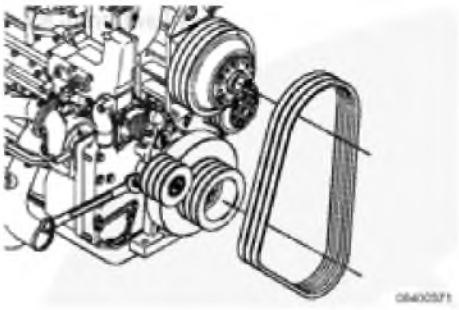
Place an open-ended wrench on the tensioner lug, as shown.



Turn the wrench to relieve the tension on the belt.

Remove the belt(s).

Slowly release pressure on the wrench until the tensioner stops.

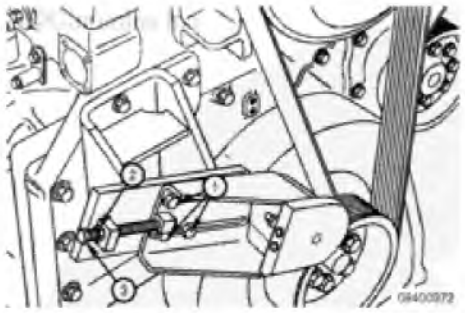


Power Generation

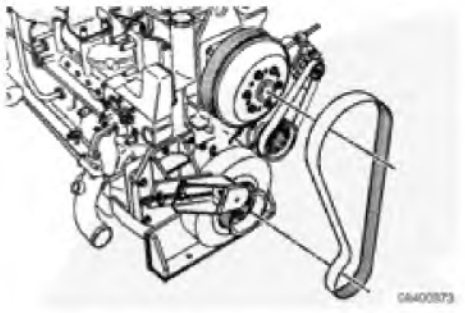
Loosen the three clamping bolts (1).

Loosen the adjusting screw locknut (2).

Turn the adjusting screw (3) **counterclockwise** to relieve the tension on the belt.



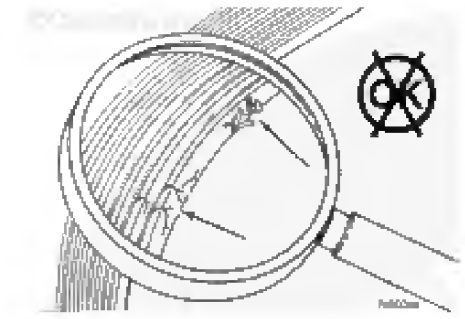
Remove the belt.



Inspect for Reuse

Inspect the belt for:

- Cracks
- Glazing
- Tears or cuts.



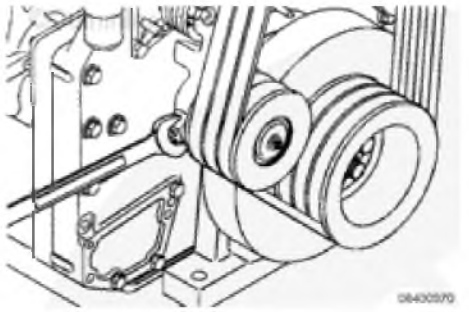
Install

Industrial Applications

WARNING

The belt tensioner is under pressure. Relieve and restore belt tension slowly to reduce the possibility of personal injury.

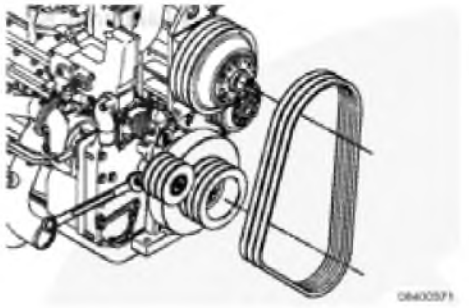
Place a wrench on the tensioner lug, as shown.



Turn the wrench to position the tensioner for belt installation.

Install the belt(s).

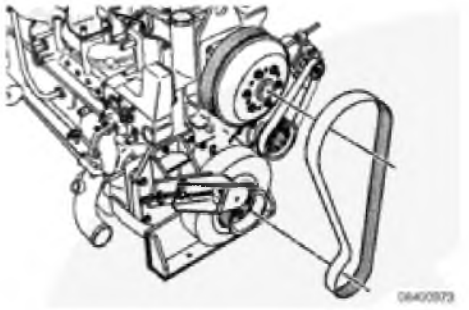
Slowly release pressure on the wrench until the tensioner is in position.



Power Generation

If necessary, loosen the adjusting screw (2) and clamping bolts (1) to allow belt installation.

Install the belt.



BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

Adjust

Power Generation

Loosen the tensioner clamping bolts (1).

Loosen the adjusting screw locknut (2).

Turn the adjusting screw (3) **clockwise** to increase belt tension and **counterclockwise** to decrease belt tension.

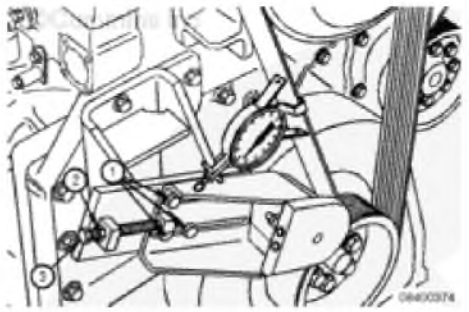
Refer to Section V for appropriate belt tension.

Once the desired tension is obtained, tighten the locknut against the tensioner bracket.

Torque Value: 196 n.m [125 ft-lb]

Tighten the clamping bolts (1).

Torque Value: 66 n.m [49 ft-lb]



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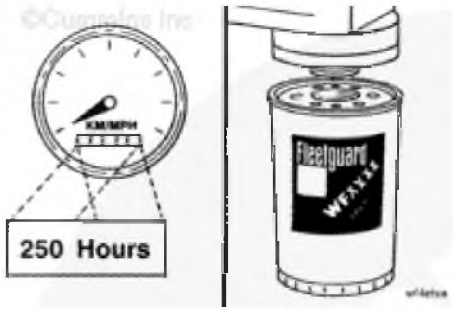
008-006 Coolant Filter

General Information

Use the correct Fleetguard® coolant filter to maintain the correct SCA concentration in the system.

Maintain the correct concentration by changing the service coolant filter at each oil drain interval.

Refer to Fleetguard® DCA4 Service Filters and Liquid Precharge in Section V of the Operation and Maintenance Manual, QSK23 Engine, Bulletin 4021374.



Change the service coolant filter at every oil and filter change interval.

The correct service coolant filter to be used is determined by the total coolant system capacity and other operational factors.

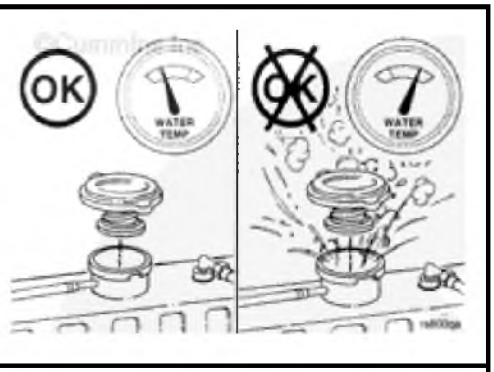
Refer to the Fleetguard® Service Filter Guide in Section V for the correct SCA precharge filter selection in the Operation and Maintenance Manual, QSK23 Engine, Bulletin 4021374.

Remove

WARNING

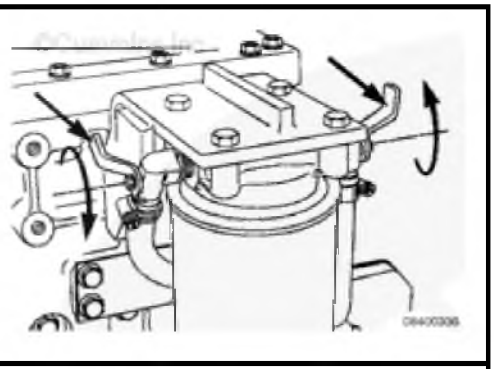
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Remove the pressure cap.



Turn the valve on the filter head to the OFF position.

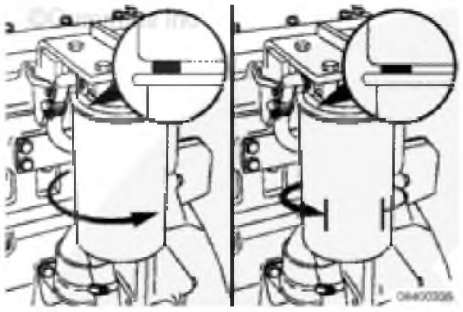
Remove and discard the coolant filter.

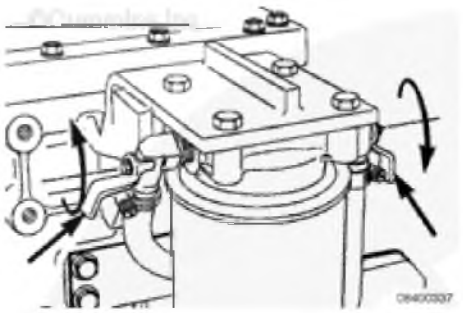


Install

Lubricate the seal on the filter with clean 15W-40 engine oil.

Do **not** allow oil to get in the filter. It will break down the SCA.

Install the coolant filter. Turn the filter until the seal touches the filter head. Turn an additional 1/2 to 3/4 of a turn after contact.		

Turn the valve to the ON position.		

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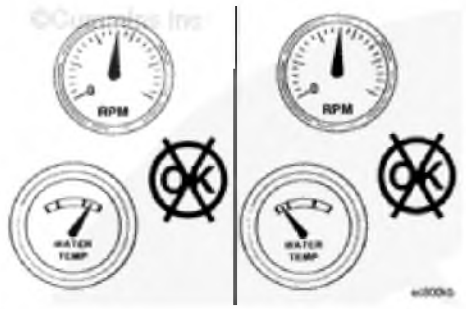
008-013 Coolant Thermostat

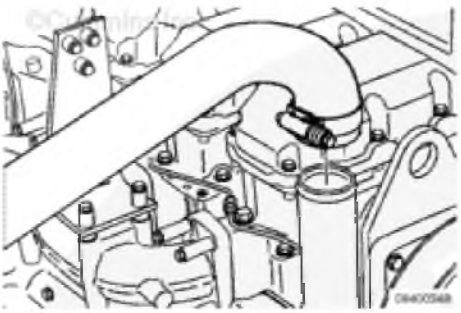
Leak Test

The engine thermostat and thermostat seal **must** operate properly in order for the engine to operate in the most efficient heat range. Overheating or overcooling will shorten engine life.



Complete this test with the engine coolant temperature below 50°C [120°F].

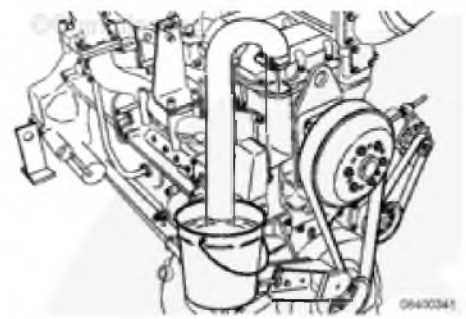
Remove the upper engine radiator hose from the thermostat housing.



Install a hose on the thermostat housing outlet long enough to reach a remote dry container.

Install and tighten the hose clamp on the housing outlet.

Put the end of the hose in the dry



container.

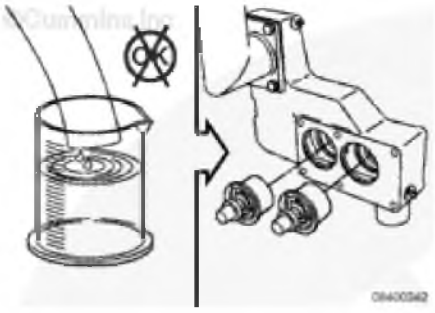
Operate engine at rated speed for 1 minute.

Shut the engine OFF and measure the amount of coolant collected.

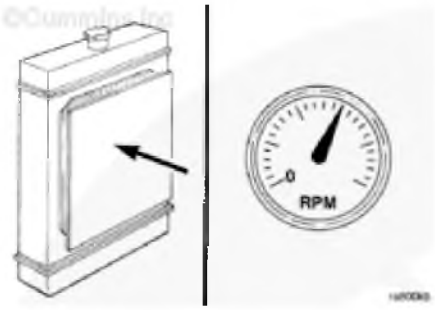
If more than 100 cc [3.3 fl oz] of coolant is collected, the thermostat or the thermostat seal is leaking.

Remove the thermostat and test operation as described in Procedure 008-013.

Remove the test equipment and install the upper radiator hose.

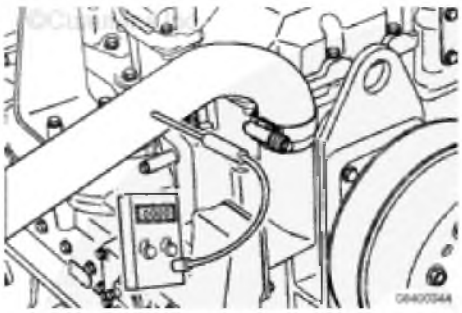


Restrict the radiator air flow. Operate the engine until the coolant temperature rises to 90-93°C [195-200°F].



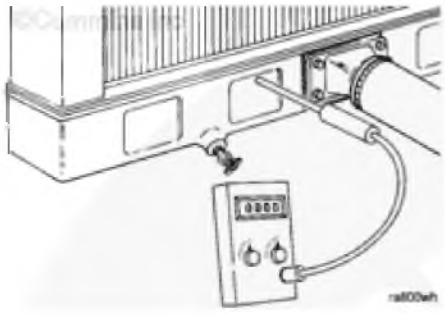
Record the temperature of the coolant outlet hose. An increase in temperature indicates the thermostats have started to open.

Use a contact pyrometer (shown) or install a temperature gauge in the desired location(s) prior to operating the engine.



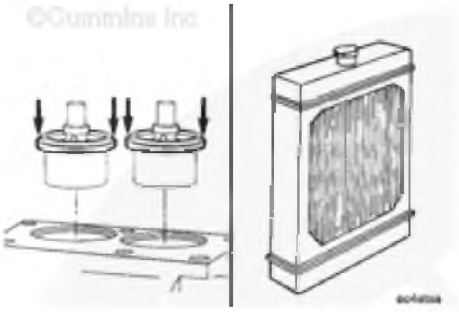
Record the temperature of the radiator

bottom tank or coolant out tube.



If the difference in temperature is more than 8°C [15°F], either the thermostats are **not** fully open or the radiator core is plugged.

To replace the thermostats, refer to Procedure 008-013. To check the radiator, refer to Procedure 008-042.



Preparatory Steps

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F]

before removing the pressure cap. Headed coolant spray or steam can cause personal injury.

- Drain the cooling system. Refer to Procedure 008-018.
- Remove the hose from the thermostat housing. Refer to Procedure 008-045.
- If equipped, remove the torque converter coolant hose.
- Disconnect the coolant temperature sensor on the side of the thermostat housing.

Remove

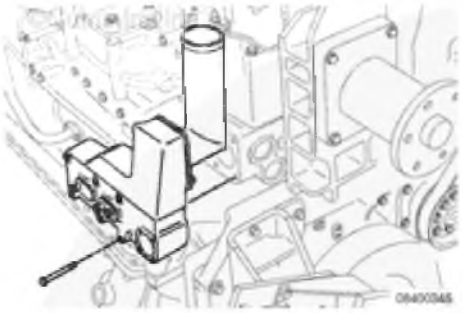
Remove the six long capscrews.

Remove the thermostat housing.

Remove and discard the gasket.

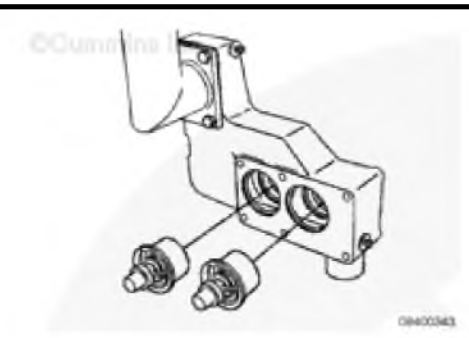
It may be necessary to loosen the bypass tube retainer and bypass tube to remove the thermostat housing.

Discard the bypass tube o-ring.

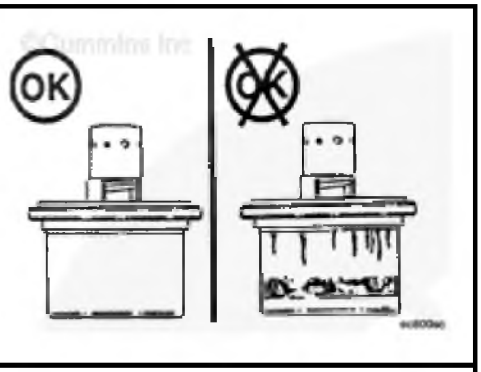


Remove the thermostats.

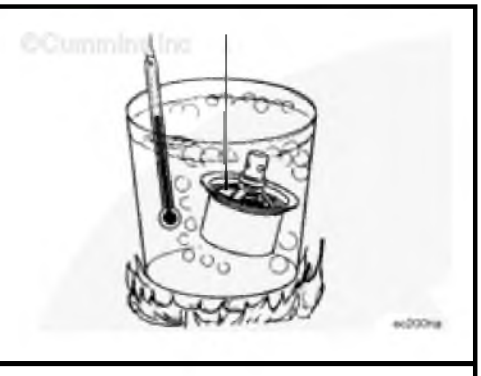
Remove the thermostat seals. Refer to Procedure 008-016.



Inspect for Reuse

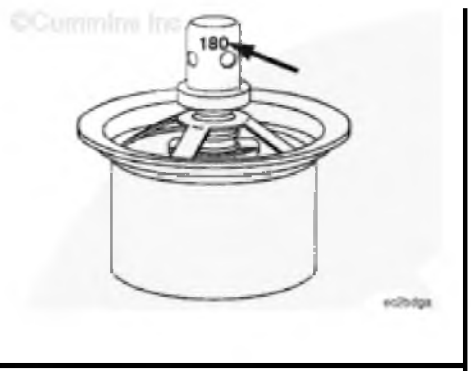
Inspect the thermostat for damage.		

Test

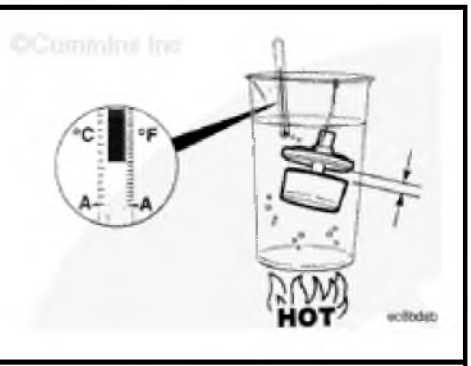
NOTE: Do not allow the thermostat or thermometer to touch the container. Suspend the thermostat and a 100°C [212°F] thermometer in a container of water. Heat the water and check the thermostat as follows.		
The nominal operating temperature is stamped on the thermostat. • Thermostat **must** begin to open within 2°C [3°F] of nominal		

temperature.
- Thermostat **must** be fully open at 12°C [22°F] above nominal temperature.

The fully open distance between the thermostat flange and housing is 11.05 mm [0.43 in].



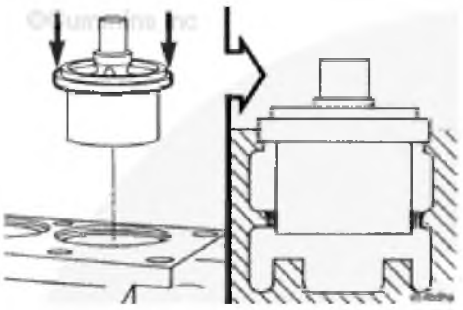
Remove the container from the heat. Check to see if the thermostat returns to the closed position.



Install

Install the thermostat seals. Refer to Procedure 008-016.

Install the thermostat by pushing on the outer rim.



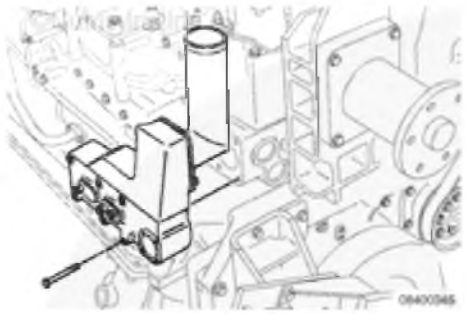
Install a new gasket.

Install the thermostat housing and

capscrews.

Tighten the capscrews.

Torque Value: 66 n.m [50 ft-lb]

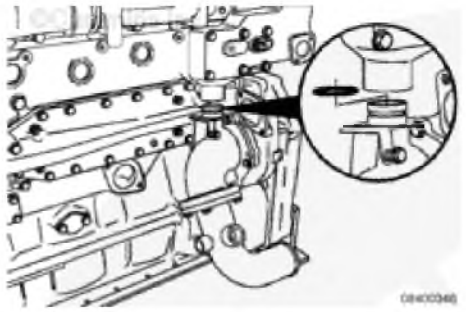


Install a new o-ring on the bypass tube. Use vegetable oil to lubricate the o-ring.

Slide the bypass tube and retainer into position.

Tighten the capscrew and the hose clamps.

Capscrew	31 n.m	[23 ft-lb]



Finishing Steps

- Connect the coolant temperature sensor on the side of the thermostat housing.
- Install the radiator hose.
- If equipped, install the torque converter coolant hose.
- Fill the cooling system. Refer to Procedure 008-018.
- Operate the engine to 70°C [160°F] coolant temperature. Check for leaks.

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008-016 Coolant Thermostat Seal

Preparatory Steps

WARNING

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

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

- Drain the cooling system. Refer to Procedure 008-018.
- Remove the upper radiator hose. Refer to Procedure 008-045.
- Remove the thermostat housing. Refer to Procedure 008-013.
- Remove the thermostats. Refer to Procedure 008-013.

Remove

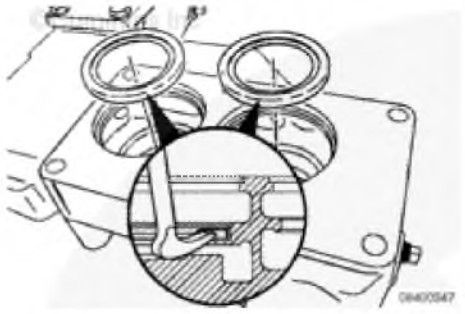
CAUTION

Do not damage the thermostat housing when removing the thermostat seals or damage to the seals can occur.

The thermostat housing has a machined counterbore to locate the seals.

Use a rolling head pry bar. Position the pry bar tip under the top flange of the seal and pry upward. Remove the seals from the housing.

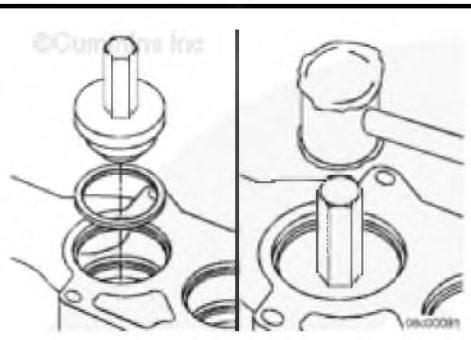
Use a Snap-On® pry bar, Part Number 1650, or equivalent. Remove the engine thermostat seals.



Install

The seal **must** be installed with the part number positioned upward.

Use a mallet and a mandrel, or a socket with a diameter the same as the diameter of the seal case. Install the seals. Be sure the seals seat in the bottom of the counterbore.



Finishing Steps

- Install the thermostats. Refer to Procedure 008-013.
- Install the thermostat housing. Refer to Procedure 008-013.
- Install the upper radiator hose. Refer to Procedure 008-045.
- Fill the cooling system. Refer to Procedure 008-018.

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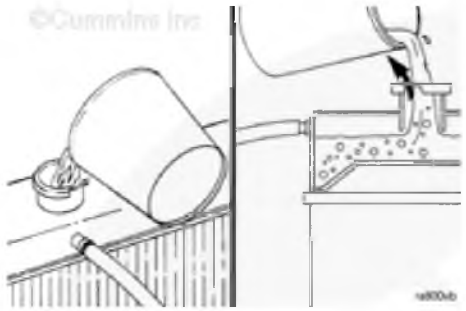
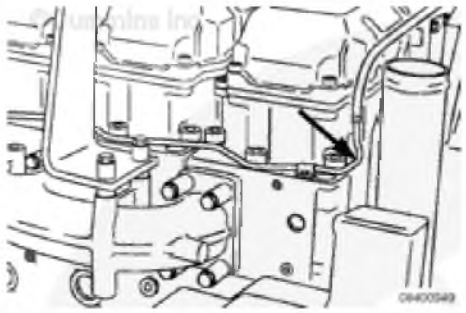
008-017 Coolant Vent Lines

General Information

The cooling system **must** be designed to allow the air to escape while filling the radiator.

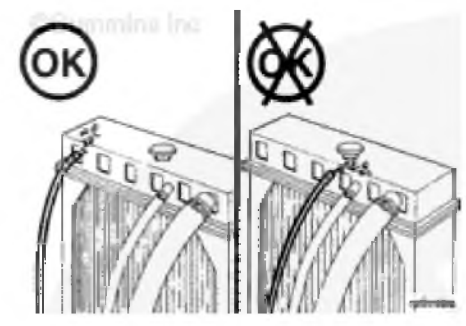


An engine vent line is routed from the cylinder heads to the radiator top tank expansion space above the water level.



CAUTION

Do not route the fill or vent line in a manner that will allow air to be trapped in the system or damage to the cooling system can occur.



Route the vent line away from the makeup or fill line. The vent line **must** have a continuous rise to prevent air lock and inadequate venting.		

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View Related Topic

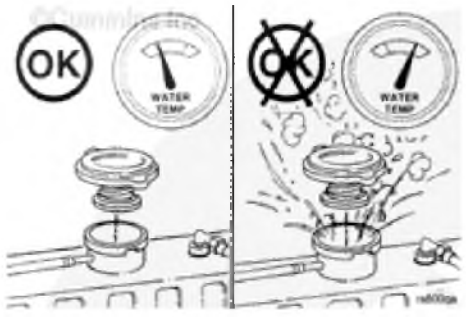
008-018 Cooling System

Drain

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Remove the radiator cap after the engine is cool.



WARNING

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

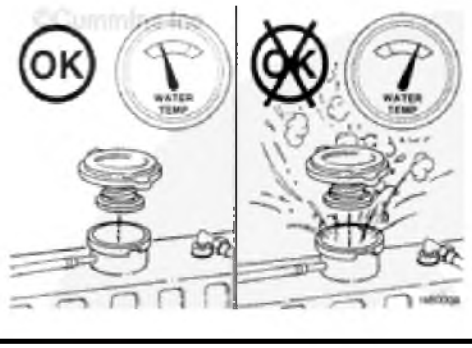
Position the vehicle on level ground. Open the draincock at the bottom of the radiator. Remove the lower radiator hose. Drain the cooling system.

Do **not** remove the coolant filter.

Flush

WARNING

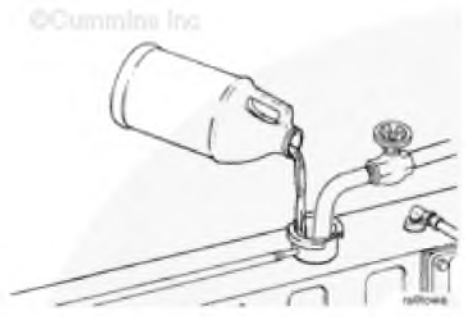
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.



The performance of RESTORE™ is dependent on time, temperature, and concentration levels. An extremely scaled or flow restricted system, for example, can require higher concentrations of cleaners, higher temperatures, or longer cleaning time. RESTORE™ can be safely used up to twice the recommended concentration levels. Extremely scaled or fouled systems can require more than one cleaning.

CAUTION

Fleetguard® RESTORE™ contains no antifreeze. Do not allow the cooling system to freeze during the cleaning operation.



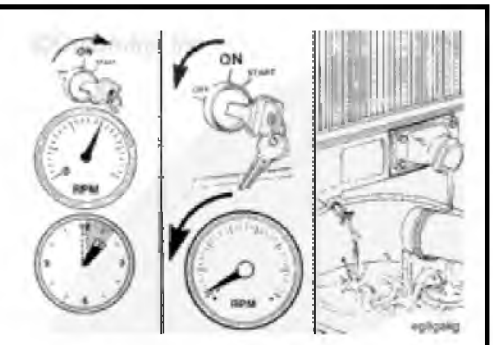
Immediately add 3.8 liters [1 gal] of Fleetguard® RESTORE™, or equivalent, for each 38 to 57 liters [10 gal] of cooling

system capacity, and fill the system with plain water.

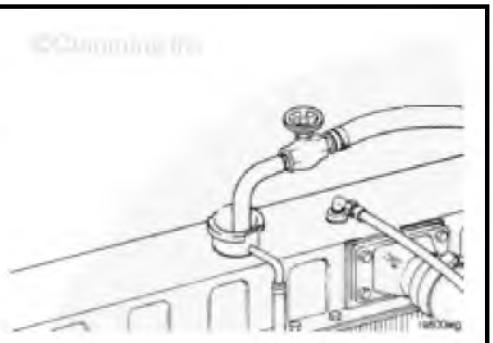
Turn the heater temperature switch to HIGH to allow maximum coolant flow through the heater core. The blower does **not** have to be in the ON position.

Operate the engine at a coolant temperature of at least 85°C [185°F] for 1 to 1-½ hours.

Shut the engine OFF and drain the cooling system.



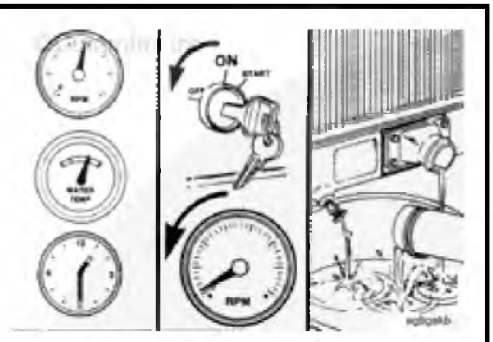
Fill the cooling system with clean water.



Operate the engine at high idle for five minutes with the coolant temperature above 85°C [185°F].

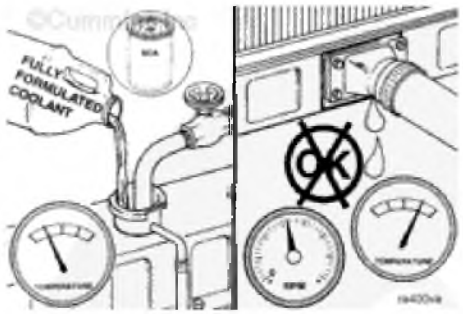
Shut the engine OFF and drain the cooling system.

If the water drained is still dirty, the system **must** be flushed again until the water is clean.

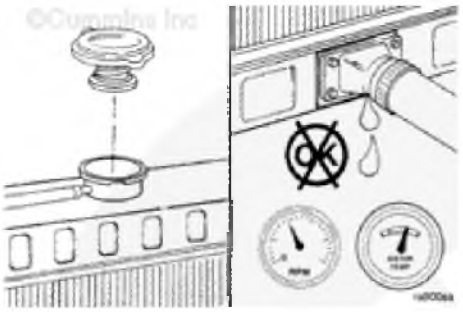


Install a new coolant filter and fill the cooling system with fully formulated coolant.

Use additional SCA to bring the coolant to the correct SCA concentration level. Refer to the specifications in this section.



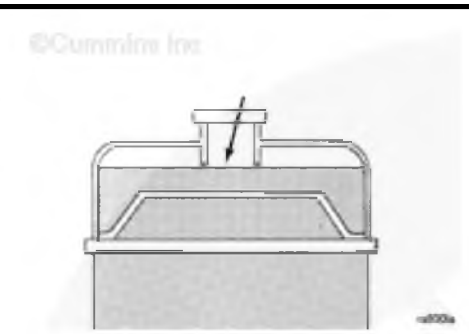
Install the radiator cap. Operate the engine until the coolant reaches a temperature of 70°C [160°F], and check for coolant leaks.



Pressure Test

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.



Check the coolant level and fill if necessary.

To aid in determining the location of the coolant leak, it could possibly be

necessary to add fluorescent tracer, Part Number 3377438, to the coolant.

Add one unit of fluorescent tracer to each 38 liters [10 gal] of coolant.

Idle the engine for 5 to 10 minutes or unit normal operating temperature is reached to allow the dye to circulate through the cooling system.

Use a high intensity black light, Part Number 3163337, or equivalent, to illuminate the dye.

If the customer experiences a coolant loss that can not be attributed to an external coolant leak or to coolant being pushed out of the overflow.

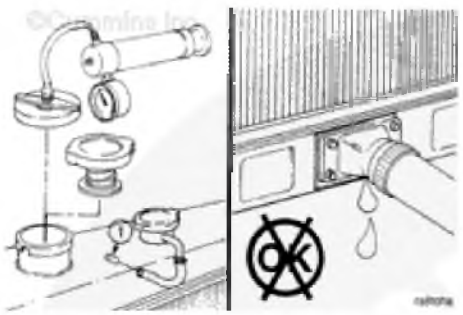
To confirm and locate external coolant leaks that occur during normal engine operation, complete this test while the engine is warm.

CAUTION

Do not apply more than 140 kPa [20 psi] air pressure to the cooling system. Excessive air pressure can damage the water pump seal.

If the radiator is equipped with a pressure relief valve, install a plug in the overflow tube (1).

Install the pressure tester on the radiator fill neck or surge tank (if equipped). Apply maximum air pressure.

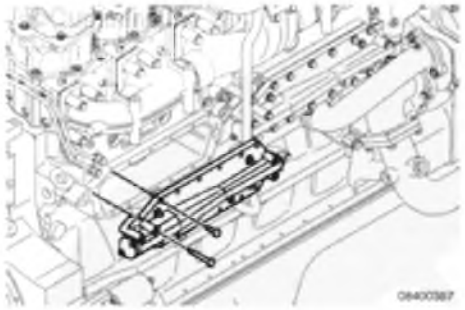


Measurements		
	kpa	psi
Maximum Air Pressure	140	20

Internal

Remove the front and rear oil cooler assemblies.

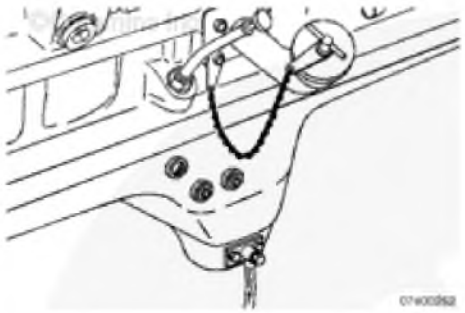
Check for coolant or coolant residue in the oil passages of the oil cooler covers and the cylinder block. If coolant or residue is present, replace the oil cooler core(s). Refer to Procedure 007-007 (Lubricating Oil Cooler Element) in Section 7.



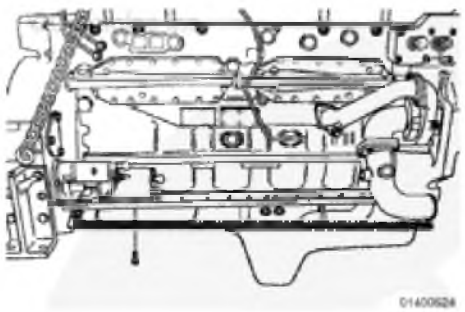
WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

If the oil cooler cores are **not** leaking, drain the oil. Refer to Procedure 007-037 (Lubricating Oil System) in Section 7. Check for coolant in the oil.

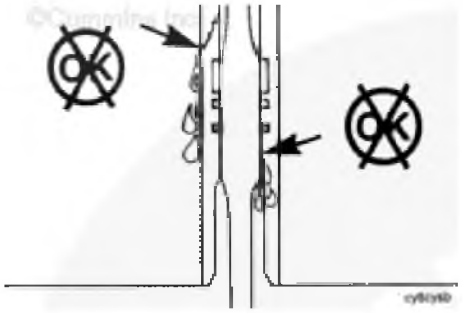


If the oil contains coolant, remove the oil pan. Refer to Procedure 007-025 (Lubricating Oil Pan) in Section 7.

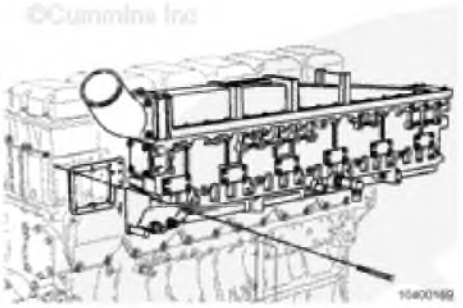


Check for leakage on the inside and outside of the cylinder liner.

Replace all cylinder liners that are leaking. Refer to Procedure 001-028 (Cylinder Liners) in Section 1.



Remove the intake manifold. Refer to Procedure 010-023 (Air Intake Manifold) in Section 10.

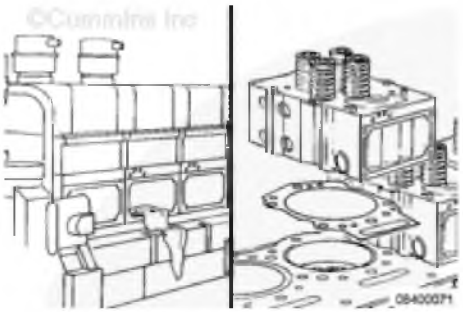


Check the intake ports and exhaust port for coolant/fluorescent dye using the black light. Presence of fluorescent dye indicates a crack.

NOTE: A green glow would be seen in the area where the leak has occurred. It is the coolant with tracer dye glowing from the light of the black light.

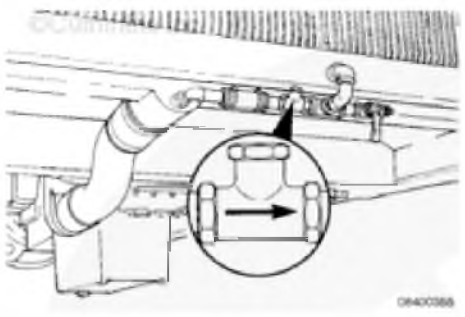
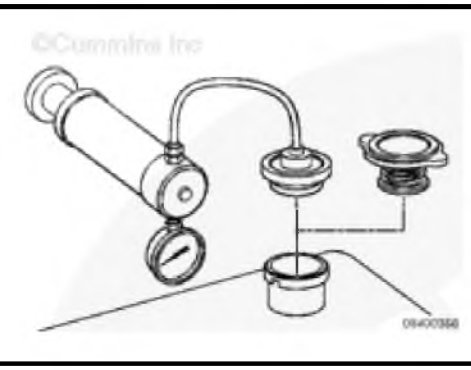
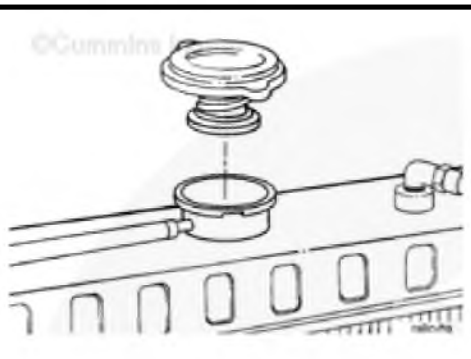
Remove the valve covers. Shine the black light in the overhead around the valve springs. If a spring deck crack is present and leaking coolant, it will glow under the black light.

Not all cracks will easily be detected by this procedure. It is also possibly to detect signs of coolant in the exhaust by looking for sign of either rust or evidence of steam cleaning in either the exhaust port in the



head or its corresponding position in the exhaust manifold. If coolant or fluorescent dye is found in the intake/exhaust ports, remove the cylinder head and test for defects. Replace if defective. Refer to Procedure 002-004 (Cylinder Liner) in Section 2.		

External

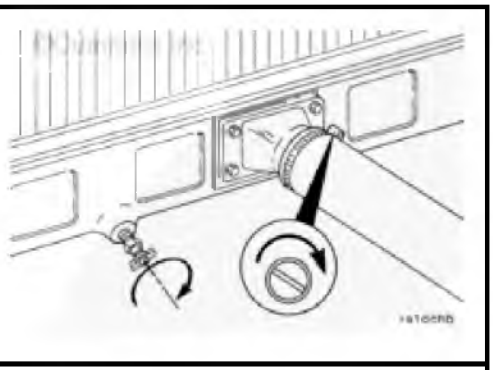
Check coolant lines, hoses, and fittings for leaks. Replace any damaged components.		
Remove the pressure test equipment and the plug from the pressure relief valve overflow tube (if equipped).		
Replace the radiator cap.		

Fill

Close the radiator draincocks.

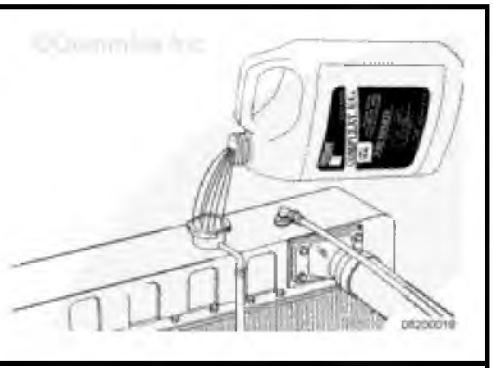
Install the lower radiator hose(s). Tighten the hose clamps.

Torque Value: 5 n.m [40 in-lb]

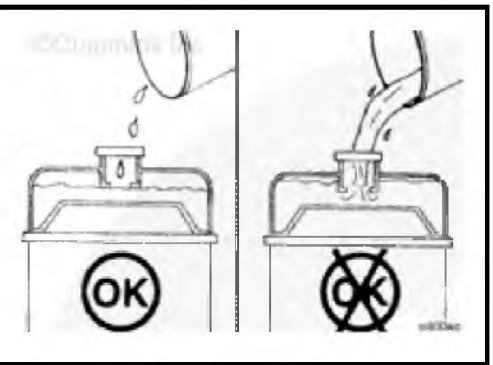


Cummins Inc. recommends using either a 50/50 mixture of good quality water and fully formulated antifreeze, or fully formulated coolant when filling the cooling system.

Use the correct units of SCA to obtain the correct cooling system protection.

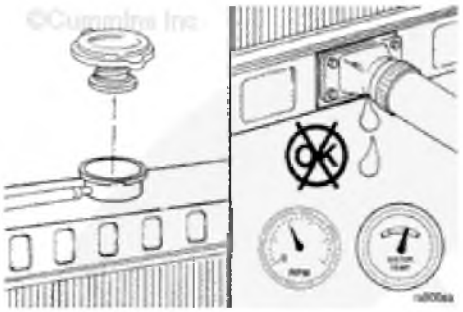


Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill (or expansion) tank.



Replace the radiator cap.

Operate the engine until the coolant reaches a temperature of 70°C [160°F]. Check for leaks.

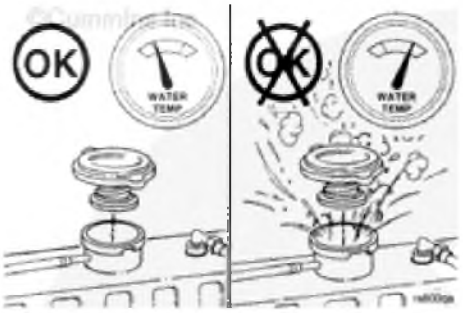


WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Shut the engine OFF and allow it to cool.

Check the coolant level and fill if necessary.



Last Modified: 28-Jun-2007

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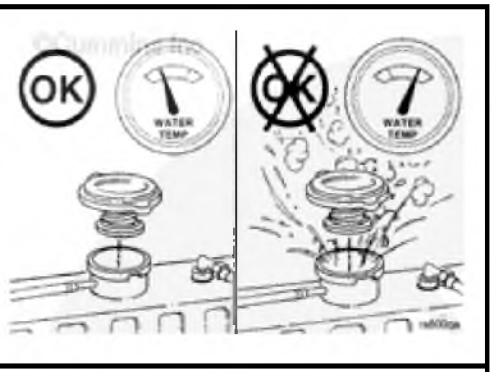
008-019 Cooling System - Air or Combustion Gas Test

Test

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

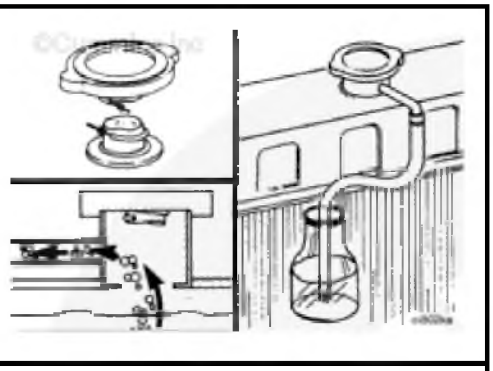
Allow the engine to cool. Remove the radiator cap.



The pressure cap **must** make a tight seal.

Install a radiator pressure cap that has had the spring and pressure relief valve removed.

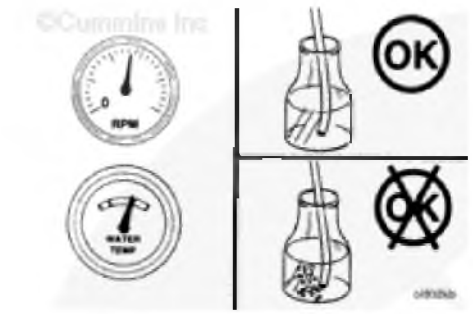
Attach a rubber hose to the radiator overflow connection. Put the free end of the hose in a container of water.



Operate the engine at rated rpm until it reaches a temperature of 80°C [180°F]

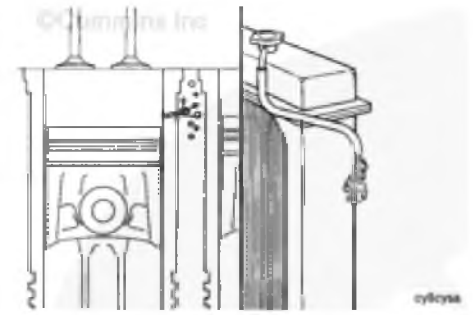
with the thermostat open.

Check for a continuous flow of air bubbles from the hose in the water container.



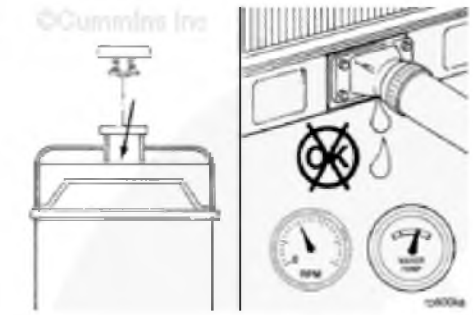
If a flow of air bubbles exist, check for defects in the following locations.

- A cylinder head combustion gas leak. Inspect the cylinder head and gasket for damage. Refer to Procedure 002-004.
- Incorrect cylinder liner protrusion. Refer to Procedure 001-028.
- Cracked or broken cylinder liners. Refer to Procedure 001-028.



If no air is in the system, do the following:

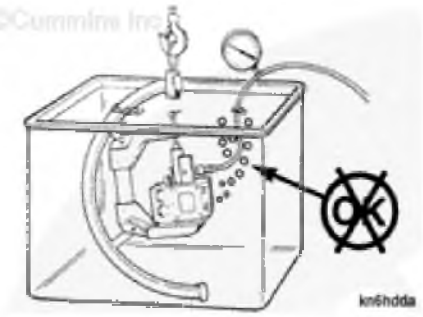
- Remove the test equipment.
- Check the coolant level and fill, if necessary.
- Install the correct radiator pressure cap.
- Operate the engine to a temperature of 80°C [180°F], and check for coolant leaks.



Cylinder Head and Cylinder Liner

A cracked or defective cylinder head will pressurize the cooling system and force the coolant out the overflow tube.

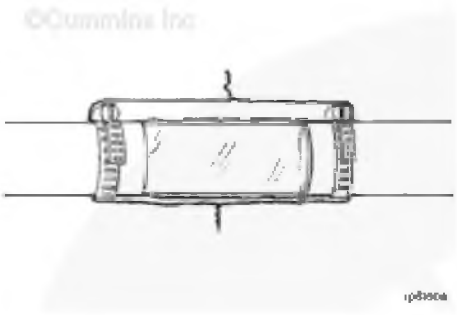
Check the cylinder head gasket. The part **must** be replaced if defective. Refer to Procedure 002-004 or Procedure 001-028.



Sight Glass Method

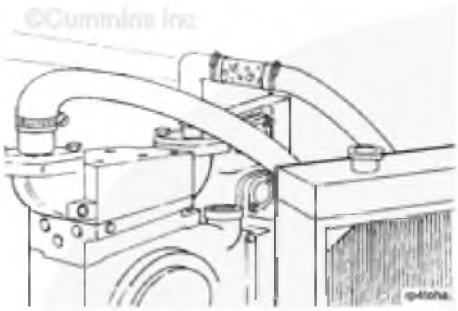
Put a clear Pyrex® tube in the water connection between the engine radiator and the thermostat housing.

If desired, put the Pyrex® tube in the vent line between the thermostat housing and the radiator.



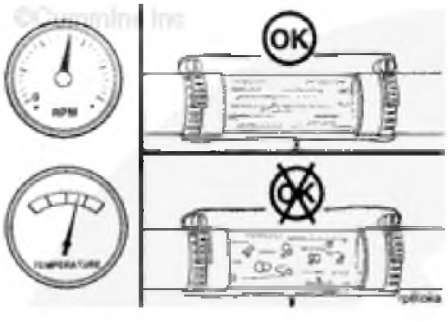
CAUTION

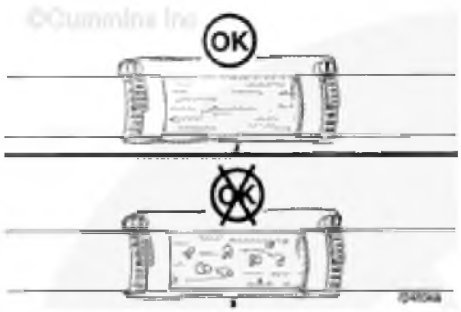
Use wire lace to connect the tube and hoses. Personal injury can result if the Pyrex® tube separates from the hoses.

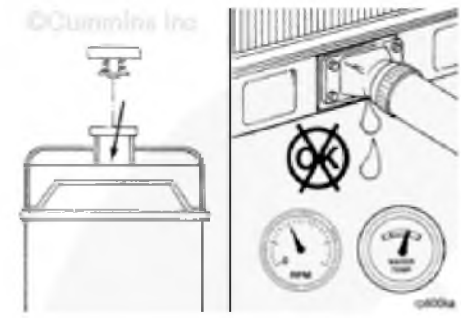


Operate the engine at 75 percent of rated rpm until it reaches an operating temperature of 80°C [180°F].

Check for a continuous flow of air bubbles in the hose.



A continuous flow of air bubbles indicates excessive air in the system. Continue to operate the engine for 25 minutes. If the flow of bubbles does **not** stop, check for the following: • A cylinder head combustion gas leak. Inspect the cylinder head and gasket for damage. Refer to Procedure 002-004. • Incorrect cylinder liner protrusion. Refer to Procedure 001-028. • Cracked or broken cylinder liners. Refer to Procedure 001-028.		

If no air is found in the system or if the flow of bubbles stops within 25 minutes, do the following. • Remove the test equipment. • Check the coolant level and fill if necessary. • Install the correct radiator pressure cap. • Operate the engine until it reaches a temperature of 70°C [160°F] and check for coolant leaks.		

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008-036 Fan Hub, Belt Driven

Preparatory Steps

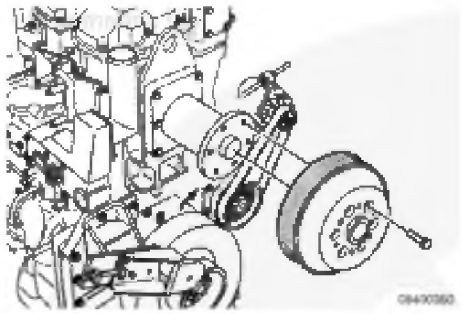
- Remove the fan. Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.

Remove

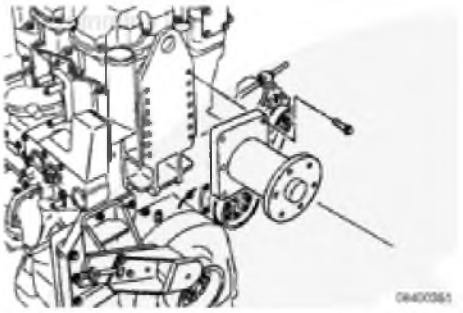
WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Remove the six bolts and the fan pulley.



Remove the six bolts and the fan hub.



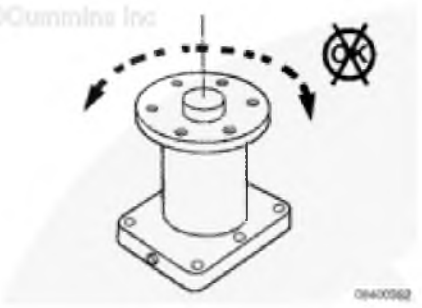
Inspect for Reuse

Inspect the fan hub for reuse. Rotate the hub to check for rough or damaged bearings.

Check bearing end clearance.

Bearing End Clearance		
mm		in
0.03	MIN	0.001
0.25	MAX	0.010

Inspect the grease seals for damage.



Install

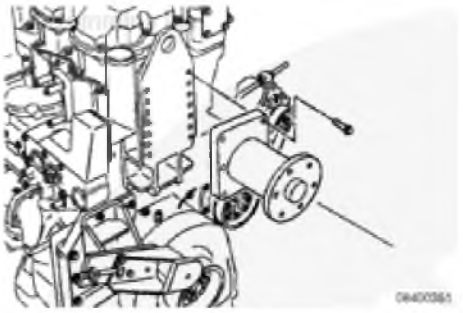
WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Install the fan hub and the six mounting bolts.

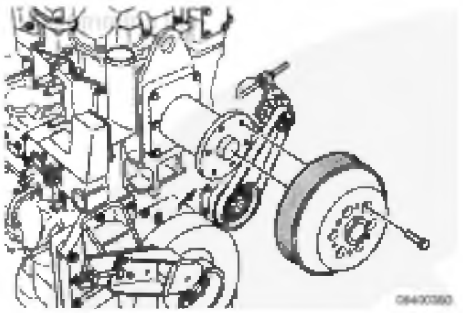
Tighten the fan hub bolts.

Torque Value: 113 n.m [83 ft-lb]



Install the fan hub pulley and six mounting bolts. Tighten the bolts.

Torque Value: 118 n.m [87 ft-lb]



Finishing Steps

- Install the fan belt. Refer to Procedure 008-002.
- Install the fan. Refer to Procedure 008-040.

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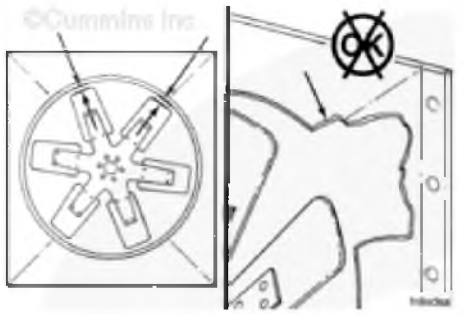
008-038 Fan Shroud Assembly

Inspect for Reuse

Inspect the fan shroud for the correct fan clearance. Refer to the vehicle manufacturer's specifications and the appropriate Installation Recommendations Bulletin. Inspect the shroud for cracks, air leaks or other damage. Replace the part, if damaged. Refer to the manufacturer's instructions.		

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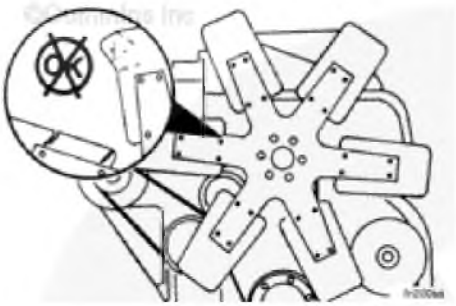
008-040 Fan, Cooling

Initial Check

WARNING

The cooling fan will engage when the engine is started. To reduce the possibility of personal injury, do not put your hands in the path of the rotating fan.

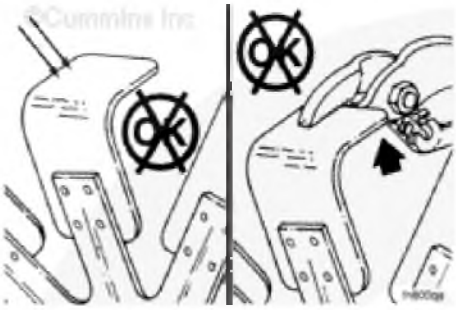
Check the fan for cracked, bent, or broken blades, and loose or worn rivets.



WARNING

Do not straighten a bent fan blade or continue to use a damage fan. A bent or damaged fan blade can fail during operation and cause personal injury or property damage.

Do **not** straighten bent fan blades. Replace if necessary.

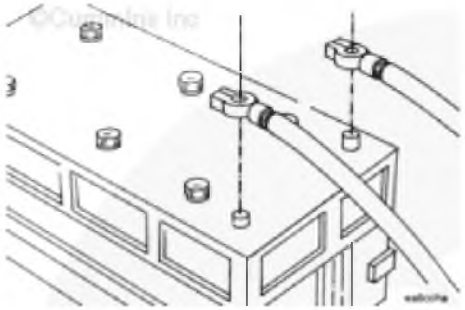


Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Disconnect the batteries or air supply line to the air starter (if equipped) to prevent accidental engine starting.

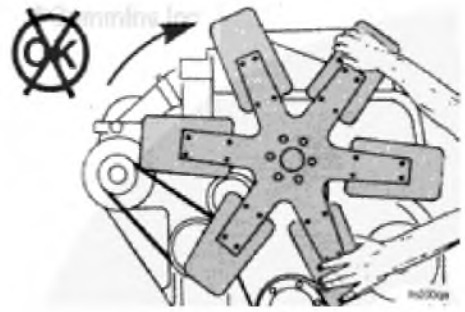


Remove

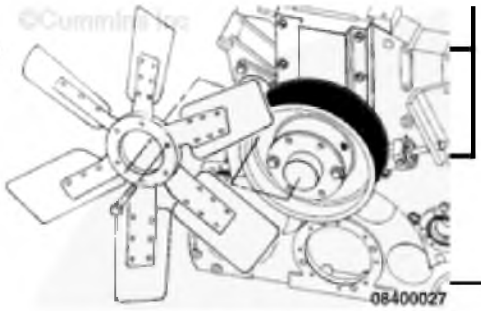
CAUTION

Do not pry or pull on the fan blades. The fan blades can be damaged.

Do **not** remove cooling fan by prying or pulling on fan blades.

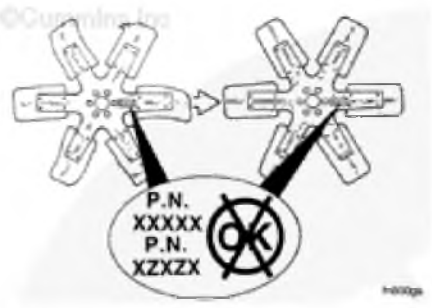


Remove the fan and spacer. Some engine applications will **not** use a fan spacer.



Install

Replace the original equipment fan with a fan of identical part number. Cummins Inc. **must** approve any fan changes.

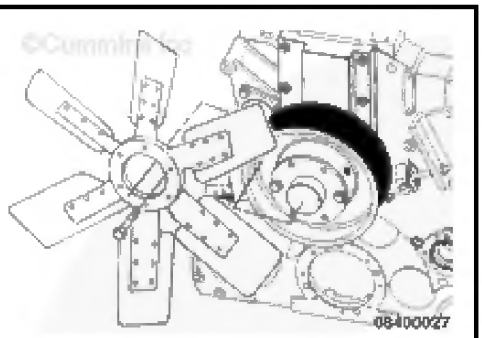


Install the fan and applicable spacer.

Tighten the mounting capscrews.

Torque Value: 135 n.m [100 ft-lb]

A minimum of 19.05 mm [3/4 in] of threads **must** be engaged in the fan hub.

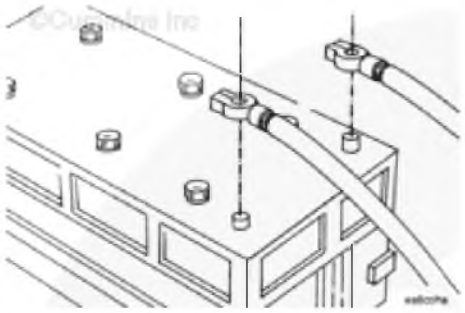


Finishing Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect the batteries or air starter (if equipped) supply line.



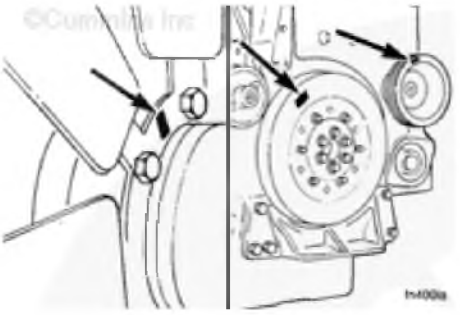
Rotation Check

Use an optical tachometer, Part Number 3377462, or a strobe light to measure the fan rpm.

Mark a spot on the fan so the fan rpm can be measured.

Mark another spot on the vibration damper or accessory drive pulley to measure engine rpm.

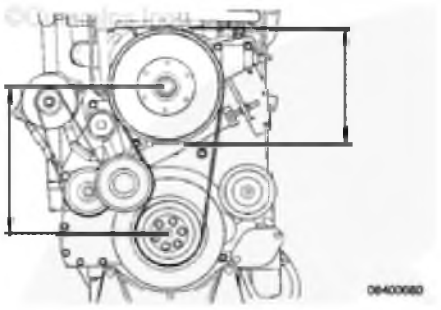
When using the optical tachometer, Part Number 3377462, use a piece of reflective tape, Part Number 3377464, to mark the spot.



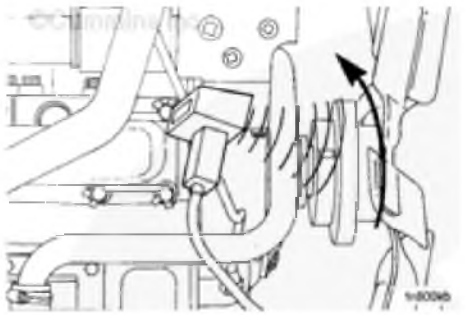
Measure the diameter of the fan belt pulley to determine the drive ratio.

Belt Driven Fan	
Fan Pulley Diameter	Fan (rpm)
311 mm [12.2 in]	0.70 x engine rpm

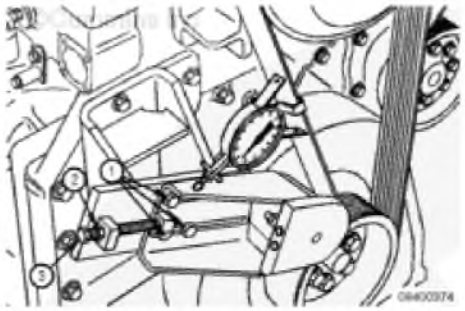
The fan center distance is the distance between the center of the fan hub and the center of the crankshaft.



Operate the engine. Read and compare the fan rpm to the engine rpm. Compare the fan rpm to the engine specification.



If the fan rpm is **not** correct, check the belt tension. Refer to Procedure 008-002.



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008-042 Radiator

Initial Check

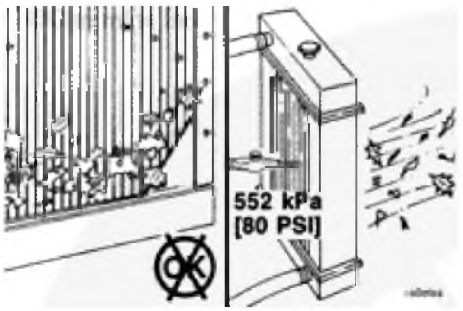
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Check for plugged radiator fins.

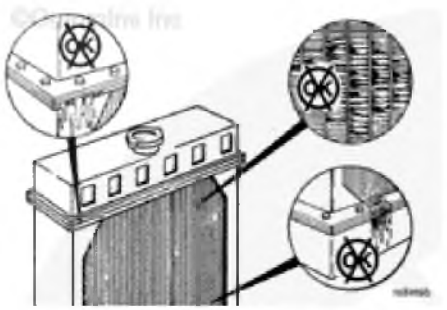
Use compressed air to blow out the dirt and debris. Blow the compressed air in the opposite direction of the fan air flow.

Measurements		
	kpa	psi
Air Pressure	552	80



Check for bent or broken radiator fins.
Check for radiator core and gasket leaks.

If the radiator **must** be replaced, refer to the manufacturer's replacement procedures.



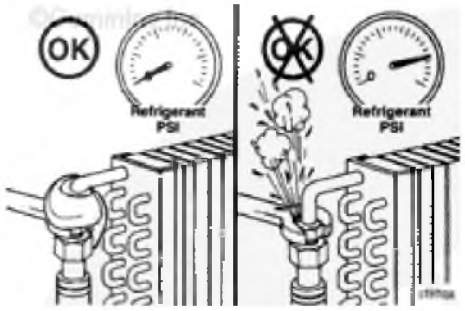
WARNING

If a liquid refrigerant system (air conditioning) is used, wear eye and face protection, and wrap a cloth around the fitting before removing. Liquid refrigerant can cause serious eye and skin injuries.

WARNING

To protect the environment, liquid refrigerant systems must be properly emptied and filled using equipment that prevents the release of refrigerant gas into the atmosphere. Federal law requires capturing and recycling the refrigerant.

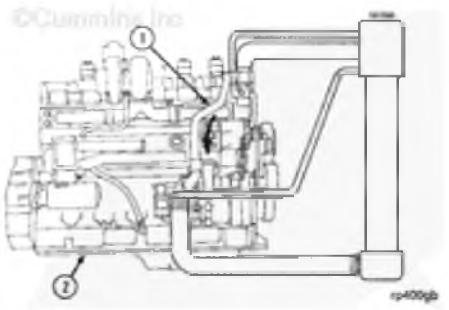
For environmental protection, federal regulations require that Freon be recycled, and **not** vented into the atmosphere.



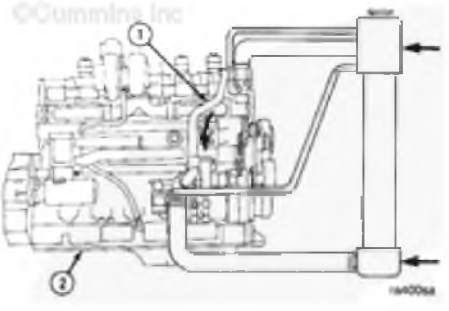
Reverse Flow Test

This test **must** be performed with the cooling system completely full and the coolant at ambient temperature.

Operate the engine at medium to high idle. Since the thermostats are closed, coolant flow is through the bypass line (1) and the engine (2).

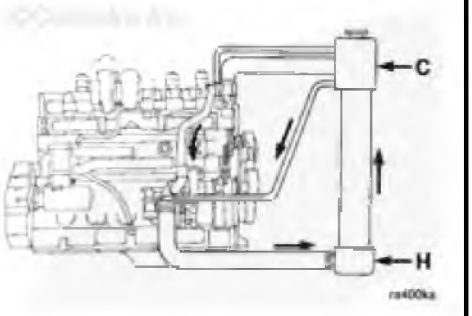


As the engine is warming up, use a contact pyrometer to check the temperature of the radiator top and bottom tanks.



If the bottom tank begins to warm and the top tank remains cold, the radiator has reverse flow. Refer to manufacturer's instructions for repair procedures.

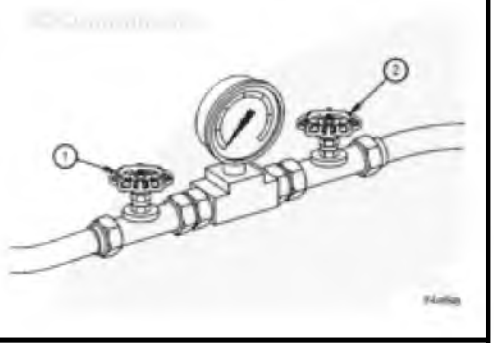
Check the piping to make sure it is the correct size and routed to specifications. Refer to the OEM service manual for installation instructions.



Test

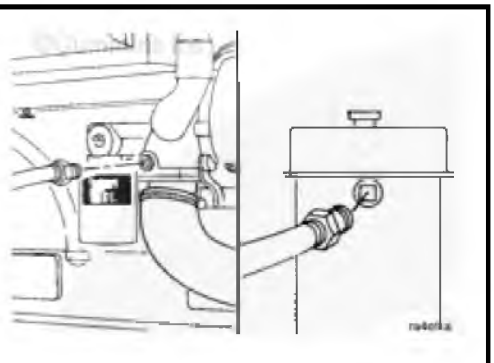
Use a pressure gauge designed to measure 0 to 100 kPa [0 to 15 psi] to measure obstruction.

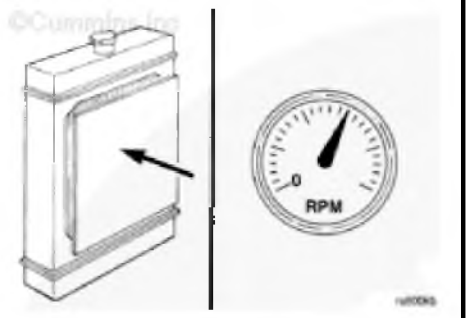
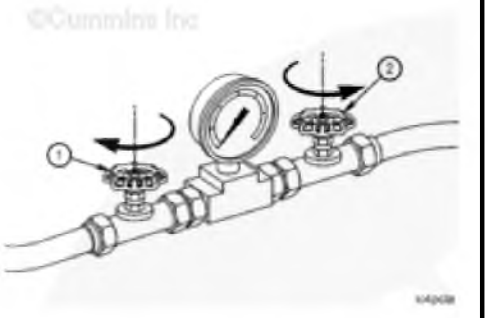
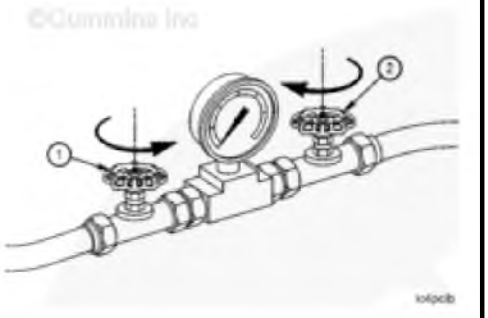
Install a shutoff valve (1)(2) on each side of the gauge.



Install one line into the water pump inlet connection and the other end into the thermostat return line on top of the radiator core.

Vent the air from the gauge lines.



Restrict the radiator air flow. Operate the engine until the coolant temperature reaches 88 to 90°C [190 to 194°F].		
Operate the engine at rated rpm. Close valve (1) and open valve (2). Record the pressure at the top of the radiator.		
Close valve (2) and open valve (1). Record the pressure at the water pump inlet. Compare the two pressure readings. If they differ by more than 35 kPa [5 psi], the radiator core or piping is obstructed.		

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008-045 Radiator Hoses

Preparatory Steps

WARNING

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

WARNING

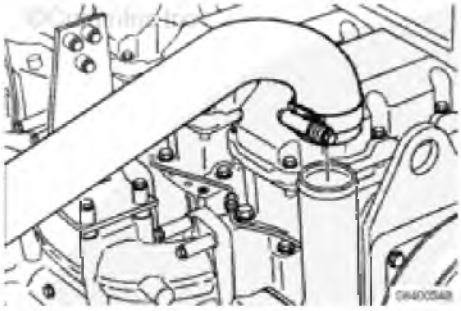
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

- Drain the cooling system. Refer to Procedure 008-018.

Remove

Loosen the hose clamp.

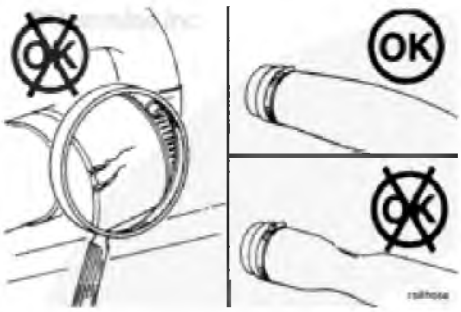
Remove the radiator hose from the engine.



Inspect for Reuse

Inspect all hoses for cracks, cuts, or collapsing.

The silicone engine coolant hose will exhibit swelling due to the elasticity of the hose.

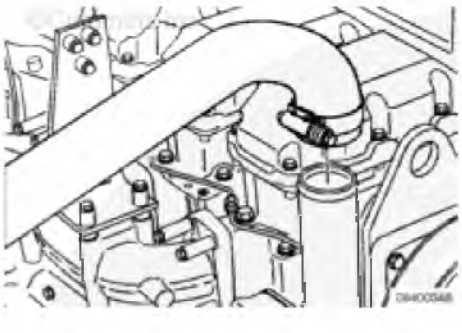


Install

Install the radiator hose.

Tighten the clamp.

Torque Value: 5 n.m [40 in-lb]



Finishing Steps

• Fill the cooling system. Refer to Procedure 008-018.		

Last Modified: 15-May-2003

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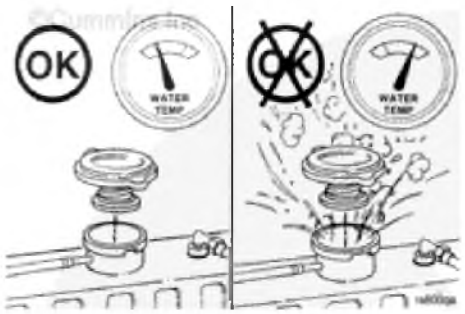
008-047 Radiator Pressure Cap

Inspect for Reuse

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

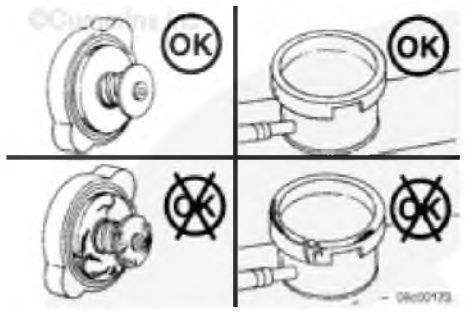
Remove the pressure cap.



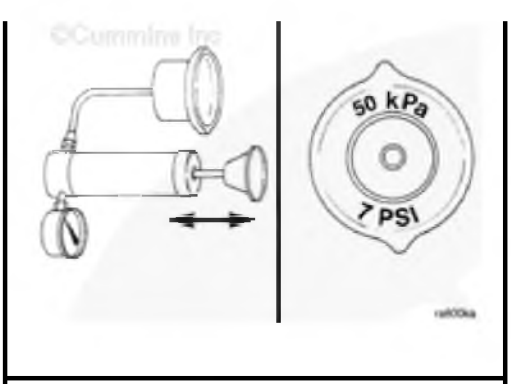
Inspect the rubber inner seal and the brass outer seal of the pressure cap for damage.

Inspect the radiator or expansion tank fill neck for cracks or other damage. Refer to the radiator manufacturer's or vehicle manufacturer's instructions if the fill neck is damaged.

Make sure the correct pressure cap is used. Refer to Cooling System Specifications.



Pressure-test the radiator cap.

The pressure cap **must** seal within 14 kPa [2 psi] of the value stated on the cap, or it **must** be replaced.		

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008-051 Radiator Top Tank

Leak Test

WARNING

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

WARNING

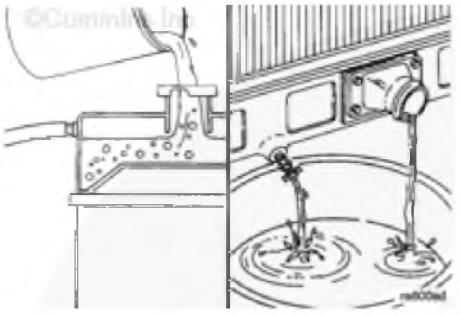
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Headed coolant spray or steam can cause personal injury.

Drain the cooling system. Refer to Procedure 008-018.

Plug the radiator fill line outlet.

Fill the top tank within 50 mm [2 in] from the top with water.

If the level drops and leakage is observed from the draincock and the lower radiator outlet, the baffle is leaking. The radiator **must** be repaired or replaced.



Last Modified: 30-May-2003

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008-062 Water Pump

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

- Disconnect the batteries or air supply line to the air starter. Refer to Procedure 013-007 in Section 13.

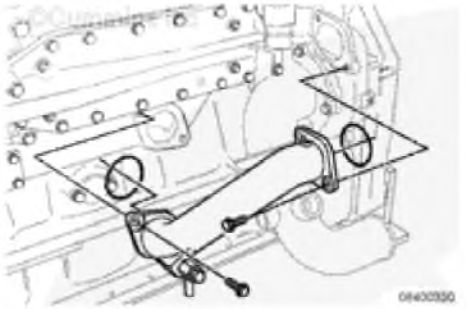
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.

Remove

Remove the four water pump outlet pipe capscrews.

Remove the water pump outlet pipe.

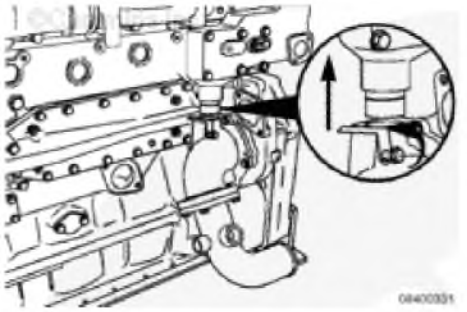
Discard the o-rings.



Loosen the bypass tube clamp.

Slide the bypass tube up into the thermostat housing.

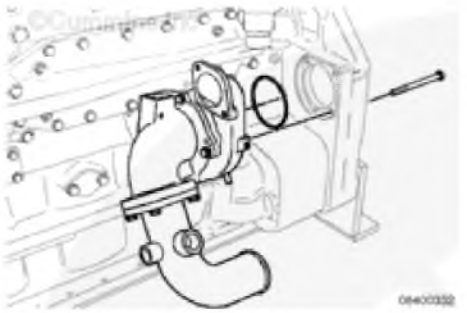
NOTE: Some components shown removed for clarity.

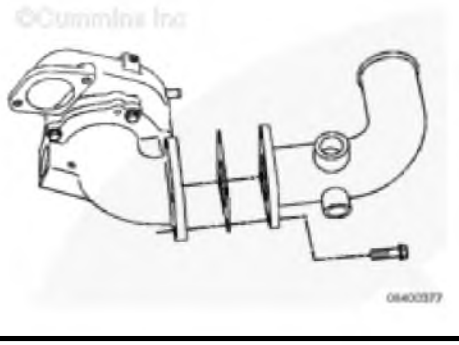


Remove the four water pump capscrews.

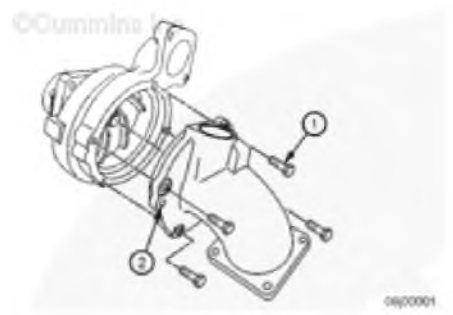
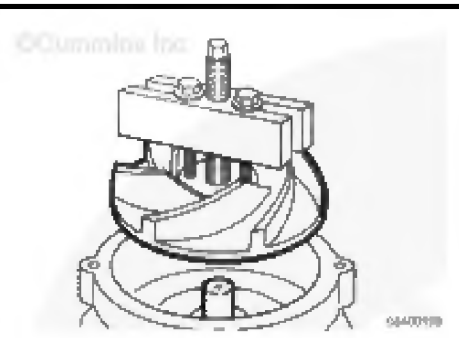
Remove the water pump.

Discard the o-ring.



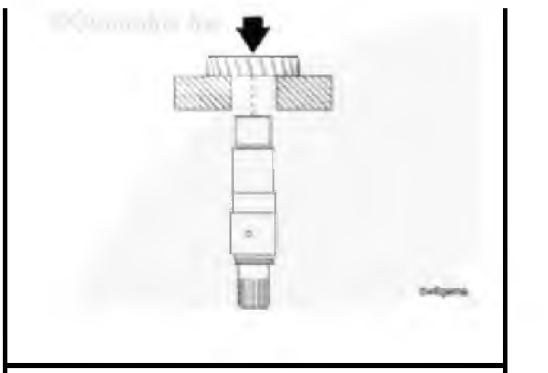
Remove the water pump inlet connection and discard the gasket.		

Disassemble

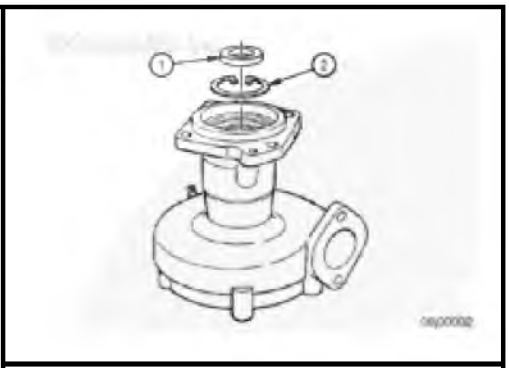
Remove the four capscrews (1) securing the inlet housing to the pump. Remove the inlet housing. If necessary, use two capscrews (1) in the threaded holes (2) to force the assembly apart. Remove and discard the large and small o-rings.		
NOTE: The jack screw in the puller must pass easily through the impeller bore to prevent damage to the impeller. Use a standard puller, Part Number ST-647 or equivalent, to remove the impeller.		
Use a water pump bearing separator, Part Number 3375326 or equivalent, to support		

the gear.

Use an arbor press. Press the shaft and water pump assembly out of the gear.

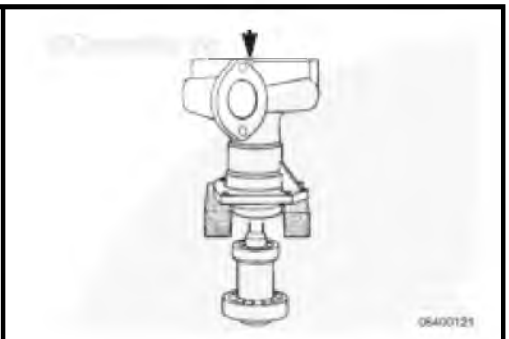


Remove the thrust ring spacer (1) and the large retaining ring (2).

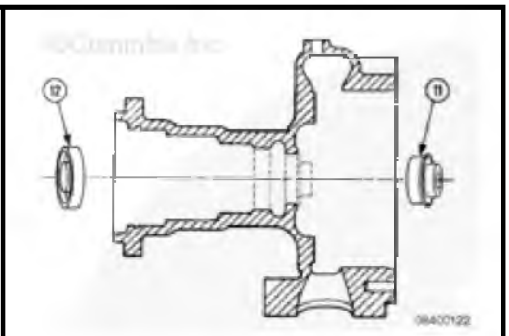


Support the water pump body, as illustrated.

Use an arbor press to push on the impeller end of the shaft. Remove the bearing and shaft assembly.



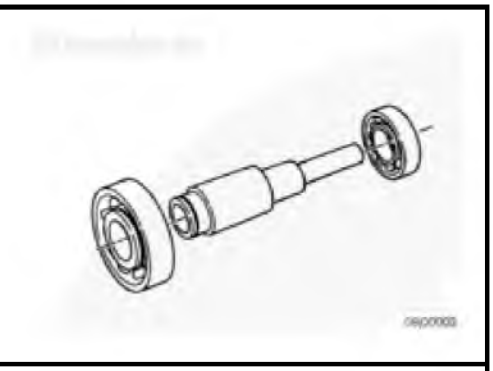
Remove and discard the water seal (11) and oil seal (12).



Before removing the shaft from the bearings, check the bearings.

If necessary, press the shaft from the bearings.

Discard the bearings.



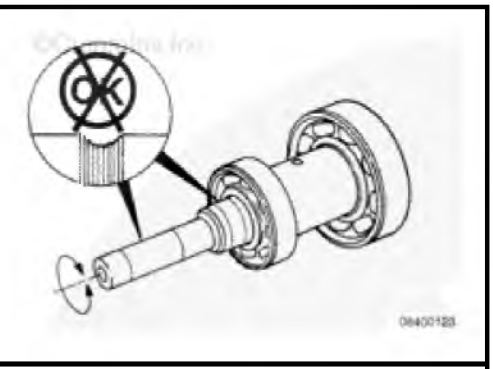
Clean and Inspect for Reuse

Inspect the bearing and shaft assembly for wear in the seal areas.

Spin the bearings to check for roughness.

If the grooves can be felt with a fingernail, the shaft **must** be replaced.

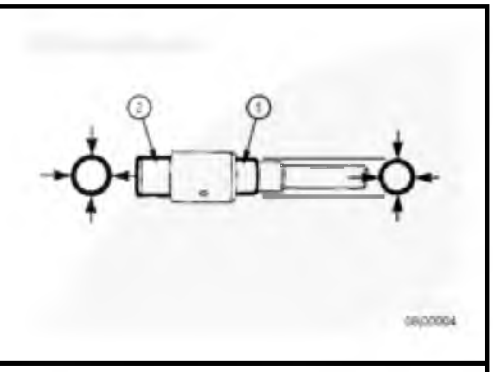
If damage to the shaft or bearings are found, they **must** be replaced.



If the bearings were removed, measure the shaft diameter at the bearing journal locations.

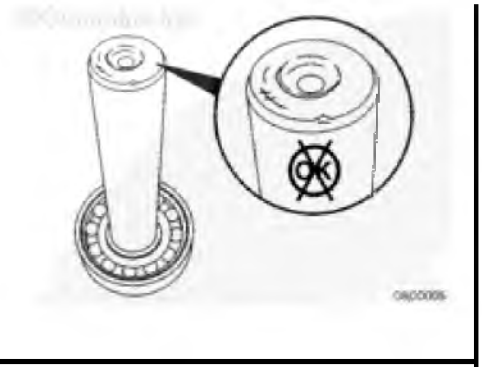
Shaft Diameter (Callout 1 and 2)

mm		in
25.002	MIN	0.9843
25.011	MAX	0.9847



Clean and inspect the end of the shaft.

Remove any burrs or debris caused by removal of the impeller, gear, or bearings.



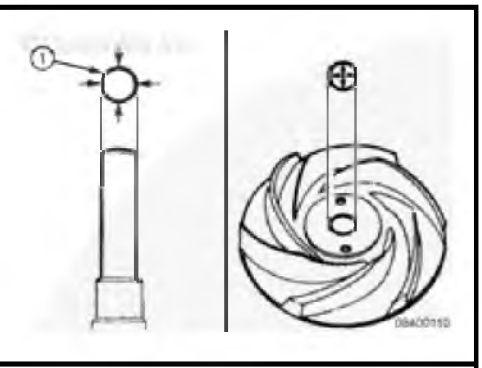
Use the following formula to determine the press fit.

Press fit = shaft outside diameter (1) minus impeller inside diameter.

Impeller to Shaft Press Fit

mm		in
0.03	MIN	0.001
0.07	MAX	0.003

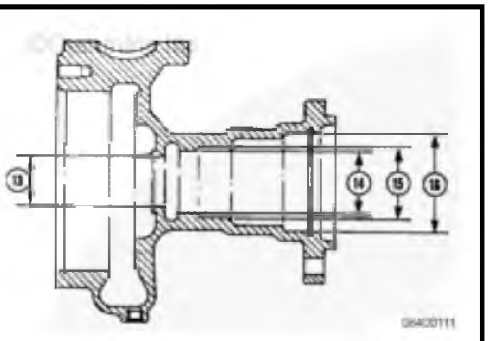
Inspect the impeller press fit area of the shaft for nicks or scratches. If any marks can be felt with a finger nail, the shaft **must** be replaced.



Measure the inside diameter of the water pump housing bore.

Housing Bore Diameter

	mm		in
(13) Water Seal	46.00	MIN	1.811
	46.25	MAX	1.821
(14) Oil Seal	42.00	MIN	1.654
	42.09	MAX	1.657
(15) Rear Bearing	51.985	MIN	2.0467
	52.004	MAX	2.0474
(16) Front Bearing	61.967	MIN	2.4396
	61.986	MAX	2.4404



BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

Assemble

CAUTION

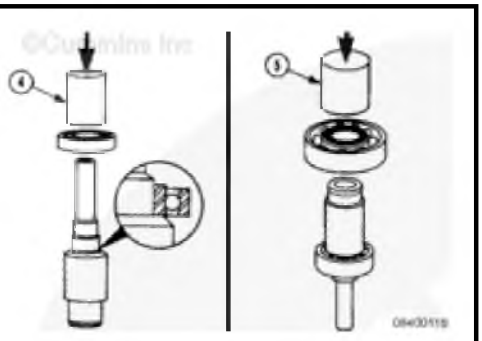
The mandrel must make contact on the inner race of the bearing to prevent damage to the bearing.

If removed, install the new bearings onto the shaft.

Support the shaft.

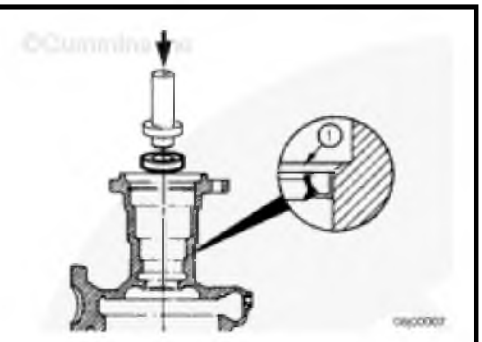
Use an arbor press and a water pump bearing mandrel to install the bearings.

NOTE: The smaller bearing (4) is pressed on the journal, closer to the middle of the shaft, while the bigger bearing (5) is closer to the end of the shaft.



Use the water pump seal driver to install the new oil seal with the stepped lip facing down toward the impeller.

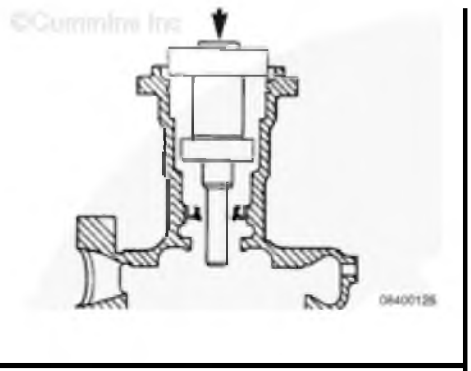
The seal must be installed so that the top of the seal is flush with the bottom edge of the chamfer (1) on the water pump body.



Support the water pump housing.

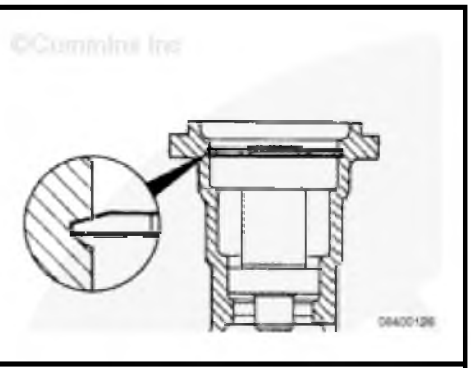
Use an arbor press to push on the end of the shaft. Install the shaft and bearing assembly.

After installing the shaft, flip the assembly over and check that the oil seal has **not** moved.



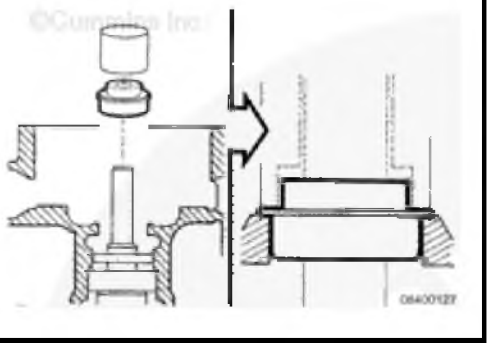
The beveled edge **must** be positioned as illustrated.

Install the large retaining ring.



Use a water pump seal driver to install the water seal.

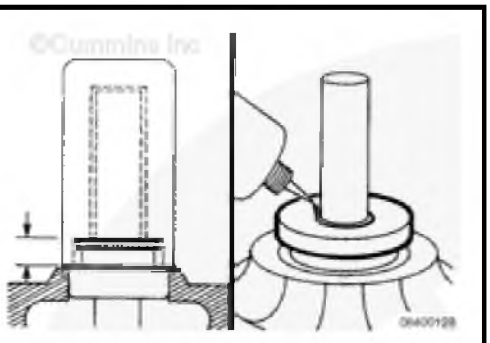
The shoulder on the seal **must** touch the housing.



CAUTION

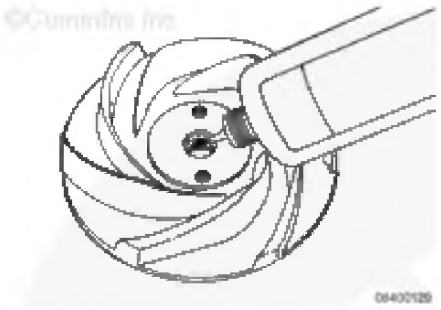
More than one drop of Loctite® 290, or equivalent, on the seal seat will glue the faces of the seal together, resulting in damage to the seal.

Use an arbor press and water pump seal driver to install the seal seat.



Apply one drop of Loctite® 290, or equivalent, to the seal seat, as illustrated.

Apply a smooth coating of Loctite® 290, or equivalent, to the inside diameter of the impeller, as illustrated.



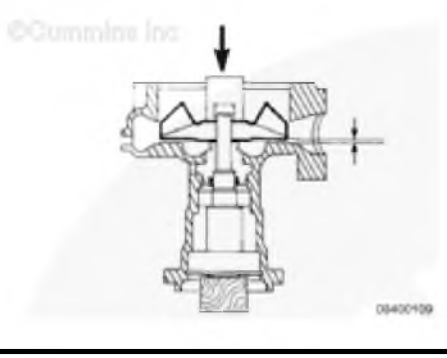
Use an arbor press and a mandrel to install the impeller to the specified clearance.

Use a feeler gauge in the water outlet port to measure the clearance.

Impeller Vane-to-Body Clearance

mm		in
2.50	MIN	0.098
2.90	MAX	0.114

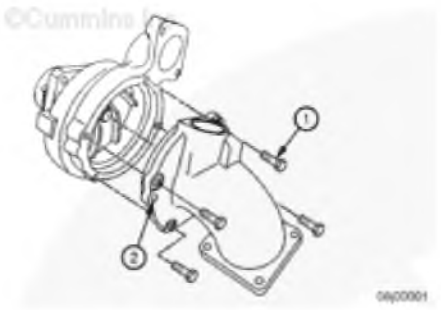
NOTE: Spin the shaft and check the clearance in multiple locations to make sure the water pump has been assembled correctly.



CAUTION

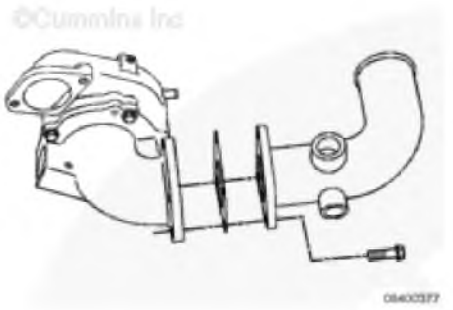
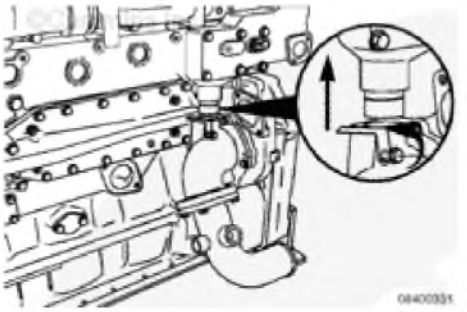
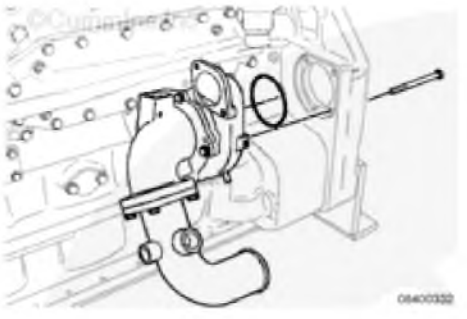
Do not use engine oil on the o-rings as it may cause them to swell.

Use vegetable oil to lubricate the o-rings (2).



Install the parts as illustrated. Install the capscrews (1). **Torque Value:** 65 n.m [48 ft-lb]		

Install

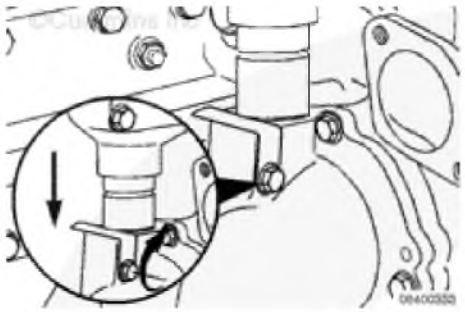
Install the inlet connection, new gasket, and capscrews. Tighten the capscrews. **Torque Value:** 70 n.m [50 ft-lb]		
Install new o-rings on the bypass tube. Lubricate the o-rings with vegetable oil. Slide the tube up into the thermostat housing. **NOTE: Some components are shown removed for clarity.**		
Install a new o-ring on the water pump. Lubricate the o-ring with clean engine oil. Install the water pump and capscrews. Tighten the capscrews.		

Torque Value: 113 n.m [83 ft-lb]

Slide the bypass tube down from the thermostat housing into the water pump.

Slide the bypass tube clamp into the groove in the bypass tube and tighten the capscrew.

Torque Value: 66 n.m [49 ft-lb]



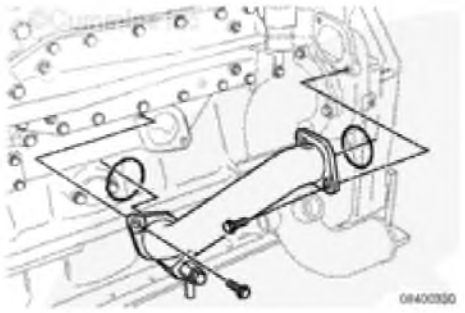
Install new o-rings on the water pump outlet pipe.

Lubricate the o-rings with vegetable oil.

Install the water pump outlet pipe and capscrews.

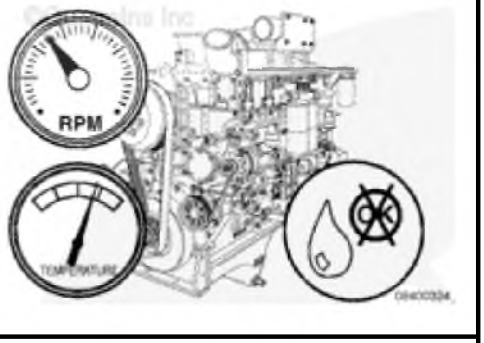
Tighten the capscrews.

Torque Value: 113 n.m [83 ft-lb]



Finishing Steps

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries or air supply line to the starter. Refer to Procedure 013-007 in Section 13.

Operate the engine to 70°C [160°F] coolant temperature and check for leaks.		

Last Modified: 06-Feb-2012

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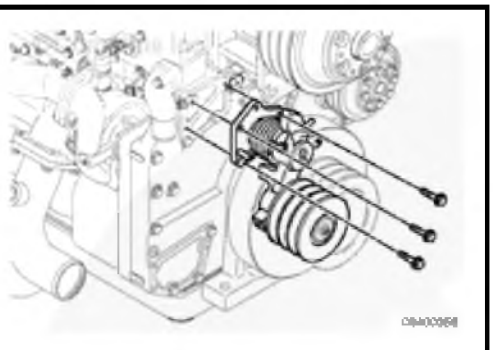
008-087 Cooling Fan Belt Tensioner

Preparatory Steps

• Remove the cooling fan belt. Refer to Procedure 008-002.		

Remove

Industrial Applications

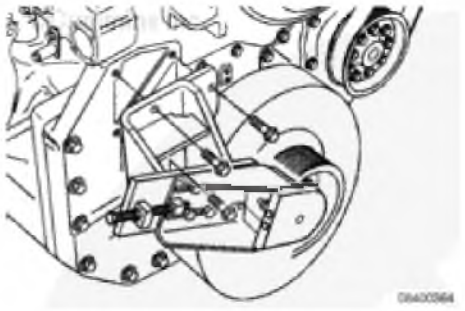
Remove the three capscrews and tensioner from the front cover.		

Power Generation

WARNING

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

Remove the three capscrews that fasten the tensioner to the front cover. Do **not** remove the three clamping bolts at the base of the adjusting screw.



Clean and Inspect for Reuse

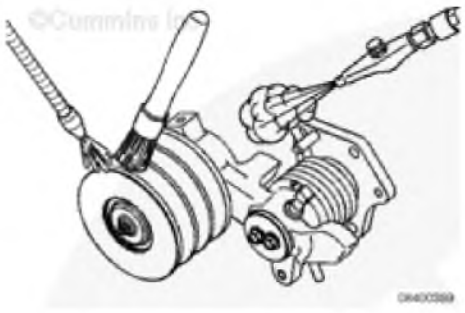
Industrial Applications

WARNING

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

WARNING

Wear appropriate eye and face protection when using compressed air.

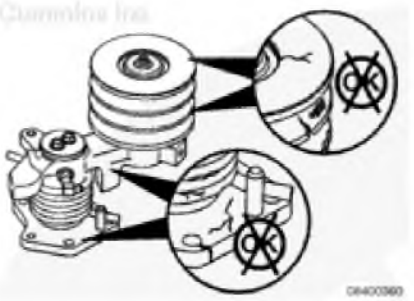


Flying debris and dirt can cause personal injury.

Clean the tensioner with a brush and solvent.

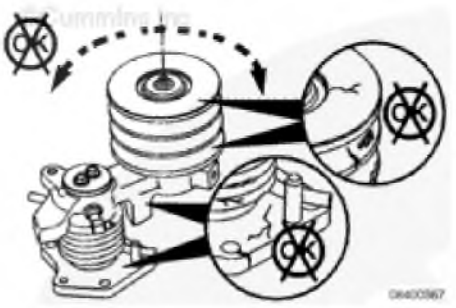
Dry with compressed air.

Check the tensioner arm, spring, and pulley for cracks and other damage.



Inspect the tensioner pulley.

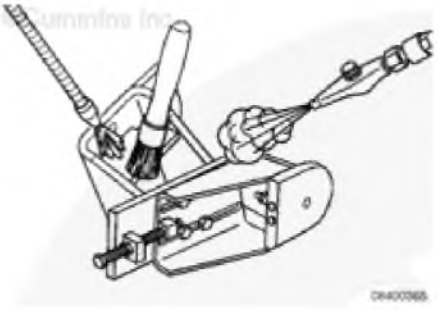
Rotate the pulley to check for rough bearings.



Power Generation

WARNING

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



WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

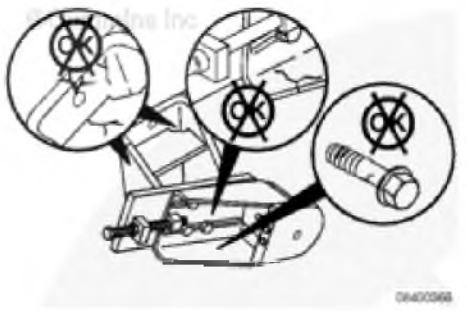
Clean the tensioner with a brush and solvent.

Dry with compressed air.

Inspect the tensioner pulley.

Check the cooling fan belt tensioner bracket and tensioner for damage or deterioration. Check the adjustable tensioner for cracks and broken bolts.

Rotate the pulley to check for rough bearings.



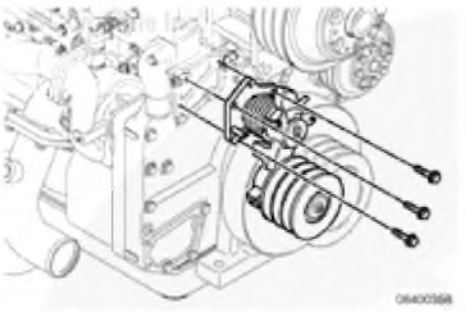
Install

Industrial Applications

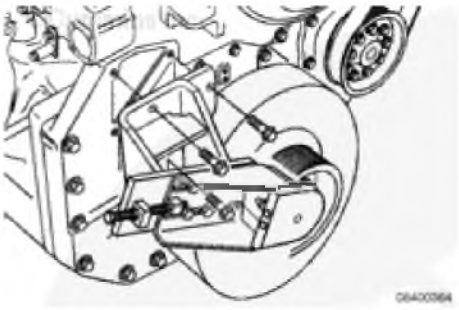
Install the tensioner and three capscrews.

Tighten the capscrews.

Torque Value: 113 n.m [83 ft-lb]



Power Generation

Install the tensioner and three mounting capscrews. Tighten the capscrews. **Torque Value:** 113 n.m [83 ft-lb]		

Finishing Steps

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

Last Modified: 30-May-2003

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009-009 Alternator Drive Gear and Shaft

Preparatory Steps

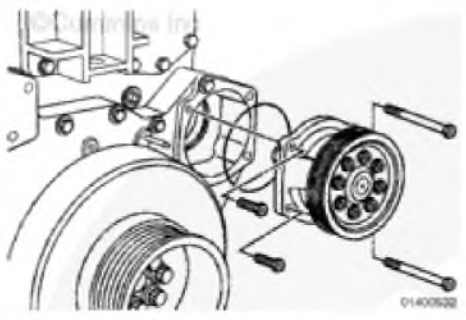
- Remove the alternator belt. Refer to Procedure 013-005 in Section 13.
- Remove the alternator drive pulley, if necessary. Refer to Procedure 009-010 in Section 9.

Remove

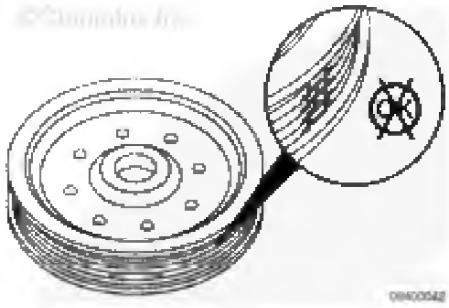
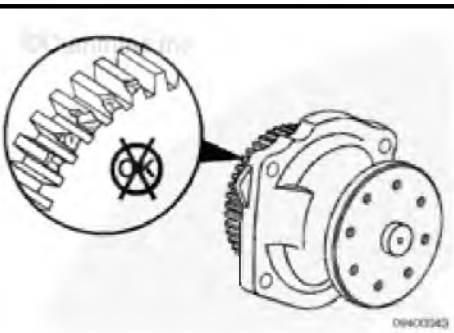
Remove the two long and the two short bolts from the alternator drive. Remove the alternator drive and o-ring.

Discard the o-ring.

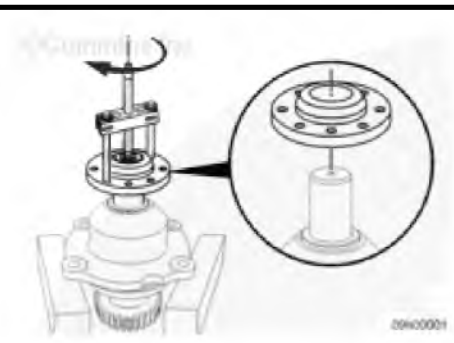
NOTE: Some components shown removed for clarity.

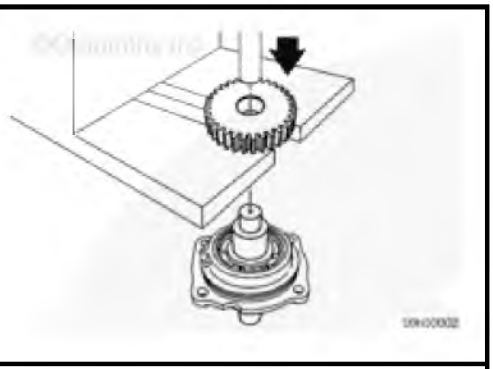
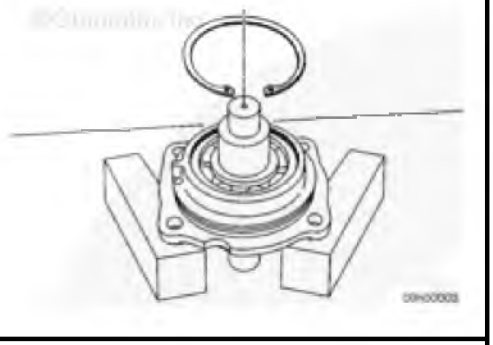
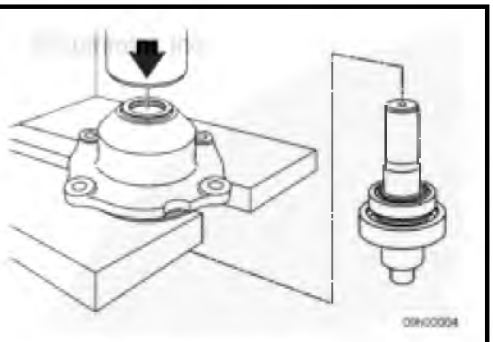
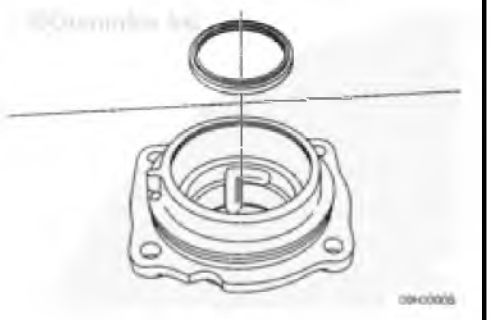


Initial Check

Inspect the pulley for nicks, cracks, or excessive wear in the belt grooves or other damage.		
Inspect the alternator drive gear for cracks, chipped, or missing teeth. Inspect the alternator drive housing for cracks and confirm that the shaft turns smoothly.		

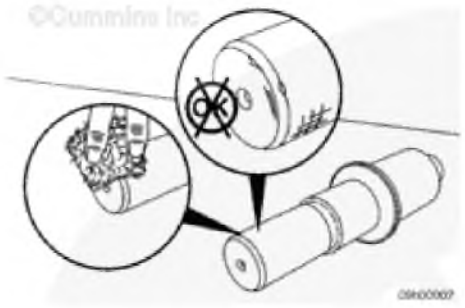
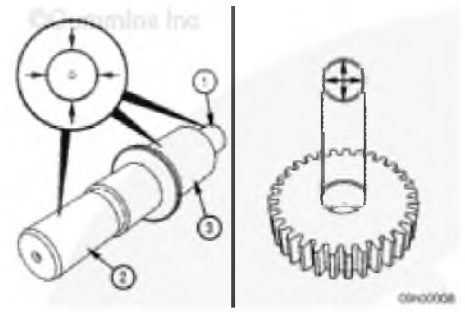
Disassemble

Use a standard puller, Part Number ST-647, or equivalent. Remove the alternator drive pulley hub.		

Use a water pump bearing separator, Part Number 3375326, or equivalent, to support the gear. Use an arbor press to remove the shaft and alternator drive assembly out of the gear. Remove the thrust plate from the shaft.		
Remove the retaining ring from the back side of the housing.		
Use an arbor press to remove the shaft and bearing assembly out of the housing.		
Remove the oil seal from the housing. Discard the oil seal.		

Use an arbor press to remove the shaft from the bearings. **NOTE: The smaller bearing may remain in the housing when the shaft is removed. If necessary, press the bearing from the housing.** Discard the bearings.		

Inspect for Reuse

Clean and inspect the end of the shaft. Use emery cloth to remove any burrs or debris caused by removal of the impeller, drive coupling, or pulley hub.		
Measure the press fit for drive gear, alternator pulley hub, and fuel pump drive coupling. Measure the outside diameter of the shaft in each location: 1. Drive gear 2. Alternator hub location 3. Fuel pump drive coupling. Measure the inside diameter of the mating		

part.

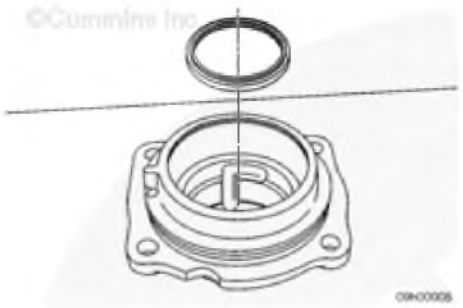
Use the following to determine the press fit.

Press fit = shaft outside diameter (1) minus the gear inside diameter.

mm		in
0.02	MIN	0.0008
0.06	MAX	0.0024

Assemble

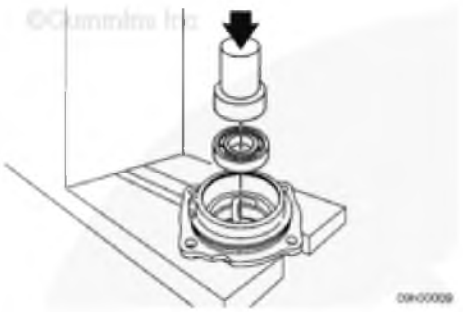
Install the oil seal into the housing.



CAUTION

Be sure that the mandrel contacts only on outer race of bearing. Contact with inner race can cause bearing damage.

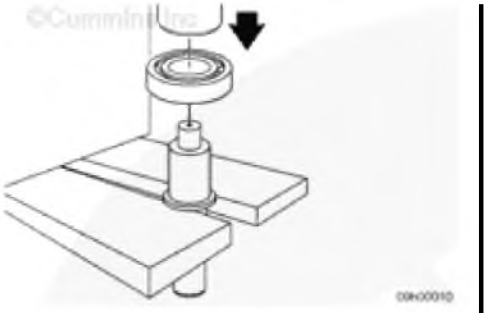
Use an arbor press and a mandrel to install a new small bearing into the housing.



CAUTION

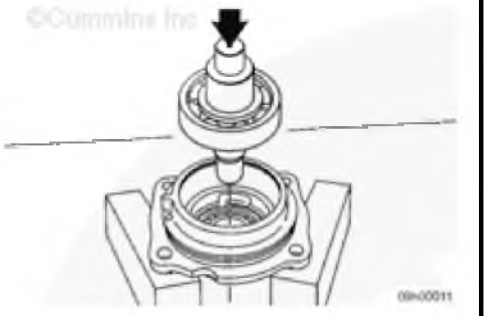
Be sure that the mandrel contacts only on inner race of bearing. Contact with outer race can cause bearing damage.

Use an arbor press and a mandrel to install a new large bearing onto the shaft. Be sure that the bearing is pressed flush against the shoulder of the shaft.



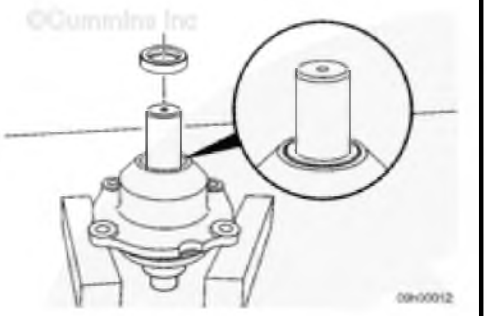
Install the shaft assembly into the housing.

If necessary, lightly press the shaft assembly into the housing. Be sure the shaft is in line with the housing as **not** to damage the bearings.



Install the oil seal into the housing.

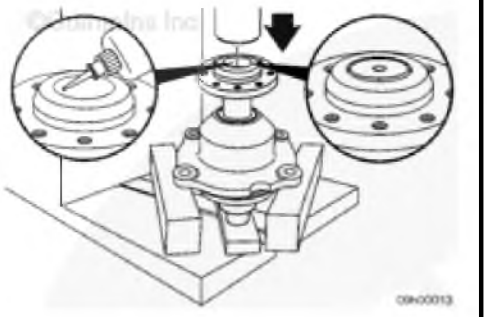
Install the seal so that it is flush with the outside of the housing.



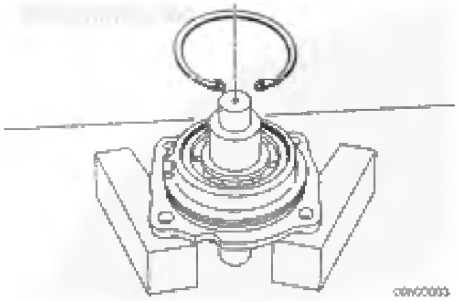
Support the shaft.

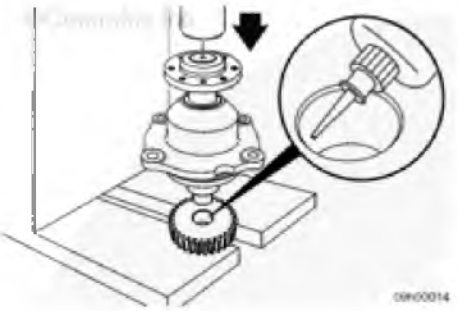
Apply Loctite™ 609, Part Number 3823718, or equivalent, to the inside diameter of the hub.

Use an arbor press to install the pulley hub onto the housing.

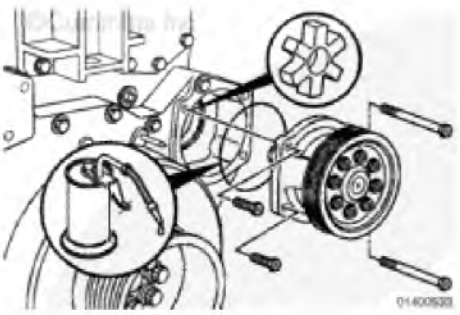


Install the hub so that it is flush with the end of the shaft.		

Install the retaining ring for the large bearing.		

Install the thrust plate onto the shaft. Apply Loctite™ 609, Part Number 3823718, or equivalent, to the gear inside diameter. Support the gear in a press. Press the shaft onto the gear.		

Install

Confirm that the alternator to fuel pump drive coupling is in place. Lubricate the alternator drive o-ring with clean engine oil and install onto the alternator drive assembly. Install the alternator drive assembly. Install the two long alternator drive		

capscrews on the right side of the assembly. Install the two short capscrews on the left side of the assembly. **Torque Value:** 113 n.m [83 ft-lb]		

Finishing Steps

• If removed, install the alternator drive pulley. Refer to Procedure 009-010 in Section 9. • Install the alternator belt. Refer to Procedure 013-005 in Section 13. • Start the engine and check for proper operation.		

Last Modified: 02-Apr-2012

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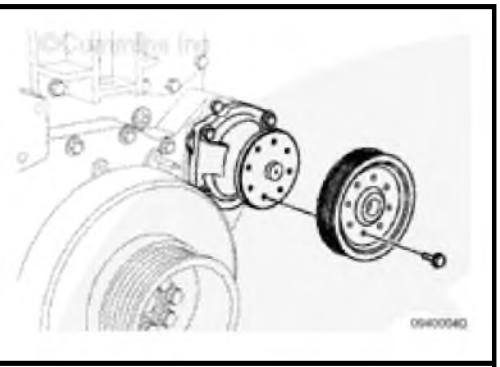
009-010 Alternator Drive Pulley

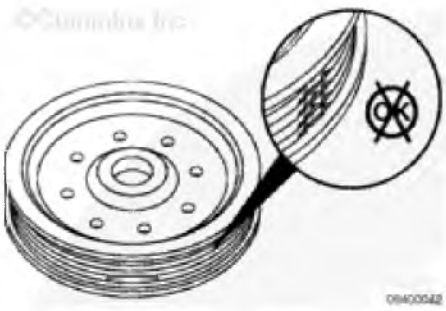
Preparatory Steps

• Remove the alternator belt. Refer to Procedure 013-005.		

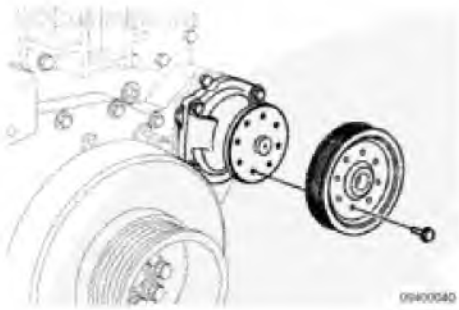
Remove

Remove the eight alternator drive pulley bolts. Remove the pulley. **NOTE: Some components shown removed for clarity.**		

Inspect for Reuse

Inspect the pulley for nicks, cracks, or excessive wear in the belt grooves or other damage.		

Install

Install the alternator drive pulley and capscrews. Tighten the capscrews. **Torque Value:** 70 n.m [50 ft-lb]	 	

Finishing Steps

• Install the alternator belt. Refer to		

Procedure 013-005.

Last Modified: 30-May-2003

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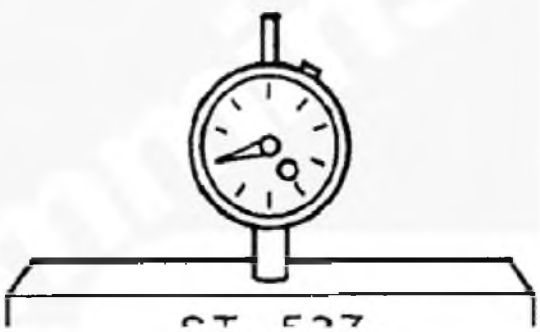
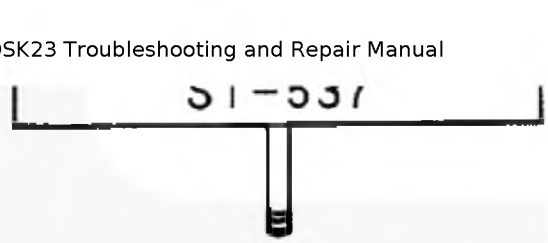
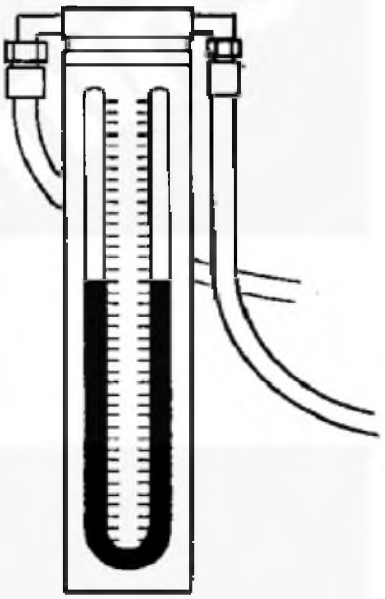
022-001 Service Tools

Air Intake System

Tool Number 3376891	**Flourescent Tracer** Used to put in fuel or oil to check for leaks.	 3376891

Tool Number ST-537	**Dial Depth Gauge** Used to check turbocharger and clearance.	

		 ST-537

Tool Number ST-1111-3	**Manometer** Used to measure air inlet restriction.	 eg100ja

Last Modified: 28-Jul-2003

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010-023 Air Intake Manifold

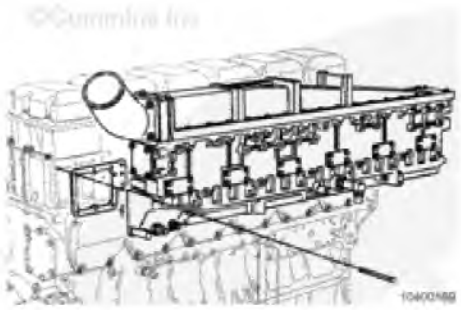
Preparatory Steps

• Remove the fuel drain lines. Refer to Procedure 006-013 in Section 6. • Remove the fuel supply lines. Refer to Procedure 006-024 in Section 6. • Remove the fuel filter assembly. Refer to Procedure 006-015 in Section 6. • Drain the cooling system. Refer to Procedure 008-018 in Section 8. • Remove the coolant filter assembly. Refer to Procedure 008-060 in Section 8. • Remove the intake piping. Refer to the OEM service manual.		

Remove

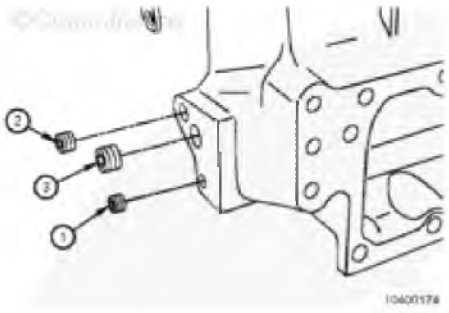
Generator-Drive

Remove the 42 capscrews and the intake manifold.		



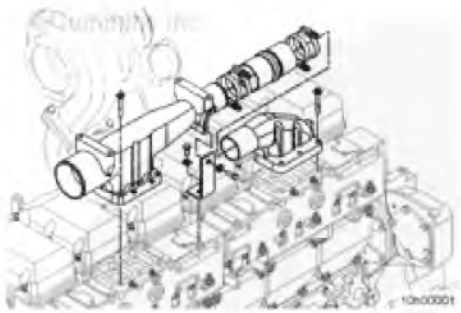
Remove the three fuel drilling plugs from the front and rear of the intake manifold.

1. Fuel rail supply drilling (1/8 inch pipe thread)
2. Fuel timing supply drilling (1/4 inch pipe thread)
3. Fuel return drilling (3/8 inch pipe thread)

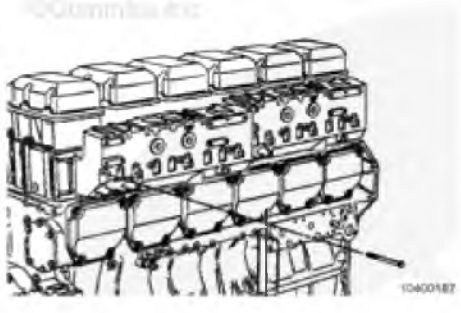


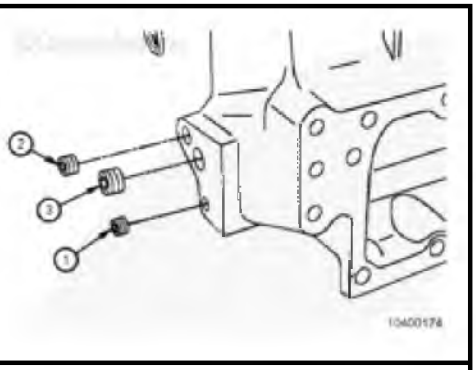
Industrial Applications

Remove the air crossover connections.

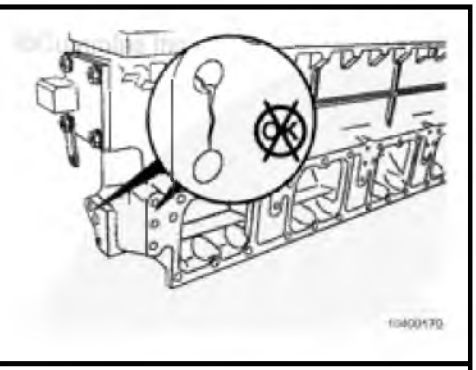


Remove the 21 capscrews from each intake manifold and remove each manifold.



Remove the three fuel drilling plugs from the rear of the intake manifolds. 1. Fuel rail supply drilling (1/8 inch pipe thread) 2. Fuel timing supply drilling (1/4 inch pipe thread) 3. Fuel return drilling (3/8 inch pipe thread)		

Inspect for Reuse

Inspect the fuel manifold for cracks in the fuel passages. The manifold **must** be replaced if damaged.		

Install

Generator-Drive

Install the 1/8-inch (1), ¼-inch (2), and 3/8-inch (3) plugs into the front and rear of the intake manifold.

Torque Value:
Plug (1):

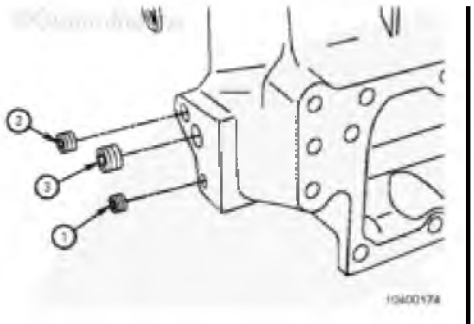
1. 5 n.m [44 in-lb]

Torque Value:
Plug (2):

1. 9 n.m [80 in-lb]

Torque Value:
Plug (3):

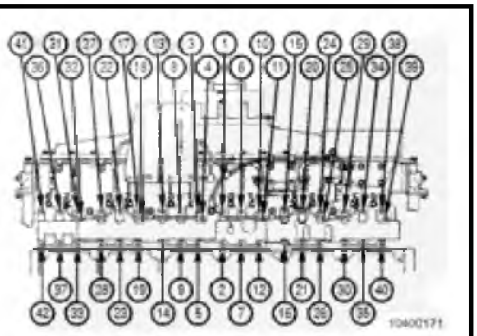
1. 17 n.m [150 in-lb]



Use guide studs when installing the manifold.

Install the intake manifold, gaskets, and 42 capscrews. Tighten the capscrews in the sequence shown.

Torque Value: 66 n.m [49 ft-lb]



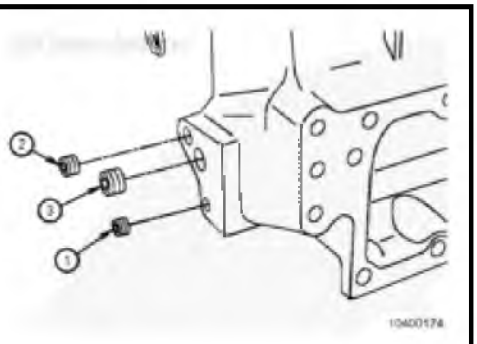
Industrial Applications

Install the 1/8-inch (1), ¼-inch (2), and 3/8-inch (3) plugs into the front and rear of the intake manifold.

Torque Value:
Plug (1):

1. 5 n.m [44 in-lb]

Torque Value:
Plug (2):



1. 9 n.m [80 in-lb]

Torque Value:
Plug (3):

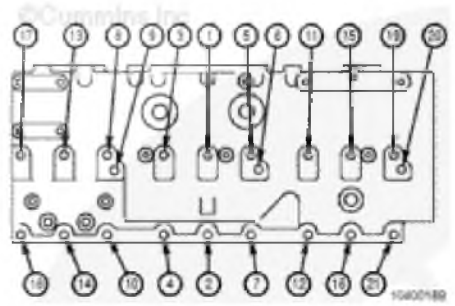
1. 17 n.m [150 in-lb]

Use guide studs when installing the manifolds.

Install 21 capscrews on each intake manifold.

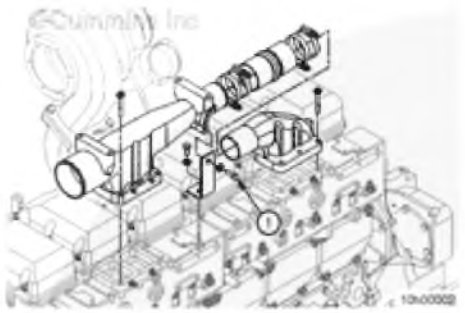
Tighten the capscrews in the sequence shown.

Torque Value: 66 n.m [49 ft-lb]



Install the air crossover connections.

Torque Value:
Capscrew (1): 30 n.m [22 ft-lb]
Torque Value:
All other air crossover capscrews: 66 n.m [49 ft-lb]



Finishing Steps

- Install the intake piping. Refer to the OEM service manual.
- Install the coolant filter and lines. Refer to Procedure 008-060 in Section 8.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.

• Install the fuel filter assembly. Refer to Procedure 006-015 in Section 6. • Install the fuel supply lines. Refer to Procedure 006-024 in Section 6. • Install the fuel drain lines. Refer to Procedure 006-013 in Section 6.		

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010-024 Air Leaks, Air Intake and Exhaust Systems

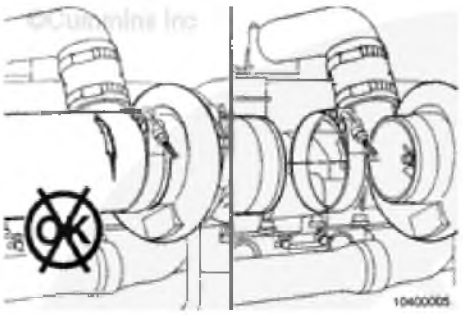
Inspect for Reuse

CAUTION

The engine air intake must be filtered to prevent dirt and debris from entering the engine. If the intake air piping is damaged or loose, unfiltered air can enter the engine and cause premature wear.

Inspect the system for damaged or loose intake piping.

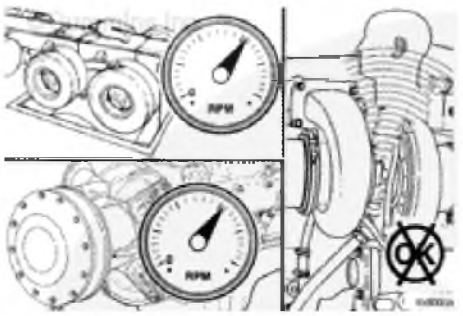
Replace damaged pipes and tighten loose clamps.

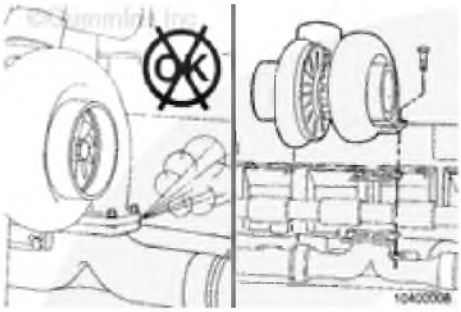
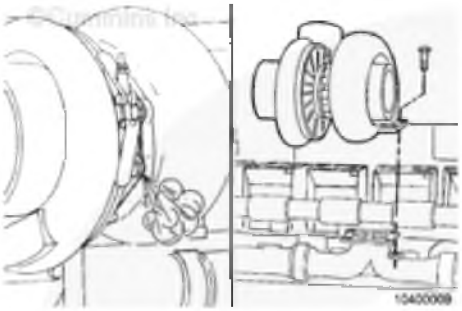
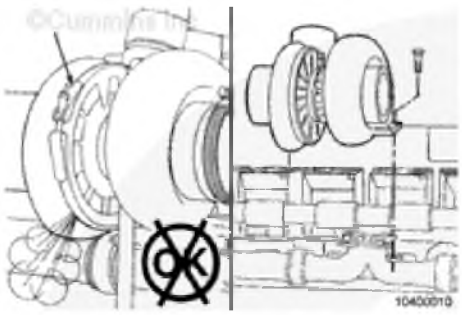


Stall speed is **not** full power.

Operate the engine at rated rpm and load.

Listen for a high pitched noise from the turbocharger.



Listen for a turbocharger-to-exhaust manifold gasket leak. Replace the gasket if a leak is detected. Refer to Procedure 010-033 in Section 10.		
Listen for a turbine housing-to-bearing housing sealing surface leak. Tighten the capscrews if a leak is detected. **Torque Value:** 20 n.m [177 in-lb] If an air leak is still present, replace the turbocharger. Refer to Procedure 010-033 in Section 10.		
Listen for a compressor housing sealing surface air leak. Tighten the v-band clamp if a leak is detected. **Torque Value:** 8 n.m [71 in-lb] If an air leak is still present, remove and replace the turbocharger. Refer to Procedure 010-033 in Section 10.		

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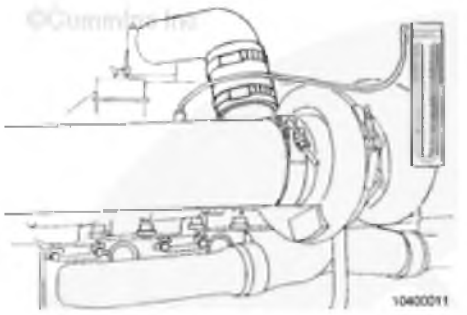
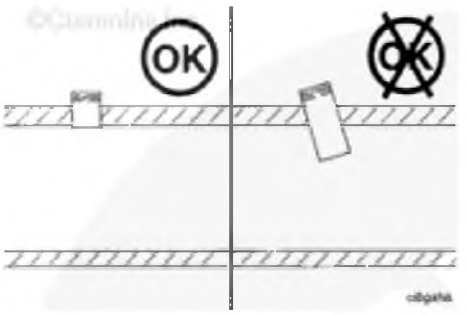
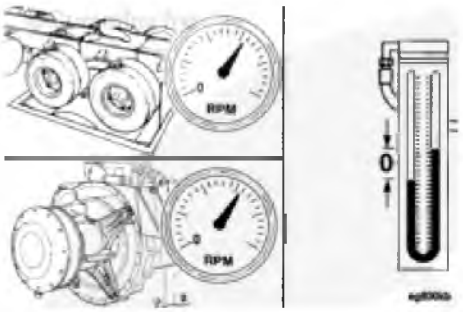
010-031 Air Intake Restriction

Measure

Install a vacuum gauge or water manometer in the intake piping between the turbocharger and the air filter. The gauge **must** have a capacity of 1270 mm H_2O [50 in H_2O].		
The gauge adapter (or fitting) **must** be installed at a 90 degree angle to the air flow in a straight section of pipe. The adapter location **must** be at least one pipe diameter before the turbocharger. The adapter **must not** extend past the inner wall of the air intake tubing. If the adapter **must** be located in a curved section of tubing, locate it on the flat side of the curve, **not** in the radius.		
Operate the engine at full throttle and rated rpm with maximum load. Record the reading of the gauge or manometer. _____		

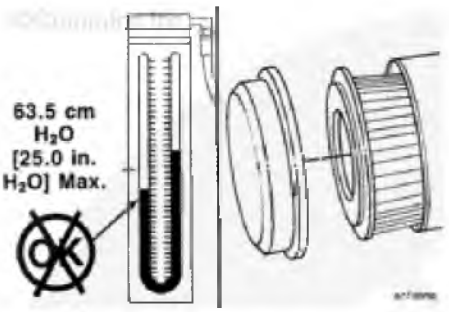
Operating Air Restriction (Dirty Filter)		
mm-h2o		in-h2o
635	MAX	25

Stall speed is **not** full power. Operate the engine at rated rpm and load.



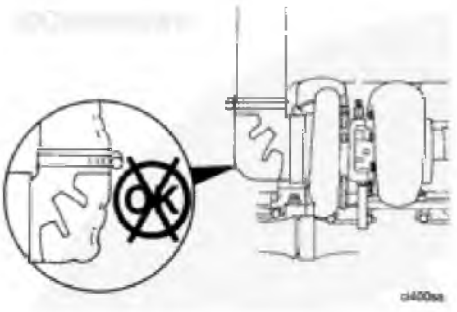
If the restriction exceeds specifications, do the following:

Replace or clean the air filter element. Refer to the equipment manufacturer's instructions.

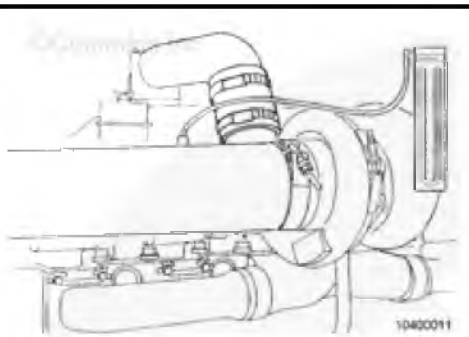


Inspect the intake air piping for damage. Refer to the equipment manufacturer's instructions.

If no damage is visible, check the size and routing of the intake air piping. Refer to the Installation Recommendations.



Remove the test equipment.



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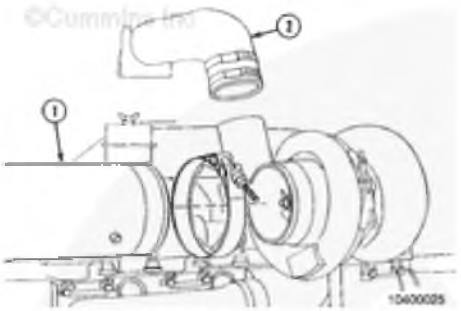
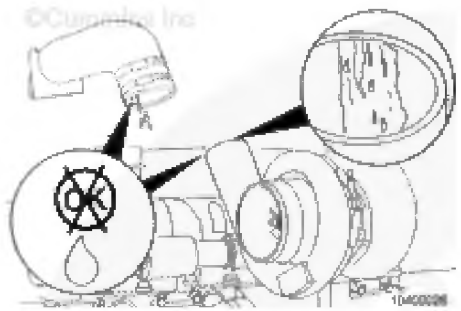
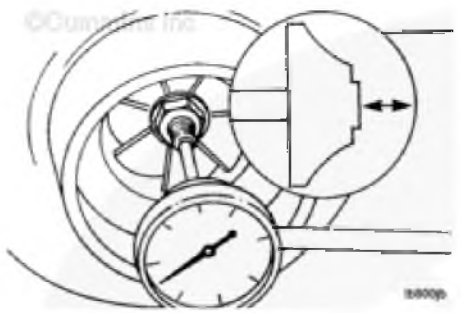
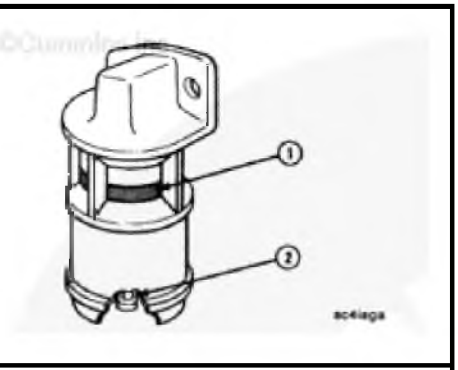
010-033 Turbocharger

Initial Check

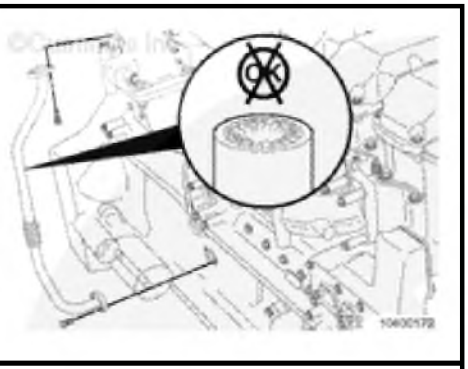
Remove the air intake pipe (1) and air crossover (2) from the turbocharger.		
Examine the compressor discharge and air crossover piping for oil.		
If oil is visible, check the turbocharger axial and radial clearance contained in this procedure.		

Check for intake restriction. Refer to Procedure 010-031 in Section 10.

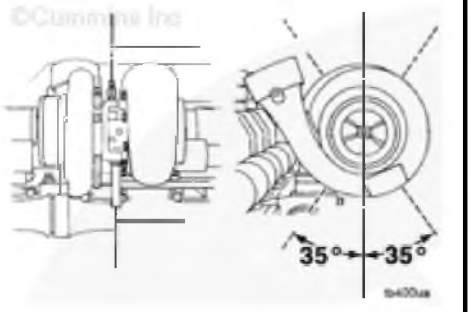
If the restriction exceeds specifications, replace or clean the air filter element. Refer to the equipment manufacturer's instructions.



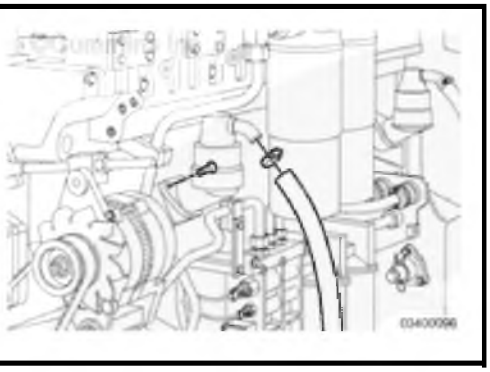
Remove the oil drain tube and check for restrictions. Clear any restrictions that are found.



Check the angle of the drain tube. The angle of the tube **must** be within 35 degrees of vertical. Adjust the turbocharger, if necessary.



If the drain tube is free of restrictions and at the correct angle, check the crankcase breathers and tubes to be sure they are **not** plugged.

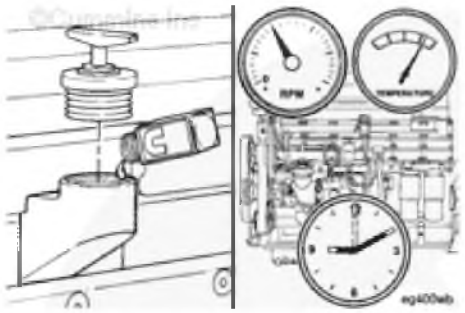


If these checks do **not** reveal the problem, measure the crankcase pressure (blowby). Refer to Procedure 014-005 in Section 14.

The following is the procedure for the fluorescent dye tracer test:

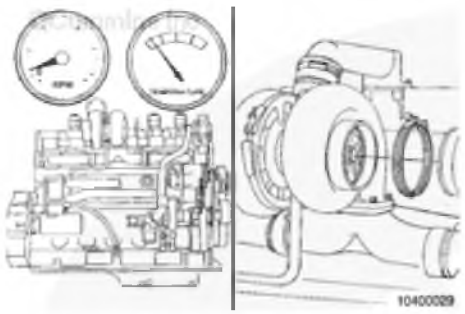
Add one unit of fluorescent tracer to each 38 liters [10 gal] of engine lubricating oil.

Operate the engine at low idle for 10 minutes.



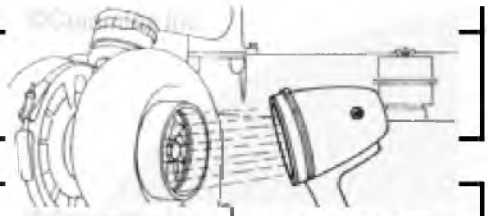
Shut the engine OFF.

Allow the turbocharger to cool and remove the exhaust pipe from the turbine housing.

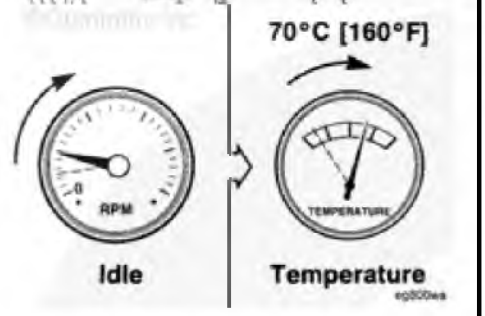


Use a high intensity black light to inspect the turbine housing outlet for oil.

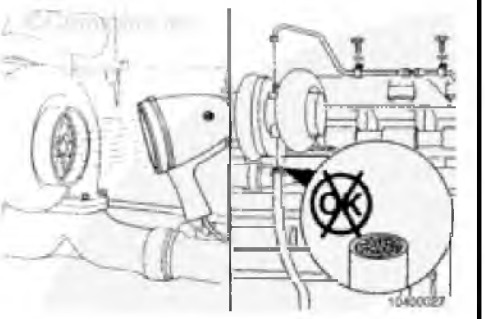
A dark blue glow indicates oil and a yellow glow indicates fuel.



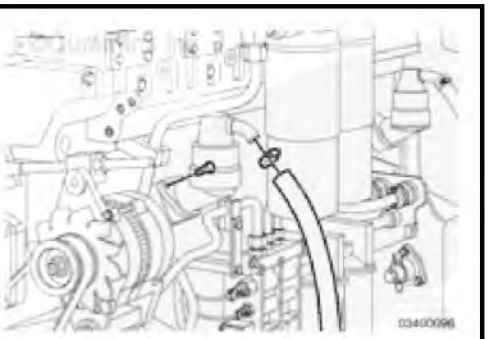
If fuel is found in the turbine housing, the problem is excess, unburned fuel. To correct the problem, decrease the idle period or increase the idle rpm. The coolant temperature needs to be maintained at a minimum of 71°C [160°F].



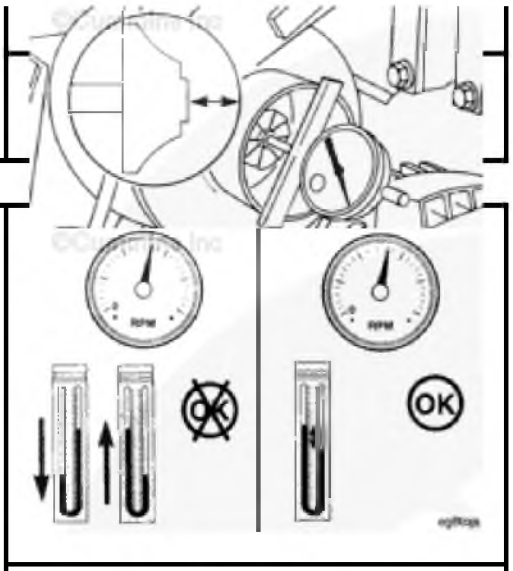
If oil is found in the turbine housing, remove the oil drain tube and check for restriction. Clear any restrictions found.



If the drain tube is free of restrictions and at the correct angle, check the crankcase breather(s) and tube(s) to be sure they are **not** plugged.



Check the turbocharger axial clearance and radial clearance contained in this procedure.

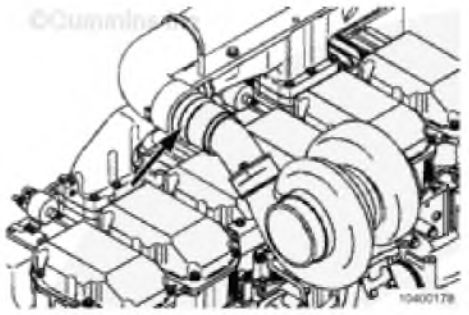


If these checks do **not** reveal the problem, measure the crankcase pressure (blowby). Refer to Procedure 014-005 in Section 14.

Remove

WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.



Loosen the clamps and remove the coupling from the turbocharger compressor outlet.

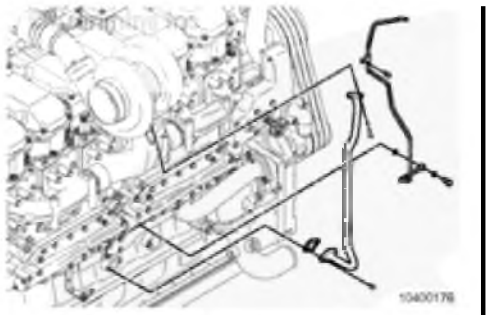
Remove any OEM supplied exhaust piping.

Remove the turbocharger oil drain line.

Remove the turbocharger oil supply line

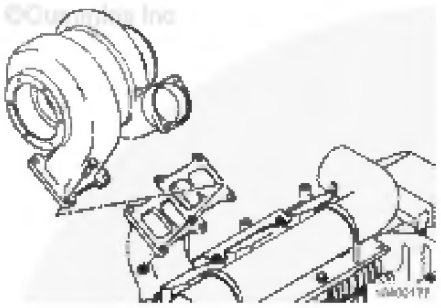
and line clamps.

NOTE: The turbocharger oil supply line can not be totally removed from the engine without removing the exhaust manifold. It is acceptable to remove all mounting hardware and allow the oil supply line to hang while removing and installing the turbocharger.



Remove the turbocharger mounting nuts and bolts.

Remove the turbocharger and gasket.

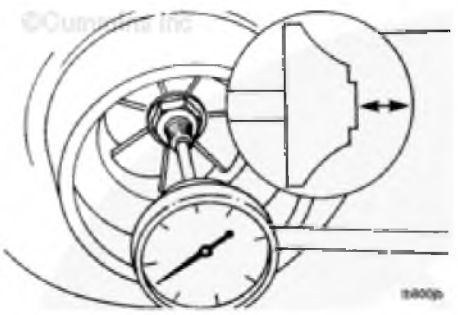


Inspect for Reuse

Use dial depth gauge, Part Number ST-537, or a dial indicator to measure the axial motion (end-to-end).

Compressor Impeller Axial Endplay

	mm	in
Holset® HX82 Turbocharger	0.025 MIN	0.001
	0.152 MAX	0.006
Holset® HX60 Turbocharger	0.051 MIN	0.002
	0.152 MAX	0.006
Holset® HX83	0.025 MIN	0.001

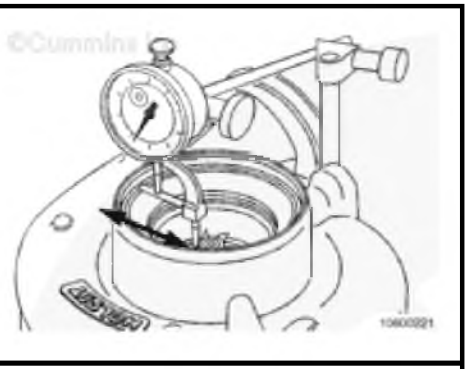


Turbocharger			
	0.152	MAX	0.006
Schwitzer S500	0.07	MIN	0.003
	0.18	MAX	0.007

Make sure the movement is within MIN/MAX Total Indicator Reading (TIR) values shown above.

NOTE: If the end clearance exceeds the specifications, the turbocharger must be replaced or rebuilt. Refer to Turbocharger Repair Manual HX/HT60, Bulletin 3580600 (HX60) or Turbocharger Repair Manual HC5A/HX80/82/85/86, Bulletin 3580999.

Measure the radial clearance (side to side) at the compressor impeller nose using a dial gauge.



Compressor Impeller Radial Endplay

	mm		in
Holset® HX82 Turbocharger	0.025	MIN	0.001
	0.152	MAX	0.006
Holset® HX83 Turbocharger	0.025	MIN	0.001
	0.152	MAX	0.006
Holset® HX60 Turbocharger	0.051	MIN	0.002
	0.152	MAX	0.006

Make sure the movement is within MIN/MAX Total Indicator Reading (TIR) values shown above.

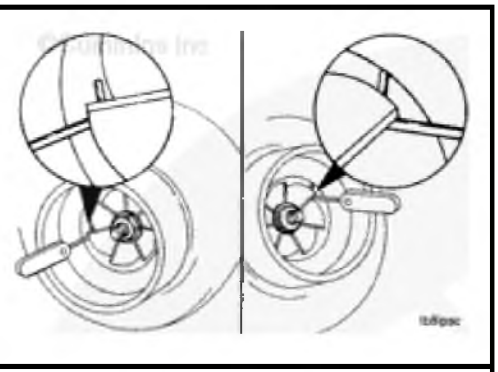
NOTE: If the radial clearance does not meet the specifications, the turbocharger must be replaced or rebuilt. Refer to Turbocharger Repair Manual HX/HT60, Bulletin 3580600 (HX60) or Turbocharger Repair Manual HC5A/HX80/82/85/86, Bulletin 3580999.

Use a wire-type feeler gauge to measure the radial clearance (side-to-side).

Schwitzer S500 Radial Clearance

mm		in
0.50	MIN	0.020
0.92	MAX	0.36

NOTE: If the radial clearance does not meet the specifications, the turbocharger must be replaced or rebuilt.



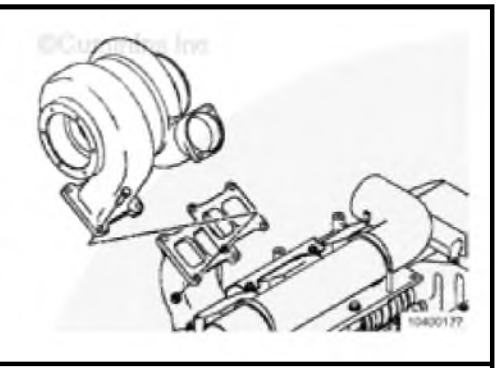
Install

Apply a film of high-temperature anti-seize compound to the turbocharger capscrew threads.

Install the turbocharger, gasket, capscrews, and nuts onto the exhaust manifold.

Tighten the nuts and capscrews.

Torque Value: 50 n.m [37 ft-lb]



Install the turbocharger oil drain tube, gaskets, and capscrews. The angle of the tube **must** be within 35 degrees of vertical.

Tighten the drain tube capscrews.

Torque Value: 66 n.m [49 ft-lb]

Install the turbocharger oil supply line, gaskets, and line clamps.

Tighten the oil supply fitting capscrews to the turbocharger.

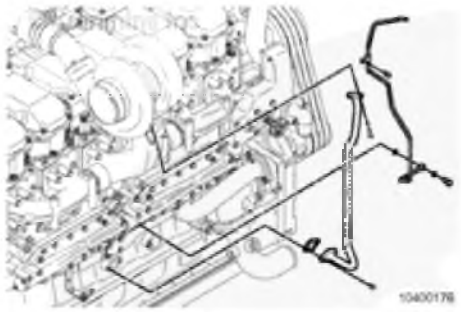
Torque Value: 66 n.m [49 ft-lb]

Tighten the banjo fitting fastener to the cylinder block.

Torque Value: 30 n.m [22 ft-lb]

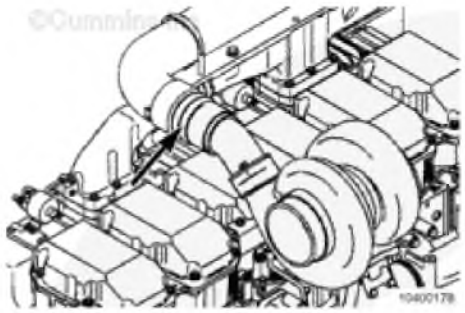
Apply a thin film of high temperature anti-seize compound to the exhaust elbow capscrew threads.

Install any OEM-supplied exhaust piping.



Install the coupling onto the turbocharger compressor outlet and tighten the clamps.

Torque Value: 10 n.m [89 in-lb]



Last Modified: 07-Sep-2011

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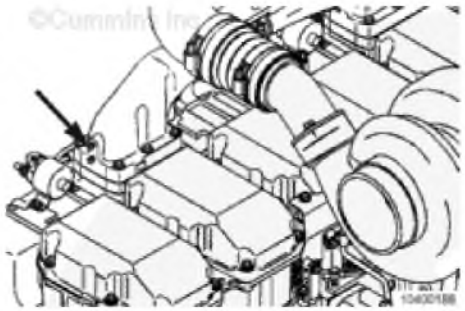
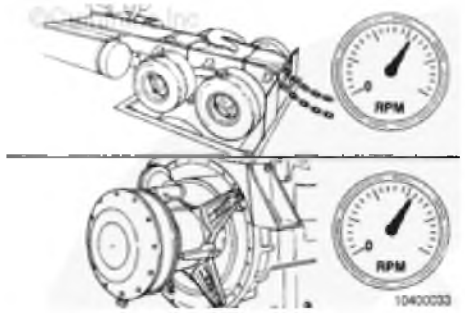
010-057 Intake Manifold Pressure

Measure

Install a 0 to 2030 mm Hg [0 to 80 in Hg] manometer (or gauge) in the straight threaded plug hole in the air intake connection. Do **not** drill and tap a hole in the air intake connection. A faulty reading can result if the air intake connection is leaking.		
Operate the engine at rated rpm and full load. Compare the value to specifications. Stall speed is **not** full power.		

Last Modified: 30-May-2003

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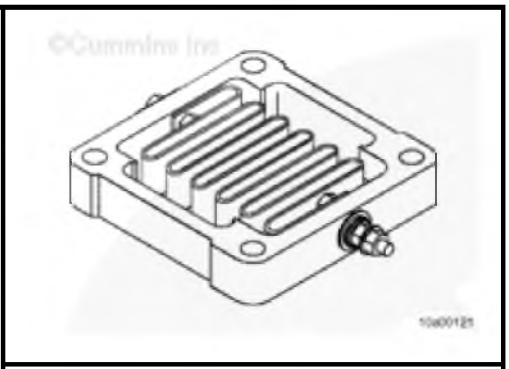
010-072 Air Intake Manifold Heater

General Information

The intake air grid heaters are controlled by the ECM, and are used to warm the intake air during cold starting conditions.

The battery power for the intake air grid heaters is supplied by the original equipment manufacturer (OEM). The system has a total amperage draw capacity of approximately 220 amperes when operational.

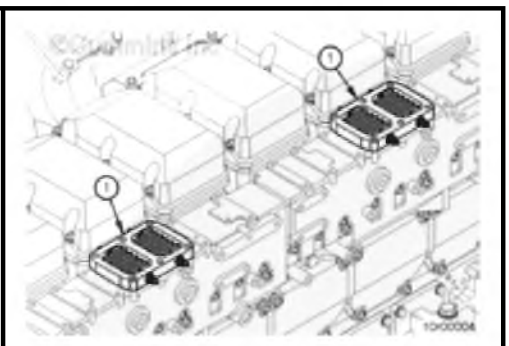


There are two intake air grid heaters (1). They are located at the inlet of each intake manifold. Each grid heater has its own solenoid.

Reference to QSK23 Industrial Wiring Diagram, Bulletin 4021394.

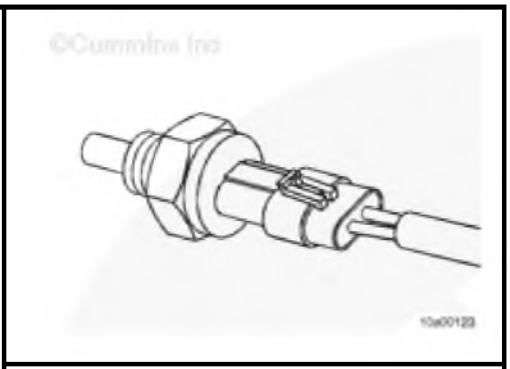
The intake air grid heaters function like a toaster. On one end a voltage or amperage is applied, and the other end is tied to the block ground.

The intake air grid heaters can stop functioning if they have a faulty ground, loss of battery supply, faulty solenoid, or the solenoid stops receiving the ECM command.



The ECM uses intake manifold air temperature as the input to determine if the grid heaters should be activated.

The grid heaters are turned on for 30 seconds after key ON if the intake manifold temperature is below 0° C [32° F]. Power is removed if the engine starts cranking and the engine speed exceeds 50 RPM.



Initial Check

WARNING

To reduce the possibility of personal injury and property damage, never use starting fluid if the grid heater option is used. Starting fluid, which contains ether, can cause an explosion.

Fill a cup with ice.

Place an intake manifold temperature sensor into the cup.

Unplug the left and right bank intake manifold air temperature sensors from the engine harness.

Use the following procedure for sensor location. Refer to Procedure 100-002 in Section E.

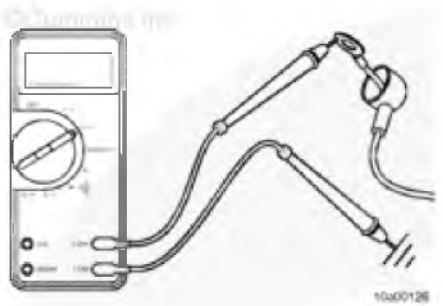
Plug the intake air manifold temperature engine harness connector into the intake

manifold air temperature sensor in the cup of ice.

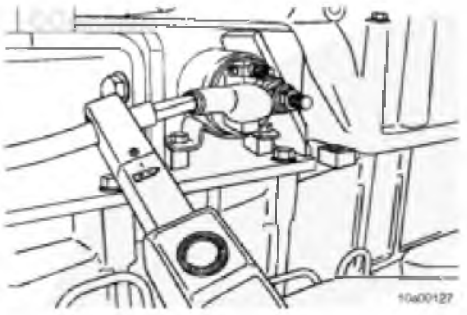
Set the multimeter to monitor VDC voltage.

Connect one lead to the intake air grid heater solenoid signal line.

Connect the other lead to block ground.



Place the clamp on the ampere meter around the battery power cable that runs from the intake air grid heater solenoid to the bank of one of the grid heaters.



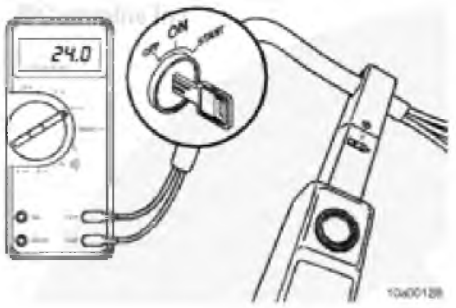
Turn the keyswitch ON.

The intake air grid heater solenoid will click.

The multimeter **must** indicate the solenoid is now receiving a 24-VDC signal from the ECM.

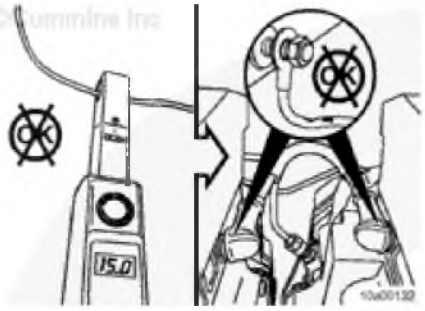
The ampere meter **must** indicate an amperage of approximately 110 amperes flowing to the intake air grid heater.

Repeat for the other intake air grid heater.



If the ampere meter reading is less than 110 amperes, perform the following checks:

- Harness connection to the grid heater is secure
- Connection between grid heater and the block ground is secure.



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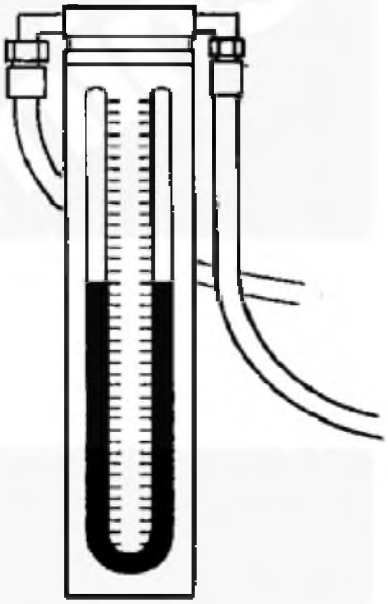
022-001 Service Tools

Exhaust System

Tool Number ST-1111-3	**Manometer** Used to check exhaust restriction.	 eg100ja

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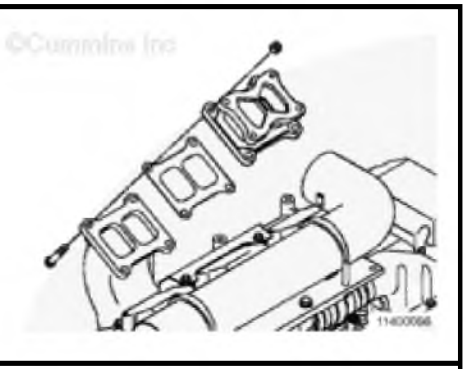
011-001 Exhaust Connection Pipe

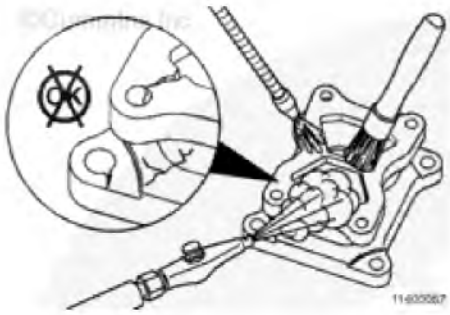
Preparatory Steps

• Remove turbocharger. Refer to Procedure 010-033.		

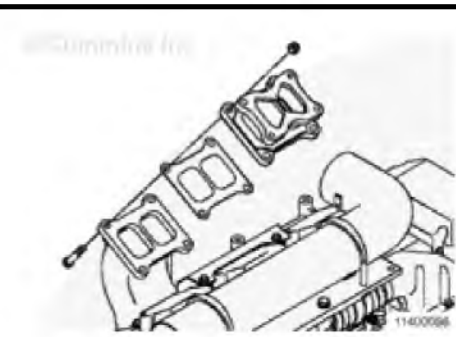
Remove

Remove the four capscrews, nuts, the gasket, and the exhaust connection pipe from the exhaust manifold. Discard the gasket. **NOTE: Industrial engines will not have this exhaust connection pipe.**		

Clean and Inspect for Reuse

Inspect the exhaust connection pipe for cracks or damage.		

Install

Apply an anti-seize compound on the capscrew threads. Install the four capscrews, nuts, the gasket, and the exhaust connection pipe on the exhaust manifold. Tighten the nuts. **Torque Value:** 45 n.m [35 ft-lb]		

Finishing Steps

Install the turbocharger. Refer to		

Procedure 010-033.

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011-007 Exhaust Manifold, Dry

Preparatory Steps

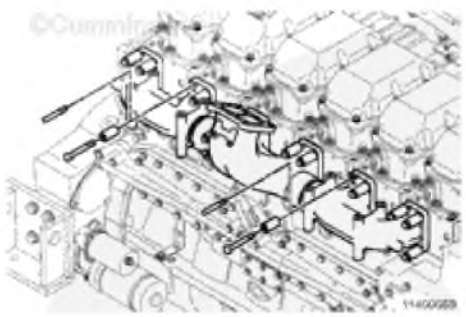
- Remove the turbocharger. Refer to Procedure 010-033.
- Remove the exhaust connection pipe (power generation **only**). Refer to Procedure 011-001.

Remove

Use two guide studs.

Remove the two capscrews, as shown.

Install the guide studs, as shown.



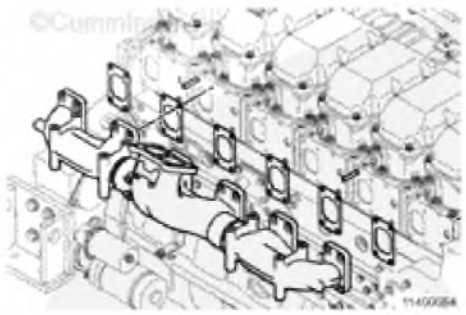
WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Remove the remaining capscrews.

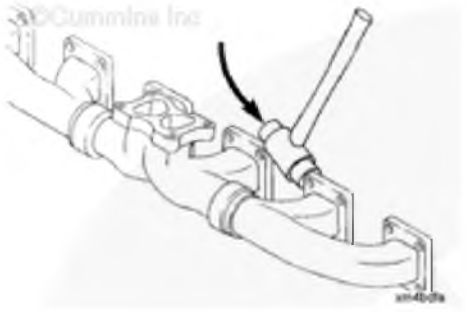
Remove the exhaust manifold and the gaskets.

Discard the gaskets.



Disassemble

Use a mallet to remove the end sections from the exhaust manifold center section.



Clean and Inspect for Reuse

WARNING

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

WARNING

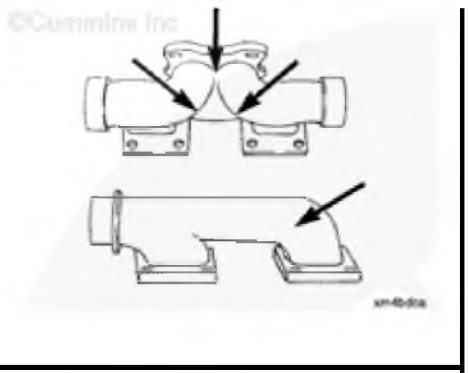
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

CAUTION

Care must be taken to not destroy the exhaust manifold heat shield insulation while cleaning.

Use steam or solvent to clean the exhaust manifold. Use a wire brush to clean the sealing joint inside and outside diameters, removing any scale that has accumulated.

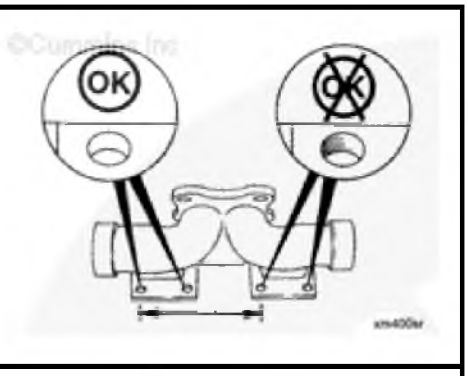
Inspect for cracks in the areas shown.



Inspect the capscrew holes in the center section for damage.

The manifold has been subjected to high temperatures if the capscrew threads are visible on the inside of the capscrew holes. High temperature can cause the manifold to shrink.

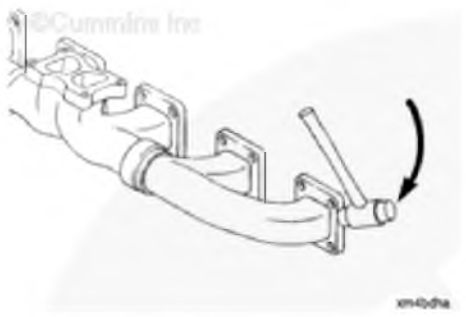
Measure the center-to-center distance between the same position capscrew holes of the two flanges on the center section and both end sections to determine if the manifold capscrew mounting holes are out of location.



Exhaust Manifold Capscrew Hole Location		
mm		in
213	MIN	8.39
215	MAX	8.46

Assemble

Use a mallet to drive the end section into the center section.



Install

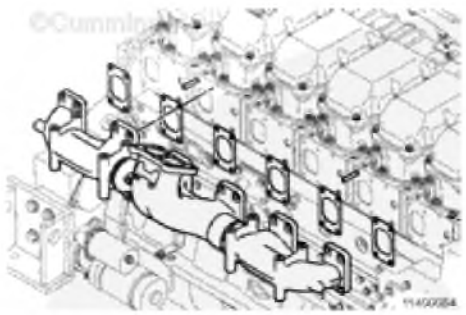
CAUTION

Do not use gasket cement or the gasket will fail.

Install the guide studs used during removal.

Use contact adhesive to attach the gasket on the cylinder head exhaust ports.

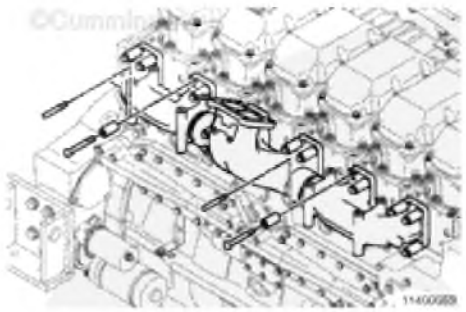
Install the exhaust manifold.



Apply an antiseize compound on the capscrew threads.

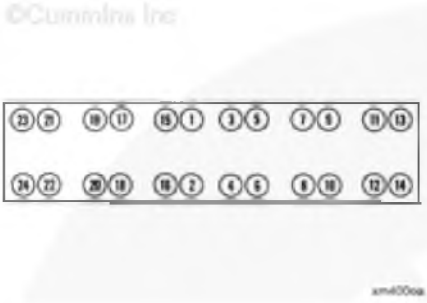
Install the capscrews.

Remove the two guide studs and install the remaining capscrews.



Tighten the capscrews in the sequence shown.

Step 1	55 n.m	[40 ft-lb]
Step 2	120 n.m	[89 ft-lb]



Finishing Steps

- Install the exhaust connection pipe (power generation **only**). Refer to Procedure 011-001.
- Install the turbocharger. Refer to Procedure 010-033.

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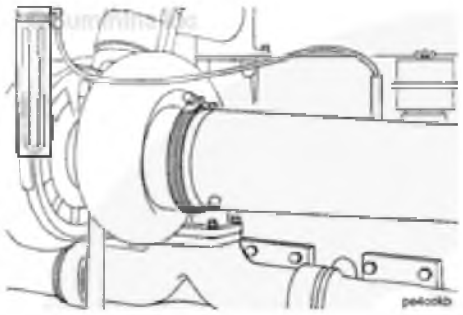
011-009 Exhaust Restriction

Measure

Connect a manometer or pressure gauge in the exhaust piping. The gauge **must** have a capacity of 152 mm Hg [6 in Hg] or 1676 mm H_2O [66 in H_2O].

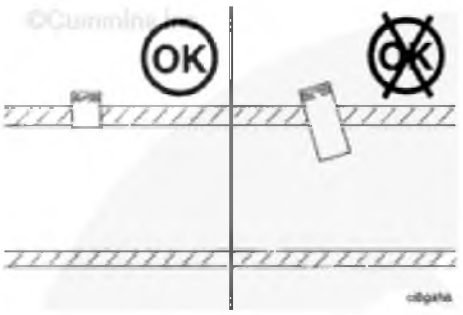


The gauge adapter (or fitting) **must** be installed at a 90 degree angle to the exhaust flow in a straight section of pipe. The adapter location **must** be a minimum of 25 mm [10.0 in] after the turbocharger.

The adapter **must not** extend past the inner wall of the exhaust tubing.

If the adapter **must** be located in a curved section of tubing, locate it on the flat side of the curve, **not** in the radius, or the measured value will **not** be accurate.

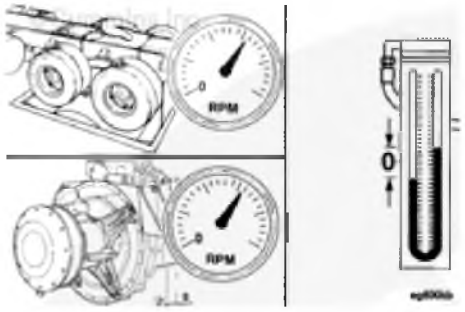
Connect a 13 mm [½ in] piece of metal tubing between the gauge adapter and the gauge hose. This will prevent damage to the hose from extreme heat.



Operate the engine at rated rpm and load and record the manometer reading.

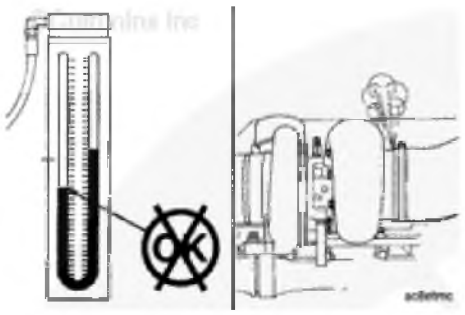
The exhaust pressure **must not** exceed 75 mm [3.0 in Hg].

Stall speed is **not** full power.

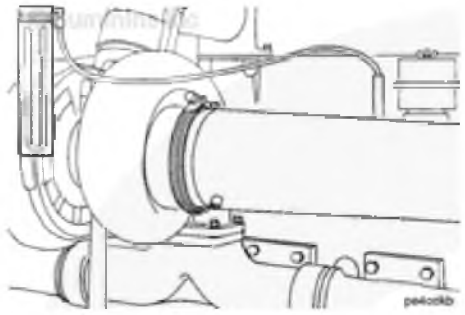


If the exhaust pressure exceeds the specification, inspect the exhaust piping for damage. Refer to the equipment manufacturer's instructions.

If no damage is visible, check the size and routing of the exhaust piping. Refer to the Installation Recommendation Bulletin.



Remove the test equipment.



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012-014 Air Compressor

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

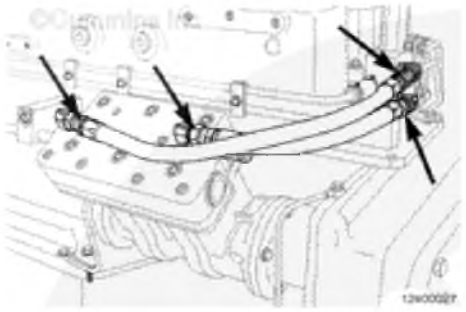
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

NOTE: Not all engines are equipped with this option.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Drain the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Remove the air inlet and outlet connections from the air compressor.

Remove

Remove the air compressor inlet and outlet coolant connections.

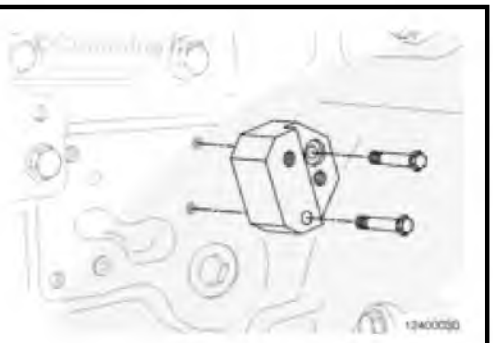


Remove the oil supply tube from the air compressor drive and the lubricating oil connection block by removing the two securing banjo bolts and washers from the oil line.

Remove the oil supply tube from the air compressor idler and the lubricating oil connection block by removing the two banjo bolts and washers from the oil line.

Remove the two capscrews securing the air compressor lubricating oil supply block.

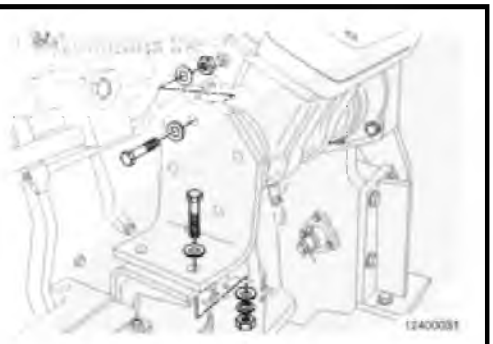
Remove the air compressor lubricating oil supply block and discard the o-ring.



Remove the six capscrews securing the rear air compressor support bracket.

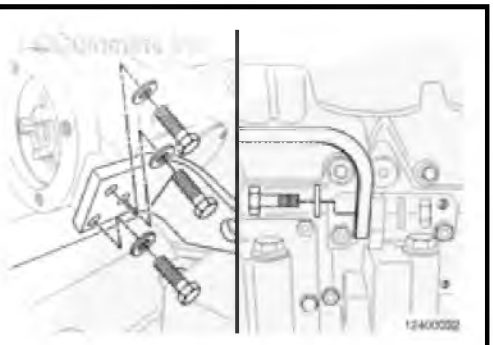
Remove the rear air compressor support bracket.

Discard the gasket.



Remove the four capscrews securing the center air compressor support bracket.

Remove the center air compressor support bracket.

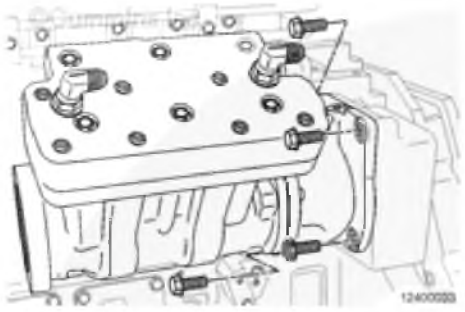


WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

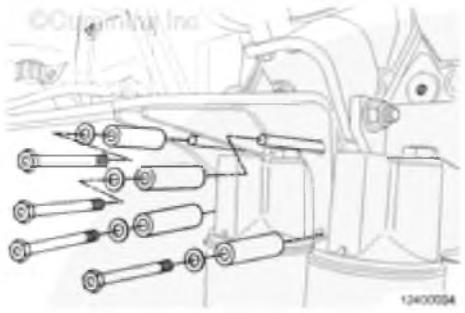
Remove the four mounting capscrews securing the air compressor and air compressor drive to the flywheel housing.

Use care **not** to damage the drive gear teeth. Remove the air compressor and drive assembly from the flywheel housing.



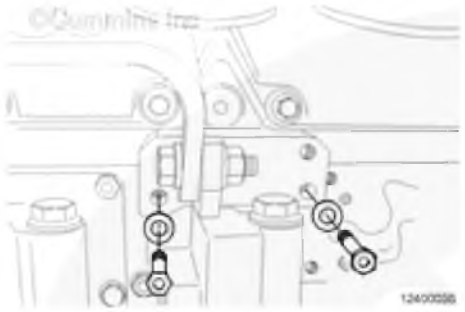
Loosen the four capscrews and spacers securing the rear air compressor lower support bracket to the lubricating filter head, if required, to remove the bracket.

Remove the rear air compressor lower support bracket.

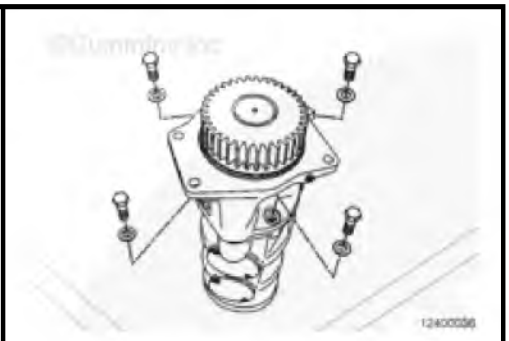


Loosen the two capscrews securing the center air compressor lower support bracket to the lubricating filter head, if required, to remove the bracket.

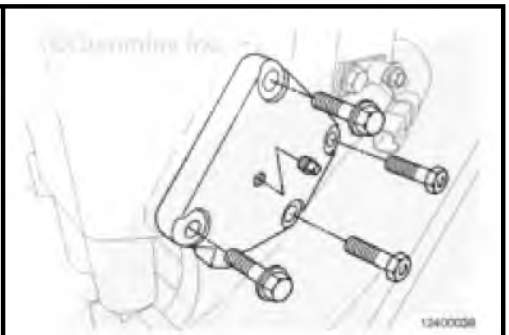
Remove the center air compressor lower support bracket.

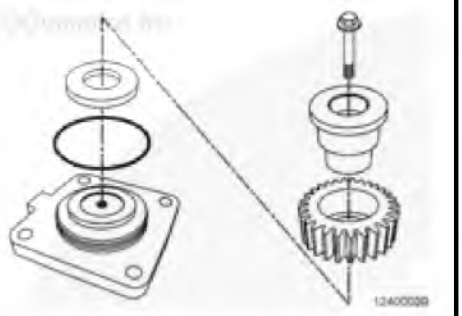


Disassemble

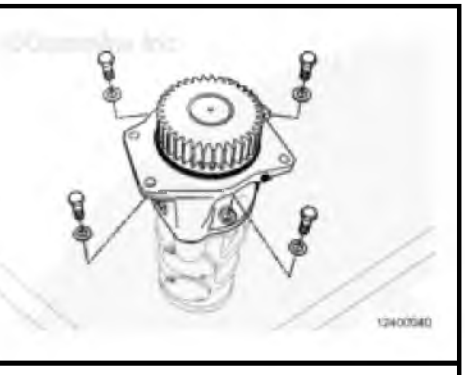
With the air compressor and drive assembly resting on a flat surface, rear end down, remove the four capscrews securing the air compressor to the drive unit. Remove the drive unit from the air compressor. Discard the gasket.		
Remove the coupling from the air compressor spline shaft.		

Rear Gear Train

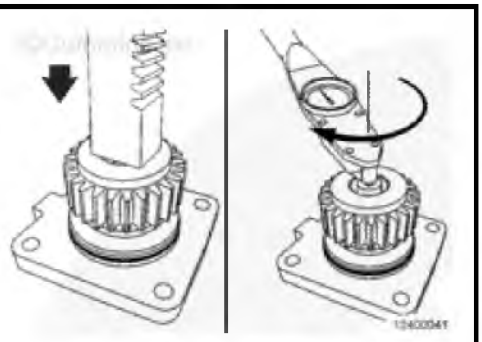
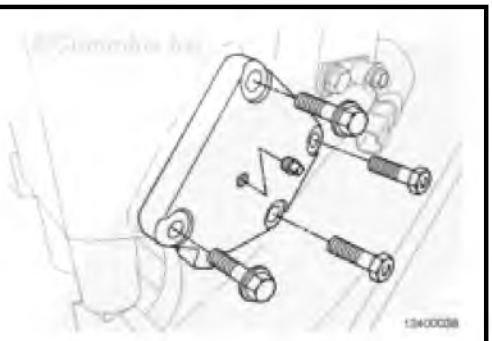
Remove the square plug from the air compressor idler gear mounting plate. Remove the four mounting capscrews securing the air compressor idler gear plate to the flywheel housing. Remove the air compressor idler gear plate from the flywheel housing. Discard the gasket.		

Remove the bolt securing the idler gear shaft onto the air compressor idler gear plate. Disassemble the idler shaft, gear, and thrust plate. Discard the o-ring.		

Assemble

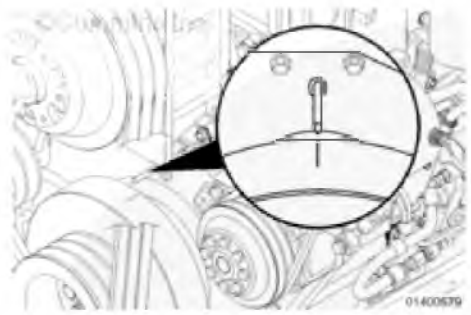
Install the coupling onto the spline shaft of the air compressor.		
With the air compressor resting on a flat surface, rear end side down, install the drive unit to the air compressor. Install a new gasket. The coupling **must** be aligned to the spline shaft of the drive unit. Install the four mounting capscrews securing the air compressor to the drive unit. **Torque Value:** 80 n.m [59 ft-lb]		

Rear Gear Train

Install a new o-ring. Assemble the air compressor idler gear mounting plate, thrust plate, gear, and idler shaft. Press fit the assembly. Tighten the mounting capscrews securing the idler gear shaft to the mounting plate. **Torque Value:** 290 n.m [214 ft-lb]		
Install the square plug into the air compressor idler gear mounting plate. Install a new gasket. Install the air compressor idler gear plate to the flywheel housing. The idler gear **must** properly engage with the cam gear. Install the four mounting capscrews. **Torque Value:** 108 n.m [80 ft-lb]		

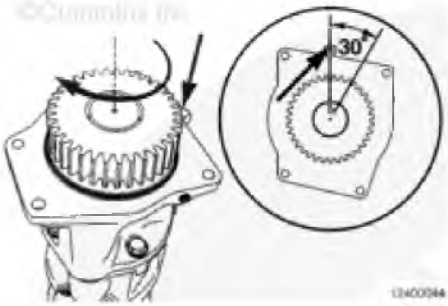
Install

Bar the engine to align the 1.6TOP indicator on the damper with the pointer.		



Rotate the air compressor drive gear by hand. Feel for the compression peak point.

Once the peak point is identified, rotate the air compressor drive gear approximately 30 degrees **clockwise** from the peak point (as viewed from the drive gear side).

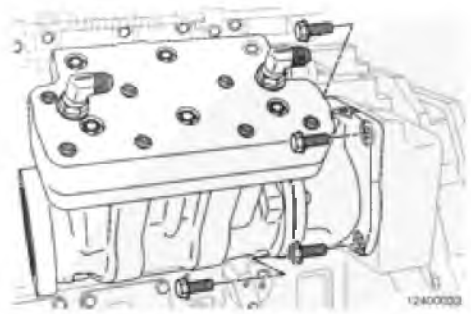


Install a new gasket. Insert the air compressor and drive unit assembly into the power take-off port in the flywheel housing.

The air compressor drive gear must properly mesh with the air compressor idler gear.

Install the top two mounting capscrews and washers.

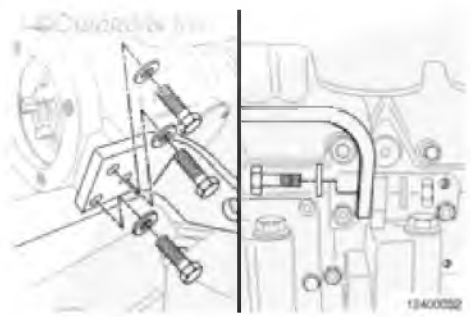
Torque Value: 68 n.m [50 ft-lb]



Assemble the air compressor center support bracket to the air compressor.

Install the three mounting capscrews to the air compressor support bracket.

Finger tighten the capscrews.

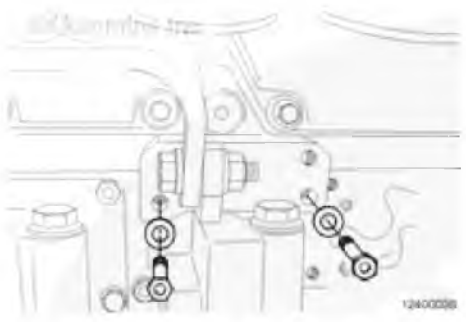


Do **not** torque the capscrews at this time.

Assemble the two mounting capscrews securing the air compressor center lower support bracket to the filter head bracket.

Finger tighten the capscrews.

Do **not** torque the capscrews at this time.

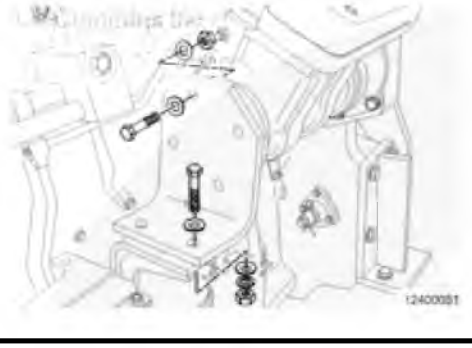


Install a new gasket. Install the air compressor rear housing support plate.

Install the four mounting capscrews securing the air compressor rear housing support bracket to the air compressor.

Finger tighten the capscrews.

Do **not** torque the capscrews at this time.



Use the alignment dowels (1) to install the rear lower air compressor support bracket.

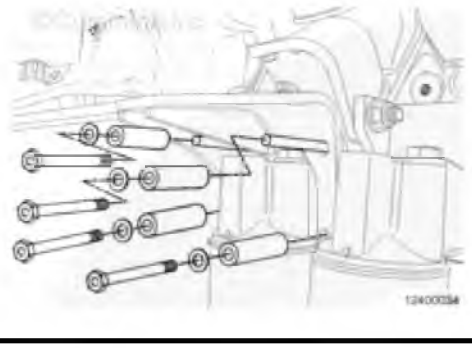
Install the lower two mounting capscrews and spacers.

Finger tighten the capscrews.

Remove the alignment dowels (1) and install the upper two mounting capscrews and spacers.

Finger tighten the capscrews.

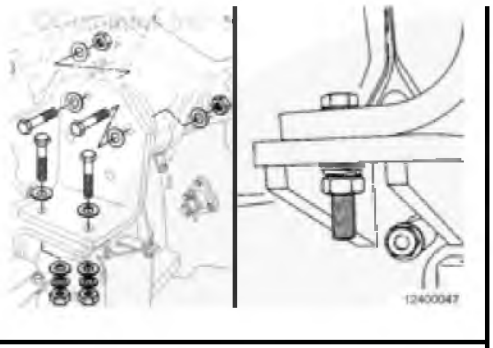
Do **not** torque the capscrews at this time.



Install the two capscrews and nuts securing the upper and lower rear air compressor support brackets.

Finger tighten the capscrews.

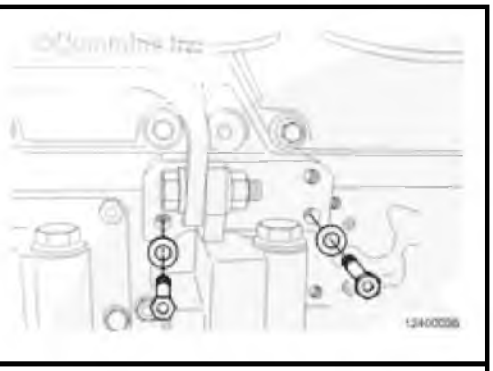
Do **not** torque the capscrews at this time.



Install the capscrew and nut securing the upper and lower center air compressor support brackets.

Finger tighten the capscrew and nut.

Do **not** torque at this time.



All slack in the mounting brackets **must** be taken up by finger tightening all capscrews.

Tighten the four capscrews securing the air compressor rear mounting plate.

Torque Value: 88 n.m [65 ft-lb]

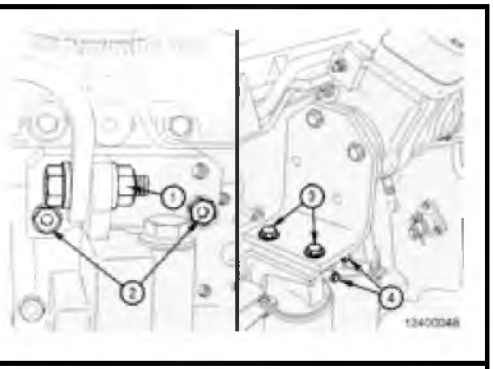
Tighten the three capscrews securing the air compressor center support bracket.

Torque Value: 50 n.m [37 ft-lb]

Tighten the remaining center and rear support brackets in the following order.

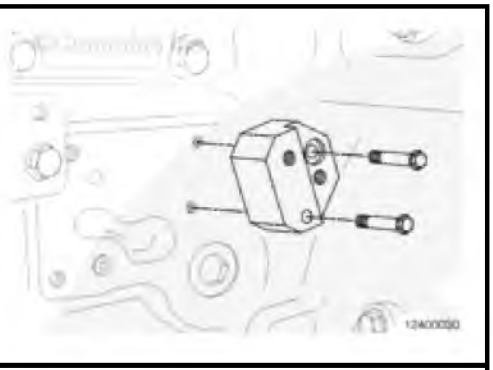
Torque Value:

1. 170 N•m 125 ft-lb
2. 68 N•m 50 ft-lb
3. 68 N•m 50 ft-lb
4. 68 N•m 50 ft-lb

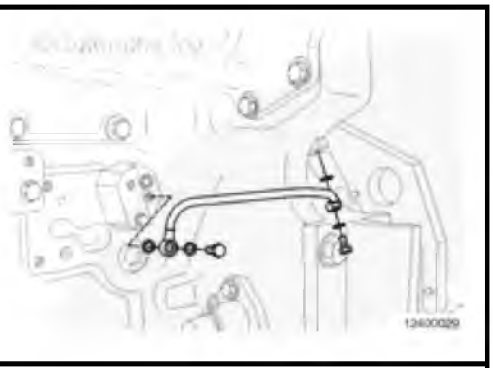


Install a new o-ring. Install the air compressor lubricating oil supply block to the rear left bank of the engine block.

Torque Value: 68 n.m [50 ft-lb]



Install the oil supply tube to the air compressor idler and the lubricating oil connection block by installing the two banjo bolts and washers to the oil line.



Install the lubricating oil supply from the air compressor lubricating oil supply block to the air compressor drive unit. Use two banjo bolts and washers.

Torque Value: 10 n.m [89 in-lb]

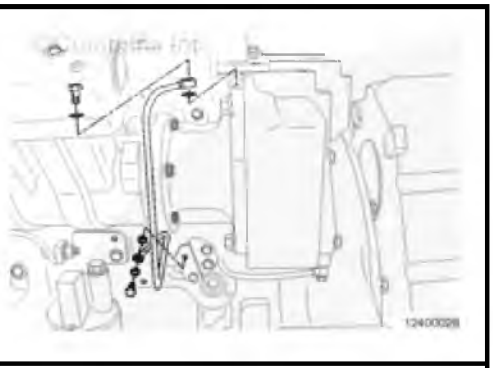
Use a p-clip to secure the lubricating oil supply tube.

Install the clip to the drive unit with the mounting capscrew in location (1).

Torque Value: 68 n.m [50 ft-lb]

Install the lubricating oil supply tube from the air compressor lubricating oil supply block to the air compressor idler plate. Use two banjo bolts and washers.

Torque Value: 10 n.m [89 in-lb]

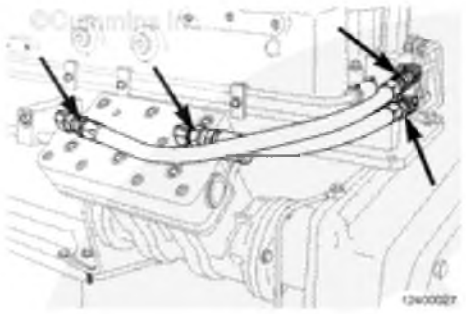


Use a p-clip to secure the lubricating oil supply tube.

Install the clip to the idler gear mounting plate with the mounting capscrew and the associated hardware in location (1).

Torque Value: 68 n.m [50 ft-lb]

Install the air compressor inlet and outlet coolant lines.



Finishing Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F]

before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

- Install the air inlet and outlet connections to the air compressor.
- Fill the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for leaks.

Last Modified: 27-Jul-2009

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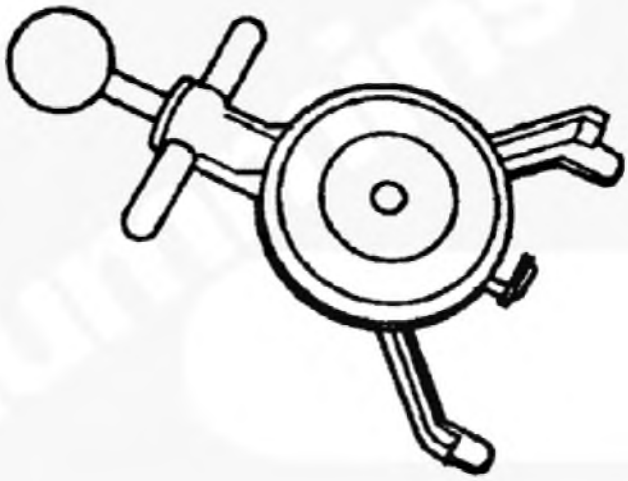
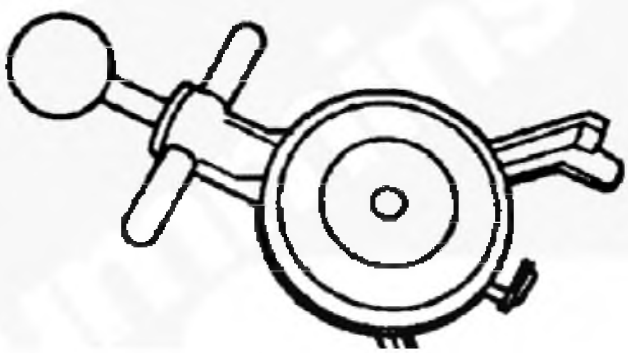
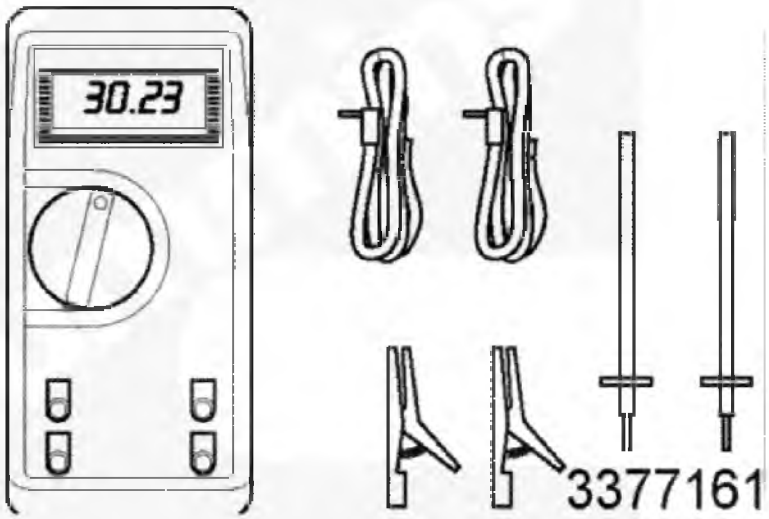
022-001 Service Tools

Electrical Equipment

Tool Number ST-1138	**Belt Tension Gauge** Used to check the belt tension on V-belts that are 1/2 to 7/8 wide.	 fa8togc

Tool Number ST-1293	**Belt Tension Gauge** Used to check the belt tension on V-ribbed belt with 6 to 9 ribs.	

		fa8togc

Tool Number 3164488	**Digital Multimeter** Used to measure voltage (VDC) and resistance (ohms) in a circuit.	

Tool Number N/A	**Battery Charger** Used to restore the state of charge of a battery.	

Tool Number N/A	**Battery Hydrometer** Used to check the specific gravity of individual battery cells (batteries with removable cell caps).	

Last Modified: 20-Jun-2003

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013-001 Alternator

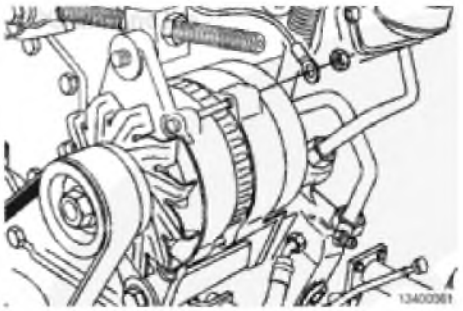
Remove

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Disconnect the batteries.

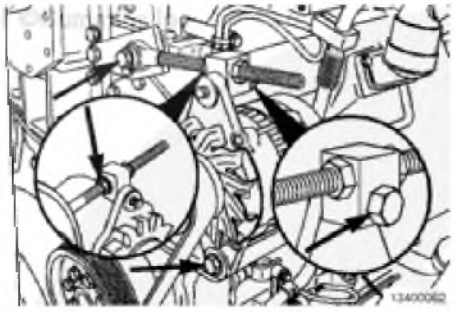
Disconnect the wiring and ground strap from the alternator.



Loosen the adjusting link and the alternator mounting capscrews.

Loosen the adjusting nut to remove tension on the alternator belt.

Remove the alternator belt.

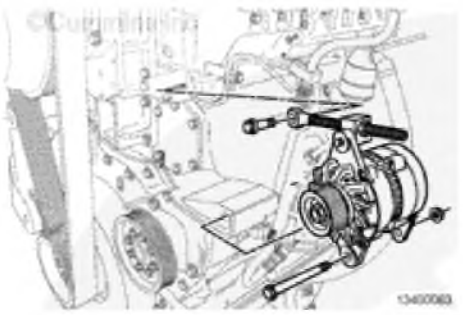


Remove the capscrew that fastens the

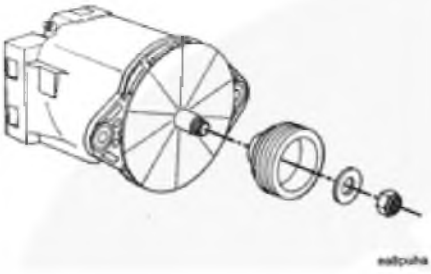
adjusting link to the alternator bracket.

Remove the lower alternator mounting capscrew and nut.

Remove the alternator and adjusting link.



Remove the nut and the pulley from the alternator.



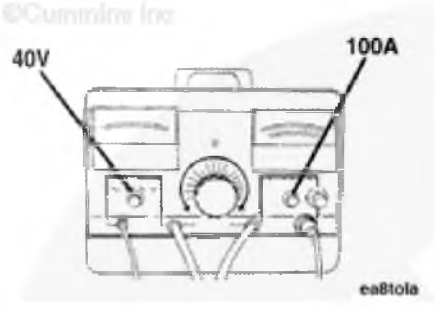
Test

The following instructions are for use with the inductive charging and cranking system analyzer or equivalent.

Before performing the following test, be sure the alternator belt is tightened to the correct specifications. Refer to Procedure 013-005.

Set the voltage selector knob to the appropriate scale. For a 24 VDC system, choose the 40 VDC scale.

Set the amp selector knob to 100 amps.

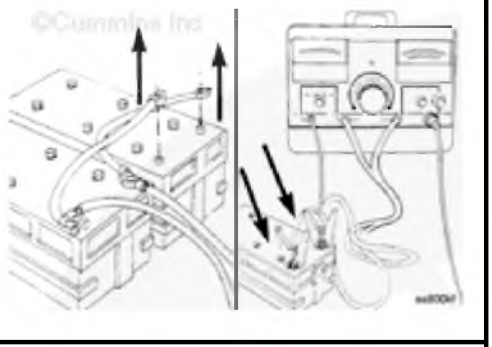


WARNING

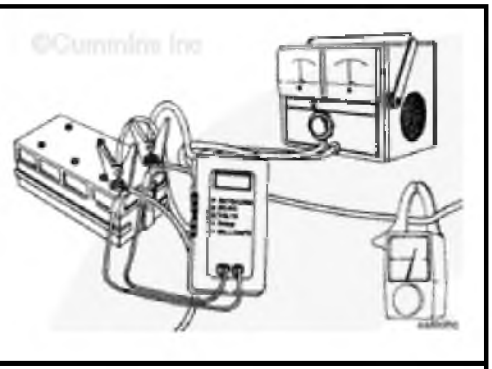
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Remove the cables to any other battery in the circuit.

Connect the correct analyzer leads to the positive and negative terminals on the battery.



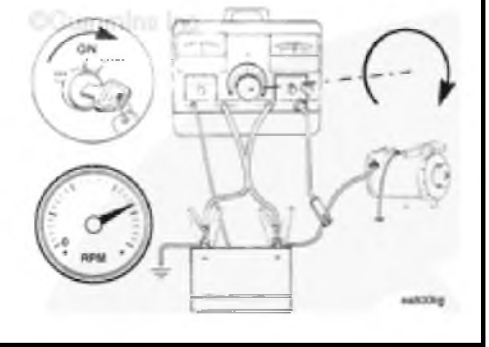
Connect the clamp-on amp pick-up to the alternator output cable as far away from the alternator as possible.



Operate the engine at high idle and turn the analyzer load control knob **clockwise** until a maximum amp reading is obtained.

Do **not** let the load voltage drop below 26 VDC for a 24 VDC system.

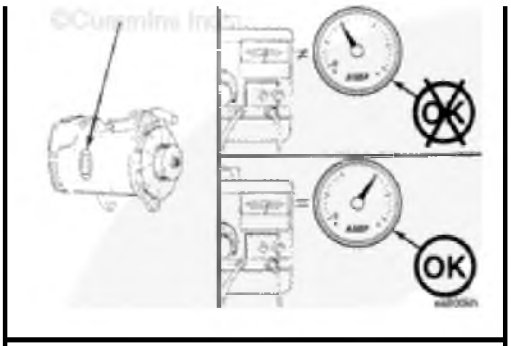
The maximum amp reading is the alternator output and **must** meet the alternator manufacturer's specifications.



The alternator maximum rated output is normally stamped or labeled on the alternator.

Also check the equipment ammeter gauge. If it does **not** read approximately the same as the test equipment, it should be replaced.

If the alternator output is **not** within 10 percent of rated output, repair or replace the alternator. Refer to the manufacturer's instructions.

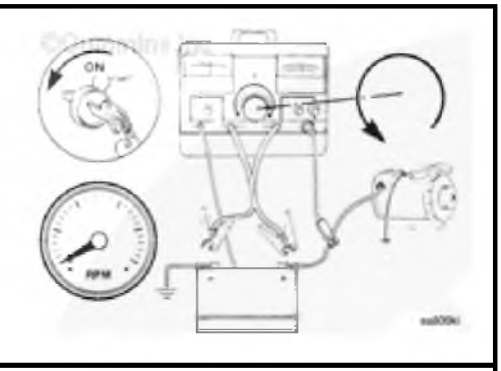


WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Turn the analyzer load control knob **counterclockwise** to the OFF position and shut off the engine.

Remove the test equipment. Connect all battery cables that were removed.



Install

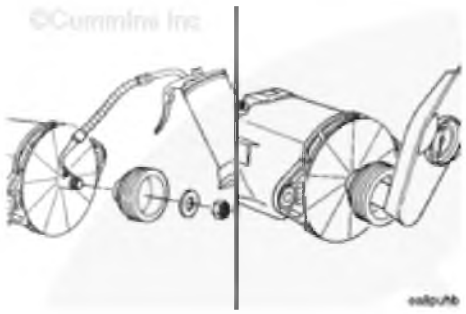
Clean and check the pulley for reuse. Refer to Procedure 013-006.

Lubricate the shaft with clean 15W-40 engine oil.

Install the pulley and nut on the alternator shaft.

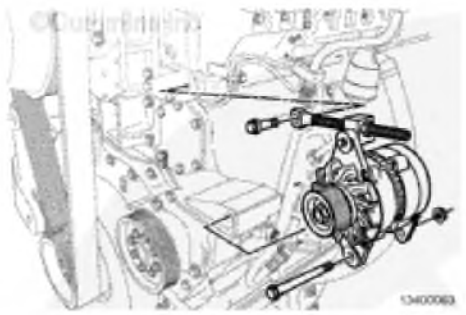
Tighten the nut.

Torque Value: 100 n.m [75 ft-lb]



CAUTION

Do not attempt to pry the belt on the pulley to avoid damage to the pulley and belt.



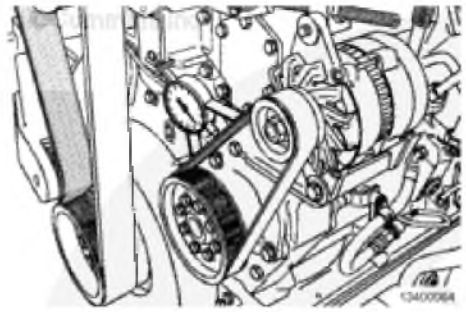
Install the alternator and the adjusting link as shown.

Leave the alternator mounting capscrews loose until the belt is adjusted.

Install the belt. Refer to Procedure 013-005.

Turn the adjusting nut **clockwise** to tighten the belt.

Tighten the belt and measure the belt tension.



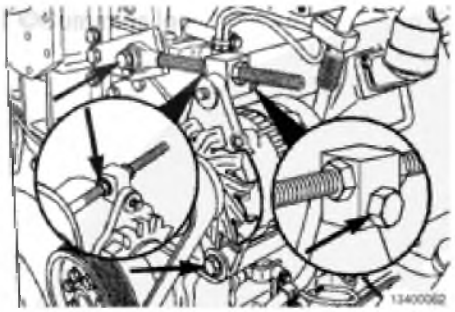
Measurements		
	n	lbf
Belt Tension	670	150

Use the (Burroughs) belt tension gauge to check the belt tension.

Tighten the jam nut on the adjusting link.

Tighten the alternator mounting capscrews.

Jam nut	196 n.m	[125 ft-lb]
Alternator mounting capscrew (Top)	75 n.m	[55 ft-lb]
Alternator mounting capscrew (Bottom)	120 n.m	[89 ft-lb]

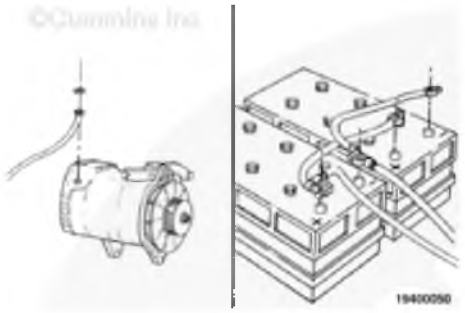


WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect the wiring to the alternator.

Connect the batteries.



Last Modified: 30-May-2003

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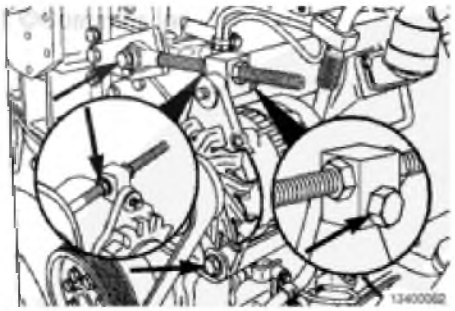
013-005 Drive Belt, Alternator

Remove

Loosen the adjusting link and the alternator mounting capscrews.

Loosen the adjusting nut to relieve tension on the alternator belt.

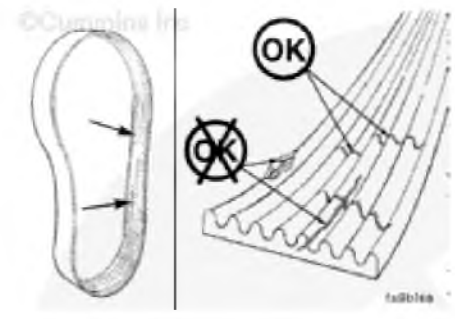
Remove the belt.



Inspect for Reuse

Poly-Vee Belt

Inspect the belts daily. Check the belt for intersecting cracks. Traverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks that intersect with transverse cracks are **not** acceptable. Replace the belt if it is frayed or has pieces of material missing. Refer to Section A for belt adjustment and replacement procedures.



Belt damage can be caused by:

- Incorrect tension
- Incorrect size or length
- Pulley misalignment
- Incorrect installation
- Severe operating environment
- Oil or grease on the side of belts.

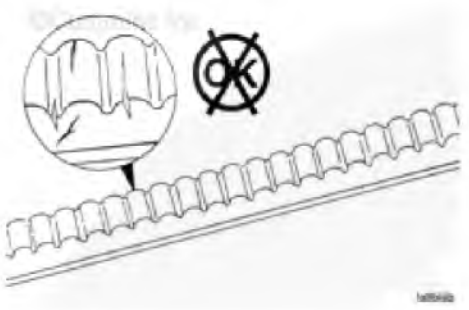
Cogged Belt

Inspect the belts daily. Replace the belts if they are cracked, frayed, or have chunks of material missing. Small cracks are acceptable.

Adjust the belts that have a glazed or shiny surface, which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear. Refer to Section A for belt adjustment and replacement procedures.

Belt damage can be caused by:

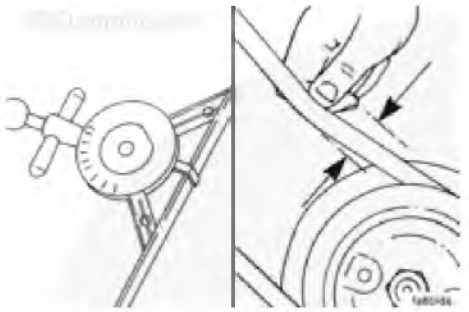
- Incorrect tension
- Incorrect size or length
- Pulley misalignment
- Incorrect installation
- Severe operating environment
- Oil or grease on the belts



Measure the belt tension in the center span of the pulleys.

Refer to the Belt Tension Chart in Section V for the correct gauge and tension value for the belt width used.

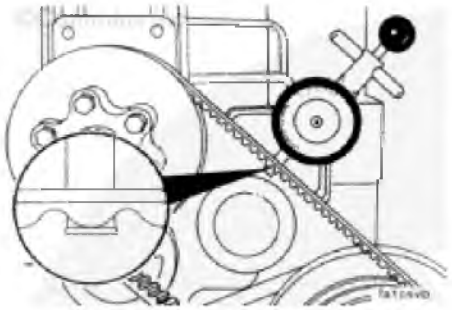
An alternate method (deflection method) can be used to check belt tension by applying 110 N [25 lbf] force between the



pulleys on v-belts. If the deflection is more than one belt thickness per foot of pulley center distance, the belt tension **must** be adjusted.

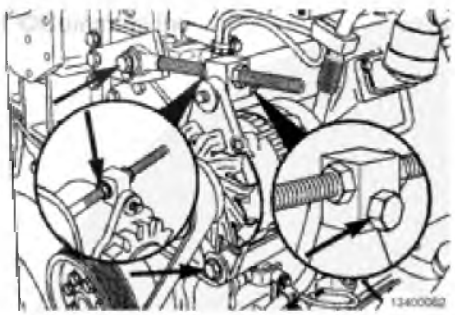
Refer to Section A for adjustment procedures.

For cogged belts, make sure that the belt tension gauge is positioned so that the center tensioning leg is placed directly over the high point (hump) of a cog. Other positioning will result in incorrect measurement.



Install

Do **not** attempt to pry the belt onto the pulley. Turn the adjusting nut **counterclockwise** to shorten the link if necessary. Install the alternator belt.



Tighten the jam nuts on the adjusting link.

Tighten the adjusting link and alternator mounting capscrews.

Jam nuts:

Torque Value: 196 n.m [125 ft-lb]

Alternator mounting capscrew (top):

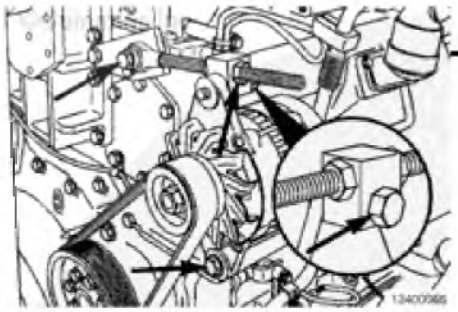
Torque Value: 75 n.m [55 ft-lb]

Alternator mounting capscrew (bottom):

Torque Value: 120 n.m [89 ft-lb]

Alternator adjusting link mounting capscrew:

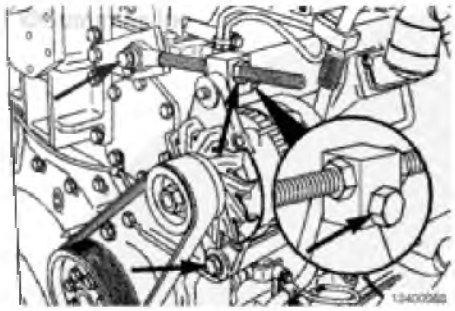
Torque Value: 75 n.m [55 ft-lb]



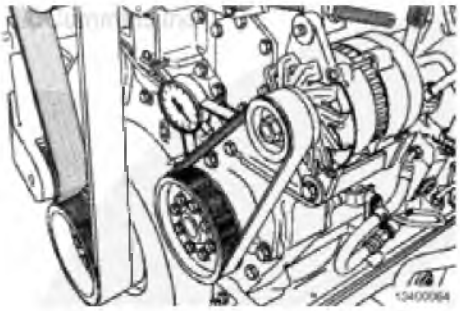
Adjust

Loosen the alternator and adjusting link mounting capscrews.

Loosen the jam nut on the adjusting link.



Turn the adjusting screw **clockwise** to tighten the belt tension.



Tighten the jam nuts on the adjusting screw.

Tighten the adjusting link and alternator mounting capscrews.

Jam nuts:

Torque Value: 196 n.m [125 ft-lb]

Alternator mounting capscrew (top):

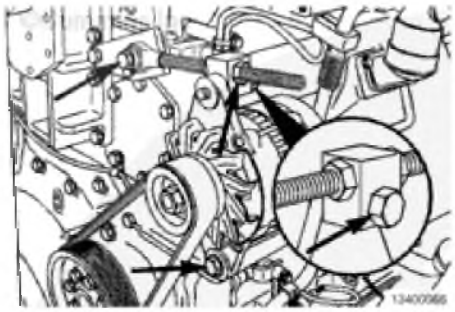
Torque Value: 75 n.m [55 ft-lb]

Alternator mounting capscrew (bottom):

Torque Value: 120 n.m [89 ft-lb]

Alternator adjusting link mounting capscrew:

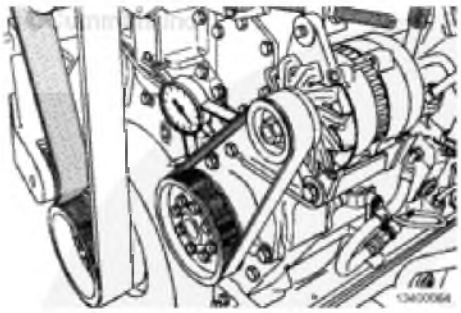
Torque Value: 75 n.m [55 ft-lb]



Check the belt tension again to be sure it is correct.

The belt tension **must** be:

Measurements		
	n	lbf
Belt Tension	670	150



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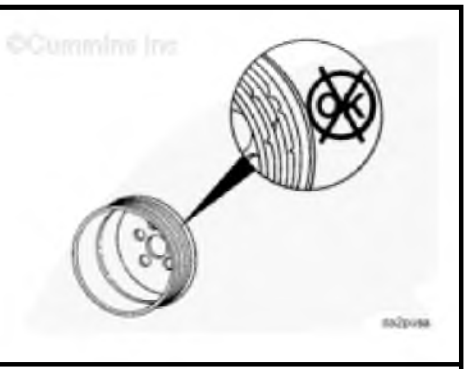
013-006 Alternator Pulley

Inspect for Reuse

WARNING

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



Clean the alternator pulley and alternator drive pulley with steam or solvent.

Check the grooves of the pulleys for wear. If the part **must** be replaced, refer to Procedures 009-010 and 013-001.

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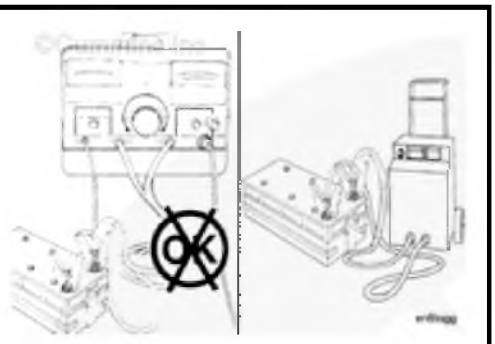
013-007 Batteries

Inspect for Reuse

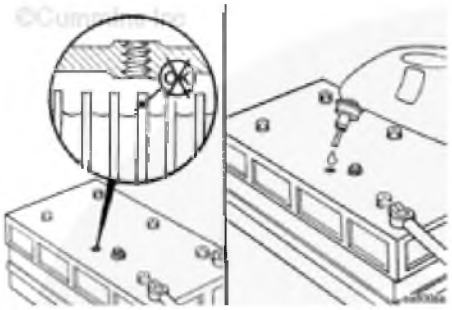
Use an inductive charging and cranking system analyzer to load test the state-of-charge of maintenance-free batteries. If the state-of-charge is low, use a battery charger to charge the battery. Refer to the manufacturer's instructions.

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



WARNING

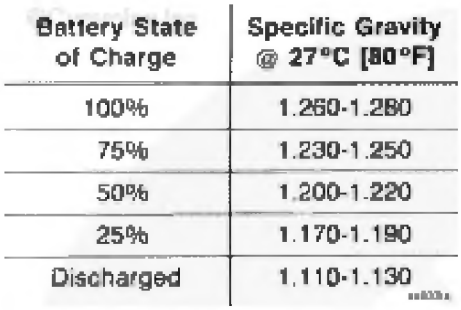
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



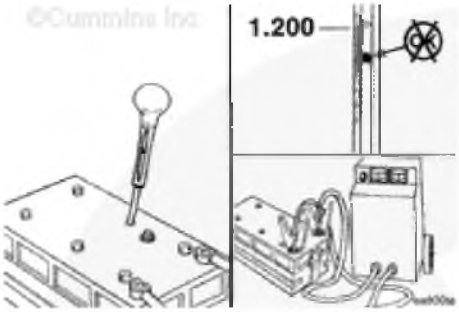
If conventional batteries are used, remove the cell caps or covers and check the electrolyte (water and sulfuric acid solution) level.

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

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

Refer to the accompanying chart to determine the battery state-of-charge based on the specific gravity readings.		

Battery State of Charge	Specific Gravity @ 27°C [80°F]
100%	1.260-1.280
75%	1.230-1.250
50%	1.200-1.220
25%	1.170-1.190
Discharged	1.110-1.130

Use a hydrometer to measure the specific gravity of each cell. If the specific gravity of any cell is below 1.200, the battery **must** be charged. Do **not** attempt to check the specific gravity of a battery immediately after adding water. If it is necessary to add water to allow use of the hydrometer, charge the battery several minutes at a high rate to mix the electrolyte.		

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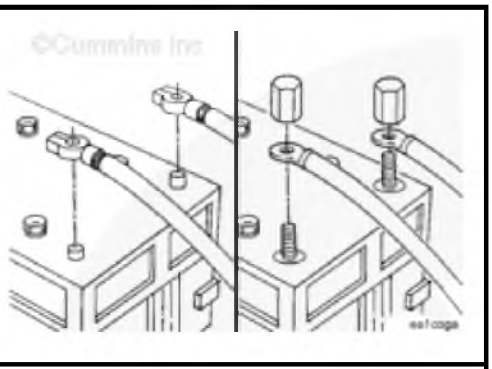
013-009 Battery Cables and Connections

Initial Check

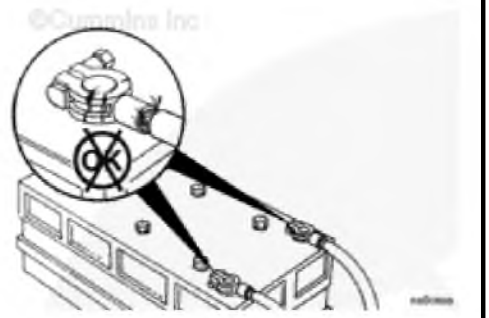
There are two possible heavy-duty battery connections:

- Battery terminal and clamp (1)
- Threaded battery terminal and nut (2).



WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

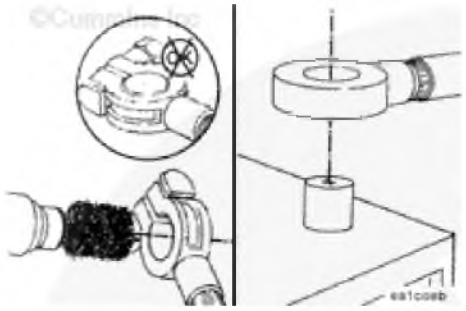


Remove and inspect the battery cables and connections for cracks or corrosion.

Replace broken terminals, connectors, or cables.

If the connections are corroded, use a battery brush or wire brush to clean the connections until shiny.

Make sure all debris is removed from the connecting surfaces.

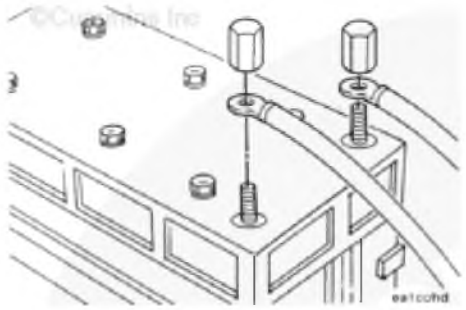


WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Install the cables and tighten the battery connections.

Coat the terminals with grease to prevent corrosion.



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013-017 Starter Magnetic Switch

Voltage Check

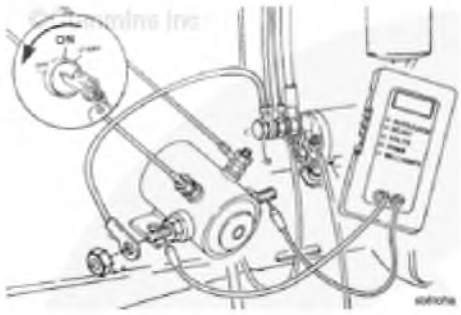
WARNING

To reduce the possibility of personal injury, do not touch any ignition wires or components while the engine is operating, unless using suitably insulated tools.

Make sure the starter switch is in the OFF position.

Remove the cable connecting the magnetic switch to the starter solenoid from the magnetic switch terminal.

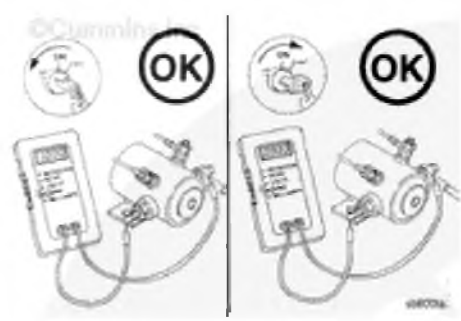
Connect the leads of the digital multimeter, Part Number 3377161, or digital multimeter, Part Number 3164488, to the two large switch terminals.

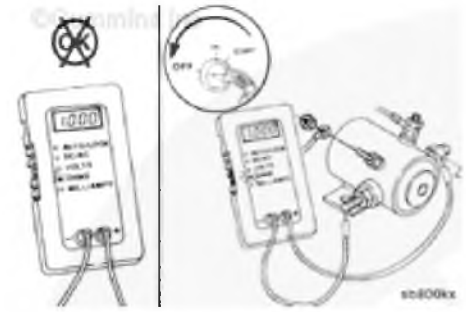
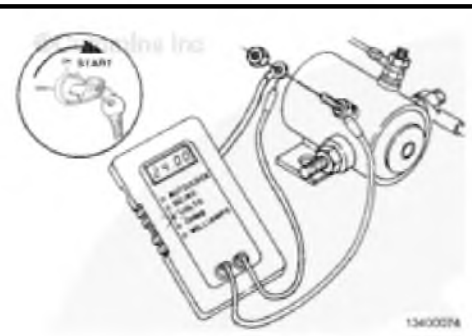
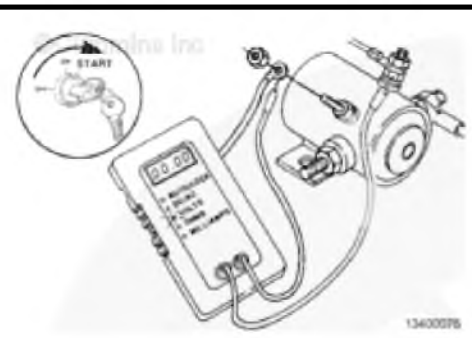


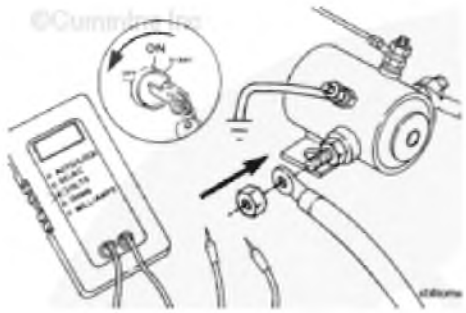
Set the multimeter to measure resistance (ohms).

With the starter switch off, the multimeter **must** indicate resistance at infinity, open circuit.

Turn the starter switch to the START position.



The multimeter **must** indicate near zero resistance, closed circuit.		
If the multimeter indicates resistance at infinity with the starter switch in the START position: • Turn the starter switch off. • Remove the ground wire that is connected to one of the small magnetic switch terminals.		
• Set the multimeter scale to indicate volts, 24-VDC or more. • Connect the positive (+) lead of the multimeter to the magnetic switch ground terminal and the other lead to the ground wire. • Turn the starter switch to the START position. • If the multimeter indicates vehicle electrical system voltage, the magnetic switch is defective and **must** be replaced.		
• If the multimeter does **not** indicate voltage connect the positive (+) lead of the multimeter to the small positive (+) terminal on the magnetic switch and the negative multimeter lead to the ground wire. • Turn the starter switch to the START position. • If the multimeter indicates vehicle electrical system voltage, the magnetic switch is defective and **must** be replaced. • If the multimeter does **not** indicate voltage, refer to Procedure 013-018.		

• Turn the starter switch to the OFF position. • Remove the multimeter leads. • Connect the starter solenoid cable to the magnetic switch terminal, and the ground wire to its corresponding terminal on the magnetic switch.		

Last Modified: 04-Sep-2003

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013-018 Starter Switch

Voltage Check

WARNING

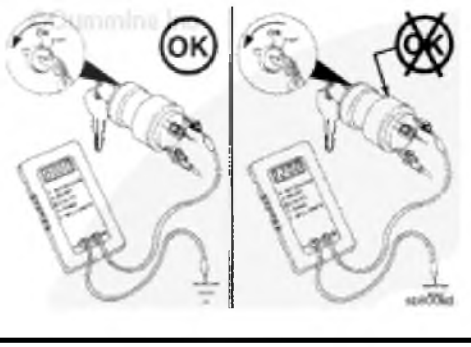
To reduce the possibility of personal injury, do not touch any ignition wires or components while the engine is operating, unless using suitably insulated tools.

Make sure the starter switch is in the OFF position.

Remove the wire connecting the starter switch to the magnetic switch from the starter switch terminal.

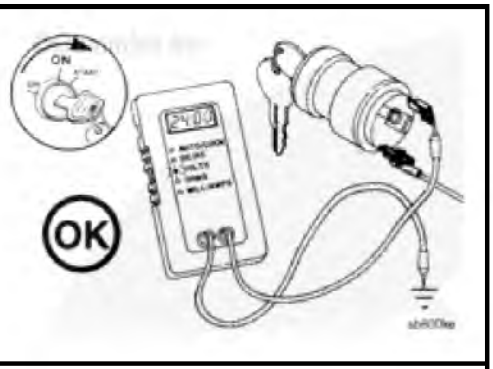
Connect the positive (+) lead of the digital multimeter, Part Number 3377161, or digital multimeter, Part Number 3164488, to the starter switch terminal and the negative (-) lead to a chassis or engine ground location.

With the starter switch in the OFF position, there **must** be no voltage at the starter switch terminal. If the multimeter indicates voltage, the starter switch is malfunctioning and **must** be replaced.



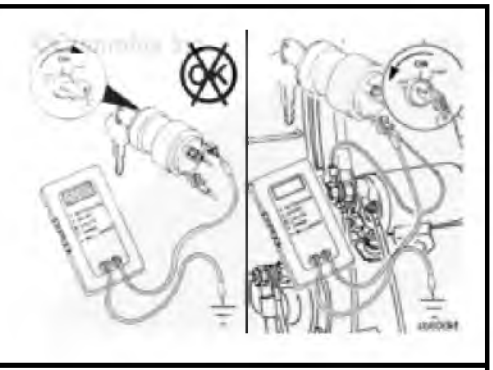
Turn the starter switch to the START position.

The multimeter **must** indicate system voltage.

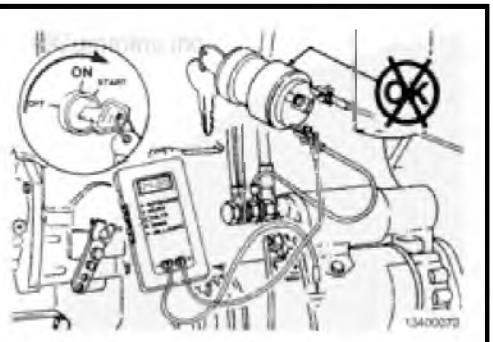


If there is no voltage:

- Turn the starter switch to the OFF position.
- Connect the multimeter positive (+) lead to the starter switch terminal having a wire connecting the starter switch to the starter solenoid.
- Turn the starter switch to the START position.



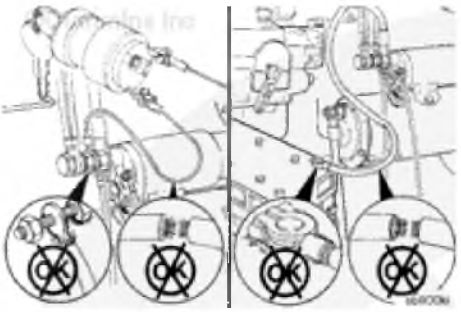
If the multimeter indicates system voltage, the starter switch is defective and **must** be replaced.



If the multimeter indicates no voltage, the switch is **not** the cause of the problem.

Inspect the wiring from the starter switch to the starter solenoid and from the starter solenoid to the battery.

Replace any broken or damaged wires.



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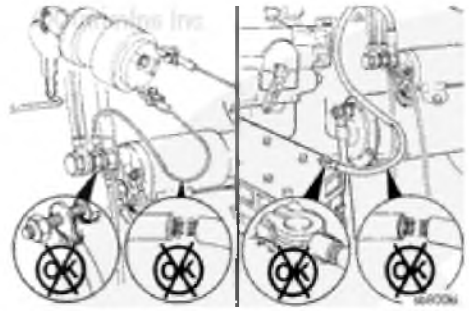
013-019 Starter Solenoid

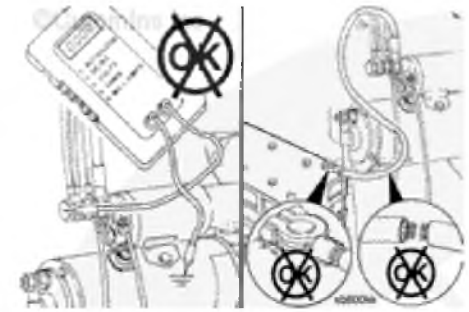
Voltage Check

Use the multimeter, Part No. 3164488, and set it to measure DC voltage.

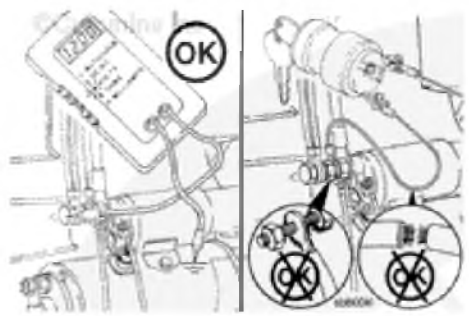
Connect the multimeter positive lead to the starter solenoid positive cable terminal and the negative lead to the battery cable connection at the starting motor. The multimeter **must** show system voltage.



If the multimeter does **not** indicate system voltage, check the battery to starting motor cable for broken, loose, or corroded connections.

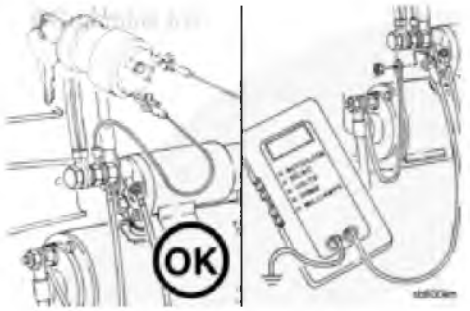


If the multimeter indicates system voltage, but the starting motor will **not** operate, check the wire connecting the starter solenoid to the starter switch for broken, loose, or corroded connections.



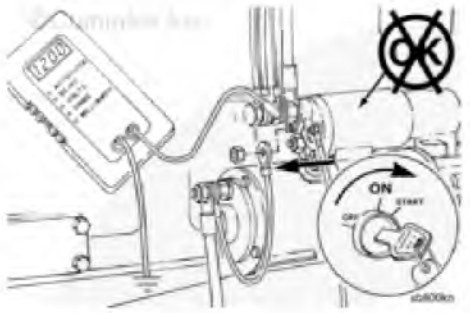
If the wire connecting the starter solenoid and starter switch is **not** loose or damaged and the starter will **not** operate:

- Remove the cable connecting the starting motor and starter solenoid from the solenoid terminal.
- Connect the multimeter positive lead to the solenoid **positive** terminal and the negative lead to a chassis or engine ground.

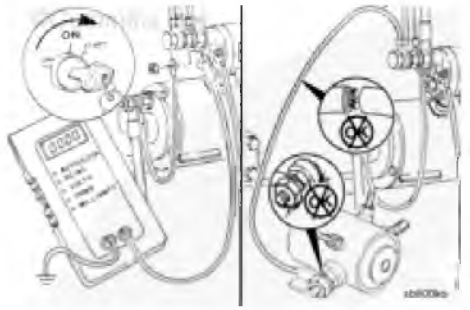


Turn the starter switch to the START position.

If the multimeter indicates system voltage, the starter solenoid is malfunctioning and **must** be replaced.



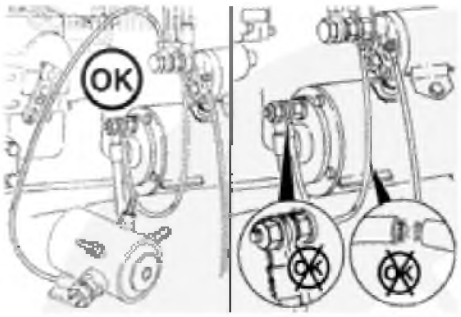
If the multimeter does **not** indicate system voltage, check the wire connecting the starter solenoid to the magnetic switch for broken, loose, or corroded connections.



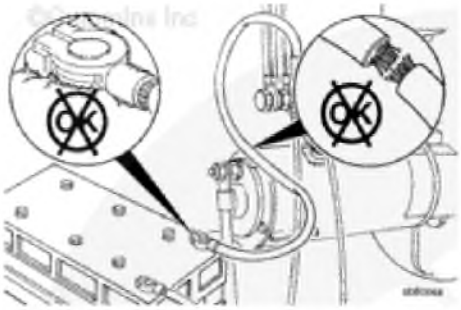
If the wire connecting the starter solenoid to the magnetic switch is **not** loose or damaged and the starting motor will **not** operate:

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

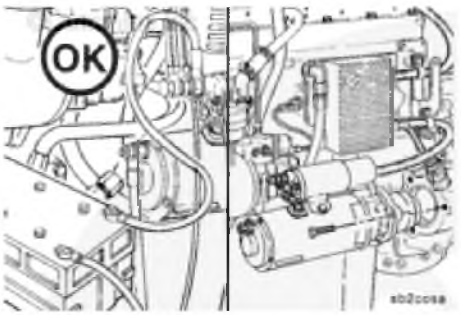
- Check the cable connecting the starter solenoid to the starting motor for broken, loose, or corroded connections.



Check the cable connecting the starter to the battery for broken, loose, or corroded connections.



If the cables are **not** loose or damaged, the starting motor is defective and **must** be replaced. Refer to Procedure 013-020.



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013-020 Starting Motor

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the battery. Refer to Procedure 013-007.
- Disconnect the electrical connections from the starting motor.

Remove

WARNING

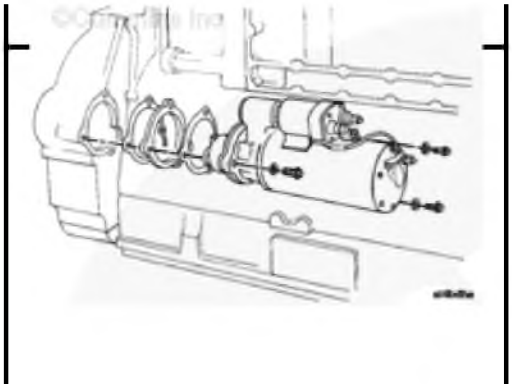
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get

assistance to lift this assembly.

Remove the starting motor capscrews, the starter, spacers, and gaskets.

Discard the gaskets.

NOTE: Some engines do not use spacers and gaskets.

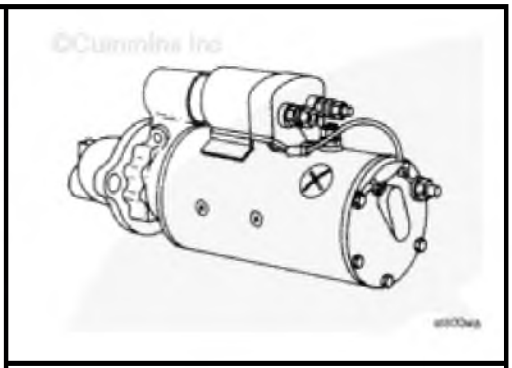


Clean and Inspect for Reuse

Powerpack

WARNING

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



Clean the exterior of the starting motor with steam.

Inspect the gear, shaft, and the bushing for wear or damage.

Lubricate the bushing with clean engine oil.

NOTE: A pipe plug must be removed to lubricate the bushing on some starter motors.

Install

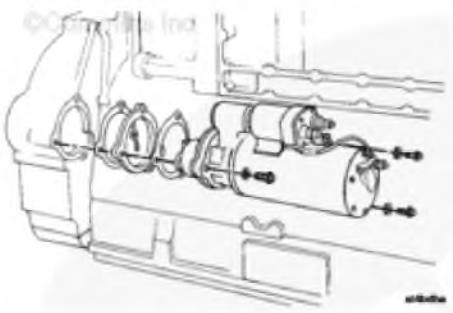
NOTE: Some engines do not use spacers.

Install any spacers or gaskets.

Install the starting motor and capscrews.

Tighten the capscrews.

Torque Value: 279 n.m [206 ft-lb]



Finishing Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Install the electrical connections to the starting motor.
- Connect the batteries. Refer to Procedure 013-007.

Last Modified: 20-Jun-2003

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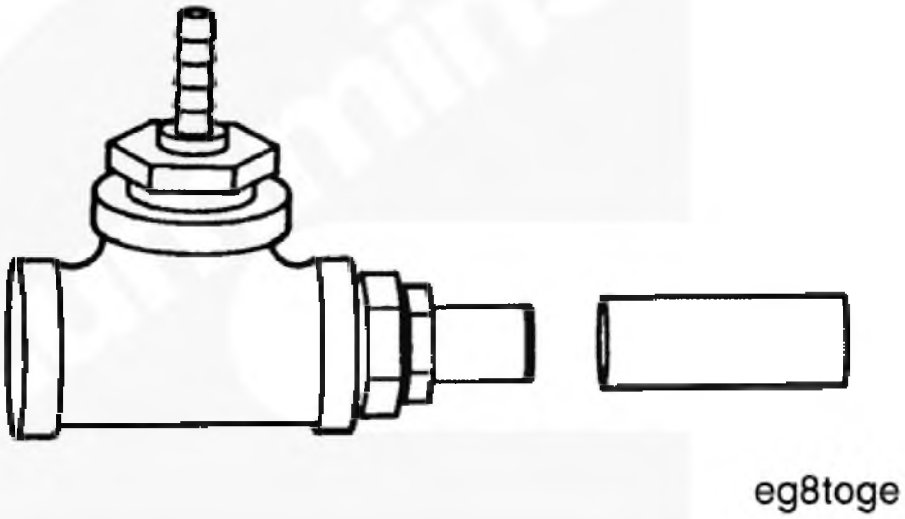
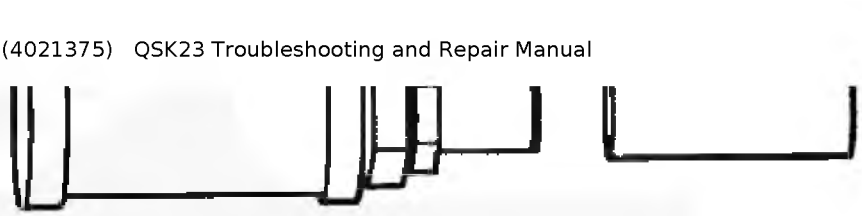
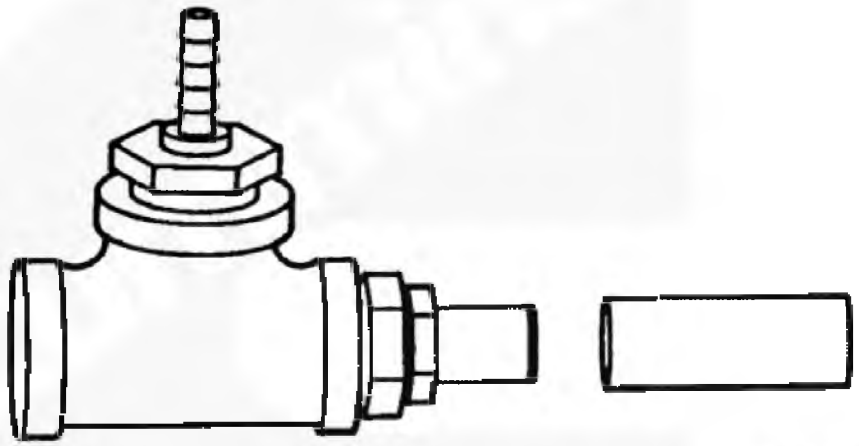
View Related Topic

022-001 Service Tools

Engine Testing

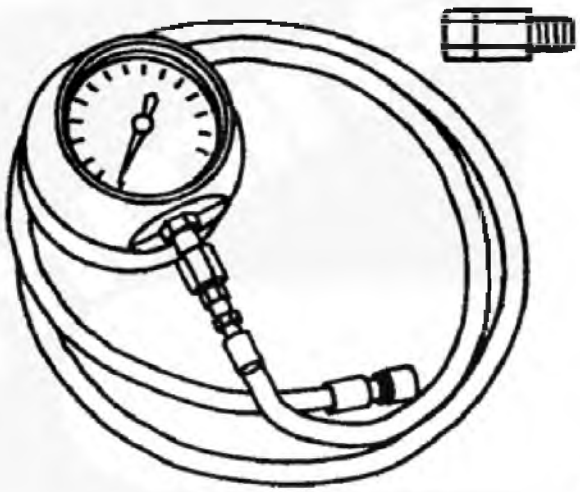
Tool Number 3822566	**Blowby Check Tool ([0.302 in] orifice)** Used with manometer, Part Number ST-1111-3 to measure the engine crankcase pressure.	
Tool Number 3822567	**Blowby Check Tool ([0.354 in] orifice)** Used with manometer, Part Number ST-1111-3 to measure the engine	

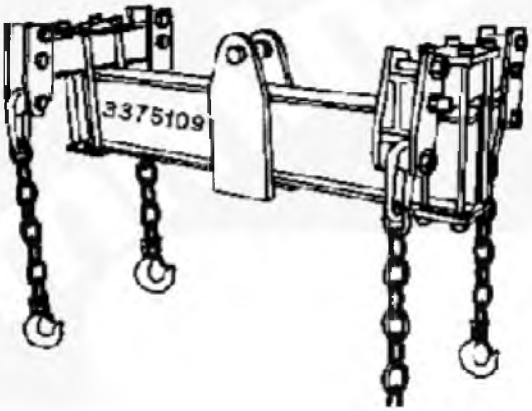
	crankcase pressure.	 eg8toge

Tool Number 3822568	**Blowby Check Tool ([0.406 in] orifice)** Used with manometer, Part Number ST-1111-3 to measure the engine crankcase pressure.	 eg8toge

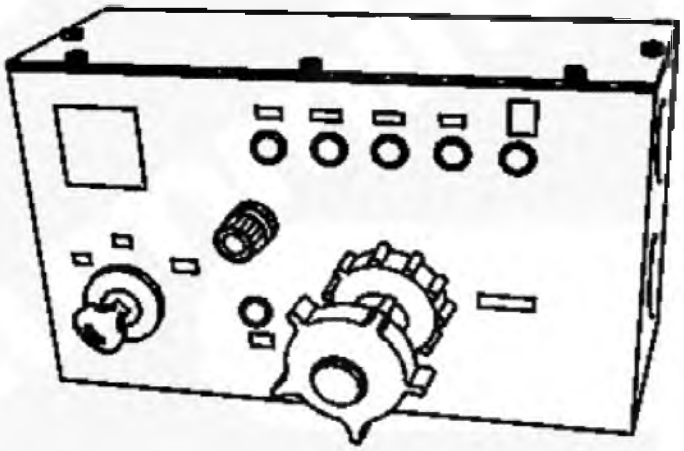
Tool Number 3375275	**Pressure Gauge [0 to 100 psi]** Used to measure lubricating oil pressure.	3375275

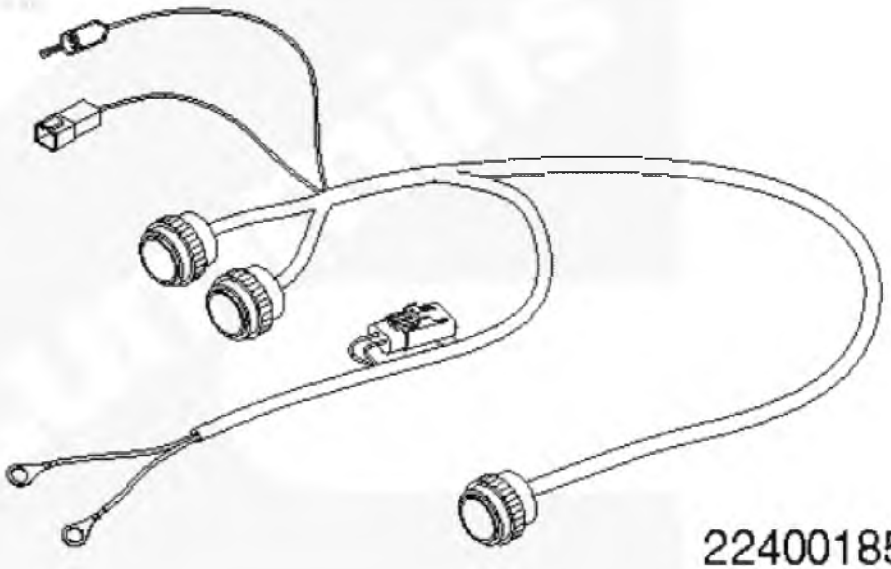
Tool Number ST-434	**Vacuum Gauge** Used to measure fuel filter or inlet air restriction.	 eg8togc

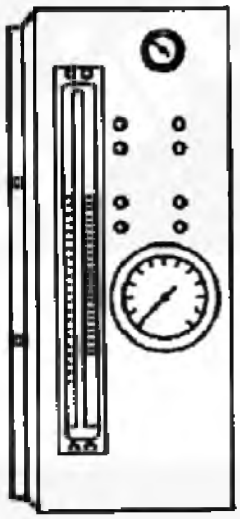
Tool Number ST-1273	**Pressure Gauge (0 to 190.5 cm Hg [0 to 75 in Hg])** Used to measure intake manifold pressure and fuel drain line restriction.	 eg8togi

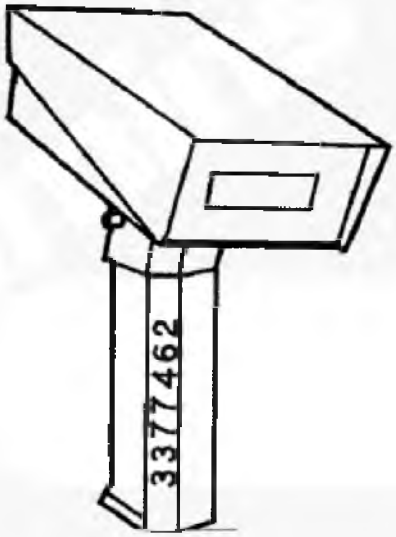
Tool Number 3163264	**Engine Lifting Fixture** This heavy-duty lifting fixture, or its equivalent, is required for lifting the QSK23 Series	

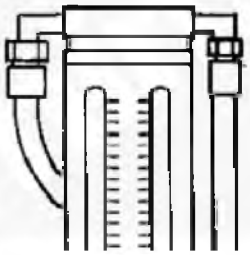
	engine.	3375109

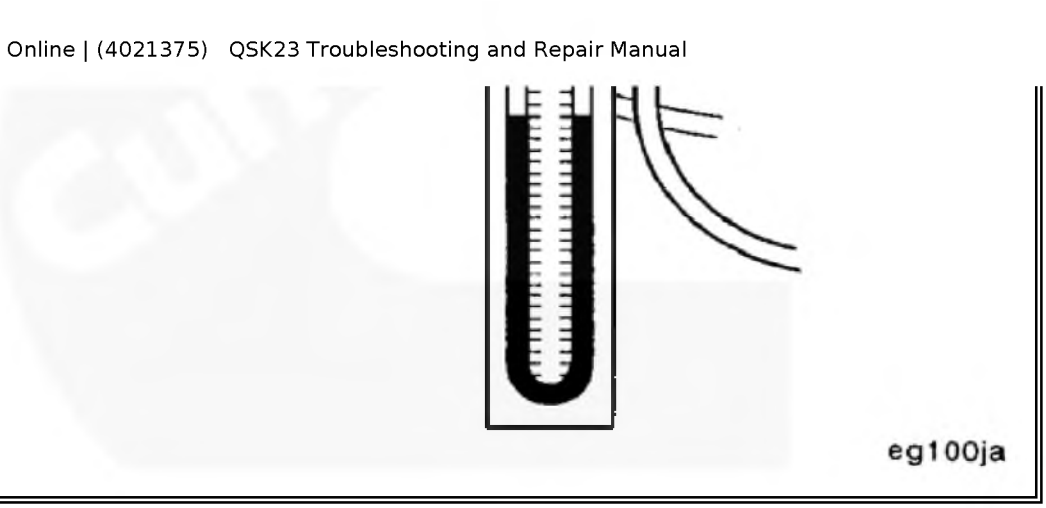
Tool Number 3163890	**Engine Control** Used to operate engine out-of-chassis. Use with Engine Control Harness, Part Number 3163891.	 22400184

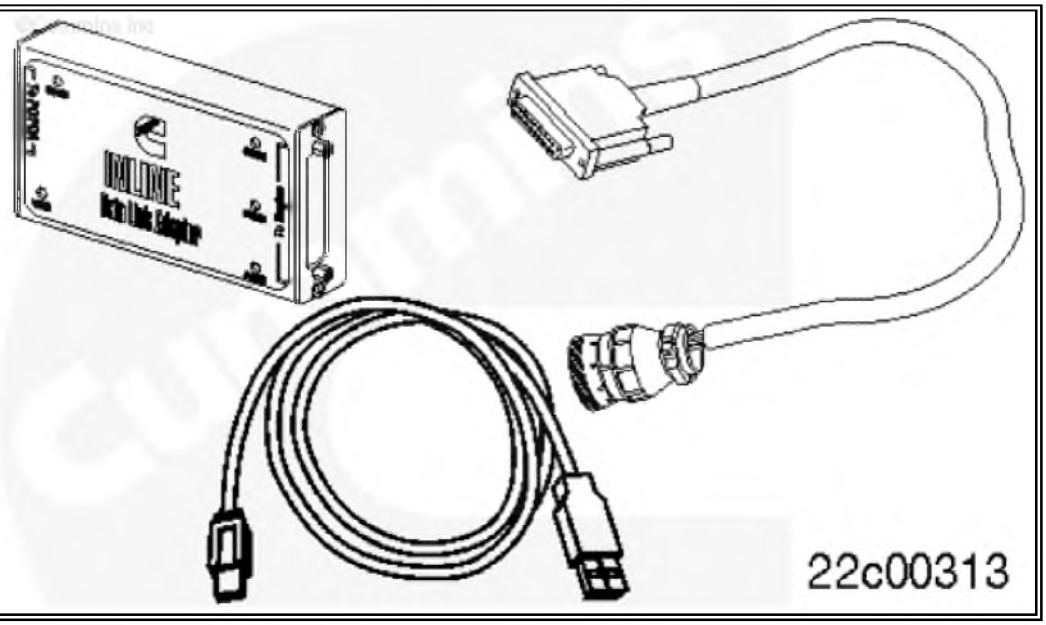
Tool Number 3163891	**Engine Control Harness** Used to operate engine out-of-chassis. Use with Engine Control, Part Number 3163890.	 22400185

Tool Number 3376375	**Fuel Measuring Device** Used to measure the rate of fuel consumption of a Cummins Inc. diesel engine.	 eg8togf

Tool Number 3377462	**Digital Optical Tachometer** Used to measure engine speed (rpm).	 3377462

Tool Number	**Manometer** Used with service tools, Part Numbers	

ST-1111-3	3822566, 3822567, and 3822568, to measure blowby.	

Tool Number 4918416	**INLINE™5 Adapter Kit** Use with Engine Control, Part Number 3163890 and Engine Control Harness, Part Number 3163891.	

Last Modified: 21-Jul-2006

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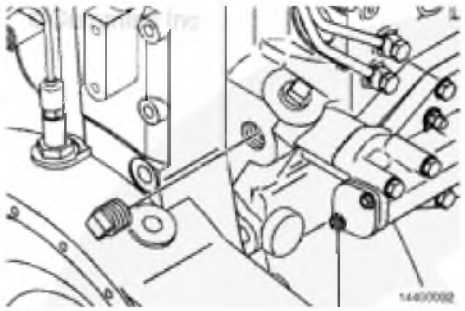
014-004 Engine Run-in (Without Dynamometer)

Preparatory Steps

CAUTION

The lubricating oil system must be primed before operating the engine after rebuild to avoid internal component damage. Do not prime the system from the bypass filter as the filter will be damaged.

Remove the large plug from the oil cooler rifle.



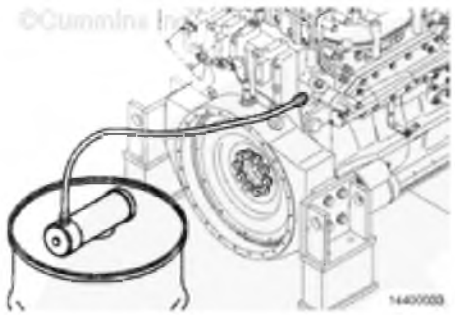
Use a pump capable of supplying 205 kPa [30 psi] continuous pressure.

Connect the pump to the oil cooler rifle as shown.

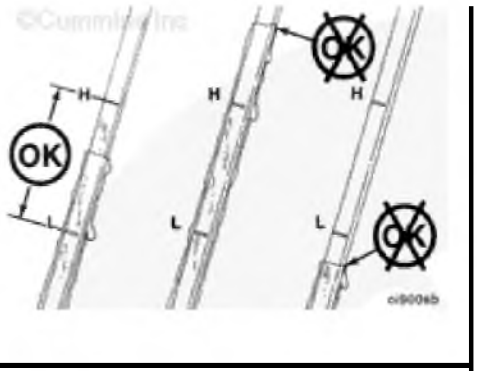
Use a supply of clean 15W-40 engine oil.

Turn the pump to the ON position.

Check the engine oil pressure gauge. When the gauge indicates oil pressure, begin monitoring the oil level in the oil pan.



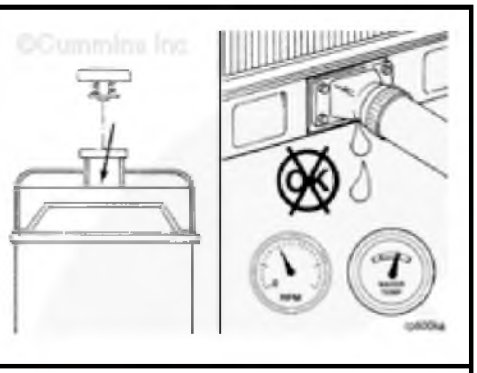
Check the engine lubricating oil level to be sure it is filled to the proper level.



WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Check the engine coolant level to make sure it is filled to the proper level. Refer to Procedure 008-018.



Use a known source of good quality number 2 diesel fuel.

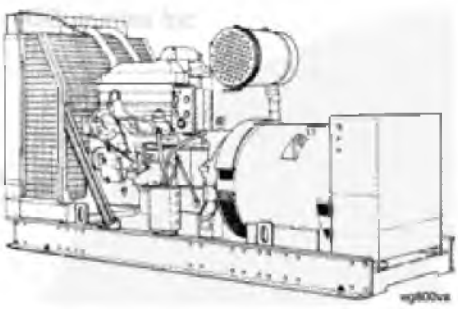
This is very important since number 1 diesel fuels, along with most other alternate fuels, are lighter (lower specific gravity, higher API gravity) than number 2 diesel fuels. The lighter the fuel, the lower the energy content (BTU) per gallon (liter, etc.).

Engine operating specifications can be found in publications available from a local Cummins authorized repair location.

Run-In Instructions

Generator Set Applications

Operate the engine in steps, varying the load from 25 to 100 percent, until blowby remains constant.



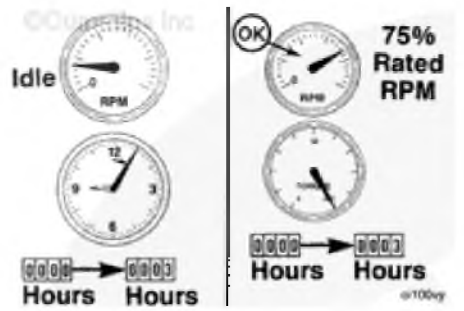
Off-Highway Applications

Operate the equipment in the normal duty cycle at part load during the first three hours after rebuild.

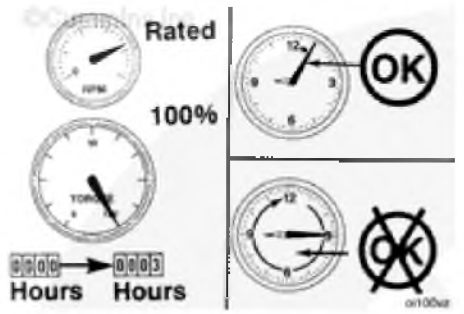
Do **not** idle the engine for more than five minutes at any one time.

Do **not** operate the engine at rated rpm. Operate at 75 percent of rated rpm or lower.

Rated RPM	Maximum RPM For First 3 Hours
2100	1575
2000	1500
1900	1425
1800	1350



Do **not** operate the engine at full load for more than five minutes at any one time.



Last Modified: 20-Jun-2003

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View Related Topic

014-005 Engine Testing (Engine Dynamometer)

General Information

This document provides procedures for the use of an engine control, Part Number 3163890. The engine control is a portable, handheld electronic control, used to start and control engine speed on the Cummins® electronic engines. It replaces the throttle pedal, driver interface panel, and fault code monitoring circuits. The engine control has a datalink provision to connect to an electronic service tool to monitor engine operation and fault codes. The engine control harnesses required for the engines are purchased separately. The engine control and engine control harnesses are designed to be used with both (+) 12-VDC and (+) 24-VDC battery systems.

NOTE: The engine control can be used on engines with frequency throttle calibrations by first downloading a linear throttle calibration to the electronic control module (ECM). After the testing/repair is complete, reload the correct frequency throttle calibration.

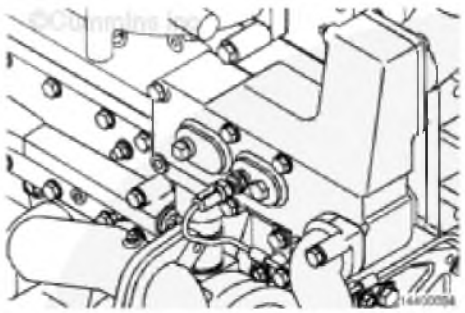
Install

Be certain that the dynamometer capacity is sufficient to permit testing at 100 percent of the engine rated horsepower. If the capacity is **not** enough, the testing procedure **must** be modified to the restrictions of the dynamometer.

Use engine lifting fixture, Part Number 3163264, or equivalent, to install the engine to the test stand. Align and connect the dynamometer. See the manufacturers instructions for aligning and testing the engine.

NOTE: Some engines are equipped with fittings used for Compuchek® testing sensors. The sensor probes used for Compuchek® and dynamometer testing are not compatible. If the same location is used, remove the Compuchek® fitting and install adapters for the dynamometer sensor.

Install the coolant temperature sensor.

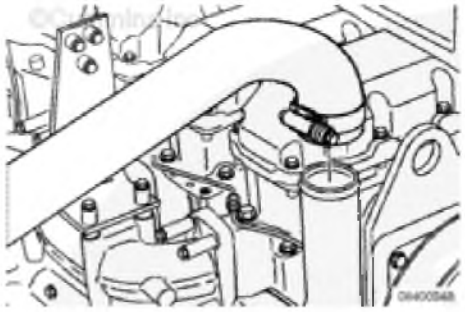


Coolant Plumbing

Connect the coolant supply to the water inlet connection.

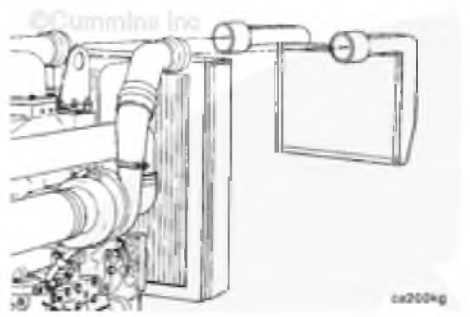
Connect the coolant return to the water outlet connection.

Connect all coolant vent lines to surge tank.

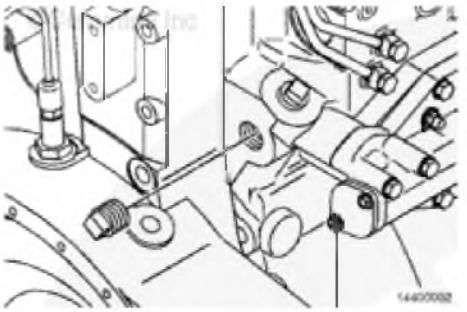
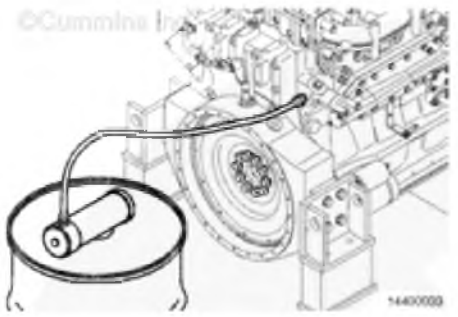


Install the drain plugs and close all the water drain cocks.		

Charge Air Cooled Engines

The use of a remote charge-air cooler is mandatory whenever a Cummins® charge-air cooled engine is attached to an engine dynamometer for the purpose of engine run-in, performance testing and engine diagnostics. Do **not** attempt to run a Cummins® charge-air cooled engine without a means of controlling the intake manifold air temperature. For more information on the charge-air cooled engines, refer to Procedure 010-027.		

Test

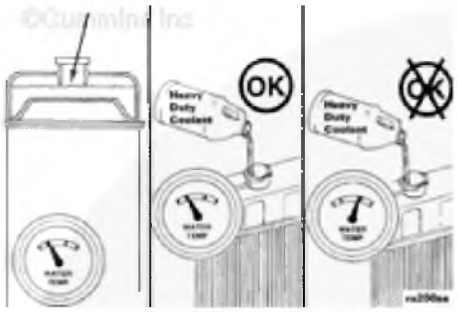
The lubricating oil system **must** be primed before operating the engine after rebuild to avoid internal component damage. Remove the large plug from the oil cooler rifle.		
Use a pump capable of supplying 205 kPa [30 psi] continuous pressure. Connect the pump to the rear of the engine oil cooler, as shown. Use a supply of clean 15W-40 engine oil. Turn the pump to the ON position. Check the engine oil pressure gauge. When the gauge indicates oil pressure, begin		

monitoring the oil level in the oil pan.

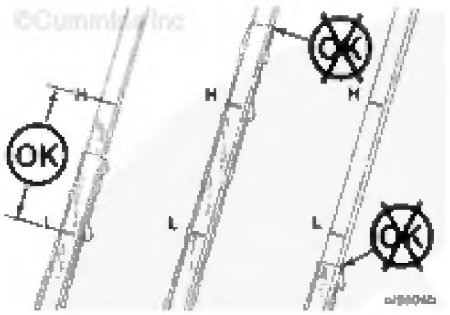
WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Check the engine coolant level to be certain that it is filled to the proper level. Refer to Procedure 008-018.



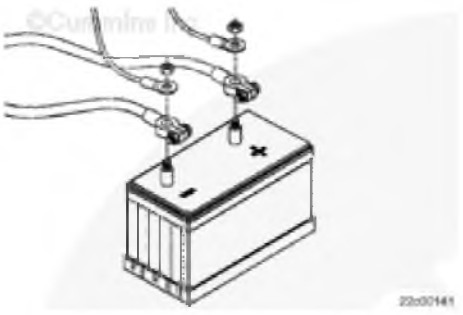
Check the engine lubricating oil level to be certain that it is filled to the proper level.



Engine Throttle Control

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first, and attach the negative (-) battery cable last.



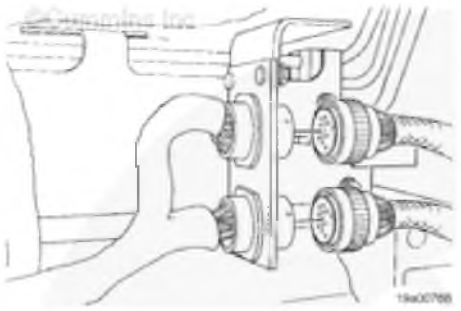
Disconnect the battery cables before beginning the following procedure.

Disconnect the OEM harness from the electronic control module (ECM) (if applicable).

Disconnect the OEM harness 21-pin and 31-pin Deutsch connectors from the engine harness.

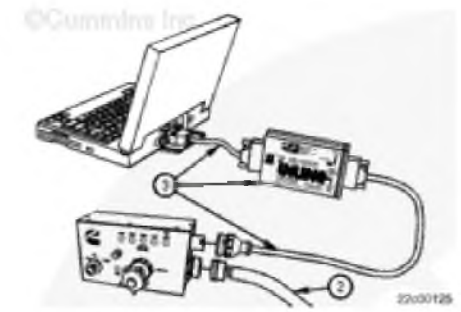
Connect the engine control harness, Part Number 3163891.

Connect the engine control harness 21-pin and 31-pin Deutsch connectors to the engine wiring harness.



NOTE: If additional cable length is needed to connect the engine control, use electrical cable, Part Number 3163895.

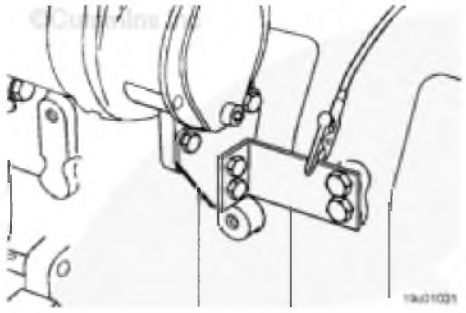
Connect the engine control harness (2) to the engine control. An INSITE™ electronic service tool equipped personal computer can be used to monitor circuits for proper operation. Connect the INLINE™5 datalink adapter kit (3), Part Number 4918416, and a personal computer to the datalink connector of the engine control.



Engines that are run on an engine dynamometer require the engine harness be installed and connected to the engine. Additionally, the engine control, Part Number 3163890, **must** be used to properly control the engine during the dynamometer run.

Ground Connection

Connect the black-wire alligator clip of the engine control harness to the engine block to achieve electrical ground.



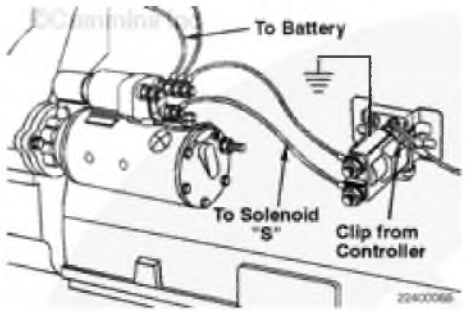
CAUTION

Do not connect the alligator clip to the starter motor solenoid “S” terminal. Doing so can cause equipment damage.

Starter Connection

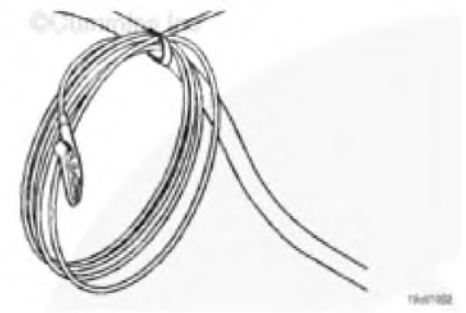
If **not** already equipped, install and wire a magnetic starter switch.

Clip the alligator connector to the positive (+) coil terminal of the magnetic starter switch.



Air Starter

If an air starter is being used, coil the red wire into a loop and secure the loop to the engine control harness to protect it from an electrical short.

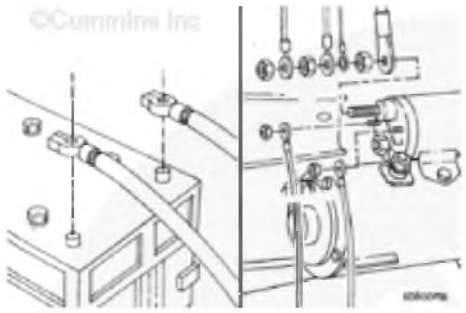


WARNING

Batteries can emit explosive gases. To avoid personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect battery power to the starter.

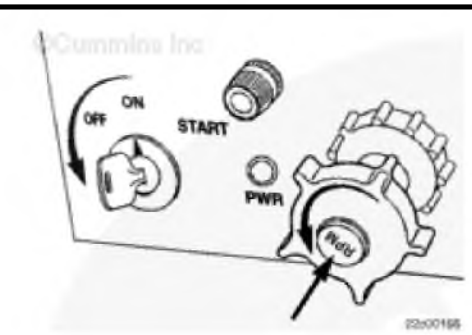
Connect the dynamometer test OEM wiring harness starter solenoid lead (yellow) to the starter solenoid. Connect the ground lead (black) to the starter solenoid. Connect the ground lead (black) to the starter or battery negative (-) or ground side. Connect the (+) 12 VDC power lead (red) to either the starter or battery positive (+) 12 VDC side.



Rotate the throttle knob fully **counterclockwise**. Push down on the throttle knob to return the throttle to the idle position.

Repeat this step three times.

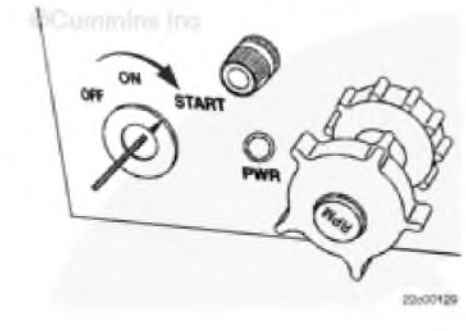
Turn the keyswitch to the OFF position for 30 seconds.



CAUTION

Check coolant and lubricating oil levels before starting and operating engine. If coolant and lubricating oil are not at the proper level engine damage can result.

Turn the keyswitch to the START position until the engine starts and release the keyswitch.



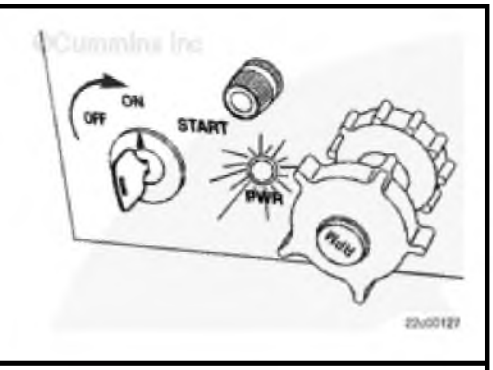
CAUTION

Verify the red wire is connected to the positive (+) battery terminal and the black wire is connected to the negative (-) battery terminal. Equipment or engine damage can result if not connected properly.

The power light will illuminate when power is supplied and the keyswitch is turned to the accessory or ON position.

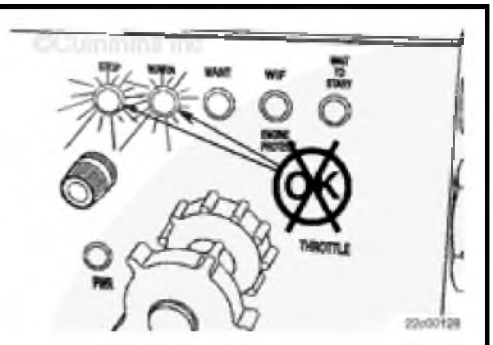
If the power light does **not** illuminate, return the keyswitch to the OFF position. Verify the red wire is connected to the positive (+) battery terminal and the black wire is connected to the negative (-) battery terminal.

Turn the keyswitch to the ON position.



Light indicators on the engine control, STOP, WARN, MAINT, WIF, and WAIT TO START, will illuminate if applicable. The light indicators will illuminate for approximately 30 seconds. If no fault codes are found, the light indicators will extinguish.

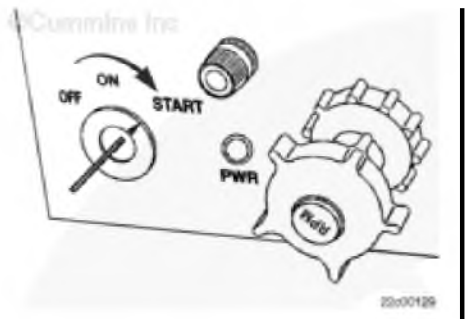
If the STOP light indicator (red) or WARN light indicator (yellow) continues to illuminate, use INSITE™ electronic service tool and the OEM service literature to diagnose the engine fault code.



CAUTION

Check coolant and lubricating oil levels before starting and operating engine. If coolant and lubricating oil are not at the proper level engine damage can result.

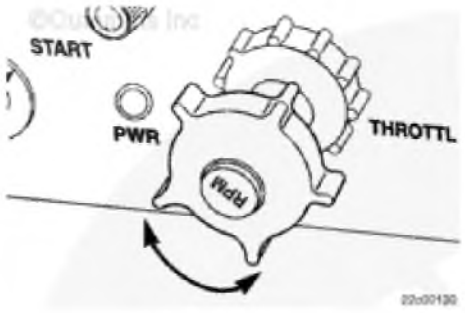
Turn the keyswitch to the START position until the engine starts and release the keyswitch.



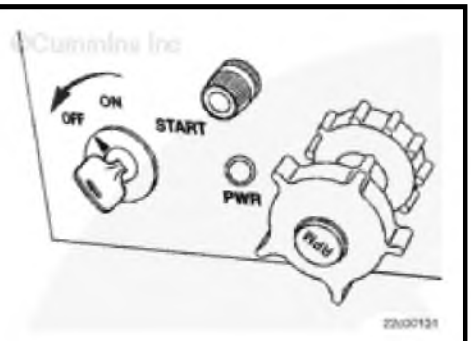
NOTE: The engine can be returned to idle at any time by pushing in on the throttle knob.

Slowly rotate the throttle knob **counterclockwise** to increase the engine rpm.

Slowly rotate the throttle knob **clockwise** to decrease the engine rpm.



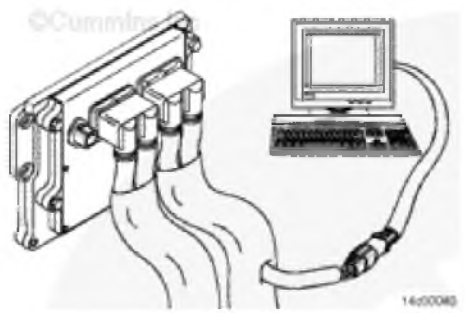
Turn the keyswitch to the OFF position to stop the engine.



Return parameters to their original values when the test or run-in is complete.

Connect the keyswitch panel datalink cable to the Cummins electronic service tool.

Use INSITE™ electronic service tool to set the engine up for the dynamometer. Refer



to Procedure 014-008 for more information on this feature.

The setup is now complete, and the auto/manual throttle can be used to control engine speed.

Engine operating specifications are available from local Cummins authorized repair locations.

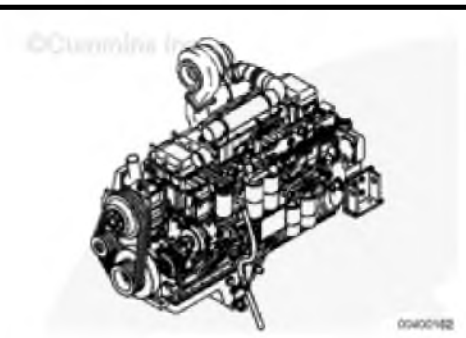
Test

Engine Operation

The INSITE™ electronic service tool will provide most, if **not** all, of the parameters.

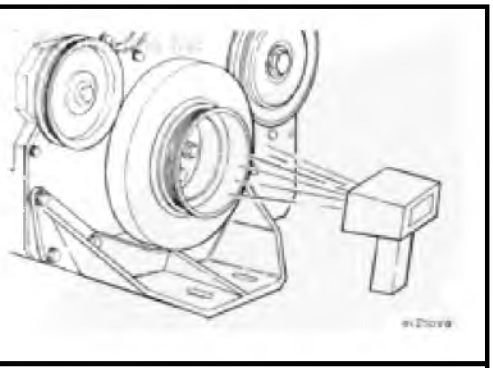
To properly monitor engine performance, record the following parameters. To limit dynamometer operating time, instrument the engine to make as many checks as possible.

- Engine speed rpm with a verified tachometer
- Fuel pressure
- Fuel rate (use service tool, Part Number 3376375, or equivalent)
- Fuel temperature (if needed to

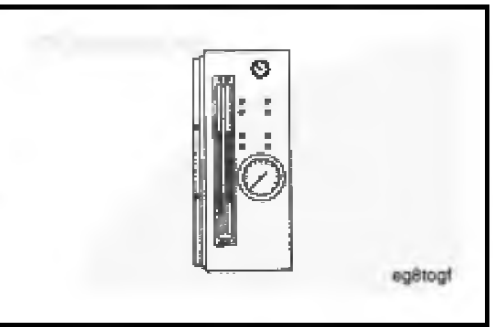


correct fuel rate) • Fuel inlet restriction • Fuel drain line restriction • Intake manifold pressure • Intake air restriction • Exhaust restriction • Coolant temperature • Engine blowby • Lubricating oil pressure • Coolant pressure • Intake manifold air temperature • Turbocharger inlet air temperature.		

Engine Speed (rpm)

Use INSITE™ electronic service tool to monitor engine speed. Observe and record the engine speed. Or use digital optical tachometer, Part Number 3377462, or equivalent, to check and verify engine speed.		

Fuel Rate

Use fuel measuring device, Part Number 3376375, to measure the rate of fuel consumption. See the manufacturers instructions.	 	

Engine Blowby

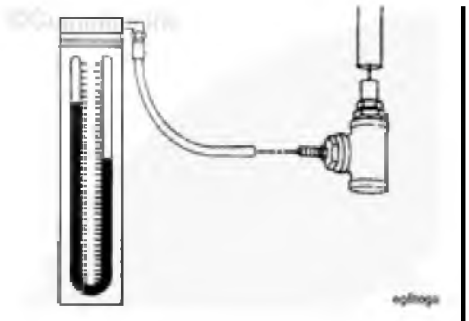
Excessive blowby indicates an air compressor, a turbocharger, or an engine malfunction, allowing combustion gases or air to enter the crankcase and build a higher than normal pressure.

This procedure describes how to measure crankcase pressure and how to determine the component that is malfunctioning.

Use one of the three blowby service tools and a water manometer, Part Number ST-1111-3. Maximum gauge capacity is 1270 mm-H $_2$O [50 in-H $_2$O].

The engine blowby tools are similar in design. The difference between the tools is in the size of the orifice.

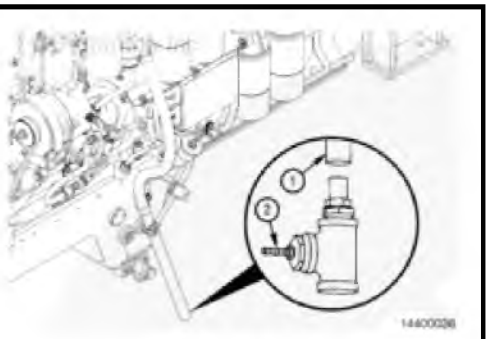
Blowby Tool	Orifice Size
Part Number	inch
3822566	0.302
3822567	0.354
3822568	0.406



Use a length of hose (1) to attach the blowby tool to one of the crankcase breathers.

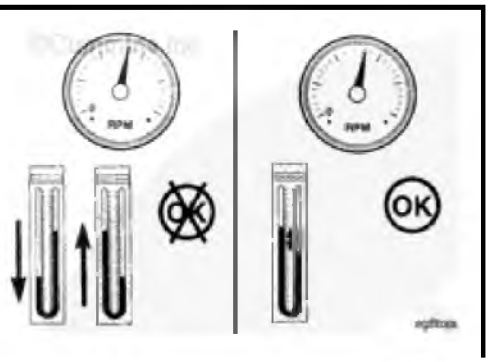
Plug all the other breathers.

Attach a manometer to the location shown (2).



Operate the engine at rated rpm and full load (wide open throttle) until a steady reading is obtained.

Compare the blowby readings to previous readings on the engine. If previous readings for the engine are **not** available,



compare the blowby reading to new engine specifications.

A sudden increase in blowby indicates a problem. A gradual increase over a period of time is normal (due to wear of internal engine components).

NOTE: The used engine limit blowby numbers are intended to be used as a guideline only, not as a hard-set rebuild limit. A basis for engine rebuild can be derived by trending blowby over time.

NOTE: For applications with two crankcase breathers, use an orifice (same size) on both breather tubes. Plug one orifice (manometer connection point). Flow through the orifice will still occur when manometer connector is plugged.

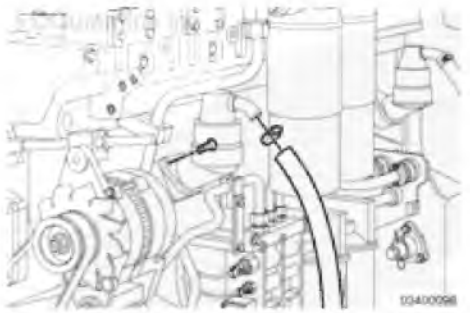
QSK23 Blowby Limits (Using one 0.302-inch-diameter orifice at rated load and speed)		
Engine hp (rpm rating)	New/Rebuilt	Used Engine Limit
CPL8353		
0 to 860 hp	453 mm H_20 [17.8 in H_20)	802 mm H_20 [31.6 in H_20)
861 to 950 hp	543 mm H_20 [21.4 in H_20)	881 mm H_20 [34.7 in H_20)
CPL8352		
All ratings	624 mm H_20 [24.6 in H_20)	900 mm H_20 [35.4 in H_20)

QSK23 Blowby Limits (Using one 0.354-inch-diameter orifice at rated load and speed)		
Engine hp (rpm rating)	New/Rebuilt	Used Engine Limit
CPL8353		
0 to 860 hp	242 mm H_20 [9.5 in H_20)	451 mm H_20 [17.8 in H_20)
861 to 950 hp	295 mm H_20 [11.6 in H_20)	500 mm H_20 [19.7 in H_20)
CPL8352		

All ratings	343 mm H_20 [13.5 in H_20)	512 mm H_20 [20.2 in H_20)

QSK23 Blowby Limits (Using one 0.402-inch-diameter orifice at rated load and speed)		
Engine hp (rpm rating)	New/Rebuilt	Used Engine Limit
CPL8353		
0 to 860 hp	109 mm H_20 [4.3 in H_20)	196 mm H_20 [7.7 in H_20)
861 to 950 hp	131 mm H_20 [5.2 in H_20)	218 mm H_20 [8.6 in H_20)
CPL8352		
All ratings	152 mm H_20 [6 in H_20)	224 mm H_20 [8.8 in H_20)

If the blowby is higher than normal, check the crankcase breathers and breather tubes to see if they are plugged.

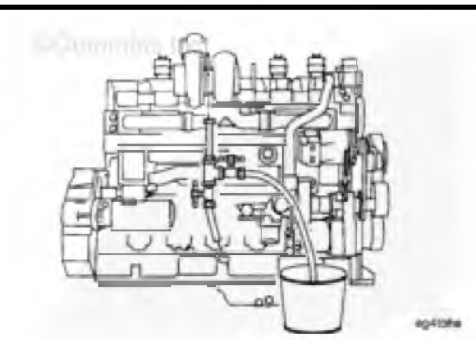


Isolate the turbocharger to determine if the high crankcase pressure is due to seal leakage in the turbocharger.

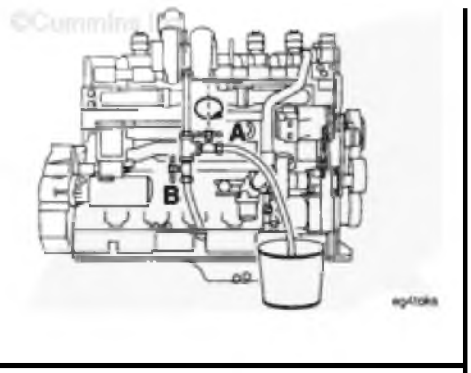
Disconnect the turbocharger drain line from the oil pan adapter.

Install a hose assembly with the two shutoff valves arranged as shown. Place the other hose in an 8 to 19 liter [2 to 5 gallon] bucket.

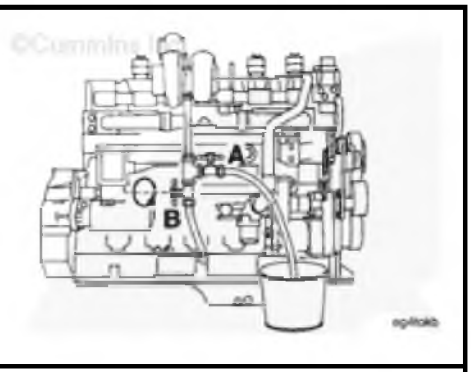
The valves **must** have a minimum inside diameter of 19 mm [0.75 in].



Close the valve (A) that allows the oil to drain into the bucket.

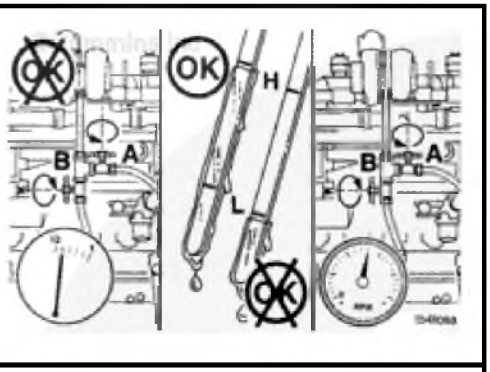


Open the valve (B) that allows the oil to drain into the engine.



CAUTION

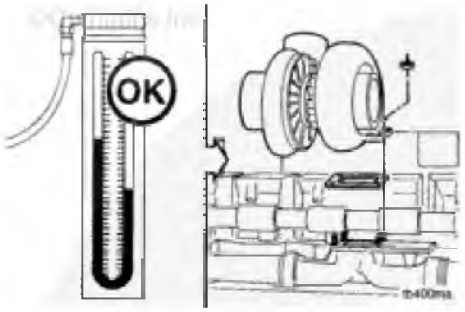
Do not operate the engine with valve A open and valve B closed for more than one minute. Operation for more than one minute can result in severe engine damage.



Operate the engine at rated speed.

Continue operating at rated speed and load. Open valve A and close valve B. Record the blowby reading.

Compare the value to the original reading. If the blowby is now acceptable, replace the turbocharger. Refer to Procedure 010-037.

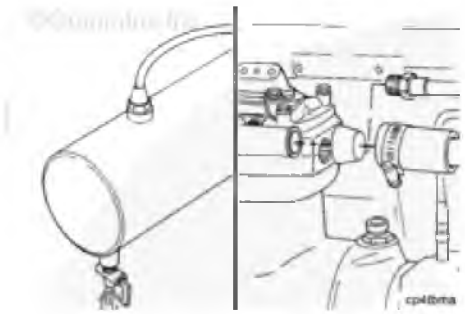


Isolate the air compressor to determine if it is malfunctioning and causing the high blowby pressure.

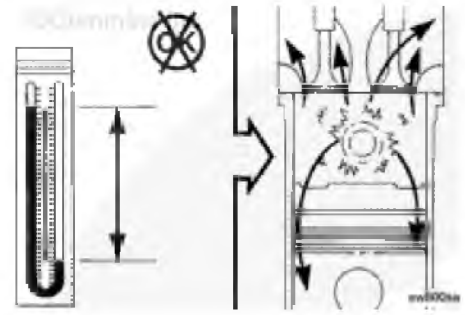
Relieve the air pressure on the first air tank in the system after the air compressor (wet tank).

Disconnect the air inlet and outlet connections. Plug the intake manifold or air piping where the inlet connection was removed.

See the OEM Service Manual.



A sudden increase in blowby or a high reading that is **not** steady indicates that there is internal damage in the engine.



Lubricating Oil Pressure

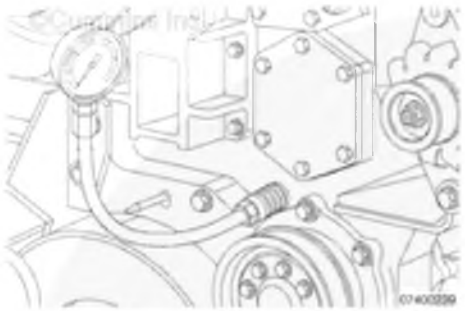
Use Pressure Gauge, Part Number 3375275, to measure lubricating oil

pressure.

Install the pressure gauge to the main oil rifle (1).

Oil pressure can be checked at other locations on the engine. Refer to Procedure 100-002 for engine views.

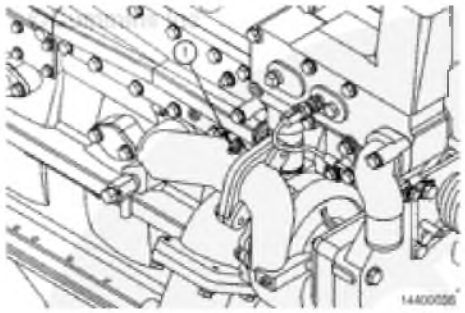
Lubricating Oil Pressure		
kpa		psi
76	MIN	11



Engine Coolant Pressure

Measure the coolant pressure at the pet cock on the water pump outlet pipe (1).

Coolant Pressure		
kpa		psi
241	MIN	35



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View Related Topic

014-006 Engine Run-in (Engine Dynamometer)

General Information

This document provides procedures for the use of an engine control, Part Number 3163890. The engine control is a portable, handheld electronic control, used to start and control engine speed on the following Cummins® electronic engine families. It replaces the throttle pedal, driver interface panel, and fault code monitoring circuits. The engine control has a datalink provision to connect to an electronic service tool to monitor engine operation and fault codes. The engine control harnesses required for the engines are purchased separately. The engine control and engine control harnesses are designed to be used with both (+) 12-VDC and (+) 24-VDC battery systems.

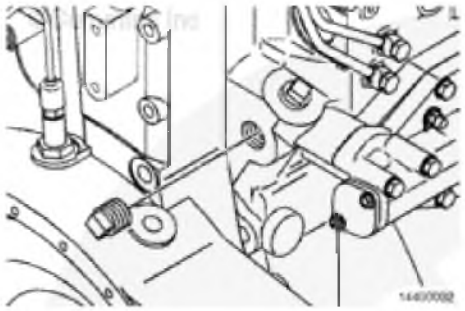
NOTE: The engine control can be used on engines with frequency throttle calibrations by first downloading a linear throttle calibration to the electronic control module (ECM). After the testing/repair is complete, reload the correct frequency throttle calibration.

Install

CAUTION

The lubricating oil system must be primed before operating the engine after rebuild to avoid internal component damage. Do not prime the system from the bypass filter as the filter will be damaged.

Remove the large plug from the oil cooler rifle.



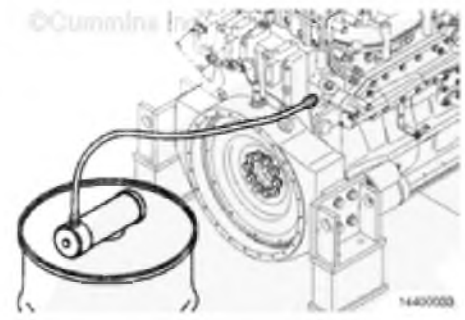
Use a pump capable of supplying 205 kPa [30 psi] continuous pressure.

Connect the pump to the oil cooler rifle, as shown.

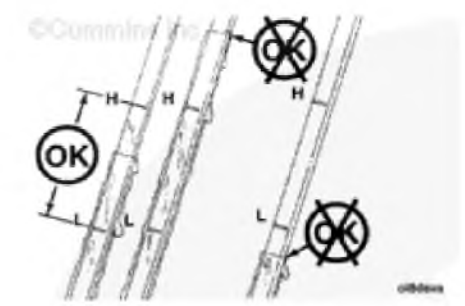
Use a supply of clean 15W-40 engine oil.

Turn the pump to the ON position.

Check the engine oil pressure gauge. When the gauge indicates oil pressure, begin monitoring the oil level in the oil pan.



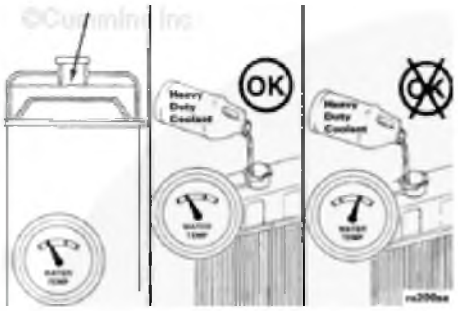
Check the engine lubricating oil level to be sure it is filled to the proper level.



WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Check the engine coolant level to make sure it is filled to the proper level. Refer to Procedure 008-018.



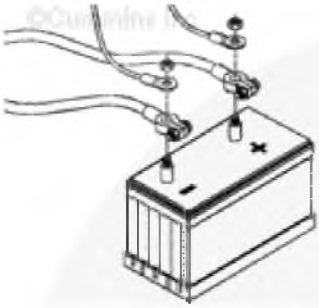
Use a known source of good quality number 2 diesel fuel.

This is very important since number 1 diesel fuels, along with most other alternate fuels, are lighter (lower specific gravity, higher API gravity) than number 2 diesel fuels. The lighter the fuel, the lower the energy content (BTU per gallon (liter, etc.).

Engine Throttle Control

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first, and attach the negative (-) battery cable last.



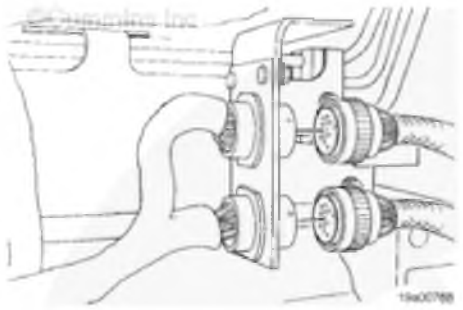
Disconnect the battery cables before beginning the following procedure.

Disconnect the OEM harness from the electronic control module (ECM) (if applicable).

Disconnect the OEM harness 21-pin and 31-pin Deutsch connectors from the engine harness.

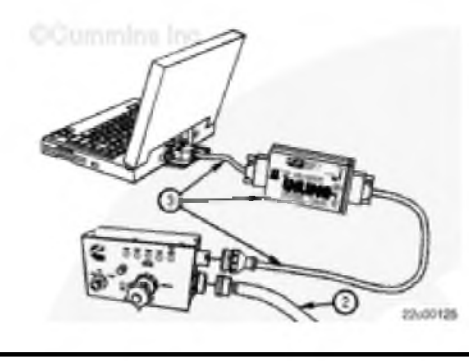
Connect the engine control harness Part Number 3163891.

Connect the engine control harness 21-pin and 31-pin Deutsch connectors to the engine wiring harness.

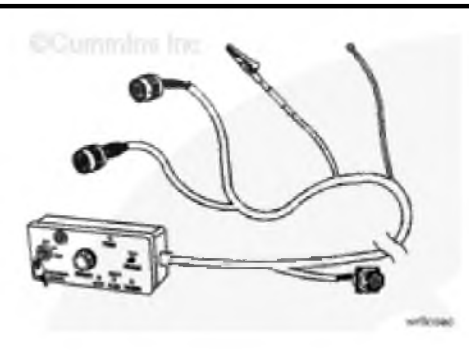


NOTE: If additional cable length is needed to connect the engine control, use electrical cable, Part Number 3163895.

Connect the engine control harness (2) to the engine control. An INSITE™ electronic service tool equipped personal computer can be used to monitor circuits for proper operation. Connect the INLINE™5 datalink adapter kit (3), Part Number 4918416, and a personal computer to the datalink connector of the engine control.

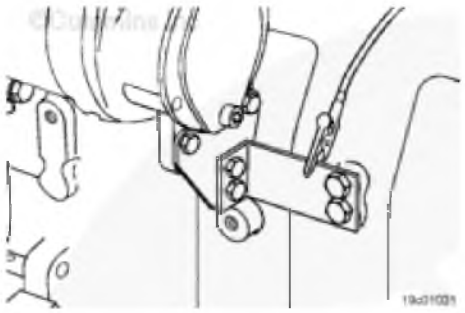


Engines that are run on an engine dynamometer require the engine harness be installed and connected to the engine. Additionally, the engine control, Part Number 3163890, **must** be used to properly control the engine during the dynamometer run.



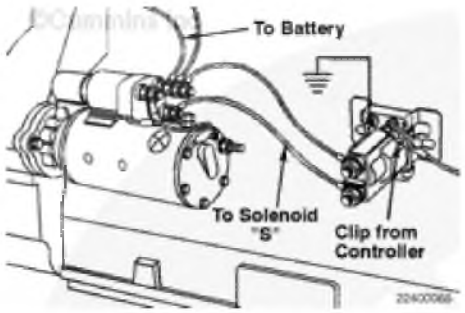
Ground Connection

Connect the black-wire alligator clip of the engine control harness to the engine block to achieve electrical ground.



CAUTION

Do not connect the alligator clip to the starter motor solenoid “S” terminal. Doing so can cause equipment damage.



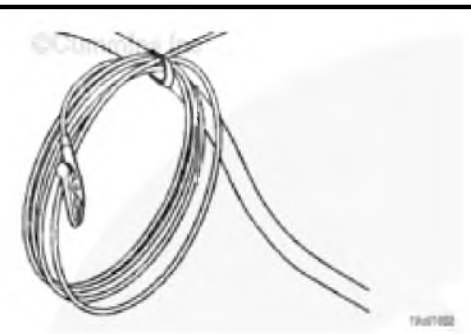
Starter Connection

If **not** already equipped, install and wire a magnetic starter switch.

Clip the alligator connector to the positive (+) coil terminal of the magnetic starter switch.

Air Starter

If an air starter is being used, coil the red wire into a loop and secure the loop to the engine control harness to protect it from an electrical short.

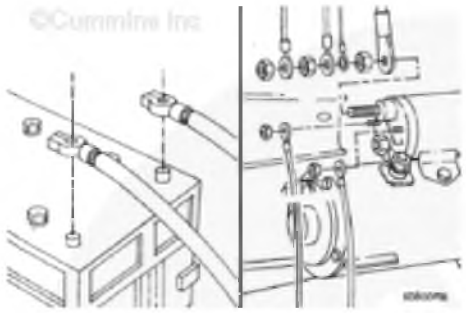


WARNING

Batteries can emit explosive gases. To avoid personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect battery power to the starter.

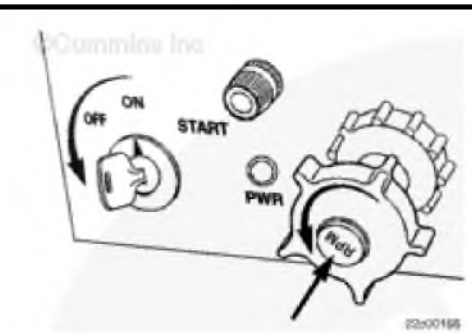
Connect the dynamometer test OEM wiring harness starter solenoid lead (yellow) to the starter solenoid. Connect the ground lead (black) to the starter solenoid. Connect the ground lead (black) to the starter or battery negative (-) or ground side. Connect the (+) 12 VDC power lead (red) to either the starter or battery positive (+) 12 VDC side.



Rotate the throttle knob fully **counterclockwise**. Push down on the throttle knob to return the throttle to the idle position.

Repeat this step three times.

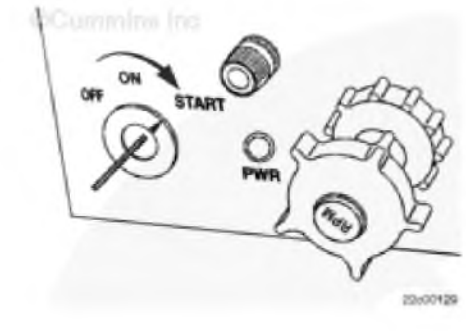
Turn the keyswitch to the OFF position for 30 seconds.



CAUTION

Check coolant and lubricating oil levels before starting and operating engine. If coolant and lubricating oil are not at the proper level engine damage can result.

Turn the keyswitch to the START position until the engine starts and release the keyswitch.



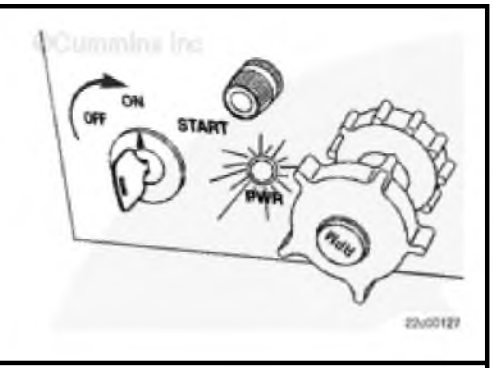
CAUTION

Verify the red wire is connected to the positive (+) battery terminal and the black wire is connected to the negative (-) battery terminal. Equipment or engine damage can result if not connected properly.

The power light will illuminate when power is supplied and the keyswitch is turned to the accessory or ON position.

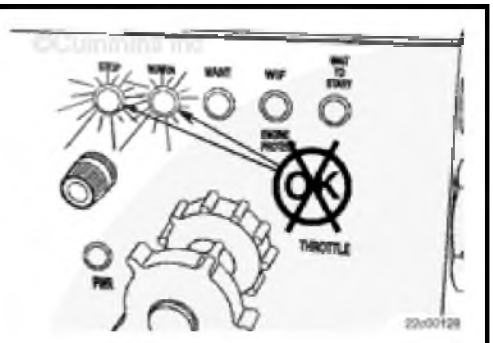
If the power light does **not** illuminate, return the keyswitch to the OFF position. Verify the red wire is connected to the positive (+) battery terminal and the black wire is connected to the negative (-) battery terminal.

Turn the keyswitch to the ON position.



Light indicators on the engine control, STOP, WARN, MAINT, WIF, and WAIT TO START, will illuminate if applicable. The light indicators will illuminate for approximately 30 seconds. If no fault codes are found, the light indicators will extinguish.

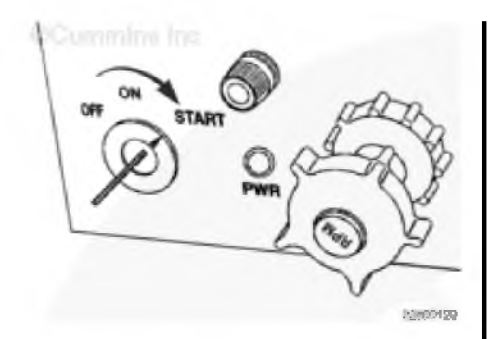
If the STOP light indicator (red) or WARN light indicator (yellow) continues to illuminate, use INSITE™ electronic service tool and the OEM service literature to diagnose the engine fault code.



CAUTION

Check coolant and lubricating oil levels before starting and operating engine. If coolant and lubricating oil are not at the proper level engine damage can result.

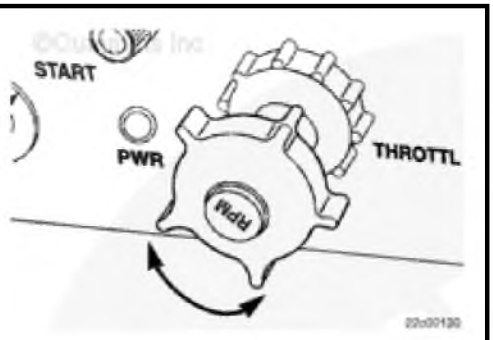
Turn the keyswitch to the START position until the engine starts and release the keyswitch.



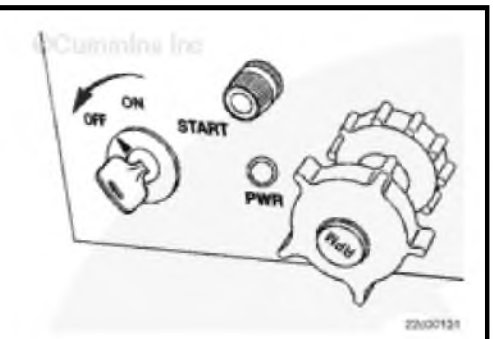
NOTE: The engine can be returned to idle at any time by pushing in on the throttle knob.

Slowly rotate the throttle knob **counterclockwise** to increase the engine rpm.

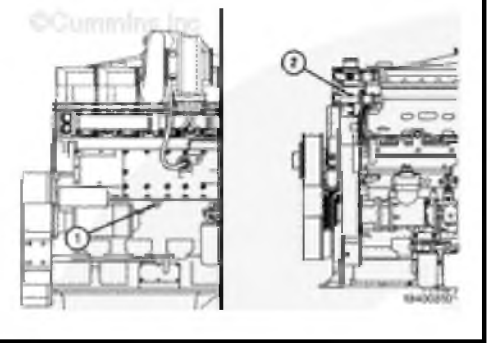
Slowly rotate the throttle knob **clockwise** to decrease the engine rpm.



Turn the keyswitch to the OFF position to stop the engine.



NOTE: Some engines are equipped with fittings used for Compucheck® testing sensors. The sensor probes used for Compucheck® and dynamometer testing are not compatible. If the same location is used, remove the Compucheck® fitting and install adapters for the



dynamometer sensor.

Install the coolant pressure sensor (1).

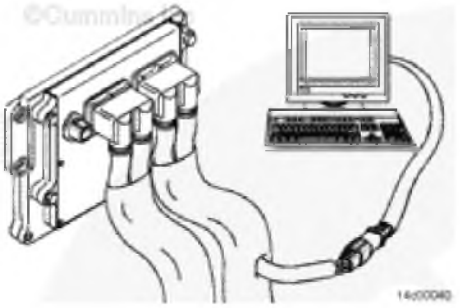
Install the coolant temperature sensor (2).

Return parameters to their original value when the test or run-in is complete.

Connect the keyswitch panel datalink cable to the Cummins electronic service tool.

Use INSITE™ electronic service tool to set the engine up for the dynamometer. Refer to Procedure 014-008 for more information on this feature.

The setup is now complete, and the auto/manual throttle can be used to control engine speed.



Engine operating specifications are available from local Cummins authorized repair locations.

Run-In Instructions

See the Engine Testing - Engine

Dynamometer, Procedure 014-005, for general operating procedures and safety precautions.

Use the following chart to determine the test load.

The run-in test **must** be performed with the engine operating at torque peak rpm. See the performance charts available through Cummins Inc.

Rated RPM	Torque Peak
2100	1300
2100	1400

CAUTION

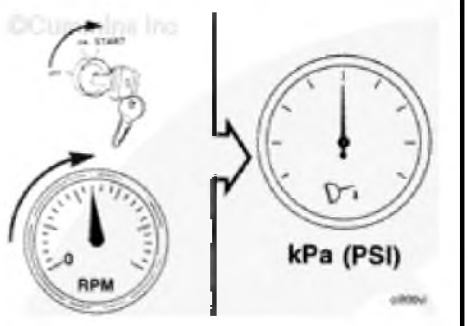
Do not crank the starting motor for more than 30 seconds. Excessive heat will damage the starter.

CAUTION

If the oil pressure is not within specifications, stop the engine immediately. Both low and high oil pressure will cause engine damage.

Start the engine. If the engine does **not** begin operating after 30 seconds, allow two minutes for the starter motor to cool.

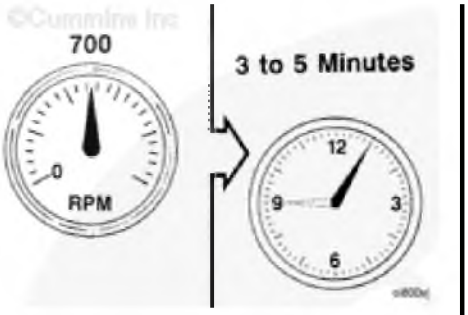
Main Oil Rifle Pressure (At Idle)		
kpa		psi
70	MIN	10



CAUTION

Do not operate the engine at idle longer than specified. Excessive carbon formation will cause engine damage.

Operate the engine in the idle position and check for leaks.

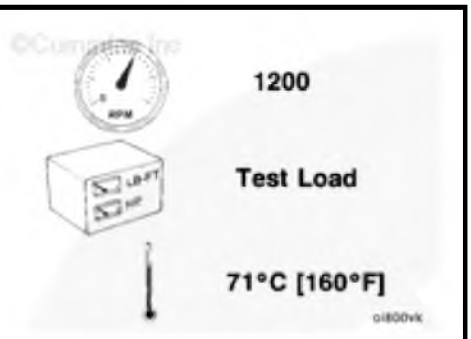


Adjust the engine rpm to 1200 rpm. Adjust the dynamometer load to the test load as previously determined. Operate the engine at this setting until the coolant temperature indicates 70°C [160°F].

Check for and fix all leaks.

Check all gauges and record the readings.

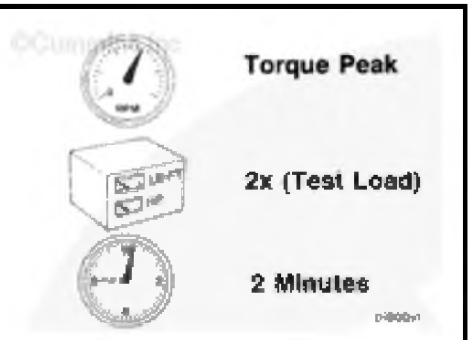
Do **not** proceed to the next step until the blowby becomes stable within specifications.



Adjust the engine rpm to the torque peak rpm. Adjust the dynamometer load to equal two times the test load. Operate the engine for two minutes.

Check all gauges and record the readings.

Do **not** proceed to the next step until the blowby becomes stable within specifications.



Maintain the engine rpm at torque peak rpm. Increase the dynamometer load to equal three times the test load.

Operate the engine at this load for two

minutes.

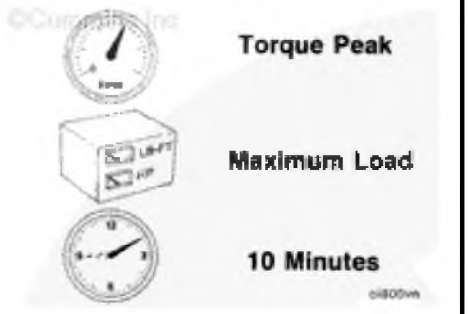
Check all gauges and record the readings.

Do **not** proceed to the next step until the blowby becomes stable within specifications.

Move the throttle lever to the full open position. Increase the load until the engine rpm is at torque peak rpm.

Operate the engine at this setting for 10 minutes or until the blowby becomes stable within specifications.

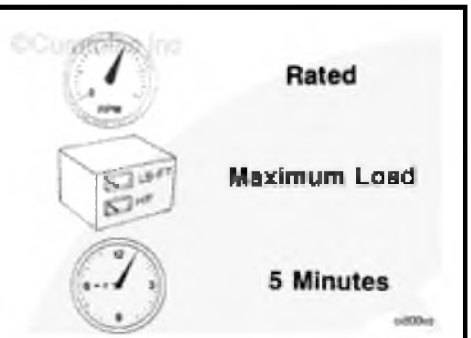
Check all gauges and record the readings.



Decrease the dynamometer load until the engine rpm increases to the rated rpm.

Operate the engine at this load for five minutes.

Check all gauges and record the readings.

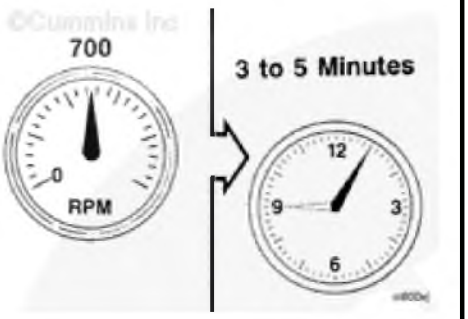


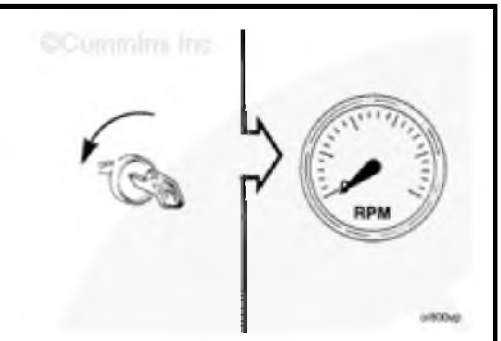
CAUTION

Do not turn the engine off immediately. The engine must be allowed to cool.

CAUTION

Do not operate the engine at idle longer



than specified. Excessive carbon formation can cause engine damage. Decrease the dynamometer load completely. Move the throttle lever to the low idle position. Operate the engine at this setting for three to five minutes. This will allow the turbocharger and the other engine components to cool.		
Turn the engine off.		

Last Modified: 26-Jun-2006

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014-008 Engine Testing (In Chassis)

Stall Speed Check

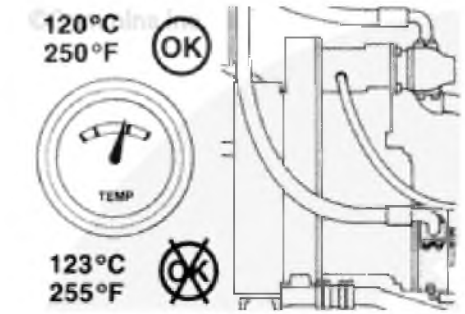
The stall speed is the engine speed (rpm) obtained at full throttle when the converter output shaft is locked.

The vehicle brakes do **not** always hold an electronically controlled transmission.

CAUTION

Do not exceed 120°C [250°F] converter oil temperature or damage to the converter can result.

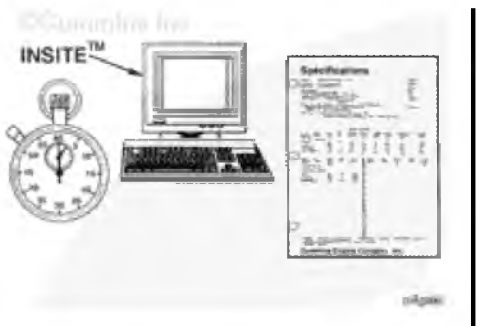
If the oil temperature exceeds 120°C [250°F], put the transmission in neutral and operate the engine until the oil temperature is below 120°C [250°F]. Check the converter oil level.



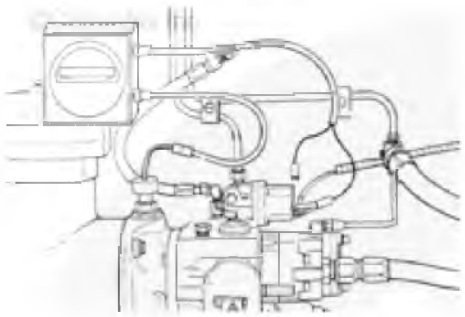
The following equipment is needed for this check:

- Stop watch

- INSITE™ electronic service tool or a handheld optical tachometer
- Equipment manufacturer's stall speed and time to stall specifications.

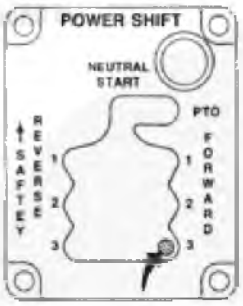


Monitor the engine RPM with an INSITE™ electronic service tool.



Put the gear selector in the highest gear or full forward.

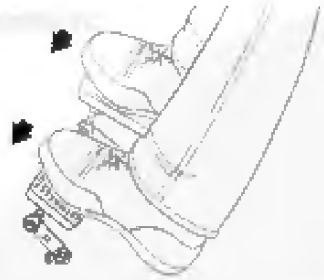
In some types of equipment it is also necessary to engage the hydraulics.



Be sure the vehicle has good brakes and air pressure in the brake system.

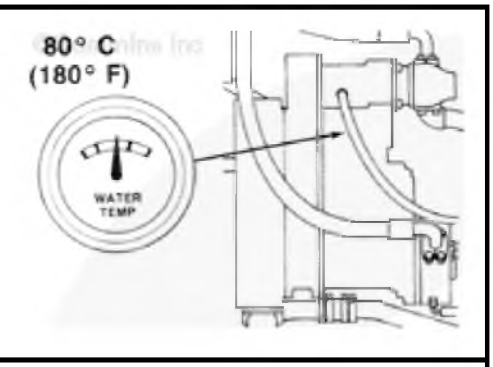
The brakes **must** prevent the vehicle from moving when the engine is at full throttle.

Engage the vehicle brakes or keep the vehicle from moving.

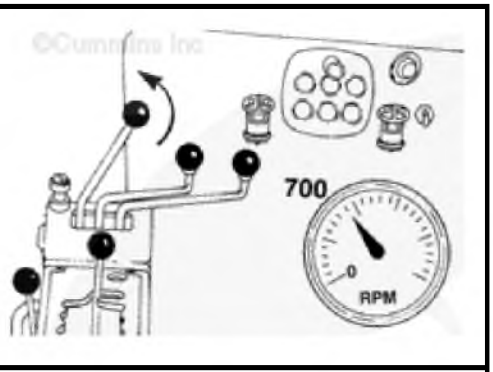


Operate the engine until the coolant temperature is up to 70°C [160°F] and the converter temperature is 80°C [180°F] or above.

Alternately, shift from neutral to the highest speed gear possible and operate at part throttle. This will warm the entire system uniformly.



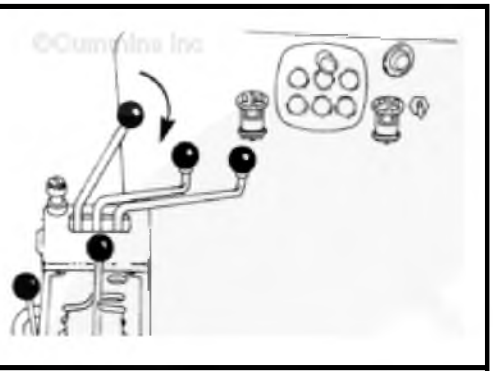
Bring the engine speed back to low idle.



CAUTION

Do **not** exceed 120°C [250°F] converter oil temperature or damage to the converter can result.

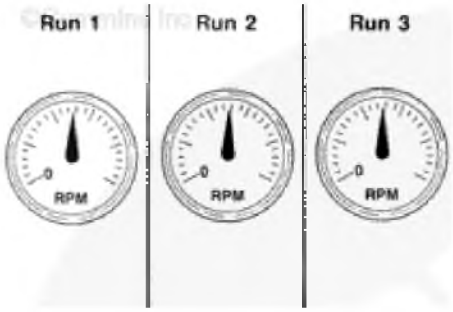
Move the throttle to the full open position. Do **not** perform this test for more than 15 seconds. If the engine speed continues to slowly increase, the torque converter fluid is being overheated.



Check the engine speed (rpm) at the point of stall.

Always hold the speed until it is stable.

Take several readings. Be sure the reading is accurate.



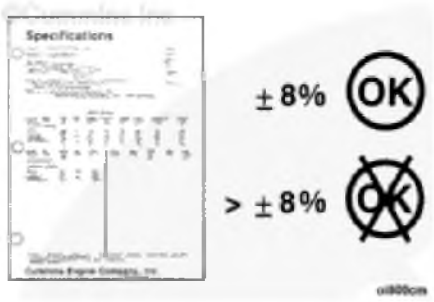
Check the stall speed (rpm) against the specifications that are for the equipment, converter, or automatic transmission.

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 Check List.

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

If the cause for the stall speed being too low is low engine power output, refer to the Engine Power Output Low Troubleshooting Chart. Make the correct repair based on the fuel rate, fuel pressure, and intake manifold pressure readings.

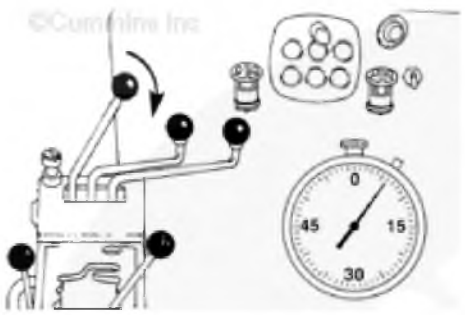


Time Speed Check

After performing the Stall Speed Check through the torque converter fluid being overheated, calculate the engine stall speed.

Example: Stall speed 2089 (2089 x 0.90 = 1880 rpm).

Quickly move the throttle to the full open position and start the stop watch at the same time.



When the engine speed is 90 percent (90%) of the stall speed rpm, stop the stop watch.

NOTE: The type of unit and the stall speed rpm will be different for different types of equipment. Most types have a stall speed between 8 and 12 seconds.

Check the equipment manufacturer's specifications for the time to stall or the acceleration time.

If the time is excessive, refer to Troubleshooting Symptoms Charts, Engine Acceleration/Response Poor.

Stall Speed Check List

Do **not** change the fuel rate to solve low stall speed. Determine the true cause to

prevent an over-fueled engine with poor durability.

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].
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. Society of Automotive Engineers (Example: SAE 30 instead of SAE 10).
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 unit is operating at an altitude high enough to affect the engine power.
9			The converter charging pressure is correct.
10			The tailshaft governor is interfering with and preventing a full throttle opening. (Disconnect the tailshaft governor.)
11			The converter blading is interfering or in a stage of failure. Check the sump or filter for metal particles.
12			The converter stators are free-wheeling instead of locking.
13			The engine is set for power other than that specified on the power curve.
14			The converter is wrong, due to improper build or rebuild of unit.
15			The converter is performing to the published absorption curve.
16			The engine and converter match is correct. Check the engine and converter models for the proper match.
17			The engine is matched to an oversized converter. (If this condition is believed to exist, please report the engine-converter-accessory information to the factory.)
18			The engine power is down. (The engine torque rise could be less than shown on the standard engine curve.) See the fuel setting adjustments and the turbocharger air manifold pressure check.

It is sometimes easier to change the engine fuel rate than to determine the true cause for low stall speed, but the customer ends up with an overfueled engine that will also

reduce durability. Do **not** increase the fuel rate as a overall fix. If the stall speed is too high, check the following:

	Yes	No	
1			The engine is high in power.
2			The tachometer is in error.
3			The accessory power requirements are less than 10 percent of the gross engine power.
4			The converter oil is aerating (foaming) - check for low oil level, air leaks in suction line, oil does **not** contain a foam inhibitor, or suction screen or filter. (Should be accompanied by a noticeable loss of machine performance.)
5			The converter is being held at full stall. Check for a slipping front disconnect clutch or a rotating output shaft. On the converter-transmission package, this can be impossible to check.
6			The converter turbine element is beginning to fail and losing blades or the converter was originally built with the wrong size element.
7			The engine and converter match is correct (due to a revision in the engine rating or the converter performance).
8			On the transmission-converter units with oil sump in the transmission, if the oil level is too high, it can cause severe aeration due to parts dipping in the oil.
9			The converter is performing to the published absorption curve.
10			The converter charging pressure is correct.

The reasons for abnormal stall speeds listed above are some which have been encountered by Cummins representatives and probably do **not** include all possible causes. The correction of the problem is either covered in the vehicle service manual, the converter service manual, or is self-explanatory.

Last Modified: 19-Jun-2003

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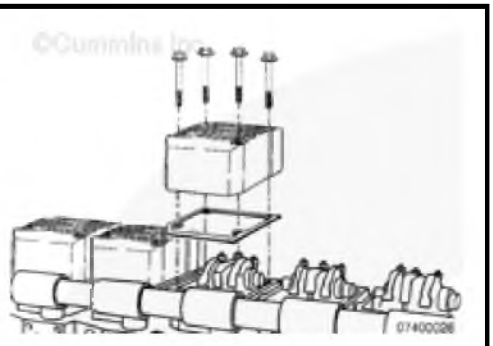
View Related Topic

014-012 Engine Compression

Preparatory Steps

- Remove the rocker lever cover. Refer to Procedure 07-04 in the Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 003-011 in the Troubleshooting and Repair Manual QSK19 Series Engines, Bulletin 3666098. Refer to Procedure 07-04 in the K38 and K50 Troubleshooting and Repair Manual, Bulletin 3810432. Refer to Procedure 003-011 in the QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual, Bulletin 3666261. Refer to Procedure 003-011 in the Troubleshooting and Repair Manual QSK78 Series Engines Bulletin 3666727. Refer to Procedure 003-011 in the Troubleshooting and Repair Manual QSK23 Series Engines, Bulletin 4021375.



- Remove the rocker lever assembly. Refer to Procedure 07-09 Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 003-009 Troubleshooting and Repair Manual QSK19 Series Engines, Bulletin 3666098. Refer to Procedure 07-09 in the K38 and K50 Troubleshooting and Repair Manual,

Bulletin 3810432. Refer to Procedure 003-009 in the QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual, Bulletin 3666261. Refer to Procedure 003-009 in the Troubleshooting and Repair Manual QSK78 Series Engines Bulletin 3666727. Refer to Procedure 003-009 in the Troubleshooting and Repair Manual QSK23 Series Engines, Bulletin 4021375.

- Remove the injector. Refer to Procedure 05-09 in the Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 006-026 in the Troubleshooting and Repair Manual QSK19 Series Engines, Bulletin 3666098. Refer to Procedure 05-09 in the K38 and K50 Troubleshooting and Repair Manual, Bulletin 3810432. Refer to Procedure 006-026 QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual, Bulletin 3666261. Refer to Procedure 006-026 in the Troubleshooting and Repair Manual QSK78 Series Engines Bulletin 3666727. Refer to Procedure 006-026 in the Troubleshooting and Repair Manual QSK23 Series Engines, Bulletin 4021375.

- Establish top dead center (TDC) on the compression stroke. Refer to Procedure 07-20 in the Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 006-025 in the Troubleshooting and Repair Manual QSK19 Series Engines , Bulletin 3666098. Refer to Procedure 07-18 in the K38 and K50 Troubleshooting and Repair Manual, Bulletin

3810432. Refer to Procedure 006-025 in the QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual , Bulletin 3666261. Refer to Procedure 006-025 in the Troubleshooting and Repair Manual QSK78 Series Engines , Bulletin 3666727. Refer to Procedure 006-025 in the Troubleshooting and Repair Manual QSK23 Series Engines , Bulletin 4021375.

Continue to rotate the crankshaft until the piston passes TDC and is 12.7 mm [0.50 inch] after top dead center (ATDC).

Rotate the crankshaft in the opposite direction to raise the piston 6.35 mm [0.250 inch] below TDC.

Setup

Install the appropriate air fitting (supplied with the differential pressure tester, Part Number 3824223) into the top of the leak test adapter with thread sealing tape.

Check all o-rings for cracks or damage prior to each cylinder test and replace if necessary.

Lubricate the o-rings and leak test adapter with 15W-40 lubricating oil.

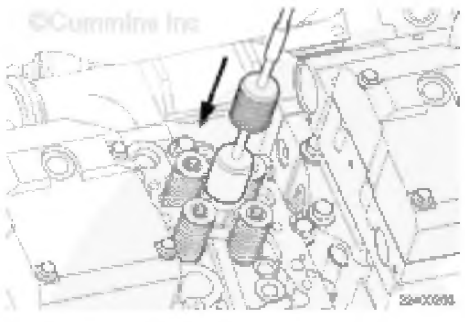
NOTE: If the injector installation tool, Part Number 3824830, is not available, use a 40 mm [1 9/16-inch] socket with

an extension and a rubber mallet to install the leak test adapter.

Install the leak test adapter and hold-down clamp into the cylinder head.

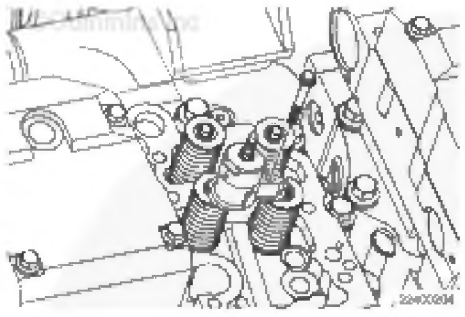
Use injector installation tool, Part Number 3824830, to seat the leak test adapter in the bore.

The slide hammer will make a dull sound when the leak test adapter is seated properly.



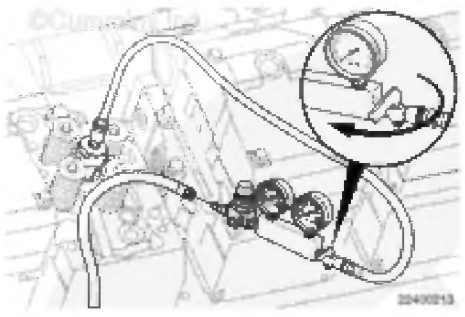
Install the injector hold-down clamp and capscrew.

Torque Value: 54 n.m [40 ft-lb]



NOTE: The crankshaft breather is not to be obstructed during this test, do not install plugs or orifices as used in traditional blowby tests.

Close the ball valve on the differential cylinder pressure tester, Part Number 3824223. Connect the differential cylinder pressure tester outlet hose to the fitting on the leak test adapter.



Pressure Differential Test

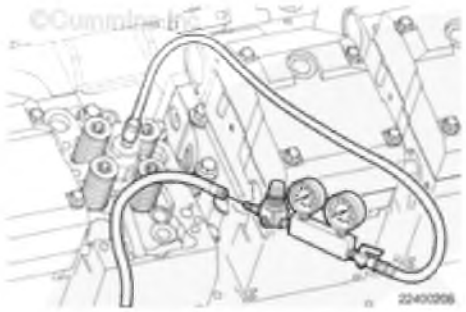
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Connect the differential cylinder pressure tester inlet hose to shop air.

Open the differential pressure tester ball valve slowly, taking careful note of any crankshaft rotation. If any rotation is apparent, the piston will **not** be correctly positioned in the cylinder. If the piston is correctly positioned in the cylinder and the engine crankshaft still rotates, the engine barring mechanism **must** be locked to prevent engine rotation.

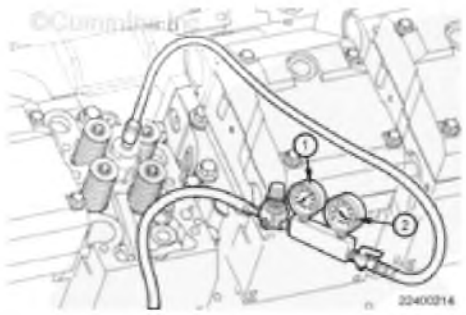
Make certain that there are no leaks at any connection joint.



Pressurize the cylinder and adjust the regulator on the differential pressure tester until gauge (1) indicates 100 psi [689 kPa]. When the reading on gauge (2) has stabilized, record the pressure reading of both gauges and record the cylinder number and bank.

If at any time during the test the reading on gauge (2) is **not** stable, lightly tap the tops of the engine valves with a rubber mallet to make certain that they are closed. If the reading on gauge (2) remains unstable, repeat positioning procedure described earlier.

Position each remaining cylinder and test.

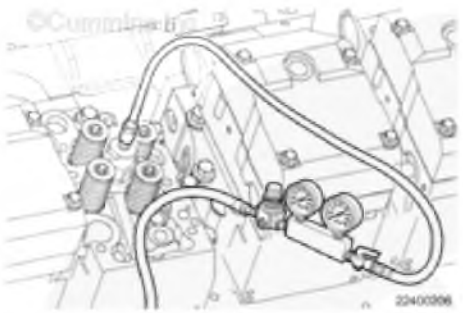


The leakdown test can be used to determine the relative condition of a cylinder when compared to other cylinders in the engine. The leakdown test can also help diagnose the source of the leak or blowby. This includes, but is **not** limited to, air flow from the breather (worn cylinder), air flow in the intake or exhaust manifold (leaking valves) or air bubbles in the coolant (leaking cylinder head gasket, cylinder head crack or cylinder block crack).

Before taking any action based on leakdown test results, repeat the leakdown test for the suspect cylinder and compare to the original results. Factory leakdown limits will **not** be established, cautious judgment **must** be used before replacing parts or taking any action due to results from the leakdown test.

Additionally, the test results subject to comparison need to be obtained within a relatively short time frame. Leakdown test results are expected to vary depending on engine temperature. Because of this, comparing leakdown results from different engines is **not** recommended.

Remove the differential pressure tester and leak test adapter.



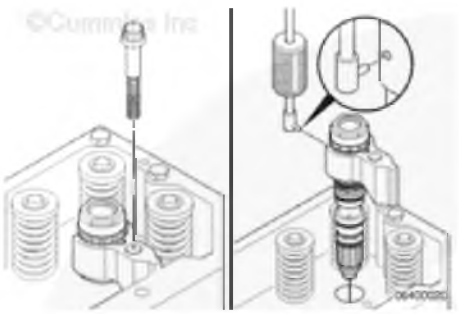
Finishing Steps

- Install the injector. Refer to Procedure 05-09 in the Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 006-026 in the

Troubleshooting and Repair Manual QSK19 Series Engines, Bulletin 3666098. Refer to Procedure 05-09 in the K38 and K50 Troubleshooting and Repair Manual, Bulletin 3810432. Refer to Procedure 006-026 QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual, Bulletin 3666261. Refer to Procedure 006-026 in the Troubleshooting and Repair Manual QSK78 Series Engines Bulletin 3666727. Refer to Procedure 006-026 in the Troubleshooting and Repair Manual QSK23 Series Engines, Bulletin 4021375.

- Install the rocker lever assembly. Refer to Procedure 07-09 Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 003-009 Troubleshooting and Repair Manual QSK19 Series Engines, Bulletin 3666098. Refer to Procedure 07-09 in the K38 and K50 Troubleshooting and Repair Manual, Bulletin 3810432. Refer to Procedure 003-009 in the QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual, Bulletin 3666261. Refer to Procedure 003-009 in the Troubleshooting and Repair Manual QSK78 Series Engines Bulletin 3666727. Refer to Procedure 003-009 in the Troubleshooting and Repair Manual QSK23 Series Engines, Bulletin 4021375.

- Install the rocker lever cover. Refer to Procedure 07-04 in the Troubleshooting and Repair Manual K19, Bulletin 3810307. Refer to Procedure 003-011 in the Troubleshooting and Repair Manual QSK19 Series Engines, Bulletin 3666098. Refer to Procedure 07-04 in the K38 and K50 Troubleshooting and Repair Manual, Bulletin



3810432. Refer to Procedure 003-011 in the QSK45 and QSK60 Base Engine Troubleshooting and Repair Manual, Bulletin 3666261. Refer to Procedure 003-011 in the Troubleshooting and Repair Manual QSK78 Series Engines Bulletin 3666727. Refer to Procedure 003-011 in the Troubleshooting and Repair Manual QSK23 Series Engines, Bulletin 4021375.		

Last Modified: 29-Mar-2004

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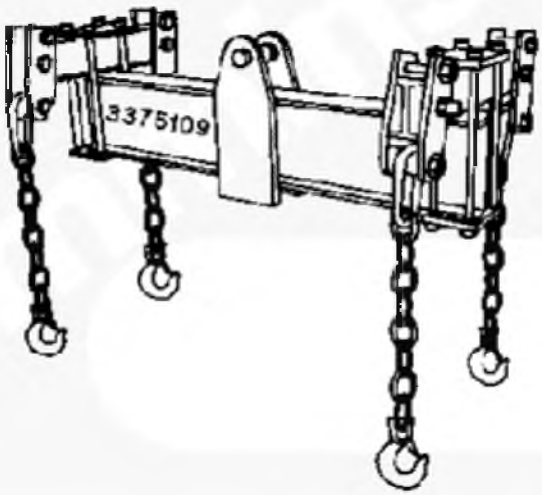
022-001 Service Tools

Mounting Adaptations

Tool Number		
3163264	**Engine Lifting Fixture** This heavy-duty lifting fixture, or its equivalent, is required for lifting the QSK23 Series engine.	 3375109

Last Modified: 30-May-2003

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016-002 Engine Support Bracket, Front

Preparatory Steps

WARNING

This component weighs 23 kg [50 b] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

- Install the engine lifting fixture, Part Number 3163264, or its equivalent.
- Remove fan shroud. Refer to manufacturer's instructions and specifications.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove vibration damper. Refer to Procedure 001-052.
- Unfasten the engine support from the chassis.
- Use a hoist to lift the weight of the engine off the front support.

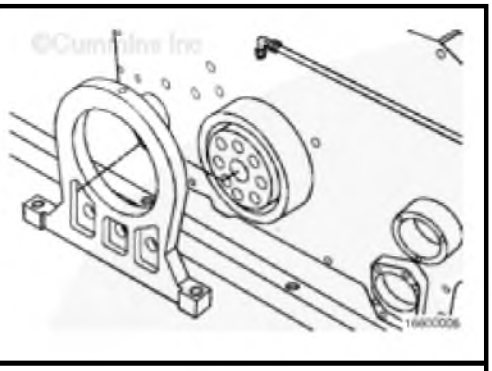
Remove

Industrial Applications

WARNING

This component weighs 23 kg [50 b] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

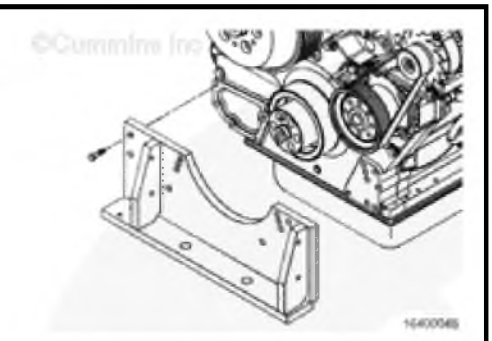
Remove the front engine support.



Power Generation

Remove the 12 capscrews securing the engine support to the front cover.

Use a mallet to gently tap the engine support off the dowel pins.

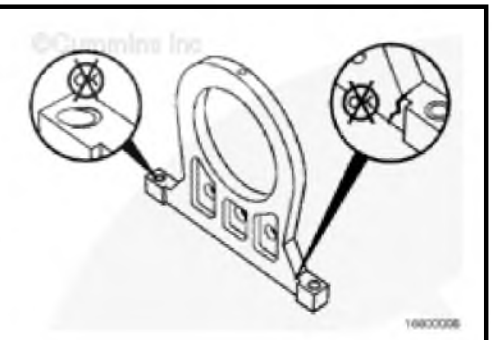


Clean and Inspect for Reuse

WARNING

This component weighs 23 kg [50 b] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

CAUTION



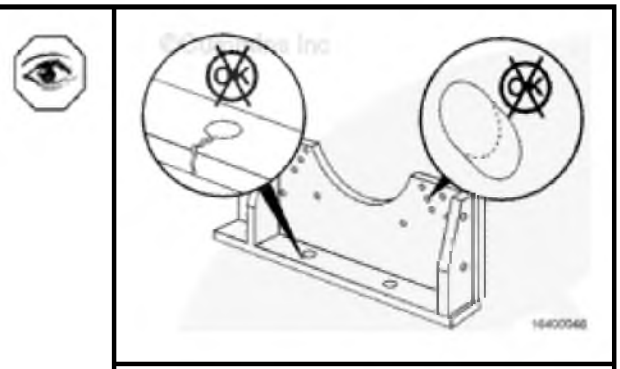
Damaged engine mounts and brackets can cause the engine to move out of alignment, damage the drivetrain components in the equipment, and result in vibration complaints.

Clean and check the support for reuse.

Inspect the front engine mount for cracks or damage.

Power Generation

Inspect all mounting brackets for cracks or damaged bolt holes.

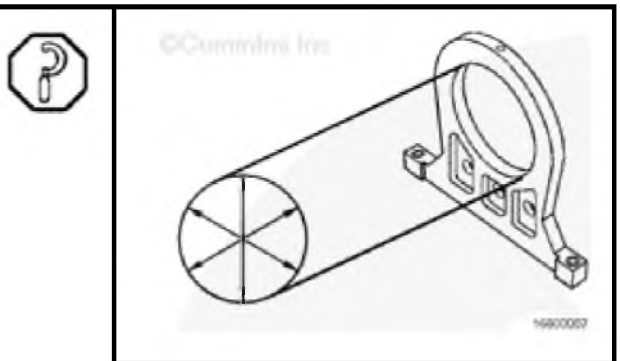


Measure

Industrial Applications

Measure the front support bore.

Front Support Bore		
mm		in
180.00	MIN	7.087
180.10	MAX	7.091



Install

Industrial Applications

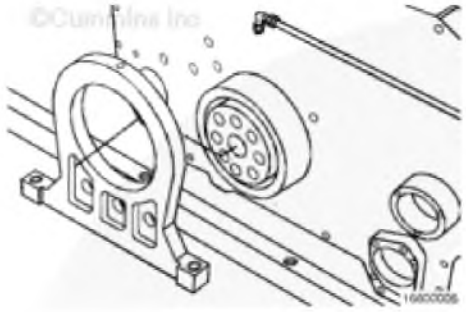
WARNING

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

Install the support onto the front cover.

Lower the engine until the front engine support is in position.

Install and tighten the capscrews. Refer to the equipment manufacturer's instructions.



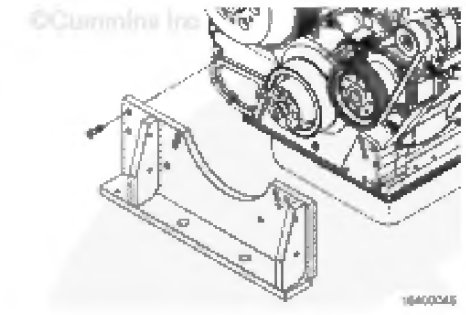
Power Generation

WARNING

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

Install the front engine support onto the dowel pins in the front cover.

Install the 12 capscrews into the engine



support. **Torque Value:** 113 n.m [85 ft-lb]		

Finishing Steps

WARNING This component weighs 23 kg [50 b] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component. • Fasten the engine support onto the chassis. Refer to the equipment manufacturer's instructions for torque specifications. • Install the vibration damper. Refer to Procedure 001-052 • Install the fan belt. Refer to Procedure 008-002. • Install the fan shroud. Refer to manufacturer's instructions and specifications. • Remove engine lift fixture, Part Number 3163264, or equivalent.		

Last Modified: 28-Jul-2003

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016-005 Flywheel

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

- Disconnect the batteries to prevent accidental engine starting. Refer to Procedure 013-007 in Section 13.
- Remove the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.

Remove

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

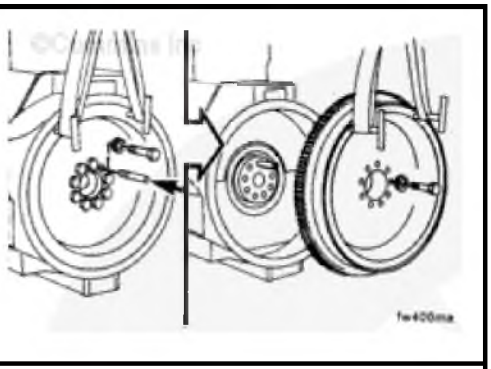
Use two 10 - 22 x 1.5 mm guide studs to prevent the flywheel from rotating. Remove two capscrews and install the guide studs.

Use a hoist, two tee handles, and a lifting sling. Install the tee handles.

Remove the remaining capscrews.

Remove the flywheel.

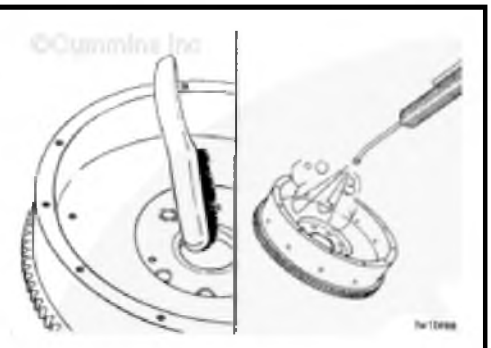
Use a mallet to tap the flywheel from the crankshaft, if necessary.



Clean and Inspect for Reuse

WARNING

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



WARNING

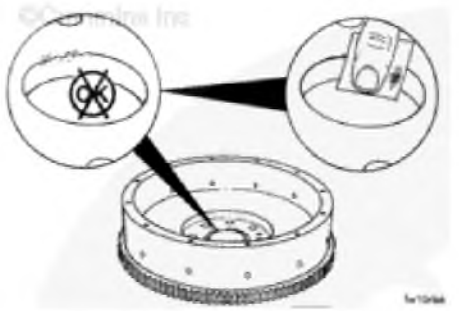
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use a wire brush to clean the crankshaft pilot bore.

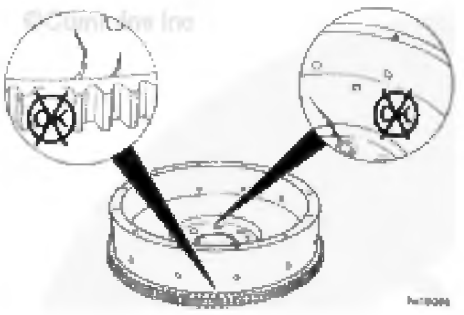
Use steam or solvent to clean the flywheel and capscrews.

Dry with compressed air.

Inspect the flywheel pilot bore for nicks or burrs. Use a crocus cloth to remove small nicks and burrs.

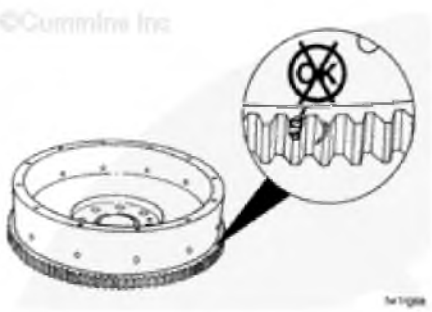


Inspect the flywheel for cracks.



Inspect the flywheel ring gear teeth for cracks and chips.

If the ring gear teeth are cracked or broken, the ring gear **must** be replaced.



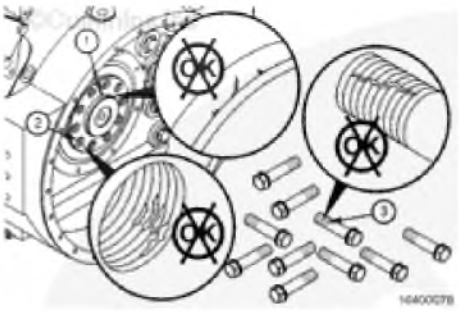
Inspect the crankshaft pilot (1) and the ten threaded capscrew holes (2) for burrs, thread damage, or other damage.

If damage to the threaded holes or the pilot is found, the crankshaft may need to be replaced.

Inspect the ten capscrews (3) for thread damage or burrs.

If damage to the capscrew threads is found, the capscrews **must** be replaced.

NOTE: Count the number of punch-marks on the head of the capscrew. If 5 marks are present, the capscrew must be replaced.



Install

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of

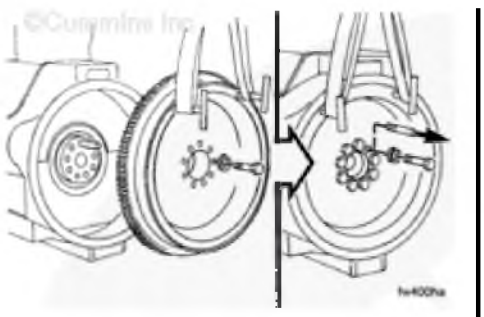
personal injury, use a hoist or get assistance to lift this assembly.

CAUTION

The flywheel mounting capscrews must be a minimum of SAE grade 8 with rolled threads. The flywheel mounting washers are hardened plain washers. Use identical replacement parts or damage to the flywheel and drivetrain can occur.

Lubricate the capscrews and washers with clean SAE 30 engine oil. Allow the excess oil to drip off the capscrews. Do **not** lubricate the threads in the crankshaft.

A guide stud will help during assembly. Install the flywheel, washers, and capscrews. The flywheel **must** be firmly against the crankshaft.



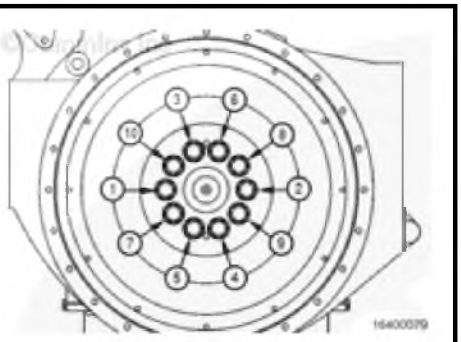
Use the following steps and the torque sequence shown to install the flywheel.

Torque Value:

1. 200 n.m [148 ft-lb]
2. 460 n.m [339 ft-lb]
3. Tighten 90 degrees

Mark the head of each capscrew with a punch-mark each time it is completely tightened.

NOTE: Capscrews must not be reused after five punch marks are present on the capcscrew head.



Measure

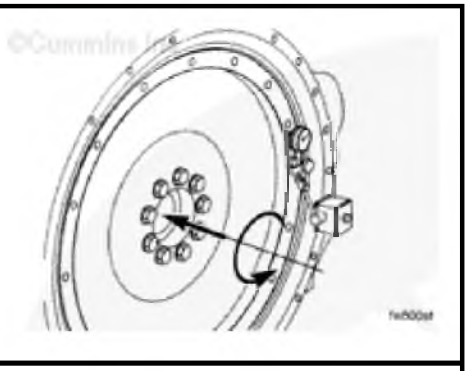
Measure the face runout of the flywheel.

NOTE: The crankshaft end clearance must be pushed or pulled in the same direction each time a point is measured.

Attach an indicator as shown. Measure the flywheel alignment at four equally spaced points.

Measure the distance from the center of the crankshaft to the indicator tip. Multiply the distance by 0.001 to obtain the maximum face runout.

If the flywheel face runout is **not** within specifications, check for interference between the flywheel and the crankshaft.



Measure the radial runout of the flywheel.

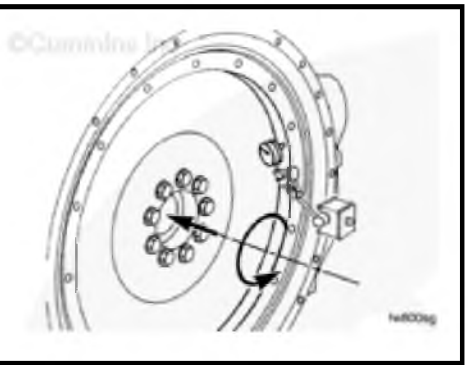
Attach an indicator as shown. Continue to look at the indicator while rotating the engine.

Flywheel Radial Runout

mm		in
0.13	MAX	0.005

If the radial runout is **not** within specification, the pilot on the flywheel is **not** positioned correctly on the crankshaft.

If the pilot is damaged, the flywheel **must** be replaced.



Finishing Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

- Install the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.
- Connect the batteries. Refer to Procedure 013-007 in Section 13.

Last Modified: 28-Jul-2010

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016-006 Flywheel Housing

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

This component weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Disconnect the batteries or air supply to the air starter to prevent accidental

engine starting. Refer to Procedure 013-009 (Battery Cables and Connections) in Section 13.

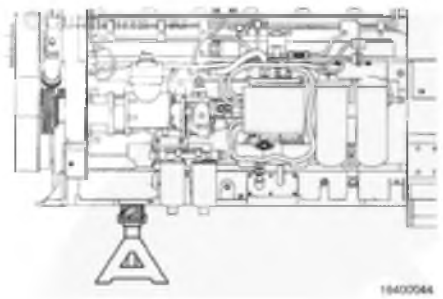
- Remove the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.
- Remove the flywheel. Refer to Procedure 016-005 (Flywheel) in Section 16.
- Remove the rear crankshaft seal. Refer to Procedure 001-024 (Crankshaft Seal, Rear) in Section 1.
- Remove the starting motor. Refer to Procedure 013-020 (Starting Motor) in Section 13.
- Drain the lubricating oil and remove the oil pan. Refer to Procedure 007-037 (Lubricating Oil Pan) in Section 7.
- Remove the stiffener plate. Refer to Procedure 001-089 (Block Stiffener Plate) in Section 1.

Remove

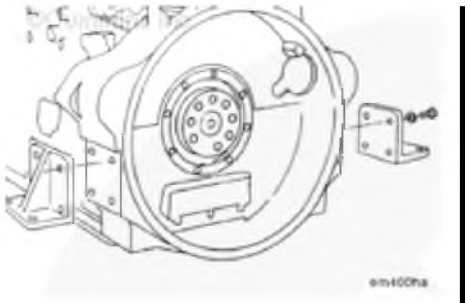
Put a wooden block the width of the engine block skirt between the floor jack and the engine block to prevent damage to the sealing surface.

Use a floor jack or a suitable lifting fixture to support the front of the engine.

Lift and support the rear of the engine with a suitable hoist.

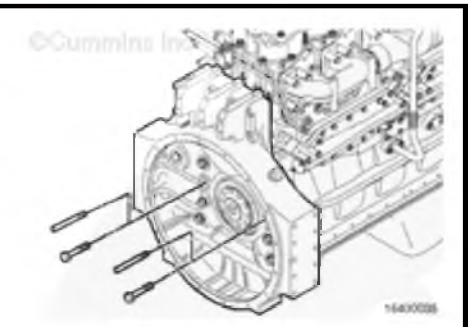


Remove the rear engine mounts from the flywheel housing.



WARNING

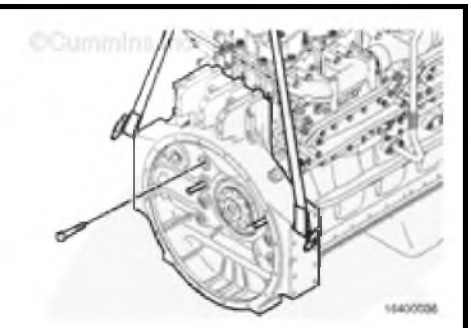
This component weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.



Use two guide studs to prevent the flywheel housing from rotating during disassembly.

Remove two capscrews.

Install the guide studs.

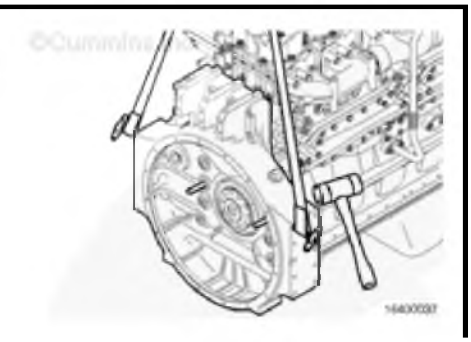


Use a hoist, T-handle, and a lifting sling.

Install the T-handles.

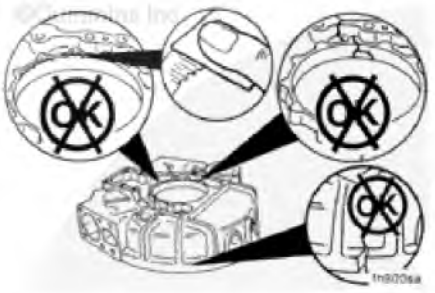
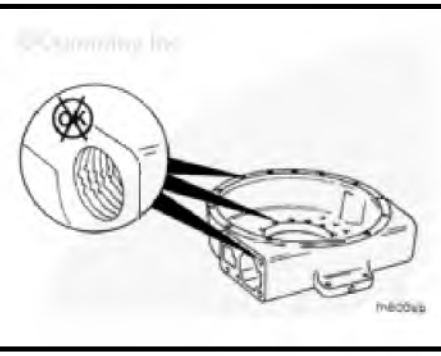
Adjust the hoist until there is tension in the lifting sling.

Remove the remaining capscrews.



Use a mallet to tap the flywheel housing off the two locating dowels. Remove and discard the gasket material.

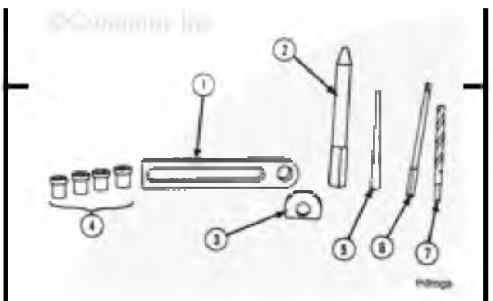
Inspect for Reuse

Inspect all surfaces for nicks, burrs, and cracks. Use a fine crocus cloth to remove small nicks and burrs.		
Inspect all threaded capscrew holes for damage. Repair or replace the housing if the capscrew holes are damaged.		

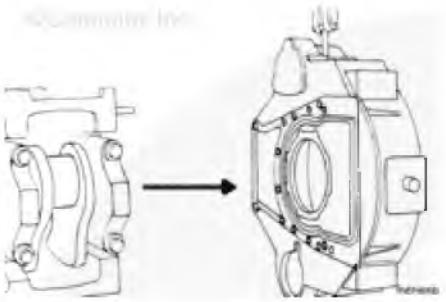
Redowel

The tools needed to perform this procedure are: Drill ream fixture, Part No. ST-1232, that contains:		

1. Plate, Part No. ST-1232-1
2. Locator pin, Part No. 3375052
3. Spacer washer, Part No. ST-1232-2
4. Drill/ream actual sizes bushing set depends on the dowel size
5. Drill adapter locally obtained; use to adapt open-shank reamers to drill-chuck
6. Reamer locally obtained
7. Drill bit locally obtained.

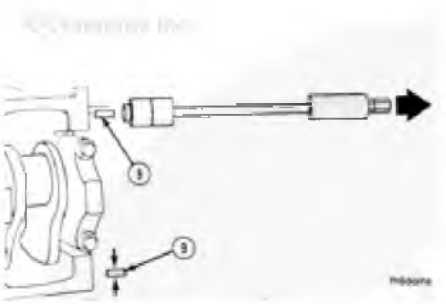


Remove the flywheel housing.



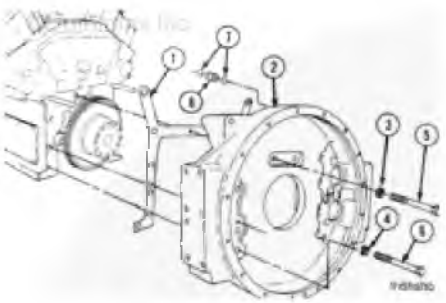
Use a dowel pin extractor, Part No. ST-1134, or equivalent. Remove the two dowels (9) from the block.

Measure a dowel pin that has been removed so that an oversize dowel pin can be determined.



Do **not** tighten the capscrews. The flywheel housing will have to be aligned.

Install the flywheel housing.

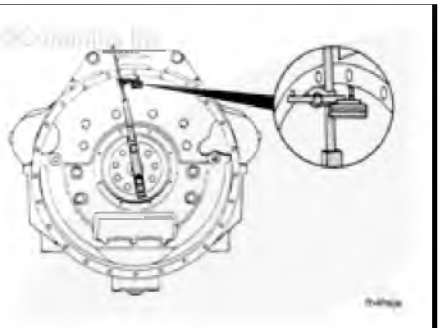


Move the housing with a mallet until the bore is within specifications. Make sure that the face of the housing is in alignment.

Measurements			
		mm	in
Flywheel Housing Inner Diameter	No. 0	648	25.5
	No. 1	511.2	20.13

Flywheel Housing - Radial Runout

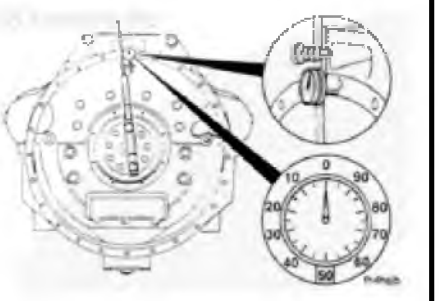
	mm		in
No. 0	0.25	MAX	0.010
No. 1	0.20	MAX	0.008



Measure the flywheel housing face runout.

Flywheel Housing - Face Runout

	mm		in
No. 0	0.25	MAX	0.010
No. 1	0.20	MAX	0.008

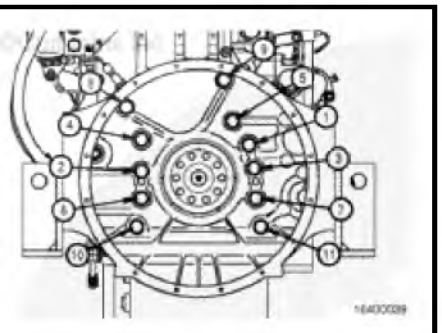


When the housing is in alignment, tighten the capscrews in the sequence shown.

Torque Value:

1. 380 n.m [280 ft-lb]
2. Loosen
3. 410 n.m [302 ft-lb]

After the capscrews are tightened, check the alignment again.



Use the appropriate capscrews.

Attach the plate, Part No. ST-1232-1, that is contained in the drill ream fixture, Part No. ST-1232, to the crankshaft.

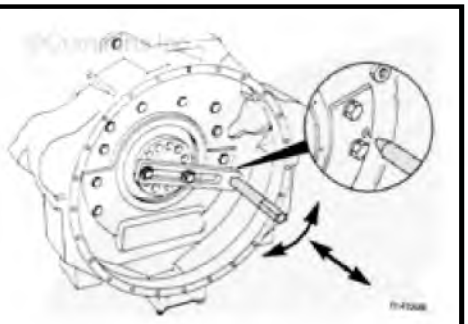
Do **not** tighten the capscrews so much that the plate does **not** move.

Use the locator pin to align the plate with the hole for the dowel pin. Tighten the capscrews. The taper on the pin **must** engage the dowel pin hole.

The locator pin **must** rotate easily after the capscrews are tightened.

The crankshaft **must** be locked in position. It **must not** turn during reaming.

"Lock" the crankshaft in position. Be sure the locator pin is still in alignment and that the locator pin can be rotated easily.

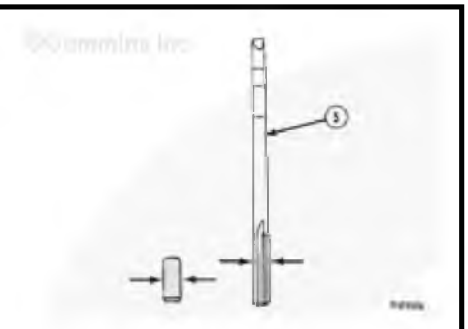


Measure the dowel pins to be installed.

Obtain a reamer (5) that is 0.013- to 0.025-mm [0.0005- to 0.001-in] smaller than the dowel.

The dowel **must** protrude from the block by one-half of the flywheel housing wall thickness.

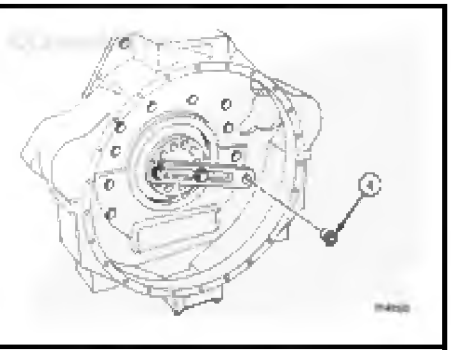
There are three oversize dowel pins available from Cummins Inc.



Measurements			
		mm	in
Oversize Dowel Pin - Outer Diameter	0.015-in Oversize	13.08	0.515
	0.030-in Oversize	13.46	0.530
	0.045-in		

Oversize	13.84	0.545	

Install the appropriate drill bushings (4). The following bushings are available from Cummins Inc.



Drill/Ream Bushing Sets - 25.4 mm [1 in]				
Oversize mm	Oversize [in]	Bushing Size	Bushing Size [mm]	Bushing Size[in]
3376495		Special	12.304	[0.4844]
		Standard	12.700	[0.5000]
0.38	[0.015]		13.096	[0.5156]
0.76	[0.030]		13.492	[0.5312]
1.14	[0.045]		13.879	[0.5464]
ST-1234		Standard	14.288	[0.5625]
0.38	[0.015]		14.684	[0.5781]
0.76	[0.030]		15.080	[0.5937]
1.14	[0.045]		15.479	[0.6094]
ST-1235		Standard	15.875	[0.6250]
0.38	[0.015]		16.271	[0.6406]
0.76	[0.030]		16.667	[0.6562]
1.14	[0.045]		17.066	[0.6719]
ST-1236		Standard	17.463	[0.6875]
0.38	[0.015]		17.859	[0.7031]
0.76	[0.030]		18.255	[0.7187]
1.14	[0.045]		18.654	[0.7344]

ST-1237		Standard	19.050	[0.7500]
0.38	[0.015]		19.446	[0.7656]
0.76	[0.030]		19.842	[0.7812]
ST-1238			22.621	[0.8906]
			23.813	[0.9375]

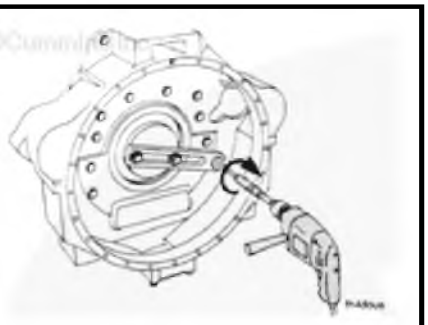
The drill bushing that is used **must** be the same size as the reamer (or the drill) that is used.

When the new dowel pins are more than 0.38-mm [0.015-in] **larger** than the old dowels, drill the hole to a size that is slightly smaller than the reamer. Then the reamer will **not** have to remove an excessive amount of material.

CAUTION

Do not allow metal chips to enter the engine. Damage to the engine will result.

Ream the hole until the reamer touches the bottom of the hole in the block.



WARNING

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

Remove the reamer. Clean the hole with solvent. Dry with compressed air. Push the reamer through the hole again. The reamer **must** touch the bottom of the hole in the block.

After reaming one hole, turn the plate and align it with the next dowel hole. Repeat the procedure in the next hole.

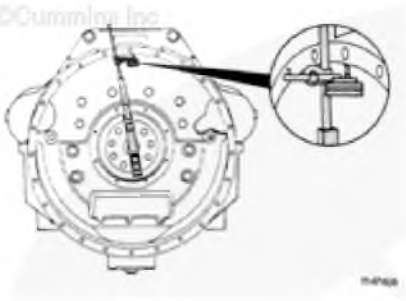
Remove the plate from the crankshaft.

CAUTION

The dowel hole must not contain any metal chips. Damage will result.

Use a square-nose drift. Push in each dowel pin until it touches the bottom of the hole in the block.

After the dowels are installed, measure the bore and the face alignment again. The specifications were given earlier in this procedure.

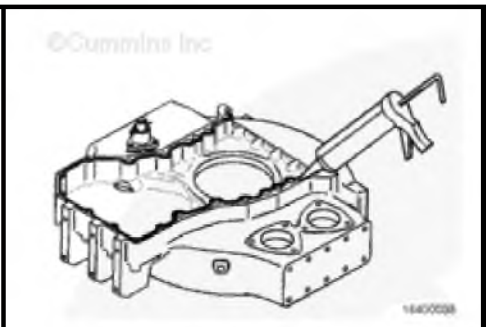


Install

WARNING

This component weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Install liquid gasket material, as shown.



Use guide bolts to help during alignment.

Install the housing and the capscrews.

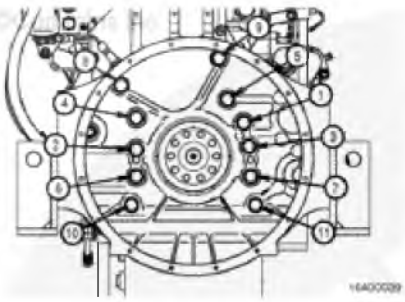
Tighten the numbered flywheel housing capscrews using the sequence shown.

Torque Value:

1. 380 n.m [280 ft-lb]
2. Loosen
3. 410 n.m [302 ft-lb]

Tighten the remaining flywheel housing capscrews **not** mentioned in sequence.

Torque Value: 100 n.m [74 ft-lb]

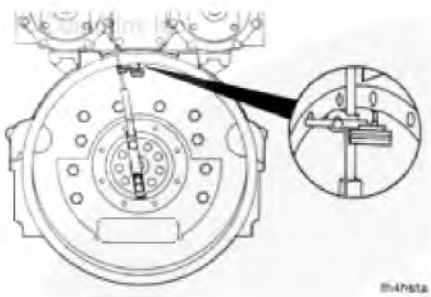


Measure the flywheel housing alignment.

The bore and the face of the housing **must** align with the crankshaft.

The indicator arm **must** be rigid for an accurate reading. It **must not** sag.

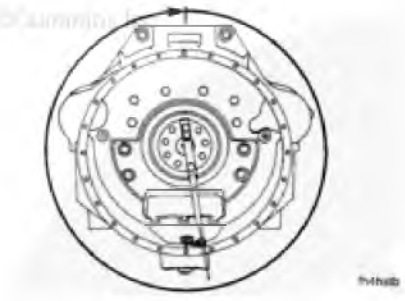
Attach an indicator to the crankshaft as shown.



Position the indicator at the 12-o'clock position. Adjust the dial until the needle points to zero. Rotate the crankshaft one complete revolution, 360 degrees.

Record the total indicator runout.

The indicator **must** return to zero when returning to the start point.



The maximum allowable total indicator runout depends on the diameter of the bore.

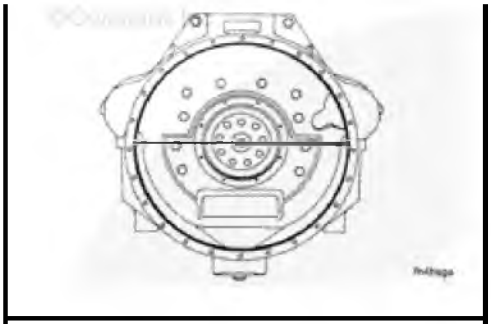
Bore Diameter/Maximum Total Indicator

Runout

	mm		in
No. 01			
0.20 mm [0.008 in]	511	MIN	20.12
	511.2	MAX	20.13
No. 0			
0.25 mm [0.010 in]	647.7	MIN	25.50
	648.0	MAX	25.51

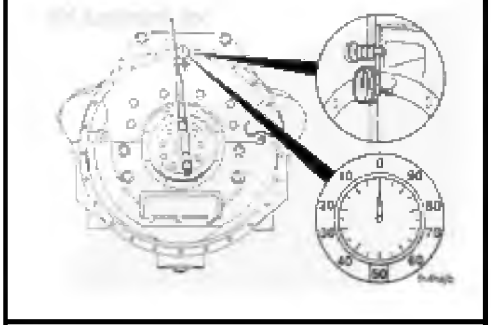
If the alignment is **not** within specifications and the bore is round, the housing can be shifted.

If the alignment is **not** within specifications and the bore is **not** round, the housing **must** be replaced.



The crankshaft end clearance **must** be pushed or pulled in the same direction each time a point is measured.

Attach an indicator as shown. Position the indicator at the 12-o'clock position. Adjust the dial until the needle points to zero.



Record the indicator reading at three different points; for example, 3 o'clock, 6 o'clock, and 9 o'clock.

Turn backward to the original position. Make sure the needle still points to zero. Determine the total indicator runout.

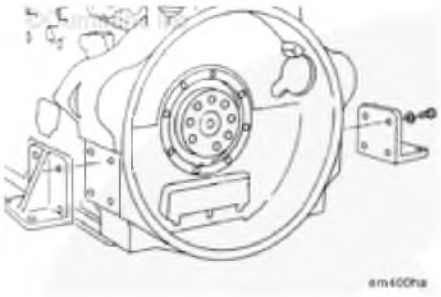
		mm	in
Example:			
	3 o'clock (2)	0.00	[0.00]
	6 o'clock (3)	+0.08	[+0.003]
	9 o'clock	-0.05	[-0.002]

Equal total indicator runout:	(4)	0.13	[0.005]

Install the rear engine support brackets, washers, and bolts.

Tighten the bolts.

Torque Value: 360 n.m [265 ft-lb]



Finishing Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

This component weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

WARNING

Some state and federal agencies have

determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Install the stiffener plate. Refer to Procedure 001-089 (Block Stiffener Plate) in Section 1.
- Fill the lubricating oil and install the oil pan. Refer to Procedure 007-037 (Lubricating Oil System) in Section 7.
- Install the starting motor. Refer to Procedure 013-020 (Starting Motor) in Section 13.
- Install the rear crankshaft seal. Refer to Procedure 001-024 (Crankshaft Seal, Rear) in Section 1.
- Install the flywheel. Refer to Procedure 016-005 (Flywheel) in Section 16.
- Install the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.
- Connect the batteries or air supply to the air starter. Refer to Procedure 013-009 (Battery Cables and Connections) in Section 13.
- Operate the engine and check for proper operation.

Last Modified: 02-May-2011

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016-010 Engine Mounts

General Information

Some vibration exists in all piston type engines, due to the pulsating power inputs and reciprocating components. Some of these vibrations are internal to the engine and are compensated, or balanced, by opposing forces within the engine structure. These are generally **not** of interest to vibration isolation designs. The vibrations that are offset or balanced internally will cause shaking moments and forces that **must** be reacted to by the engine mounts. If these moments and forces are **not** adequately reduced by the engine mounting and isolation systems, they can cause customer dissatisfaction and/or damage, due to component fatigue.

The effectiveness of an engine mounting system in isolating the vehicle structure from engine vibration depends on the relationship between the frequency of the vibration coming from the engine and the natural frequency of the engine mounting system. The mounting system effectiveness is commonly measured with the term “transmissibility”. Transmissibility is the amount of engine vibration which is transmitted through the mounting system to the vehicle structure.

Transmissibility values greater than one indicate the engine mounting system is actually transmitting more vibration into the vehicle structure than is coming from the engine. This is possible if the natural frequency of the mounting system is close to the frequency of the engine vibration. This can result in the mounting system operating at or near resonance, with a resulting magnification of the input vibration. This is obviously an undesirable situation.

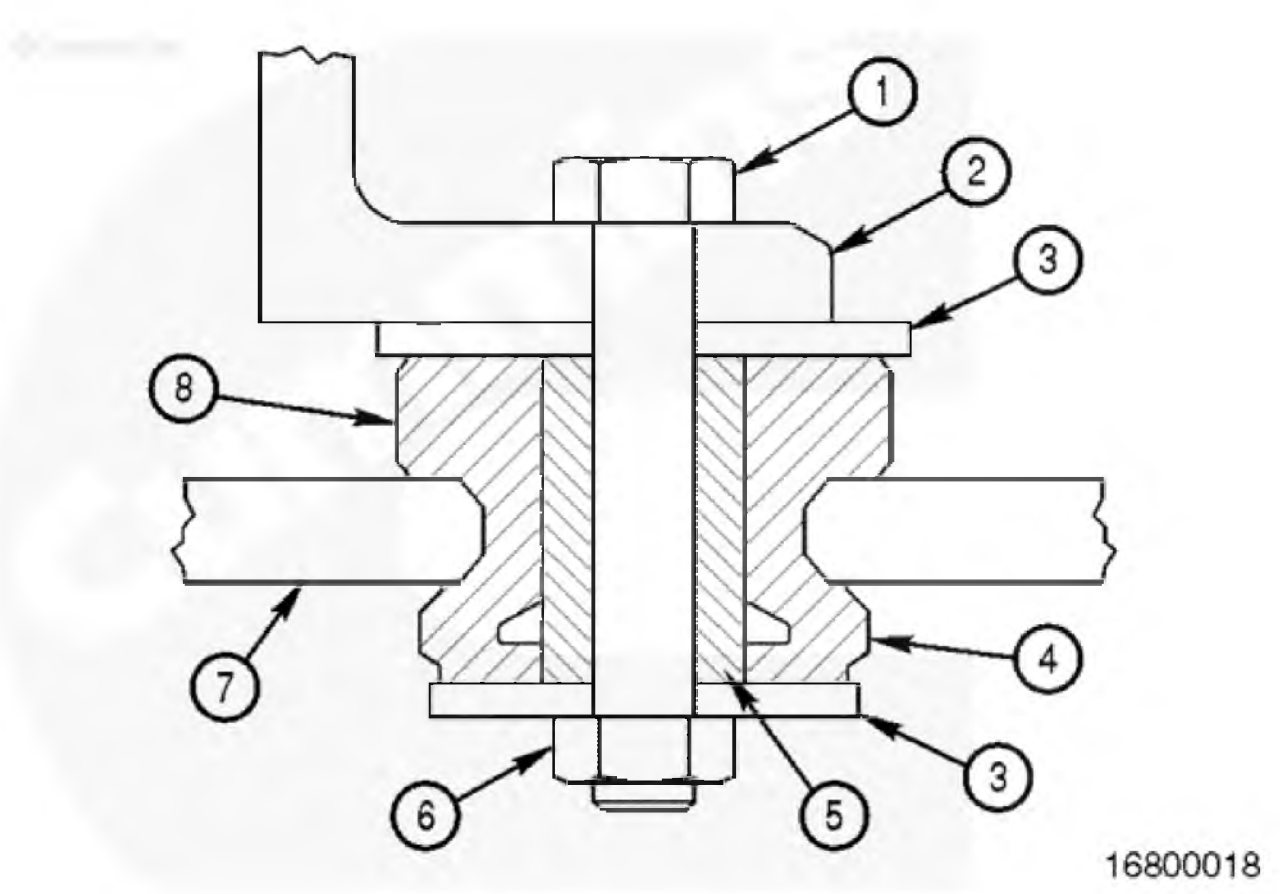
Transmissibility values of less than one indicate the mounting system is transmitting **only** a fraction of the vibration input from the engine, thus isolating the vehicle from engine vibration. Good engine mounts will reduce the amount of engine vibration transmitted to the chassis frame by at least 50 percent at idle.

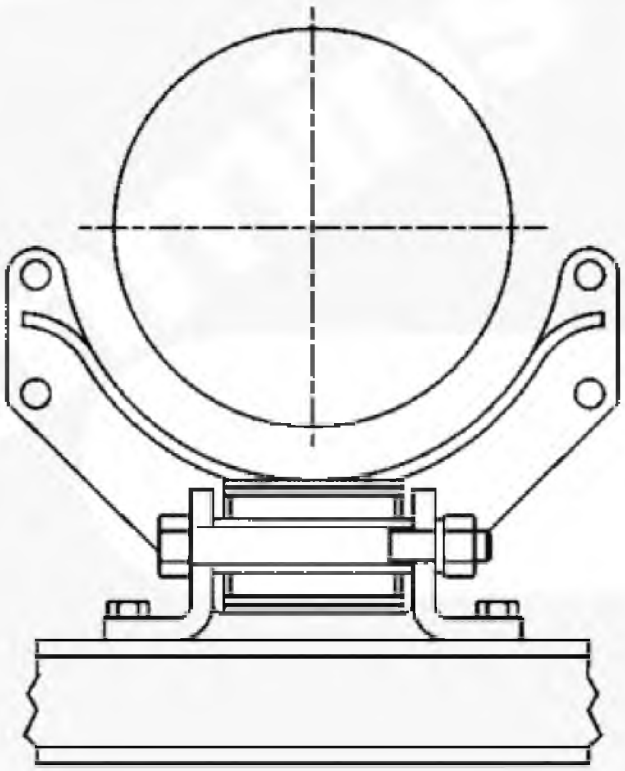
Stiffness (durometer) and size of the isolator, along with the weight of the engine or component applied, are the determining factors when designing a mounting system. An isolator that is correct for one engine may **not** be right for another. Likewise, because of weight differential, a particular isolator designed for the rear of an engine probably will **not** be ideal for the front. Hard engine mounts will give little or no isolation, and can actually magnify the vibration transmitted to the chassis.

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

The following are illustrations of typical FRONT engine mounts.

1. Bolt
2. Supported member
3. Snubbing washer (or flat bracket surface of equal diameter
4. Rebound tail
5. Bonded metal center
6. Locknut
7. Supporting member
8. Rubber mount.





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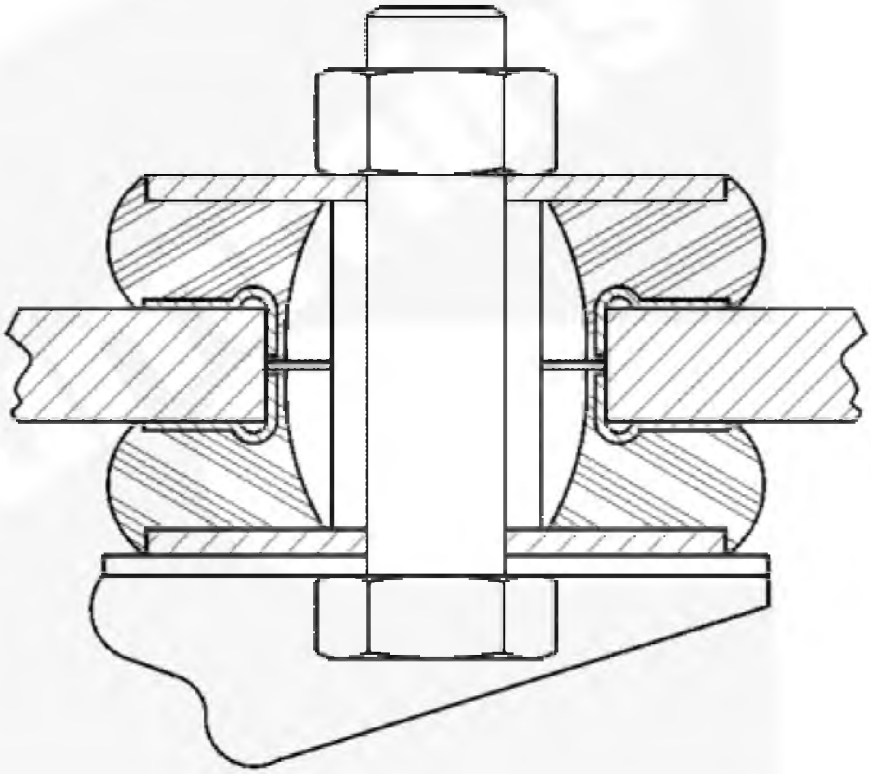

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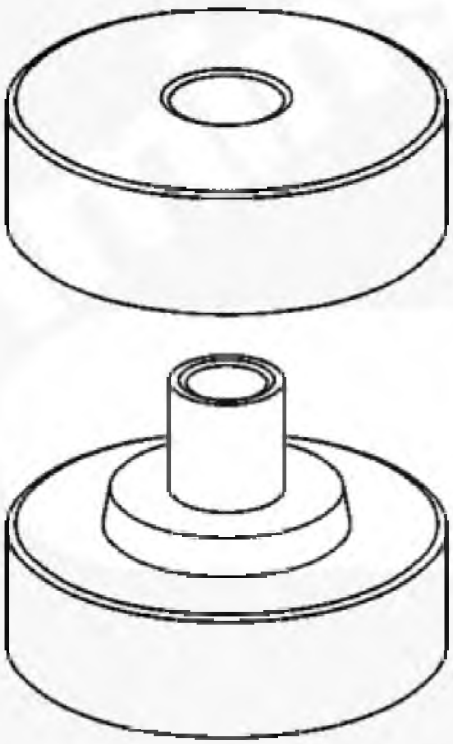

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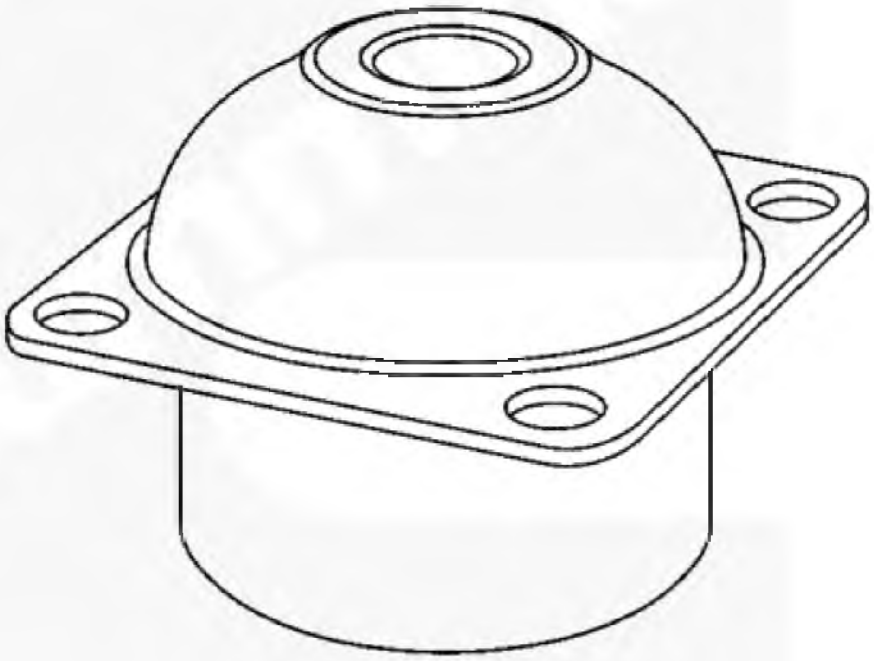
The following are illustrations of typical REAR engine mounts.



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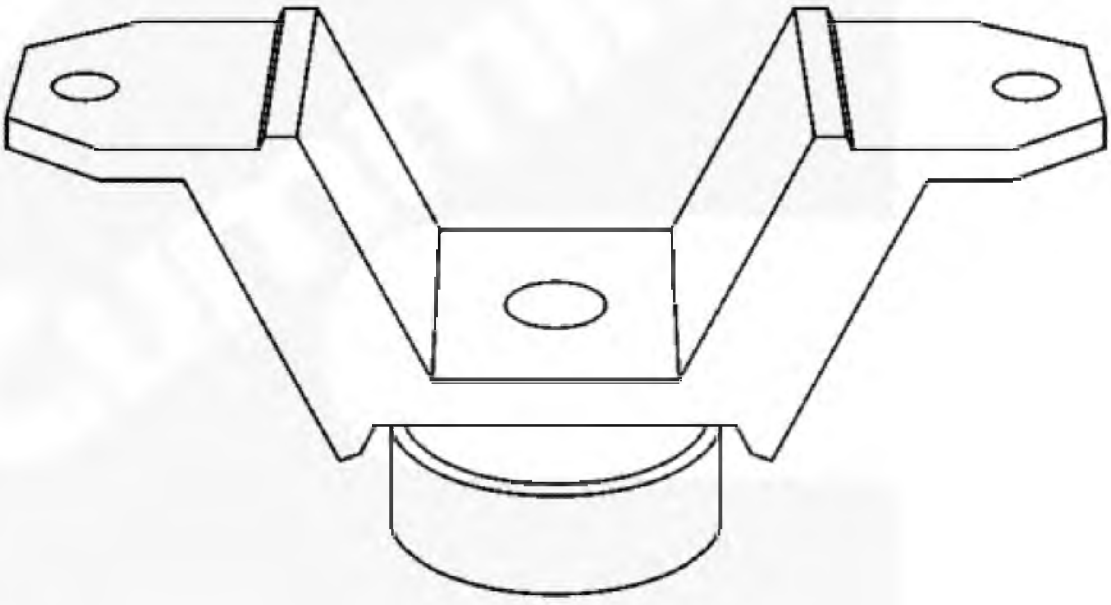

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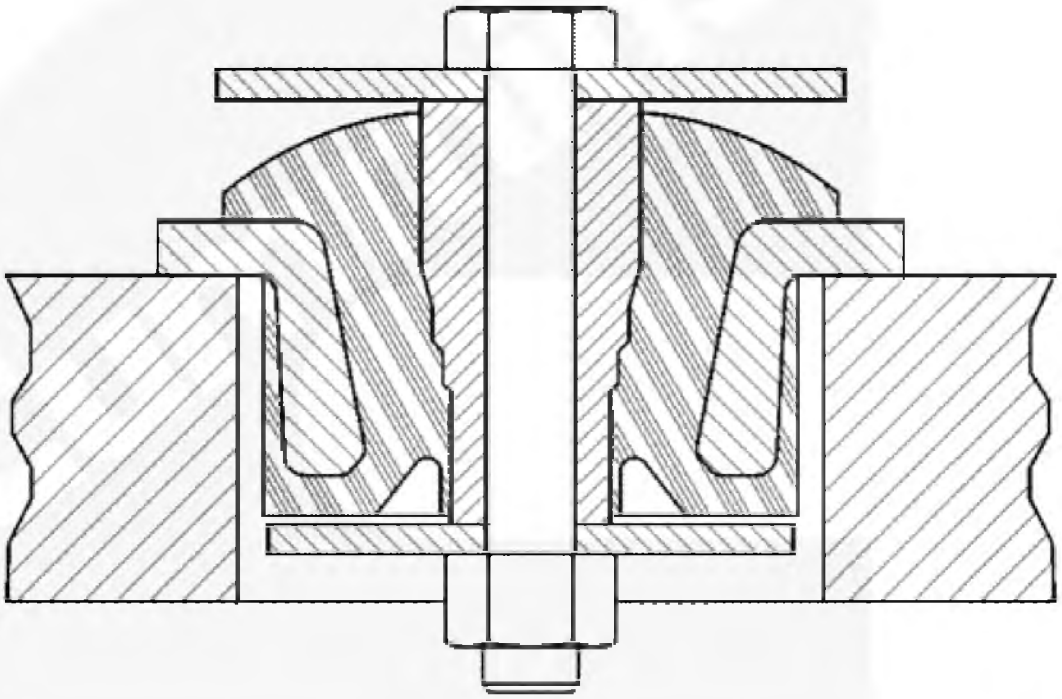

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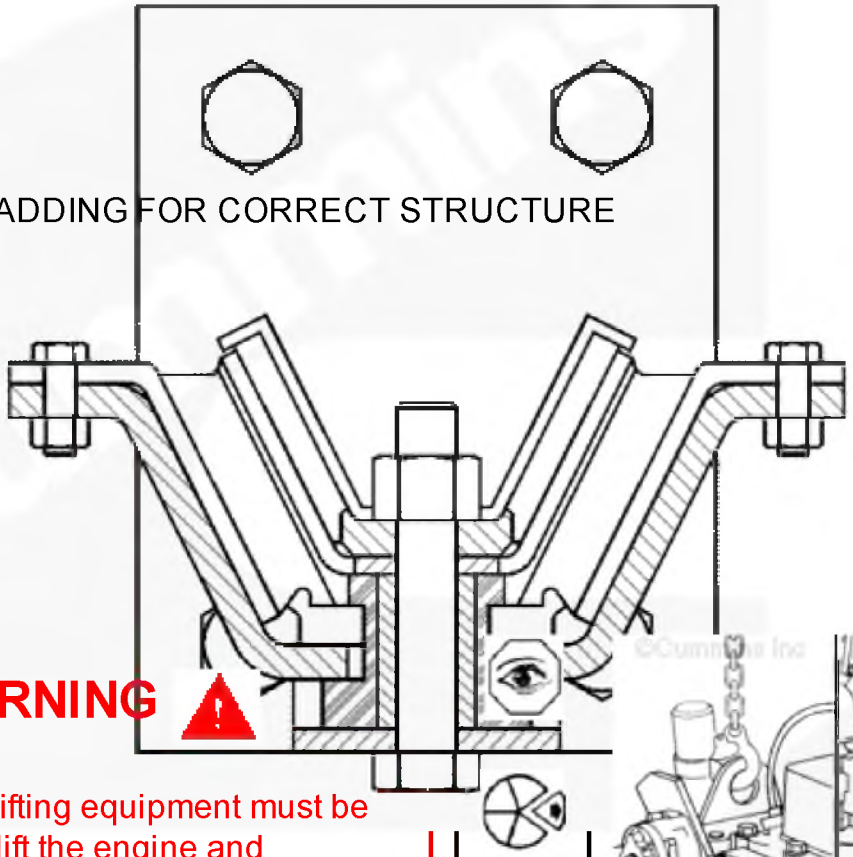


NEEDS TEXT ADDING FOR CORRECT STRUCTURE

Remove

WARNING

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

WARNING

This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Use a hoist or lifting fixture to support the engine.

NOTE: When removing the engine mount fasteners, note the location of any shims or spacers used.

Remove the capscrews from the engine mounts.

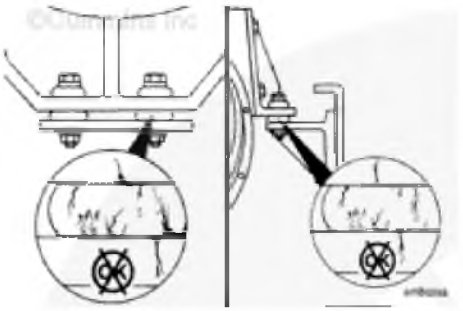
NOTE: Certain applications will require loosening of the rear engine mount fasteners to allow removal of the front

engine support bracket.

Inspect for Reuse

CAUTION

Damaged engine mounts and brackets can cause engine misalignment. Drivetrain component damage can result in excessive vibration complaints.



Inspect all rubber-cushioned mounts for cracks and other damage. Look for interference or contact between metal components.

Inspect all mounting brackets for cracks and damaged bolt holes.

Inspect the mounting capscrew to make sure it is **not** too long, which will **not** provide enough preload on the mount.

Replace any damaged parts as necessary.

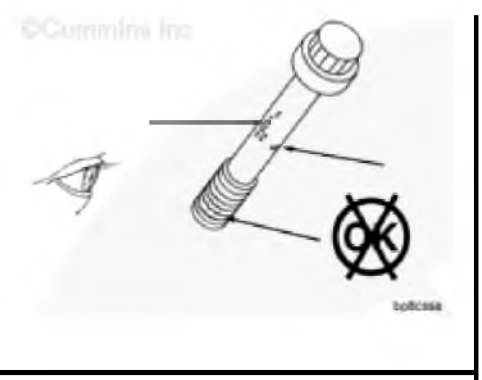
NOTE: Damaged engine mounts, brackets, and mounting hardware can cause the engine to move out of alignment and damage the driveline components in the equipment. This can result in vibration complaints.

Inspect the capscrew for the following:

- Damaged threads
- Rust or corrosion-caused pitting

- Nicked, bent, stretched, or galled.

The capscrew **must** be replaced if it has any of the listed damages.



For barrel mounts, inspect for signs of contact between the side brackets and the front engine support bracket.

Contact between the engine mount and side brackets can cause vibration complaints. If contact is found, replace the front engine support bracket.

Install

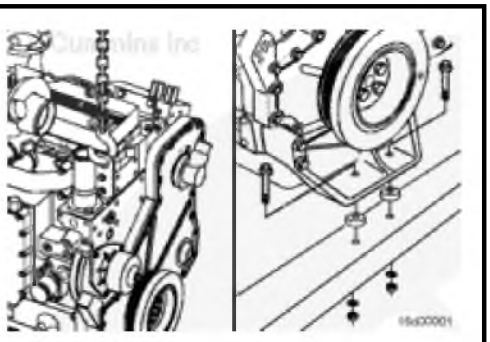
NOTE: Make sure to install any shims or spacers in the same location as removed.

Align the engine in the chassis.

Install the engine mount fasteners and tighten. Refer to the OEM service manual for torque specifications.

Remove the lifting fixture or hoist from the engine lifting brackets.

Connect all engine and chassis mounted accessories that were removed.



Last Modified: 18-Jan-2012

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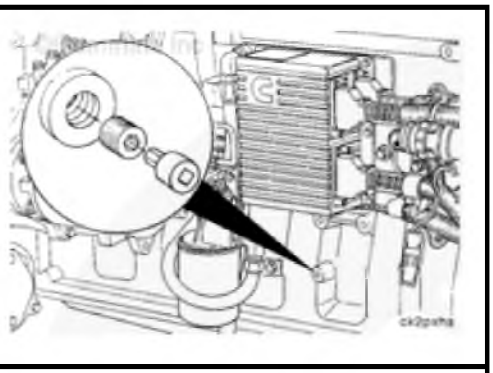
017-007 Pipe Plug

Remove

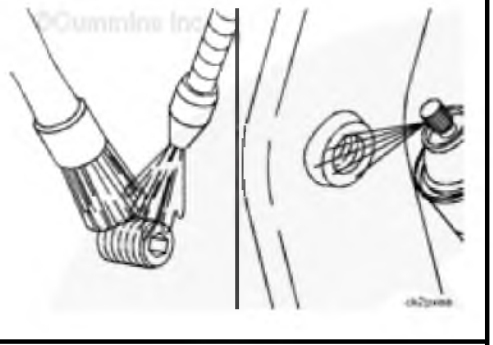
Select the appropriate-size Allen wrench and remove the pipe plug.



Clean

WARNING

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



WARNING

Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

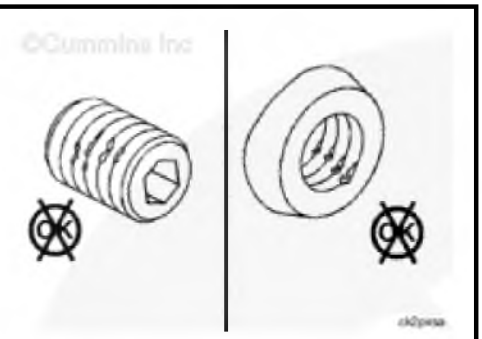
Use spray cleaner, Part Number 3824510 or equivalent, to clean the threads of the pipe plugs and threaded bores.

Inspect for Reuse

Inspect the threads of the pipe plugs for mutilation or damage.

Inspect the threaded bores for damage.

Repair the bores, if necessary.

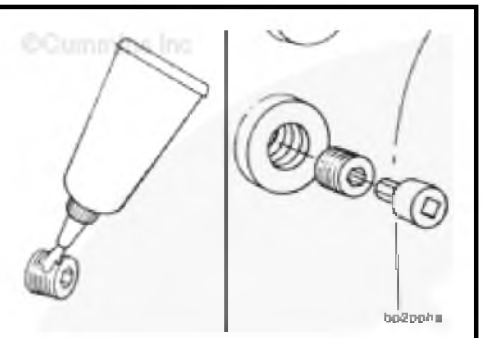


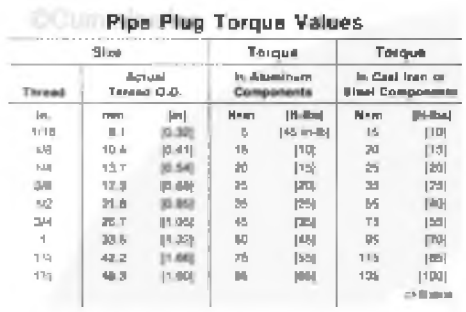
Install

Apply a film of pipe plug sealant, Part Number 3375066 or equivalent, to the threads.

Install and tighten the pipe plugs.

If torque value is not specified, refer to the following chart for torque values:



Tighten the pipe plugs to the appropriate torque values.		

Pipe Plug Torque Values

Size			Torque		Torque	
Thread	Actual Tenon O.D.		In Aluminum Components		In Cast Iron or Steel Components	
in.	mm	[in]	N•m	[lb-ft]	N•m	[lb-ft]
1/16	8.1	[0.32]	5	[45 in-lb]	15	[10]
1/8	10.4	[0.41]	15	[10]	20	[15]
1/4	13.7	[0.54]	20	[15]	25	[20]
3/8	17.3	[0.68]	25	[20]	33	[25]
1/2	21.8	[0.86]	35	[25]	55	[40]
3/4	26.7	[1.052]	45	[35]	73	[55]
1	33.5	[1.32]	60	[45]	95	[70]
1 1/4	42.2	[1.66]	75	[55]	115	[85]
1 1/2	48.3	[1.90]	85	[65]	135	[100]

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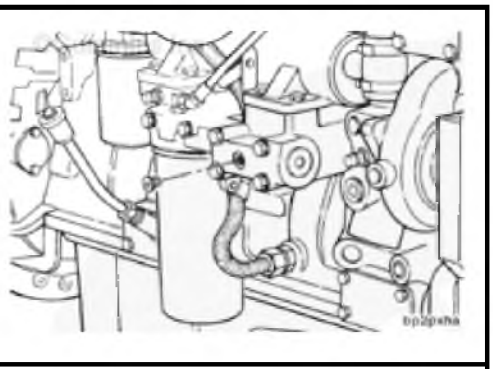
017-011 Straight Thread Plug

Remove

Select the appropriate Allen wrench or socket and remove the plug.

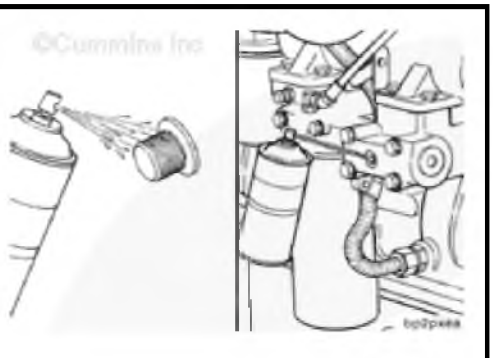


Clean

WARNING

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

WARNING



Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

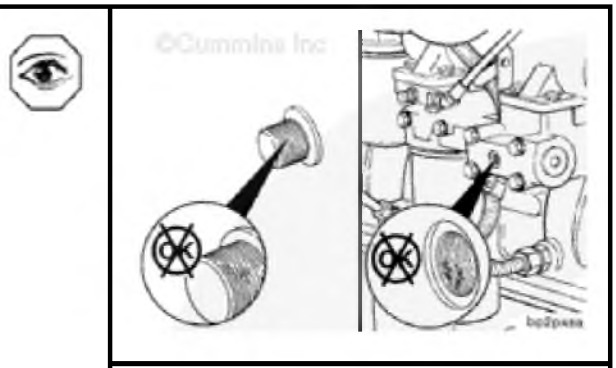
Use spray cleaner, Part Number 3824510, or equivalent, to clean the threads of the straight-thread plugs and threaded bores.

Inspect for Reuse

Inspect the threads of the plug for mutilation or damage.

Inspect the threaded bores for damage.

Repair the bores, if necessary.



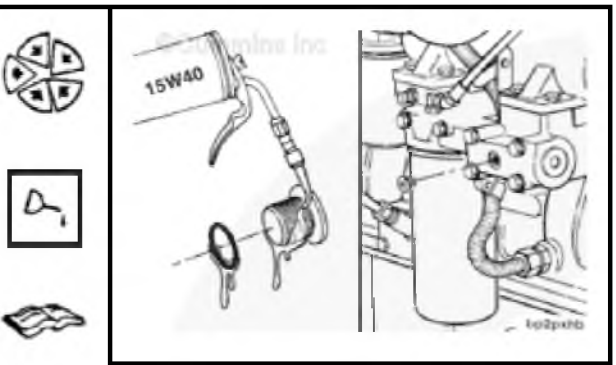
Install

Install a new o-ring on the plug.

Lubricate with clean SAE 15W-40 oil.

Install and tighten the plugs.

If the torque value is **not** specified, refer to the following chart for torque values:



Tighten straight-thread plugs to the appropriate torque value.		

Thread Size	Torque (N•m)	Torque (ft-lb)
M8	8	71 [in-lb]
M10	15	133 [in-lb]
M12	25	18
M14	35	26
M16	40	30
M18	45	33
M22	50	44
M27	100	74
M33	160	118

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View Related Topic

205-001 Additional Service Literature

General Information

The following publications can be purchased.

Bulletin	Title of Publication
4021374	Operation and Maintenance Manual, QSK23 Series Engines
3666113	Troubleshooting and Repair Manual, Electronic Control System, QSK19, QSK23, QSK45, QSK60, and QSK78 Engines
4021393	QSK23 Generator-Drive Wiring Diagram
4021394	QSK23 Industrial Wiring Diagram
4021405	QSK23 Power-Generation Wiring Diagram (PPC)
4056521	Power-Generation Parts Book
4056522	Industrial Parts Book
3810340	Cummins® Engine Oil Recommendations
3379001	Fuel for Cummins® Engines
3379000	Air For Your Engines
3666286	Cummins® Requirements for Cooling System Extended Service Intervals
3666132	Cummins® Coolant Requirements and Maintenance
3666209	Extended Service Interval, Cooling System Maintenance

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205-002 Service Literature Ordering Location

Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at 1-800-646-5609 or Order online at www.powerstore.cummins.com
All Other Countries	Cummins Distributors or Dealers

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205-004 Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contains only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number. Your name and engine model identification even appears on the catalog spine. Everybody will know that Cummins created a catalog specifically for you.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to the Cummins Electronic Parts Catalog or the Cummins Parts Microfilm System.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

North American customers can contact their Cummins Distributor or call Gannett Direct Marketing Services at 1-800-646-5609 and order by credit card. Outside North America order on-line or make an International call to Gannett at (++)502-454-6660.

Ordering On-Line

The Customized Parts Catalog can be ordered On-Line from the Cummins Powerstore by credit card.

Contact GDMS or the CUMMINS POWERSTORE for the current price; Freight may be an additional expense.

Information we need to take your Customized Parts Catalog Order. This information drives the cover content of the CPC.

- Customer Name
- Street Address
- Company Name (optional)
- Telephone no.
- Credit Card No.
- Cummins Engine Serial Number (located on the engine data plate)
- Please identify the required media: Printed Catalog, CD-ROM, or PDF File

Unfortunately not all Cummins Engines can be supported by this parts catalog. Engines older than 1984 or newer than 3 months may not have the necessary parts information to compile a catalog. We will contact you if this occurs and explain why we are unable to fill your order.

Customized Parts Catalogs are produced specifically for a single customer. This means they are not returnable for a refund. If we make an error and your catalog is not useable, we will correct that error by sending you a new catalog.

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View Related Topic

018-015 General Engine

General Specifications

For performance and fuel rate values, refer to the engine data sheet or the fuel pump code for the particular model involved.

Engine speed	Refer to the fuel pump calibration data for optional speed rating.
Displacement	23.15 liters [1413 cu in]
Bore and stroke	170 mm x 170 mm [6.69 in x 6.69 in]

Engine weight:

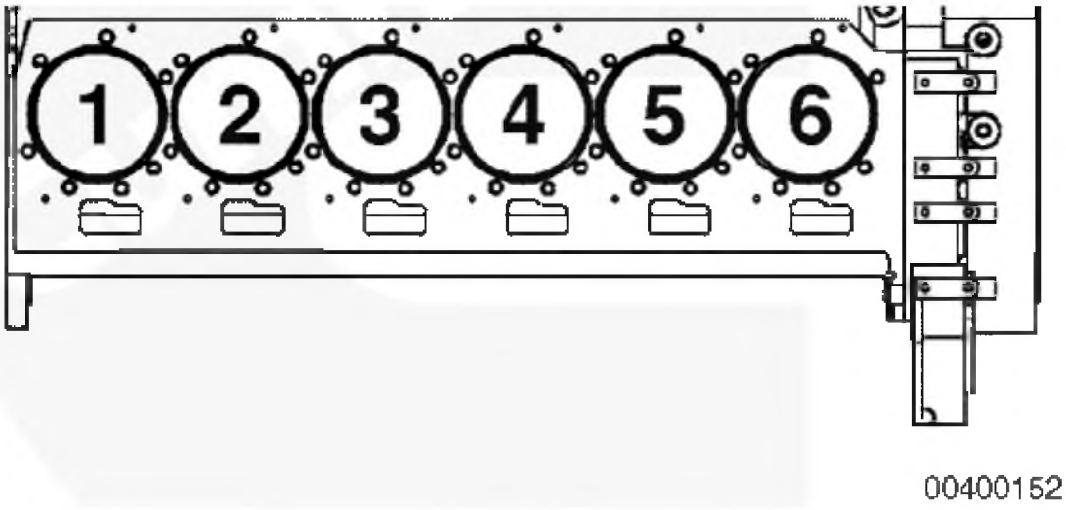
Dry	2858 kg [6300 lb]
Wet	2905 kg [6404 lb]

Valve and injector settings (cold):

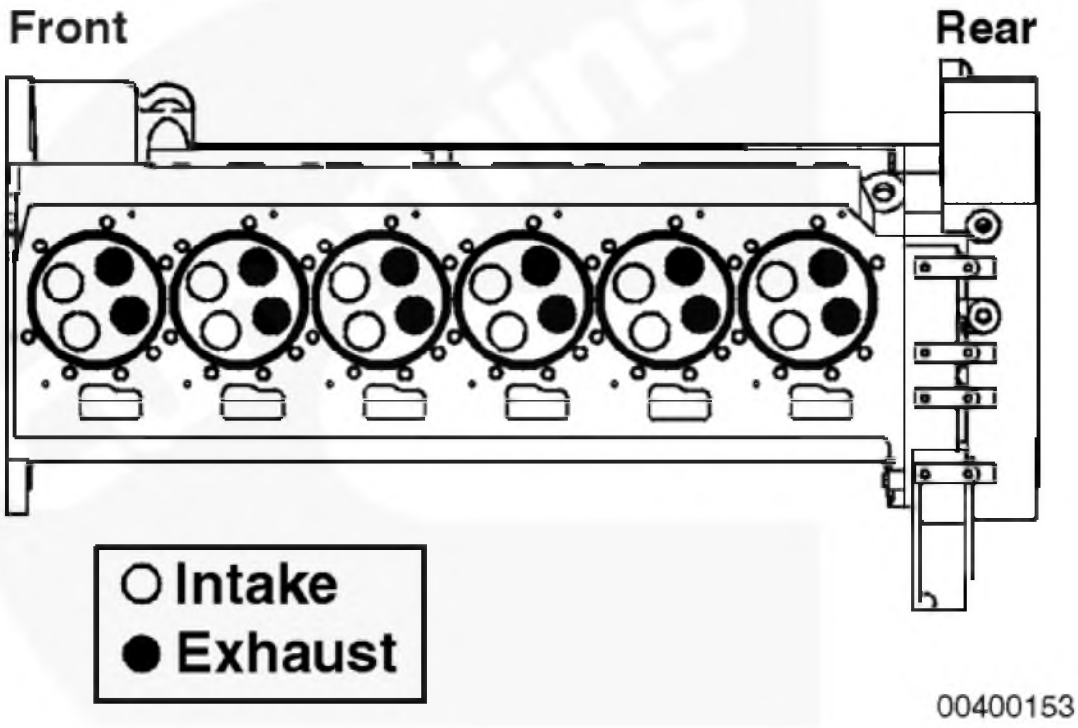
Intake valve adjustment	0.32 mm [0.013 in]
Intake valve limits	0.30 to 0.34 mm [0.012 to 0.013 in]
Exhaust valve adjustment	0.62 mm [0.024 in]
Exhaust valve limits	0.60 to 0.64 mm [0.024 to 0.025 in]
Injector OBC method adjustment (in engine)	32 N•m [24 ft-lb]

Compression ratio	16.0:1
Crankshaft rotation (viewed from the front of the engine)	Clockwise

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



Cylinder locations.



Intake and exhaust valve locations.

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018-016 Fuel System

Specifications

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

Engine Idle Speed	700 ± 25 rpm

Fuel Inlet Maximum Restriction:

Clean Fuel Filter	100 mm Hg [4.0 in Hg]
Dirty Fuel Filter	229 mm Hg [9.0 in Hg]

Fuel Drain Line Restriction:

With Check Valves	0 to 21 kPa [0 to 3 psi]
With Check Valves Removed	14 to 34 kPa [2 to 5 psi]

Fuel Check Valve Between Fuel Pump and Cylinder Head (integral to fuel pump):

Opening Pressure	21 to 35 kPa [3 to 5 psi]

Engine Minimum Cranking Speed	130 rpm

Fuel Check Valve in Fuel Drain Line:

Opening Pressure	13 to 25 mm Hg [1/4 to 1/2 psi]

Derate Engine Fuel Rate for High Altitude	4 percent per 300 m [1000 ft] above 3600 m [12,000 ft]
Derate Engine Fuel Rate for Hot Weather	2 percent per 11°C above 38°C [1 percent per 10°F above 100°F]
Shutoff Valve Solenoid Coil Resistance in ohms 24 VDC	28 to 32 ohms
Fuel Pump Cranking Pressure - Minimum	172 kPa [25 psi] @ 150 rpm

Fuel Pump Pressure - Minimum (on engine measurement):

1500 rpm	1779 kPa [258 psi]
1800 rpm	2117 kPa [307 psi]
2100 rpm	2344 kPa [340 psi]

Fuel Filter Specifications:

Efficiency	98.7 percent at 10 microns/96.0 percent at 8 microns/86.0 percent at 5 microns
Water Removal	Free = 95 percent/Emulsified = 95 percent

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018-017 Lubricating Oil System

Specifications

Oil Pressure (with 15W-40 oil at 107°C [225°F]):

At Idle (minimum allowable)	70 kPa [10 psi]

At Rated Speed (minimum allowable)	210 kPa [30 psi]

Oil Temperature:

Maximum	120°C [250°F]

Oil Filter Capacity:

Combination Filter (two LF9325 Fleetguard®)	5.3 liters [1.4 gal]

Oil Sump Capacity:

Rated Sump Capacity	Sump Capacity at Low Level Mark on Dipstick in Liters [Gal]	Sump Capacity at High Level Mark on dipstick in Liters [Gal]	Total System Capacity (Sump and Two Combo Oil Filters) in Liters [Gal]
56 liters [14.8 gal]	46 liters [12.1 gal]	56 liters [14.8 gal]	61 liters [16.1 gal]
70 liters [18.5 gal]	56 liters [14.8 gal]	70 liters [18.5 gal]	75 liters [19.8 gal]
95 liters [25 gal]	67 liters [17.8 gal]	95 liters [25 gal]	100 liters [26.4 gal]
135 liters [35.7 gal]	67 liters [17.8 gal]	135 liters [35.7 gal]	140 liters [37 gal]

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018-018 Cooling System

Specifications

Coolant Capacity (engine **only**)	46.6 liters [49 qt]
Standard Modulating Thermostat Range	82° to 94°C [180° to 202°F]
Maximum Coolant Pressure (exclusive of pressure cap)	241 kPa [35 psi]
Maximum Allowable Top Tank Temperature	100°C [212°F]
Minimum Recommended Top Tank Temperature	70°C [160°F]
Maximum Allowable Deaeration Time	25 minutes
Minimum Allowable Drawdown or 10% of System Capacity (whichever is greater)	4.7 liters [4.9 qt]
Minimum Allowable Pressure Cap	50 kPa [7 psi]

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018-019 Air Intake System

Specifications

Maximum Allowable Intake Restriction (at rated speed and load):

With Clean Filter Element	380 mm H2O [15 in H2O]
With Dirty Filter Element	635 mm H2O [25 in H2O]

Maximum Allowable Charge Air Cooling System Restriction (including piping):

Maximum (at rated speed)	100 mm Hg [4.0 in Hg]

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018-020 Exhaust System

Specifications

Back Pressure - Maximum (at rated speed and load)	75 mm Hg [3.0 in Hg]

Exhaust Pipe Size (normally acceptable inside diameter):

All Ratings	152 mm [6.0 in]

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018-021 Electrical System

Specifications

Maximum Starting Circuit Resistance:

24-VDC starter	0.00200 ohm

Battery Cable Sizes - American Wire Gauge (maximum length in cranking motor circuit)

24 to 32-VDC

Number 00	6.1 m [20 ft]
Number 000	8.2 m [27 ft]
Number 0000 or two Number 0*	10.7 m [35 ft]
Two Number 00	13.7 m [45 ft]

Minimum Cranking Speed without Starting Aid	130 rpm

* Two strands of Number 0 cable can be used instead of one Number 0000 cable, provided that all connections are carefully made to provide equal current flow in each parallel cable.

NOTE: Starting aids, such as block heaters, lubricating oil pan heaters, and so forth, are available to aid in cold weather starting.

System Voltage	Ambient Temperatures			
	-18°C [0°F]		0°C [32°F]	
	Cold Cranking Amperes	Reserve Capacity* Amperes	Cold Cranking Amperes	Reserve Capacity* Amperes
24 VDC**	900	320	640	240

* The number of plates within a given battery size determines reserve capacity. Reserve capacity is the length of time sustained cranking can occur.

** CCA ratings are based on two 12-VDC batteries in series.

Battery State of Charge	Specific Gravity @ 27°C [80°F]
100%	1.260 to 1.280
75%	1.230 to 1.250
50%	1.200 to 1.220
25%	1.170 to 1.190
Discharged	1.110 to 1.130

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018-009 Capscrew Markings and Torque Values

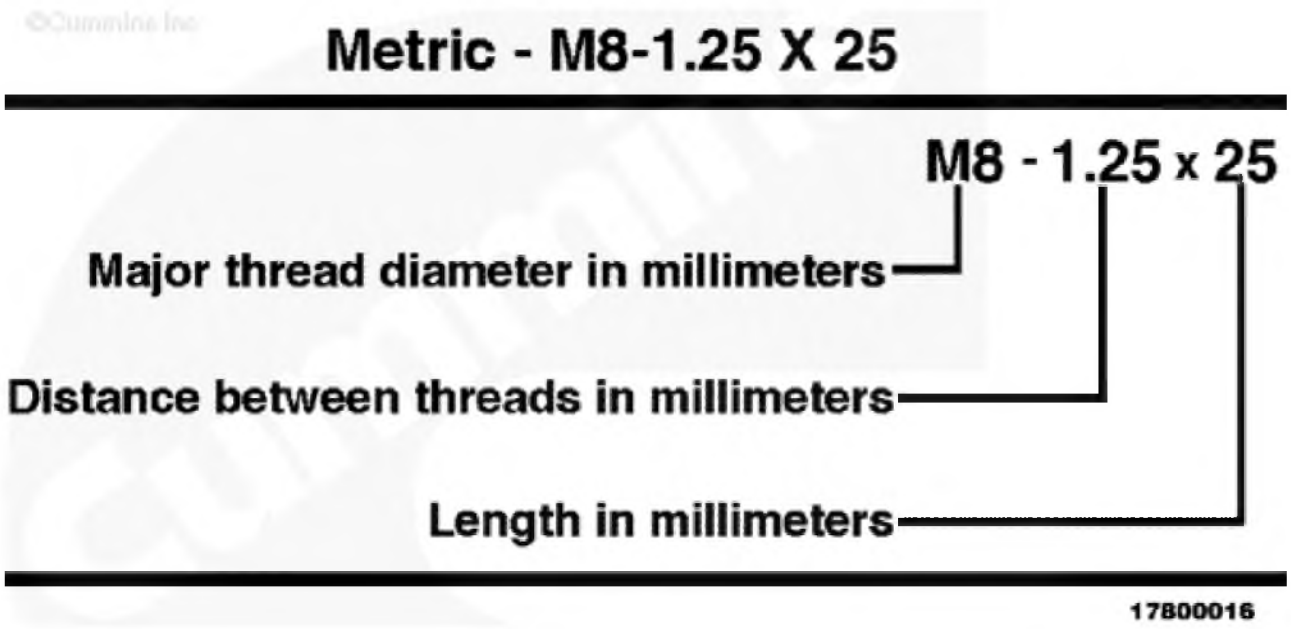
General Information

CAUTION

When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

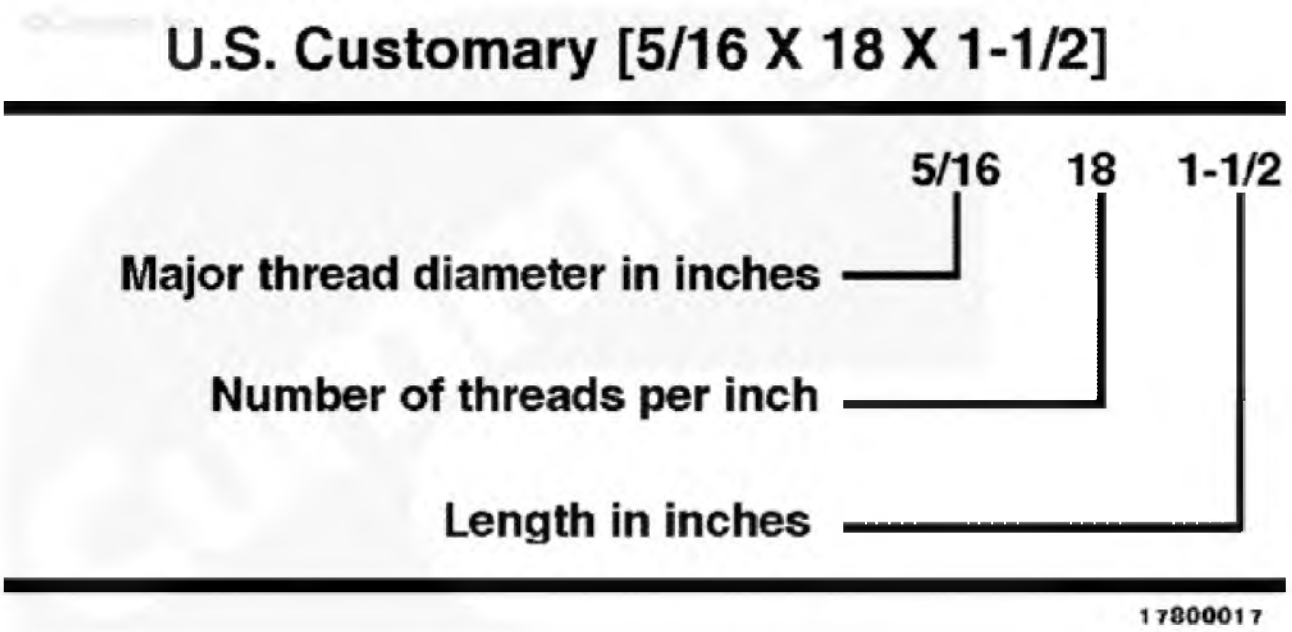
Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:



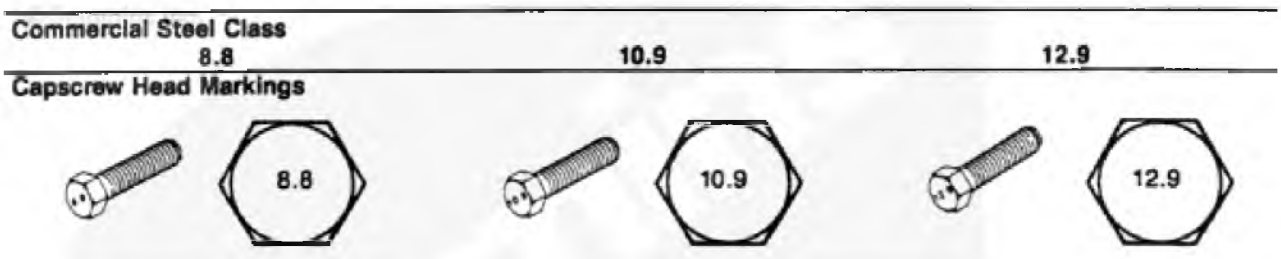
- **Always** use the torque values listed in the following tables when specific torque values are **not** available.

- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.



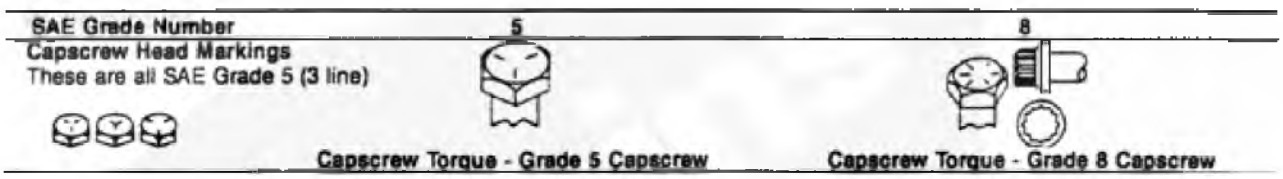
- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

Capscrew Markings and Torque Values - Metric



Body Size	Torque				Torque				Torque			
Diameter	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
mm	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	—	—	550	400	—	—	—	—	—	—

Capscrew Markings and Torque Values - U.S. Customary



Capscrew Body Size	Cast Iron		Aluminium		Cast Iron		Aluminium	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1/4 - 20	9	7	8	6	15	11	8	6
1/4 - 28	12	9	9	7	18	13	9	7
5/16 - 18	20	15	16	12	30	22	16	12
5/16 - 24	23	17	19	14	33	24	19	14
3/8 - 16	40	30	25	20	55	40	25	20
3/8 - 24	40	30	35	25	60	45	35	25
7/16 - 14	60	45	45	35	90	65	45	35

7/16 - 20	65	50	55	40	95	70	55	40
1/2 - 13	95	70	75	55	130	95	75	55
1/2 - 20	100	75	80	60	150	110	80	60
9/16 - 12	135	100	110	80	190	140	110	80
9/16 - 18	150	110	115	85	210	155	115	85
5/8 - 11	180	135	150	110	255	190	150	110
5/8 - 18	210	155	160	120	290	215	160	120
3/4 - 10	325	240	255	190	460	340	255	190
3/4 - 16	365	270	285	210	515	380	285	210
7/8 - 9	490	360	380	280	745	550	380	280
7/8 - 14	530	390	420	310	825	610	420	310
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

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018-010 Fraction, Decimal, Millimeter Conversions

Conversion Chart

Fraction	inch	mm	Fraction	inch	mm
1/64	0.0156	0.397	33/64	0.5156	13.097
1/32	0.0313	0.794	17/32	0.5313	13.494
3/64	0.0469	1.191	35/64	0.5469	13.891
1/16	0.0625	1.588	9/16	0.5625	14.288
5/64	0.0781	1.984	37/64	0.5781	14.684
3/32	0.0938	2.381	19/32	0.5938	15.081
7/64	0.1094	2.778	39/64	0.6094	15.478
1/8	0.1250	3.175	5/8	0.6250	15.875
9/64	0.1406	3.572	41/64	0.6406	16.272
5/32	0.1563	3.969	21/32	0.6563	16.669
11/64	0.1719	4.366	43/64	0.6719	17.066
3/16	0.1875	4.763	11/16	0.6875	17.463
13/64	0.2031	5.159	45/64	0.7031	17.859
7/32	0.2188	5.556	23/32	0.7188	18.256
15/64	0.2344	5.953	47/64	0.7344	18.653
1/4	0.2500	6.350	3/4	0.7500	19.050
17/64	0.2656	6.747	49/64	0.7656	19.447
9/32	0.2813	7.144	25/32	0.7813	19.844
19/64	0.2969	7.541	51/64	0.7969	20.241
5/16	0.3125	7.938	13/16	0.8125	20.638

BDC for Manuals - specs - Bolt torques
https://barringtondieselclub.co.za/

21/64	0.3281	8.334	53/64	0.8281	21.034
11/32	0.3438	8.731	27/32	0.8438	21.431
23/64	0.3594	9.128	55/64	0.8594	21.828
3/8	0.3750	9.525	7/8	0.8750	22.225
25/64	0.3906	9.922	57/64	0.8906	22.622
13/32	0.4063	10.319	29/32	0.9063	23.019
27/64	0.4219	10.716	59/64	0.9219	23.416
7/16	0.4375	11.113	15/16	0.9375	23.813
29/64	0.4531	11.509	61/64	0.9531	24.209
15/32	0.4688	11.906	31/32	0.9688	24.606
31/64	0.4844	12.303	63/64	0.9844	25.003
1/2	0.5000	12.700	1	1.0000	25.400

Conversion Factor: 1 inch = 25.4 mm

Last Modified: 03-Mar-2004

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018-011 Newton-Meter to Foot-Pound Conversions

Conversion Chart

N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1	9 in-lb	55	41	155	114
5	44 in-lb	60	44	160	118
6	53 in-lb	65	48	165	122
7	62 in-lb	70	52	170	125
8	71 in-lb	75	55	175	129
9	80 in-lb	80	59	180	133
10	89 in-lb	85	63	185	136
11	97 in-lb	90	66	190	140
12	106 in-lb	95	70	195	144
14	124 in-lb	100	74	200	148
15	133 in-lb	105	77	205	151
16	142 in-lb	110	81	210	155
18	159 in-lb	115	85	215	159
20	15 ft-lb	120	89	220	162
25	18	125	92	225	165
30	22	130	96	230	170
35	26	135	100	235	173
40	30	140	103	240	177
45	33	145	107	245	180
50	37	150	111	250	184

NOTE: To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.

Last Modified: 03-Mar-2004

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018-012 Pipe Plug Torque Values

Torque Table

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
in	**in**	**N•m**	**ft-lb**	**N•m**	**ft-lb**
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Last Modified: 03-Mar-2004

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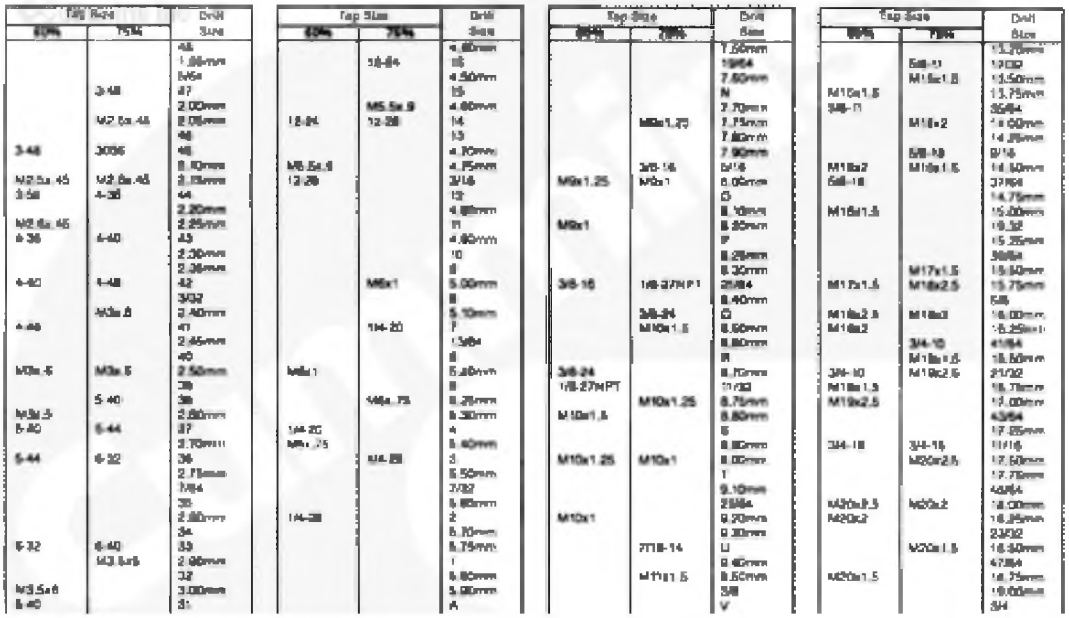
018-013 Tap-Drill Chart - U.S. Customary and Metric

General Information

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.



Last Modified: 03-Mar-2004

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018-014 Weights and Measures - Conversion Factors

Conversion Chart

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

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Manual Change History

(4021375) QSK23 Troubleshooting and Repair Manual				
Date	**Section**	**Procedure Number**	**Procedure Title**	**Update Reason**
02-Apr-2012	Section 9 - Drive Units - Group 09	89-009-009	Alternator Drive Gear and Shaft	Added assemble and disassemble sections to the procedure.
21-Mar-2012	Section 1 - Cylinder Block - Group 01	89-001-024	Cylinder Block	Updated seal removal/installation tool, Part Number 5298540, and instructions.
21-Mar-2012	Section 1 - Cylinder Block - Group 01	89-001-024	Cylinder Block	Added seal removal/installation tool, Part Number 5298540.
06-Feb-2012	Section 8 - Cooling System - Group 08	89-008-062-tr	Water Pump	Updated procedure by adding Assemble and Disassemble sections.
03-Feb-2012	Section 10 - Air Intake System - Group 10	89-010-072-tr	Air Intake Manifold	Updated the procedure with current informtion and added it to some manual outlines.
23-Nov-2011	Section 10 - Air Intake System - Group 10	89-010-023	Air Intake Manifold	Added steps for Remove and Install air crossover connection.
23-Nov-2011	Section 10 - Air Intake System - Group 10	89-010-072-tr	Air Intake Manifold	
07-Jun-2011	Section 1 - Cylinder Block - Group 01	89-001-028	Cylinder Liner	Removed reference to oversized cylinder liners as these are not available on the QSK23 engine.
03-May-2011	Section 16 - Mounting Adaptations - Group 16	89-016-006	Flywheel Housing	Added in Install step a paragraph to install rear engine support brackets, washers, and bolts and torque 360 N•m [265 ft-lb].
03-May-2011	Section V - Maintenance Specifications	89-018-017	Lubricating Oil System	Added Oil Sump Capacity table.
10-Jan-2011	Section 1 - Cylinder Block - Group 01	89-001-008	Camshaft	Removed statement about injector timing in the Preparatory and Finish sections.
10-Jan-2011	Section 1 - Cylinder Block - Group 01	89-001-010	Camshaft Bushings	Removed statement about injector timing in the Preparatory and Finish sections.
10-Jan-2011	Section 1 - Cylinder Block - Group 01	89-001-012	Camshaft Gear (Camshaft Installed)	Removed statement about injector timing in the Preparatory and Finish sections.
10-Jan-2011	Section 1 - Cylinder Block - Group 01	89-001-013	Camshaft Gear (Camshaft Removed)	Removed statement about injector timing in the Preparatory and Finish sections.
10-Jan-2011	Section 1 - Cylinder Block - Group 01	89-001-056	Camshaft Thrust Bearing	Removed statement about injector timing in the Preparatory and Finish sections.

21-Dec-2010	Section 1 - Cylinder Block - Group 01	89-001-016-tr	Crankshaft	Removed Maintenance Check step from procedure and updated technical information for measuring the outisde diameter.
10-Dec-2010	Section 1 - Cylinder Block - Group 01	89-001-006	Bearings, Main	Added General Information to procedure, updated graphic, and technical information in table in the Install step.
30-Nov-2010	Section 1 - Cylinder Block - Group 01	89-001-007	Bearings, Thrust	Changed technical information in table of Inspect for Reuse step.
04-OCT-2010	Section 01 - Cylinder Block	89-001-054	Piston and Connecting Rod Assembly	Added General Information Step
25-May-2010	Section i - Introduction	99-204-003-tr	How to Use the Manual	
24-Mar-2010	Section i - Introduction	99-204-009	Acronyms and Abbreviations	
24-Mar-2010	Section 16 - Mounting Adaptations - Group 16	89-016-005	Flywheel	
25-Feb-2010	Section TS - Troubleshooting Symptoms	4021375-t102-tr	Lubricating Oil Consumption Excessive	
25-Jan-2010	Section i - Introduction	99-204-006-tr	General Safety Instructions	
25-Jan-2010	Section V - Specifications	99-018-009	Capscrew Markings and Torque Values	
08-Oct-2009	Section i - Introduction	99-204-007-tr	General Repair Instructions	
10-Sep-2009	Section i - Introduction	99-204-002-tr	About the Manual	
27-Jul-2009	Section 12 - Compressed Air System - Group 12	89-012-014	Air Compressor	
22-Jul-2009	Section L - Service Literature	99-205-004	Cummins Customized Parts Catalog	
25-Jun-2009	Section TS - Troubleshooting Symptoms	99-t00-001-tr	Troubleshooting Procedures and Techniques	
26-Mar-2009	Section TT - Troubleshooting Symptoms	105-t02-1005a	Vibration Excessive	
20-Jan-2009	Section 2 - Cylinder Head - Group 02	89-002-004	Cylinder Head	
13-Nov-2008	Section 16 - Mounting Adaptations - Group 16	00-016-010	Engine Mounts	
24-Sep-2008	Section 3 - Rocker Levers - Group 03	89-003-006	Overhead Set (OBC)	

24-Sep-2008	Section L - Service Literature	89-205-001-tr	Additional Service Literature
24-Sep-2008	Section V - Specifications	89-018-015	General Engine
06-Feb-2008	Section 16 - Mounting Adaptations - Group 16	89-016-006	Flywheel Housing
05-Dec-2007	Section TS - Troubleshooting Symptoms	4021375-t027-tr	Crankcase Gases (Blowby) Excessive
03-Aug-2007	Section 8 - Cooling System - Group 08	89-022-001_08-tr	Service Tools
24-Jul-2007	Section i - Introduction	99-204-008	General Cleaning Instructions
23-Jul-2007	Section TS - Troubleshooting Symptoms	4021375-t021-tr	Coolant Loss - Internal
23-Jul-2007	Section TS - Troubleshooting Symptoms	89-t00-004	Troubleshooting Overview
28-Jun-2007	Section 8 - Cooling System - Group 08	89-008-018-tr	Cooling System
16-May-2007	Section V - Specifications	89-018-016	Fuel System
16-May-2007	Section V - Specifications	89-018-017	Lubricating Oil System
16-May-2007	Section V - Specifications	89-018-018	Cooling System
16-May-2007	Section V - Specifications	89-018-019	Air Intake System
16-May-2007	Section V - Specifications	89-018-020	Exhaust System
16-May-2007	Section V - Specifications	89-018-021	Electrical System
21-Jul-2006	Section 14 - Engine Testing - Group 14	89-022-001_14	Service Tools
27-Jun-2006	Section L - Service Literature	99-205-002	Service Literature Ordering Location
26-Jun-2006	Section 14 - Engine Testing - Group 14	89-014-005	Engine Testing (Engine Dynamometer)
26-Jun-2006	Section 14 - Engine Testing - Group 14	89-014-006	Engine Run-in (Engine Dynamometer)
22-May-2006	front	tr-frwd	foreword
25-Oct-2004	back	4021375-backcover	Backcover
29-Sep-2004	Section 1 - Cylinder Block -	89-001-028	Cylinder Liner

29-Mar-2004	Group 01 Section 14 - Engine Testing - Group 14	00-014-012	Engine Compression	
03-Mar-2004	Section V - Specifications	99-018-010	Fraction, Decimal, Millimeter Conversions	
03-Mar-2004	Section V - Specifications	99-018-011	Newton-Meter to Foot-Pound Conversions	
03-Mar-2004	Section V - Specifications	99-018-012	Pipe Plug Torque Values	
03-Mar-2004	Section V - Specifications	99-018-013	Tap-Drill Chart - U.S. Customary and Metric	
03-Mar-2004	Section V - Specifications	99-018-014	Weights and Measures - Conversion Factors	
19-Dec-2003	Section 1 - Cylinder Block - Group 01	89-001-014	Connecting Rod	
13-Nov-2003	Section 6 - Injectors and Fuel Lines - Group 06	89-006-026	Injector	
23-Sep-2003	front	4021375-titlepage	titlepage	
23-Sep-2003	Section 2 - Cylinder Head - Group 02	89-022-001_02	Service Tools	
23-Sep-2003	Section 6 - Injectors and Fuel Lines - Group 06	89-006-012	Fuel Drain Line Restriction	
23-Sep-2003	Section 6 - Injectors and Fuel Lines - Group 06	89-006-015	Fuel Filter (Spin-On Type)	
23-Sep-2003	Section 2 - Cylinder Head - Group 02	89-002-004-tr	Cylinder Head	Updated technical content of Vacuum Test section.
15-Sep-2003	Section 3 - Rocker Levers - Group 03	89-022-001_03	Service Tools	
15-Sep-2003	Section 6 - Injectors and Fuel Lines - Group 06	89-022-001_06	Service Tools	
15-Sep-2003	Section 6 - Injectors and Fuel Lines - Group 06	89-006-003	Air in Fuel	
15-Sep-2003	Section 7 - Lubricating Oil System - Group 07	89-007-007	Lubricating Oil Cooler Element	
04-Sep-2003	Section 13 - Electrical Equipment - Group 13	89-013-017	Starter Magnetic Switch	
04-Sep-2003	Section 13 - Electrical	89-013-018	Starter Switch	

	Equipment - Group 13		
26-Aug-2003	Section 13 - Electrical Equipment - Group 13	99-013-009	Battery Cables and Connections
04-Aug-2003	Section F - Familiarization	89-009-999	Drive Untis - Overview
04-Aug-2003	Section F - Familiarization	89-013-999	Electrical Equipment - Overview
04-Aug-2003	Section F - Familiarization	89-014-999	Engine Testing - Overview
04-Aug-2003	Section 1 - Cylinder Block - Group 01	89-022-001_01	Service Tools
04-Aug-2003	Section 1 - Cylinder Block - Group 01	89-001-001	Alternator Drive Seal
04-Aug-2003	Section 1 - Cylinder Block - Group 01	89-001-008	Camshaft
04-Aug-2003	Section 1 - Cylinder Block - Group 01	89-001-012	Camshaft Gear (Camshaft Installed)
04-Aug-2003	Section 17 - Miscellaneous - Group 17	89-017-007	Pipe Plug
04-Aug-2003	Section 17 - Miscellaneous - Group 17	89-017-011	Straight Thread Plug
28-Jul-2003	Section 1 - Cylinder Block - Group 01	89-001-018	Crankshaft Gear, Front (Crankshaft Installed)
28-Jul-2003	Section 1 - Cylinder Block - Group 01	89-001-031	Gear Cover, Front
28-Jul-2003	Section 1 - Cylinder Block - Group 01	89-001-052	Vibration Damper, Viscous
28-Jul-2003	Section 1 - Cylinder Block - Group 01	89-001-054	Piston and Connecting Rod Assembly
28-Jul-2003	Section 1 - Cylinder Block - Group 01	89-001-055	Gear Train Backlash, Front
28-Jul-2003	Section 1 - Cylinder Block - Group 01	89-001-089	Block Stiffener Plate
28-Jul-2003	Section 6 - Injectors and Fuel Lines - Group 06	89-006-049	Fuel Control Valve Body Assembly
28-Jul-2003	Section 7 - Lubricating Oil System - Group	89-007-028	Lubricating Oil Pressure Gauge

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28-Jul-2003	Section 10 - Air Intake System - Group 10	89-022-001_10	Service Tools
28-Jul-2003	Section 10 - Air Intake System - Group 10	89-010-033	Turbocharger
28-Jul-2003	Section 13 - Electrical Equipment - Group 13	89-013-019	Starter Solenoid
28-Jul-2003	Section 16 - Mounting Adaptations - Group 16	89-016-002	Engine Support Bracket, Front
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t033-tr	Engine Acceleration or Response Poor
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t041-tr	Engine Decelerates Slowly
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t043-tr	Engine Difficult to Start or Will Not Start (Exhaust Smoke)
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t044-tr	Engine Difficult to Start or Will Not Start (No Exhaust Smoke)
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t057-tr	Engine Power Output Low
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t061-tr	Engine Runs Rough at Idle
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t062-tr	Engine Runs Rough or Misfires
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t066-tr	Engine Speed Surges at Low or High Idle
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t080-tr	Engine Will Not Reach Rated Speed (RPM)
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t087-tr	Fuel Consumption Excessive
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t116-tr	Smoke, Black - Excessive
16-Jul-2003	Section TS - Troubleshooting Symptoms	4021375-t118-tr	Smoke, White - Excessive
08-Jul-2003	Section E - Engine Identification	89-100-002	Engine Diagrams

08-Jul-2003	Section F - Familiarization	89-001-999	Cylinder Block - Overview
08-Jul-2003	Section F - Familiarization	89-002-999	Cylinder Head - Overview
08-Jul-2003	Section F - Familiarization	89-003-999	Rocker Levers - Overview
08-Jul-2003	Section F - Familiarization	89-004-999	Cam Followers/Tappets - Overview
08-Jul-2003	Section F - Familiarization	89-005-999	Fuel System - Overview
08-Jul-2003	Section F - Familiarization	89-006-999	Injectors and Fuel Lines - Overview
08-Jul-2003	Section F - Familiarization	89-007-999	Lubricating Oil System - Overview
08-Jul-2003	Section F - Familiarization	89-008-999	Cooling System - Overview
08-Jul-2003	Section F - Familiarization	89-010-999	Air Intake System - Overview
08-Jul-2003	Section F - Familiarization	89-011-999	Exhaust System - Overview
08-Jul-2003	Section F - Familiarization	89-016-999	Mounting Adaptations - Overview
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-005	Bearings, Connecting Rod
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-006	Bearings, Main
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-007	Bearings, Thrust
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-010	Camshaft Bushings
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-011	Camshaft Cover Plate
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-013	Camshaft Gear (Camshaft Removed)
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-020	Crankshaft Gear, Rear (Crankshaft Installed)
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-023	Crankshaft Seal, Front
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-024	Crankshaft Seal, Rear
20-Jun-2003	Section 1 - Cylinder Block - Group 01	89-001-026	Cylinder Block
	Section 1 -		

20-Jun-2003	Cylinder Block - Group 01	89-001-036	Idler Gear, Camshaft
20-Jun-2003	Section 11 - Exhaust System - Group 11	89-022-001_11	Service Tools
20-Jun-2003	Section 11 - Exhaust System - Group 11	89-011-001	Exhaust Connection Pipe
20-Jun-2003	Section 11 - Exhaust System - Group 11	89-011-007	Exhaust Manifold, Dry
20-Jun-2003	Section 11 - Exhaust System - Group 11	89-011-009	Exhaust Restriction
20-Jun-2003	Section 13 - Electrical Equipment - Group 13	89-022-001_13	Service Tools
20-Jun-2003	Section 13 - Electrical Equipment - Group 13	89-013-020-tr	Starting Motor
20-Jun-2003	Section 14 - Engine Testing - Group 14	89-014-004	Engine Run-in (Without Dynamometer)
19-Jun-2003	Section 14 - Engine Testing - Group 14	89-014-008	Engine Testing (In Chassis)
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-022	Crankshaft Pulley
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-043	Piston
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-046	Piston Cooling Nozzle
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-047	Piston Rings
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-056	Camshaft Thrust Bearing
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-097	Idler Gear, Alternator Drive
30-May-2003	Section 1 - Cylinder Block - Group 01	89-001-098	Idler Gear, Oil Pump
30-May-2003	Section 3 - Rocker Levers - Group 03	89-003-001-tr	Crankcase Breather (External)
30-May-2003	Section 3 - Rocker Levers - Group 03	89-003-009	Rocker Lever Assembly

30-May-2003	Section 3 - Rocker Levers - Group 03	89-003-011	Rocker Lever Cover
30-May-2003	Section 3 - Rocker Levers - Group 03	89-003-013	Rocker Lever Housing
30-May-2003	Section 4 - Cam Followers/Tappets - Group 04	89-004-001	Cam Follower Assembly
30-May-2003	Section 4 - Cam Followers/Tappets - Group 04	89-004-014	Push Rods or Tubes
30-May-2003	Section 5 - Fuel System - Group 05	89-022-001_05	Service Tools
30-May-2003	Section 5 - Fuel System - Group 05	89-005-010	Fuel Consumption
30-May-2003	Section 5 - Fuel System - Group 05	89-005-016	Fuel Pump
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-022-001_07	Service Tools
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-009	Lubricating Oil Dipstick
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-011	Lubricating Oil Dipstick Tube
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-013	Lubricating Oil Filter (Spin-On)
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-015	Lubricating Oil Filter Head
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-024	Lubricating Oil Leaks
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-025	Lubricating Oil Pan
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-031	Lubricating Oil Pump
	Section 7 -		

30-May-2003	Lubricating Oil System - Group 07	89-007-038	Lubricating Oil Temperature Gauge
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-044	Lubricating Oil Contamination
30-May-2003	Section 7 - Lubricating Oil System - Group 07	89-007-050	Cylinder Smokes (Blue Smoke)
30-May-2003	Section 8 - Cooling System - Group 08	89-008-002	Drive Belt, Cooling Fan
30-May-2003	Section 8 - Cooling System - Group 08	89-008-006	Coolant Filter
30-May-2003	Section 8 - Cooling System - Group 08	89-008-013	Coolant Thermostat
30-May-2003	Section 8 - Cooling System - Group 08	89-008-016	Coolant Thermostat Seal
30-May-2003	Section 8 - Cooling System - Group 08	89-008-017	Coolant Vent Lines
30-May-2003	Section 8 - Cooling System - Group 08	89-008-051	Radiator Top Tank
30-May-2003	Section 8 - Cooling System - Group 08	89-008-087-tr	Cooling Fan Belt Tensioner
30-May-2003	Section 9 - Drive Units - Group 09	89-009-010	Alternator Drive Pulley
30-May-2003	Section 10 - Air Intake System - Group 10	89-010-023	Air Intake Manifold
30-May-2003	Section 10 - Air Intake System - Group 10	89-010-024	Air Leaks, Air Intake and Exhaust Systems
30-May-2003	Section 10 - Air Intake System - Group 10	89-010-031	Air Intake Restriction
30-May-2003	Section 10 - Air Intake System - Group 10	89-010-057	Intake Manifold Pressure
30-May-2003	Section 13 - Electrical Equipment - Group 13	89-013-001	Alternator
30-May-2003	Section 13 - Electrical Equipment - Group 13	89-013-006	Alternator Pulley

30-May-2003	Section 13 - Electrical Equipment - Group 13	89-013-007	Batteries
30-May-2003	Section 16 - Mounting Adaptations - Group 16	89-022-001_16	Service Tools
15-May-2003	Section 0 - Complete Engine - Group 00	89-000-001	Engine Removal
15-May-2003	Section 0 - Complete Engine - Group 00	89-000-002	Engine Installation
15-May-2003	Section 8 - Cooling System - Group 08	89-008-019	Cooling System - Air or Combustion Gas Test
15-May-2003	Section 8 - Cooling System - Group 08	89-008-038	Fan Shroud Assembly
15-May-2003	Section 8 - Cooling System - Group 08	89-008-040	Fan, Cooling
15-May-2003	Section 8 - Cooling System - Group 08	89-008-042	Radiator
15-May-2003	Section 8 - Cooling System - Group 08	89-008-045	Radiator Hoses
15-May-2003	Section 8 - Cooling System - Group 08	89-008-047	Radiator Pressure Cap
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t004-tr	Air Compressor Air Pressure Rises Slowly
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t006-tr	Air Compressor Noise is Excessive
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t007-tr	Air Compressor Pumping Excess Lubricating Oil into the Air System
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t008-tr	Air Compressor Will Not Maintain Adequate Air Pressure (Not Pumping Continuously)
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t009-tr	Air Compressor Will Not Pump Air
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t010-tr	Air Compressor Will Not Stop Pumping
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t013-tr	Alternator Not Charging or Insufficient Charging

14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t014-tr	Alternator Overcharging
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t020-tr	Coolant Loss - External
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t022-tr	Coolant Temperature Above Normal - Gradual Overheat
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t023-tr	Coolant Temperature Above Normal - Sudden Overheat
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t024-tr	Coolant Temperature Below Normal
14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t047-tr	Engine Noise Excessive
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14-May-2003	Section TS - Troubleshooting Symptoms	4021375-t049-tr	Engine Noise Excessive - Connecting Rod
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