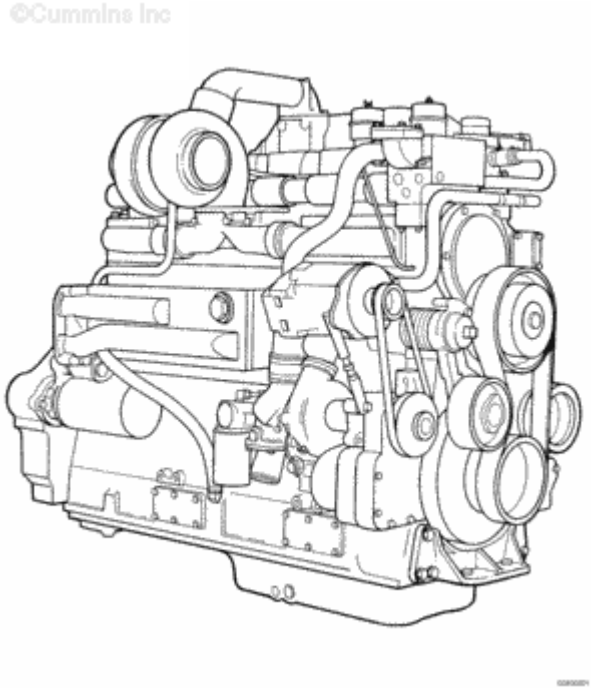
Jahan Compressor

Service Manual (4021499)

K19



Bulletin Number 4021499

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Foreword

This manual contains instructions for troubleshooting and repairing this engine in the chassis, complete rebuild procedures and specifications. Disassembly, cleaning, inspection, and assembly instructions are included. A listing of accessory and component suppliers is located in Section M - Component Manufacturers. Suppliers can be contacted directly for any information not covered in 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.

The repair procedures in this manual are based on the engine or component removed from chassis. Some rebuild procedures require the use of special service tools. Make sure the correct tools are used as described in the procedures.

When a specific brand name, number, or special tool is referenced in this manual, an equivalent product can be used in place of the recommended item.

A series of specific service manuals (for example: Troubleshooting and Repair, 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).

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 is 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 Service Manual is intended to aid in determining the cause of engine related problems and to provide recommended repair procedures. Additionally the manual is intended to aid mechanics in disassembly, inspecting parts for reuse, rebuilding and assembly of components.

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 and describe specific rebuild procedures.

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 divided into the same group system used for previous manuals and the Cummins' filmcard system. Section 00 is organized into a logical sequence of engine disassemble/assemble, all other sections are in numerical sequence. Refer to the Table of Contents at the front of the book to determine the section that details the desired information.

The disassemble/assemble sections of this manual is divided into the same group system used for previous manuals and the Cummins' filmcard system.

Section 00 is organized into a logical sequence of engine disassemble/assemble, all other sections are in numerical sequence. Refer to the Table of Contents at the front of the book to determine the section that details the desired information.

Each section contains the following in sequence:

- Table of Contents
- Required Service Tool Listings
- General Information containing the basic service, maintenance, design and revision information necessary to assist in the rebuild of an engine or a component
- Procedure instructions for the disassembly, inspection, maintenance, and assembly that can be required to rebuild an engine; additional procedures that are **not** necessary during **every** rebuild, but can be necessary, are included. These procedures depend on the length of time an engine has been in service and the conditions of the parts.

All the procedures are identified with a name and a number. Each digit in the procedure number has a specific meaning.

The first three digits of the number refer to the specific section that the procedure can be found within the manual. In this example, “001” represents Section 01 - Cylinder Block. This number will range from 000 to 022.

The second three digits of the number are unique and refer to a specific subject. In this example, “028” represents Cylinder Liner. This number will range from 001 to 999.

Refer to Section V for specifications recommended by Cummins Engine Company, Inc. for your engine. Specifications and torque values for each engine system are

given in that section.

NOTE: Discharge of oil or oily water into or upon the water is a direct violation of today's laws. Violators are subject to a penalty of various monetary charges. Dispose of these substances in accordance with standards set by the local enviromental governing agency.

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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:

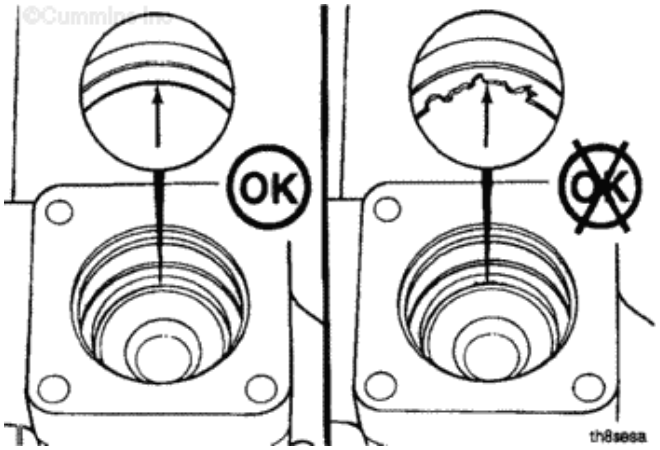
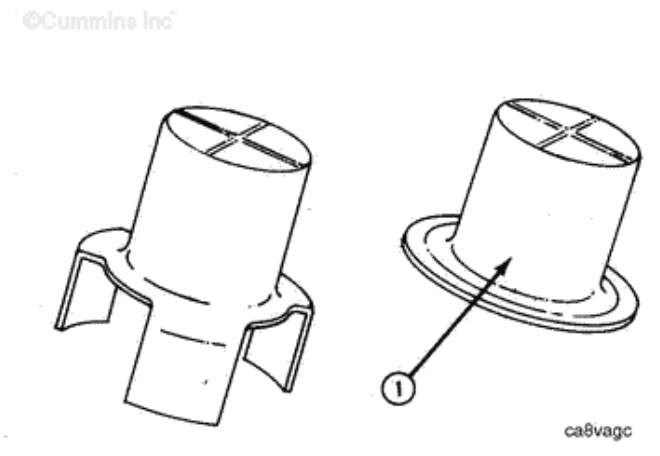


Last Modified: 12-Mar-2002

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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.
- 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
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
- Belts and Hoses
- Bearings (ball or taper roller)
- Electronic Control Module (ECM)
- ECM Connectors
- Capacitive Coil Driver Module (CCD)
- Ignition Coils and Leads
- NOx Sensor
- Fuel Control Valve
- Throttle Driver and Actuator.

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.

Last Modified: 30-Apr-2013

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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
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

Last Modified: 30-Apr-2012

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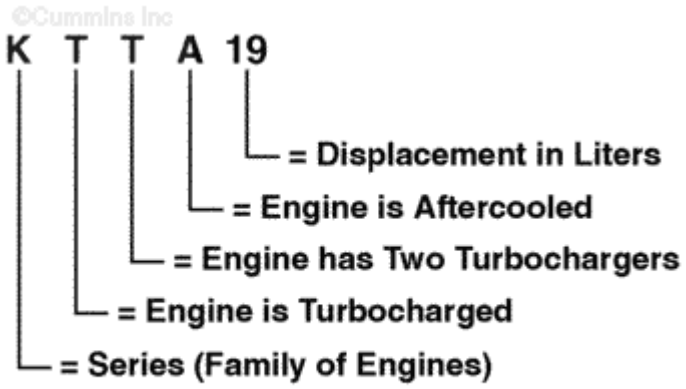
100-001 Engine Identification

Cummins® Engine Nomenclature

The model name provides identification data for the engine. The graphic illustrates model name identification.

The application 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.



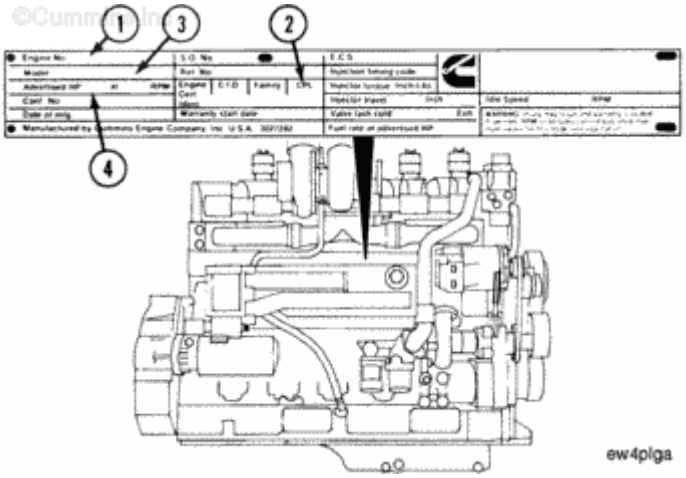
Engine Dataplate

The engine dataplate shows specific information about the engine.

(1) Engine serial number (ESN)

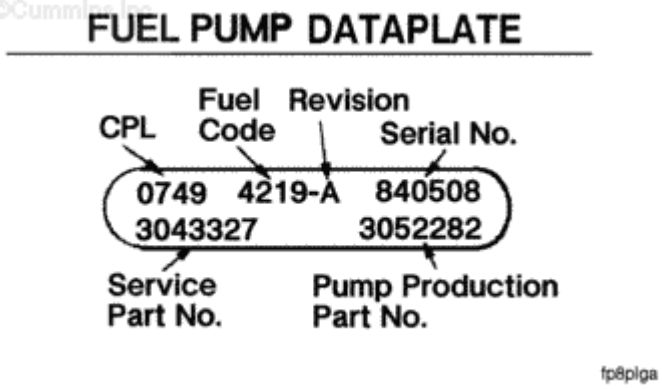
(2) Control parts list (CPL)
(3) Model
(4) Provide information for ordering parts and service needs.

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

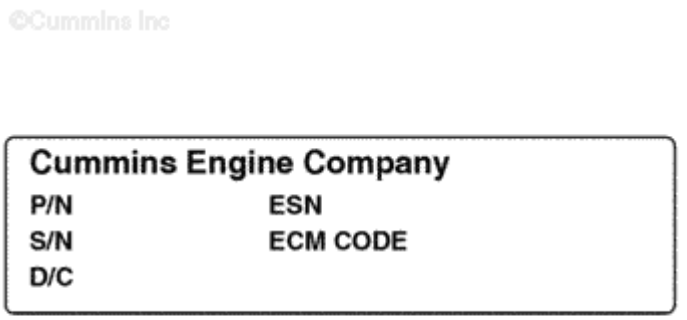
The external ECM dataplate is located on top of the ECM.

The dataplate contains the following:

- ECM part number (P/N)
- ECM serial number (S/N)
- Manufacturer date code (D/C)
- Engine serial number (ESN)
- Calibration loaded in the ECM (ECM code).

On the ECM mounting flange the following information is provided:

- ECM part number
- Voltage rating
- ECM serial number.



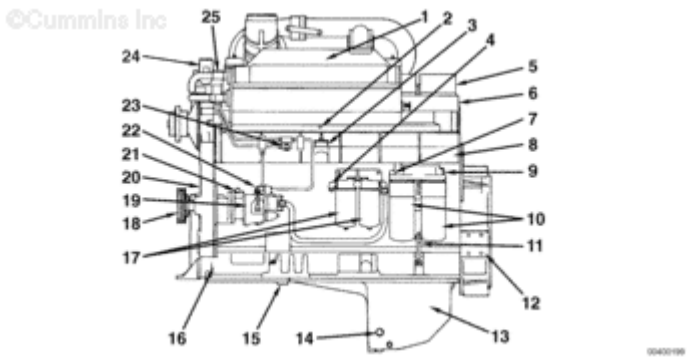
Last Modified: 06-Oct-2004

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100-002 Engine Diagrams

Engine Views

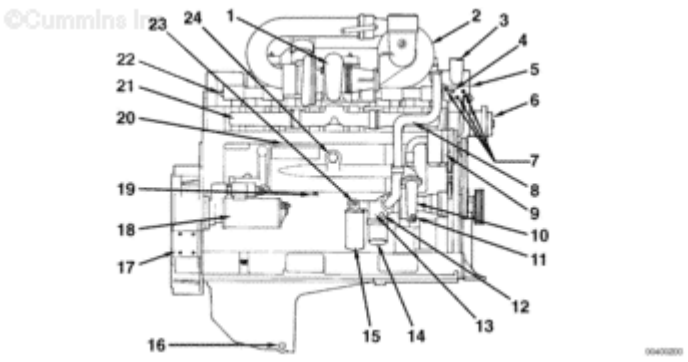
The illustrations show the locations of the major external engine components, the filters and other service and maintenance points. Some external components will be at different locations for different engine models. The engine shown is a KTTA19, KT19 and KTA19 engines will **not** have the low pressure turbocharger and piping.



Left Side View

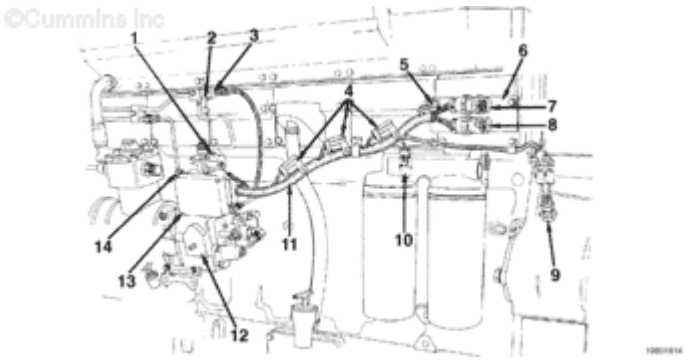
1. Aftercooler
2. Cold start port
3. Oil fill
4. Fuel inlet
5. Rocker lever cover
6. Rocker lever housing
7. Provision for oil pressure gauge
8. Cam follower covers
9. Bypass oil filter supply
10. Full flow oil filters
11. Dipstick tube
12. Flywheel housing
13. Oil pan
14. Provision for sump heater
15. Front plate oil drain
16. Oil pan adapter
17. Fuel filters
18. Accessory drive pulley
19. Fuel pump
20. Front gear cover
21. Tachometer drive

22. Fuel pressure port
23. Fuel Return to tank
24. Water outlet
25. Engine coolant vent.



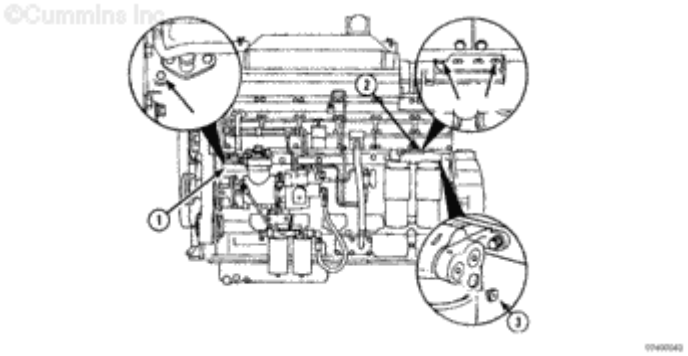
Right Side View

1. High pressure turbocharger
2. Low pressure turbocharger
3. Water outlet
4. Water pressure pickup
5. Thermostat housing
6. Fan hub (gear driven)
7. Water pressure or temperature pickup
8. Water bypass tube
9. Alternator
10. Water pump
11. Petcock for water drain
12. Heater return port
13. Water pump inlet housing
14. Water inlet connection
15. Coolant filter
16. Oil drain
17. Flywheel housing
18. Starter
19. Petcock for water drain
20. Oil cooler
21. Exhaust manifold
22. Heater supply port
23. Water shutoff valve
24. Coolant heater port.



CENTRY™ System Models, Left Side

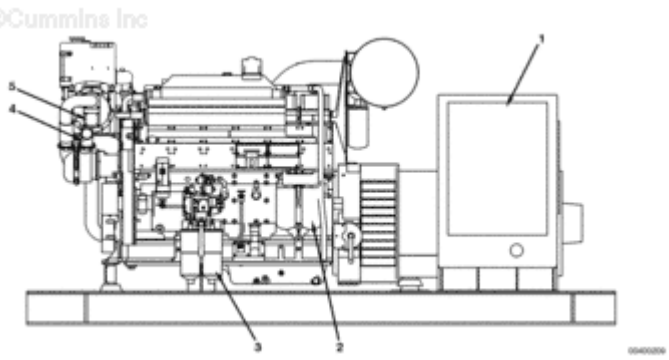
1. Fuel shutoff valve
2. Fuel block
3. Rail pressure sensor
4. Fuses (5 amp)
5. System ground connector
6. OEM C5 and C6 connector bracket
7. C5 connector
8. C6 connector
9. Engine speed sensor
10. Engine side datalink connector
11. Engine harness
12. Fuel pump
13. ECM
14. Electronic fuel control valve.



Oil Pressure Ports

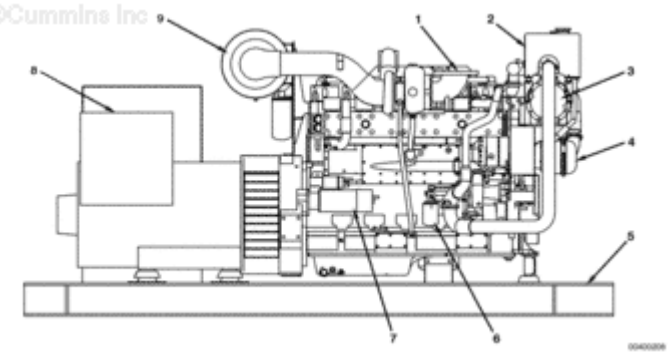
1. Engine oil rifle plug
2. Plug - filtered oil
3. Plug - unfiltered oil.

Generator Set Applications



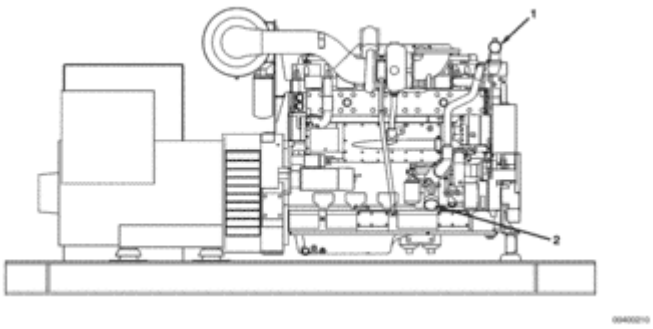
C Power Heat Exchanger Cooled Left Side

1. Control panel
2. Lubricating oil filters
3. Fuel filters
4. Sea water inlet connection
5. Sea water outlet connection.



C Power Heat Exchanger Cooled Right Side

1. Turbocharger exhaust outlet connection
2. Coolant expansion tank
3. Heat exchanger
4. Sea water pump
5. Base rail
6. Coolant filter
7. Starter
8. Alternator
9. Air Cleaner.



C Power Keel Cooled Right Side

1. Coolant outlet connection to keel cooler
2. Coolant inlet connection from keel cooler.

Last Modified: 03-Oct-2006

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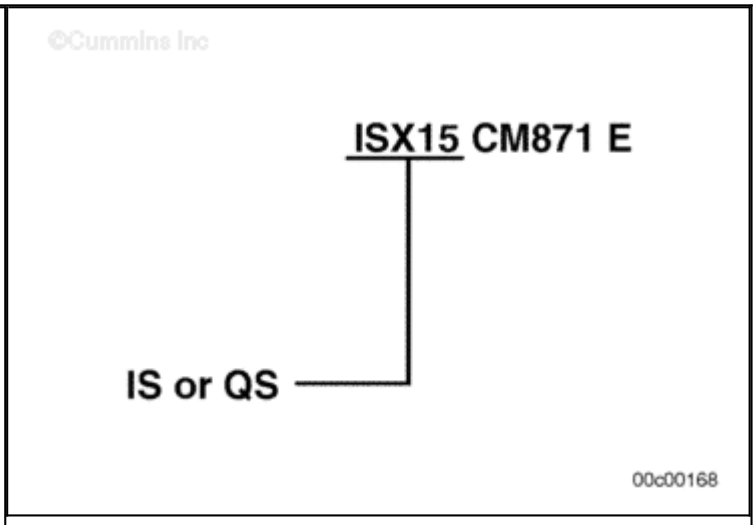
100-003 Cummins® Service Engine Model Product Identification

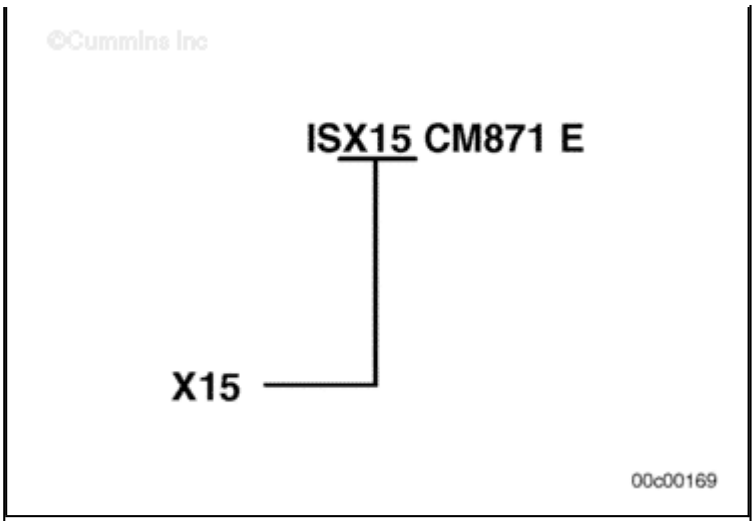
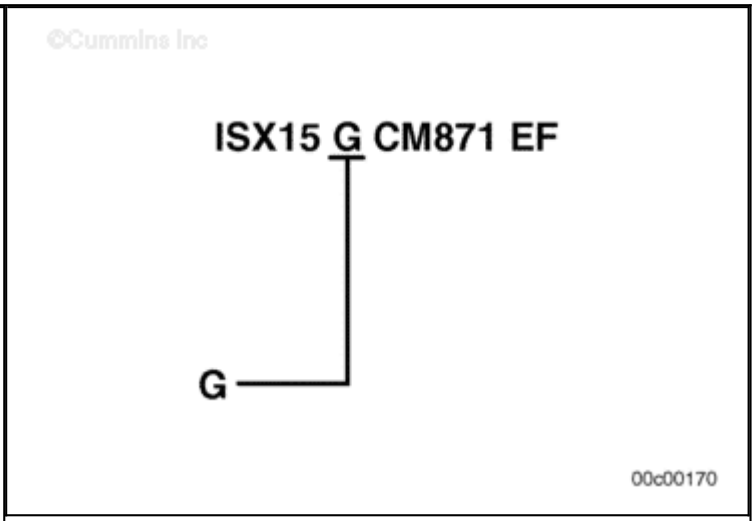
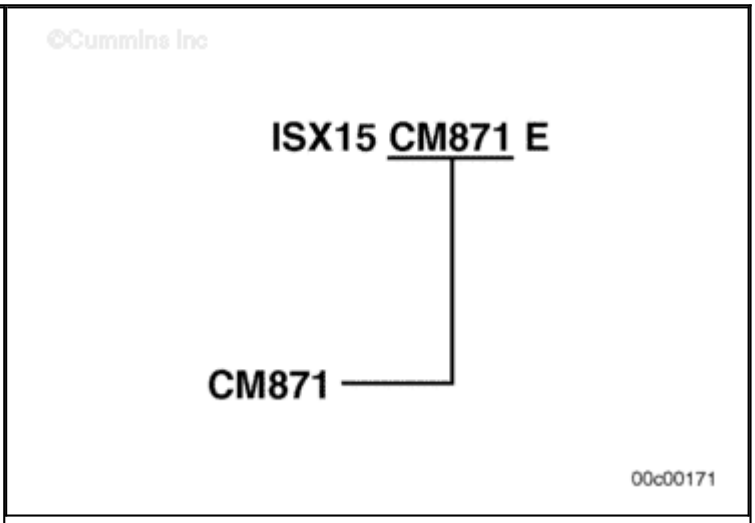
General Information

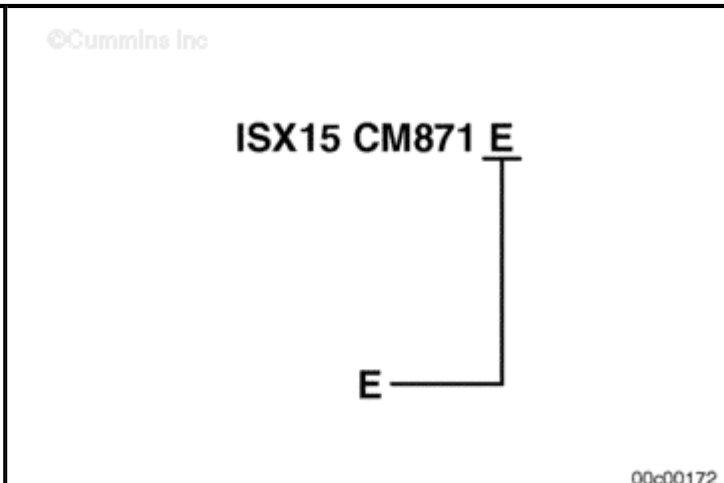
The Cummins® Service Engine Model Nomenclature procedure describes how engines are identified within Cummins service organization. This method was introduced for models after and including manufacture year 2007.

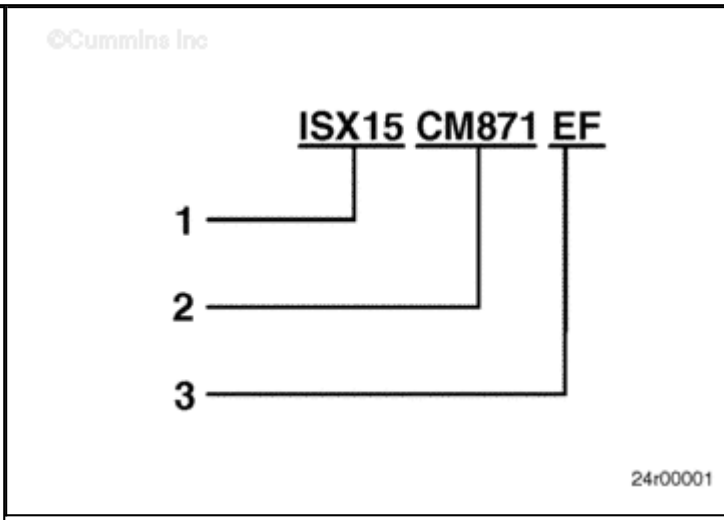


Electronic engines are identified by the first two letters, either an "IS" for On-Highway automotive or "QS" for Off-Highway industrial market applications.



The third letter is the engine platform designation followed by the engine liter size.		
If the engine operates on a fuel type other than diesel, the type will be identified after the liter size.		
The control system is identified with the letters "CM" followed by the control system model number.		

The technology identifier after the control system designates the prevailing technology used with the engine. (See table in this procedure for letter designations.)		

Example: 1. On-Highway automotive "X" 15 liter engine 2. Control system number 871 3. Technology supported; Electric EGR and Diesel Particulate Filter		

Technology	Name	Suffix
Exhaust Gas Recirculation	Not used	None
	Pneumatic	P
	Electric	E
Diesel Particulate Filter (DPF)	Not used	None
	Full Flow DPF	F
	Partial Flow DPF	F2
Diesel Oxidation Catalyst	Not used	None
	DOC	C

3-Way Oxidation Catalytic Converter	Not used	None
	3-Way Catalyst	J
Selective Catalytic Reduction System	Not used	None
	Air Driven	S
	Airless	A
Nox Sensor	Not used	None
	Nox Sensor	N
Modular Common Rail System	Used only on QSK19, 38, 50 , 60 HHP Engines	MCRS
Integrated Dosing Control Unit	Not Used	None
	Integrated	I

Last Modified: 12-Dec-2012

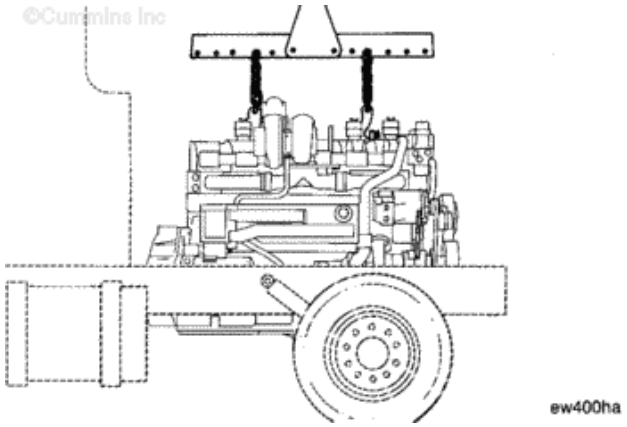
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000-999 Complete Engine - Overview

General Information

WARNING

Lifting the K19 engine improperly can cause equipment damage, severe personnel injury or death. Lifting must be done only by trained, experienced technicians in accordance with instructions in this manual.



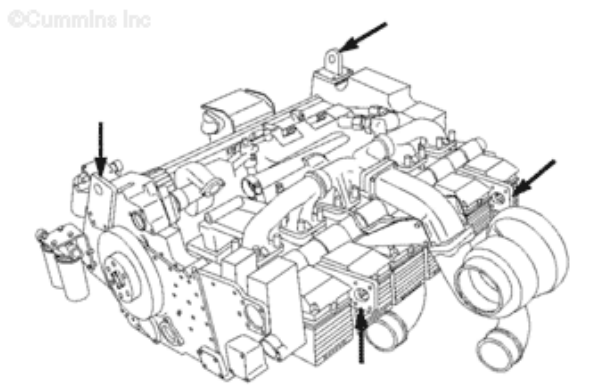
The procedures required to replace an engine will vary with different engine models, the type of equipment, optional equipment, and the shop facilities. Use the following procedures as a guide.

NOTE: All replacement steps do not apply to all types of equipment. Complete only the steps that apply to the equipment involved. Use the equipment manufacturer's recommendations and precautions for removal of chassis parts to gain access to the engine.

Rail Applications

Because the K19 rail engine is mounted in a horizontal position, the engine has two additional lifting bracket locations to aid in the lifting of the engine. The front lifting bracket is mounted on the lubricating oil pan adapter by

three capscrews. The rear lifting bracket is mounted on the flywheel housing by four metric capscrews. The K19 rail engine also uses the two K19 standard lifting brackets located between the rocker lever housings.



Last Modified: 11-Nov-2004

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001-999 Cylinder Block - Overview

General Information

Barring Mechanism

The type of barring mechanism depends on the style of the front cover. On a one-piece front cover, the barring mechanism is inside the front cover. The front cover **must** be removed from the engine to service or rebuild the barring mechanism.

This barring mechanism contains a spring loaded worm gear. The worm gear engages the camshaft gear when the barring shaft is pushed in the front cover and turned in a **counterclockwise** direction. The barring mechanism will **only** turn the engine in the direction of normal rotation. Turn the barring shaft in a **clockwise** direction to disengage the worm gear. If the worm gear remains engaged accidently during engine start, the engine rotation will disengage the parts without damage.

The rebuild procedure for this type of barring mechanism is located in Procedure 001-031.

The barring mechanism on engines that contain a two-piece front cover mounts on the back of the gear housing. The general and information and the rebuild procedures for this type of barring mechanism are located in Procedure 009-035.

Camshaft

The injection timing is adjusted by using different camshaft keys. The selection of a key will change the position of the camshaft lobes in relation to the timing mark on the camshaft gear. The gear **must** be removed to change the injection timing.

The camshaft end clearance is determined by the clearance between the camshaft and the thrust plate. The camshaft gear **must** be removed to adjust the camshaft end clearance.

On some marine engines the camshaft gear contains mounting holes for a ring gear to be mounted. The ring gear is designed to power a sea water pump.

The camshaft does **not** have to be removed to remove the camshaft gear. Use the camshaft gear puller kit, Part Number 3376400. The two reversible jaws **must** point opposite from the center of the gear.

Camshafts that are damaged or worn on the injector or the valve lobes **must** be replaced. Cummins Inc. does **not** recommend the grinding of camshaft lobes.

Connecting Rod

Two styles of connecting rods have been used on K19 engines. The two styles are completely interchangeable and can be mixed.

The original style contains two locating dowel rings between the connecting rod and the connecting rod cap. This connecting rod **only** has one balance pad.

The current style contains four locating dowels between the connecting rod and the connecting rod cap. This connecting rod has a balance pad on both the connecting and connecting rod cap.

Crankshaft

When the K19 engine was original introduced, the crankshaft contained bolt-on counterweights. These counterweights **must** be removed before grinding the main bearing journals. The counter weights **must** be installed in their original location.

On the current crankshaft the counterweights are forged in place. Both styles of crankshafts are completely interchangeable.

On engines that contain the bolt-on counterweight style crankshaft, the connecting rod journals **must** be positioned at top dead center before the pistons can be removed. On engines that contain the forged-on counter weight style crankshaft, the pistons can be removed when the connecting rod journals are positioned at top dead center or bottom dead center.

Some crankshafts contain a dowel on the vibration damper mounting surface. This dowel is required to align the vibration damper correctly. This type of crankshaft **must** be used in applications that require the timing marks to be located on the vibration damper.

Oversize main bearings and thrust bearings are available for service. Cummins Inc. recommends grinding of all of the main or the connecting rod journals when one requires grinding.

Cylinder Block

Since the introduction of the K19 engine, the design of the cylinder liner counterbore has been changed. Refer to Procedure 001-026 to determine the counter bore design of the engine being serviced.

On cylinder blocks with engine serial number 31118624 and greater, the top of the main bearing cap contains a 45 degree chamfer around the capscrew. A chamfered plain washer **must** be used on all blocks that do **not** contain a chamfer.

Current engines contain three vent holes. The vent holes connect the oil cooler water cavity to the water hole. The water hole supplies water to the cylinder heads. The vent holes improve the fill of the coolant and the deaeration of the oil cooler. If the engine being serviced does **not** have the vent holes, these can be machined by using a 3/16-inch drill. Place the drill in the 3/16-inch water hole between cylinders 1 and 2, cylinders 3 and 4, and cylinders 5 and 6. Drill the hole into the water cavity.

On engines manufactured since 1977 with engine serial number 31103629 and greater, a thick wall camshaft bushing with an oil groove on the outside diameter is used. This oil groove provides sufficient oil pressure to operate a Jacobs® engine brake.

During the initial production, the K19 engine contained a thin wall camshaft bushing. This bushing does **not** contain an oil groove on the outside diameter. Do **not** use a Jacobs® engine brake on an engine that contains a standard thin wall bushing.

An optional thin wall bushing that contains a 131 degree oil groove on the outside diameter is available. This bushing **must** be used on engines that have a Jacobs® engine brake. The oil groove provides the additional oil pressure required to operate the Jacobs® engine brake.

It is permissible, but **not** necessary, to machine an old block to convert from the thin wall bushing to the thick wall bushing. Both types of bushings are available as a service part. The inside diameter is identical on both types of bushings.

Cylinder Liner

Since the introduction of the K19 engine, the design of the cylinder liner has been changed. Refer to Procedure 001-026 to identify the design and the type contained in the engine being serviced.

The inside diameter is the same on all of the different designs.

The installed liner protrusion is the same for all of the different designs.

Gear Cover

Two different styles of front covers are used on the K19 engine. The two styles are **not** interchangeable. Service parts are available for both styles.

The first style was used on engines built before 1980 and is still used on some marine engines. This style is commonly referred to as the two-piece front cover. This design contains two cast parts; a gear housing and a cover. Both pieces are available in cast iron or aluminum.

The second style is used o most of the other engines and on some marine engines. It is commonly referred to as the one-piece front cover. This design contains a flat steel plate and an aluminum front cover.

Both styles require different rebuild procedures. Instructions for both styles are included in this manual.

Special capscrews **must** be used to attach the gear cover plate or the gear housing to the cylinder block. These capscrews contain a cone shaped washer mounted permanently on the capscrew. A different length capscrew **must** be used for each style.

A gasket sealant or grease **must not** be used when installing the plate to the block, or the gear housing to the block gasket. This gasket is designed to become larger

when it contact engine oil.

Gears

The idler gear bushings are machined after installation in the gear. Replacement bushings that have already been machined are **not** available as service parts.

Engines built before 1978 contained a shaft that was press fit into the block. A 3/8-inch capscrew was used to retain the gear on the shaft. Do **not** remove the press fit shaft from the block unless it is damaged.

Other engines contain idler shafts that are attached to the block by use of a capscrew. A 13/16-inch capscrew is used to retain the shaft and the gear in the block.

Some engines do **not** contain a hydraulic pump idler gear and shaft. The oil drilling to this shaft **must** be plugged by installing a 13/16-inch capscrew and a plain washer.

Oil Seals

All crankshaft seals on the K19 are the Teflon™ lay-down lip (scroll) type. Many other shaft seals are also the Teflon™ lay-down lip type. The Teflon™ lay-down lip type seal does **not** contain a spring on the back of the sealing lip. The sealing lip is a thin, stiff piece of Teflon™. Some Teflon™ type seals contain a second sealing lip that performs as a dust lip. These seals **must** be used in severe operating environments, such as a high dust environment.

Teflon™ seals **must** be dry before installation. Do **not** lubricate the seal or the shaft. After the first few turns of the shaft, a thin film of Teflon™ is transferred from the seal lip to the shaft. If the shaft is **not** clean and dry, this transfer will **not** occur and the seal will leak.

If the seal is **not** the Teflon™ type, lubricate both the sealing lip and the shaft with either grease or engine oil.

All oil seals **must** be installed in one of two ways; even with the cast surface, or even with the bottom of the entry chamfer on the seal bore.

Pistons

A piston is available **only** as a kit. The kit contains a piston, a piston pin, and two retaining rings.

Two styles of pistons are available for the K19 engine. The two styles are the premium piston and the standard piston.

On the premium piston both compression ring grooves are machine in the ni-resist insert. The top of the piston is anodized for additional heat resistance.

On the standard piston **only** the top compression ring groove is machined in the ni-resist insert. The top of the piston is **not** anodized.

The premium piston is designed to perform at higher duty cycles and temperatures

than the standard piston. Use of the premium piston where the standard piston will **not** perform satisfactorily.

All pistons are **not** interchangeable. Some pistons **must not** be mixed. The following table indicates pistons that are interchangeable for the 14.5:1 and 15.5:1 compression ratios. The piston part numbers that are noted with an asterisk (*) are premium pistons.

Piston Compatibility (Compression Ration 14.5:1)				
Piston Part Number	**Piston Part Number 3036073***	**Piston Part Number 3028124**	**Piston Part Number 3004730**	**Piston Part Number 206740**
3036073* Compatible with	Yes	No	Yes	No
3028124 Compatible with	No	Yes	Yes	No
3004730 Compatible with	Yes	Yes	Yes	Yes
206740 Compatible with	No	No	Yes	Yes

Piston Compatibility (Compression Ration 14.5:1)				
Piston Part Number	**Piston Part Number 3036074***	**Piston Part Number 3026270**	**Piston Part Number 3007750**	**Piston Part Number 207330**
3036074* Compatible with	Yes	No	No	Yes
3026270 Compatible with	No	Yes	Yes	No
3007750 Compatible with	No	Yes	Yes	No
207330 Compatible with	Yes	No	No	Yes

Vibration Damper

The vibration damper controls the twisting or torsional vibration of the crankshaft. A vibration damper is engineered for use on a specific engine model. There are two types of vibration dampers used on K19 engines. One is a rubber element type and the second is a viscous type.

It is **not** economical to repair a vibration damper in the field. Install a new or rebuilt

vibration damper if the inspection indicates that a vibration damper is defective.

The viscous vibration damper has a limited service life. The damper **must** be replaced after 576,000 km [360,000 mi] or 15,000 hours of service.

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002-999 Cylinder Head - Overview

General Information

Cylinder Head

All K engines use the same cylinder head casting. Some models require different valves and/or valve guides because of special engine applications. Check the parts books and the CPL to determine the correct valves and correct valve guides for the engine application being serviced.

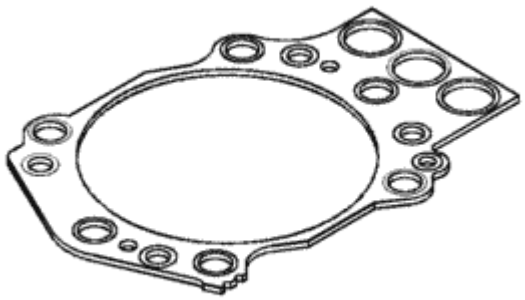
After thousands of hours of severe use, small cracks will begin to appear on the combustion surface between the valves and around the injector bore. Cylinder heads with cracks that extend into, but **not** across the valve seat insert bore of the head can be used again. Cummins Inc. does **not** recommend the cracks be repaired by pinning or welding.

Because of the large surface area of the valves, the valve depth in the cylinder head is critical to the engine operation. Valves that are installed to a depth greater than 0.05 mm [0.020 in] will result in excessive white smoke when an engine is operating in cold temperatures.

Cylinder Head Gasket

There are two types of cylinder head gaskets compatible with the K19 engines. The K-profile cylinder head gasket and the QSK19-profile cylinder gasket

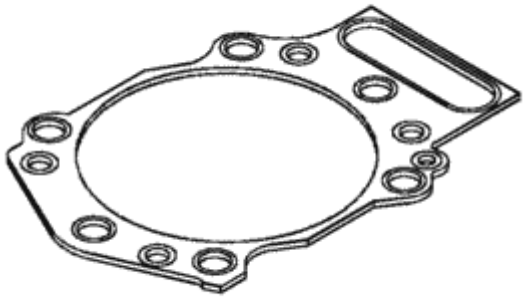
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02600023

K-Profile Gasket

©Cummins Inc



02600024

QSK19-Profile Gasket

The QSK19-profile gasket has a single oblong hole surrounding all three push tubes. The overall length on the push tube end of the QSK19-profile gasket is approximately 2 mm [0.08 in] longer than the K-profile gasket, causing the gasket to protrude beyond the edge of the cylinder head.

All K19 engines are manufactured with the QSK19-profile gasket. The K-profile gasket is available for service.

Use the QSK19-profile gasket if the mating surface of the block and head are refreshed during repair, or if the cylinder head gasket is being replaced.

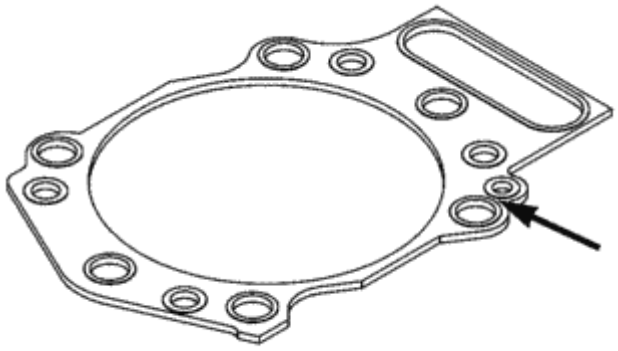
The K-profile gasket uses glued-in grommets to seal the coolant and oil passages.

The K-profile gasket has individual holes around each push tube.

Use the K-profile gasket when the mating surface of the cylinder block and head are **not** refreshed during repair, or if a K-profile gasket is being replaced.

Field experience has found, in some cases, the K-profile gasket provides better sealing characteristics than the QSK19-profile gasket on worn cylinder blocks.

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02400124

QSK19-Profile Steel Bridge Enhancement

As a product improvement, a steel bridge has been added to the gasket carrier between one of the cylinder head capscrew drillings and the high pressure oil passage. The location of the durability enhancement is shown with an arrow in the illustration above.

Intake and Exhaust Valves

An engine with two turbochargers require special valves. The special valves have a higher temperature resistance than the standard valves. The special valves can be used, but are **not** required in other K engine models.

The exhaust valves are manufactured from a material that is capable of operating in higher temperatures than the intake valves. Do **not** install an intake valve in an exhaust valve location.

Exhaust and Intake Valve Seat Inserts

The intake valve seat insert has a wide valve seat area than the exhaust valve seat insert. This change was implemented to reduce the rate of intake valve beat-in. Do **not** install an intake valve seat insert in an exhaust valve location. Poor engine performance will result because of restricted flow of exhaust gas. Oversize valve seats are available in the listed sizes.

Outside Diameter Oversize	Depth (Thickness) Oversize
0.25 mm [0.010 in]	Standard
0.51 mm [0.020 in]	0.13 mm [0.005 in]
0.76 mm [0.030 in]	0.25 mm [0.010 in]
1.02 mm [0.040 in]	0.38 mm [0.015 in]

Anti-Swirl Plate

When the K19 engine was introduced, the cylinder head did **not** contain an anti-swirl plate under the intake valve seat insert.

Any engine that is rebuilt to the CPL number 127, 159, or 171 **must not** contain an anti-swirl plate in the cylinder head. Use any K cylinder head casting with an insert spacer plate installed under the intake valve seat insert.

Two anti-swirl plates have been used. These anti-swirl plates are **not** interchangeable.

For optimum engine performance, **always** use the correct anti-swirl plate or the insert spacer plate. Check the CPL for the correct cylinder head casting number for the engine being serviced.

Valve Guides

The standard valve guide has a tapered top surface. Both the intake valve guide and the exhaust valve guide are the same. There are valve guides with a flat top available for use with the valve stem seal. Cummins Inc. recommends the use of the flat top guides and the valve stem seals in the exhaust location on any engine that operates at idle for extended periods of time, such as a locomotive application.

The standard tapered top valve guides are available in two lengths. Both of the tapered type styles **must** be installed so the top of the guide is within 34.93 to 35.31 mm [1.375 to 1.390 in] above the cylinder head.

The flat top guides **must** be installed so the top of the guide is within 25.58 to 30.23 mm [1.175 to 1.190 in] above the cylinder head. This height allows for the installation of a stem seal.

There are valve guides that are oversize on the outside diameter available for both the standard tapered top type and the flat top type. The two oversizes are 0.25 mm [0.010 in] and 0.38 mm [0.015 in].

Crosshead

Two crosshead designs have been used on the K19 engine. The current design contains an adjusting screw that has a contact face that is larger than the thread diameter. The previous design contains an adjusting screw that has a contact face slightly smaller than the thread diameter.

The previous design can be modified to use the new adjusting screw. The depth of the valve stem pocket **must** be within 7.24 to 7.75 mm [0.285 to 0.305 in] to use the new adjusting screw. Use a 37/64-inch diameter end mill to machine the valve stem pocket approximately 4.19 mm [0.165 in] deeper.

An oversize crosshead guide is available for service. The cylinder head **must** be machined to maintain a 0.13 to 0.53 mm [0.0005 to 0.0021 in] press fit. The oversize guide is oversize **only** in the part that presses into the cylinder head. A standard crosshead is used with an oversize guide.

Stemless crossheads were introduced on the K19 in July 1995 ESN first 37158462.

The stemless crosshead requires no adjustment and can be positioned on the valve stem tips in either direction. Stemless and Stemmed crossheads can be intermixed within an engine. Stemless crossheads can be used with the crosshead guide installed.

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003-999 Rocker Levers - Overview

General Information

Rocker Lever Adjusting Screw

Some of the engines previously manufactured contain a slotted adjusting screw. A non-slotted adjusting screw **must** be used if a Jacobs® Engine Brake is going to be installed. The non-slotted adjusting screw will maintain sufficient oil pressure to operate the Jacobs® engine brake.

Rocker Levers

All of the rocker levers contain replaceable bushings. The rocker lever pad on the intake and exhaust levers is precision ground and **must not** be repaired. The socket on the injector lever is replaceable.

Both the intake and exhaust levers contain a blind rivet. The rivet plugs the oil drilling in the lever. The rivets **must** be present. The rivets provide sufficient oil pressure to operate a Jacobs® engine brake. A special injector rocker lever **must** be used if a Jacobs® engine brake is going to be installed. This lever contains an arm that makes contact with the actuator piston on the Jacobs® engine brake.

Rocker Lever Shaft

Some rocker lever shafts have two oil holes at the exhaust lever location. If a Jacobs® engine brake is going to be installed, the oil hole that is **not** in alignment with the oil hole at the intake lever location **must** be plugged. Use a rocker lever shaft plug. The plug is needed to maintain sufficient oil pressure to allow the Jacobs® engine brake to operate properly.

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004-999 Cam Followers/Tappets - Overview

General Information

Pressurized engine oil is supplied to each cam follower assembly through an oil drilling in the shaft rear mounting capscrew of each assembly. The special slotted capscrews permit the oil on flow to the shaft, levers, sockets, and rollers.

Cam Follower Cover

There are four styles of cam follower covers available:

- Plain
- With an oil fill
- With a crankcase breather
- With a tapped hole to mount the high volume variable time oil drain back tube.

All cam follower covers are manufactured from aluminum. The mounting location for each style depends to the selected engine option.

Cam Follower Assembly

The cam follower assembly torque is important because of the special slotted screws. the capscrews **must** be tightened within 39 to 42 N•m [29 to 31 ft-lb]. Excess torque can cause the capscrew to break. Insufficient torque can cause the capscrew to loosen during engine operation.

New cam follower lever and roller assemblies are coated with a heavy preservative compound. They **must** be cleaned and lubricated with engine oil before each assembly is installed on the engine.

Cam Follower Shaft

The oil drilling in the shaft is open at both ends. This means that either end of the shaft can be installed toward the front of the engine. The ring dowel bores **must not** have any burrs to install the assembly by hand. The cup plug in the end of the shaft keeps the flow of the pressurized oil in the shaft instead of dumping the oil into the camshaft cavity in the block. This cup plug **must** be installed on the end of the shaft, outside the capscrew hole.

Cam Follower Sockets

The Cummins K engine family uses a replaceable cam follower socket. This socket allows pressurized oiling of the roller, pin, and push rod. Sockets in the valve and the injector levers are interchangeable.

The sockets have a press fit into the lever. To maintain a press fit, the loose sockets **must** be replaced if the socket is worn or damaged in the area where it contacts the push rod.

Cam Follower Push Rods

Some of the previous Cummins K engine family push rods have hollow tube style injector push rods. The ends of the push rods are press fit into the tube. These push rods can be used again if both ends are secure and **not** loose.

The current push rods are machined from solid bar stock instead of tubing. The ball end and the socket are machined on the rod. A loose socket end retainer on the push rod is acceptable as long as the retainer is **not** in danger of separating from the rod.

It is a good service practice to mark the push rods for location when removing them from the engine. The valve and injector push rods are **not** interchangeable. The cam follower socket **must** be replaced if the push rod is worn or damaged in the area where it contacts the socket. Replace both the rocker lever adjusting screw and push rod if the socket surface in the rod or on the adjusting screw is damaged.

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005-999 Fuel System - Overview

General Information

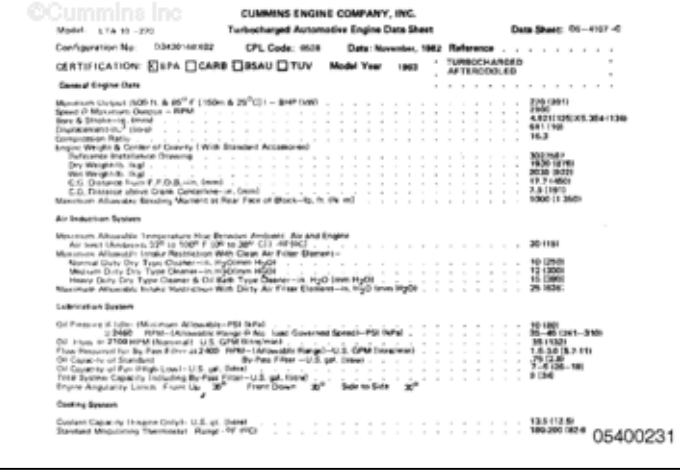
The listed publications are available to provide fuel system installation recommendations approved by Cummins Inc.:

- Automotive Installation Recommendations (Fuel System), Bulletin 952849

For parts and service publication purchase information, refer to Additional Service Literature Procedure 205-001.



Contact the nearest Cummins authorized repair location for engine fuel system specifications and requirements provided on the engine data sheet for the specific engine and application.



Theory of Operation - STC Fuel System

STC was previously referred to as hydraulic variable timing. The STC system allows an engine to operate with advanced injection timing under a light load condition at any engine speed. STC allows an engine to operate with normal injection timing under a heavy load condition.

Injection timing is changed by supplying engine oil in metered amounts to a hydraulic tappet located on the injector. When the tappet is filled with engine oil the injection timing is advanced. When the tappet is **not** filled with engine oil the injection timing is to the normal mode.

When the fuel rail pressure exceeds 365 kPa [53 psi], the injection timing will change from the advanced mode to the normal mode. When the fuel rail pressure drops below 159 kPa [23 psi], the injection timing will return from the normal mode to the advanced mode. It will remain in the advanced mode until the fuel rail pressure exceeds 365 kPa [53 psi].

The STC tappet assembly contains a plunger and sleeve that are machined to a very precise tolerance. The assembly is then matched by a selection process at the factory (matched-fit). **Never** interchange or mix the plungers and the sleeves.

The tappet assembly and injector are **not** matched sets. The tappet assembly can be used in any STC injector. Cummins Inc., recommends STC tappet disassembly **only** if there is evidence that the debris that caused the failure has moved beyond the full-flow filters. Any debris in the tappet will adversely effect the tappet operation.

The method of adjusting the injection timing and injector rocker lever travel on engines with STC is the same as the method used on engines without STC. The specification for injector travel and injection timing on engines with STC is different than engines without STC.

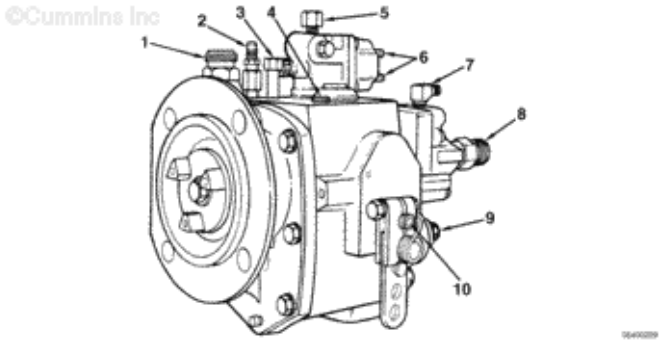
The fuel pressure switch is compatible with both the 12 VDC and 24 VDC system. The fuel pressure switch is normally in the closed position. The switch will be in the open position when the fuel rail pressure exceeds 365 kPa [53 psi]. One terminal of the switch is wired to the positive terminal of the fuel pump shutoff valve. The second terminal is wired to the positive terminal on the STC control valve.

A STC oil control valve is available for the 12 VDC or 72 VDC systems. It is normally in the closed position. The valve will be in the open position to allow the oil to flow to the STC oil manifold when the solenoid is energized.

The STC pressure relief valve contains a 0.51 mm [0.020 in] orifice to control the flow of the oil to the STC oil manifold during normal injection timing. A 14 to 40 kPa [2 to 6 psi] check ball maintains a supply of pressurized oil in the oil manifold to prevent air from entering the system during the normal mode.

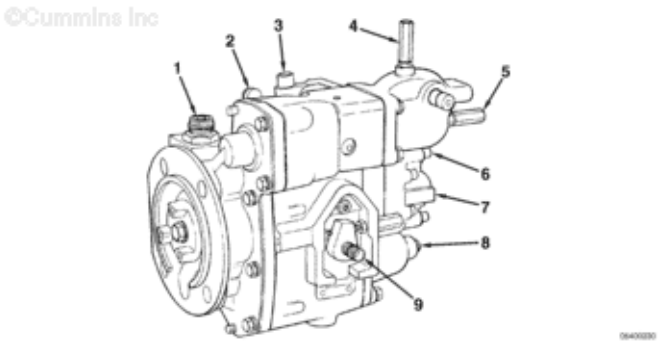
The wiring harness receives power from the fuel pump solenoid. The wiring will send signals from the fuel rail pressure switch to the oil control valve. A diode is contained in the wiring harness. The wires and the diode can be checked for defects by using a multimeter, Part Numbers 3164488, 3164489, or ay multimeter or volt-ohmmeter that has a rating of 10,000 ohm per volt or greater.

The hydromechanical control valve replaces the electric fuel pressure switch and the electric oil control valve. The hydromechanical valve provides the same function as the parts it replaces. This manual does **not** cover calibration of the hydromechanical control valve. Refer to Additional Service Literature Procedure 205-001 for further reference.



PT (Type G) AFC Connection and Adjustment Locations

1. Tachometer drive
2. AFC air supply
3. AFC fuel return
4. Priming plug
5. Fuel to the injector
6. Shutoff valve electric connection
7. Gear pump fuel return to drain
8. Fuel inlet connection
9. Idle speed screw location
10. Fuel rate (pressure) screw.



PT (Type G) AFC-VS Connection and Adjustment Locations

1. Tachometer drive
2. AFC air supply
3. Fuel to the injectors
4. VS high speed screw
5. VS low (idle) speed screw
6. Gear pump fuel return to drain
7. Fuel inlet connection
8. Idle speed screw location
9. Fuel rate (pressure) screw.

Fuel Recommendations

Cummins diesel engines have been developed to take advantage of the high energy content and generally lower cost of Number 2 diesel fuels. A Cummins diesel engine will also operate satisfactorily on Number 1 or other fuels within the specifications found in the Fuels for Cummins Engines, Bulletin 3379001.

For information on PT fuel pump rebuild and calibration, refer to the Fuel Pump PT (Type G) Rebuild Calibration Instructions, Bulletin 3379084.

For PT fuel pump calibration values use the table below to select the correct bulletin.

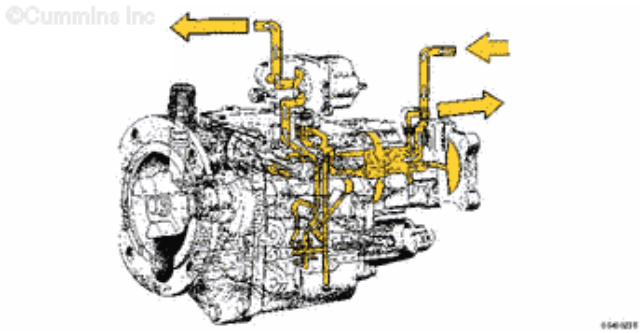
Pump Code Release Date	Calibration Value Bulletin
1970 to 1975	3379068
1976 to 1980	3379182
1981 to 1989	3379352
1990 to 2004	3666011

Last Modified: 30-Jul-2007

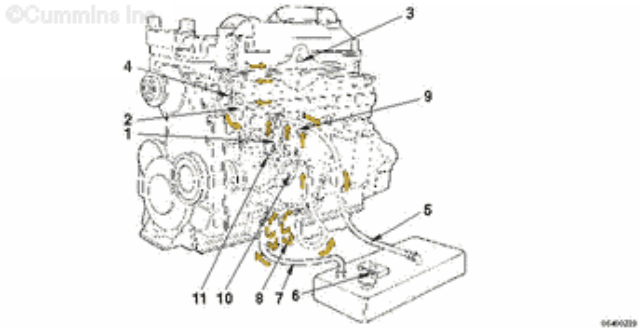
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200-001 Flow Diagram, Fuel System

Flow Diagram



Fuel Flow Through Fuel Pump



1. AFC cavity drain
2. Fuel rail pressure line
3. Injector
4. Injector fuel drain return
5. Fuel return to tank
6. Fuel tank breather
7. Fuel inlet supply
8. Fuel filter
9. Gear pump coolant drain
10. Fuel pump
11. Tachometer drive.

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006-999 Injectors and Fuel Lines - Overview

General Information

Step Timing Control

The step timing control system allows an engine to operate with advanced injection timing under a light load condition at any engine speed. Step timing control allows an engine to operate with normal injection timing under a heavy load condition.

Injection timing is changed by supplying engine oil in metered amounts to a hydraulic tappet located on the injector. When the tappet is filled with engine oil the injection timing is advanced. When the tappet is **not** filled with engine oil the injection timing is in the normal mode.

When the fuel rail pressure exceeds 365 kPa [53 psi], the injection timing will change from the advanced mode to the normal mode. When the fuel rail pressure drops below 159 kPa [23 psi], the injection timing will return from the normal mode to the advanced mode. It will remain in the advanced mode until the fuel rail pressure exceeds 365 kPa [53 psi].

The step timing control tappet assembly contains a plunger and sleeve that are machined to a very precise tolerance. The assembly is then matched by a selection process at the factory (match-fit). **Never** interchange or mix the plungers and the sleeves.

The tappet assembly and injector are **not** matched sets. The tappet assembly can be used in any step timing control injector. Cummins Inc. recommends step timing control tappet disassembly **only** if there is evidence that the debris that caused the failure has moved beyond the full-flow filters. Any debris in the tappet will adversely effect the tappet operation.

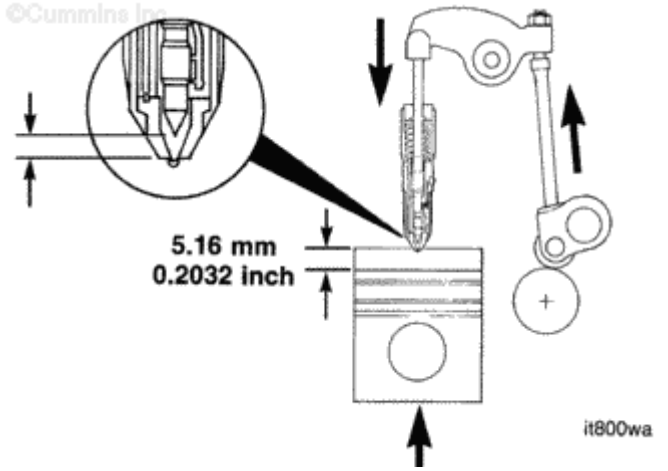
The method of adjusting the injection timing and injector rocker lever travel on engines with step timing control is the same as the method used on engines without step timing control. The specification for the injector travel and injection timing on engines with step timing control is different than engines without step timing control.

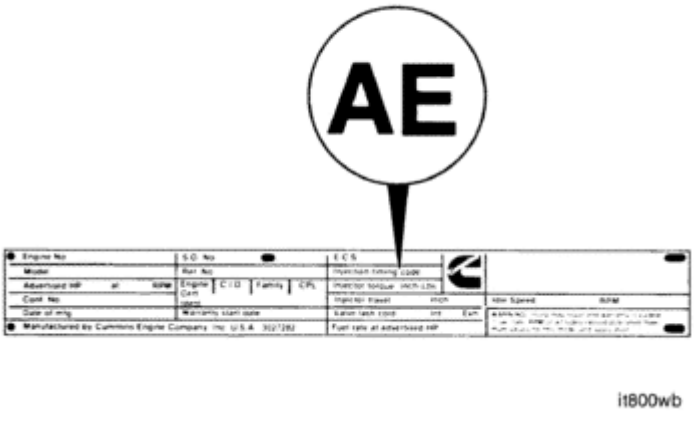
The fuel pressure switch is compatible with both the 12 VDC and 24 VDC system. The fuel pressure switch is normally in the closed position. The switch will be in the open position when the fuel rail pressure exceeds 365 kPa [53 psi]. One terminal of the switch is wired to the positive terminal of the fuel pump shutoff valve. The second terminal is wired to the positive terminal on the step timing control valve.

A step timing control oil control valve is available for either the 12 VDC or the 24 VDC system. It is normally in the closed position . The valve will be in the open position to allow the oil flow to the step timing control oil manifold when the solenoid is energized.

The step timing control pressure relief valve contains a 0.51 mm [0.020 in] orifice to control the flow of the oil to the step timing control oil manifold during normal injection timing. A 14 to 40 kPa [2 to 6 psi] check ball maintains a supply of pressurized oil in the oil manifold to prevent air from entering the system during the normal mode.

The wiring harness receives power from the fuel pump solenoid. The wiring will send signals from the fuel rail pressure switch to the oil control valve. A diode is contained in the wiring harness. The wires and diode can be checked for defects by using a multimeter or any volt-ohmmeter that has a rating of 10,000 ohm per volt or greater.

The junction timing is the relative measurement of the distance remaining between the injector plunger and the injector cup when the piston is 5.16 mm [0.2032 in], or 19 degrees before top dead center on the compression stroke. Injector timing is expressed by the amount of push rod travel remaining.		

The injector timing code appears on the engine dataplate. Codes are alphabetic letters that relate to a numerical specification. Specifications can be found in this manual and the CPL manual.		

The timing codes and specifications for K19 engines are shown in the graphic.

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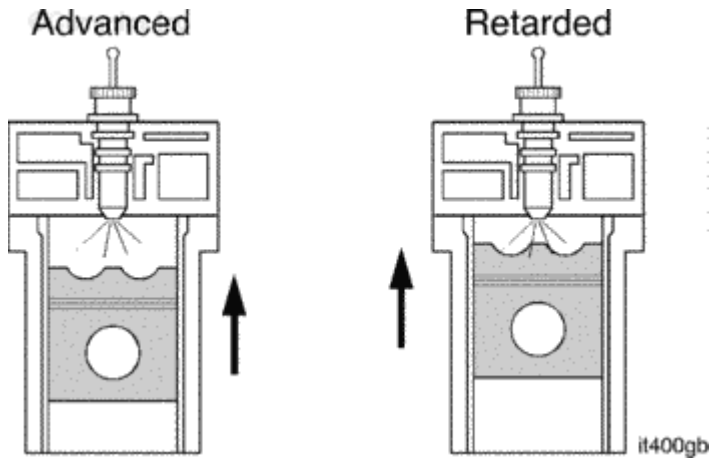
K-19 Timing Codes

Code	Push Rod Travel mm (in.)	Tolerence mm (in.)
AE	2.74 (0.108)	±.05 (0.002)
CI	2.90 (0.114)	±.05 (0.002)
AM	3.00 (0.118)	±.05 (0.002)
AJ	3.20 (0.126)	±.05 (0.002)
CU	3.25 (0.128)	±.05 (0.002)
CL	3.66 (0.144)	±.05 (0.002)

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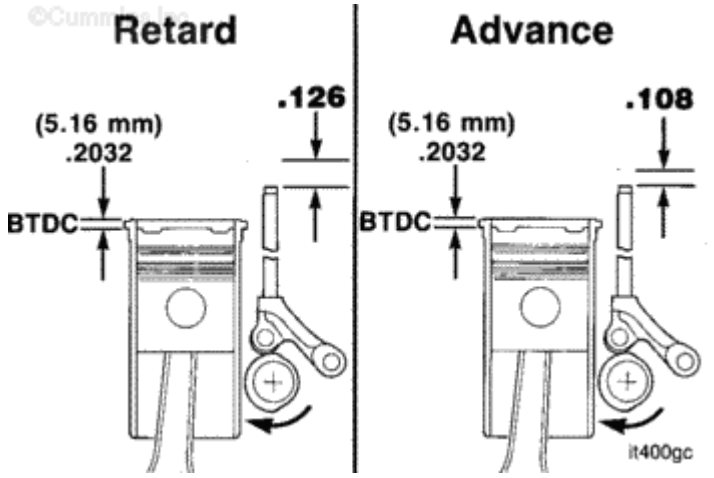
Advanced timing means the fuel is injected earlier into the cylinder during the compression stroke.

Retarded timing means the fuel injection occurs closer to top dead center in the cylinder.



The amount of push rod travel determines the time of fuel injection in relation to the piston position.

The higher the numerical value of the push rod travel remaining indicates a greater degree of retarded or slow timing.

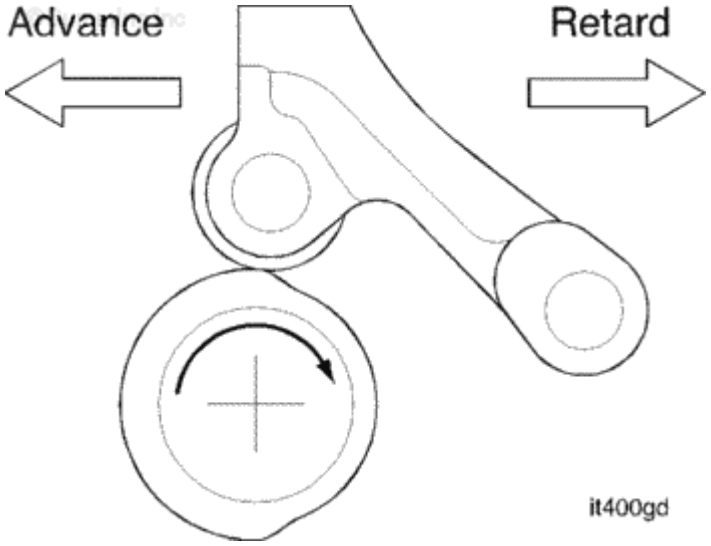


The lower the numerical value of the push rod travel remaining indicates a greater degree of advanced or fast timing.

Injector timing changes are accomplished by advancing or retarding the cam follower action in relation to the piston position.

This is accomplished by changing the orientation of the camshaft lobe to the cam follower using different camshaft gear keys.

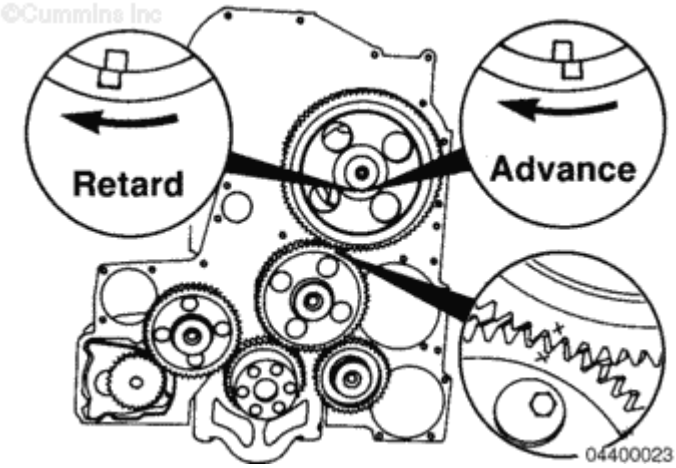
Gear train timing (index mark alignment) **always** remain the same.



The camshaft key provides a means of indexing the camshaft with the gear.

Offset keys allow the camshaft profile to be rotated slightly while the gear train timing remains the same.

The more the top of the offset is moved in the direction of the camshaft normal rotation, the more



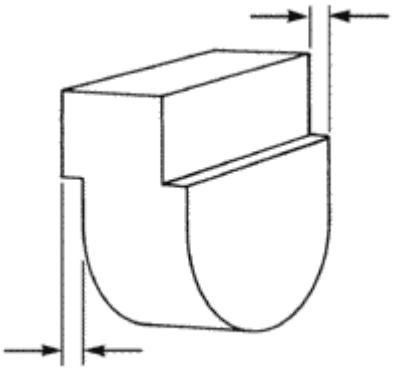
the injection timing will be retarded. The push rod travel numerical value will increase.

The direction of normal rotation on a K19 engine crankshaft is **clockwise** as viewed from the front.

Offset keys can be identified by measuring the offset and referring to the following chart.

Each 0.025 mm [0.001 in] of offset will cause a 0.0127 mm [0.0005 in] change in the push rod travel from a straight key.

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it4kega

Use the recommended key shown if the camshaft, gear, or the timing code has been changed.

If checking or setting the injection timing, it is recommended to use a testing gear. A testing gear is a camshaft gear that has been modified to provide a slip-fit on the crankshaft.

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Timing Code	Recommended Key	Direction of Offset
AE	216782	Opposite Cam Rotation
CI	200711	With Cam Rotation
AM	216782	With Cam Rotation
AJ	200706	With Cam Rotation
CU	3000492	With Cam Rotation
CL	S-302	None

04400024

Last Modified: 29-Nov-2004

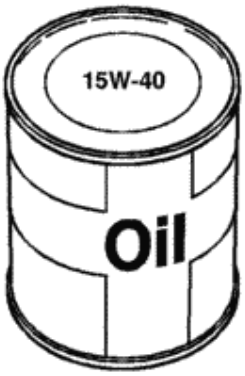
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007-999 Lubricating Oil System - Overview

General Information

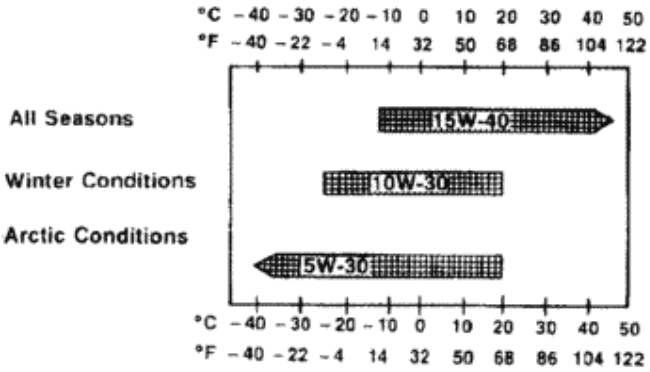
WARNING

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.



oi809ga

The use of low viscosity oil, such as 10W or 10W-30, can be used to aid in starting the engine and in providing sufficient oil flow at ambient temperatures below -5°C [23°F], but continuous use of low viscosity oil can decrease engine life due to wear.

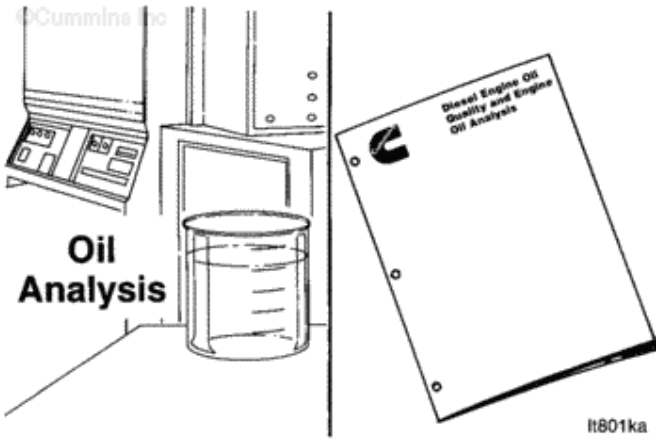


oi900da

A used oil analysis can help diagnose internal damage and determine if it was caused by one of the following:

- Intake air filter malfunction
- Coolant leaks
- Oil diluted with fuel
- Metal particles causing wear.

Do **not** disassemble an engine for repair based **only** on the results of an oil analysis. Also, inspect the oil filter. If the filter shows evidence of internal damage, find the source of the problem and repair the damage. Refer to Procedure 007-083 for oil filter inspection.



The Lubricating Oil Filter Head contains two spring loaded plungers. One plunger controls the oil pressure for the piston cooling nozzles. The second spring plunger will bypass oil if a filter element becomes plugged or clogged.

When installing a new filter element, **always** check to be sure there is no interference between the filter head adapter and the element.

The oil filter remote option has a transfer connection and a remote filter head. The transfer connection is attached to the block in the same manner as the standard filter head. The transfer connection also houses the pressure regulator plunger for the piston cooling nozzles. The remote filter head houses the pressure regulator plunger for the filter bypass.

NOTE: The transfer connection gasket is the same as the filter head gasket, but the tab on the end of the gasket must be removed.

Lubricating Oil Pan sumps are available in various capacities. Refer to Procedure 018-017 for oil pan capacities. When a rear gear train option is specified, add 7.5 liters [2 U.S. gallons] to the sump capacity.

Service dipsticks are available in two types. The first type is the locking type. The second is the bottle stopper type that does **not** lock. When converting from one style to the other, change both the dipstick and oil gauge tube.

NOTE: Service dipsticks are supplied by length. The dipsticks do not have the high and low marks indicated. Do not calibrate the dipstick until the engine is installed in the application that its to be used.

Lubricating Oil Pumps on engines manufactured after engine serial number 31117701 contain a lubricating oil pump that uses a roll pin to secure the pressure regulator assembly. The lubricating oil pump **must** be removed from the engine to service the pressure regulator assembly.

Engines manufactured prior to engine serial number 31117702 contain a lubricating oil pump that uses a retaining ring to secure the pressure regulator assembly. The lubricating oil pump does **not** need to be removed to service the pressure regulator assembly. Use a pressure regulator removal tool, Part Number 3375055.

The Lubricating Oil Cooler on engines manufactured prior to 1976 contain two oil transfer tubes. The tubes connect the oil cooler housing to the block. These tubes can be omitted when using the current block to oil cooler housing gasket.

Oil cooler housings and covers are cast iron. Oil cooler housings made from aluminum are no longer available for production or service.

Do **not** reuse an oil cooler element after a progressive damage failure has resulted in metal particles in the lube oil filter. There is no practical method to clean the oil cooler core and metal particles can be circulated through the lubricating system and cause engine damage after a repair. Do **not** allow dirt or gasket material to enter the oil passages when cleaning the oil filter head or cylinder block surfaces.

Oil cooler elements used in production and service before September 1997 have 3/8-24 UNF threads in the mounting feet. Oil cooler elements used in production and service beginning September 1997 have 3/8-16 UNC thread in the mounting feet. It is acceptable to use old and new coolers in the same engine.

The oil cooler elements used on K19 engines and QSK19 engines are **not** interchangeable. The QSK19 oil cooler element is larger than the K19.

The engine mounted Torque Converter Cooler/Marine Gear Cooler are available as an option. This option can be added to a standard engine by purchasing the torque converter cooler housing, the cooler cover, and the elements.

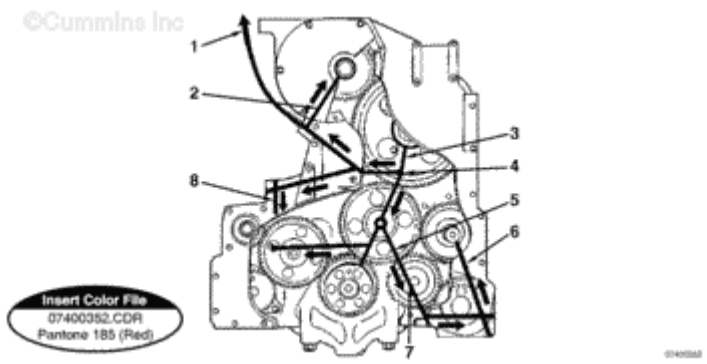
The location of the turbocharger drain line and other components will have to be changed on some engines. The torque converter cooler is mounted and replaces the lubricating oil cooler cover. When the torque converter cooler option is selected, longer mounting capscrews **must** be used.

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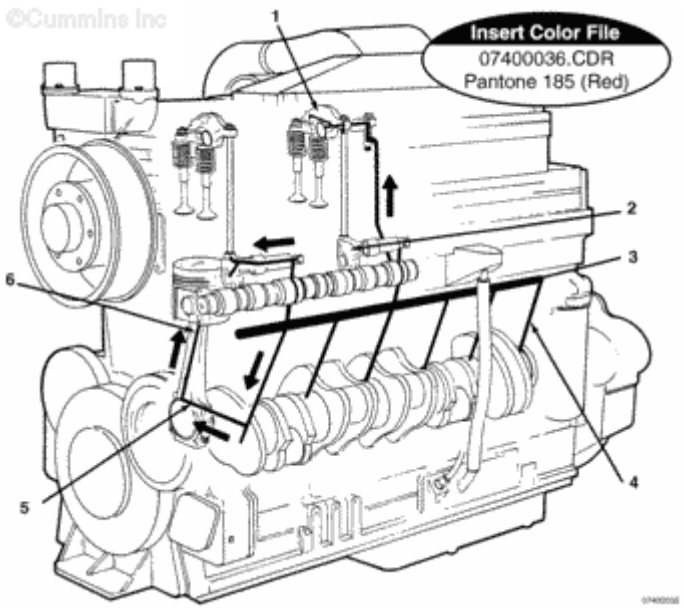
200-002 Flow Diagram, Lubricating Oil System

Flow Diagram



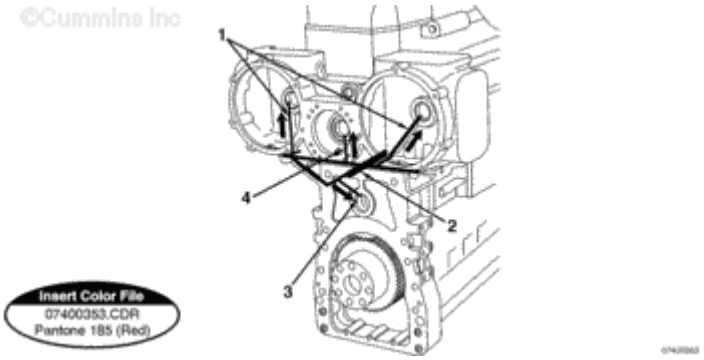
Front View

1. Oil supply to turbocharger
2. Oil supply to fan hub
3. Oil supply to camshaft bushing
4. Main oil rifle
5. Oil supply to idler gear and hydraulic pump drive
6. Oil supply to air compressor and fuel pump drive
7. Oil supply to main bearing and idler
8. Oil supply to water pump housing.



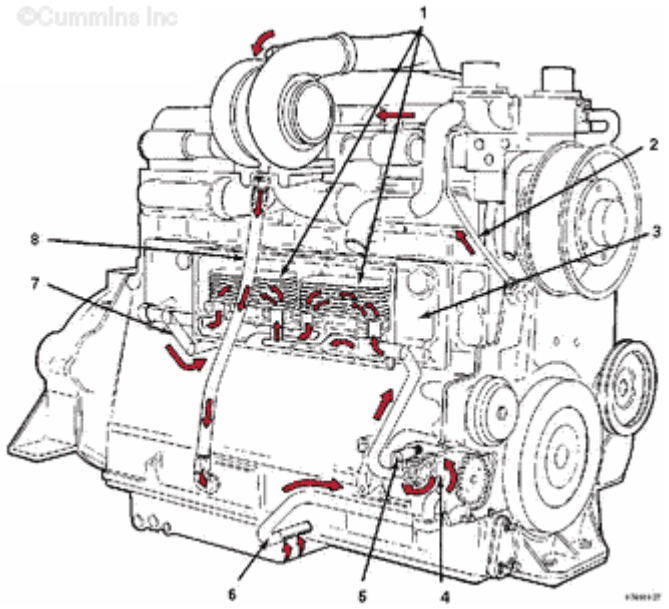
Left Side View

1. Rocker lever
2. Cam follower
3. Main oil rifle
4. Oil supply to main bearings
5. Oil supply to connecting rods
6. Oil supply to piston pin bushing.



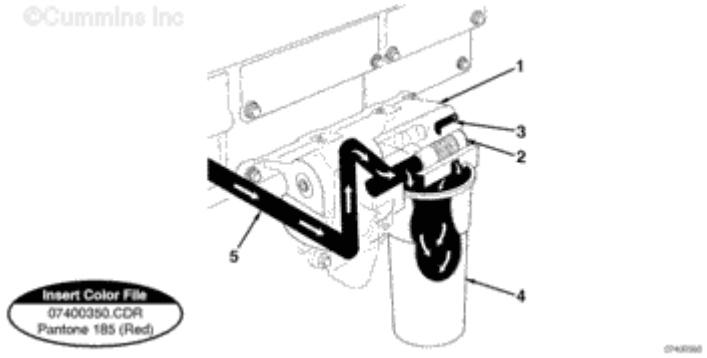
Rear View

1. Oil supply to hydraulic pump driveshaft bushings
2. Main oil rifle
3. Oil supply to lower idler shaft
4. Oil supply to center hydraulic pump driveshaft bushing.



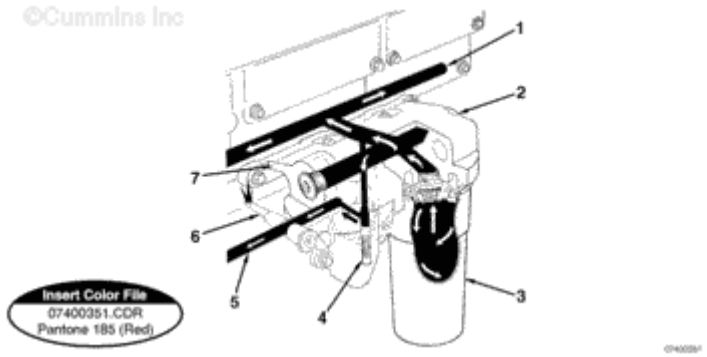
Right Side View

1. Oil cooler elements
2. Turbocharger oil supply
3. Oil cooler housing
4. Lubricating oil pump
5. Lubricating oil pump regulator
6. Oil suction tube
7. Oil to filter head
8. Turbocharger oil drain.



Filter Head

1. Filter head
2. Filter bypass valve
3. Oil before filter
4. Full flow filter
5. Oil to filter head.



Filter Head

1. Main oil rifle
2. Oil filter head
3. Full flow filter
4. Piston cooling control valve
5. Piston cooling oil rifle
6. Piston cooling nozzle
7. Oil after filter.

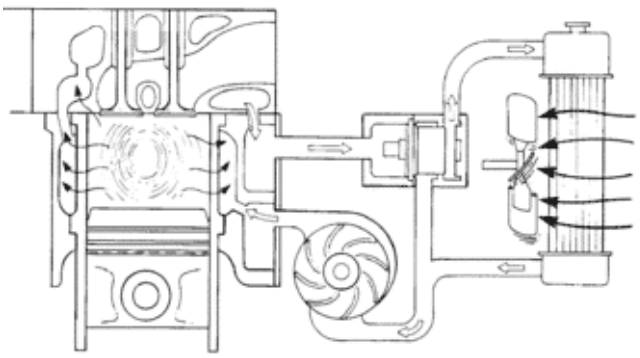
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008-999 Cooling System - Overview

General Information

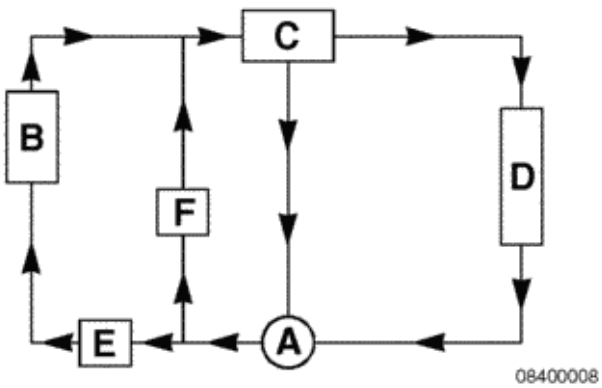
The primary function of the cooling system is to remove heat energy, created by the combustion process, from the engine. The excess heat energy that is **not** removed by the cooling system is carried away by exhaust gases and radiation into the atmosphere.



The accompanying chart illustrates the Conventional Aftercooling coolant flow through the engine.

For more details, refer to the coolant flowcharts in Procedure Refer to Procedure 200-003.

A. Pump
B. Engine cylinder head
C. Thermostat housing
D. Radiator
E. Oil cooler
F. Aftercooler.

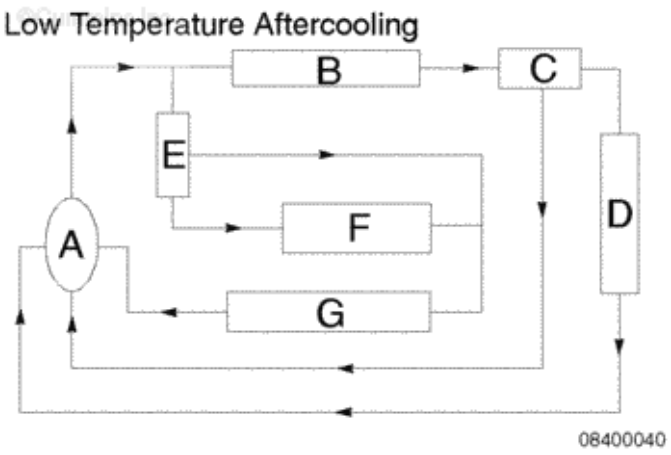


The accompanying chart illustrates the Low Temperature Aftercooling coolant flow through the engine.

For more details, refer to the coolant flowcharts in Procedure Refer to Procedure 200-003.

A. Water pump
B. Base engine
C. Engine thermostat
D. Engine radiator
E. Low temperature aftercooling thermostat
F. Low temperature aftercooling radiator
G. Aftercooler.





The Cummins Inc. K19 engine requires a minimum pressure cap rating of 48 kPa [7 psi]. This provides a positive head pressure at the water pump inlet.

The Water Pump is a centrifugal type pump. It can have either the cast iron, or the phenolic resin impeller. The cast iron impeller has been the standard for production beginning August, 2001.

On aftercooled engines, the water pump impeller maintains 172 kPa [25 psi] block pressure. At 2100 rpm, the water flow is 830 liters per minute [220 U.S. gallons per minute]. The block pressure is measured at the number six rocker lever housing.

On non-aftercooled engines, the water pump impeller maintains 241 kPa [35 psi] block pressure. At 2100 rpm, the water flow is 757 liters per minute [220 U.S. gallons per minute]. The block pressure is measured at the number six rocker lever housing.

The water pump is gear driven by a splined drive shaft. The shaft connects the pump to the water pump drive. Drive shafts are available in two sizes. One is a 11/16-inch diameter shaft for use with a water pump containing a phenolic impeller. The second is a 3/8-inch diameter for the use with a water pump containing a cast iron impeller.

CAUTION

The use of the wrong drive shaft can result in failure of the splines or the impellers.

The water pump contains two antifriction bearings that are ball type. The bearings are lubricated with pressurized oil supplied from the engine.

The water pump contains an oil seal and a water seal. The cavity between these seals is vented. The vent prevents contamination of the lubricating or coolant in case of a seal leak. Oil and coolant seeping from the vent will **not** harm the operation. Check the vent for any obstruction at each scheduled maintenance interval.

CAUTION

DO not touch the sealing surfaces of the seal and seat. The oil from your fingers can cause the seal to fail. If necessary, clean the sealing surfaces with a solvent that does not have an oil base.

The water pump contains a one-piece or unitized water seal. The seal and the seat are fastened together. This helps prevent failures caused from dirt or oil contacting the seal faces during installation.

CAUTION

The water pump seal must be installed to the correct dimension from the water pump body. Correct installation will result in proper spring tension. Incorrect spring tension will cause the seal to fail. One drop of Loctite® 290, Part Number 3823682 (50 mL), 3824039 (10 mL) or equivalent, must be applied at the joint between the seat and the shaft. More than one drop of fluid can get on the sealing faces and cause the seal to fail.

Fan Hubs are available in three types:

1. Belt driven assembly with one of two types of spring loaded idler or an idler with a shock absorber.
2. Gear driven assembly
3. Clutch driven assembly

NOTE: For installation and operation of the clutch driven assembly, reference Bulletin 3387082, K-1150 Fan Clutch Operation and Installation. For rebuild instructions for the clutch driven assembly, reference Bulletin 3387063, K-1150 Fan Clutch Rebuild.

Belt Driven Fan Hub equipped engines have the fan belt tensioned by the spring loaded idler assembly and does **not** require adjustment.

CAUTION

To prevent accidents, always release the spring tension before replacing the fan belt.

When the pivot arm cap is aligned properly with the spring, tension is a minimum of 54 n•m [40 ft-lb].

A grease nipple is on some pivot arms. The pivot arm **must** be greased at each schedule maintenance interval. Do **not** grease the pivot arm that does **not** have a grease fitting. If there is no grease fitting then the bushings work without grease.

Either a turnbuckle, an enclosed spring, or a shock absorber is used to limit the travel of the idler pulley. Check the shock absorber for fluid leakage and loss of vibration absorption at each scheduled maintenance interval.

Fan hubs are available in various drive ratios and fan center locations. When replacing the fan hub, **always** check the part number to be sure the replacement is compatible.

All of the belt driven fan supports contain antifriction bearings that are tapered roller type. Bearing end clearance is controlled by the use of an inner and outer bearing spacer. It is a good service practice to tag the bearings for location when removing them. **Always** replace both the bearing and bearing race if either piece requires replacement.

The idler pulley contains two antifriction bearings that are tapered roller type. The bearing end clearance is set properly by matching select components in the kit.

CAUTION

Always replace the complete bearing kit when any one piece requires replacement. Failure to do this will result in premature equipment failure.

The kit includes a retaining ring, an inner spacer, two bearings, and two bearing races.

CAUTION

Never use too much grease on the bearings. Too much grease will cause an overheating due to the agitation of the grease. Excessive agitation of grease will result in failure.

The following is the proper method of applying water pump type grease. Do **not** use lithium base grease for fan hub bearings.

1. Pack both bearings with grease.
2. Fill the cavity between the bearings 2/3-full with grease.
3. Fill the cavity above the front bearing 2/3-full with grease.

Gear Driven Fan Hubs support assemblies are available in various drive ratios. When replacing either the fan support assembly, or the gear and shaft assembly, check the part numbers to be sure the replacement part is compatible.

WARNING

To reduce the possibility of personal injury or damage to equipment, never remove the gear from the shaft. Damage to the press can result due to the high press fit or weld between the gear and the shaft.

The fan hub support contains two antifriction bearings that are tapered roller type. The fan hub bearings are pressure lubricated by the engine lubrication system. The bearing end clearance is set properly by matching select components in the bearing kit. **Always** replace the entire kit if any of the parts require replacement. This kit includes two bearings, two bearing races, two retaining rings, and inner spacer. It is a good service practice to tag the bearings for location when removing.

The fan is isolated from gear train vibration by a rubber divider in the fan hub. The hub support assembly does **not** have to be removed from the engine to replace the fan hub. A retainer is installed on the hub. The retainer will prevent the fan from separating from the engine id the rubber member fails. On some models, this retainer is already cast on the inner part of the hub and can **not** be removed.

WARNING

Never attempt to rotate the engine by pulling or prying on the fan. This practice can result in serious personal injury and damage to the fan. Use only the proper engine barring techniques to manually rotate the engine.

Engine Fans **must** be inspected for missing balance weights at each regular maintenance interval. Do **not** attempt to repair broken or bent fans, or fans with missing balance weights.

Most equipment that has a Cummins® engine uses a radiator and fan. The radiator and fan transfer heat from the cooling water to the atmosphere. The fan selection process **must** conclude that the fan, the fan mounting arrangement, and the fan drive system are designed and matched for compatibility.

Upon request Cummins® Customer Engineering Department will assist in determining the proper selection. Reference any fan changes other than the direct replacement of a fan with precisely the same Cummins® part number first to a Cummins® Authorized Repair Location for assistance.

Examples that require approval are:

1. Using an approved fan from one engine model on a different engine model.
2. Using an approved fan on an engine with a different fan mounting arrangement.
3. Using an approved fan on an engine with a different fan drive arrangement.
4. Converting an engine from one market model to another. An example is the conversion of a G-drive engine to a power unit application.
5. Converting an engine model to a different model. An example is converting a KT19 to a KTA19 model.

This list is **not** inclusive. **Always** contact Application Engineering for assistance.

At times an existing fan can yield **ONLY** marginal cooling capability when being considered for a new application.

CAUTION

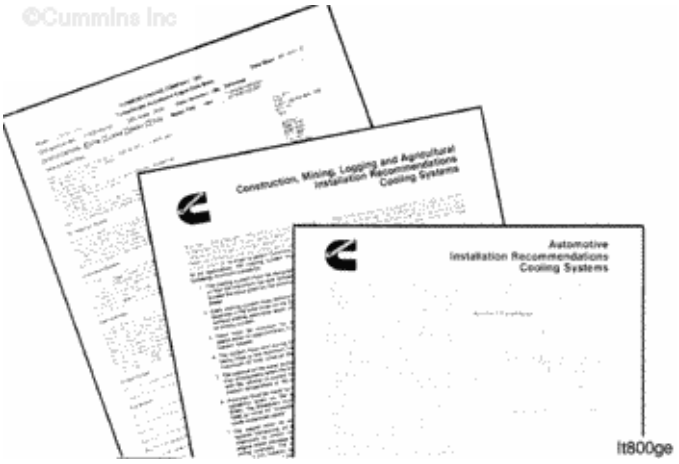
Never repitch (bend) the blades to obtain additional air delivery. Bending the blades or

spider creates stress in the material used for the construction of the fan. Repitching (bending) will cause fan failure. The proper diameter fan must be selected. Never modify an existing fan.

The following publications, available through a Cummins® Authorized Repair Location, provide cooling system installation recommendations and specifications approved by Cummins Inc.

- Operation of Diesel Engines in Cold Climates, Bulletin 3379009.
- Generator Drive and Generator Set Installation Recommendations (Cooling System), Bulletin 3382395.
- Coolant Requirements and Maintenance, Bulletin 3666132.

NOTE: Refer to Procedure 205-002 (Service Literature Ordering Location) in section L for literature ordering information.

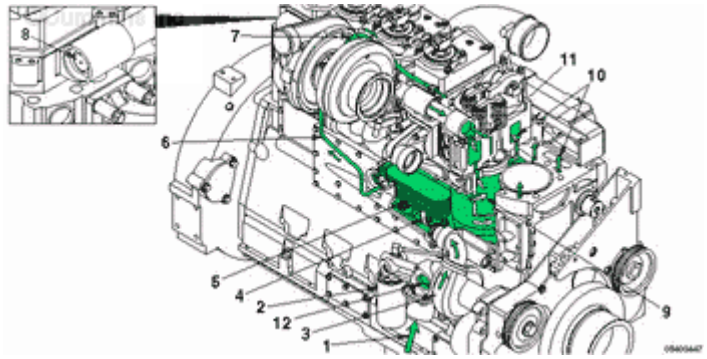


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200-003 Flow Diagram, Cooling System

Flow Diagram



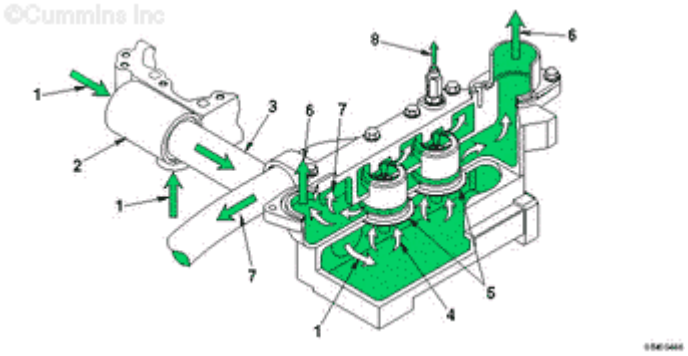
1. Coolant inlet
2. Coolant filter
3. Coolant pump
4. Coolant supply to engine block
5. Lubricating oil cooler
6. Coolant supply to turbocharger
7. Coolant return from turbocharger
8. Cabin heater port
9. Coolant flow to cylinder liners
10. Coolant flow to cylinder head
11. Coolant return to thermostat housing
12. Coolant bypass from thermostat.



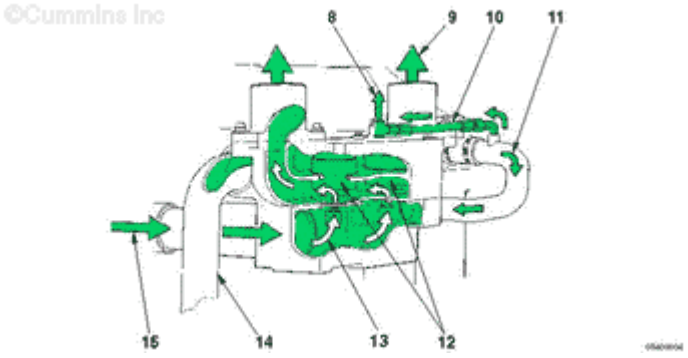
1. Coolant out of aftercooler
2. Coolant to aftercooler

3. Cylinder liner
4. Water pump
5. Coolant bypass from thermostat
6. Water inlet
7. Water filter.

Aftercooled Engines

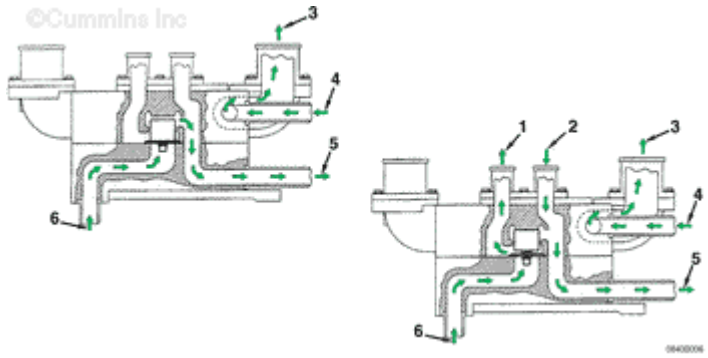


1. Coolant flow from cylinder heads
2. Rocker housing
3. Coolant manifold
4. Coolant before thermostat
5. Thermostats
6. Coolant return to radiator
7. Coolant bypass to coolant pump
8. Vent to radiator.

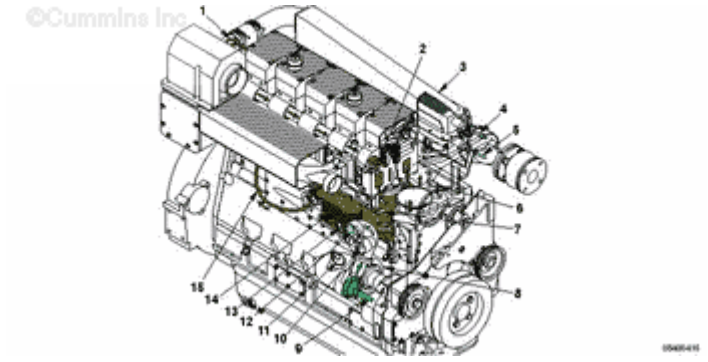


8. Vent to radiator top tank
9. Coolant to radiator
10. Vent line from aftercooler
11. Coolant out of aftercooler
12. Thermostats
13. Coolant before thermostats
14. Coolant bypass
15. Coolant manifold.

LTA

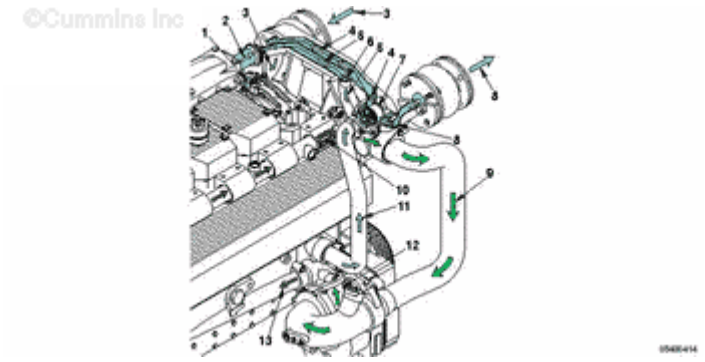


1. To aftercooler radiator
2. From aftercooler radiator
3. To radiator
4. From aftercooler
5. To aftercooler
6. From coolant pump.



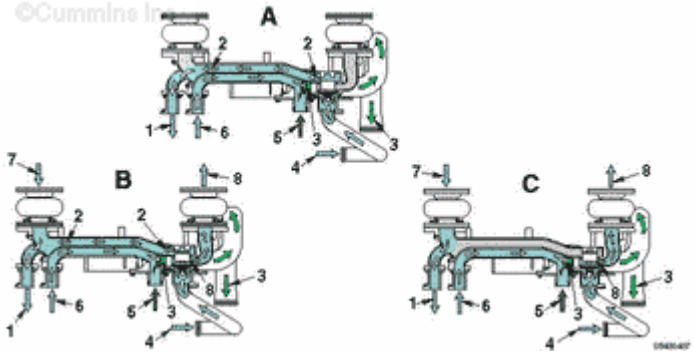
Single Loop LTA Cooling

1. Coolant return from turbocharger
2. Coolant return to thermostat housing
3. Aftercooler
4. Coolant return from aftercooler
5. Coolant supply to aftercooler
6. Coolant flow to cylinder head
7. Coolant flow to cylinder liners
8. Coolant pump
9. Coolant return to coolant pump
10. Emergency pump connection outlet
11. Emergency pump connection inlet
12. Coolant supply to thermostat housing
13. Coolant supply to engine block
14. Lubricating oil cooler
15. Coolant supply to turbocharger.



Single Loop LTA Keel Cooling

1. Aftercooler coolant supply
2. Aftercooler coolant return to thermostat housing
3. Coolant supply from keel cooler
4. Coolant bypass flow to aftercooler
5. Aftercooler coolant return to coolant pump
6. Coolant make-up line from expansion tank
7. Thermostat
8. Coolant supply to keel cooler
9. Coolant return to coolant pump
10. Coolant return to thermostat housing
11. Coolant supply to thermostat housing
12. Coolant pump
13. Coolant supply to engine block.



Single Loop LTA Thermostat Housing Coolant Flow

A. Thermostat closed (up to 66°C [150°F])
B. Thermostat partially open (66 to 79°C [150 to 175°F])
C. Thermostat open (above 79°C [175°F]).

1. Aftercooler coolant supply
2. Coolant bypass flow to aftercooler
3. Coolant return to coolant pump
4. Coolant supply from coolant pump
5. Block coolant return to thermostat housing
6. Aftercooler coolant return to thermostat housing
7. Coolant from keel cooler

8. Coolant to keel cooler.

Last Modified: 03-Oct-2006

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011-999 Exhaust System - Overview

General Information

Exhaust Manifold

CAUTION

Failure can result if the high strength manifold is not used on the KTTA engines.

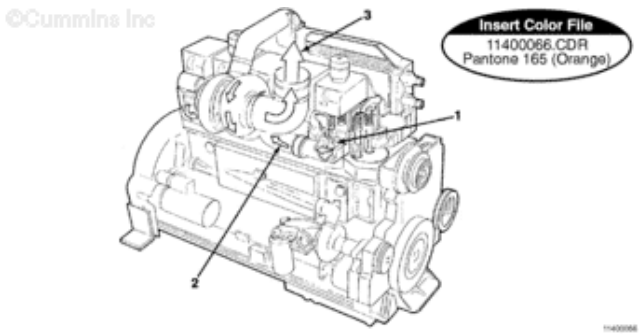
The exhaust manifold on an engine with two turbochargers is manufactured from a higher strength material that the exhaust manifold used on an engine with one turbocharger. The high strength manifold can be used on KT and KTA engines.

Last Modified: 20-Dec-2004

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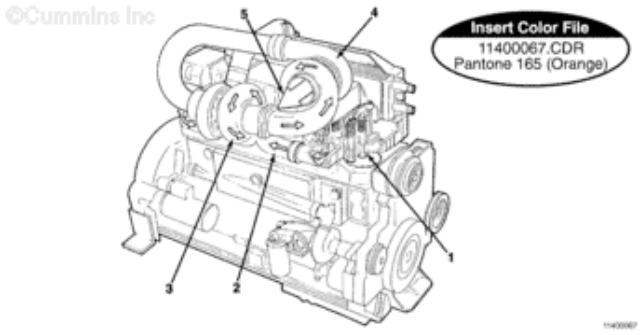
200-005 Flow Diagram, Exhaust System

Flow Diagram



Exhaust System

1. Exhaust valve ports
2. Exhaust manifold
3. Turbocharger exhaust outlet.



KTTA Exhaust System

1. Exhaust valve ports
2. Exhaust manifold
3. High stage turbocharger
4. Low stage turbocharger
5. Turbocharger exhaust outlet.

Last Modified: 03-Oct-2006

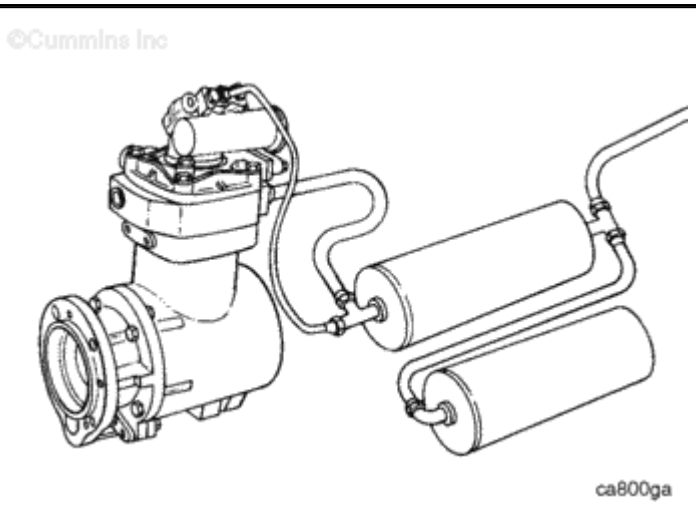
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012-999 Compressed Air System - Overview

General Information

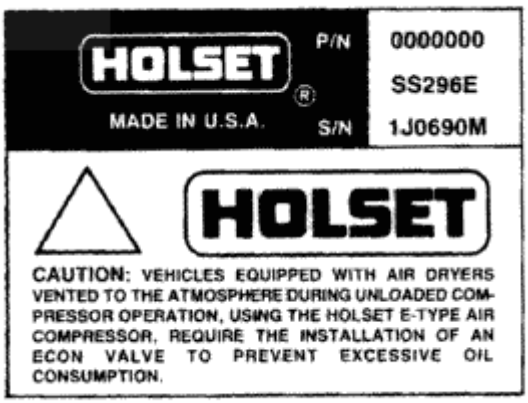
The compressed air system normally consists of a gear-driven air compressor, an air governor, air tanks and all necessary plumbing.

The Holset and Cummins single and two cylinder air compressors are engine-driven, piston-type compressors which supply compressed air to operate air activated devices. The compressor runs continuously, but has a loaded and unloaded operating mode.



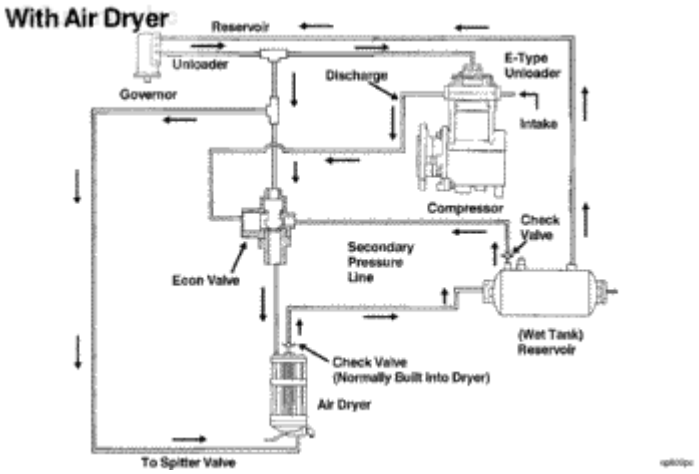
Holset SS and ST model air compressors built with the E-Type unloader can be identified by the letter “E” (SS296E, SS338E, ST676E, and ST773E), and by the caution on the data plate.

All QE (QE296 and QE338) model air compressors are equipped with the E-Type unloader.

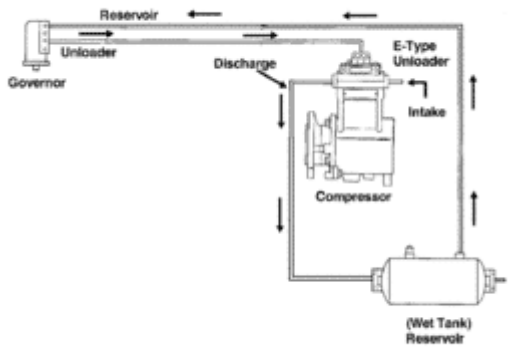


Vehicles equipped with air dryers vented to the atmosphere during unloaded compressor operation, using the Holset E-Type air compressor, require the installation of an econ valve to prevent excessive oil consumption.

NOTE: Some air dryers can have a built-in econ valve. Check with the manufacturer as to which type is installed.



Air systems without air dryers, or with air dryers **not** vented to the atmosphere during unloaded compressor operation, can use the Holset E-Type unloader valve without modifying

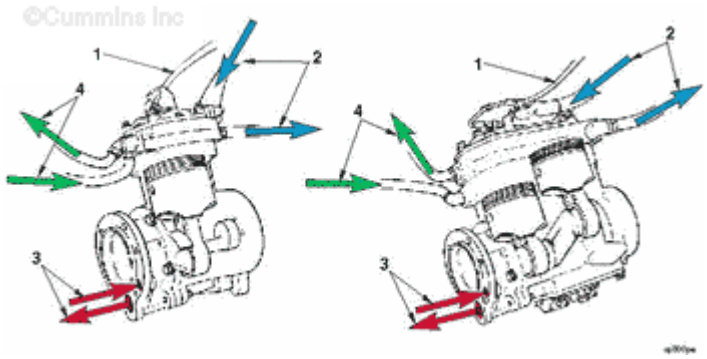
the air system.		Without Air Dryer 

Last Modified: 29-Nov-2004

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200-006 Flow Diagram, Compressed Air System

Compressed Air System



1. Air governor signal
2. Air
3. Lubrication
4. Coolant

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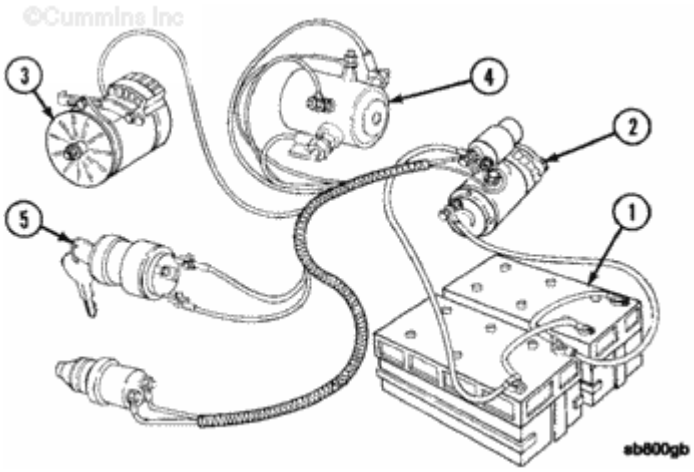
013-999 Electrical Equipment - Overview

General Information

The basic heavy-duty electrical system consists of:

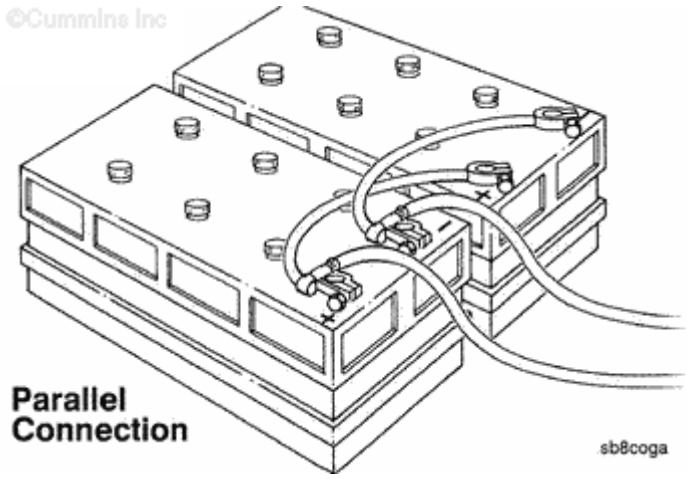
- Batteries (1) (usually two or four connected in parallel)
- Starting motor (2)
- Alternator (3)
- Magnetic switch (4)
- Ignition switch (5)
- Necessary wiring

All components **must** be carefully matched.

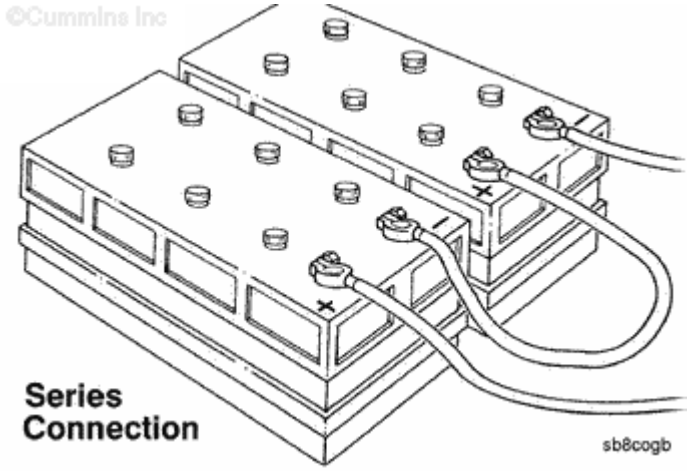


The accompanying illustrations show typical parallel and series battery connections.

- Parallel connection



- Series connection



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016-999 Mounting Adaptations - Overview

General Information

The Mounting Adaptations group consists of the flywheel housing, flywheel, and the front engine support.

Flywheel Housings for various applications, are available in different styles, sizes, and materials. Check the appropriate parts book and the engine parts listing for the correct part number for the engine application being serviced.

The Flywheel and Ring Gear is available **only** as an assembly. The assembly includes the flywheel and the ring gear. The ring gear is available for service.

Flywheel Housing - redowel to the cylinder block, Procedure 016-006, will describe how to install the oversize locating dowel pins in a flywheel housing and a cylinder block.

There are two dowel pins in the cylinder block. The pins protrude into holes in the flywheel housing. The pins are used to align the housing properly to the cylinder block when it is installed.

The flywheel housing **must** be in proper alignment. If the housing is **not** in proper alignment, the holes in the flywheel housing and the block **must** be reamed for a bigger dowel.

The dowel holes on K19 engine blocks and flywheel housings are precision doweled. The holes are machined to 12.7 mm [0.500 in] separately. The parts are assembled and the alignment is checked. If the alignment is **not** within specifications, oversize dowels are installed at the factory. Replacing the block or the flywheel housing does **not** necessarily mean that the flywheel housing and the cylinder block have to be redoweled.

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Air Compressor Air Pressure Rises Slowly

Symptom Tree t004

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 Procedure 012-019 and the OEM service manual.
OK	
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to Procedure 012-017.
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 Procedures 012-003 and 010-033.
OK	
E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the Master Repair Manual Holset Air Compressors, Bulletin 3666121.



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



Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to Procedure 012-013.



Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to Procedures 012-013, 012-104, and 012-106.

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Air Compressor Noise is Excessive

Symptom Tree t006

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 Procedures 012-003 and 010-033.
OK	
Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to Procedure 012-013.
OK	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to Procedure 012-103, 012-104, or 012-106.
OK	
Splined drive coupling or gear is excessively worn	Check the coupling for wear. Refer to Procedure 012-014.
OK	

Pin bore wear is excessive	Check for pin bore wear. Refer to Procedure 012-010.



Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to Procedure 012-014 and the Master Repair Manual, Holset Air Compressors, Bulletin 3666121. Replace the desiccant element on the Turbo/CR 2000 air dryer (if equipped). Refer to the manufacturer's instructions.



Air compressor drive gear or engine gear train is worn or damaged	Inspect the accessory drive gears and gear train. Refer to Procedure 009-011.

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Air Compressor Pumping Excess Lubricating Oil into the Air System

Symptom Tree t007

This is symptom tree

Cause	Correction

Follow this symptom tree to identify and repair the source of excessive lubricating oil in the air system. Then check for carbon buildup in the air discharge line, check valve, and air compressor cylinder head. Clean or replace the air system components if necessary. Refer to Procedures 012-003, 012-103, 012-104, 012-106, or the manufacturer's instructions.

Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002, Maintenance Schedule, in the Operation and Maintenance Manual, K19, KTA19, and KTTA19 Series Engine, Bulletin 3666013.

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 Master Repair Manual, Holset Air Compressors, Bulletin 3666121.



E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the Master Repair Manual, Holset Air Compressors, Bulletin 3666121.



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 Procedures 012-103, 012-104, and 012-106.



Turbocharger compressor oil seal is leaking	Check the compressor oil seal. Refer to Procedure 010-033.



Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to Procedure 012-014 and the Master Repair Manual, Holset Air Compressors, Bulletin 3666121. 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

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 Procedure 012-019 and the OEM service manuals.
OK	
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to Procedure 012-017.
OK	
E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the Master Repair Manual, Holset Air Compressors, Bulletin 3666121.
OK	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to Procedures 012-103, 012-104, and 012-106.

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Air Compressor Will Not Pump Air

Symptom Tree t009

This is symptom tree

Cause	Correction
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to Procedure 012-017.
OK	
E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the Master Repair Manual, Holset Air Compressors, Bulletin 3666121.
OK	
Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to Procedure 012-013.
OK	
Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to Procedures 012-103, 012-104, and 012-106.
OK	

Splined drive coupling or gear is excessively worn	Check the coupling for wear. Refer to Procedure 012-014.



Air compressor is excessively worn or internally damaged	Replace or rebuild the air compressor. Refer to Procedure 012-014 and the Master Repair Manual, Holset Air Compressors, Bulletin 3666121. 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

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 Procedure 012-019 and the OEM service manuals.
OK	
Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Refer to Procedure 012-017.
OK	
Air governor signal line or actuator line is plugged	Inspect the signal line and actuator line. Refer to the manufacturer's instructions.
OK	
E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the Master Repair Manual, Holset Air Compressors, Bulletin 3666121.



Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to Procedure 012-013.



Air compressor intake or exhaust valve leaks air	Inspect the air compressor intake and exhaust valve assemblies. Refer to Procedures 012-103, 012-104, and 012-106.

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Alternator Not Charging or Insufficient Charging

Symptom Tree t013

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.
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.



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.



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



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



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.



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

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Alternator Overcharging

Symptom Tree t014

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.

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Coolant Loss - External

Symptom Tree t020

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 malfunctioning	Replace pressure cap with the correct rating for the cooling system. Refer to 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 Procedure 008-022.

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 - Sea Water Cooling System 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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Coolant Loss - Internal

Symptom Tree t021

This is symptom tree

Cause	Correction
Air compressor cylinder head is cracked or porous, or has a leaking gasket	Inspect the air compressor cylinder head and gasket. Refer to Procedures 012-103, 012-104, and 012-106.
OK	
Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks. Refer to Procedure 007-007.
OK	
Fuel heater is leaking coolant	Check the fuel heater for coolant leaks. Refer to the manufacturer's instructions.
OK	
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.
OK	

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



Heat exchanger core leaks internally	Pressure-test the cooling system. Refer to Procedure 008-018.



Cylinder liner is corroded or cracked, or the cylinder block is cracked or porous	Remove the oil pan. Pressure-test the cooling system to check for leaks. Refer to Procedure 008-018.



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



Cylinder head is cracked or porous	Pressure-test the cylinder head. Refer to Procedure 002-004.

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Coolant Temperature Above Normal - Gradual Overheat

Symptom Tree t022

This is symptom tree

Cause	Correction
Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary. *Refer to Procedure 008-004 and the OEM service manual.*
OK	
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.



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



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



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



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 Procedure 008-022.



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.



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



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



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 008-020.

OK

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

OK

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 Procedure 008-042.

OK

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

OK

Engine is overfueled	Check the engine fuel rate. Refer to the OEM specifications.

OK

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.

OK

Sea water cooling system is malfunctioning	Troubleshoot the sea water system. Refer to the Coolant Temperature Above Normal - Sea Water Cooling System symptom tree.

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Coolant Temperature Above Normal - Sudden Overheat

Symptom Tree t023

This is symptom tree

Cause	Correction
Fan drive belt is broken	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002.
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 Procedure 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.



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



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 specifications.



Cooling system component is malfunctioning	Perform the cooling system diagnostics test. Refer to Procedure 008-020.



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



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



Sea water cooling system is malfunctioning	Troubleshoot the sea water system. Refer to the Coolant Temperature Above Normal - Sea Water Cooling System symptom tree.

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Coolant Temperature Below Normal

Symptom Tree t024

This is symptom tree

Cause	Correction
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 Operation of Diesel Engines in Cold Climates, Bulletin 3379009.
OK	
Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary. *Refer to Procedure 008-004 and the OEM service manual.*
OK	
Coolant temperature sensor is malfunctioning	Use an electronic service tool to check the coolant temperature sensor circuit. Refer to Procedure 019-019 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
OK	
Cooling system component is malfunctioning	Perform the cooling system diagnostics test. Refer to Procedure 008-020.



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

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View Related Topic

Crankcase Gases (Blowby) Excessive

Symptom Tree t027

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.



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, CENTRY™ System, Bulletin 3666070.



Blowby sensor wiring harness connector is damaged	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. 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, CENTRY™ System, Bulletin 3666070.



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.



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.



One or more power cylinders are damaged	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 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

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 CENTRY™ System, Bulletin 3666070 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 Procedures 019-085 and 019-086 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
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.



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 CENTRY™ System, Bulletin 3666070, and the appropriate electronic service tool 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 manufacturer's instructions.



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

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.

OK

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

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

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

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

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.*

OK

AFC signal line is restricted or leaking	Check the AFC signal line for restriction and leaks. Refer to Procedure 005-001.

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 high-quality fuel. Refer to the 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

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

EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

OK

Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-115 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

OK

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 or 006-022.



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.*



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

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Engine Decelerates Slowly

Symptom Tree t041

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 CENTRY™ System, Bulletin 3666070.
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 Procedures 019-085 and 019-086 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
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	
	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored

Electronic control module (ECM) calibration is malfunctioning	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 CENTRY™ System, Bulletin 3666070, 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.



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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

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.
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 Operation of Diesel Engines in Cold Climates, Bulletin 3379009.



Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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 019-031 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070, and the appropriate electronic service tool manual.



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 start) symptom tree.



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.



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 CENTRY™ System, Bulletin 3666070.



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



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



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.



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



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-115 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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 CENTRY™ System, Bulletin 3666070.



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 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 006-022 or 006-024.



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

	006-022 or 006-024

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

Symptom Tree t044

This is symptom tree

Cause	Correction
Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK	
Fuse(s) malfunctioning	Replace the fuse(s) in the OEM interface harness. Refer to Procedure 019-198 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
OK	
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 CENTRY™ System, Bulletin 3666070.
OK	
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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 019-031 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070, and the electronic service tool manual.



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 in this manual, 019-198 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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



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



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.



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.



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



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 CENTRY™ System, Bulletin 3666070.



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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.*



Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-083.

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Engine Noise Excessive

Symptom Tree t047

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 Procedure 007-009.



Lubricating oil pressure is below specification	Check the oil pressure. If the pressure is low, refer to Procedure 007-028.



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



Lubricating oil is thin or diluted	Refer to Cummins Engine Oil Recommendations, Bulletin 3810340. *If the oil pressure is low, refer to the Lubricating Oil Pressure Low symptom*

	tree.



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



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



Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to Procedure 016-010 and the OEM service manual.



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.



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 Engine Noise Excessive - Turbocharger symptom tree.

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

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 009-011.

OK

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



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 refrigerant 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 Procedure 001-036, 001-039 and 001-040.



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



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



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



Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-083.



Rear engine power take-off (REPTO) noise is excessive	Disassemble and repair the REPTO as necessary. Refer to the Rear Gear Drive Shop Manual, Bulletin 3666060.

Engine Noise Excessive — Combustion Knocks

Symptom Tree t048

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 Coolant Temperature Below Normal symptom tree.

OK

Ether starting aid is malfunctioning	Repair or replace the ether starting aids. Refer to the manufacturer's instructions.

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 for Cummins Engines, Bulletin 3379001.

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

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 Procedure 007-009.

OK

Lubricating oil pressure is below specification	Check the oil pressure. If the pressure is low, refer to Procedure 007-028.

OK

Lubricating oil is thin or diluted	Refer to Cummins Engine Oil Recommendations, Bulletin 3810340. *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 001-054.



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



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.



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

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.



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.



Crankshaft journals are damaged or out of round	Inspect the crankshaft journals. Refer to Refer to Procedure 001-016.

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Engine Noise Excessive — Piston

Symptom Tree t051

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 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	
	Remove the cylinder head and check for carbon deposits on the pistons. If

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



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.



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



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

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Engine Noise Excessive — Turbocharger

Symptom Tree t052

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.



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.



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 Power Output Low

Symptom Tree t057

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. Follow the instructions on the forms before continuing with this tree.
OK	
Perform a stall speed test (if applicable)	Perform a stall speed test. Refer to Procedure 014-008.
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	
Drivetrain is **not** correctly matched to the engine	Check for correct gearing and drivetrain components. Refer to the OEM vehicle specifications.



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



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 specifications.



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 007-025.



Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.



Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070 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 CENTRY™ System, Bulletin 3666070, and the appropriate electronic service tool manual.



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.



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 Procedures 019-085 and 019-086 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



Air intake system restriction is above	Check the air intake system for restriction. Clean or replace the air filter

specification	and inlet piping as necessary. Refer to Procedure 010-031.



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.



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 CENTRY™ System, Bulletin 3666070.



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.



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



	Check the fuel drain lines for restriction. Clear or replace the fuel lines, check

Fuel drain line restriction	valves, or tank vents as necessary. Refer to Procedure 006-012.



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



Intake manifold air temperature is above specification	Refer to the Intake Manifold Air Temperature Above Specification symptom tree.



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



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



Turbocharger is malfunctioning	Monitor the turbocharger boost pressure with an electronic service tool. Refer to Procedure 010-037.

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 for Cummins Engines, Bulletin 3379001.

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

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.

OK

Debris in the fuel passages	Check the fuel tubes and fuel manifold for debris. Refer to Procedure 006-022 or 006-024.

OK

EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

OK

AFC signal line is restricted or leaking	Check the AFC signal line for restriction and leaks. Refer to Procedure 006-002.



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



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.



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 at Idle

Symptom Tree t061

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 CENTRY™ System, Bulletin 3666070 for fault code troubleshooting.
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	
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.



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 for Cummins Engines, Bulletin 3379001.



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 019-031 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070, 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.



Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to Procedure 016-010.



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 CENTRY™ System, Bulletin 3666070.



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



STC oil delivery system is restricted or has a flow loss	Check the STC oil delivery system. Refer to Procedure 019-181 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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



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 or 006-022.



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

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 the Fuel 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 CENTRY™ Systems, Bulletin 3666070 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 CENTRY™ Systems, Bulletin 3666070, and the appropriate electronic service tool manual.



STC oil delivery system is restricted or has a flow loss	Check the STC oil delivery system. Refer to Procedure 019-181 in the Troubleshooting and Repair Manual CENTRY™ Systems, Bulletin 3666070.



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 CENTRY™ Systems, Bulletin 3666070.



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ Systems, Bulletin 3666070.



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.



Electronic control module (ECM) is malfunctioning	Replace the ECM. Refer to Procedure 019-031 in the Troubleshooting and Repair Manual CENTRY™ Systems, Bulletin 3666070.



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 CENTRY™ Systems, Bulletin 3666070

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Engine Shuts Off Unexpectedly or Dies During Deceleration

Symptom Tree t064

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 CENTRY™ System, Bulletin 3666070 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, equipment, or vessel keyswitch circuit. Refer to Procedure 019-064 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
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 and Procedures 019-198 and 019-050 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

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 CENTRY™ System, Bulletin 3666070.*

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

EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

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.*



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



Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to Procedure 016-010.



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



Debris in the fuel passages	Check the fuel tubes and fuel manifold for debris. Refer to Procedure 006-022 or 006-024.



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

	006-022 or 006-024

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Engine Speed Surges at Low or High Idle

Symptom Tree t066

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 CENTRY™ System, Bulletin 3666070 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 CENTRY™ System, Bulletin 3666070, 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.



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 Procedures 019-085 and 019-086 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



Engine speed sensor or circuit is	Check the engine speed sensor for correct adjustment and for debris on the sensor. Check the engine speed sensor

malfunctioning	circuit. Refer to Procedures 019-042 and 019-106 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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.



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



STC oil delivery system is restricted or has a flow loss	Check the STC oil delivery system. Refer to Procedure 019-181 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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.



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



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



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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Engine Starts But Will Not Keep Running

Symptom Tree t072

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 CENTRY™ System, Bulletin 3666070 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.
OK	
Engine-driven units are engaged	Disengage engine-driven units.
OK	

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

OK

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

OK

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

OK

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 CENTRY™ System, Bulletin 3666070.

OK

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

OK

Keyswitch circuit is malfunctioning	Check the vehicle keyswitch circuit. Refer to Procedure 019-064 in the Troubleshooting and Repair Manual

	CENTRY™ System, Bulletin 3666070.



Auxiliary shutdown circuit malfunctioning	Check auxiliary shutdown circuit. Refer to the OEM service manuals.



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 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 Procedures 005-016 and 005-031.



Electronic control module (ECM) is malfunctioning	Replace the ECM. Refer to Procedure 019-031 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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



Battery voltage supply to the electronic control module (ECM) has been lost	Check the engine harness, fuses, and ground connection. Refer to the OEM service manuals and Procedure 013-009.



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

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Engine Vibration Excessive

Symptom Tree t075

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 CENTRY™ System, Bulletin 3666070 for fault code troubleshooting.
OK	
Engine is misfiring	Refer to the Engine Runs Rough or Misfires 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	
Fan is loose, damaged, or **not** balanced	Check the fan. Refer to Procedure 008-040.
OK	

Belt-driven accessories are malfunctioning	Check the fan hub, alternator, refrigerant compressor, and hydraulic pump for interference. Isolate belt-driven accessories and check for vibration. Refer to the OEM service manual.



Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to Procedure 016-010.



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



Drivetrain components are malfunctioning or are **not** correct	Compare the drivetrain components to the engine and equipment specifications. Isolate the drivetrain components and check for vibrations. Refer to the OEM instructions and specifications.



Gear-driven accessories are malfunctioning	Check the hydraulic pump and air compressor. Isolate gear-driven accessories and check for vibration. Refer to the OEM service manual.



Flywheel housing is **not** aligned correctly	Check the flywheel housing alignment.

	Refer to Procedure 016-006.



Flywheel is loose or damaged	Check the flywheel. Refer to Procedure 016-005.

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Engine Will Not Crank or Cranks Slowly (Air Starter)

Symptom Tree t077

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 specificationthe OEM service manual	Install an oil pan heater, or drain the oil and fill the system with warm oil.
OK	
Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-037. *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.



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 manufacturer's instructions.



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.*



Hydraulic lock in a cylinder	Remove the injectors and rotate the crankshaft. Look for the source of fluid in the cylinder. Refer to Procedure 006-026 and 001-016.



Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-083.

Engine Will Not Crank or Cranks Slowly (Electric Starter)

Symptom Tree t078

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.

OK

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

OK

Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-037. *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

Battery capacity is below specification	Refer to Procedure 013-007. 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.



Starting motor pinion or ring gear is damaged	Remove the starting motor, and inspect the gear. *Refer to Procedure 013-020.*



Hydraulic lock in a cylinder	Remove the injectors and rotate the crankshaft. Look for the source of fluid in the cylinder. Refer to Procedure 006-026 and 001-016.



Internal engine damage	Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-083.

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Engine Will Not Reach Rated Speed (RPM)

Symptom Tree t080

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 CENTRY™ System, Bulletin 3666070 for fault code troubleshooting.



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 Procedures 019-085 and 019-086 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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.



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 for Cummins Engines, Bulletin 3379001.



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 specifications.



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



EFC valve is malfunctioning	Check the EFC valve for sticking or leakage. Refer to Procedure 019-102 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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 Will Not Shut Off

Symptom Tree t081

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 CENTRY™ System, Bulletin 3666070 for fault code troubleshooting.
OK	
Keyswitch circuit is malfunctioning	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to Procedure 019-064 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
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 Procedures 019-049 and 019-050 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.
OK	
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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Fault Code Warning Lamps Stay On (No Apparent Reason)

Symptom Tree t083

This is symptom tree

Cause	Correction
Diagnostic switch is in the ON position	Turn off the diagnostic switch.
OK	
Diagnostic shorting plug is installed	Remove the diagnostic shorting plug.
OK	
Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070 for fault code troubleshooting.
OK	
Fault code warning lamp circuit is malfunctioning	Check the fault code warning lamp circuit. Refer to Procedure 019-047 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



Diagnostic switch or circuit is malfunctioning	Check the diagnostic switch and circuit. Refer to Procedures 019-027 and 019-028 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.

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Fuel Consumption Excessive

Symptom Tree t087

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 at the end of 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, K19 Series Engine, Bulletin 3666013.
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 007-025.

OK

Equipment and enviromental factors are affecting fuel consumption	Consider ambient temperatures, wind, load, loaded profile and idle time 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 specifications.

OK

Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070 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 CENTRY™ System, Bulletin 3666070.



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.



Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-115 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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.*



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 the Fuel for Cummins Engines, Bulletin 3379001.



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.



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



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



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

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.
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

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.



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.



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



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



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 Pressure (Boost) is Below Normal

Symptom Tree t097

This is symptom tree

Cause	Correction
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 010-037.
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 010-008.



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



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 and 005-031.

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Lubricating Oil Consumption Excessive

Symptom Tree t102

This is symptom tree

Cause	Correction
Lubricating oil leak (external)	Inspect the engine and OEM installed components of the lubricating oil system for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets and other components, if necessary. Refer to Procedure 007-024 in Section 7 and the OEM service manuals.
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.



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.



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



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 troubleshooting symptom tree.



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



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



Lubricating oil dipstick calibration is **not** correct	Check the dipstick calibration. Refer to the OEM service manual..



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.



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



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Lubricating Oil Pressure High

Symptom Tree t104

This is symptom tree

Cause	Correction
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. *Use the oil type recommended in Section V of the operation and maintenance manual.*
OK	
Main oil pressure regulator is malfunctioning	Check the main oil pressure regulator assembly. Refer to Procedure 007-029.

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Lubricating Oil Pressure Low

Symptom Tree t105

This is symptom tree

Cause	Correction
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 the OEM service manual.
OK	
Engine angularity during operation exceeds specification	Refer to the engine option specification data sheet.
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	

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



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



Lubricating oil filter is plugged	Change the oil and filter. *Refer to Procedure 007-013. Verify the oil change interval is correct. Refer to the operation and maintenance manual.*



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.



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



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



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 007-025.



Main oil pressure regulator is malfunctioning	Check the main oil pressure regulator assembly. Refer to Procedure 007-029.



Lubricating oil cooler is plugged	Check the oil cooler. *Refer to Procedure 007-003.*



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 Procedure 007-083.

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Lubricating Oil Sludge in the Crankcase Excessive

Symptom Tree t106

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 007-037. *Use the oil type recommended in Section V of the operation and maintenance manual.*
OK	
Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002, Maintenance Schedule, in the Operation and Maintenance Manual, K19, KTA19, and KTTA19 Series Engines, Bulletin 3666013.
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 for Cummins Engines, Bulletin 3379001.



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



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



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



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



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



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

This is symptom tree

Cause	Correction
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

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 007-003.
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 Procedure 001-026.

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Smoke, Black — Excessive

Symptom Tree t116

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 CENTRY™ System, Bulletin 3666070 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 019-032in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070 and the OEM service manual.
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.



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.*



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



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 for Cummins Engines, Bulletin 3379001.



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 010-037.



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



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



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



Rail pressure sensor is malfunctioning	Check the rail pressure sensor. Refer to Procedure 019-115 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



Base engine problem	Check the engine for high crankcase pressure, low compression, static injection timing, damaged pistons, camshaft, and other parts. Procedure 019-115 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070

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Smoke, White — Excessive

Symptom Tree t118

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 Operation of Diesel Engines in Cold Climates, Bulletin 3379009.
OK	
Engine is cold	Allow the engine to warm to operating temperature. If the engine will **not** reach operating temperature, refer to 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 CENTRY™ System, Bulletin 3666070 for fault code troubleshooting.
OK	
	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

Electronic control module (ECM) calibration is malfunctioning	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 CENTRY™ System, Bulletin 3666070, and the appropriate electronic service tool manual.



Coolant temperature sensor is malfunctioning	Use an electronic service tool to check the coolant temperature sensor circuit. Refer to Procedure 019-019 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.



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



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 for Cummins Engines, Bulletin 3379001.



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.*



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



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



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

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Turbocharger Leaks Engine Oil or Fuel

Symptom Tree t122

This is symptom tree

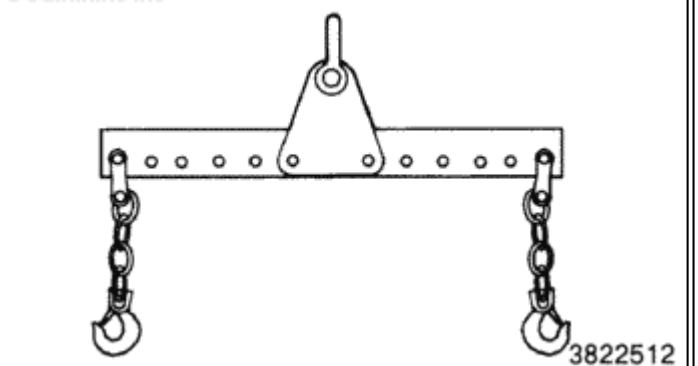
Cause	Correction
Engine is operating for extended periods under light- or no-load conditions (slobbering)	Review the engine operating instructions in Section 1 in the Operation and Maintenance Manual, K19, KTA19, and KTTA19 Series Engine, Bulletin 3666013.
OK	
Turbocharger is **not** correct	Check the 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 Procedure 010-033.*
OK	
Turbocharger oil drain line is restricted	Remove the turbocharger oil drain line and check for restriction. Clean or replace the oil drain line. Refer to Procedure 010-045.

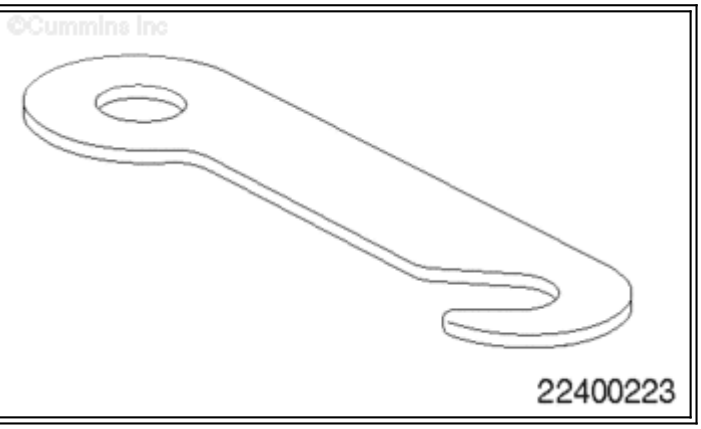
Last Modified: 20-Dec-2004

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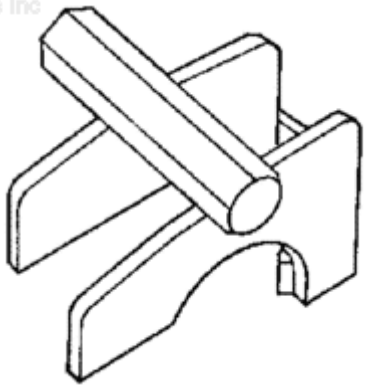
022-001 Service Tools

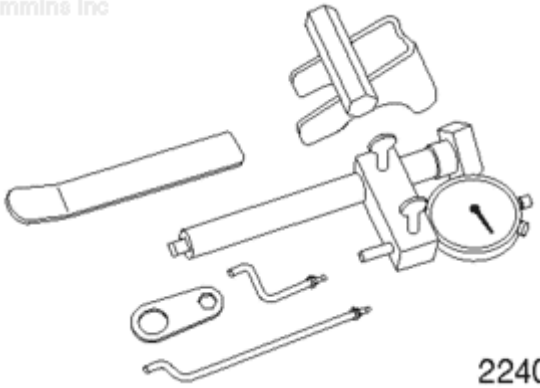
Engine Disassembly/Assembly

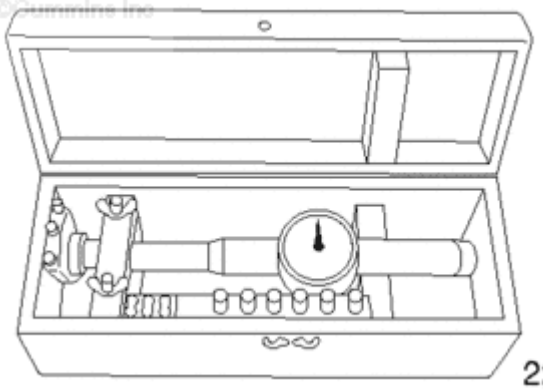
Tool Number		
3162871	**Engine Lifting Fixture** Designed to lift an engine up to 2722 kg [6000 lb].	

Tool Number		
3163091	**Lifting Hook** Designed to hook onto the lifting lugs of the cylinder heads. Use with Engine Lifting Fixture, Part Number 3162871 to attach to these lifting hooks to lift the engine as required.	

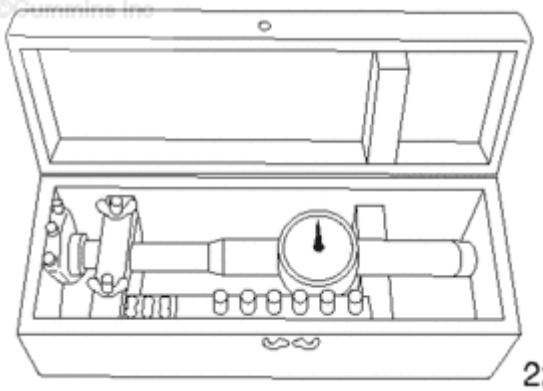
Tool Number	Rocker Lever Actuator	

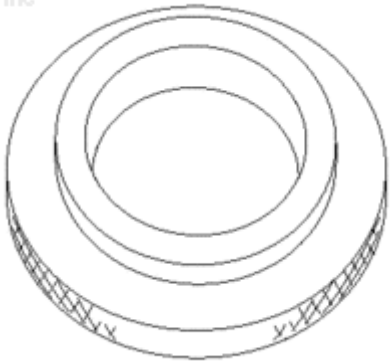
3822574	Used to actuate the rocker levers.	 3822574

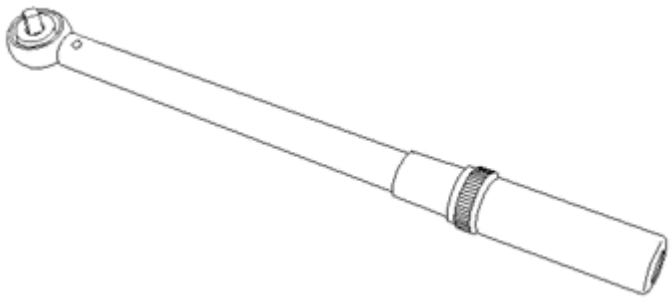
Tool Number 3822575	**Injector and Valve Adjustment Kit** Used to adjust valves and injectors.	 22400224

Tool Number 3375072	**Dial Bore Gauge Kit (Short Handle)** Used to measure the diameters of bores from three inches to 8 inches.	 22400225

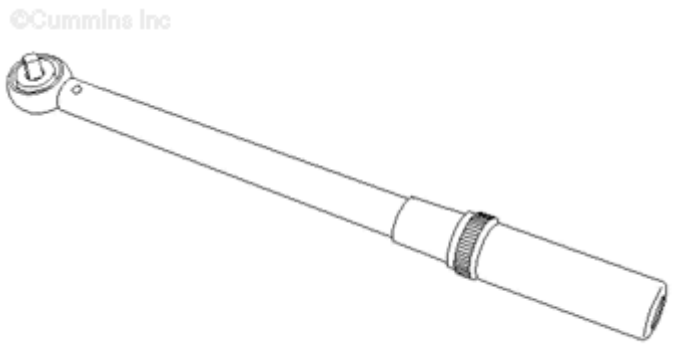
Tool Number	**Dial Bore Gauge Kit (Long Handle)**	

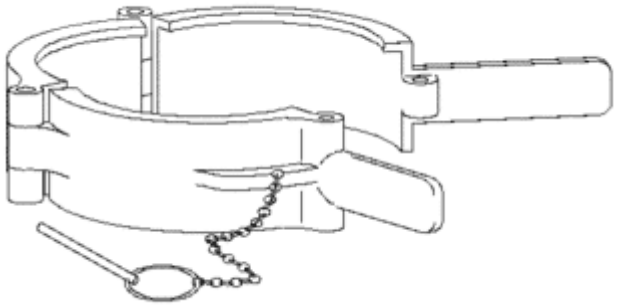
3376619	Used to measure the diameters of bores from three inches to 8 inches.	 22400225

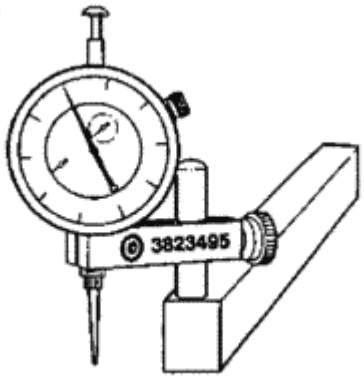
Tool Number ST-1291	**Cylinder Liner Ring Gauge (6.251 K19, K38, K50)** Used for checking cylinder liner bores.	 22400226

Tool Number 3164796	**Torque Wrench (30 to 250 ft-lb)** Used for general purpose when a specified torque is required.	 22400227

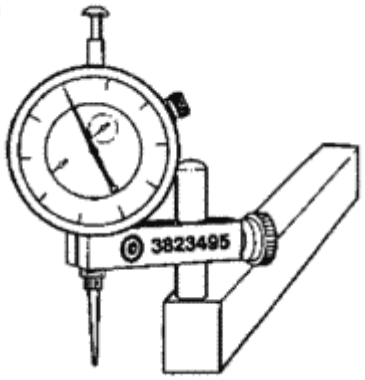
Tool Number	**Torque Wrench (100 to 600 ft-lb)**	

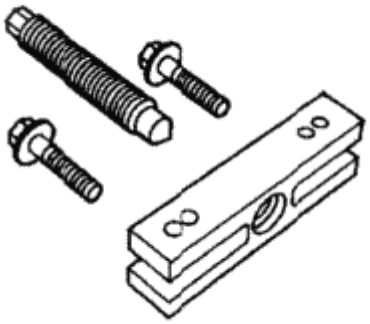
3164797	Used for general purpose when a specified torque is required.	 22400227

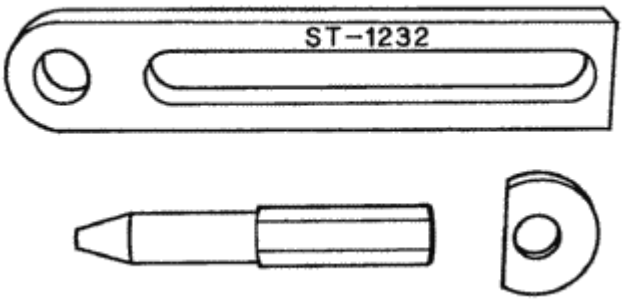
Tool Number 3823294	**Piston Ring Compressor** Used to compress the piston rings during piston installation.	 3163158

Tool Number 3164438	**Depth Gauge Assembly** Measure cylinder liner protrusion and cylinder liner counterbore ledge angle.	 3823495

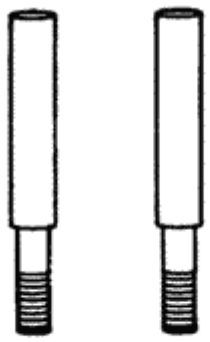
Tool Number	**Depth Gauge Assembly**	

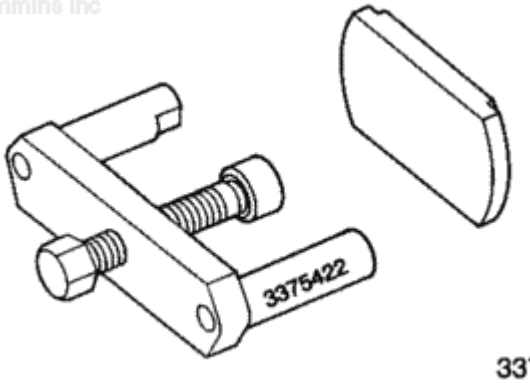
3823495	Measure cylinder liner protrusion and cylinder liner counterbore ledge angle.	 3823495

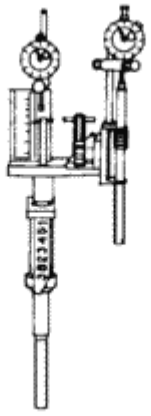
Tool Number ST-647	**Puller** Remove the alternator and accessory drive pulleys.	 ad8toga

Tool Number ST-1232	**Drill Ream Fixture** Machine dowel hole to install oversized dowels in cylinder block and flywheel housing. Use with drill, reamer, and the appropriate drill/ream bushing set.	 st-1232

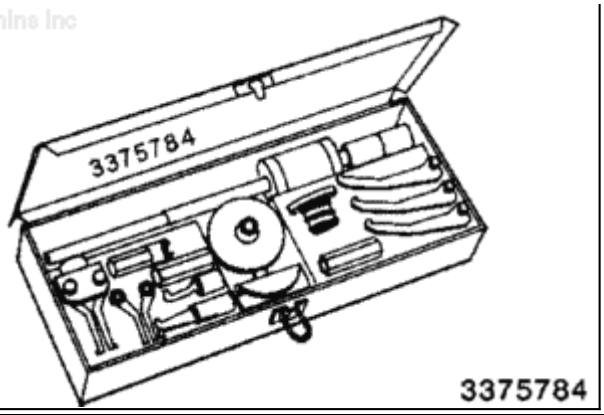
Tool Number	**Connecting Rod Guide Pins** Special nylon pins	

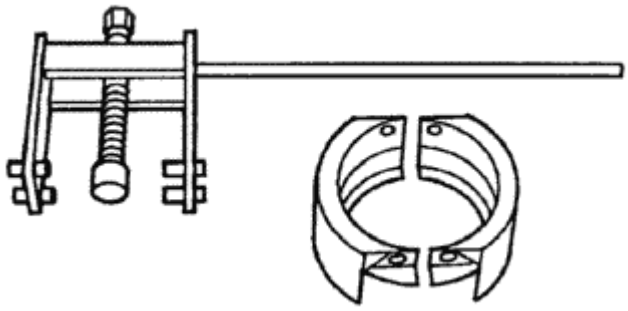
3375098	used to protect the crankshaft journals by guiding the connecting rod during installation and removal.	 cx8togg

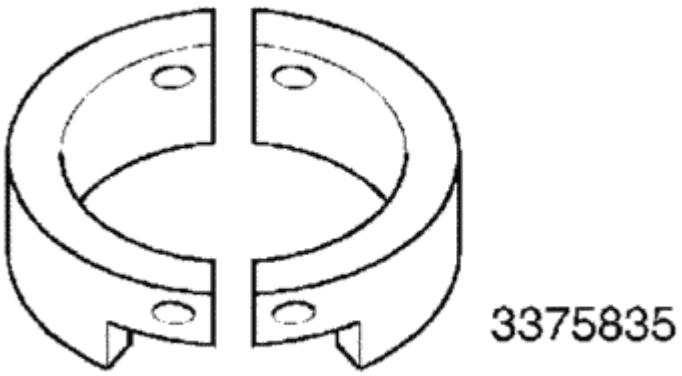
Tool Number 3375422	**Liner Installation Tool** Install cylinder liner in engine.	 3375422

Tool Number 3824942	**Injection Timing Tool** Check injection timing. This timing fixture is designed to determine the push tube travel in relation to the piston travel.	 3823451

Tool Number	**Light Duty Puller Kit**	

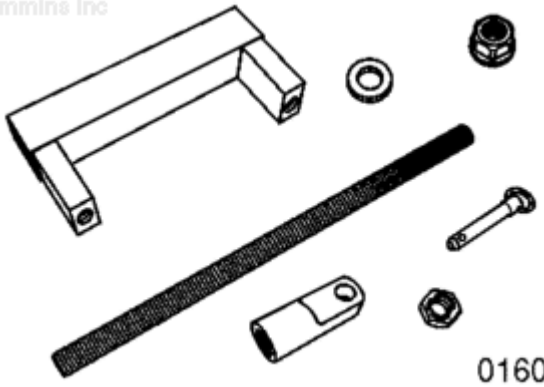
335784	Remove small bushings, oil seals, and bearings.	

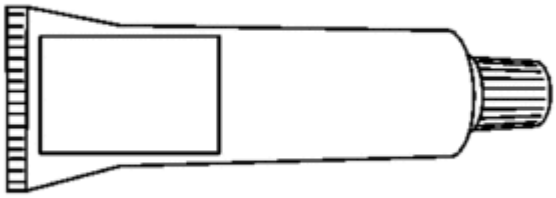
Tool Number 3375834	**Puller Assembly** Remove the crankshaft front gear from the crankshaft. Use with Puller Jaw, Part Number 3375835.	

Tool Number 3375835	**Puller Jaw** Remove the crankshaft front gear from the crankshaft. Use with Puller Assembly, Part Number 3375834.	

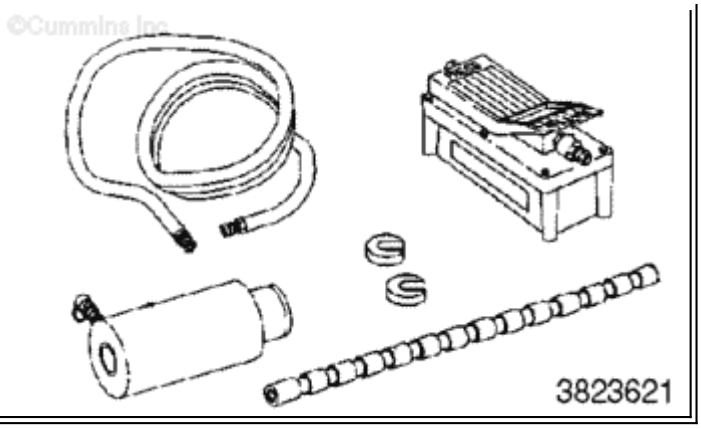
	Pulley Installation	

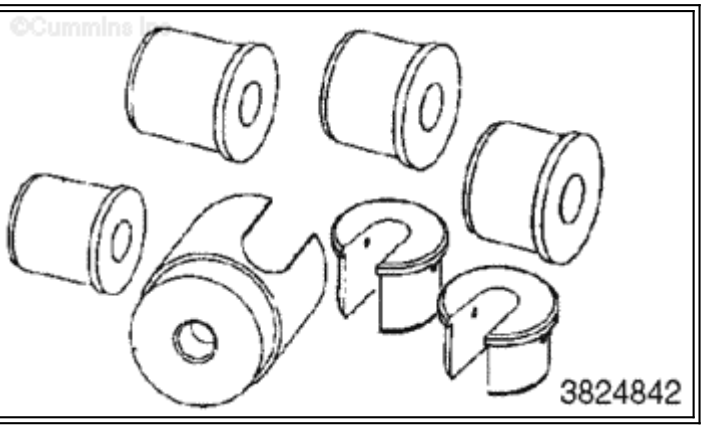
Tool Number	Tool	
3376326	Install the alternator and accessory drive pulleys.	 ad8togb

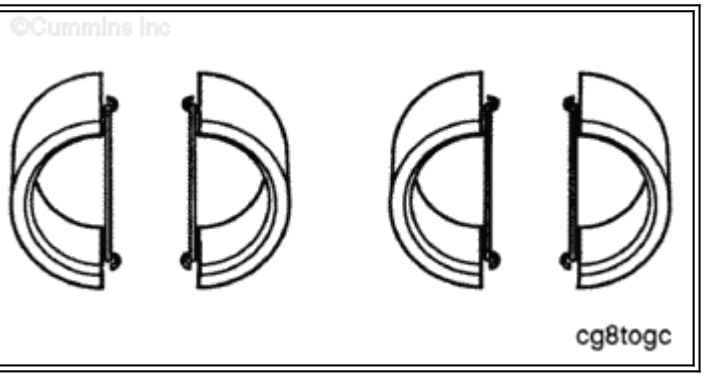
Tool Number	Cylinder Liner Remover	
3163745	Use with remover plate, Part Number 3162886.	 01600269

Tool Number	Silicone Sealer	
3164067	Silicone gasket maker. Room Temperature Vulcanizing (RTV), non-corrosive.	 07c00280

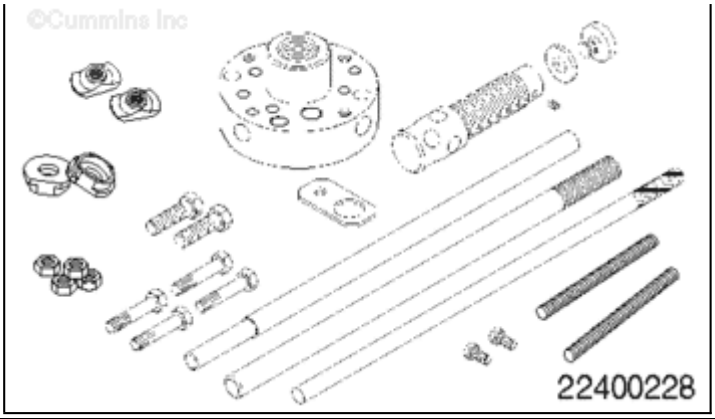
Tool Number	Camshaft Bushing Installation/Removal Kit	
	Hydraulic ram	

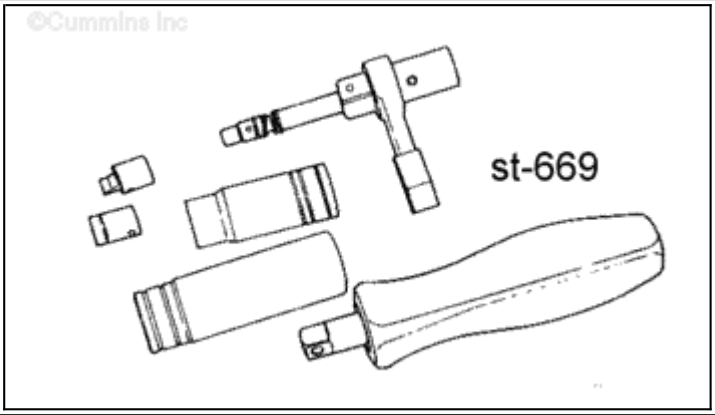
3823621	provides the force to install/remove cam bushings when used with installation/removal kit.	

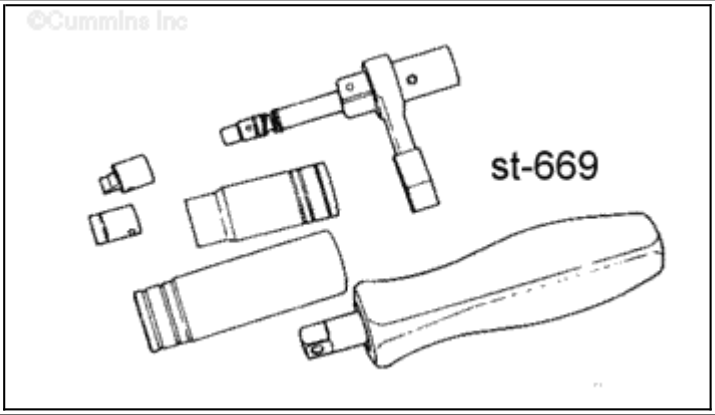
Tool Number 3823647	**Camshaft Bushing Installation/Removal Kit** Used with the Camshaft Bushing Installation/Removal Kit, Part Number 3823621 to remove the camshaft bushings.	

Tool Number 3376280	**Camshaft Pilot** Install camshaft without damaging the camshaft bushings or camshaft.	

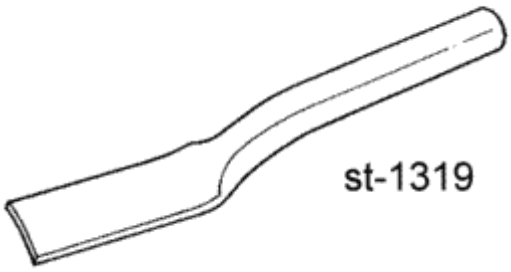
Tool Number	**Camshaft Gear Puller Kit** Remove camshaft gear from camshaft	

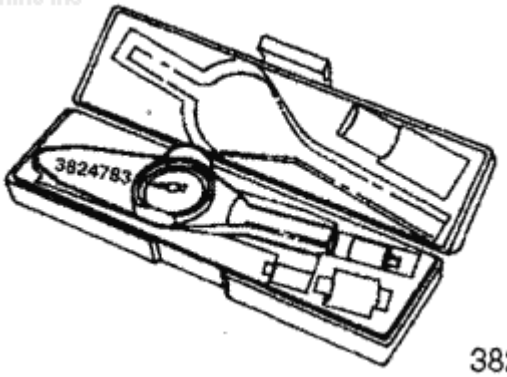
3162895	without removing camshaft from engine.	

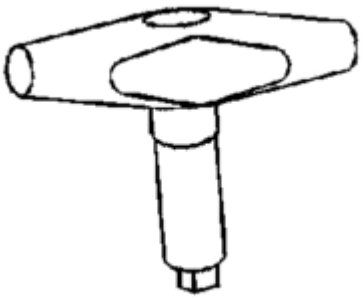
Tool Number 3163198	**Torque Wrench Adapter** Secures the rocker lever adjusting screw while tightening the lock nut.	

Tool Number ST-669	**Torque Wrench Adapter** Secures the rocker lever adjusting screw while tightening the lock nut.	

Tool Number	**Water Tube Driver** Used to install or	

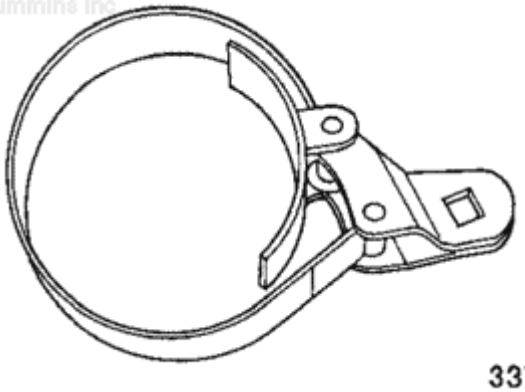
ST-1319	remove the water transfer tubes from the rocker housing.	©Cummins Inc 

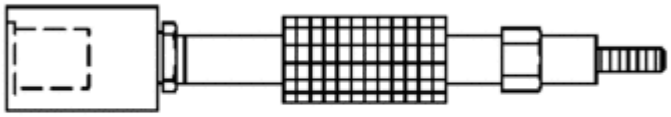
Tool Number 3164795	**Torque Wrench** A 3/8 drive, 300 inch-pound dial-type torque wrench used to accurately adjust injectors in inch-pounds.	©Cummins Inc  3824783

Tool Number 3376592	**Torque Wrench** Six inch-pound torque wrench used to tighten the valve lever adjusting screw. Does not require screwdriver attachment.	©Cummins Inc  3376592

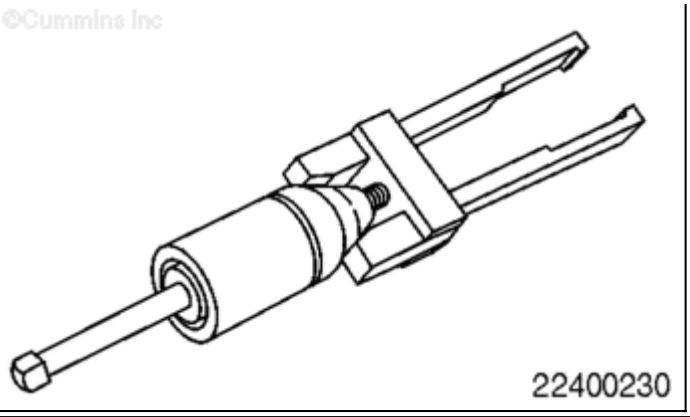
Tool Number	**Fuel Pump/Air Compressor Ratchet Wrench**	

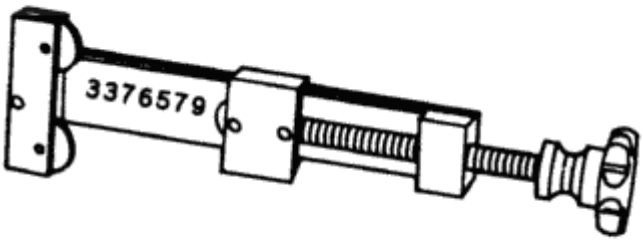
3376845	Used to reach nuts when removing or installing the fuel pump or air compressor.	 3376845

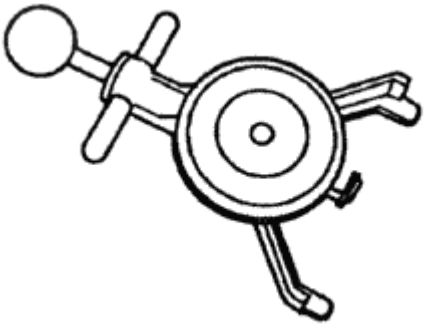
Tool Number 3400157	**Filter Wrench, Band Type 118 to 130 mm [4.65 to 5.12 inch]** Used to remove spin on filters.	 3375049

Tool Number 3824653	**Injector Puller** Used to remove and install injector. 3824653 must be used on STC injectors and can be used on non-STC injectors.	 22400229

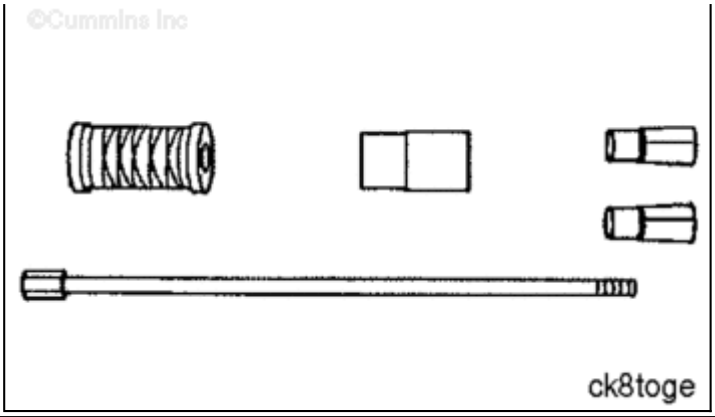
Tool Number	**Injector Puller** Used to remove and	

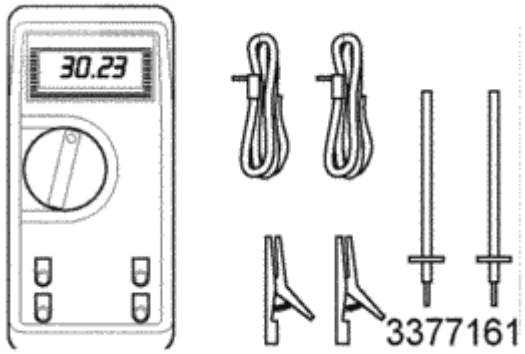
3823024	install injector. 3823024 is for standard PTD injectors.	 22400230

Tool Number 3376579	**Filter Cutter** Used to open spin-on full-flow filter for inspection.	 lf8togd

Tool Number ST-1293	**Belt Tension Gauge** Measure the accessory drive and alternator belt tension.	 fa8togc

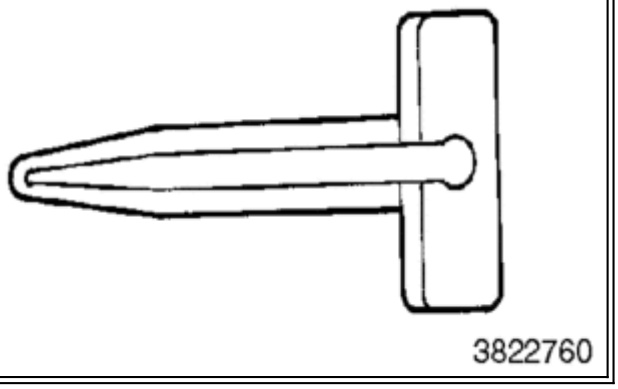
Tool Number		

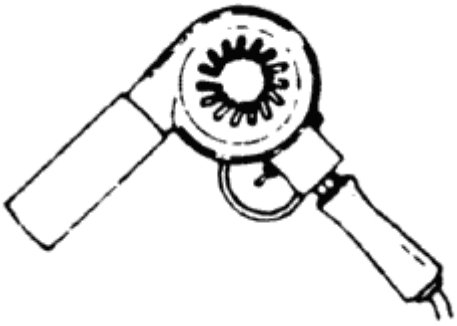
ST-1134	**Dowel Pin Extractor** Remove dowel pins.	

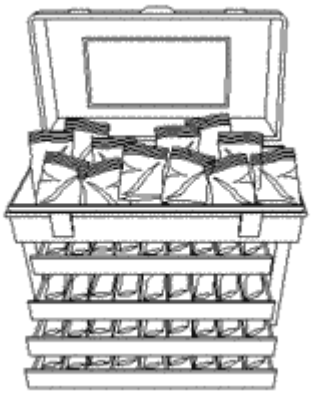
Tool Number 3377161	**Digital Multimeter** Measure electrical currents; voltage (VDC), resistance (ohms), and current (amperes).	

Tool Number 3822608	**Weather-Pack Terminal Removal Tool** Used to repair Weather-Pack connectors.	

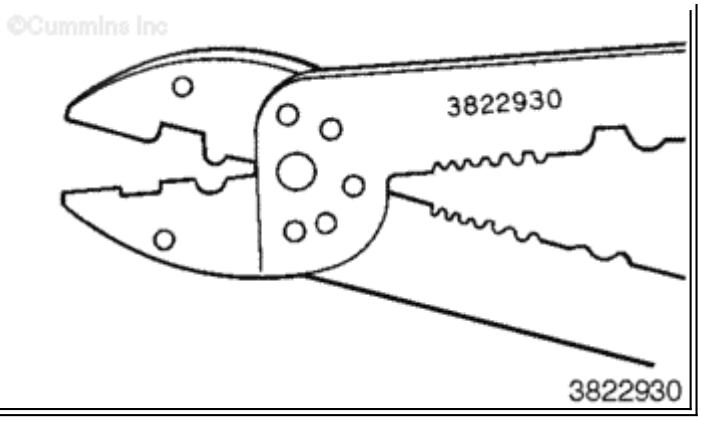
Tool	**Deutsch Terminal**	

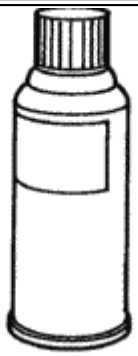
Number	Removal Tool	
3822760	Used to repair Deutsch connectors.	 3822760

Tool Number	Heat Gun	
3822860	Used to repair connector wires.	

Tool Number	Wiring Repair Kit	
3824904	Contains a variety of connectors, pins, seals, terminals, test leads, and other tools used to repair connectors.	 22400231

Tool Number	Wire Crimping Pliers	

3163109	Used when repairing connector wires.	 3822930

Tool Number 3824510	**Electrical Contact Cleaner** Used to clean electrical contacts and connectors.	 oi8togt

Last Modified: 20-Mar-2013

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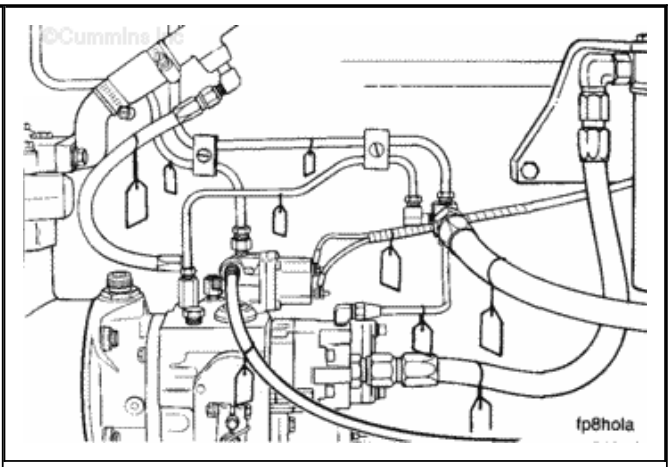
000-001 Engine Removal

Remove

All Applications

Put a tag on all hoses, lines, linkage, and electrical connections as they are removed to identify location and aid during the installation process.





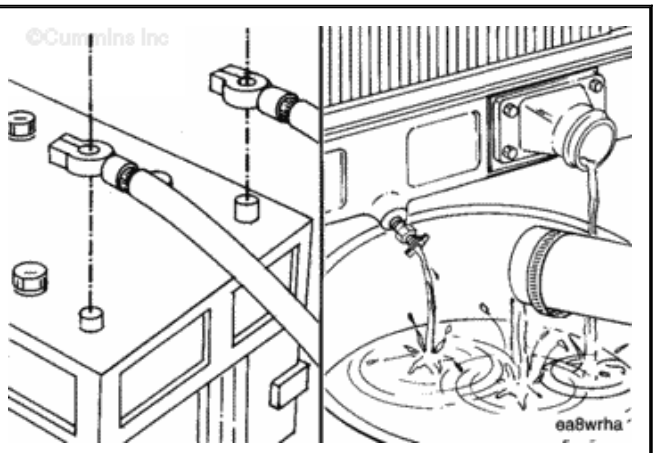
WARNING

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

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 in accordance with local environmental regulations.

Disconnect the battery cables.

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

WARNING

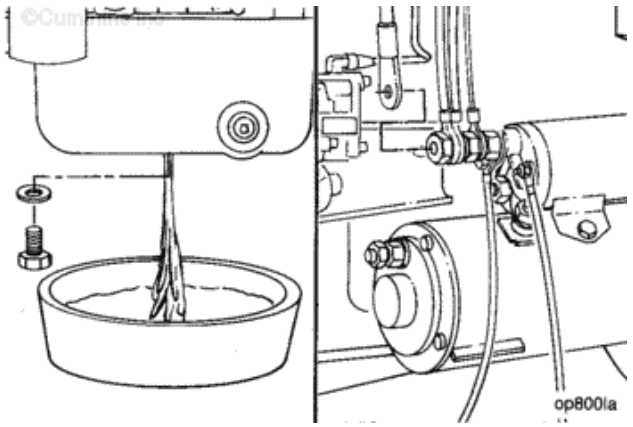
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

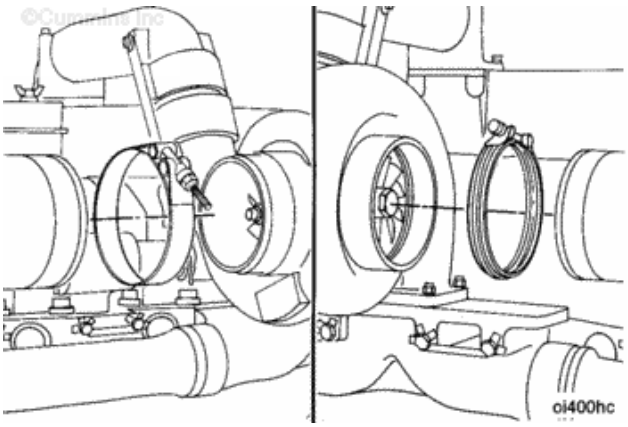
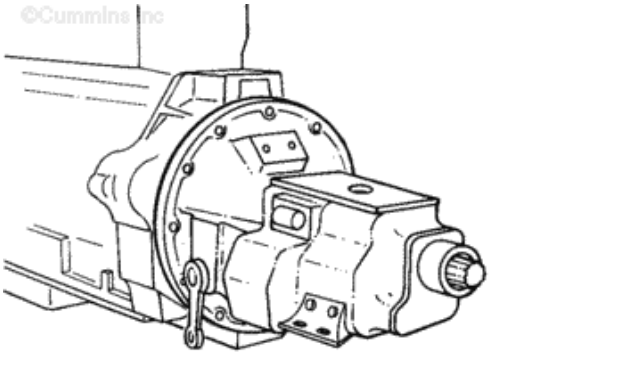
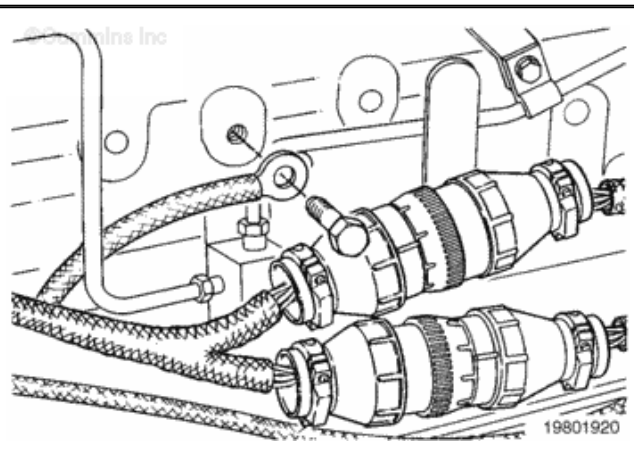
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Drain the lubricating oil. Refer to Procedure 007-037.

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



Disconnect the intake and exhaust system pipes.

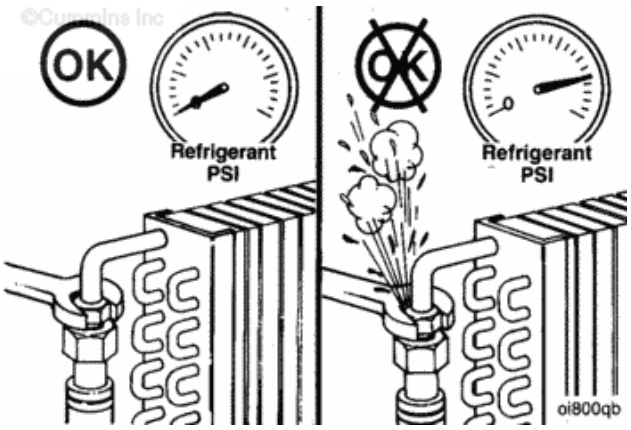
		
Disconnect the drive units from the flywheel housing and flywheel.		
Disconnect the OEM wiring harness from the ECM connector. Refer to Procedure 019-043 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.		
WARNING		

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.

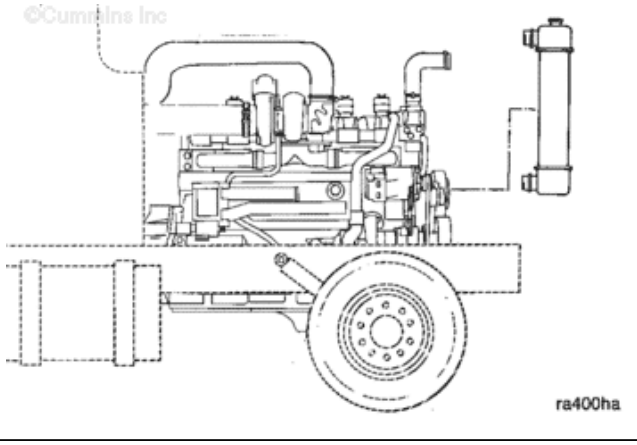
WARNING

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.

Remove the refrigerant from the air conditioning system.



Remove all chassis components necessary to remove the engine from the equipment.



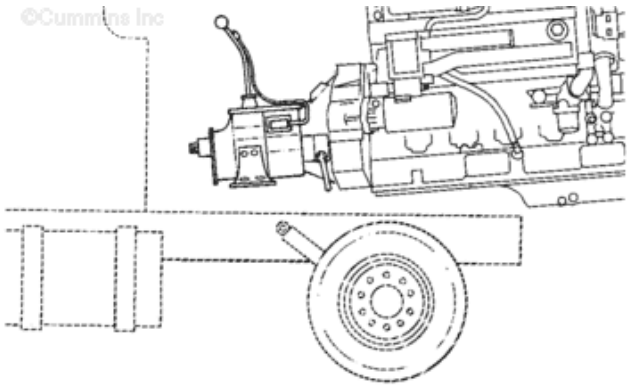
All Applications Except Rail

WARNING

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

NOTE: On applications when the rear engine mounts are attached to the drive unit, it is sometimes necessary to remove the engine and drive unit as an assembly.

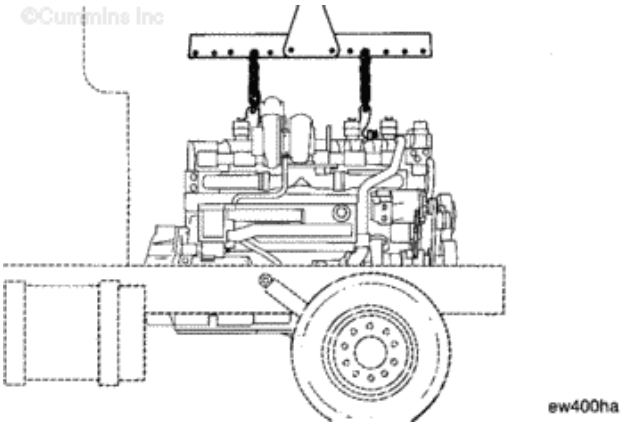
Refer to the equipment manufacturer's specifications for the weight of the drive unit. The Part Number 3162871 Lifting Fixture is designed to lift a maximum of 3175 kg [7000 lb].



Use a properly rated hoist lifting fixture and two engine lifting hooks, Part Number 3163091, to support the weight of the engine. Remove the front and rear engine support capscrews. The lifting hooks fit around lugs that are cast into the rocker lever housings.

Use a properly rated hoist, engine lifting fixture, Part Number 3162871, and two engine lifting hooks Part Number 3163091, to remove the engine.

NOTE: If the drive unit is not removed, put a support under the drive unit to prevent it from falling.



Rail Applications

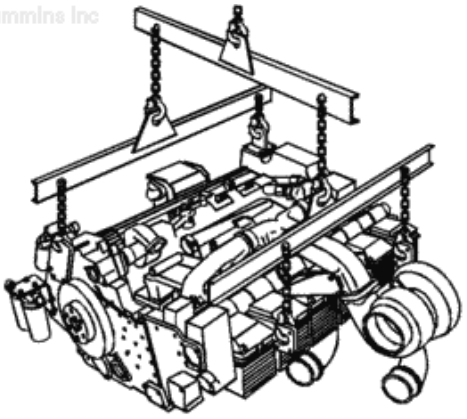
WARNING

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

Install engine lifting fixture, Part

Number 3822512, to engine lifting brackets as shown. (three lifting fixtures recommended)

Remove the engine.



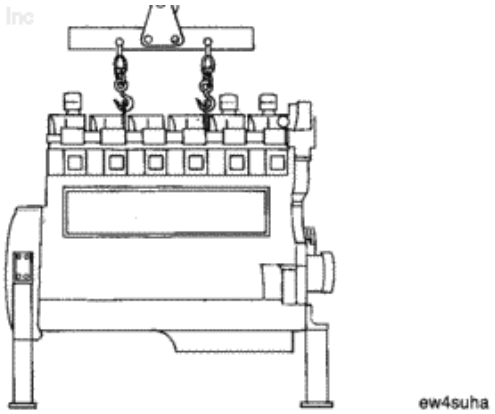
WARNING

Use a 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.

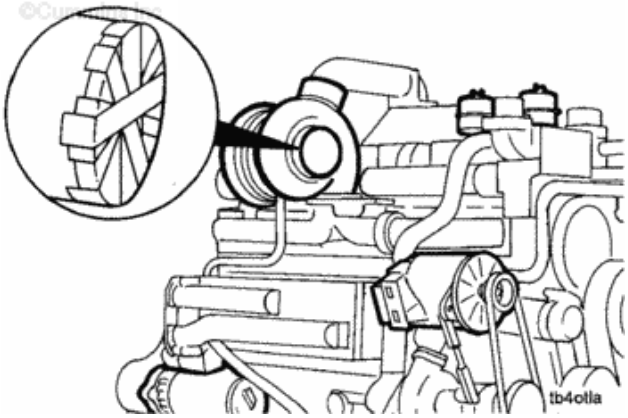
CAUTION

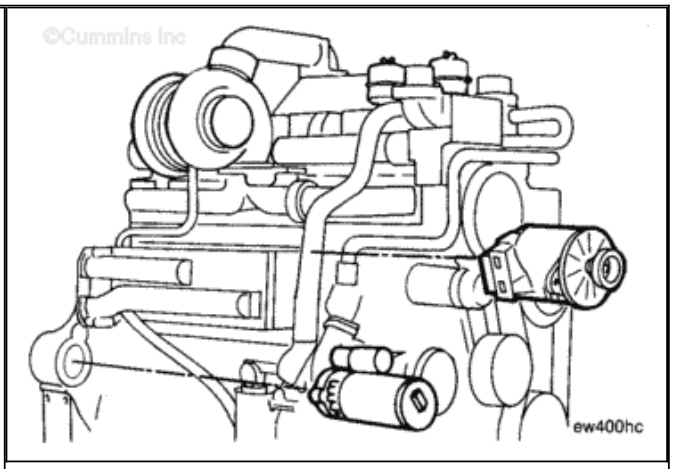
The oil sump or cover plate will not support the weight of the engine. Damage to the engine can occur.

Put the engine on the 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.		

Last Modified: 04-Nov-2004

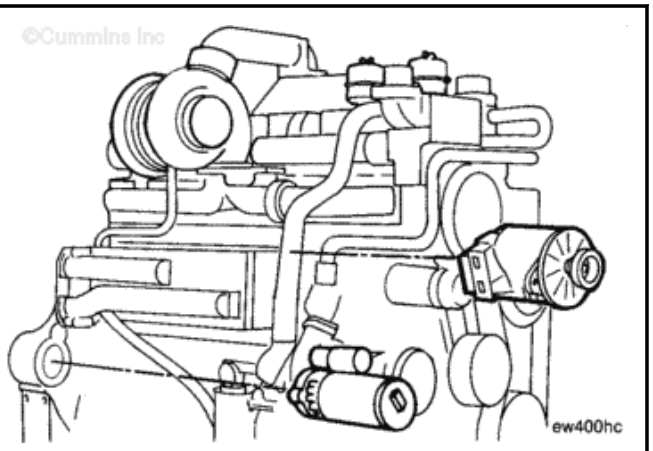
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000-002 Engine Installation

Install

All Applications Except Rail

Install all accessories and brackets that were removed from the engine.



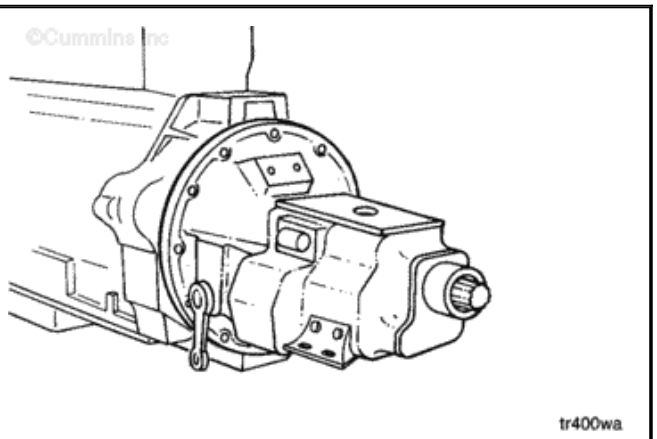
WARNING

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

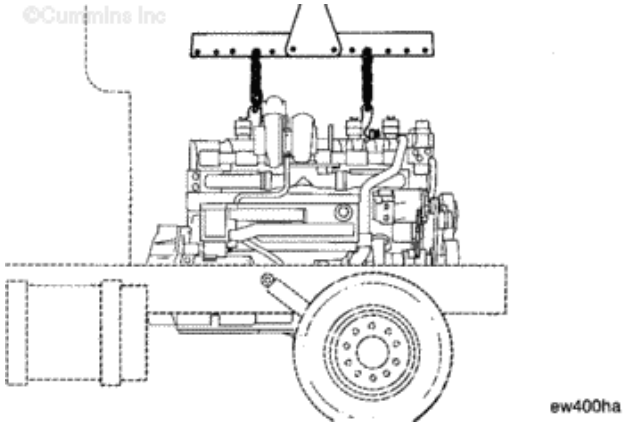
NOTE: On applications that the rear engine mounts are attached to the drive unit, it is sometimes necessary to install the engine and drive unit as an assembly.

Inspect engine lifting brackets for damage or cracks. Do **not** attempt to lift engine if cracks or damage is visible.

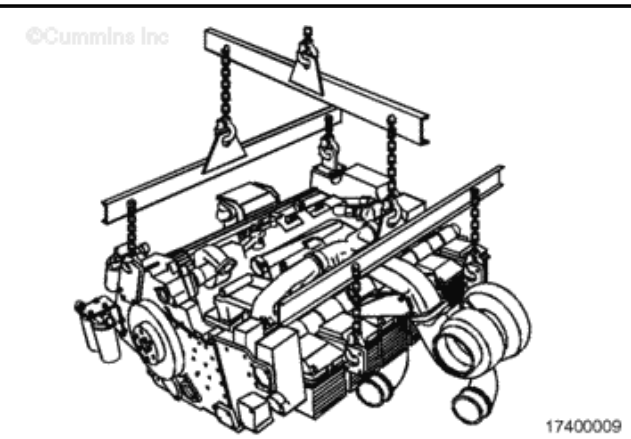
Engine Weight (Wet): 2045 kg



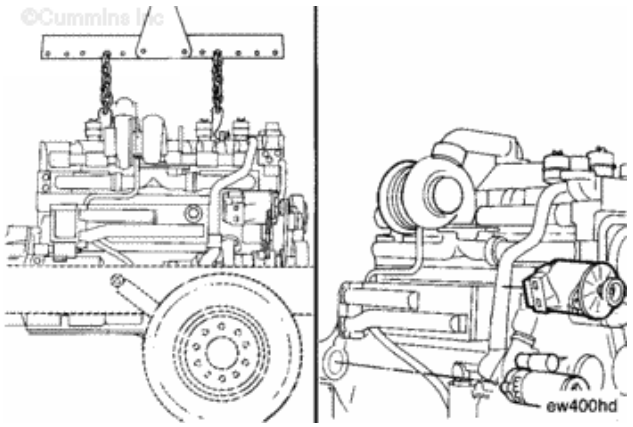
[4508 lb] Refer to the equipment manufacturer's specifications for the weight of the drive unit. The Part Number 3162871 Lifting Fixture is designed to lift a maximum of 3175 kg [7000 lb].		

Use a properly rated hoist, engine lifting fixture, Part Number 3162871, and two engine lifting hooks, Part Number 3163091, to install the engine. The lifting hooks fit around lifting lugs that are cast into the rocker lever housings.		

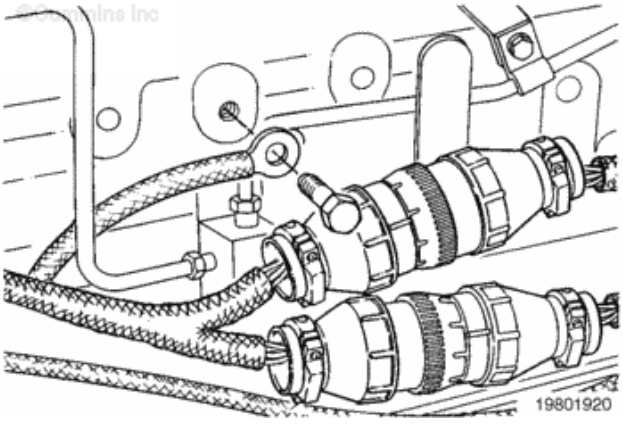
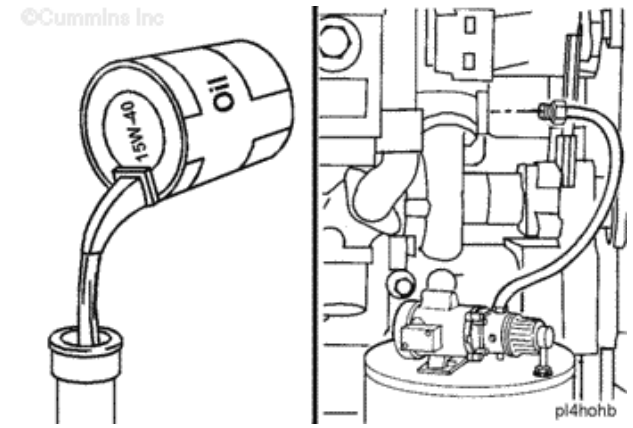
Rail Applications

WARNING Engine weighs 2045 kg [4508 lb]. Use a properly rated hoist and engine lifting fixture, Part Number 3822512, to lift the engine. Rigging and lifting must be done by trained, experienced personnel. Inspect engine lifting brackets for damage or cracks. Do **not** attempt to lift engine if cracks or damage is visible. Install engine lifting fixture, Part Number 3822512, to engine lifting brackets as shown. Install the engine.	 	

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.		

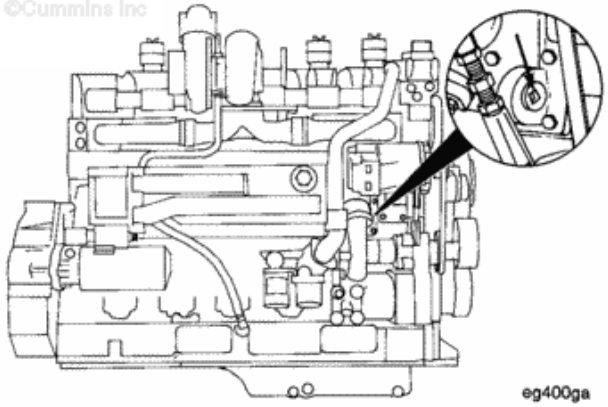
All Applications

Connect the ECM OEM wiring harness connector. Refer to Procedure 019-043 In the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.		
Fill the engine with clean 15W-40 lubricating oil. Refer to Procedure 018-017 for total oil system capacity. **NOTE: The engine must be prelubricated by pumping pressurized oil through the system prior to starting the engine.**		

CAUTION

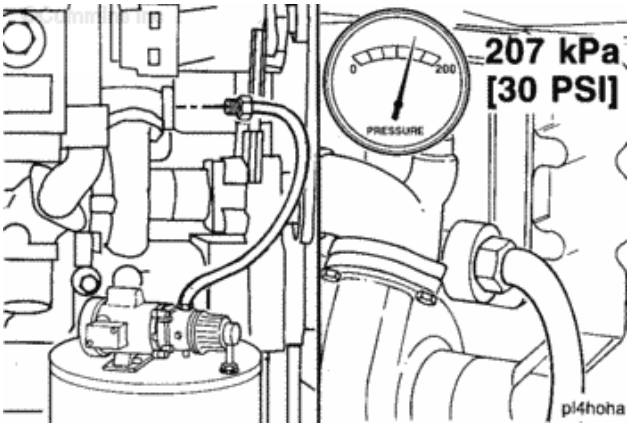
The lubricating oil system **must** be primed before operating the engine after rebuild to avoid internal component damage. Do **not** prime the system from the bypass filter as the filter will be damaged.

Remove the large plug [1-12 inch UNF] from the oil cooler housing.



Use a pump capable of supplying 205 kPa [30 psi] continuous pressure. Connect the pump to the front of the engine oil cooler as shown.

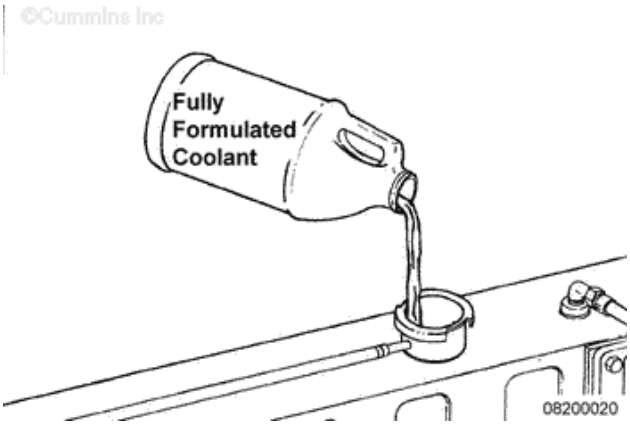
Use a supply of clean oil. Turn the pump to the ON position. Check the engine oil pressure gauge. When the gauge indicates oil pressure, begin monitoring the oil level in the oil pan.



Fill the cooling system with fully formulated coolant. Refer to Procedure 008-018.

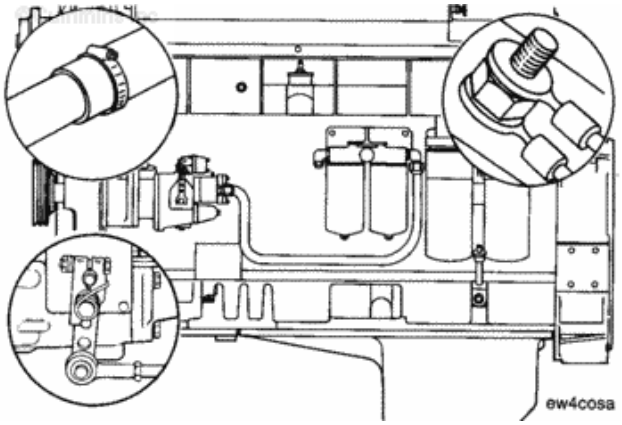
Total Coolant Capacity (Engine **Only**): 30 liter [32 qt]

Refer to the equipment manufacturer's specifications for radiator and system capacity.



Complete a final inspection to be sure that all hoses, wires, linkages, and

components have been properly installed and tightened.

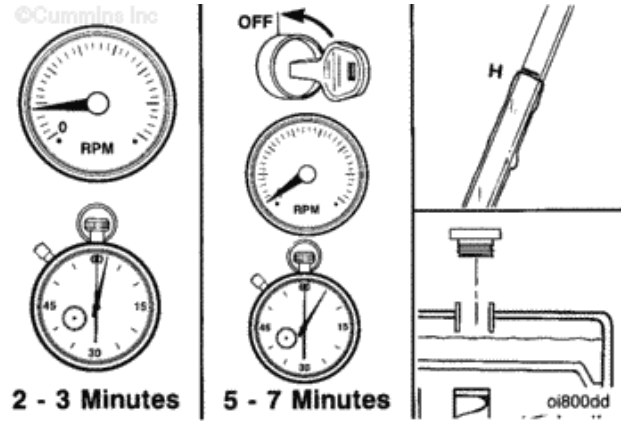


WARNING

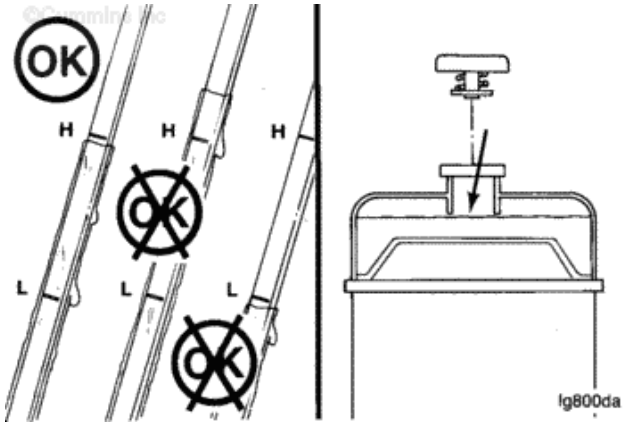
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

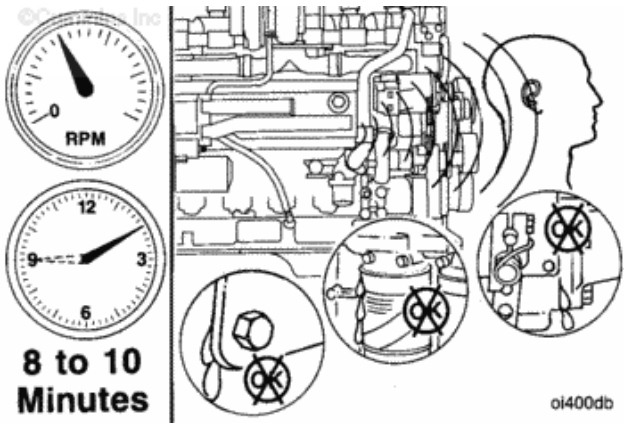
Operate the engine at low idle for two to three minutes.

Stop the engine and wait five to seven 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 Procedure 018-018 for coolant specifications.



Operate the engine for eight to 10 minutes to check for proper operation, unusual noises, and coolant, fuel or lubricating oil leaks. Repair all leaks and component problems. Refer to the appropriate procedures.		

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000-005 Engine Storage - Long Term

General Information

CAUTION

After 24 months in storage, the engine cooling system must be drained and flushed with a suitable solvent or a hot, lightweight mineral oil. Repeat flushing procedure a second time before being put back into service.

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.

This procedure describes the proper method for the long-term (more than 6 months) storage of an engine that is currently in running condition. This procedure applies to this engine either remaining in chassis - or being removed out of chassis upon completion of the steps below.

CAUTION

DO NO use fuel system preservative oil on Natural Gas or Propane Engines.

- Operate the engine at high idle until the coolant temperature is 70°C [160°F].
- Turn the engine off.
- Drain the oil.
- Install the drain plugs.
- Fill the engine to the high mark using Tectyl™ 910 or equivalent engine preservative oil. This will provide long term engine rust protection. The oil **must**

meet military specification MIL-PRF-21260, Type P-10, Grade 2, SAE 30.
- Let the engine run for approximately 25 minutes at low idle in order to ensure that the engine preservative oil (Tectyl 910 E or equivalent) is distributed around the engine and its internal components.

- Turn the engine "OFF"
- Drain all the preservative oil from the engine oil pan sump, the air compressor (if applicable), and all the fuel filters and oil filters.
- Install the drain plugs.
- If the engine is being stored as a loose engine, drain the engine coolant and cover all cooling system openings with plastic and tape.
- If the engine is not being removed from chassis and the engine has an extended life coolant with rust inhibitor, then coolant does NOT need to be drained.
- If the engine will remain in storage for over 24 months, the engine cooling system must be drained and flushed with a suitable solvent or a hot, lightweight mineral oil. Repeat after each 24 month period.
- Remove the intake and exhaust manifolds.
- Spray preservative oil into the intake and exhaust ports in the cylinder heads and in the exhaust manifolds only. Do NOT use preservative oil on the intake manifold or any fuel system components as this may permanently damage sensors or valves.
- Spray preservative oil in the inlet port on the air compressor (if applicable)
- Remove the rocker lever covers.
- Spray the rocker levers, the valve stems, the springs, the valve guides, the crossheads, and the push rods with preservative oil.
- Install the rocker lever covers, intake and exhaust manifolds.
- Brush or spray the preservative oil on all the exposed metal surfaces that are **not** painted. Preservative oil should NOT be applied to any plastic, rubber, or similar surfaces. Make sure to coat the flywheel, flywheel housing and all other unpainted machined surfaces with this preservative oil. Use a rust preservative oil compound that meets military specification MIL-C-16173C, type P-2, Grade 1 or 2.
- For components containing exposed bearings that are not easily accessible e.g. Fan Hubs, remove the component to aid access. Brush or spray preservative oil on all surfaces that are not painted and refit the component. Use a rust preservative oil compound that meets military specification, MIL-C-16173C, type P-2, Grade 1 or 2
- Cover all the openings (engine and components) with heavy paper and tape to prevent dirt and moisture from entering the engine. Cover the entire engine with plastic.
- Put a warning tag on the engine. The tag **must** indicate:
  - Do **not** operate the engine.
  - Do **not** bar the crankshaft.
  - The engine has been treated with preservatives.
  - The coolant has been removed.
  - The date of treatment.
  - The date of the 6 week inspection if required.

CAUTION

The engine must be stored in an area that is dry and has uniform temperature.

- Remove any accessory drive belts to prevent localized stretching and deformation.
- If the engine can be stored inside a designated storage facility isolated from the external environment , ignore the following step.
- Excluding the crankshaft, ensure that all external dynamic engine components are rotated every 6 weeks. Ensure parts are free from corrosion, debris and water ingress. Record and date this on the engine tag created.

NOTE:

To remove the engine from long term storage, follow the following steps:

CAUTION

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

- Flush the engine preservative oil out of the engine by removing the plug from the main engine oil rifle and pumping a hot, lightweight mineral oil through it. Make sure that the engine crankshaft is barred at least three to four revolutions during this flushing procedure.
- Drain all the mineral oil that was used to flush the engine clean of the engine preservative oil.
- Install the drain plugs.
- Install new oil, fuel and coolant filters.
- Fill the engine to the high mark with engine oil.
    - If the engine has been in storage for less than 24 months and if the cooling system was drained, fill the cooling system with coolant. Refer to Procedure 018-004(Coolant Recommendations/Specifications) in Section V for antifreeze, water, and SCA specifications.
    - If the engine has been in storage for 24 months, every 24 months the engine cooling system must be drained and flushed with a suitable solvent or a hot, lightweight mineral oil. Fill the cooling system with coolant. Refer to Procedure 018-004(Coolant Recommendations/Specifications) in Section V for antifreeze, water, and SCA specifications.
    - If the engine has been in storage for less than 24 months and the engine has an extended life coolant with a rust inhibitor, drain the cooling system. Fill the cooling system with coolant. Refer to Procedure 018-004(Coolant Recommendations/Specifications) in Section V for antifreeze, water, and SCA specifications.
- Adjust the engine brake (if applicable) and valve clearances. Refer to the Overhead Set procedure in the corresponding Base Troubleshooting and Repair Manual or Service Manual for the engine being serviced.
- Tighten the intake and exhaust manifold mounting capscrews.
- Prime the lubricating system.
- Reinstall any accessory drive belts that were removed.
- Replace all spark plugs. Refer to the Spark Plugs procedure in the corresponding Base Troubleshooting and Repair Manual or Service Manual for

engine being serviced.
- Make sure all fuel lines are securely tightened and all fuel shutoff valves are open prior to attempting to start the engine.
- Start the engine.
    - Note that if might take multiple cranking attempts to start the engine. Do not crank the engine more than 30 seconds at a time as this might cause the starter to overheat and fail.
    - Note that the engine might run rough until the fuel system is completely primed or until all residual fuel system preservative oil is completely flushed out of the fuel system (if the fuel has been treated with fuel system preservative oil).
- Install the exhaust aftertreatment components (if applicable).
- Force an active regeneration (if applicable).

Last Modified: 14-Jun-2012

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007-037 Lubricating Oil System

Drain

WARNING

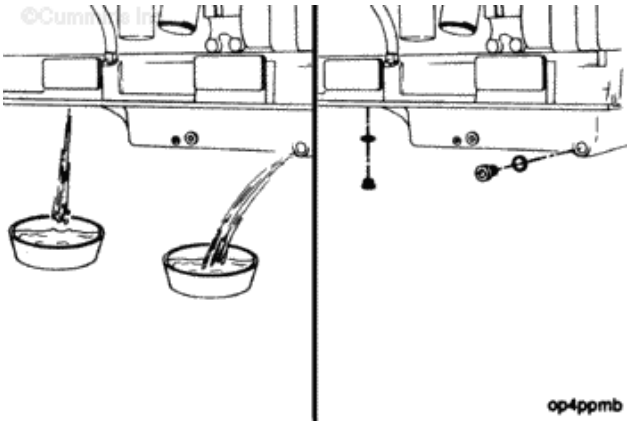
To reduce the possibility of personal damage, avoid direct contact of hot oil with your skin.

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.

NOTE: Drain the engine oil when the temperature is approximately 60°C [140°F].

Remove the oil drain plug and copper washers from the bottom of the oil sump and the oil pan adapter cover plate and drain the oil.



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008-018 Cooling System

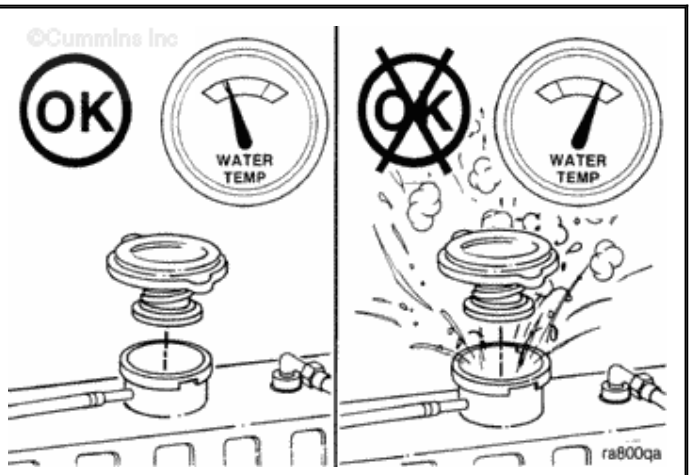
Drain

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.

NOTE: Marine engines will have a heat exchanger or keel coolers instead of a radiator.

Remove the radiator pressure cap after the engine is cool.



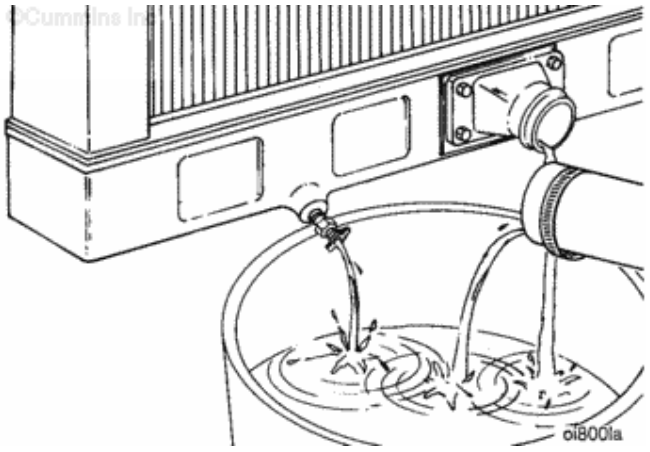
WARNING

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.



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008-006 Coolant Filter

Remove

WARNING

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

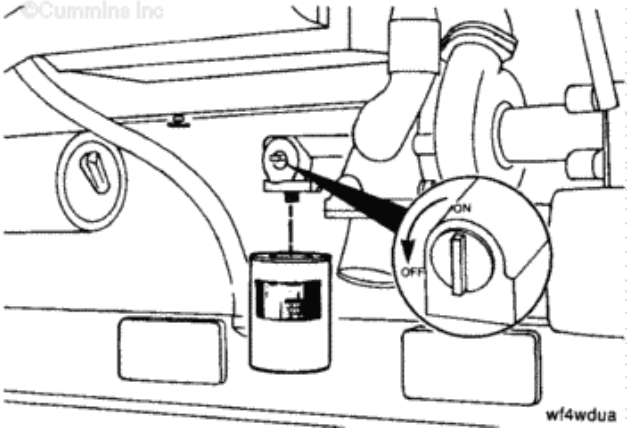
WARNING

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.

NOTE: The valve does not completely stop the flow of coolant from the filter head. It is recommended to have the new filter ready to install before removing the old filter.

Turn the valve on the filter head to the OFF position.

Remove and discard the coolant filter.



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006-011 Fuel Filter, Remote Mounted

Remove

Rail Applications

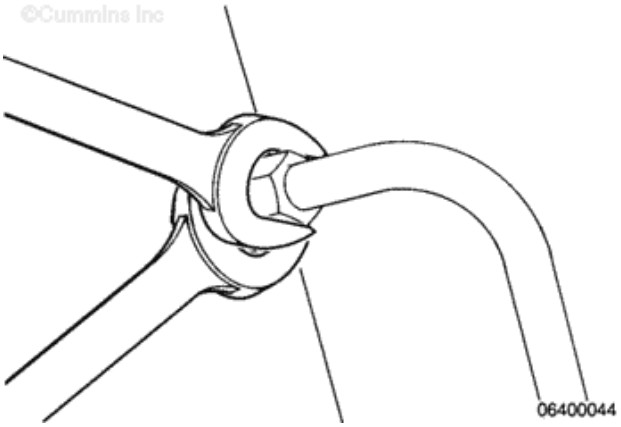
WARNING

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.

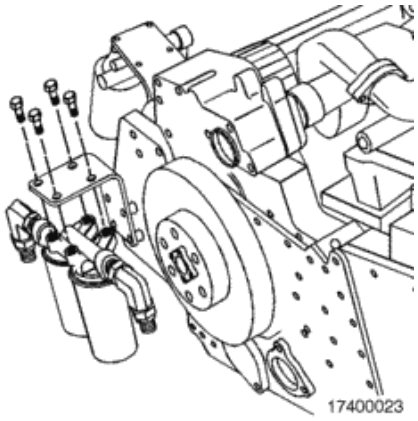
Use two wrenches to remove the fuel hoses.

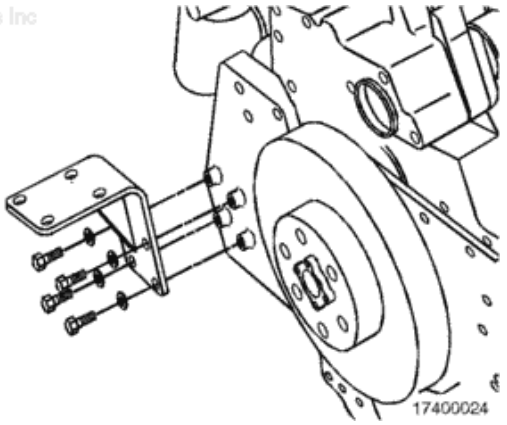
Support the mating fittings with a wrench. Loosen the fuel hose nuts with the other wrench.

Remove the inlet hose, outlet hose, and o-rings from the fuel filter head.



Remove the four capscrews and fuel filter head from the bracket.



Remove the bracket and four capscrews from the lubricating oil pan.		

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006-015 Fuel Filter (Spin-On Type)

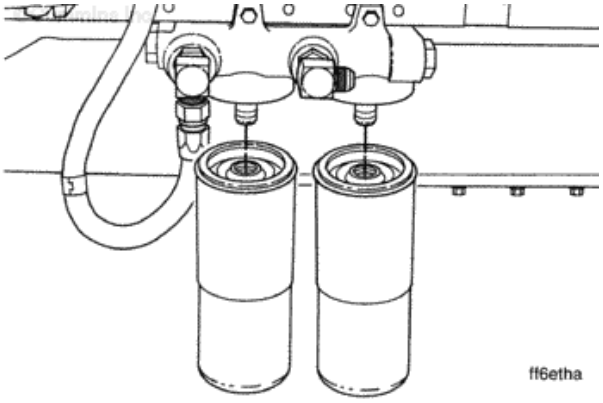
Remove

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.

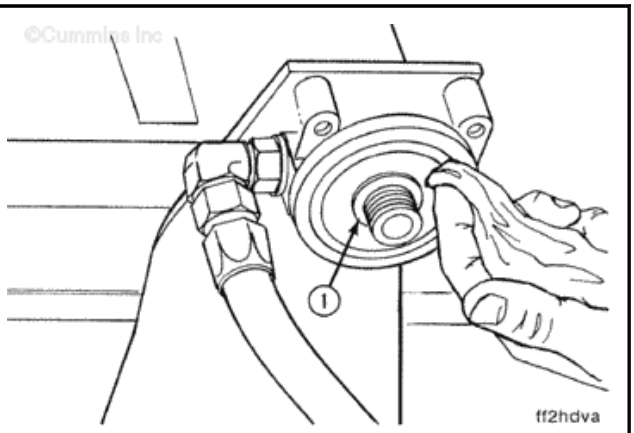
Close the fuel line shutoff valve before changing the fuel filters, or the overhead tank can drain, causing a fuel leak.

Remove the fuel filter with filter wrench, Part Number 3376807.



Remove the thread adapter sealing ring (1).

Use a clean, lint-free towel to clean the surface of the filter head gasket.

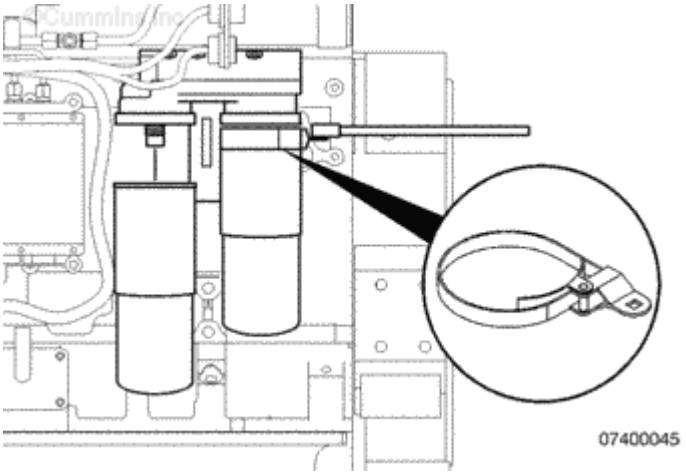


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007-013 Lubricating Oil Filter (Spin-On)

Remove

NOTE: The following steps show the combination oil filter. Use the same procedures when changing the remote bypass oil filters. Remove the oil filters with oil filter wrench, Part Number 3400157 or 3400158, or equivalent. Discard the oil filters if they are **not** needed for failure analysis.		

Last Modified: 28-Jul-2006

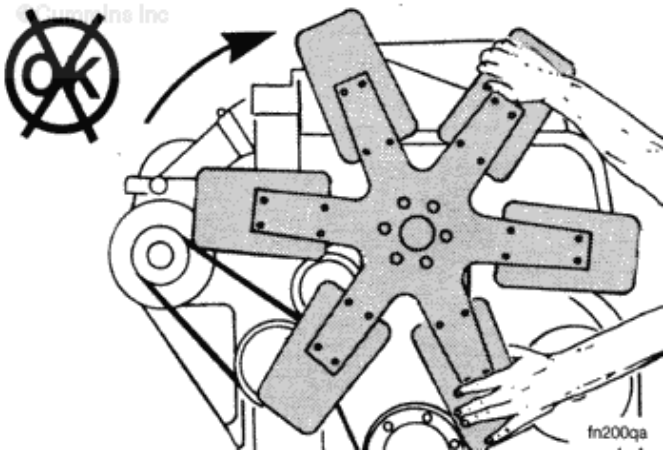
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008-040 Fan, Cooling

Remove

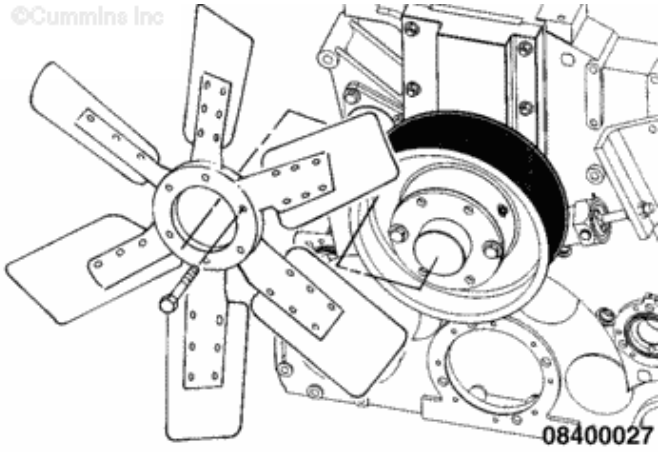
CAUTION

Do not pry or pull on the fan. The fan blades can be damaged.



NOTE: Fans can be installed as either a blower or suction type. Make a note of how the fan is installed to prevent an assembly error.

Remove the capscrews, fan and fan spacer.



Last Modified: 20-Dec-2004

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008-002 Drive Belt, Cooling Fan

Remove

WARNING

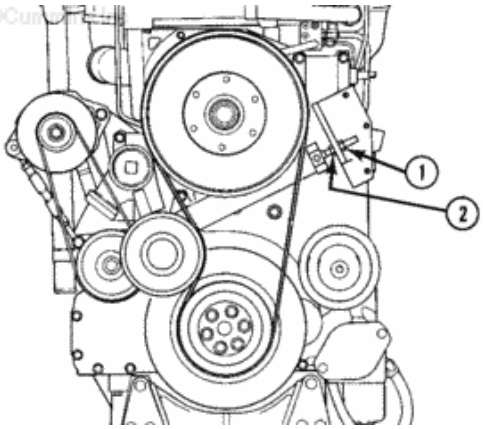
The fan belt idler is under tension. To reduce the possibility of personal injury do not place hands between the idler and the fan belt or the fan hub.

Three types of fan belt tensioning arrangements are used on the K19 engines:

- Enclosed spring
- Control rod with spring (turnbuckle).
- Shock absorber

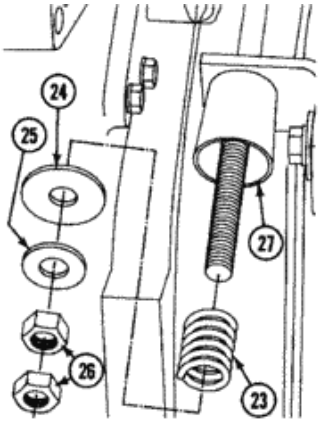
For the enclosed spring style of fan belt tensioner, turn the nut (1) **counterclockwise** to the end of the threaded rod, to relieve fan belt tension.

Loosen nut (2).



NOTE: The parts are not removed, the graphic is for clarity.

For the control rod with spring style, loosen the two jam nuts (26) to relieve the fan belt tension.

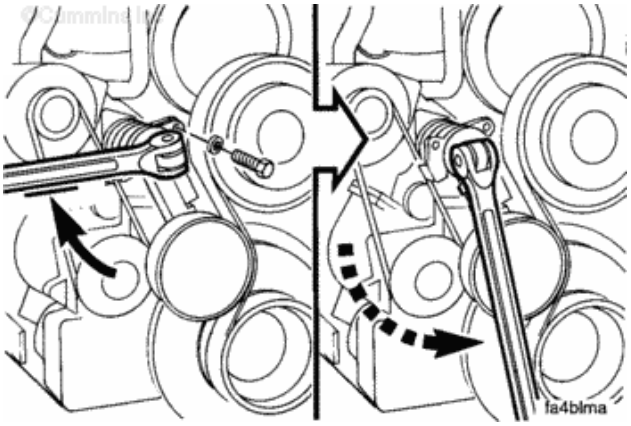


WARNING

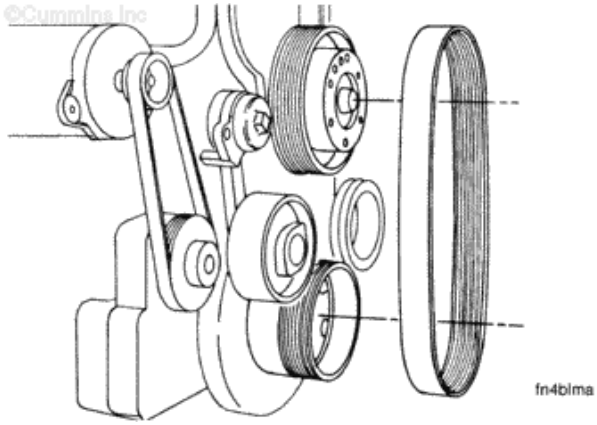
The fan belt idler is under tension. To reduce the possibility of personal injury do not place hands between the idler and the fan belt or the fan hub.

For the shock absorber style, use an 8-point socket and breaker bar or a large wrench on the lug on the idler cap to turn the arm against the spring tension. Remove the capscrew.

Slowly turn the breaker bar or wrench until the tension is relieved.



Remove the fan belt.

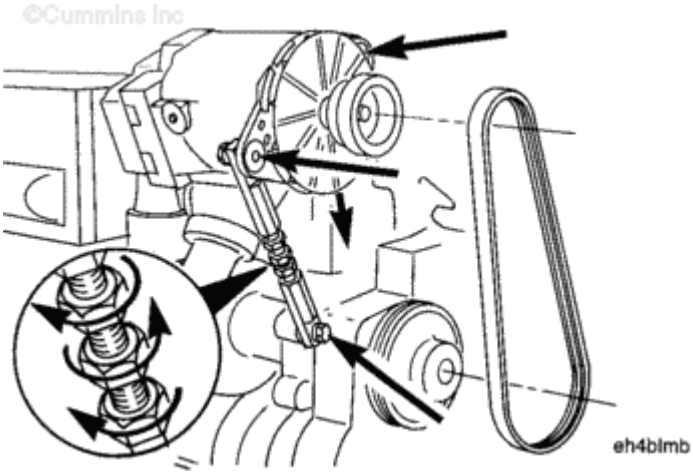
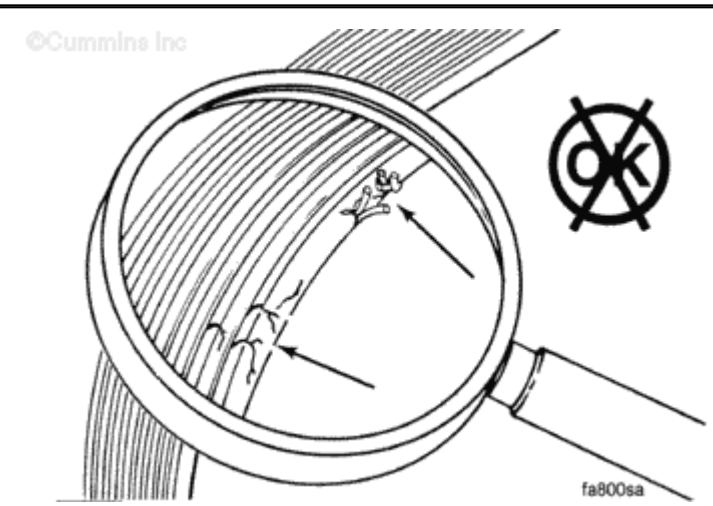


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013-005 Drive Belt, Alternator

Remove

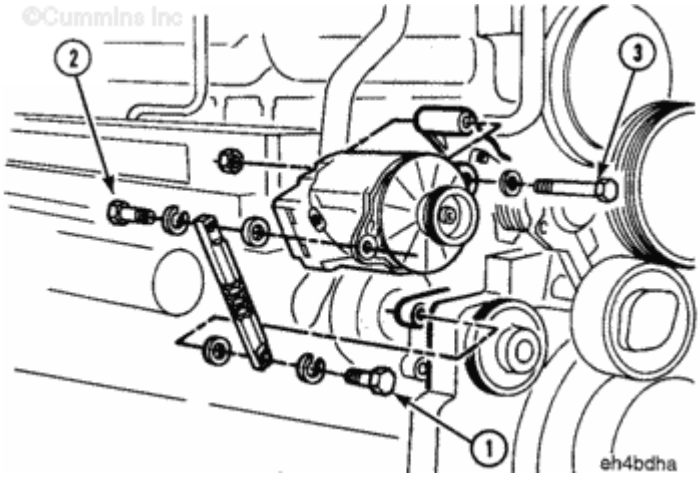
Loosen the adjusting link and the alternator mounting capscrews. **NOTE: The lower jam nut has left-hand threads.** Loosen both of the jam nuts. Turn the adjusting screw to relieve the belt tension. Remove the belt.		
Check the belt for wear. If the belt indicates any wear, it **must** be replaced.		

Last Modified: 07-Jan-2011

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013-001 Alternator

Remove

Disconnect the wiring and ground strap from the alternator. Remove capscrews (1) and (2) and the adjusting link. Remove capscrew (3) and nut. Remove the alternator.		

Last Modified: 22-Nov-2004

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008-037 Fan Hub, Gear Driven

Remove

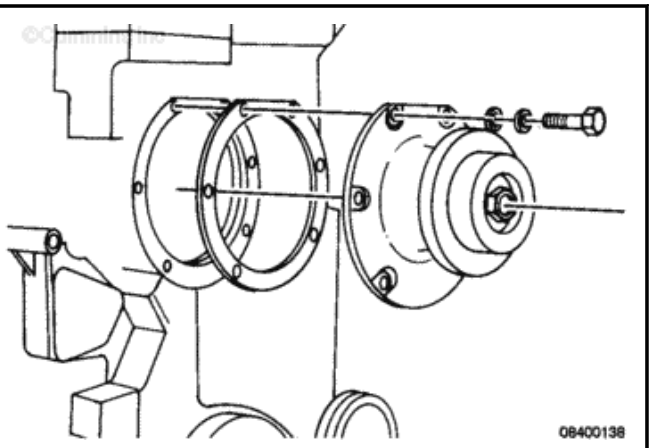
WARNING

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.

Two of the capscrews contain a nut on the back side of the gear cover plate.

Remove the capscrews, nuts and fan hub.

Remove and discard the gasket.



Last Modified: 31-Jul-2006

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008-036 Fan Hub, Belt Driven

Remove

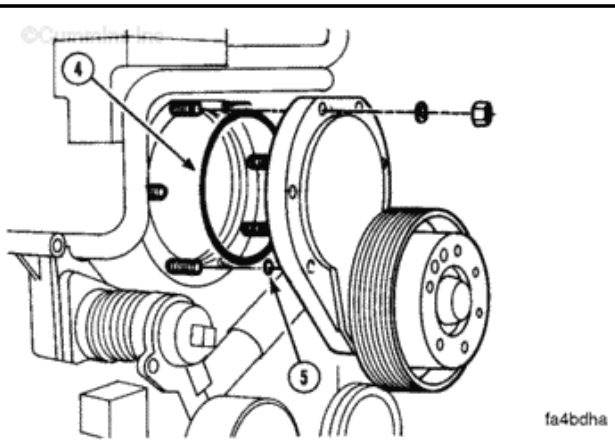
WARNING

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 seven fan hub mounting nuts and remove the fan hub.

Remove the o-ring (4) and seal (5).

Discard the o-ring and seal.



Last Modified: 31-Jul-2006

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008-029 Fan Drive Idler Arm Assembly

Remove

WARNING

The belt tensioner and pivot arm assembly will rotate during removal. To reduce the possibility of personal injury, use a hoist or get assistance to remove the belt tensioner and pivot arm assembly.

Three types of fan belt tensioning arrangements are used on K19 engines:

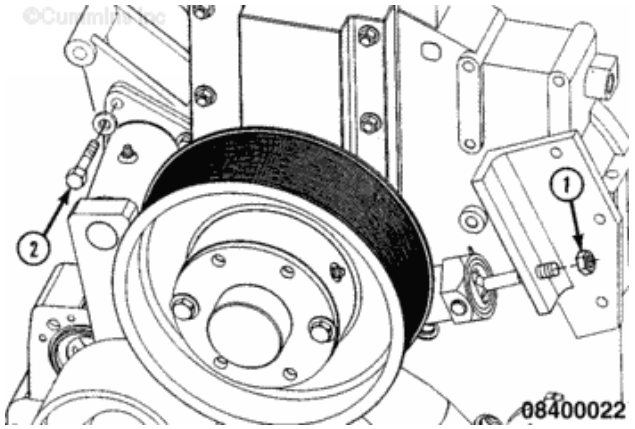
- Shock absorber
- Control rod with spring (turnbuckle)
- Enclosed spring.

Only the enclosed spring style is shown. The procedure is the same for all types of arrangements except where indicated.

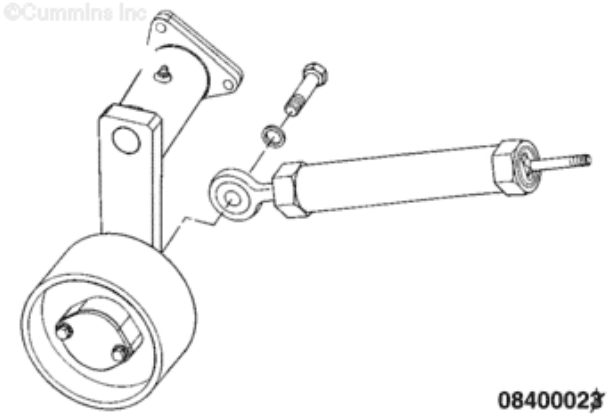
Remove the belt adjusting nut (1) from the tensioner assembly.

Remove the three capscrews (2) from the pivot arm assembly.

Remove the pivot arm and belt tensioner as an assembly.



Remove the belt tensioner from the idler arm assembly.



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008-057 Sea Water Pump

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.

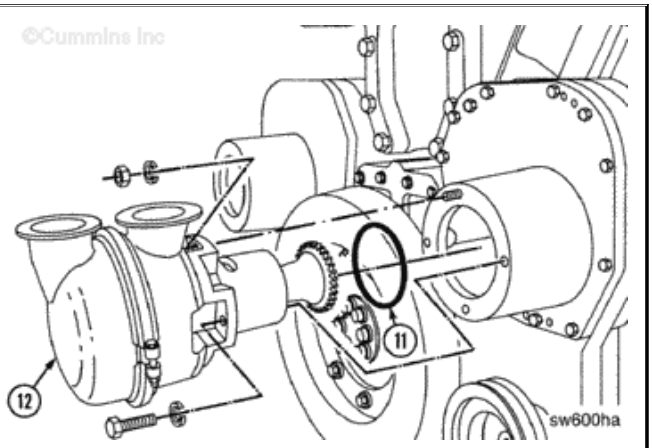
NOTE: Not all engines are equipped with this option.

Remove the three capscrews and the nut.

Remove the sea water pump (12) and the o-ring seal (11).

Discard the seal.

Remove the outer pump.



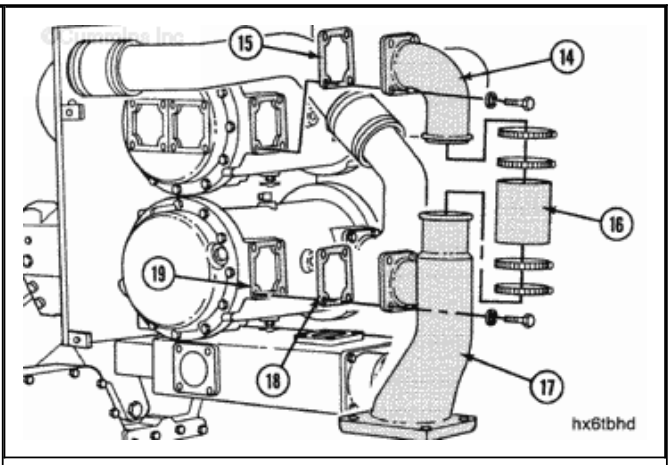
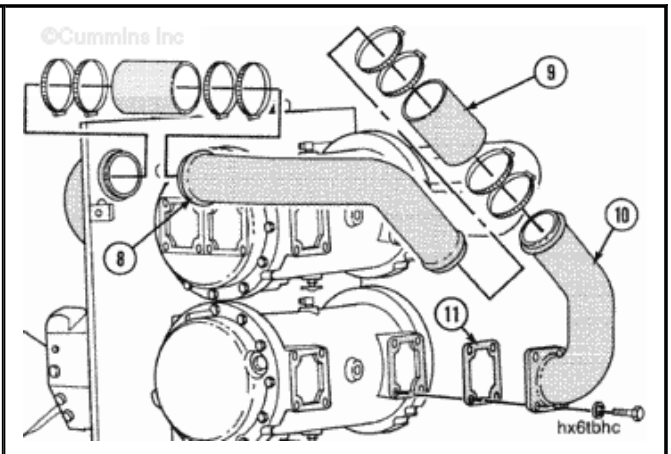
Last Modified: 01-Apr-2009

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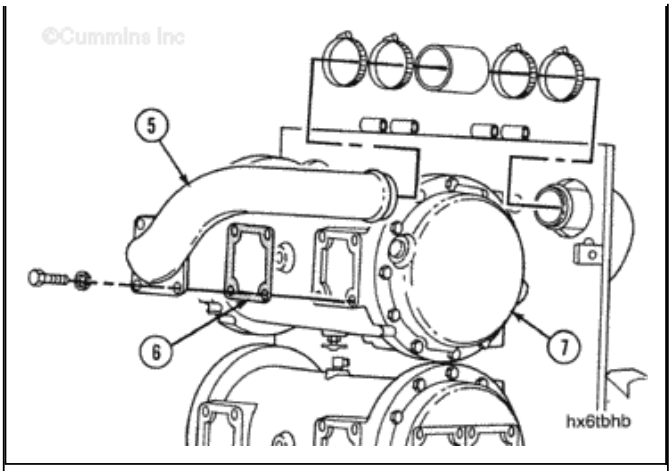
008-053 Heat Exchanger

Remove

Tube Type

Remove the water pump inlet connection to heat exchanger outlet pipe (17). Loosen the heat exchanger outlet pipe hose clamps. Remove the eight outlet pipe capscrews and the outlet pipe (14). Remove and discard the hose (16).		
Loosen the eight hose clamps. Remove the four capscrews. Remove the pipes (8) and (10) and the gasket. Discard the gasket and hoses.		
Loosen the hose clamps. Remove the four capscrews. Remove the pipe (5) and gasket.		

Discard the hose and gasket.



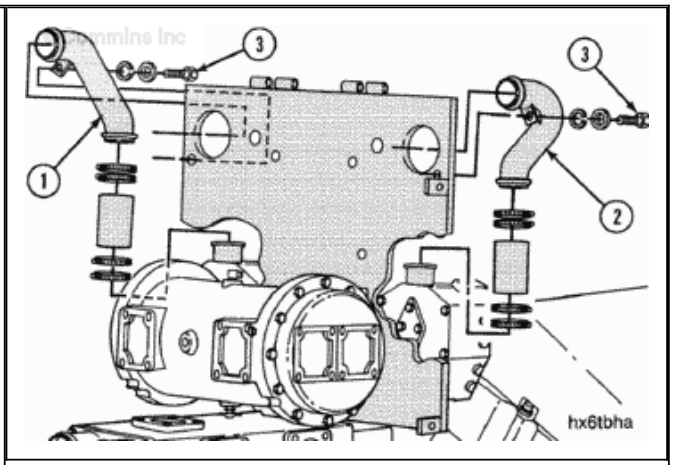
NOTE: A portion of the heat exchanger support is not shown for clarity.

Loosen the hose clamps.

Remove the two capscrews (3).

Remove the engine outlet pipes (2) and (1).

Discard the hoses.



WARNING

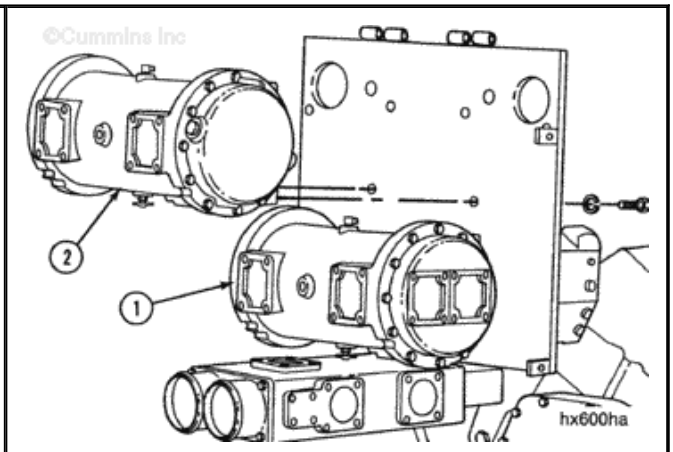
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

NOTE: Not all engines are equipped with the upper and lower heat exchanger option.

Remove the capscrews.

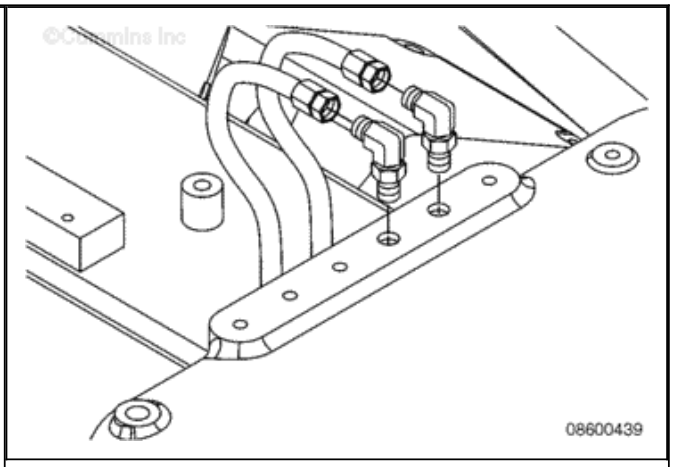
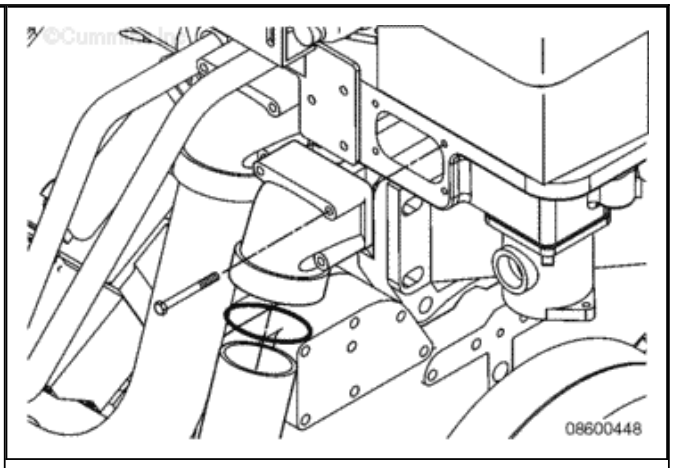
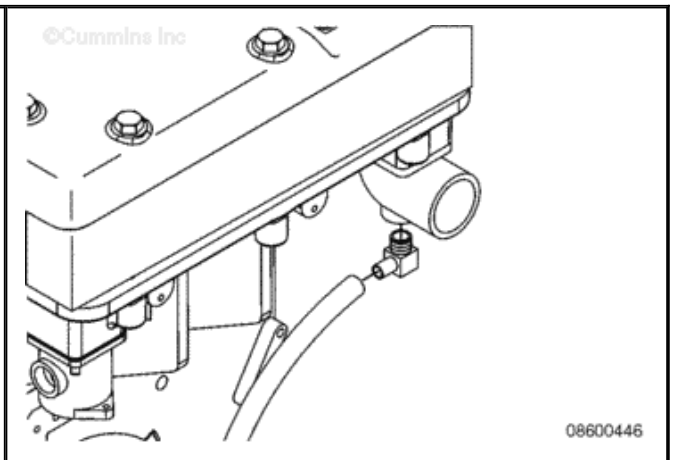
Remove the upper heat exchanger (2).

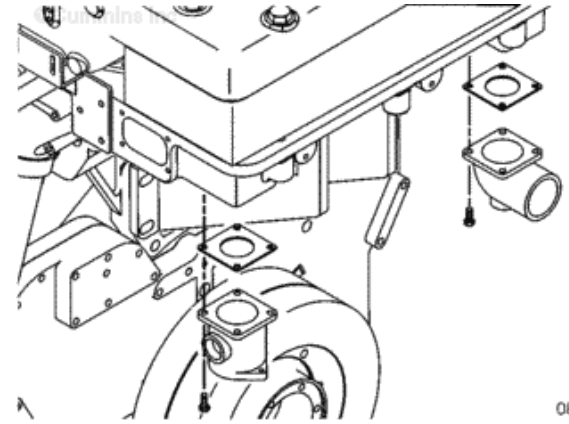
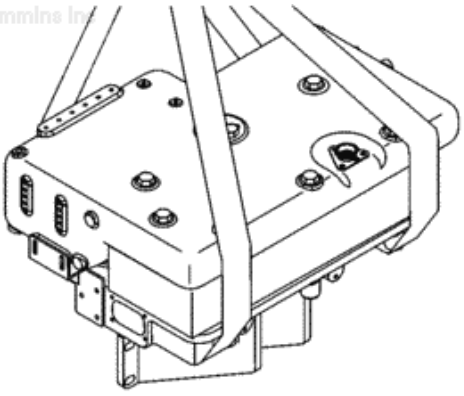
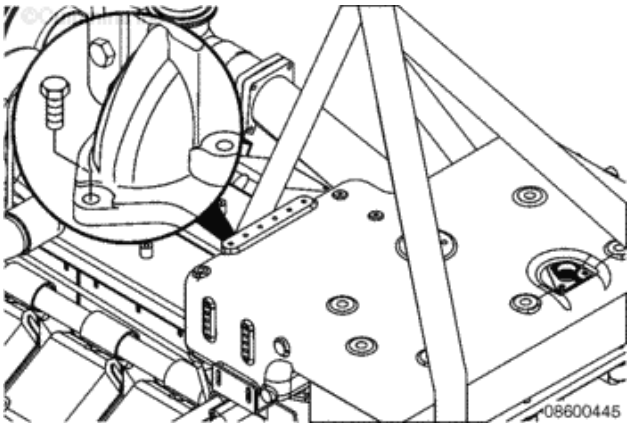
Remove the lower heat

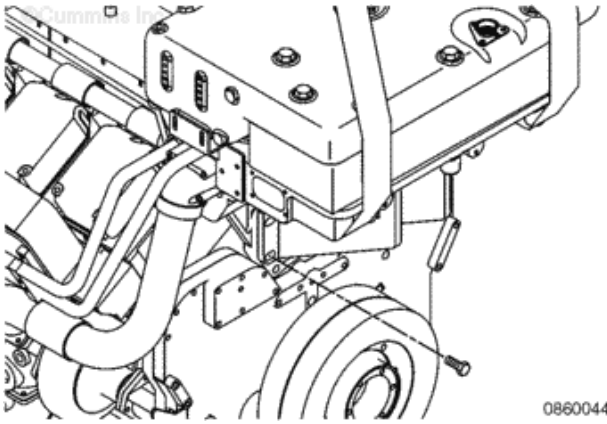


exchanger (1).		

Plate Type

Remove the vent lines from the expansion tank.		
Disconnect and remove the coolant outlet tube.		
Disconnect the sea water pump prime discharge line from heat exchanger sea water outlet connection.		

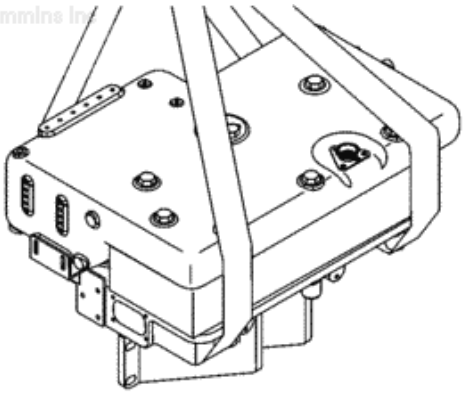
Disconnect the sea water inlet and outlet tube.		
Attach a chain fall or other lifting equipment with straps around the heat exchanger assembly as shown.		
Remove the six jacket water manifold capscrews that hold the jacket water manifold to the thermostat housing. Remove the four LTA transfer tube mounting capscrews that hold the tubes to the thermostat housing.		
Disconnect the lower mounting bracket capscrews that fasten the bracket to the engine block.		



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.

Lift the heat exchanger assembly away from the engine.

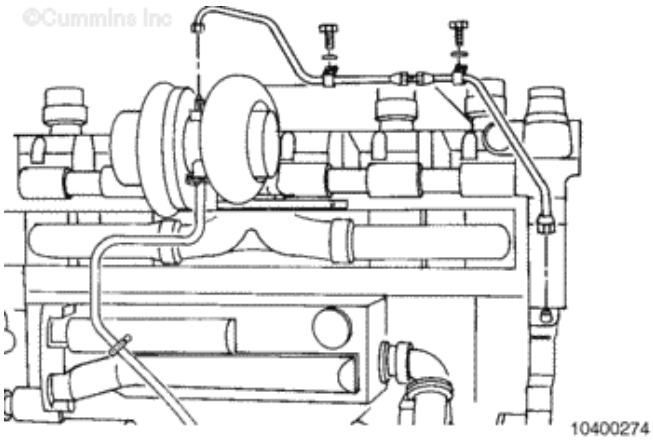
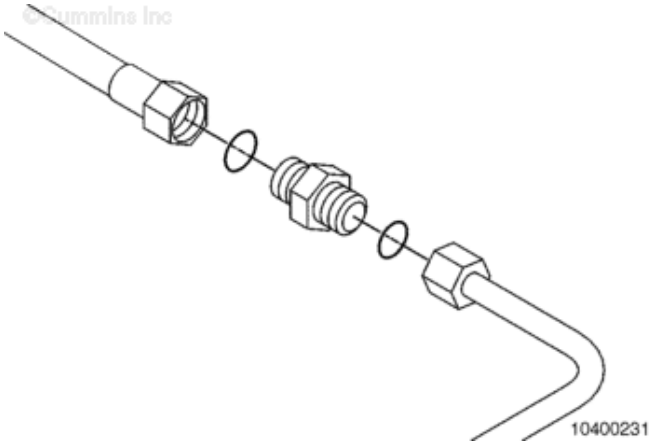


Last Modified: 04-Nov-2004

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010-046 Turbocharger Oil Supply Line

Remove

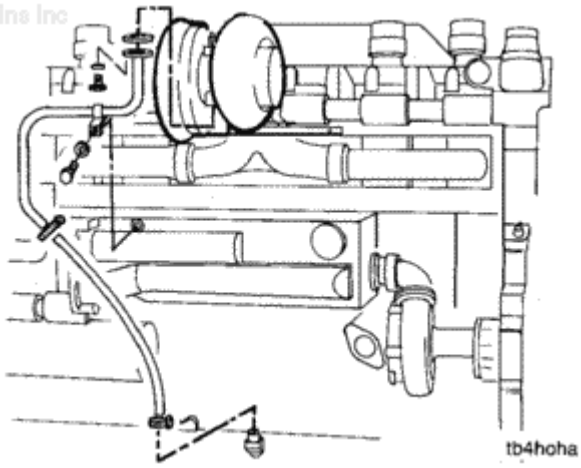
Remove the turbocharger oil supply line.		
Disconnect the turbocharger oil supply hose from the turbocharger supply tube at the male union. Discard the o-rings from the male union.		

Last Modified: 29-Nov-2004

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010-045 Turbocharger Oil Drain Line

Remove

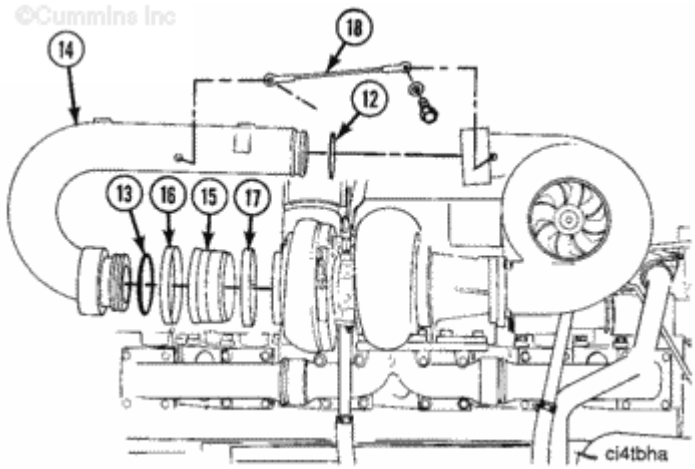
Remove the capscrews and disconnect the oil drain line from the turbocharger. Remove and discard the gasket. Disconnect the oil drain tube from the union and remove the oil drain line. Remove the adapter elbow from the cylinder block.		

Last Modified: 29-Nov-2004

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010-018 Air Connection Pipe (Turbocharger to Turbocharger)

Remove

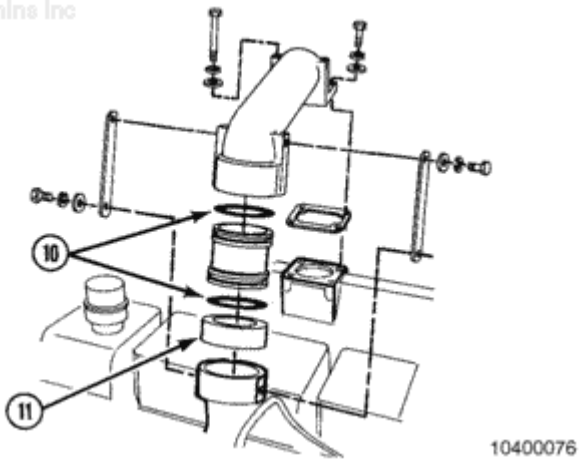
Remove the two retaining straps (18). Loosen hose clamps (16) and (17). Remove the air transfer tube. Remove and discard the o-rings (12 and 13) and the dust seal (15).		

Last Modified: 29-Nov-2004

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010-019 Air Crossover

Remove

NOTE: Some engines contain a hose and clamps in place of the o-ring, dust seal, and retainer straps. Remove the four capscrews and two retaining straps from the air crossover. Remove the air crossover assembly. Remove the o-rings and dust seal. Discard the o-rings and dust seal.		

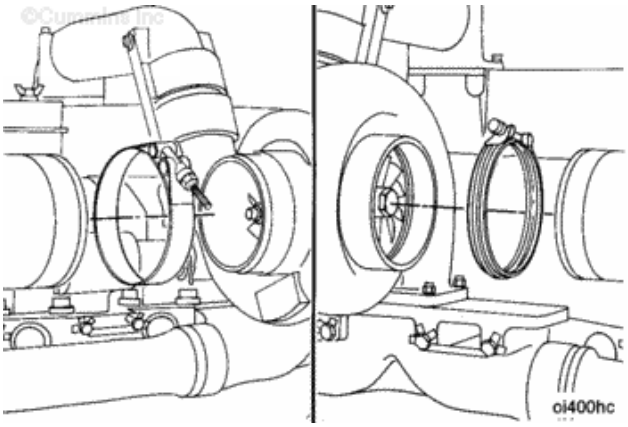
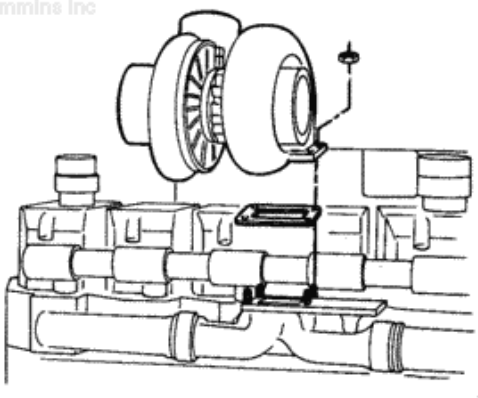
Last Modified: 25-Sep-2012

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010-033 Turbocharger

Remove

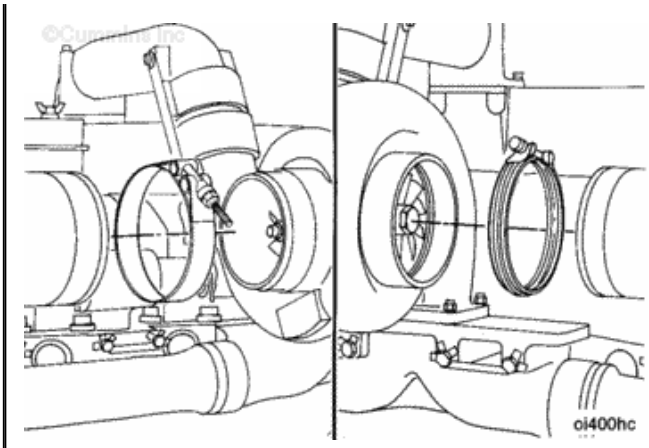
Single Turbocharger

Remove the intake and exhaust pipes from the turbocharger.		
Remove the turbocharger mounting nuts and washers. Remove the turbocharger and gasket. Discard the gasket.		

Multiple Turbochargers

Remove the intake tubing from the low stage turbocharger.		

Remove the exhaust connection from the low stage turbocharger.

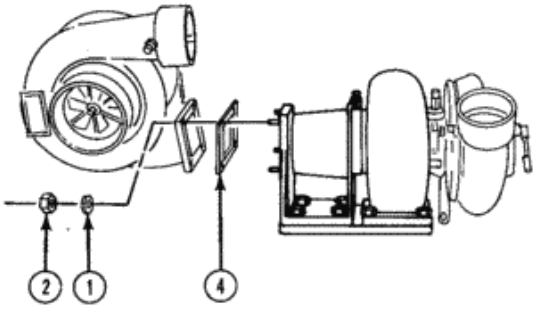


Tag the turbocharger mounting nuts and washers for future identification. The nuts are designed for high strength.

Remove the turbocharger mounting nuts (2) and washers (1).

Remove the low stage turbocharger and gasket (4).

Discard the gasket.



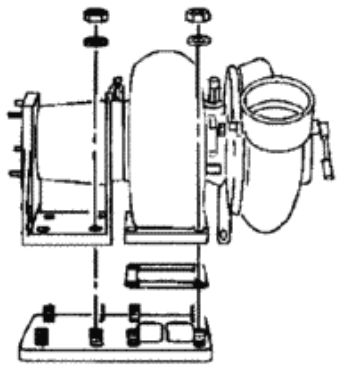
WARNING

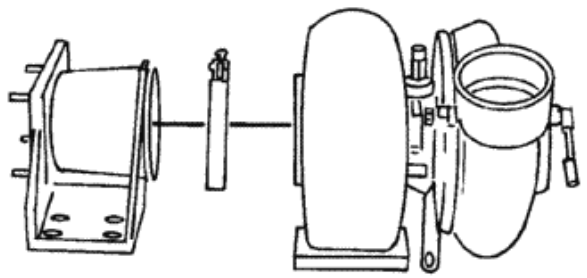
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Remove the mounting nuts and washers.

Remove the high stage turbocharger and support assembly.

Remove and discard the gasket.



Loosen the v-band clamp and separate the high stage turbocharger and mounting support.		

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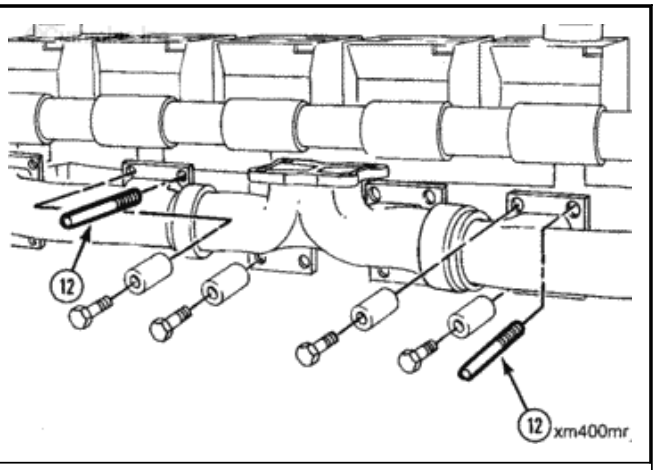
011-007 Exhaust Manifold, Dry

Remove

Remove two capscrews.

Install two 7/16-14 x 5 inch guide studs (12) as shown.





WARNING

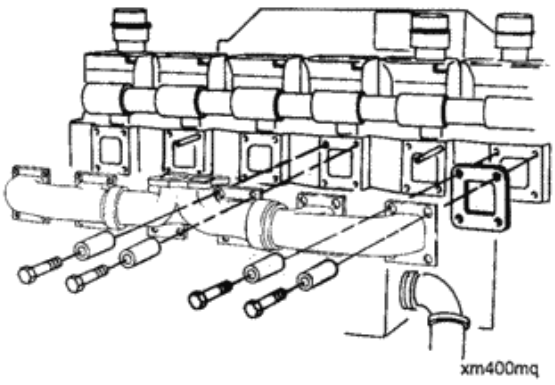
This component weighs more than 23 kg [50 lb]. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component.

Remove the remaining capscrews.

Remove the exhaust manifold and the gaskets.

Discard the gaskets.



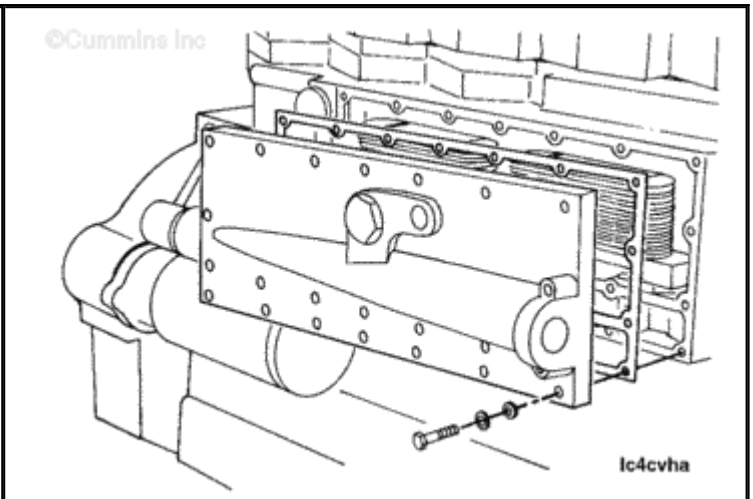


Last Modified: 19-Oct-2004

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007-045 Lubricating Oil Cooler Cover

Remove

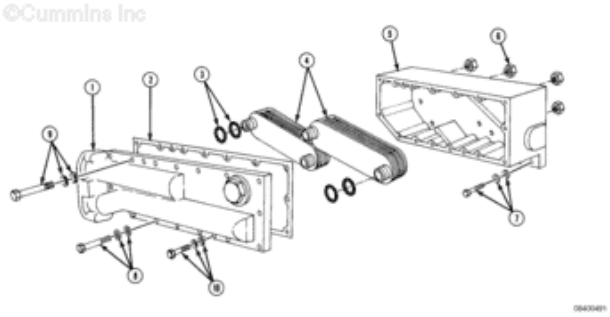
Remove the lubricating oil cooler cover capscrews. Remove the lubricating oil cooler cover. Remove and discard the gasket.		

Last Modified: 19-Oct-2004

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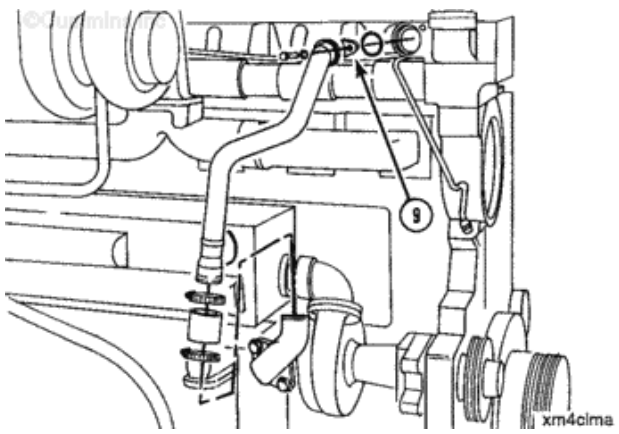
008-065 Torque Converter Cooler

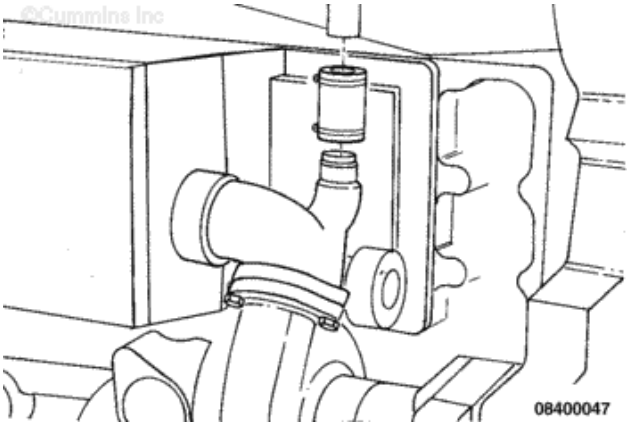
Exploded View

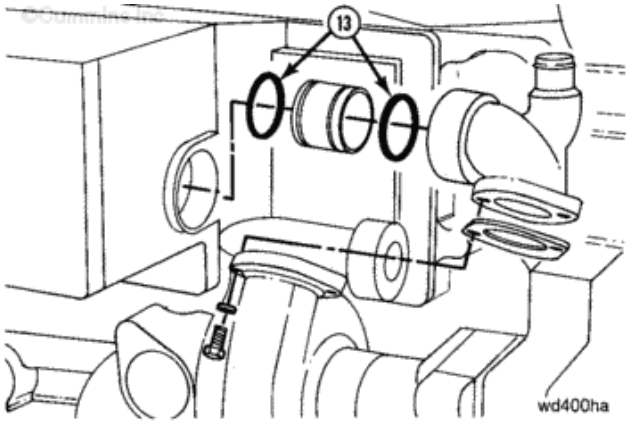


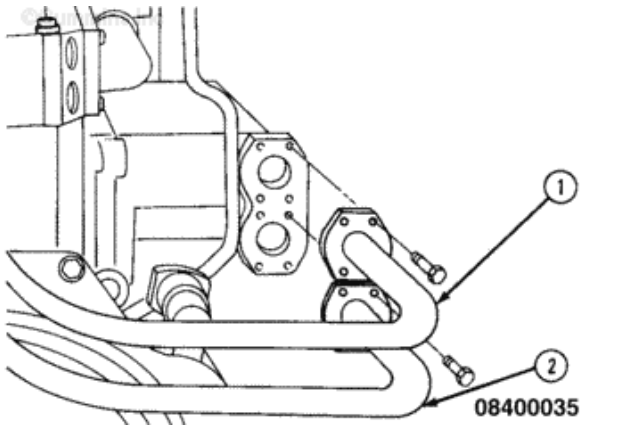
1. Torque converter oil cooler cover
2. Torque converter oil cooler cover gasket
3. O-ring
4. Torque converter oil cooler element
5. Torque converter oil cooler housing
6. Self-locking nut
7. Capscrew, lock washer, and plain washer
8. Capscrew and lock washer
9. Capscrew, lock washer, and plain washer
10. Capscrew, lock washer, and plain washer.

Remove

Remove the water bypass tube clamp (9). Loosen both lower bypass tube clamps. Remove the water bypass tube and discard the o-ring.		

Disconnect the aftercooler supply hose from the water pump outlet connection.		

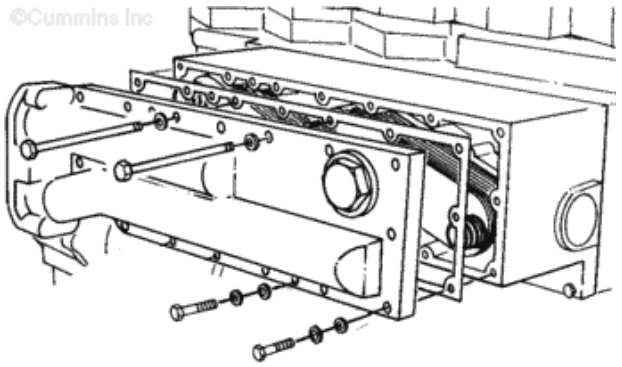
Remove the water pump outlet connection assembly. Remove the water transfer tube from the water outlet connection. Remove and discard the to o-rings (13) and the gasket.		

Remove the oil supply (1) and oil return (2) tubes from the torque converter cooler.		

Remove the torque		

converter cooler cover mounting capscrews.

The cover **must** be pried from the housing because of the tight fit between the cover and the o-rings on the elements.



WARNING

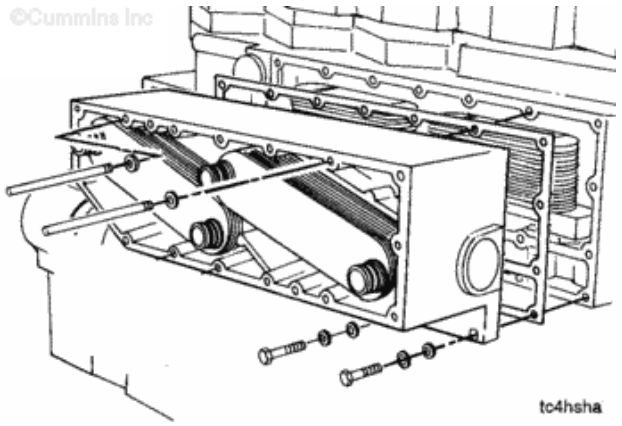
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Install two 3/8-16 x 12-in guide studs to support the housing while the capscrews are being removed.

Remove the remaining torque converter cooler housing capscrews.

Remove the torque converter cooler housing and the gasket.

Discard the gasket.

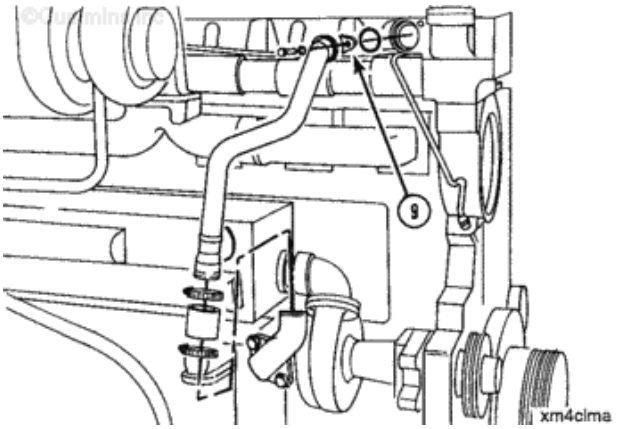
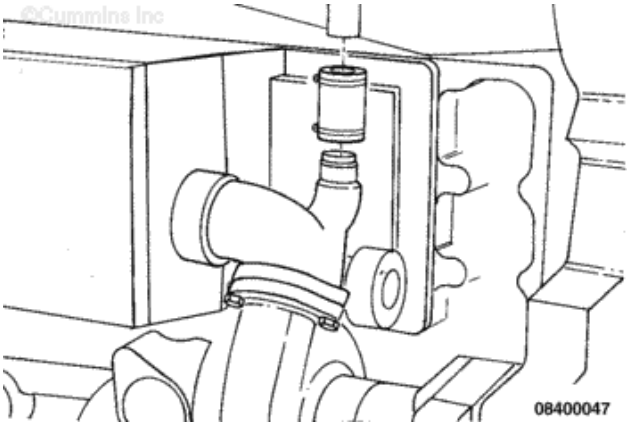


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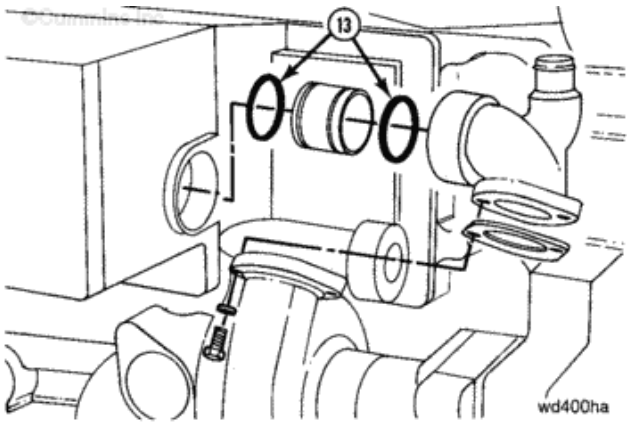
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008-041 Marine Gear Oil Cooler

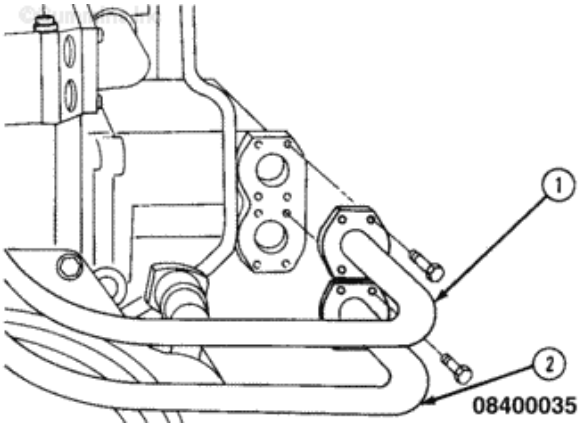
Remove

Remove the water bypass tube clamp (9). Loosen both lower bypass tube clamps. Remove the water bypass tube and discard the o-ring.		
Disconnect the aftercooler supply hose from the water pump outlet connection.		
Remove the water pump outlet connection assembly. Remove the water transfer tube from the water outlet connection. Remove and discard the to		

o-rings (13) and the gasket.

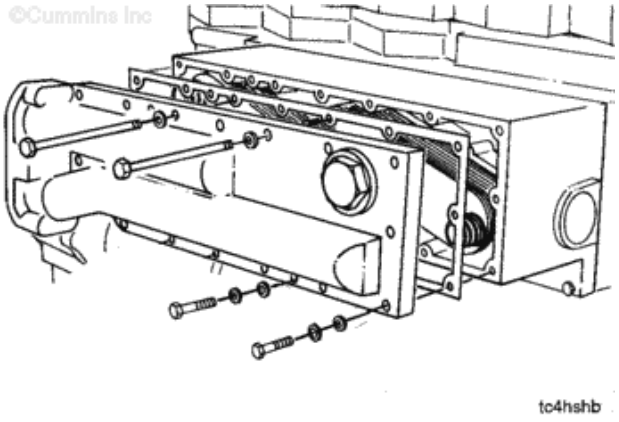


Remove the oil supply (1) and oil return (2) tubes from the marine gear oil cooler.



Remove the marine gear oil cooler cover mounting capscrews.

The cover **must** be pried from the housing because of the tight fit between the cover and the o-rings on the elements.



WARNING

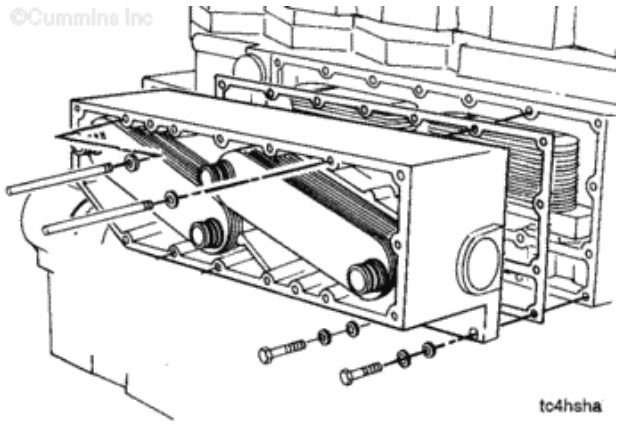
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Install two 3/8-16 x 12-in guide studs to support the housing while the capscrews are being removed.

Remove the remaining marine gear oil cooler housing capscrews.

Remove the marine gear oil cooler housing and the gasket.

Discard the gasket.

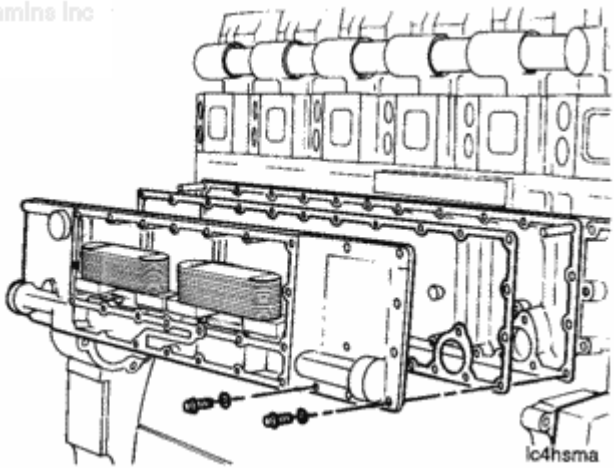


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007-046 Lubricating Oil Cooler Housing

Remove

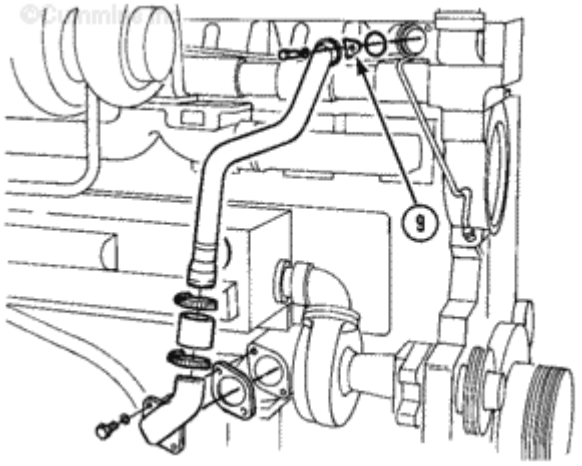
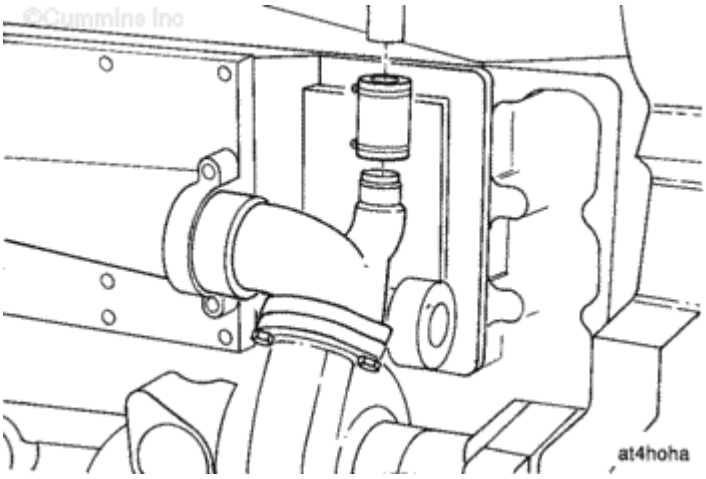
Remove the lubricating oil cooler housing capscrews. Remove the lubricating oil cooler cover housing. Remove and discard the gasket.		

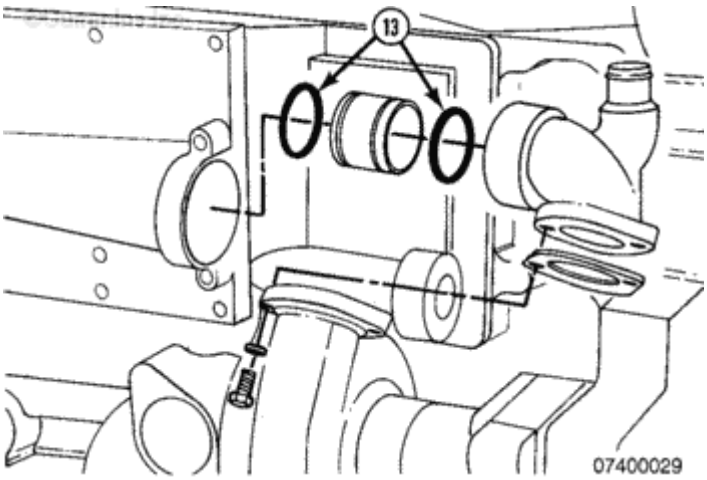
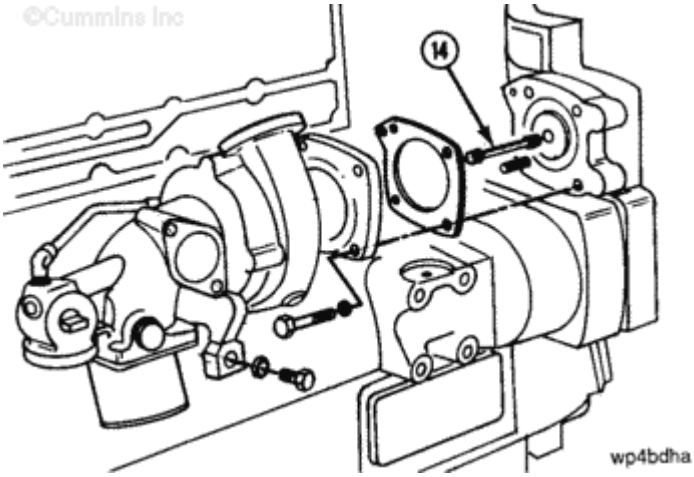
Last Modified: 19-Oct-2004

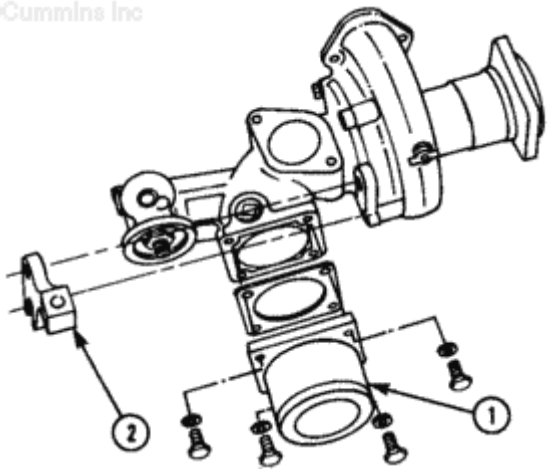
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008-062 Water Pump

Remove

Remove the water bypass tube clamp (9). Loosen both hose clamps. Remove the water bypass tube.		
Disconnect the aftercooler supply hose from the water pump outlet connection.		
Remove the water pump		

outlet connection assembly. Remove the water transfer tube from the water connection. Remove and discard the two o-rings (13) and the gasket.		
Remove the capscrew from the water pump support bracket. Remove the three capscrews and the nut from the water pump mounting flange. Remove the water pump and gasket. Discard the gasket. Remove the water pump drive shaft (14).		
Remove the water inlet connection and gasket (1). Remove the support bracket (2).		

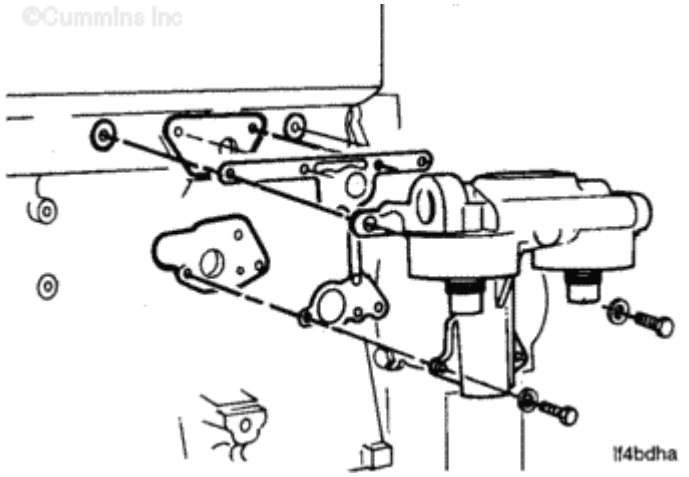


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007-015 Lubricating Oil Filter Head

Remove

Remove the six oil filter head mounting capscrews. Remove the oil filter head assembly. Remove and discard the gasket.		

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007-018 Lubricating Oil Filter Head Adapter

Remove

Threaded

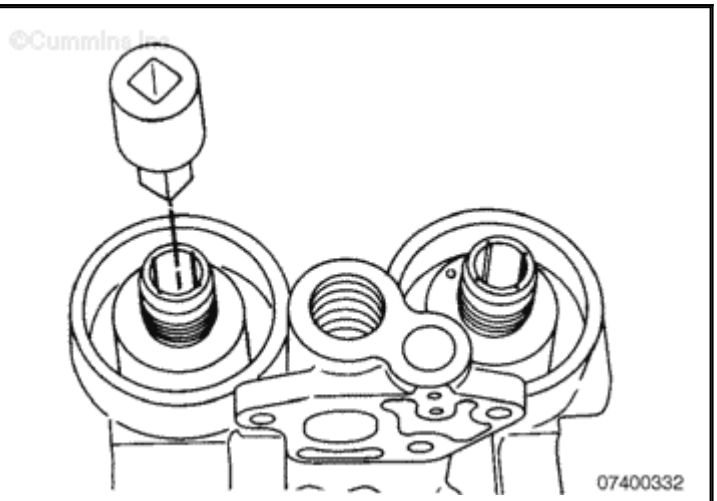
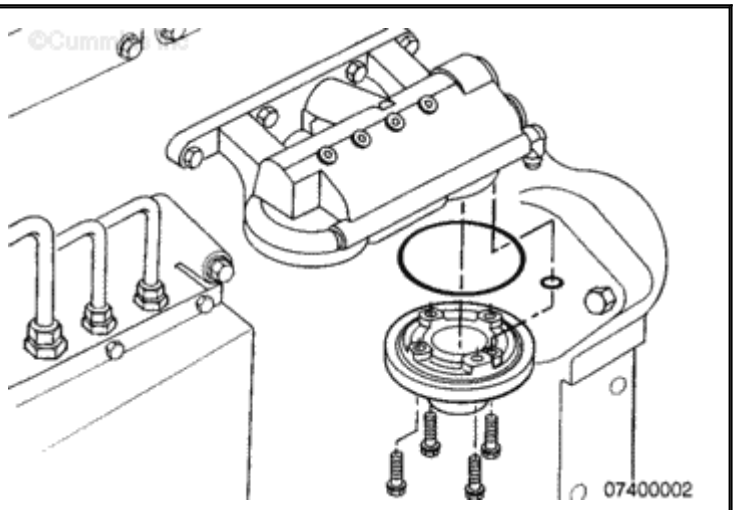
Remove the adapter using a ¾-in drive tool.		

Plate Type

Remove the four capscrews. Remove the oil filter head adapter. Remove and discard the o-ring.		

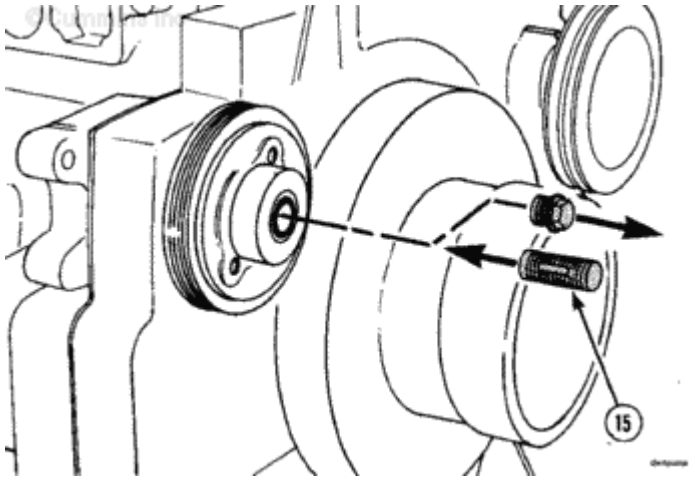
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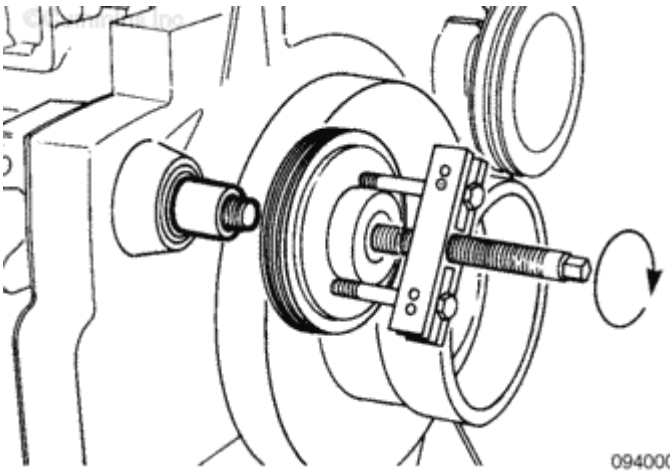
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View Related Topic

009-010 Alternator Drive Pulley

Remove

Remove the plastic plug at the end of the shaft. Insert the adapter (15), Part Number 3376089, into the shaft to prevent damage. The adapter is included with the pulley installation kit, Part Number 3376326. If the adapter is **not** available, a ¾-16 inch capscrew with the head ground smaller than the pulley inside diameter can be used.		
Attach standard puller, Part Number ST-647, to the drive pulley using the two supplied capscrews. Remove the		

pulley. Remove the adapter. **NOTE: Standard Puller, Part Number ST-647, includes two capscrews that measure 7/16-20x1 inch.**		

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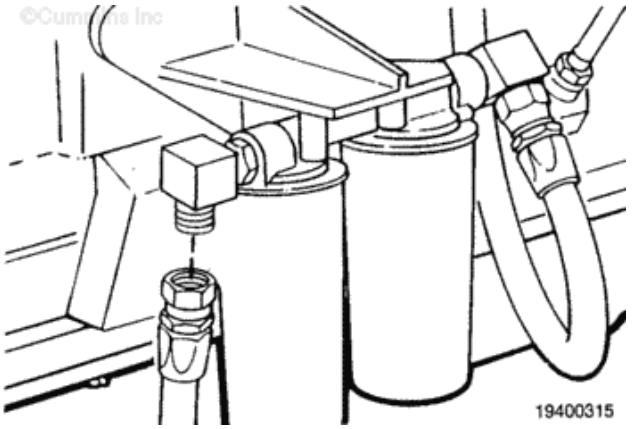
006-024 Fuel Supply Lines

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 a fuel system.

Remove the fuel tank to fuel filter inlet hose.

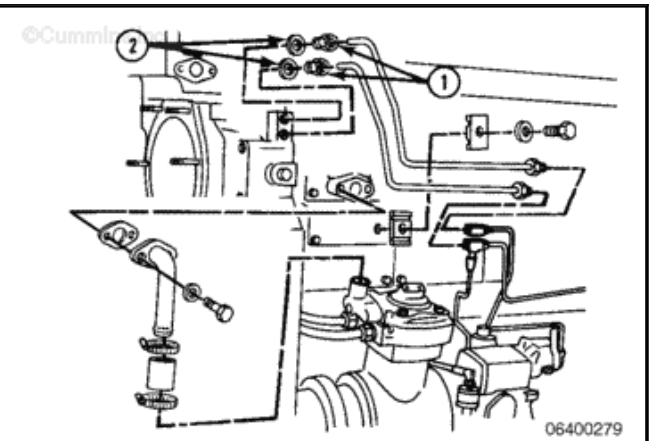


Disconnect the fuel supply tube.

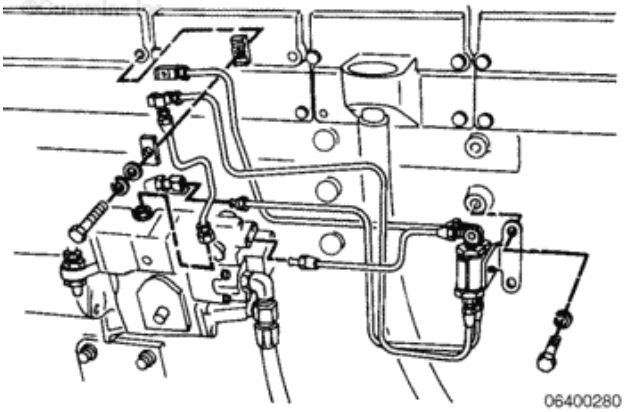
Disconnect the fuel manifold end of the fuel supply tube. The fuel drain tube connects closest to the bottom of the fuel manifold.

On engines with an air compressor, remove the air inlet connection.

Discard the connection hose and gasket.



Disconnect the fuel pump end of the fuel supply tube.



WARNING

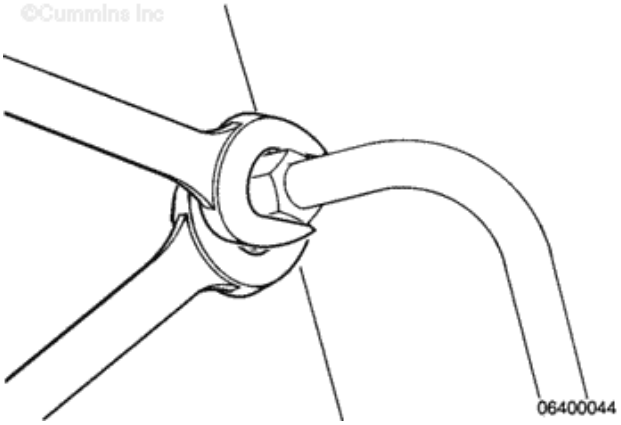
Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on a fuel system.

Use two wrenches on fuel tubes and hoses.

Support the mating fittings with a wrench.

Loosen the fuel tube nuts with the other wrench.

Remove the fuel tubes and hoses.



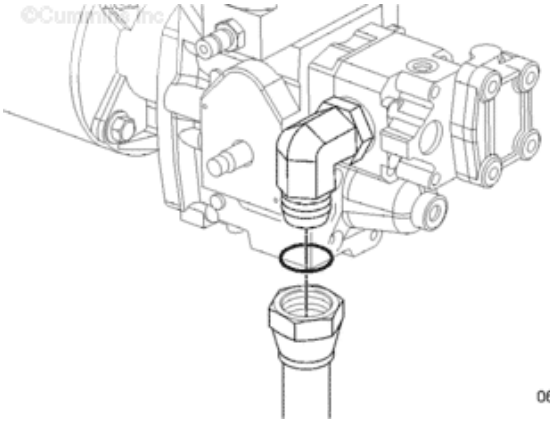
WARNING

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 a fuel system.

Remove the hose between the fuel filter head outlet and the fuel pump inlet fitting.

Remove and discard the o-rings.

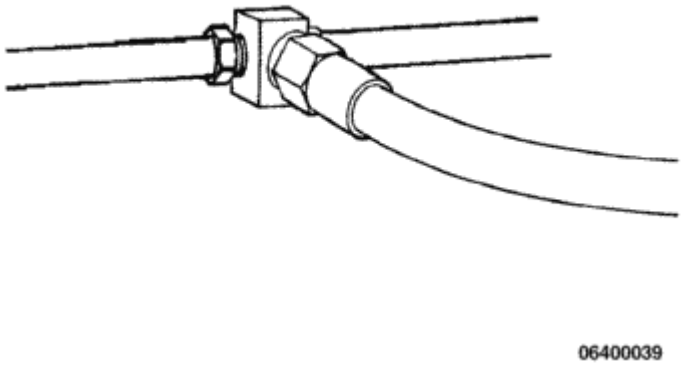
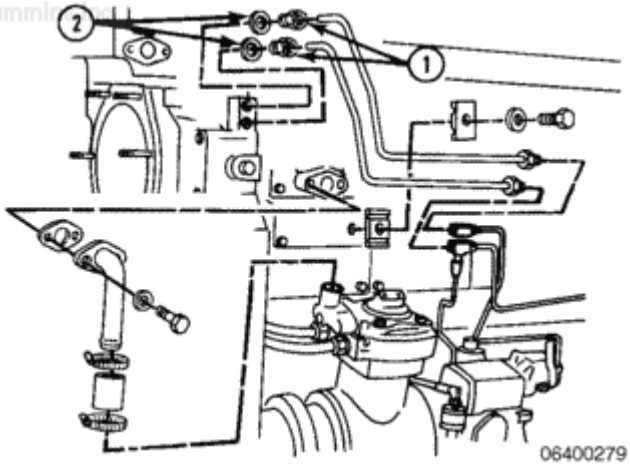


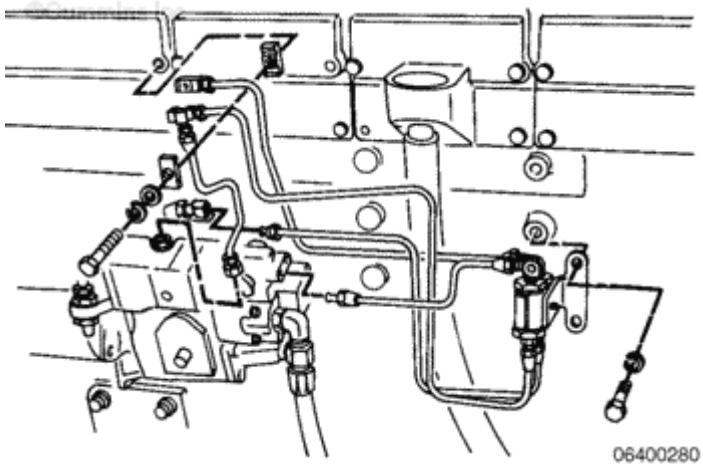
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006-013 Fuel Drain Lines

Remove

Remove the fuel drain hose from the engine.		 06400039
The fuel drain tube connects closest to the top of the fuel manifold. Disconnect the fuel manifold end of the fuel drain tube.		 06400279
Disconnect the fuel pump end of		

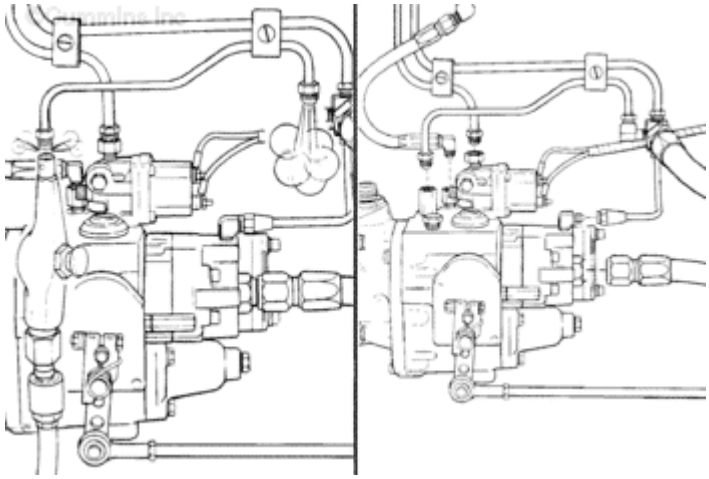
the fuel drain tube.		

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006-051 Injector Supply Lines (High Pressure)

Remove

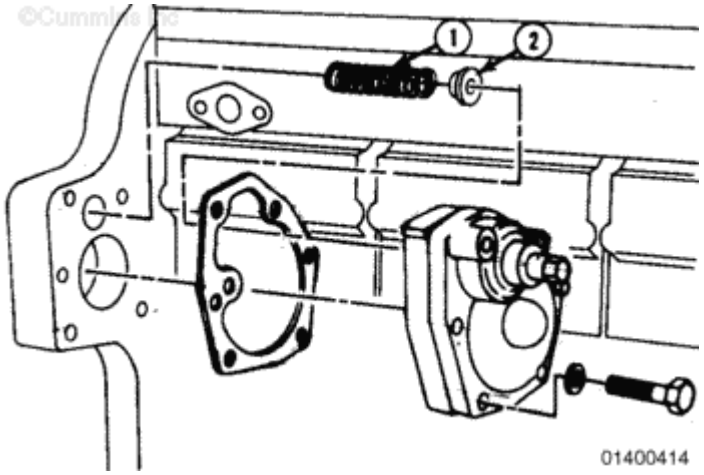
Remove the fuel lines.		

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009-035 Engine Barring Device

Remove

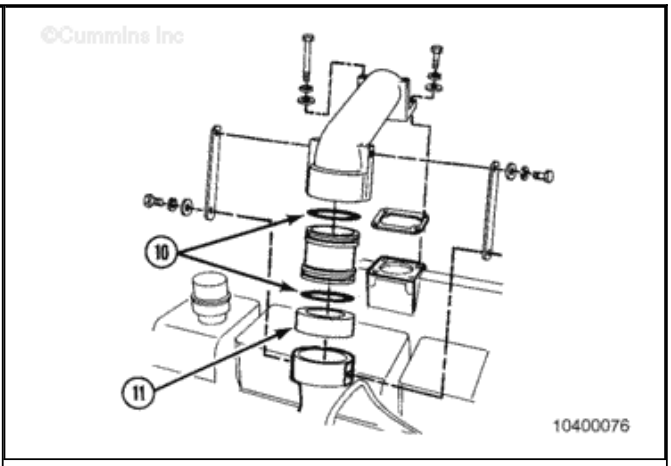
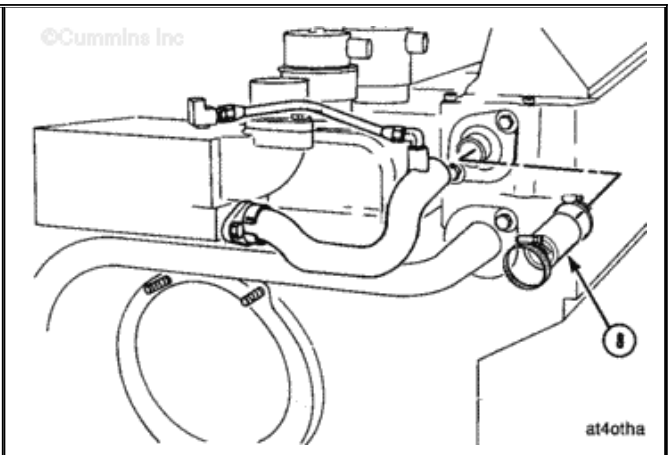
Remove the five mounting capscrews and the barring mechanism. Remove and discard the gasket. Remove the spring guide (2) and the spring (1).		

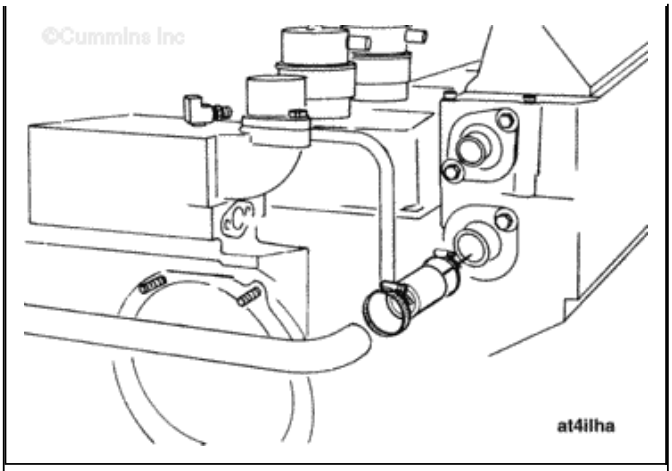
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010-002 Aftercooler Assembly

Remove

Remove the four mounting capscrews at the aftercooler cover. Remove the air crossover (hose connection design). Remove the retainer straps (o-ring connection design shown). Remove the air crossover. Discard the o-rings (10) and the dust seal (11).		
Loosen the two hose clamps and remove the outlet hose (8). Remove the coolant vent tube.		
Loosen the two hose clamps and remove the inlet hose.		



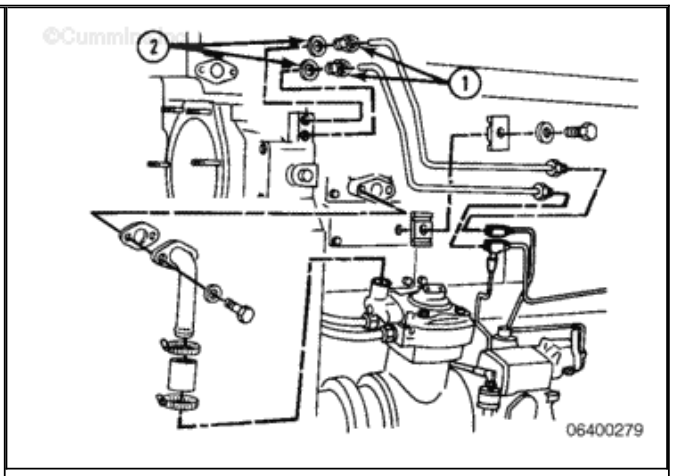
Remove the air compressor air inlet connection.

Remove and discard the hose.

Loosen the fuel tubing nuts at the fuel junction block on the fuel manifold.

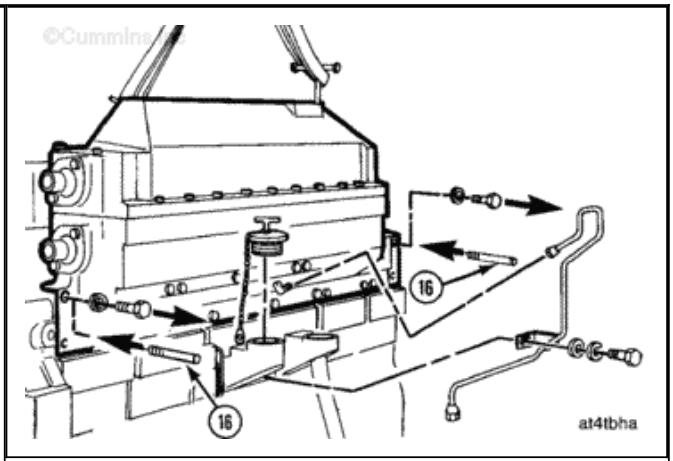
Remove the fuel tubing mounting clamp and the fuel tubes.

Remove and discard the grommets.



Remove AFC tube and oil fill cap.

If the engine contains a crankcase breather in one of the cam follower covers, remove the cam follower cover.



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 two mounting capscrews.

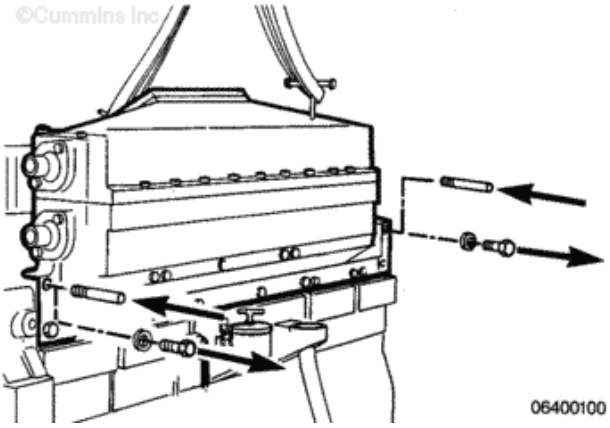
Install two 3/8x16 in guide studs.

Attach two tee handles to the aftercooler housing.

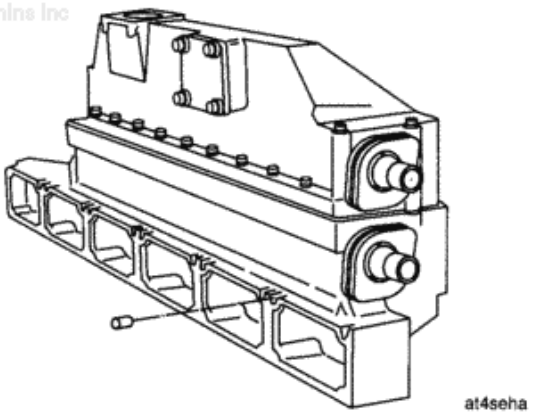
Attach the sling and hoist and raise the hoist until there is tension on the sling.

Remove the remaining capscrews and aftercooler assembly.

Remove and discard the gaskets.



Remove and discard the aftercooler bolt seals from the aftercooler housing.

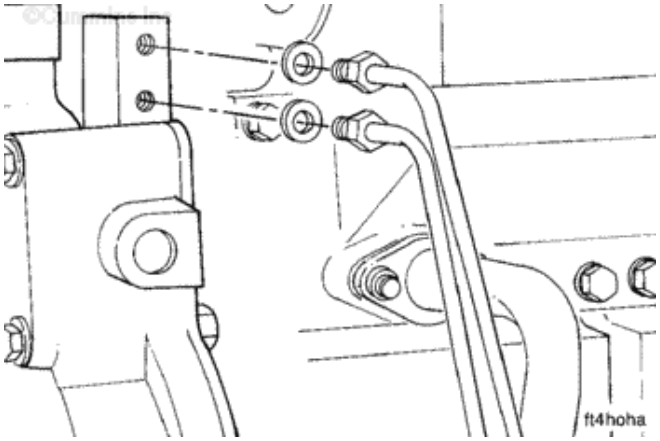
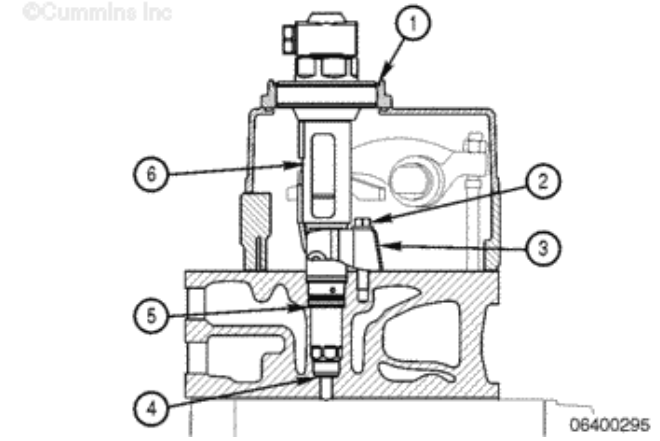


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006-022 Fuel Manifold (Supply)

Remove

Disconnect the fuel lines at the fuel block. It will possibly be necessary to remove the tube clamp at the cam follower cover to enable the tubes to be pulled out of the fuel block.		
Remove the fuel manifold. Remove the 12 o-rings. Discard the o-rings.		

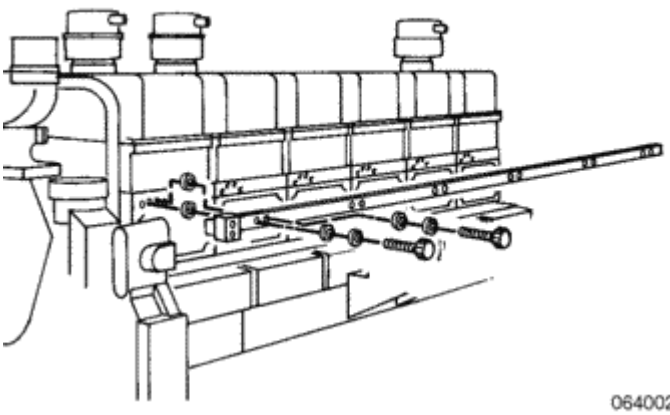
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006-038 STC Oil Manifold

Remove

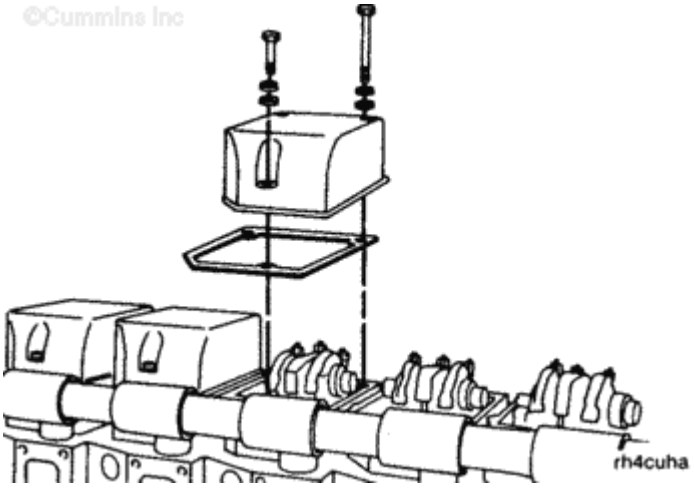
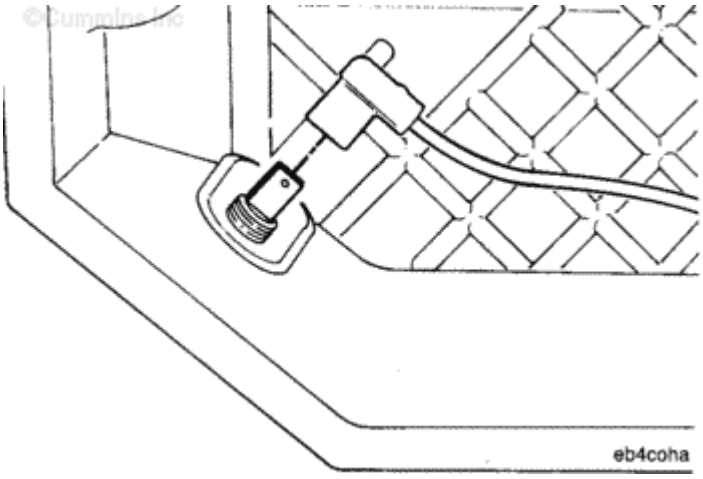
Remove the STC oil manifold capscrews. Remove the STC oil manifold. Remove and discard the o-rings.		

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003-011 Rocker Lever Cover

Remove

Crankcase breathers can be mounted in any cylinder location. Record the number of breathers and their location, before removing. Remove the rocker lever cover capscrews. Remove the rocker lever cover and gasket. Discard the gasket.		
Disconnect the solenoid wire from inside the cover on engines equipped with an engine brake.		

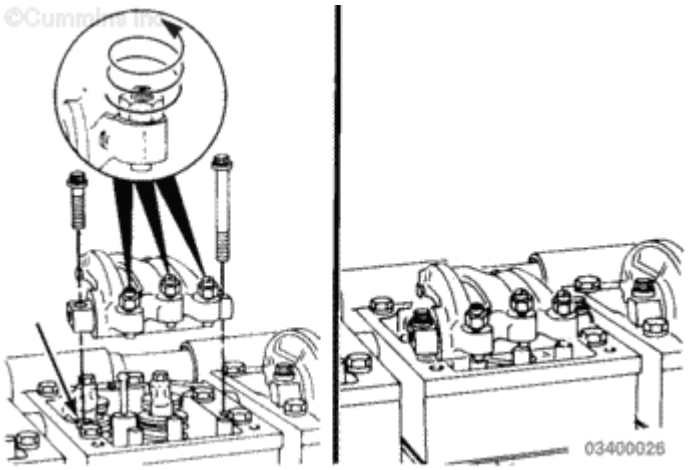
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003-009 Rocker Lever Assembly

Remove

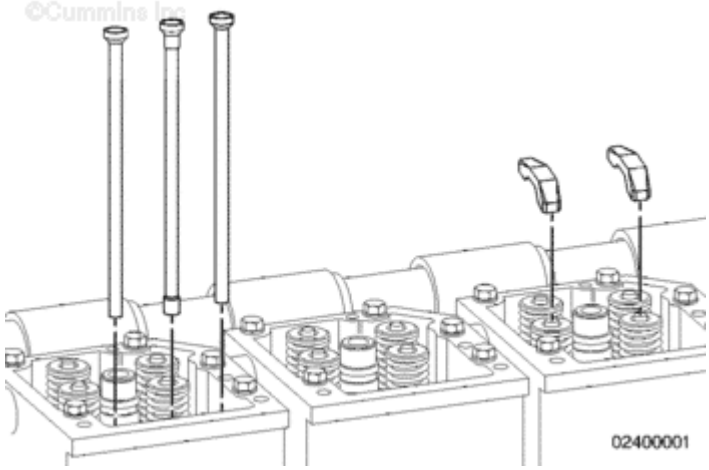
Do **not** allow the rocker levers to fall off the shaft during removal. Remove the two capscrews. Remove the rocker lever assemblies.		

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004-014 Push Rods or Tubes

Remove

Mark the push rods, so they can be installed in their original position. Remove the push rods and crossheads.		

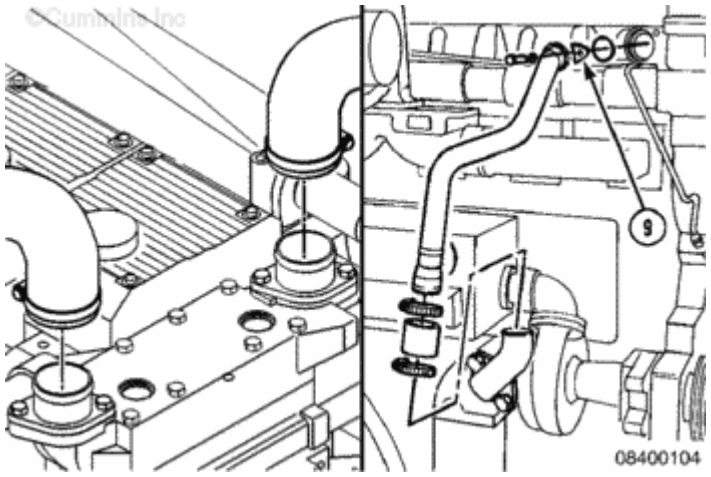
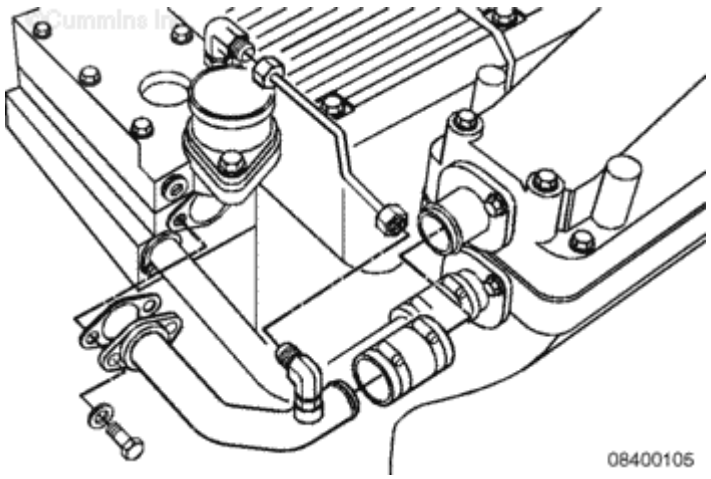
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008-015 Coolant Thermostat Housing Support

Remove

Aftercooled Engines

Remove both upper radiator hoses from the thermostat housing. Remove the bypass tube clip (9). Loosen both bypass tube hose clamps. Remove the bypass tube.		
Remove the aftercooler coolant return tube, aftercooler coolant supply tube, gasket, and hoses from the thermostat housing support.		

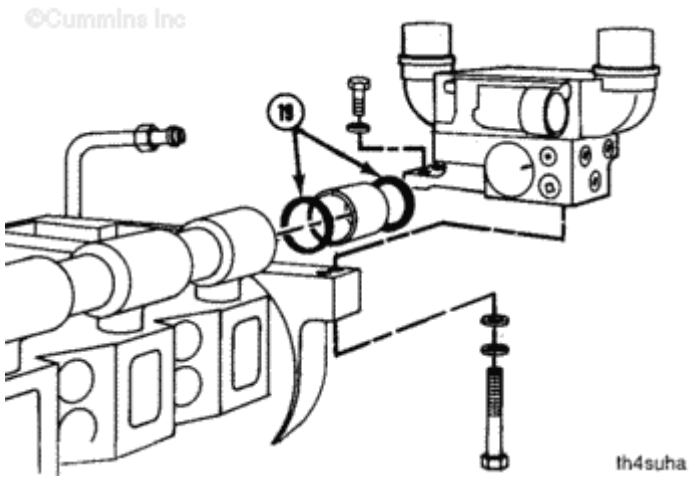
If the engine is equipped with an air compressor, disconnect the air compressor water outlet tube from the thermostat housing.

Disconnect the coolant temperature sensor wire.

Remove the four mounting capscrews and thermostat housing assembly.

Remove the water transfer tube.

Remove and discard the two o-rings (19).

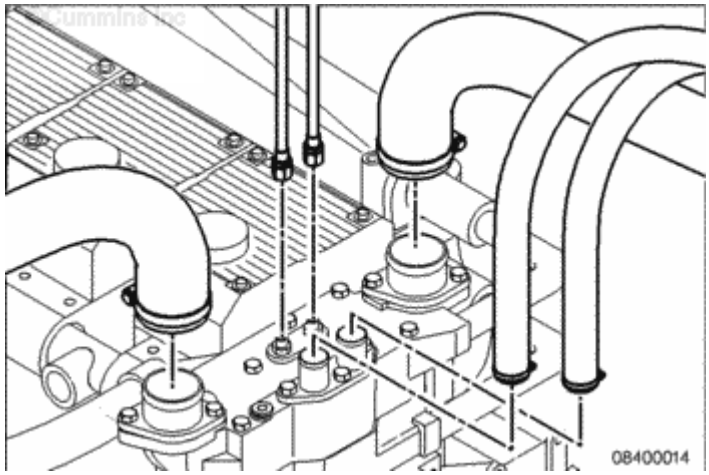


LTA

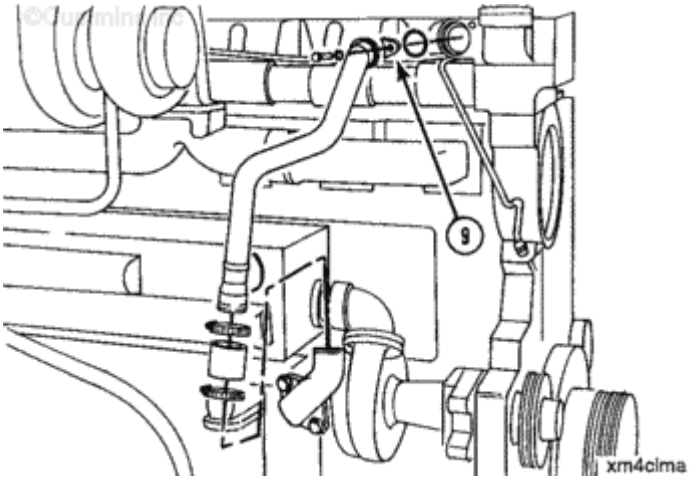
Remove both of the upper radiator hoses from the thermostat housing.

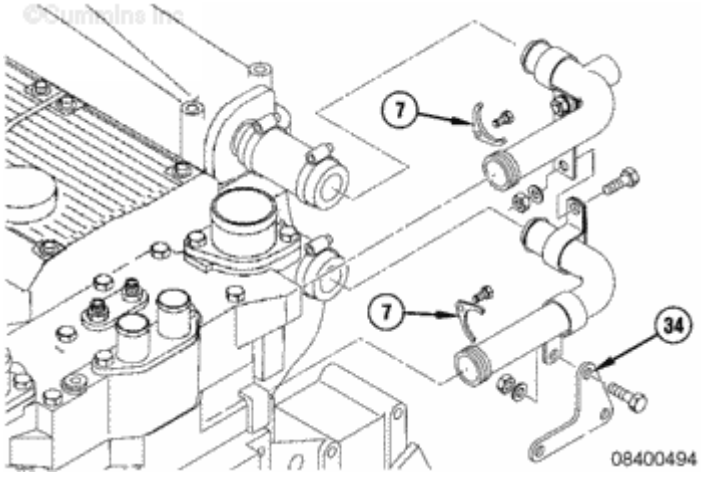
Remove both of the upper low temperature aftercooling radiator hoses from the thermostat housing.

Remove both of the vent hoses

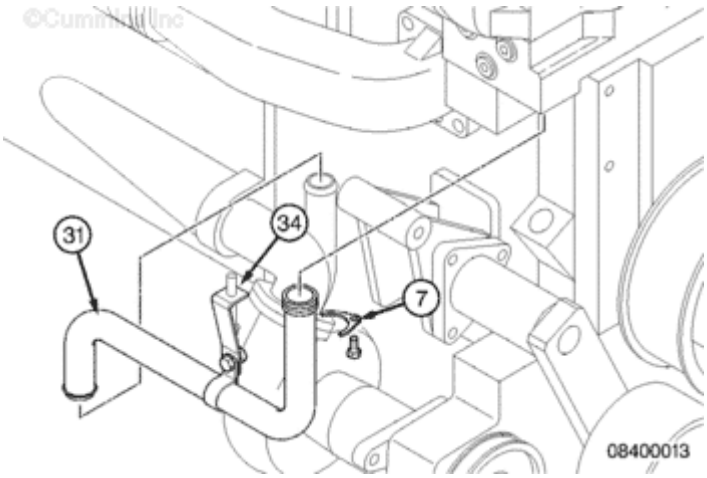


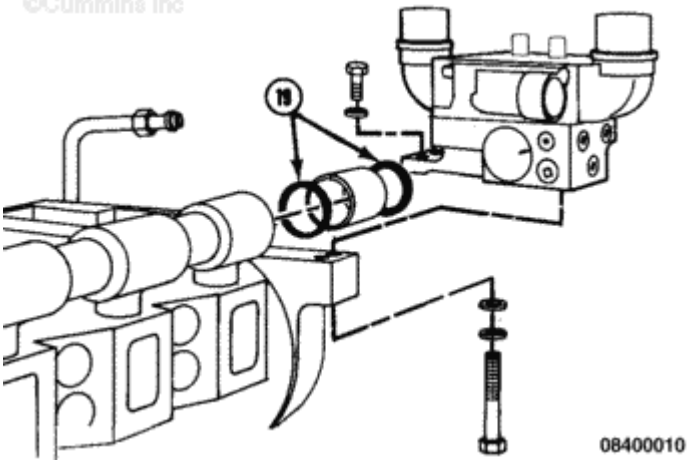
from the thermostat housing.		

Remove the bypass tube hold down clamp (9). Loosen both hose clamps. Remove the bypass tube, hose and water connection.		

Remove the water inlet and outlet tube clips (7). Loosen the hose clamps. Remove the aftercooler water tube support bracket (34). Remove the aftercooler water tubes. Remove and discard the o-rings.		

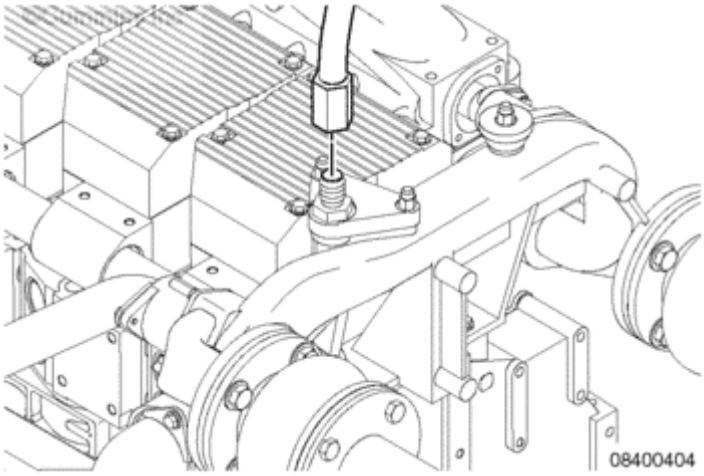
Remove the aftercooler water supply tube clip (7).		

Loosen the hose clamps. Remove the support bracket (34). Remove the tube (31). Remove and discard the o-ring.		

Remove the four thermostat housing mounting capscrews. Remove the thermostat housing assembly. Remove the water transfer tube. Remove and discard the two o-rings (19).		

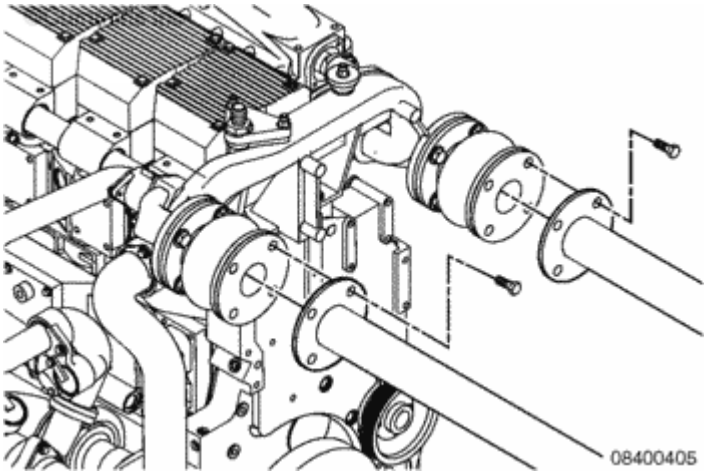
Marine Applications

Disconnect the supply and vent hoses.		



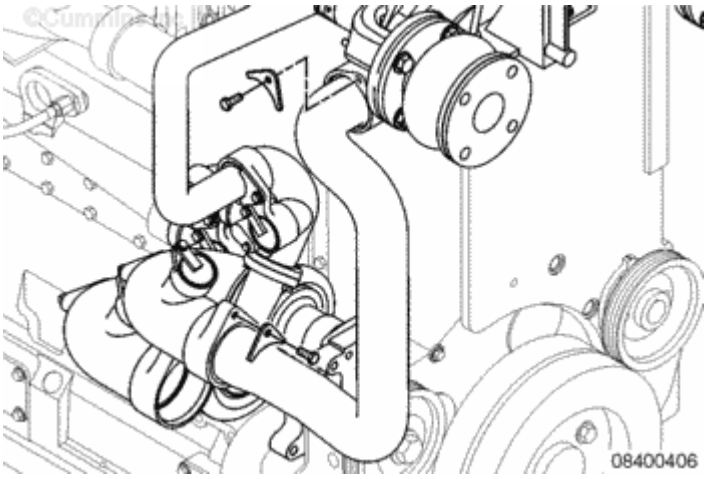
Disconnect the keel cooler supply and return pipes.

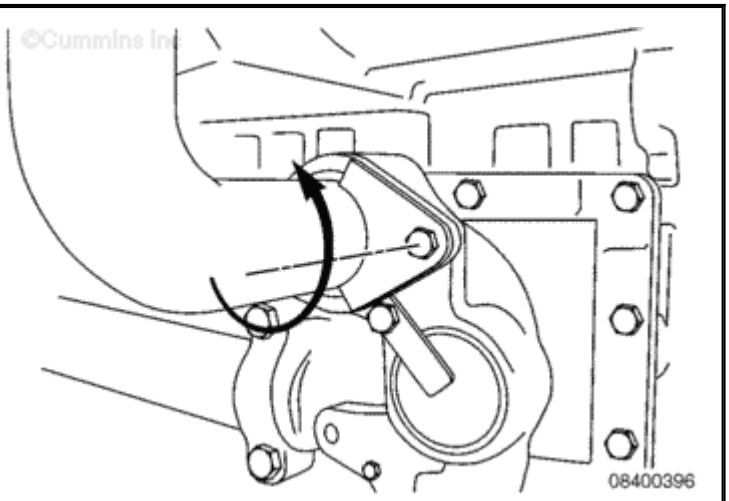
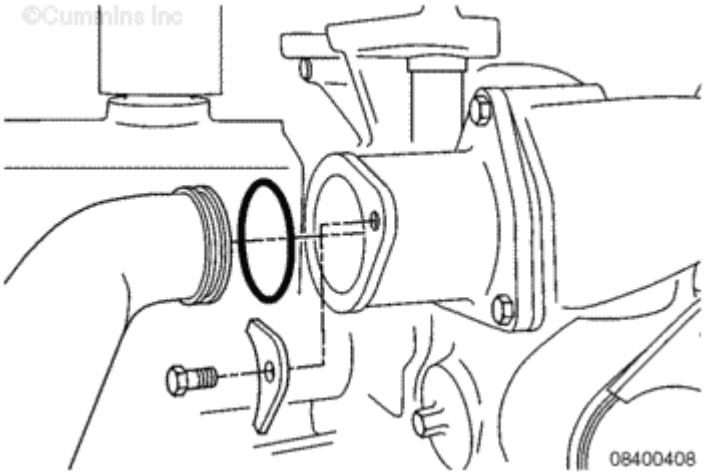
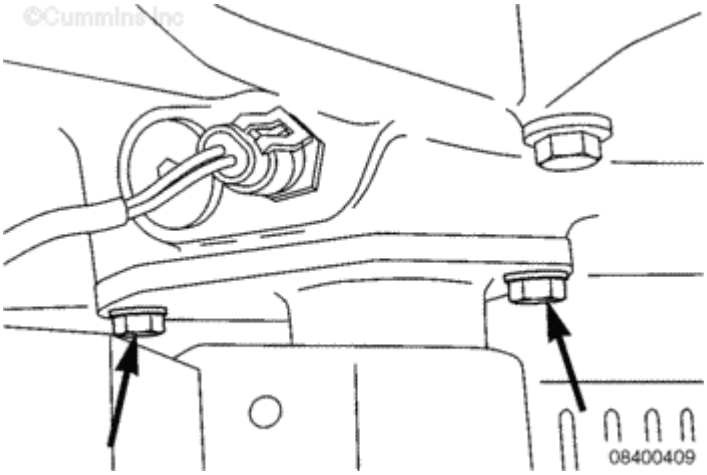
Remove the flexible connections if necessary.

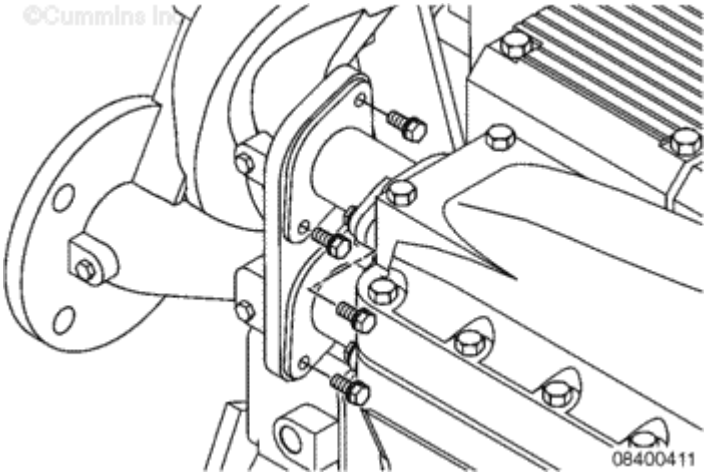


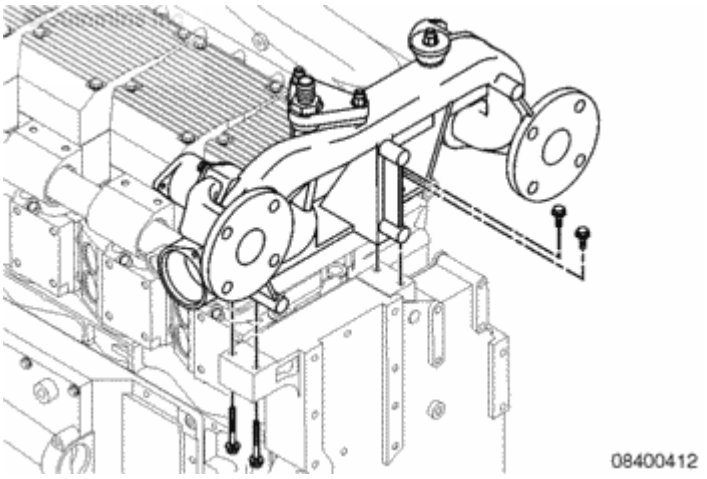
Remove the retaining clips from the water pump inlet pipe at the water pump and at the thermostat housing.

Remove the water pump inlet pipe.



Loosen the retaining clip on the lower end of the LTA supply pipe.		
Remove the retaining clip at the thermostat housing and pull the LTA supply pipe out of the thermostat housing. The pipe will rotate around the lower end.		
Remove the two capscrews holding the water rail flange to the thermostat housing. Discard the o-ring.		

Remove the four capscrews from the aftercooler supply and return tubes. Discard the o-rings.		

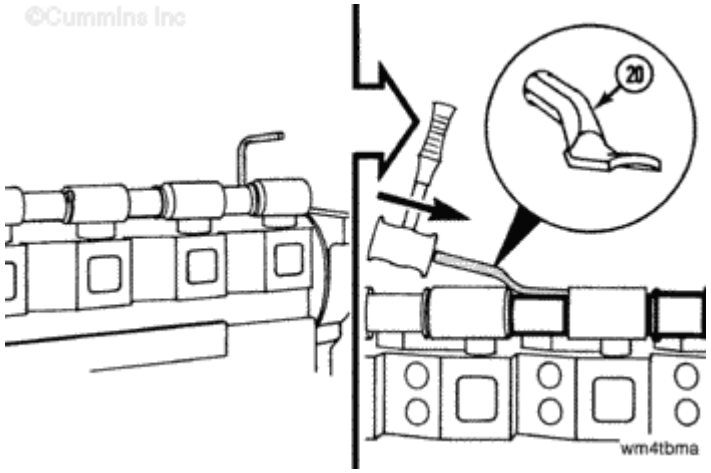
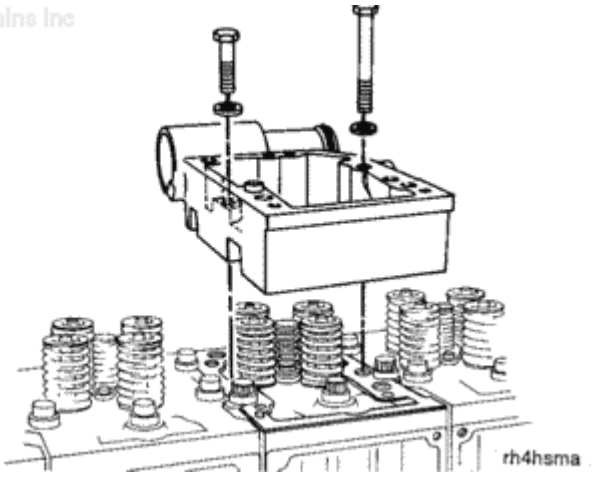
Remove the four capscrews holding the thermostat housing to the gear cover. Remove the thermostat housing.		

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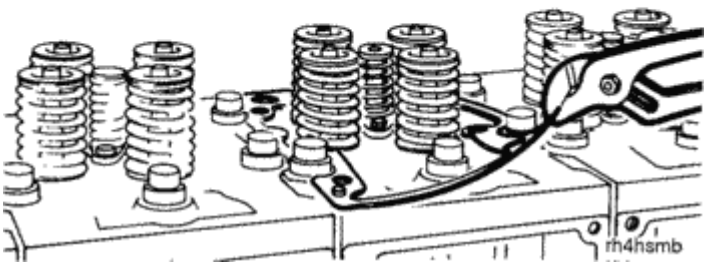
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003-013 Rocker Lever Housing

Remove

Using a hammer and water tube driver (20), Part Number ST-1319, drive the water tube toward the front of the engine until the back part of the tube clears the rocker lever housing.		
Some rocker lever housings have brackets, lifting eyes, and supports installed on the side of the housing. Record the location of the components so they can be installed in the correct location. Remove the seven rocker lever housing mounting capscrews. Remove the		

rocker lever housing.		

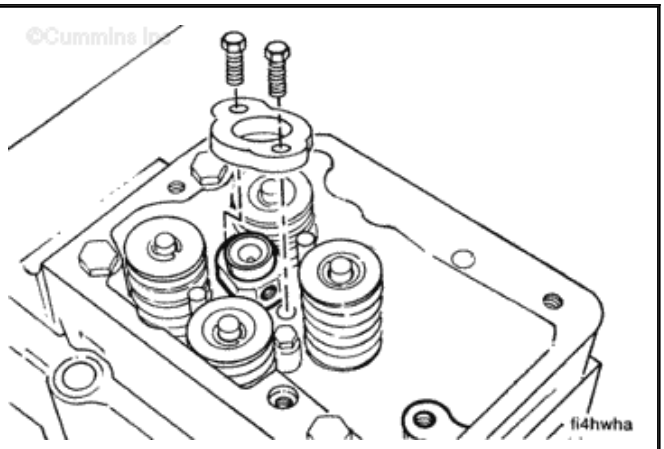
Remove and discard the rocker lever housing gasket.		

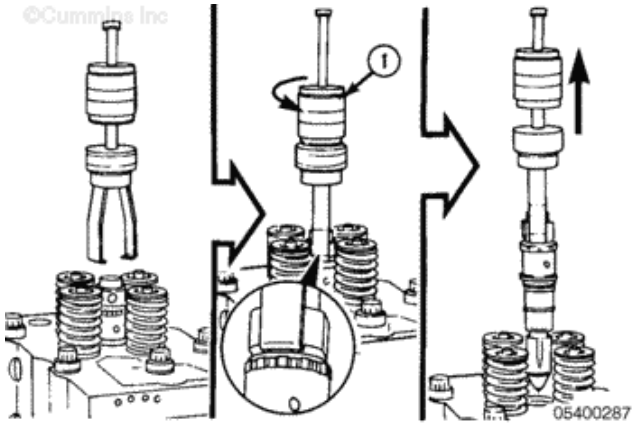
Last Modified: 28-Jun-2013

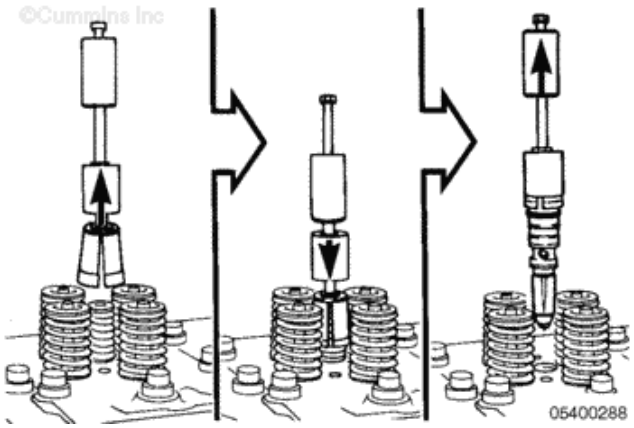
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006-026 Injector

Remove

Remove the injector hold down clamp capscrews. Remove the injector hold down clamp.		

CAUTION Do not allow the STC tappet to fall out of the injector, engine damage can result. **NOTE: The rocker housing has been removed from the illustration for clarity.** For top stop injectors, use injector puller, Part Number 3376497. Make sure the puller arms are firmly under the top stop screw. Tighten the clamping ring (1). Use the slide hammer to remove the injector.		

For standard injector injectors use puller, Part Number 3376000 or 3376497. Place the split collar over the injector. Slide the locking collar over the split collar. Use the slide hammer to remove the injector.		

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002-004 Cylinder Head

Remove

WARNING

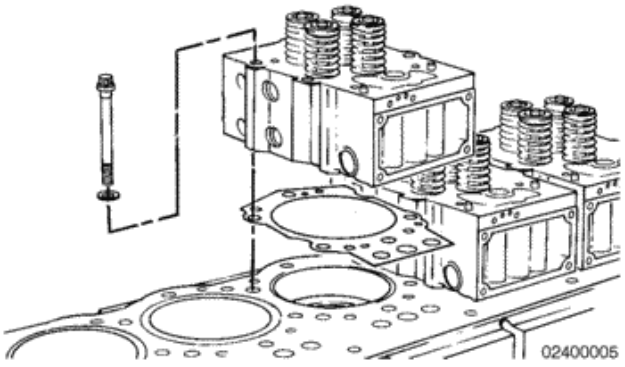
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Remove the six cylinder head capscrews.

Remove the cylinder head and the gasket.

Record the cylinder head gasket part number to determine if the gasket has standard or oversized thickness.

Discard the gasket.

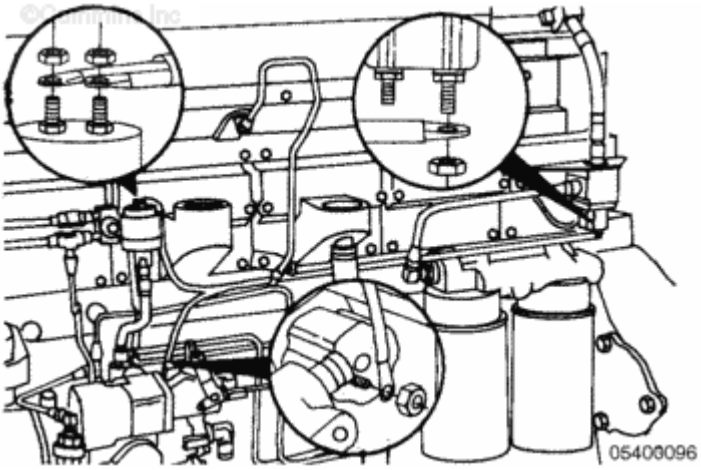


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006-042 STC Wiring Harness

Remove

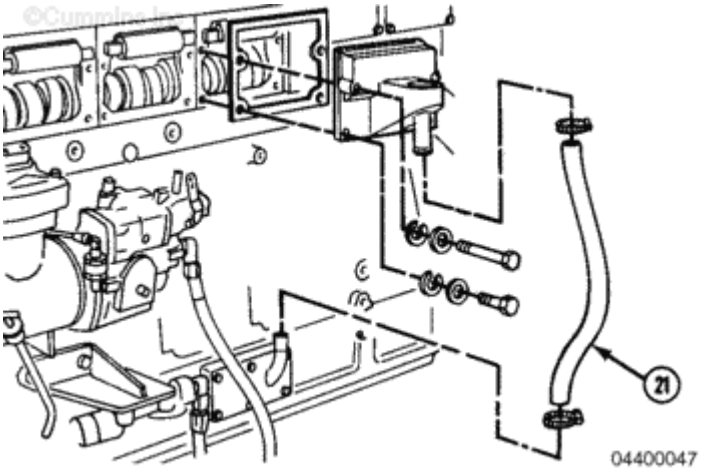
Place tags on all of the STC wiring harness wires to identify mounting locations. Remove the wiring harness.		

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004-002 Cam Follower Cover

Remove

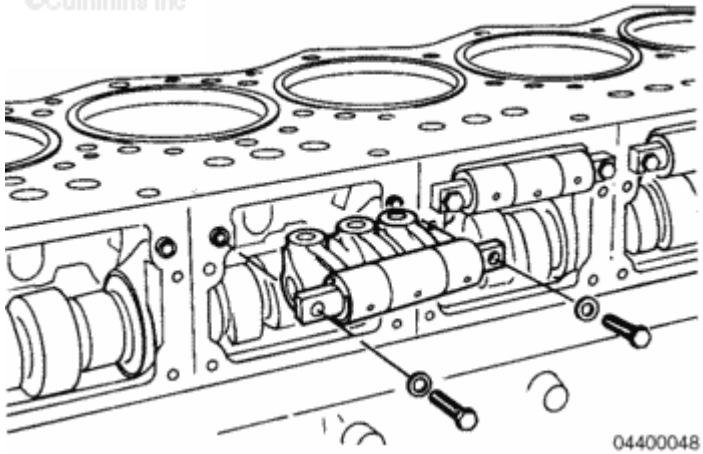
NOTE: Some camshaft follower covers can not be removed until other parts, such as the wiring harness, fuel tubing, ant the crankcase vent hose (21) are removed. Remove the camshaftshaft follower cover capscrews. Remove the camshaft follower cover. Remove and discard the gasket.		

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004-001 Cam Follower Assembly

Remove

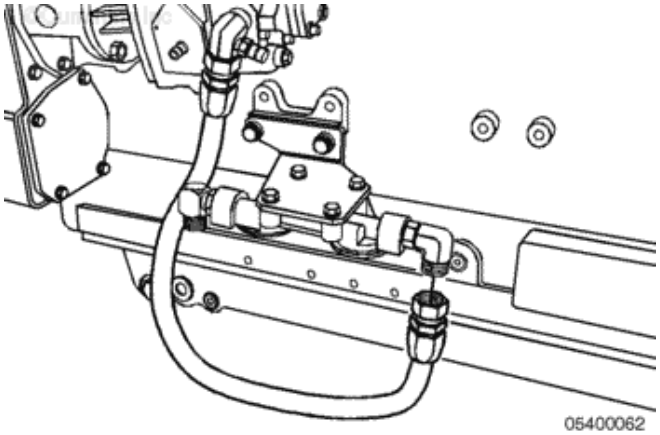
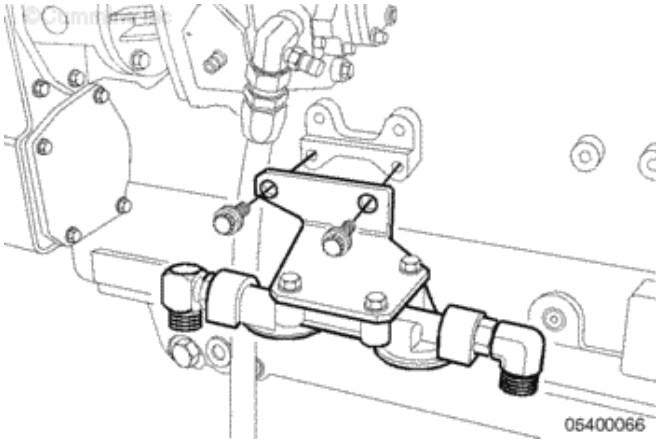
The cam follower assembly capscrews are a special slotted design. Remove the cam follower assembly mounting capscrews and tag them for future identification. Pull the cam follower assembly straight out until the shaft is off of the ring dowels.		

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006-017 Fuel Filter Head

Remove

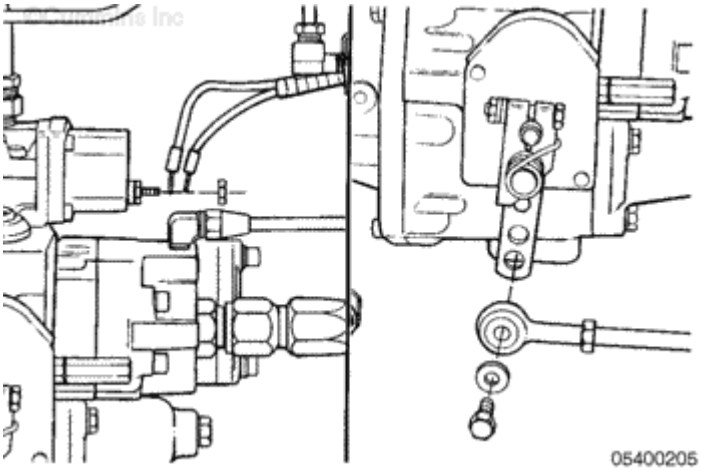
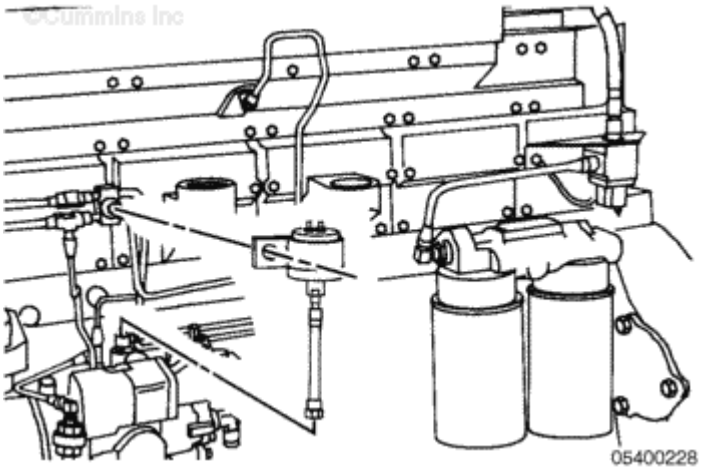
Disconnect the fuel line from the fuel filter head.		
Remove the two mounting capscrews. Remove the fuel filter head.		

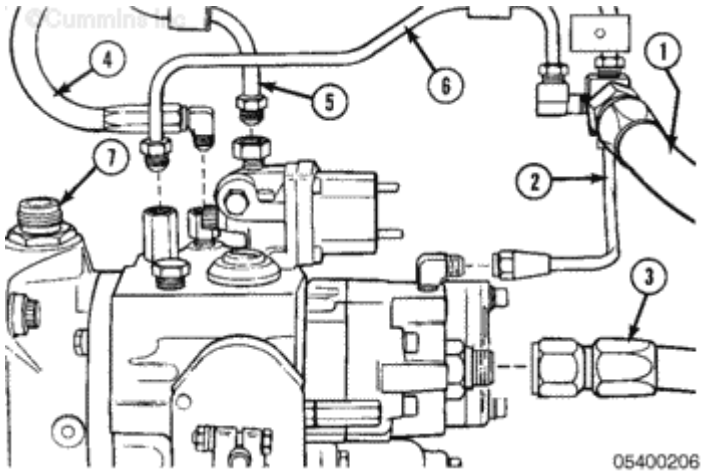
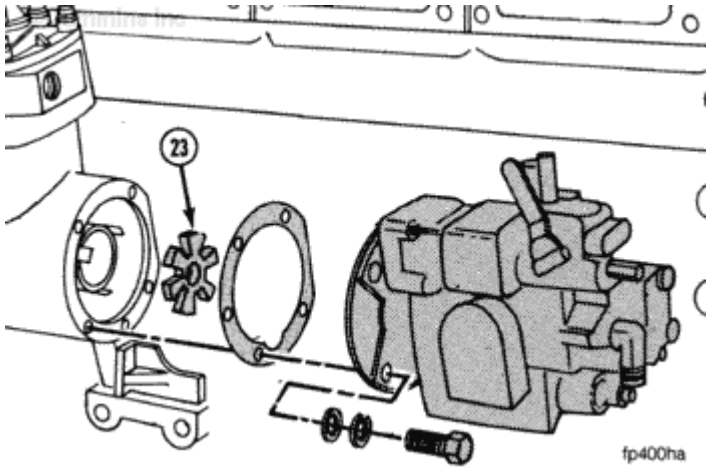
Last Modified: 04-Nov-2004

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005-016 Fuel Pump

Remove

Remove the wire to the fuel shutoff valve. Remove the linkage from the throttle lever.		
NOTE: This step applies only to engines equipped with STC. Remove the STC fuel rail switch.		
Remove the below listed		

items: • Fuel drain (1) • Gear pump cooling drain (2) • Gear pump suction line (3) • AFC fuel drain (4) • Fuel supply to injectors (5) • AFC supply hose (6) • Tachometer cable (7).		
Remove the four fuel pump mounting capscrews. Remove the fuel pump. Remove the drive coupling (23). Remove and discard the gasket.		

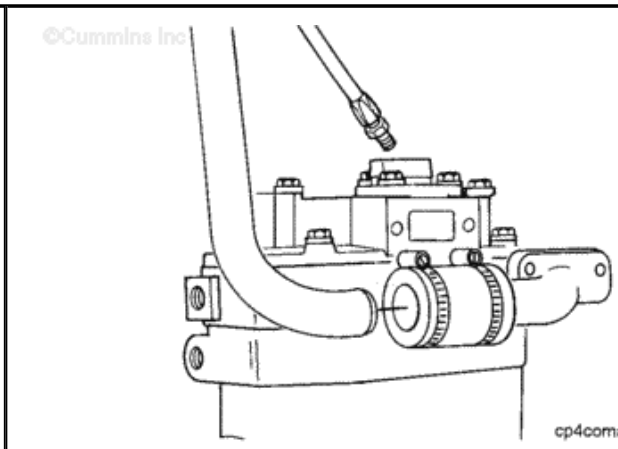
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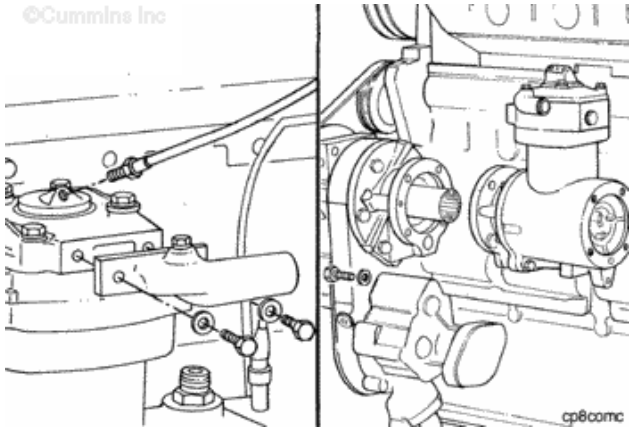
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012-014 Air Compressor

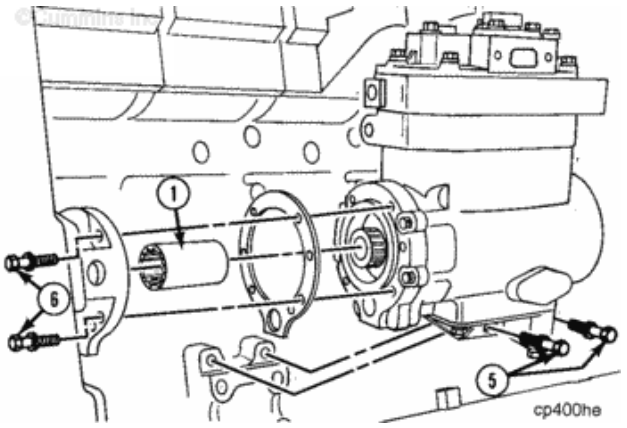
Remove

Single Cylinder

Remove the air inlet and outlet connections from the air compressor.		

WARNING This component or assembly weighs greater than 23 kg [50 lbs]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly. Remove the air connections from the air compressor. Remove the air compressor support bracket and capscrews. Remove the four capscrews, the air compressor, and splined coupling.		

Twin Cylinder

Remove the air compressor support mounting capscrews (5). Remove the four capscrews (6). Remove the air compressor. Remove the splined coupling (1). Remove and discard the gasket. It a two-piece bracket is used, remove the bolts and nuts securing the brackets together. Remove the bracket from the compressor and the bracket from the block.		

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009-004 Accessory Drive Pulley

Remove

CAUTION

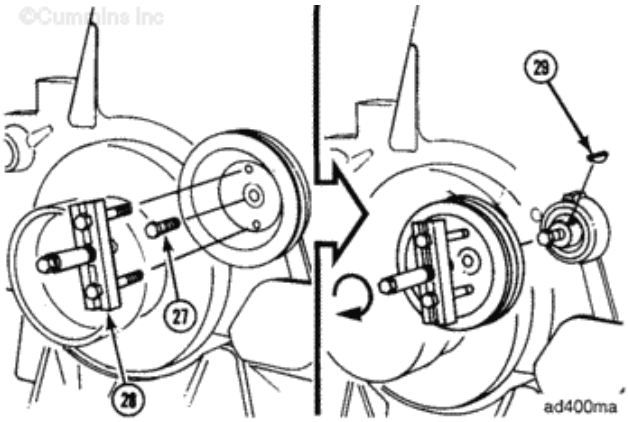
To reduce the possibility of damage to the shaft, make sure a capscrew in the shaft.

Install a 7/16-20 x 1 inch capscrew (27) in the shaft.

Remove the accessory drive pulley with standard puller, Part Number ST-647, or equivalent (28).

Remove the woodruff key (29) from the shaft with a brass drift.

Remove the capscrew from the shaft.



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009-011 Fuel Pump Drive

Remove

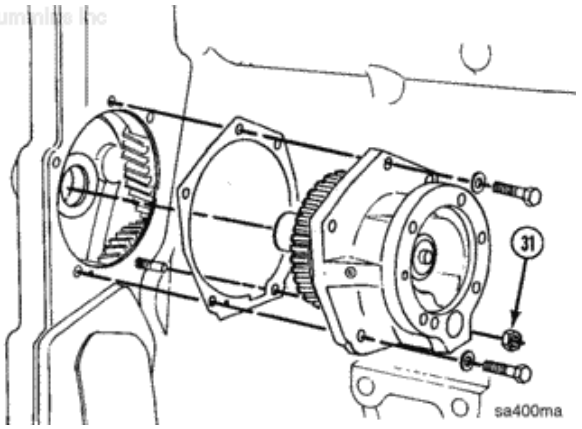
CAUTION

The woodruff key must be removed before removing the fuel pump drive assembly. The bushing will be damaged if the woodruff key is not removed.

Remove the woodruff key.

Remove the four capscrews and nut (31).

Remove the fuel pump drive assembly.

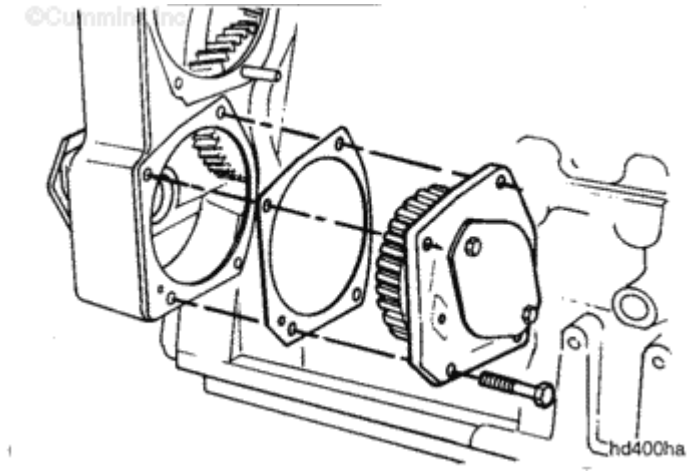


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009-016 Hydraulic Pump Drive

Remove

Remove the four hydraulic pump drive mounting capscrews. Remove the hydraulic pump drive. Remove and discard the gasket.		

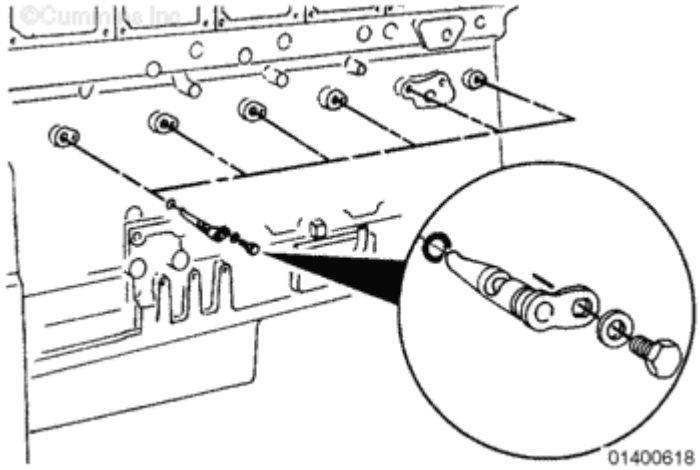
Last Modified: 01-Dec-2004

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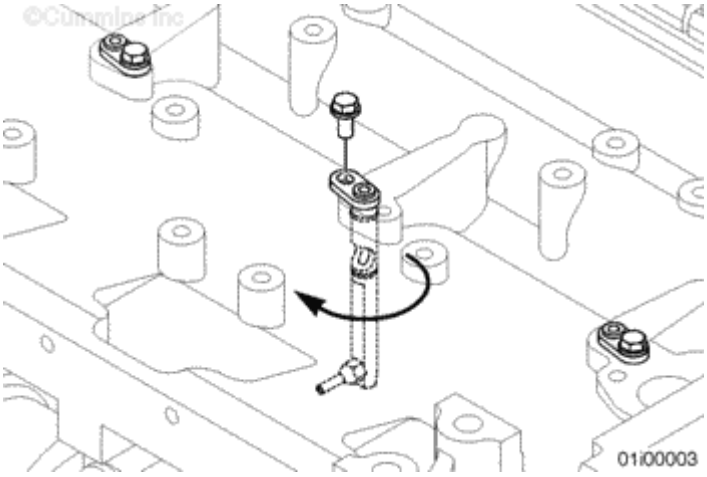
001-046 Piston Cooling Nozzle

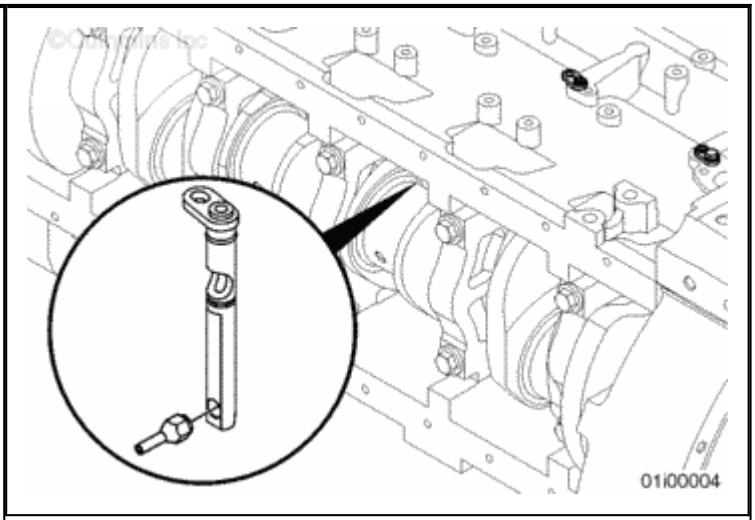
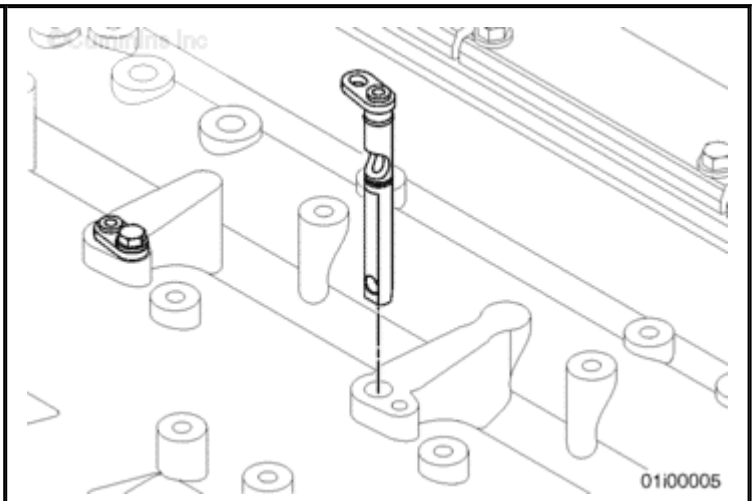
Remove

One Piece Design, All Applications

Remove the piston cooling nozzle capscrew. Remove the piston cooling nozzle.		

Two Piece Design, All Applications

Remove the piston cooling nozzle capscrew. Rotate the nozzle body so the tip points toward the oil pan.		

Remove the piston cooling nozzle tip.		
Remove the piston cooling nozzle body.		

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001-052 Vibration Damper, Viscous

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.

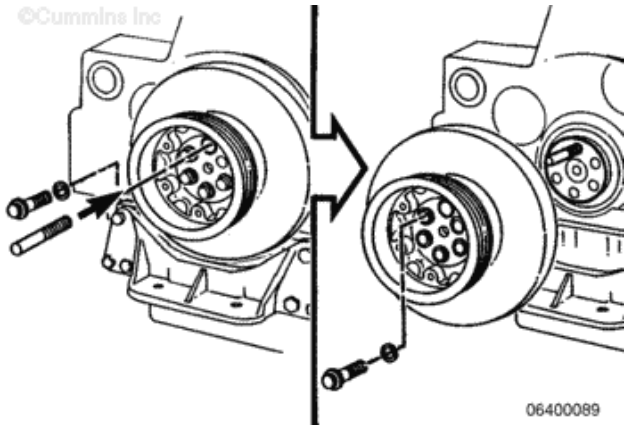
CAUTION

Do not pry or hammer on the vibration damper. Damage to the vibration damper can result.

Remove one capscrew and install a [3/4-16x5 in] guide stud.

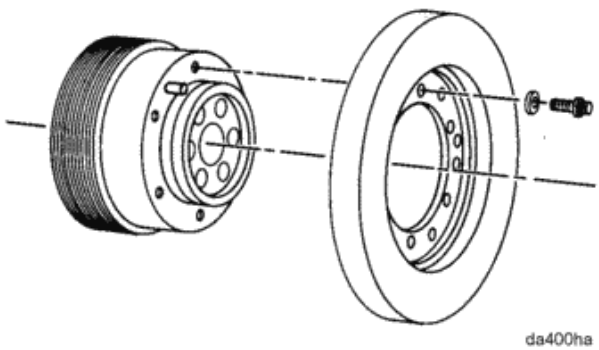
Remove the remaining capscrews from the vibration damper.

Remove the guide stud.



NOTE: Engines that do not have a belt driven fan hub have an adapter instead of a pulley.

Remove the pulley from the vibration damper.



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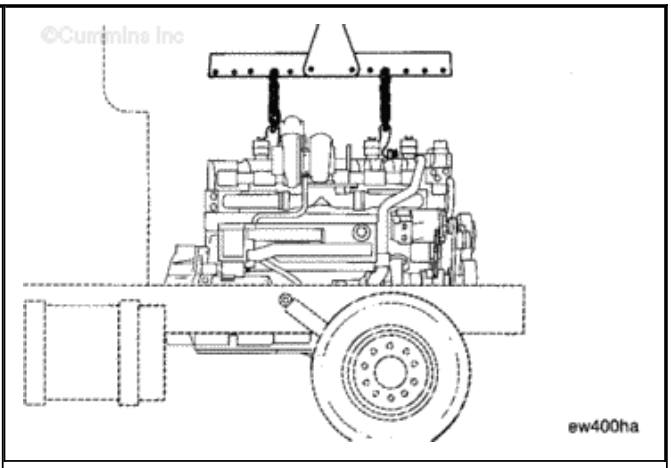
016-002 Engine Support Bracket, Front

Remove

WARNING

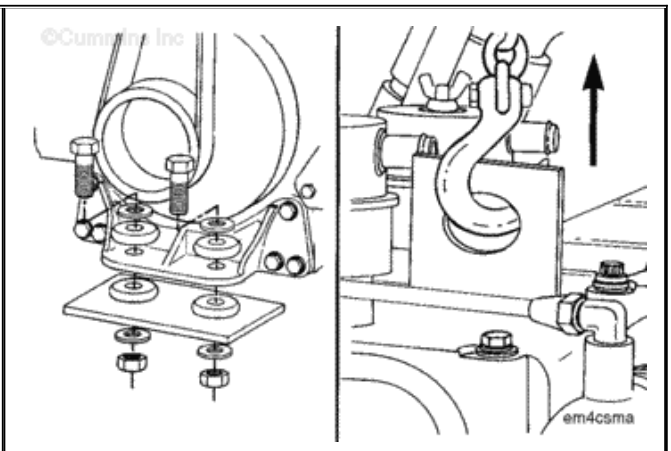
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component.

Install engine lifting fixture, Part Number 3822512.



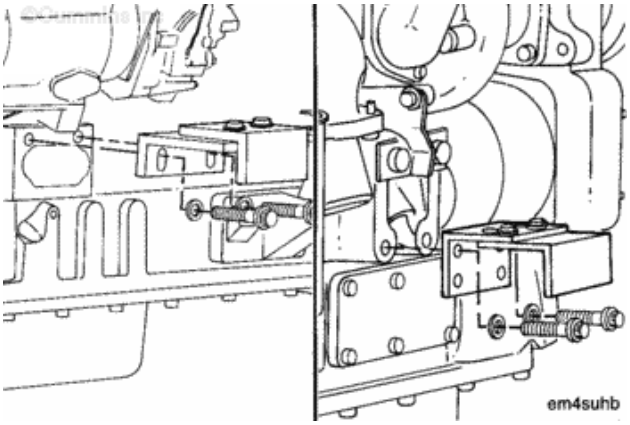
Remove the two capscrews that attach the support to the equipment frame.

Use a hoist to lift the weight of the engine off the front support.

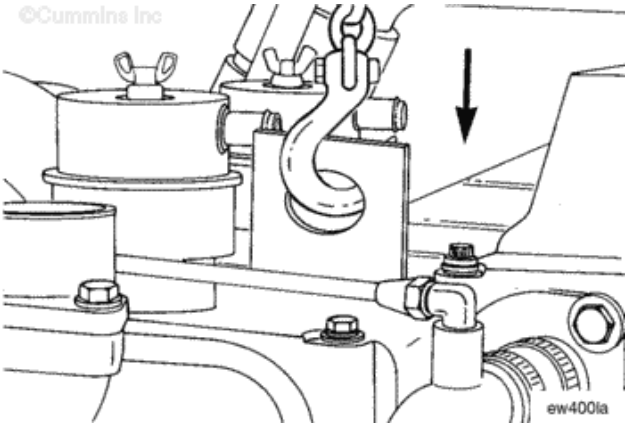


Use the engine support bracket kit, Part Number 3375272.

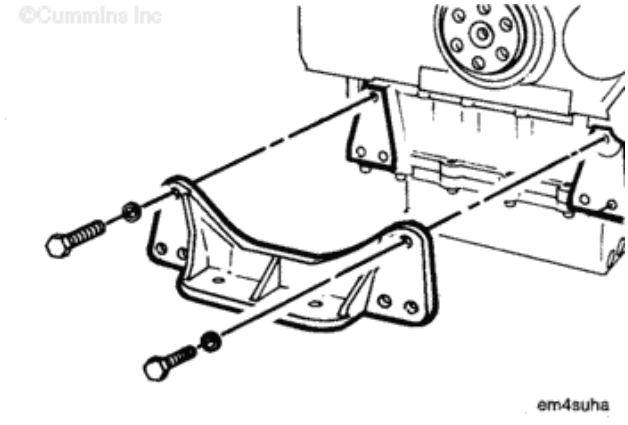
Install one bracket on each side of the engine.



Lower the engine until the brackets are supporting the weight.



Remove the front engine support.



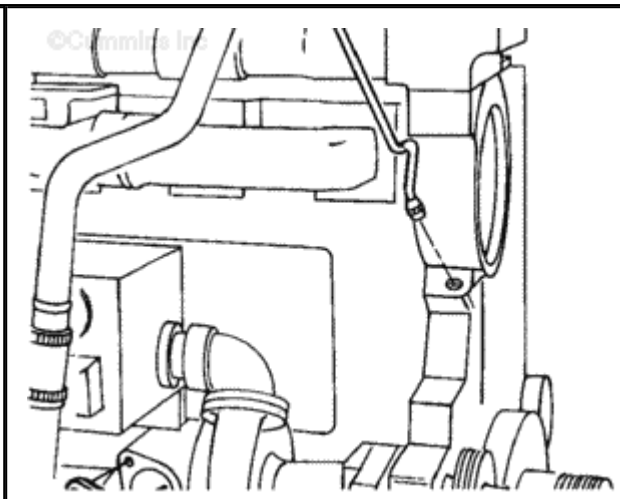
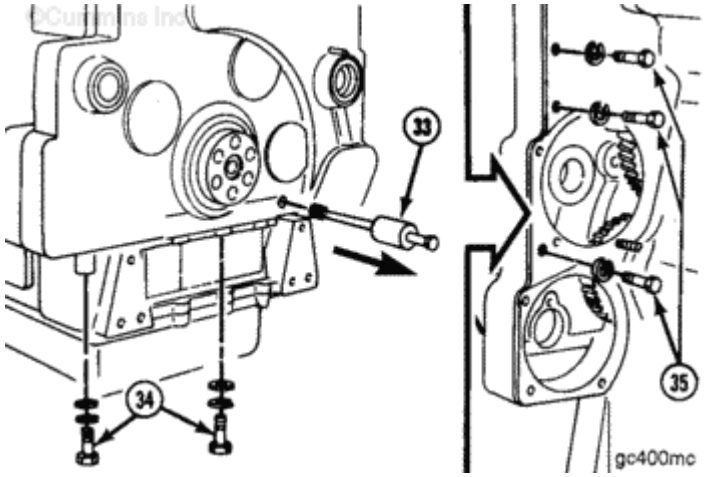
Last Modified: 28-Jul-2006

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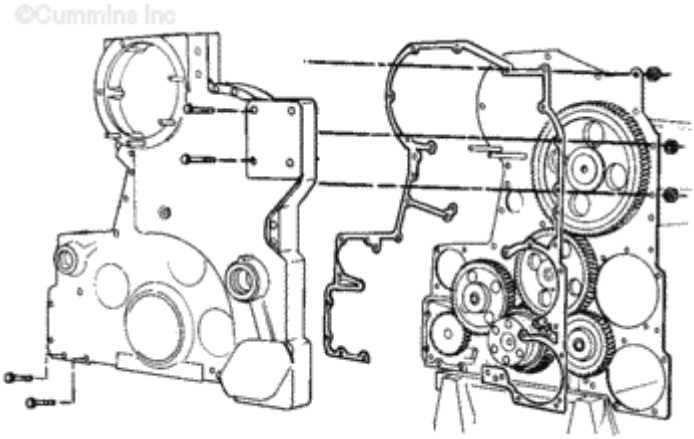
001-031 Gear Cover, Front

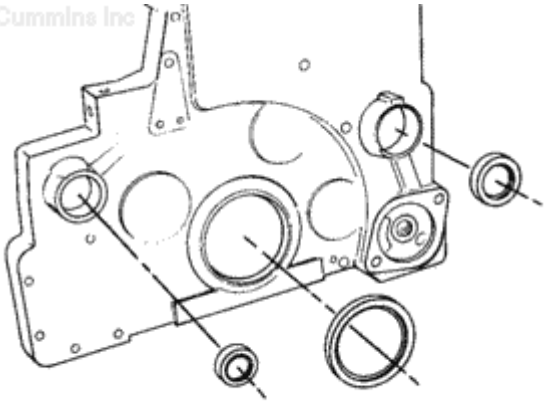
Remove

One Piece Design, All Applications

Disconnect the turbocharger oil supply line from the front cover.		
The master dowel **must** be removed before the gear cover can be removed. Use a slide hammer (33) or a 5/16-18 inch capscrew or threaded rod and an old piston pin to remove the dowel. The front cover contains five capscrews on the		

bottom (34) and three capscrew on the back (35). Remove the bottom capscrews (34) and the back capscrews (35).		

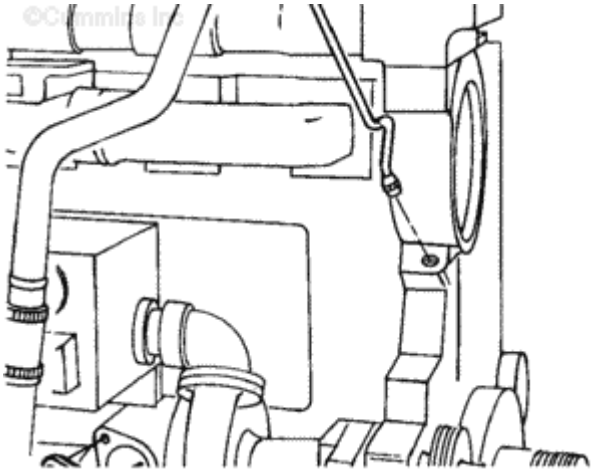
Remove the 15 capscrews located in the front of the front cover. Remove the front cover and gasket. Discard the gasket.		

Remove the oil seals with a mandrel or drift and a mallet.		

Two Piece Design, All Applications

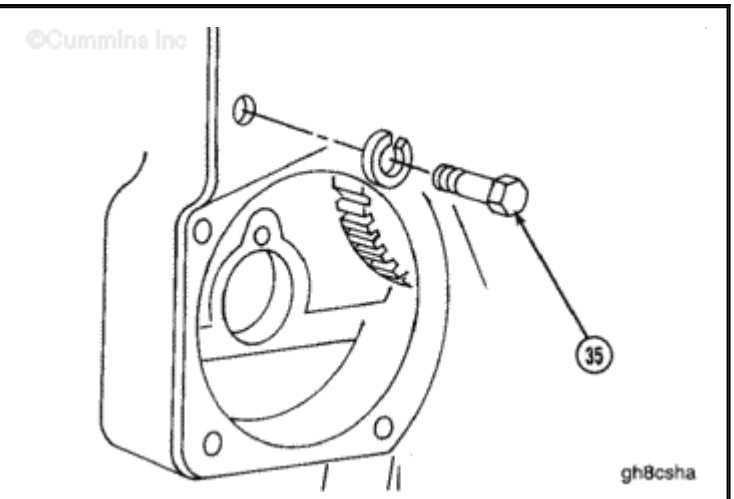
Disconnect the turbocharger oil		

supply line from the front cover.



There is one capscrew that **must** be removed from the back of the housing.

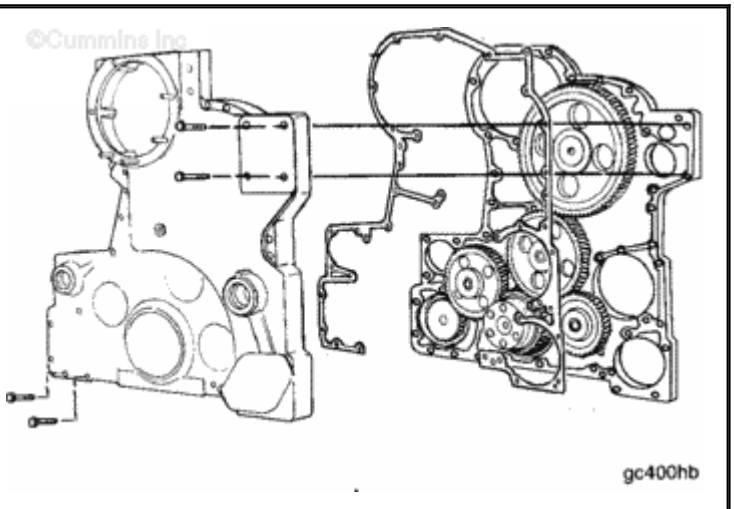
Remove the capscrew (35).

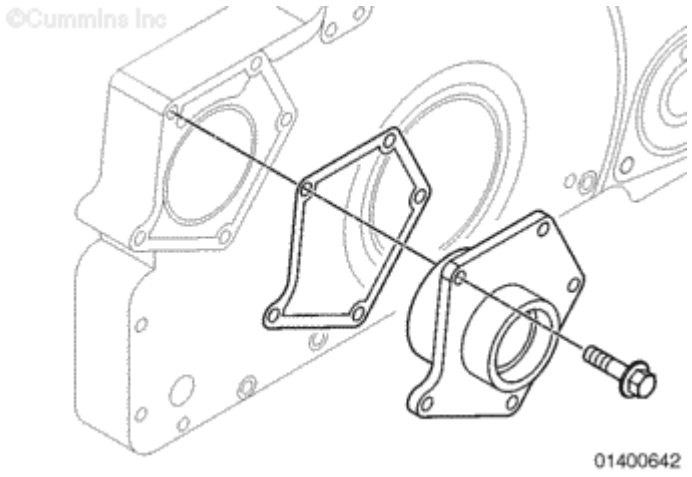


Remove the 18 capscrews from the front cover.

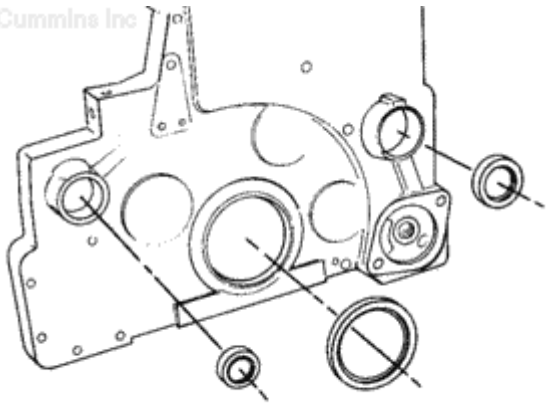
Remove the front cover and gasket.

Discard the gasket.



NOTE: It is not necessary to remove the alternator support from the gear cover unless the gasket is leaking. It is not necessary to remove the alternator support to replace the bushing or seal. Some alternator supports are slightly larger than the machined area of the front gear cover. These supports **must** be frozen prior to installation into the cover. Do **not** attempt to drive the cover into place or both parts will be damaged beyond reuse. If needed, remove the five capscrews, the support, and the gasket from the cover.		

Use a mandrel and drift to remove the oil seals from the front cover and/or alternator drive support.		



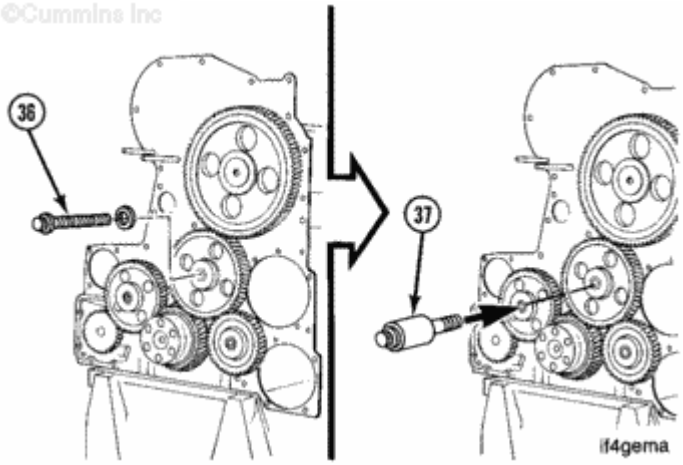
Last Modified: 07-Dec-2004

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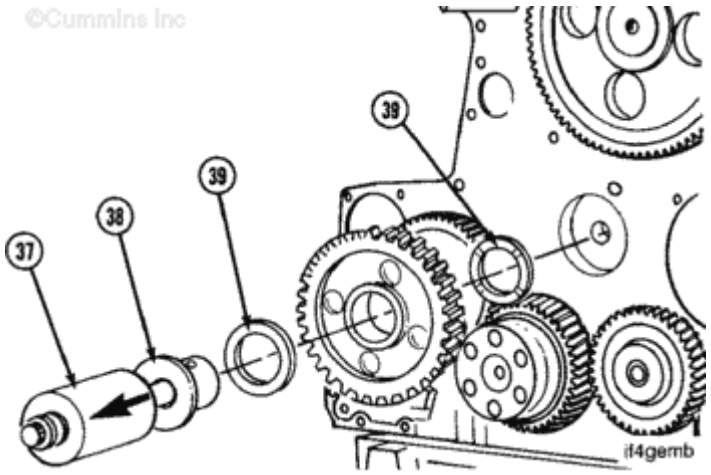
001-036 Idler Gear, Camshaft

Remove

Bolt-On Type

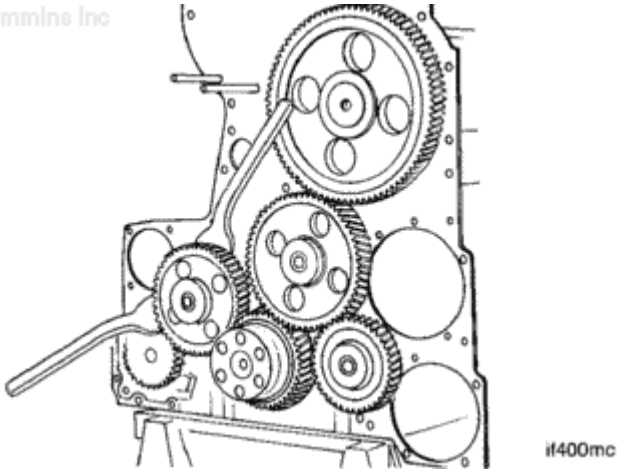
The bolt in idler shaft has a flange that requires the shaft, gear, and thrust washers to be removed as an assembly. **NOTE: The shafts used in newer engines do not have threads to be used with a puller. Loosen the capscrew (36), but do not completely remove it.** Remove the capscrew (36). Use an old piston pin and a K19 cylinder head capscrew as a slide hammer (37). Thread the capscrew into the idler shaft.		

Use the slide hammer (37) to remove the shaft (38), two thrust washers (39), and the gear as an assembly.



For shafts used in newer engines, make sure the capscrew is threaded into the cylinder block.

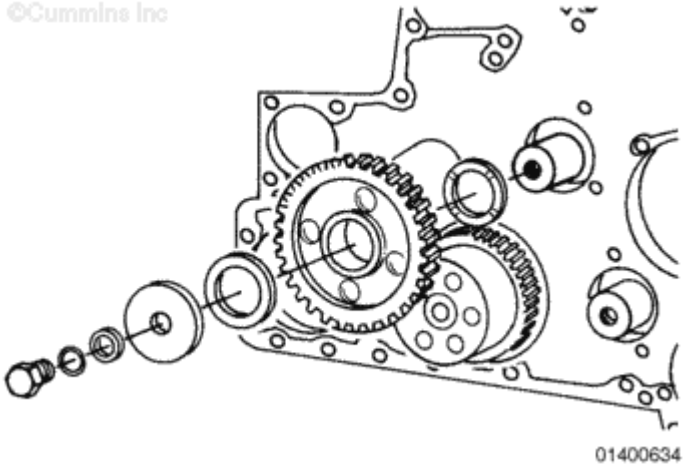
Pry the gear and shaft assembly out of the cylinder block with two pry bars.



Press-Fit Type

Some engines have a press fit design idler shaft that does **not** have to be removed from the block to remove the idler gear.

Remove the capscrew, washers, gear, and thrust



washer.		

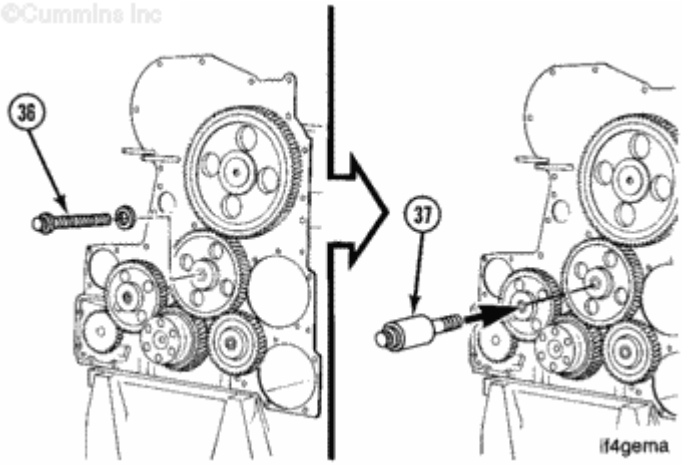
Last Modified: 25-Aug-2004

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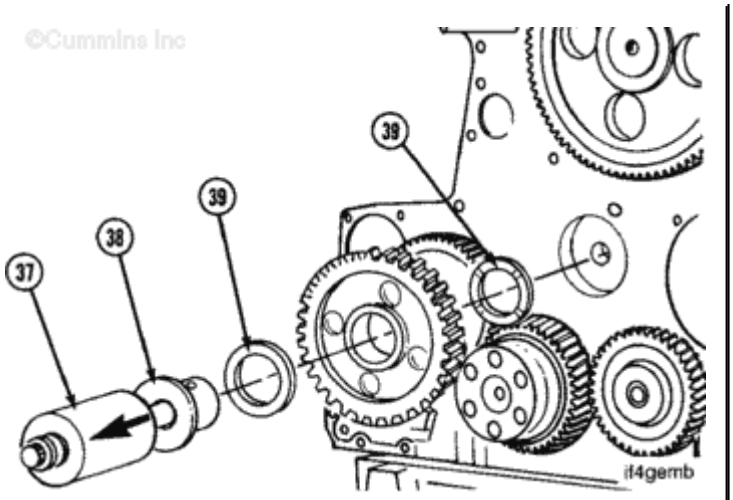
001-039 Idler Gear, Hydraulic Pump

Remove

Bolt-On Type

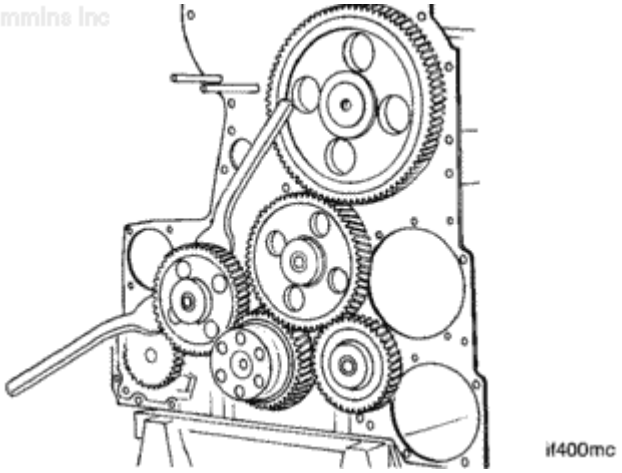
The bolt in idler shaft has a flange that requires the shaft, gear, and thrust washers to be removed as an assembly. **NOTE: The shafts used in newer engines do not have threads to be used with a puller. Loosen the capscrew (36), but do not completely remove it.** Remove the capscrew (36). Use an old piston pin and a K19 cylinder head capscrew as a slide hammer (37). Thread the capscrew into the idler shaft.		

Use the slide hammer (37) to remove the idler shaft (38), two thrust washers (39) and the gear as an assembly.



For shafts used in newer engines, make sure the capscrew is threaded into the cylinder block.

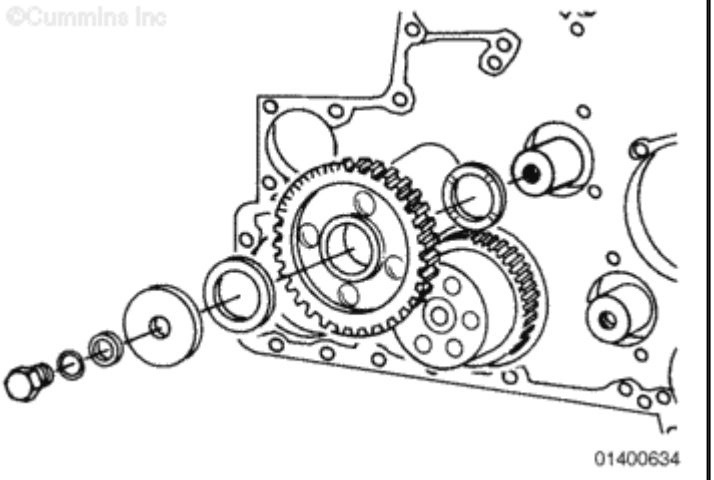
Pry the gear and shaft assembly out of the cylinder block with two pry bars.



Press-Fit Type

Some engines have a press-fit design idler shaft that does **not** have be removed from the cylinder block to remove the idler gear.

Remove the capscrew, washers, gear, and thrust



washer.		

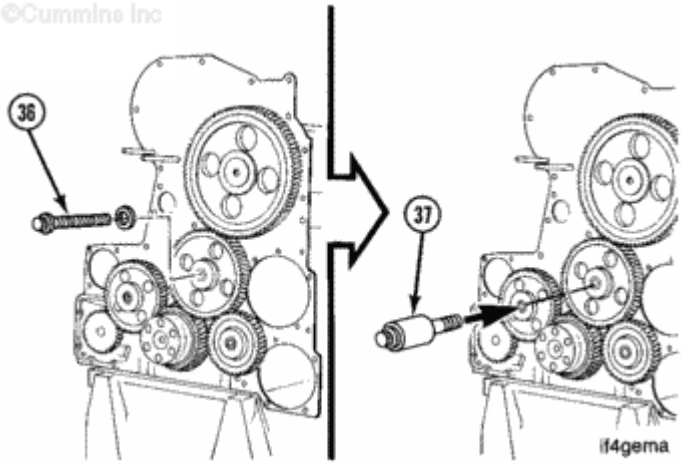
Last Modified: 04-Nov-2004

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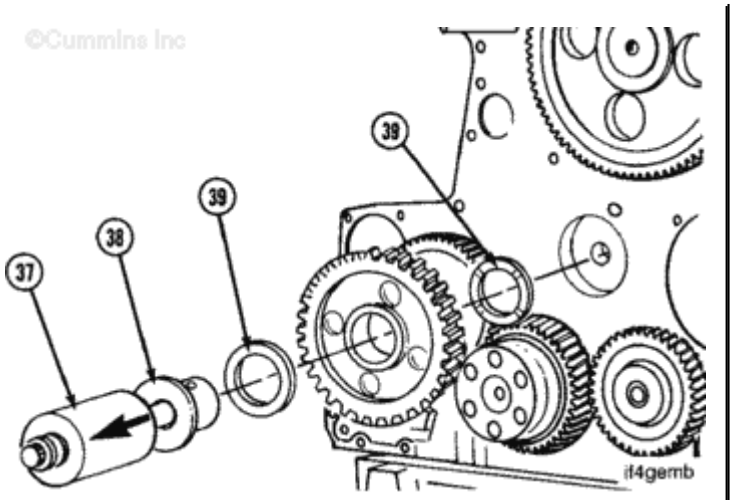
001-040 Idler Gear, Water Pump

Remove

Bolt-On Type

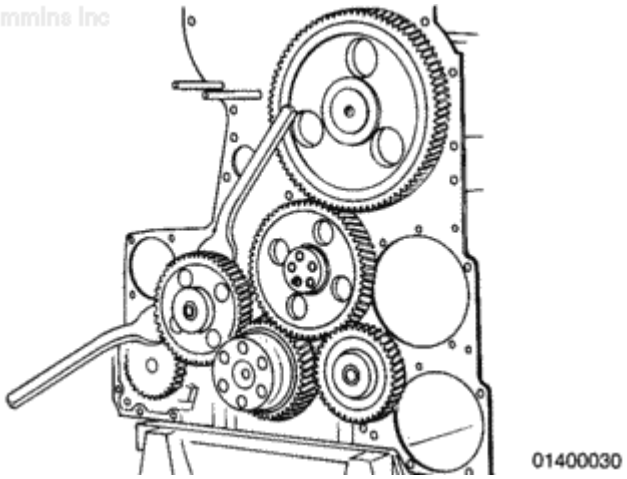
The bolt in idler shaft has a flange that requires the shaft, gear, and thrust washers to be removed as an assembly. **NOTE: The shafts used in newer engines do not have threads to be used with a puller. Loosen the capscrew (36), but do not completely remove it.** Remove the capscrew (36). Use an old piston pin and a K19 cylinder head capscrew as a slide hammer (37). Thread the capscrew into the idler shaft.		

Use the slide hammer (37) to remove the shaft (38), two thrust washers (39), and gear as an assembly.



For shafts used in newer engines, make sure the capscrew is threaded into the cylinder block.

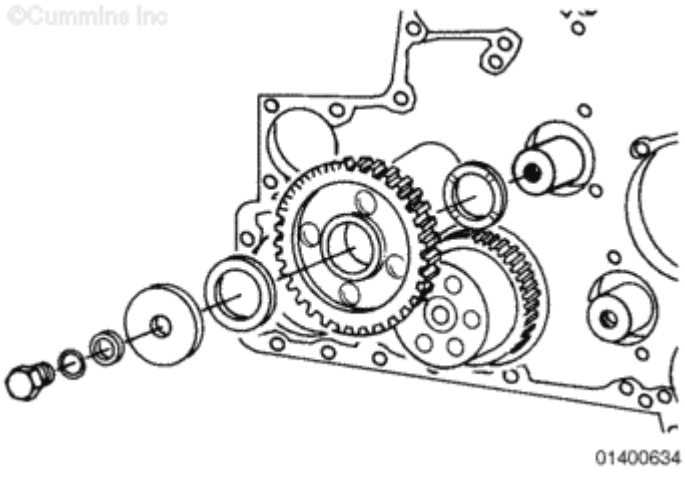
Pry the gear and shaft assembly out of the cylinder block with two pry bars.



Press-Fit Type

Some engines have a press fit design idler shaft that does **not** have to be removed from the block to remove the idler gear.

Remove the capscrew, washers, gear, and thrust



washer.		

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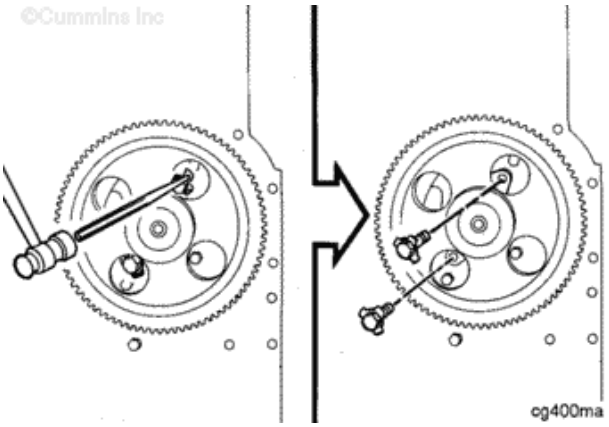
001-008 Camshaft

Remove

Use a hammer and a drift to bend the lockplates off of the two mounting capscrews.

Remove the capscrews and lockplates.

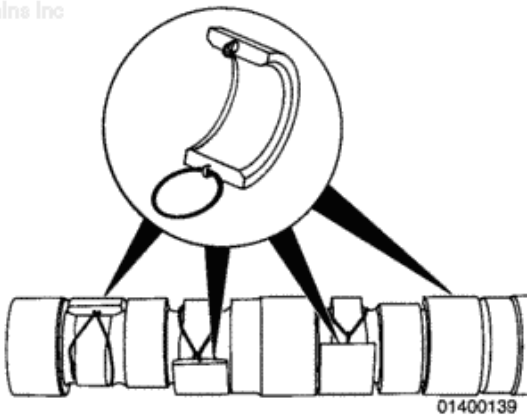
Discard the lockplates.



CAUTION

Pilots must be used to prevent damage to the camshaft and the bushings. Be sure the hooks do not damage the camshaft bushings.

Place camshaft installation pilots, Part Number 3376280, on the inner base circle of the valve lobes for the number 5 and 6 cylinders before removing the camshaft from the block.

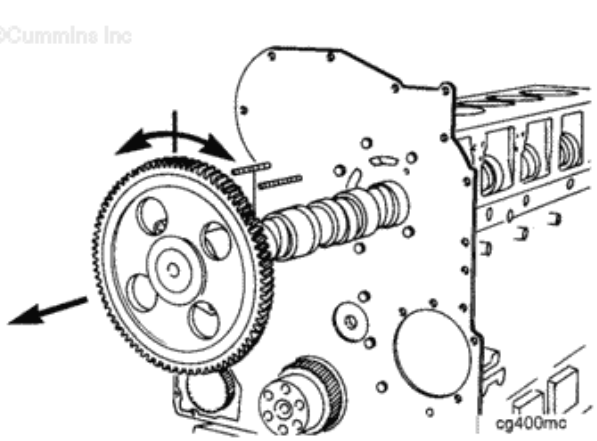


WARNING

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.

Rotate the camshaft during removal so that one of the pilots is always on the downward side to support the camshaft.

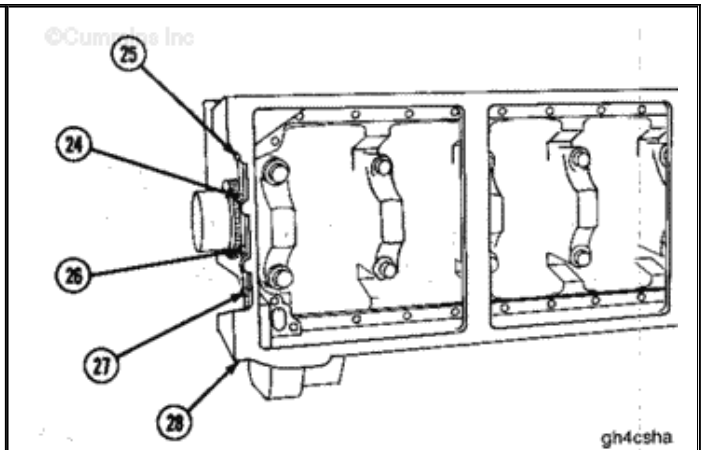
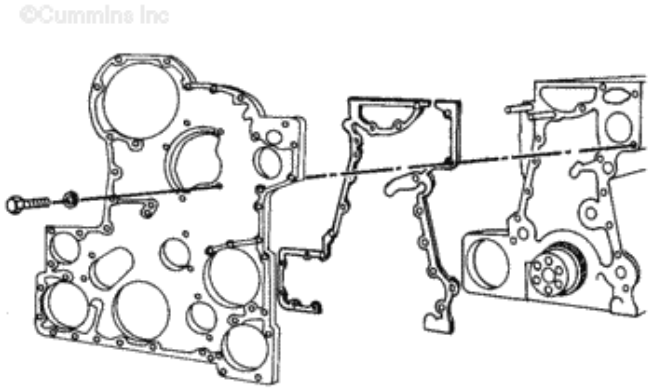


Last Modified: 14-Nov-2011

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001-033 Gear Housing, Front

Remove

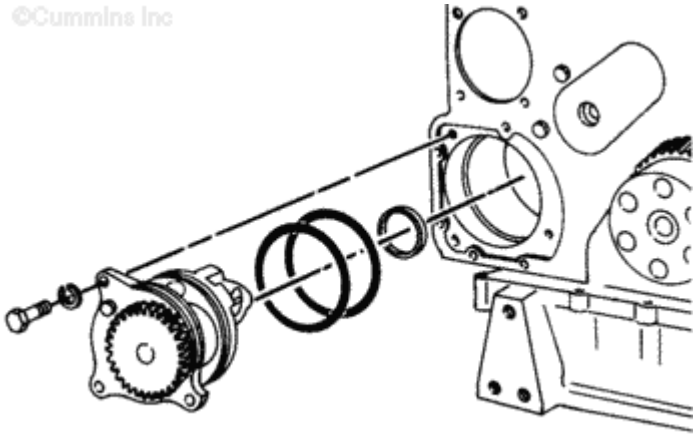
Remove the five capscrews that attach the bottom of the gear housing to the oil pan adapter.		
Remove and tag the 11 gear housing capscrews. Remove the gear housing and gasket. Discard the gasket.		

Last Modified: 08-Dec-2004

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007-031 Lubricating Oil Pump

Remove

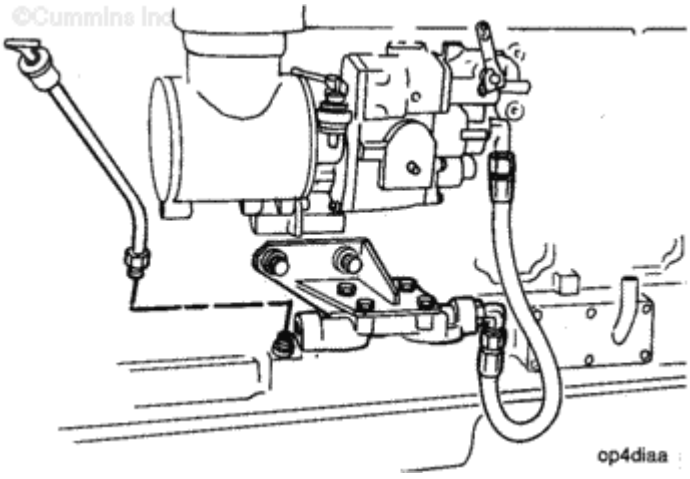
Remove the three capscrews from the oil pump mounting flange. Use a pry bar and gently pry the oil pump out of the engine block. Remove and discard the two o-rings and the seal ring from the lubricating oil pump.		

Last Modified: 01-Dec-2004

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007-011 Lubricating Oil Dipstick Tube

Remove

Remove the dipstick and dipstick tube.		

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016-005 Flywheel

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.

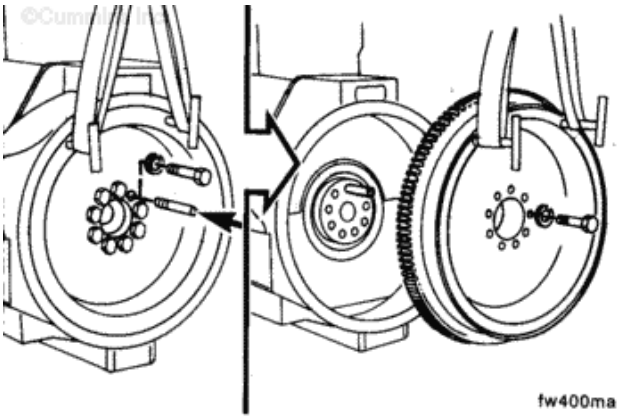
Use two [5/8-18 inch] guide studs to prevent the flywheel from rotating. Remove two capscrews and install the guide studs.

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.



Last Modified: 29-Nov-2004

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001-024 Crankshaft Seal, Rear

Remove

NOTE: If a service seal with a wear sleeve has been installed the wear sleeve must be removed from the crankshaft. Refer to Procedure 001-025.

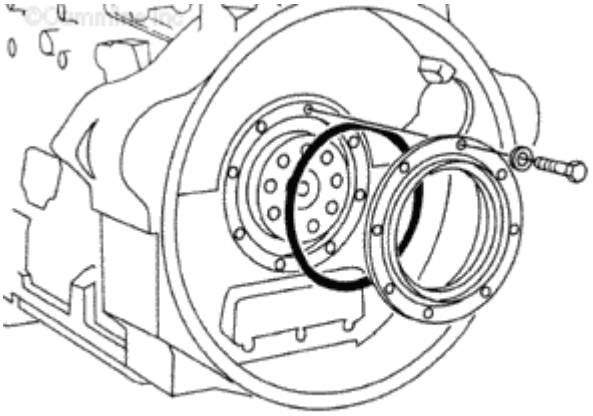
The seal removal and installation procedures are the same for the wet type seal as for the dry type seal.

Remove the seal mounting capscrews.

Remove the seal and o-ring.

Discard the o-ring.





ks4sehd

Last Modified: 29-Sep-2004

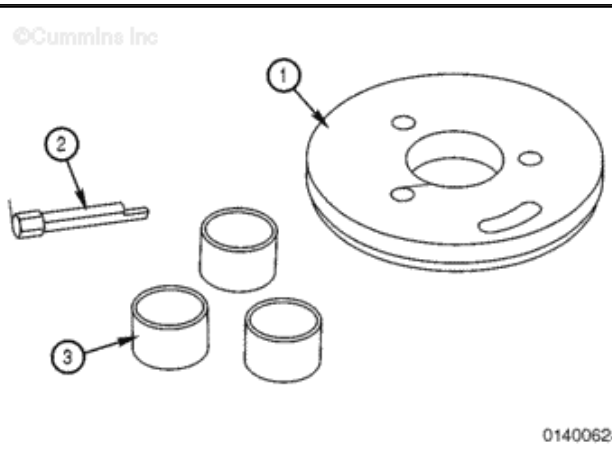
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001-067 Crankshaft Wear Sleeve, Rear

Remove

The parts contained in the Wear Sleeve Installer/Remover kit, Part Number 3824971 are:

(1) Mandrel, Part Number 3824972
(2) Expander (wedge), Part Number 3824763
(3) Spacer



CAUTION

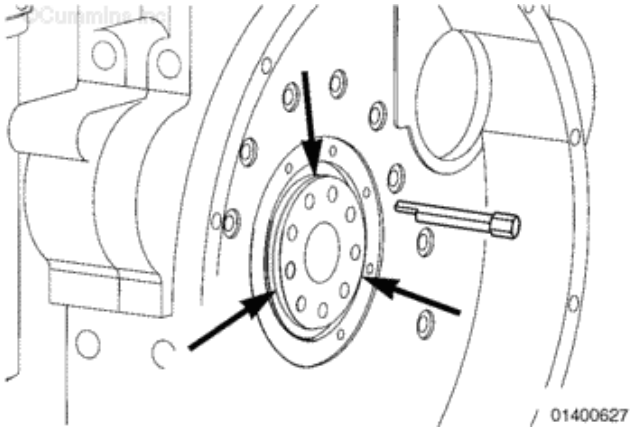
It is not necessary to completely cut the wear sleeve. If the sleeve is completely cut, the crankshaft can be damaged.

Insert the expander (wedge) between the wear sleeve and flywheel housing.

Turn the expander (wedge) so the wedge nose deforms the wear sleeve.

Repeat this process at three or four points around the wear sleeve.

The wear sleeve press fit will be reduced and it can be



removed from the crankshaft. Remove the wear sleeve from the crankshaft.		

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001-023 Crankshaft Seal, Front

Remove

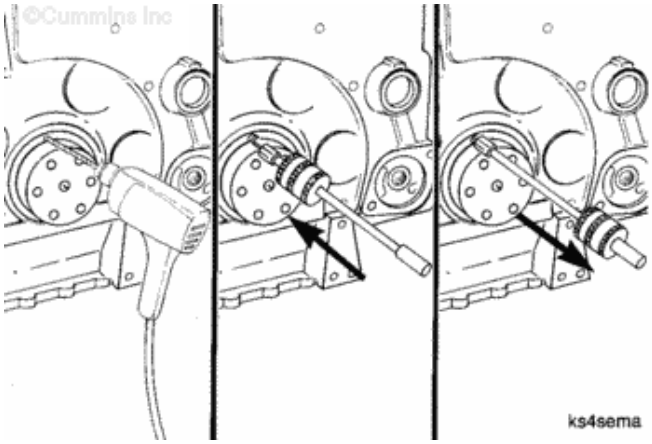
Use a drill, sheet metal screw, and the following from the light duty pulley kit, Part Number 3375784:

- Slide hammer
- Hook.

Drill a hole in the seal and install a sheet metal screw.

Use the hook and the slide hammer to remove the seal.

NOTE: If a service seal with a wear sleeve has been installed the wear sleeve must be removed from the crankshaft. Refer to Procedure 001-025.



Last Modified: 24-Sep-2004

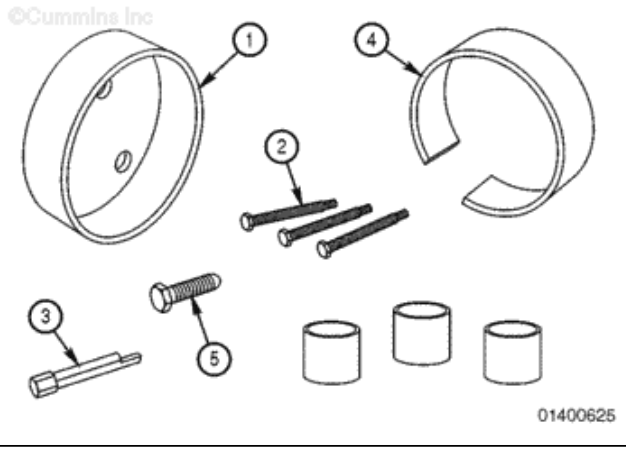
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001-025 Crankshaft Wear Sleeve, Front

Remove

The parts contained in the Oil Seal/Wear Sleeve Installer/Puller, Part Number 3824760 are:

(1) Mandrel, Part Number 3824761
(2) Special puller screws, Part Number 3824762
(3) Expander (chisel), Part Number 3824763
(4) Protective sleeve, Part Number 3824764
(5) Center puller screw, Part Number 3375099.



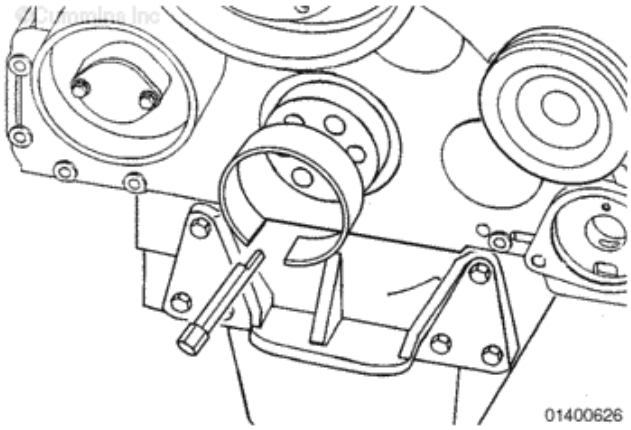
CAUTION

It is not necessary to completely cut the wear sleeve. If the sleeve is completely cut the crankshaft can be damaged.

If a service seal with a wear sleeve has been installed the wear sleeve **must** be removed from the crankshaft.

Install the protective sleeve, Part Number 3824764, in the seal bore of the front gear cover. The protective sleeve will protect the front gear cover bore from damage.

Insert the expander (chisel), Part Number 3824763,



between the wear sleeve and protective sleeve. Turn the expander (chisel) so the nose deforms the sleeve. Repeat this procedure at three or four points around the sleeve. The sleeve press fit will be reduced and can be lifted off of the crankshaft. Remove the protective sleeve from the gear cover.		

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007-025 Lubricating Oil Pan

Remove

All Applications Except Rail

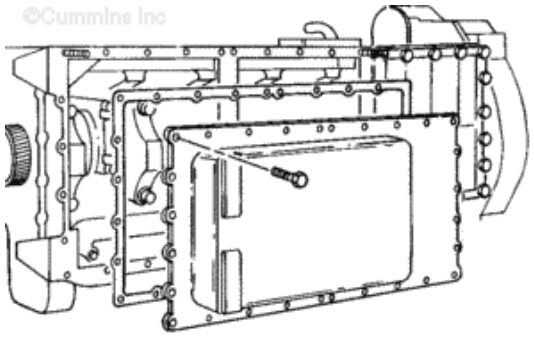
WARNING

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

Remove the 28 capscrews.

Remove the lubricating oil pan.

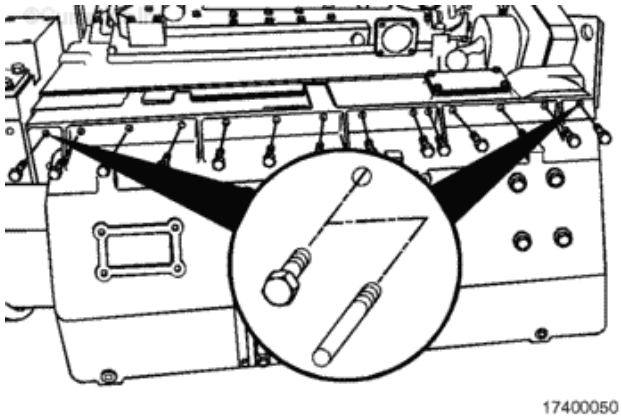
Remove and discard the gasket.



Rail Applications

Remove 15 capscrews on the top of the lubricating oil pan.

Install two 3/8- 16 guide studs in the capscrew holes.



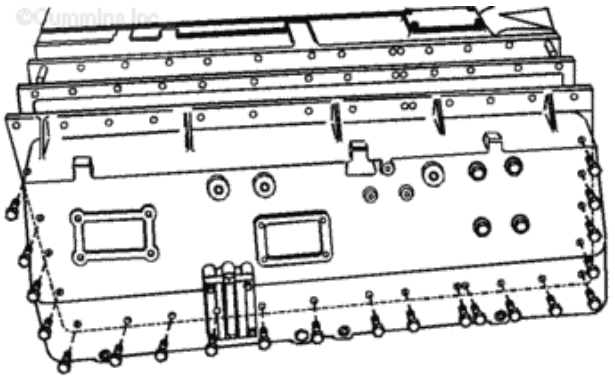
WARNING

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

Remove the remaining 23 capscrews.

Remove the lubricating oil pan.

Remove and discard the gasket.

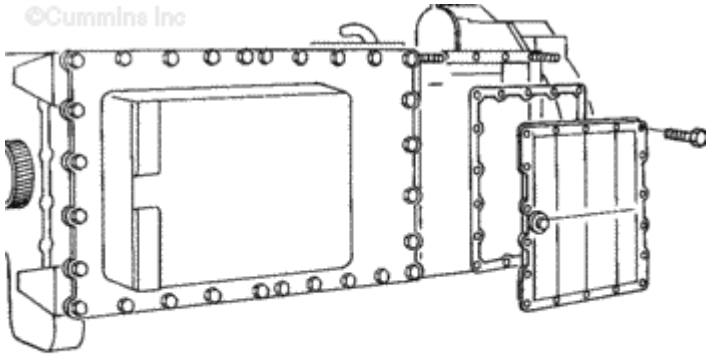


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007-026 Lubricating Oil Pan Adapter Cover Plate

Remove

Remove the 18 capscrews. Remove the lubricating oil pan adapter cover plate. Remove and discard the gasket.		

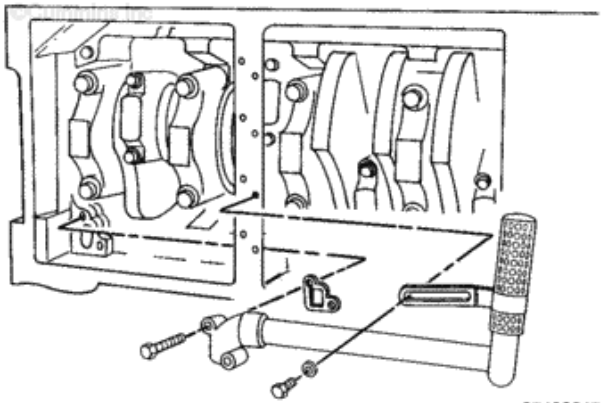
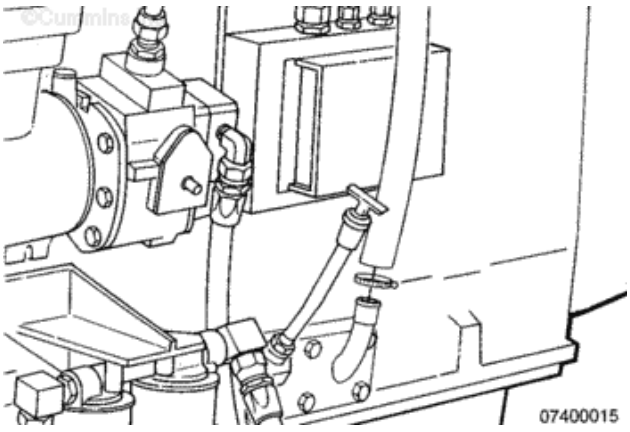
Last Modified: 20-Dec-2004

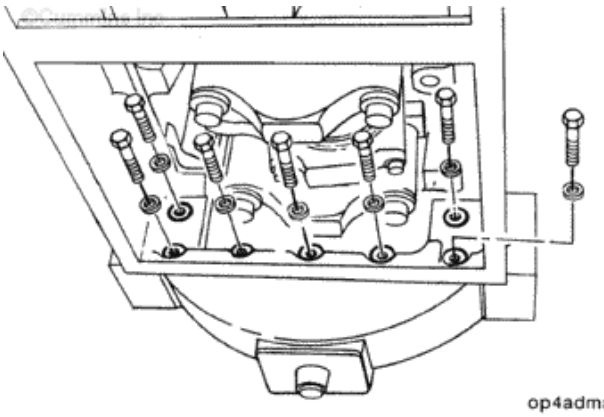
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View Related Topic

007-027 Lubricating Oil Pan Adapter

Remove

Remove the three capscrews from the suction tube. Remove the oil pan suction tube. Remove and discard the gasket.		
Disconnect the breather vent hose from the handhole cover.		
Remove the two 7/16-14 inch and five 3/8-16 inch capscrews from the flywheel housing.		



WARNING

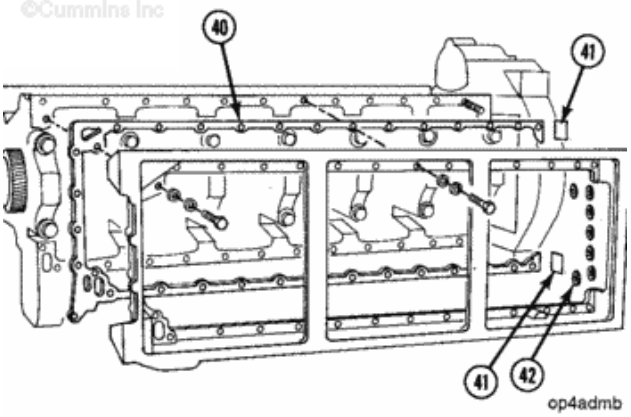
This component weighs 23 kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Remove all of the capscrews and the oil pan adapter.

Remove and discard the gasket (40).

Remove and discard the two rectangular seals (41).

Remove and discard the seven capscrew seals (42) from the adapter.

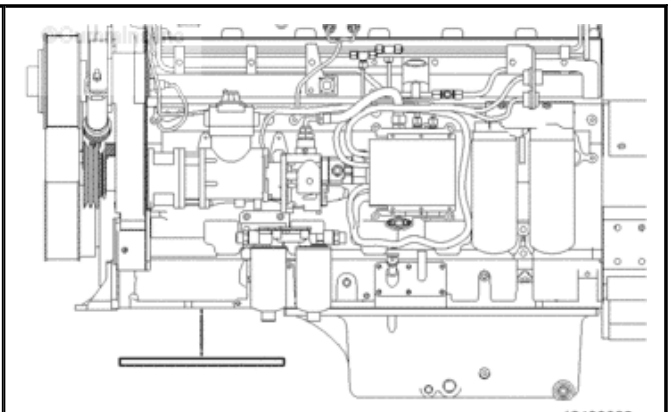
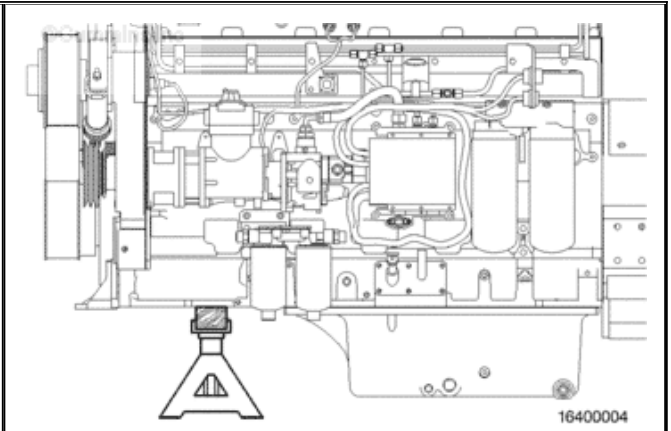


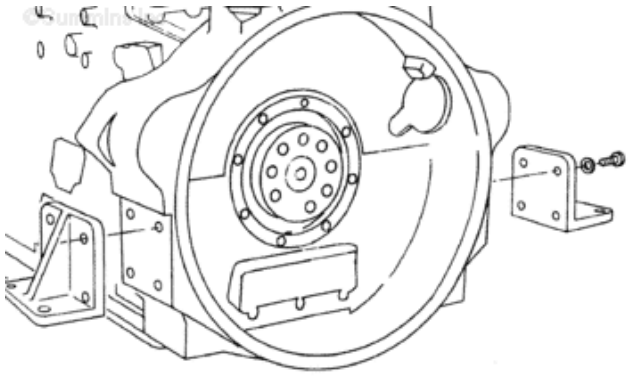
Last Modified: 24-Oct-2006

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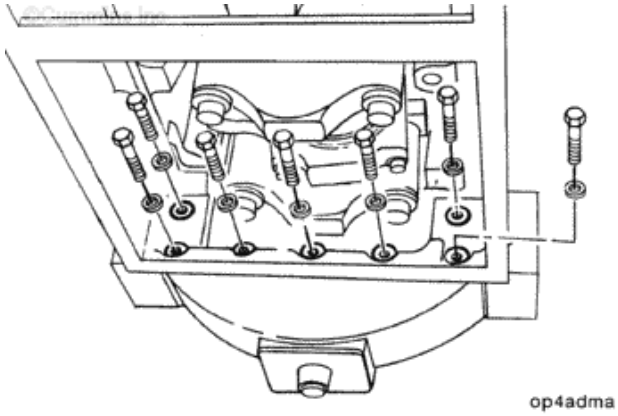
016-006 Flywheel Housing

Remove

Remove the adapter cover plate or oil sump (whichever is in the front position).		
Place a wooden block the width of the oil pan adapter between the floor jack and the oil pan adapter to prevent damage to the engine. Use a floor jack or a suitable lifting fixture to support the front of the engine. Put the support in position to allow access to the capscrews in the oil pan adapter that attach to the flywheel housing.		
Remove the rear engine mounts from the flywheel housing.		



Remove the two [7/16-14 inch] capscrews, and the five [3/8-16 inch] capscrews from the flywheel housing.



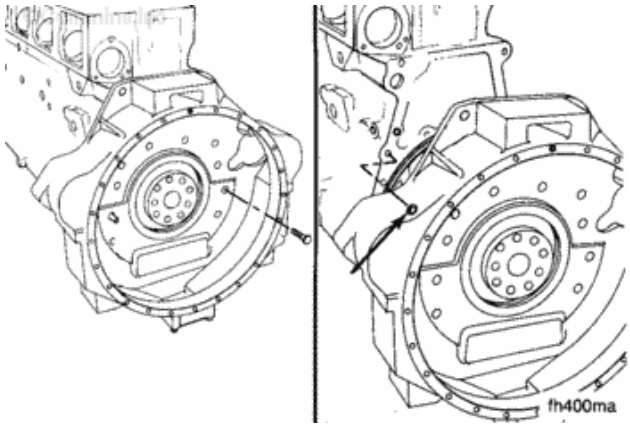
WARNING

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.

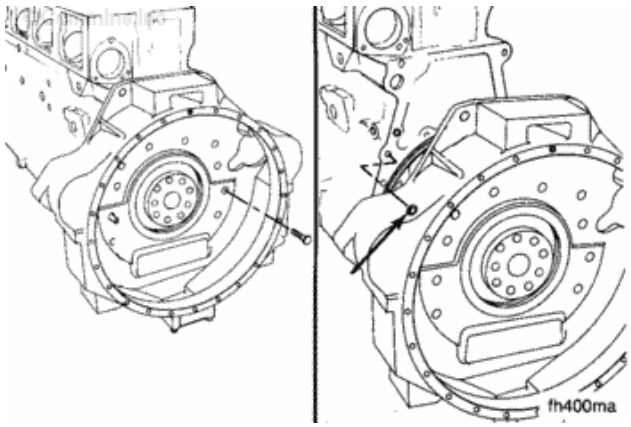
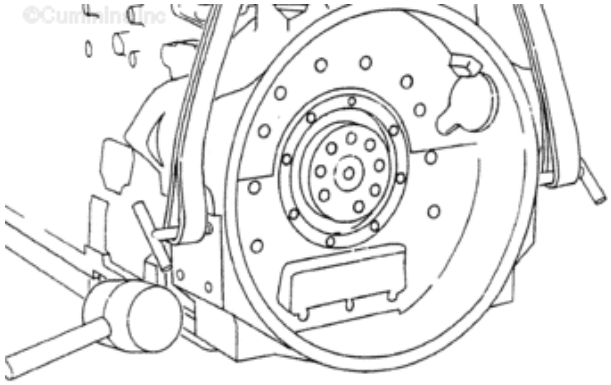
Use two guide studs to prevent the flywheel housing from rotating during disassembly.

Remove the two capscrews.

Install the guide studs.



Use a hoist, a tee handle,

and a lifting sling. Install the tee handle. Adjust the hoist until there is tension in the lifting sling. Remove the remaining capscrews.		
Use a mallet and tap the flywheel housing off the two locating dowels. Remove and discard the rectangular seal and the bolt seals.		

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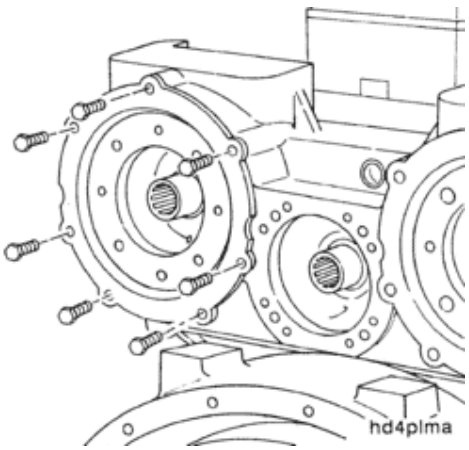
009-036 Outer Hydraulic Pump Support Drive

Remove

NOTE: Some engines will not have an outer hydraulic drive. These engines require a cover plate and a non-splined shaft, but do not use a hydraulic gear.

If a cover plate is used, remove the cover plate and non-splined shaft.

Remove the seven capscrews from the hydraulic drive.



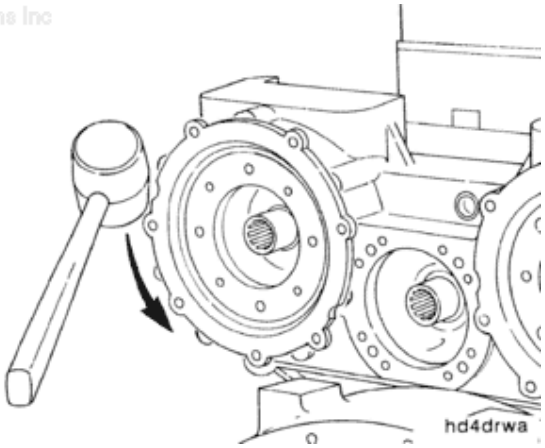
WARNING

This component weighs 23 kg [50 lb] or more. Tor reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

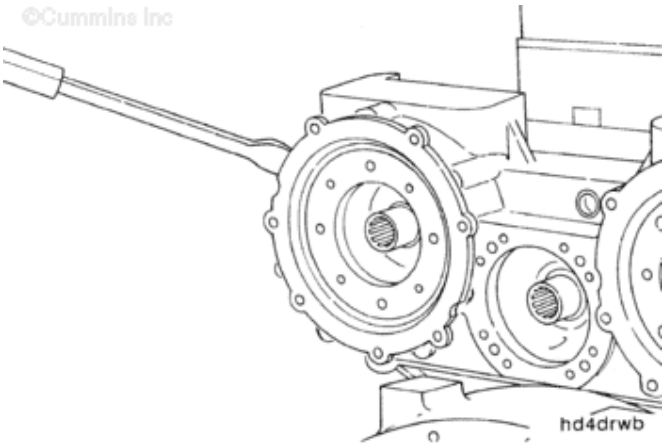
CAUTION

Care must be taken to avoid possible breakage of the capscrew mounting flanges.

The outboard hydraulic pump supports **must** be rotated to remove them from the housing.



Use a mallet, and carefully tap the side of the support.		

Remove the outboard hydraulic pump supports with a pry bar. Remove the gaskets. Discard the gaskets.		

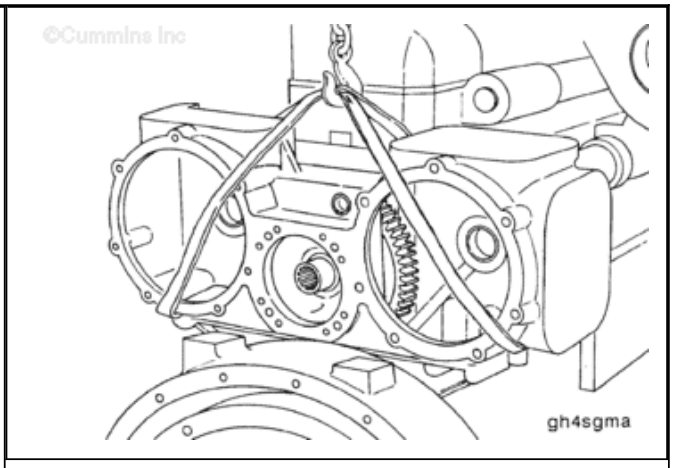
Last Modified: 11-Nov-2004

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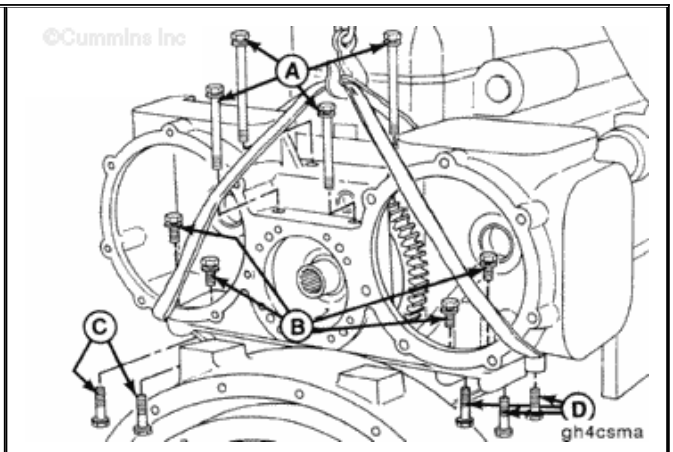
009-024 Rear Gear Drive (Upper Assembly)

Remove

Install the lifting sling around both sides of the upper housing. Adjust the hoist until there is tension in the lifting sling.



Remove the four capscrews from the top of the housing (A), four internal capscrews (B), two capscrews from the bottom of the upper housing on the left side (C), and three capscrews from the bottom on the right side (D).



WARNING

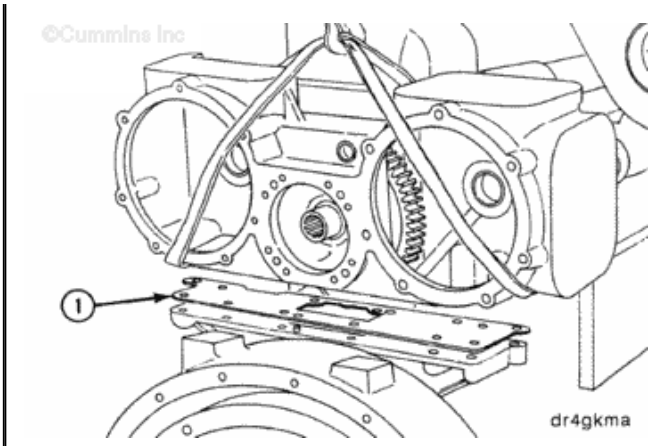
The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get

assistance to lift the component.

CAUTION

The hydraulic gear protrudes out of the bottom of the housing. Place the upper housing upside down on a workbench to prevent damage to the gear or bushing.

Remove the rear gear train upper housing from the lower housing. Remove the gasket (1). Keep the gasket for future use.

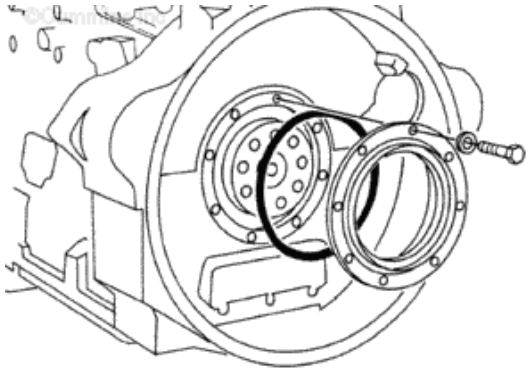
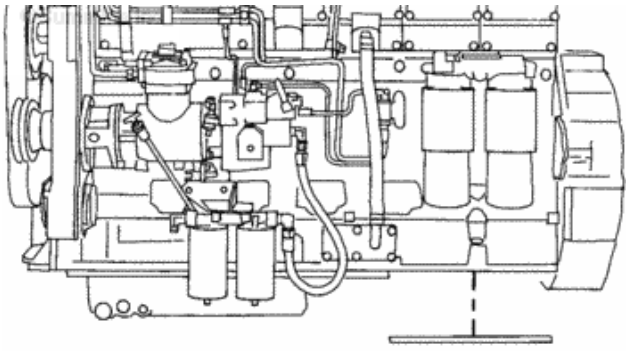


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009-023 Rear Gear Drive (Lower Assembly)

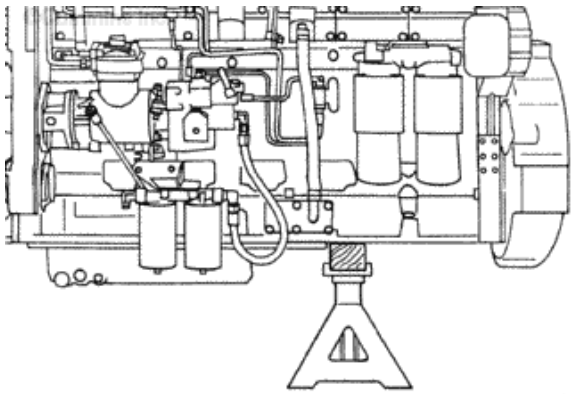
Remove

Remove the capscrews and the rear crankshaft seal. Remove and discard the o-ring and seal.		 ks4sehd
Remove the adapter cover plate or the oil pan (whichever is in the rear position). Angle the cover plate to allow the oil to drain. Remove and discard the gasket.		 ew4plhb
WARNING This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get		

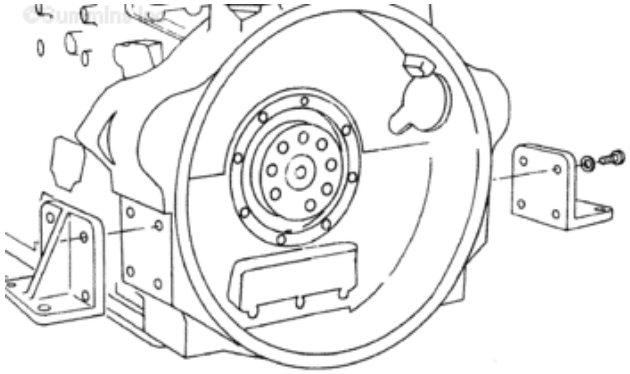
assistance to lift the component.

Put a wooden block the width of the oil pan adapter between the support and the oil pan adapter to prevent damage to the engine.

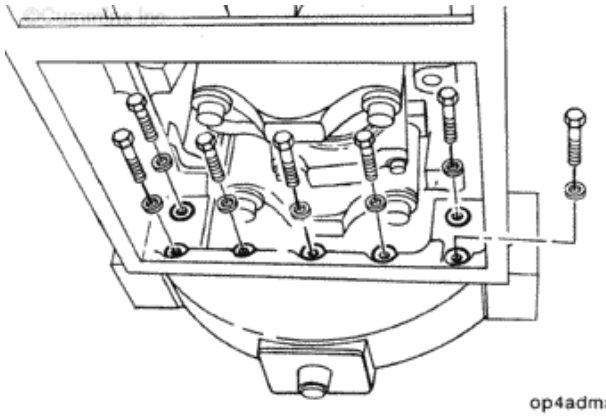
Use a jack stand or a suitable lifting fixture to support the rear of the engine. Put the support in position to allow access to the capscrews in the oil pan adapter that attach to the flywheel housing.



Remove the rear engine mounts from the flywheel housing if necessary.



Remove the two 7/16 in capscrews and the five 3/8 in capscrews that attach the oil pan adapter to the flywheel housing.



CAUTION

Be sure the rear gear train lower housing is secure before removing the flywheel housing. The lower housing rests on the guide studs and dowel pins, but is not fastened to the block.

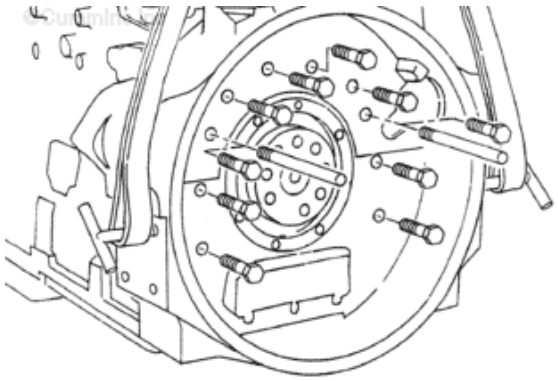
Use two 5/8x6-1/2 in guide studs. Remove two capscrews.

Install the guide studs.

Use a hoist, a tee handle, and a lifting sling. Install the tee handle.

Adjust the hoist until there is tension in the lifting sling.

Remove the remaining capscrews, lock washers, and nuts.

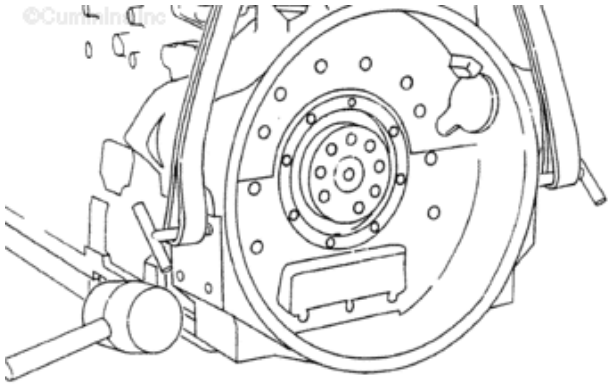


fh400mb

Two pry bars can be used to separate the lower housing of the rear gear train from the flywheel housing.

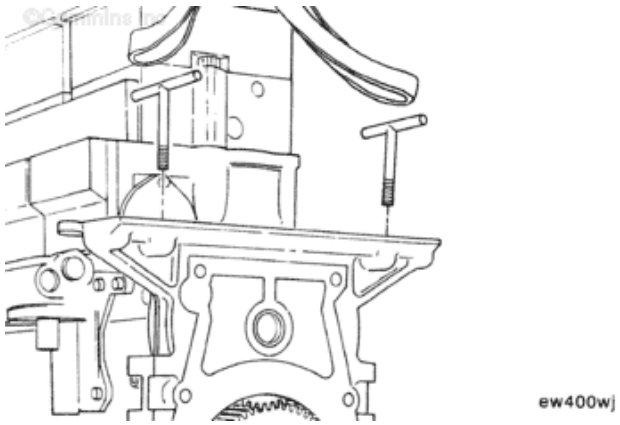
Use a mallet to tap the flywheel housing off the two locating dowels.

Remove and discard the rectangular seal and the bolt seals.



fh4hsma

Use a hoist, two tee handles, and a lifting sling. Install the tee handles. Adjust the hoist until there is tension in the lifting sling.

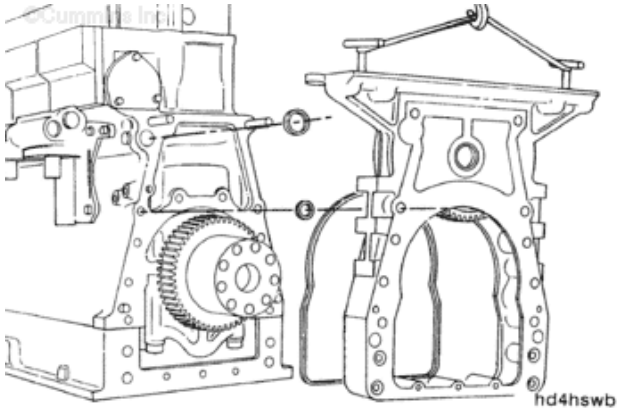


WARNING

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

Use a mallet to tap the lower housing of the rear gear train off the two locating dowel pins in the rear face of the cylinder block.

Remove and discard the rectangular seal, bolt seals, and main oil rifle seal.

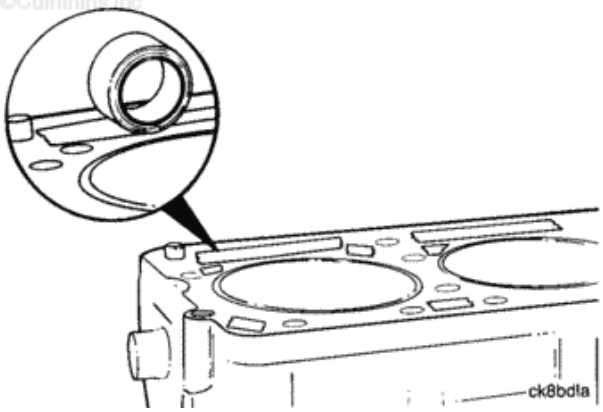
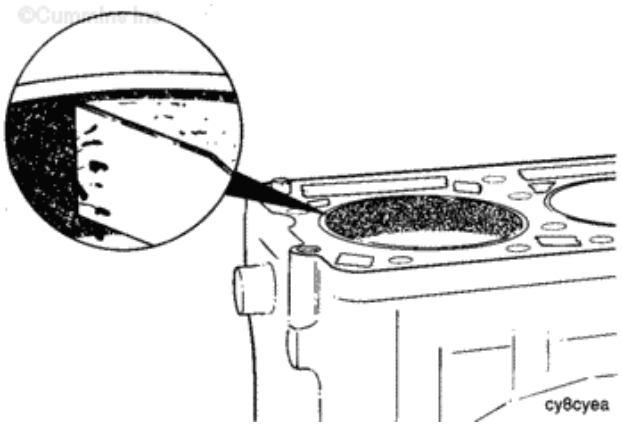


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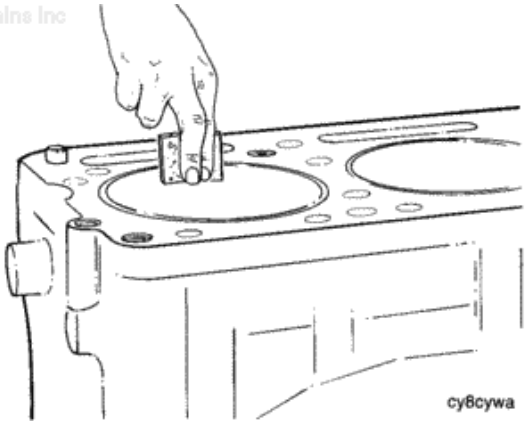
001-054 Piston and Connecting Rod Assembly

Remove

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 from abrasive paper will cause severe engine damage. Use a scraper or a similar blunt-edged tool to loosen the carbon deposits in the cylinder liner.		
CAUTION Use extreme care to make sure that no abrasive cleaners or materials are used in the piston ring		

travel area.

Remove the remaining carbon with a nylon abrasive pad, Scotch-Brite™ 7448, or equivalent, and solvent. The carbon **must** be removed, but the surface does **not** have to appear like new metal.



WARNING

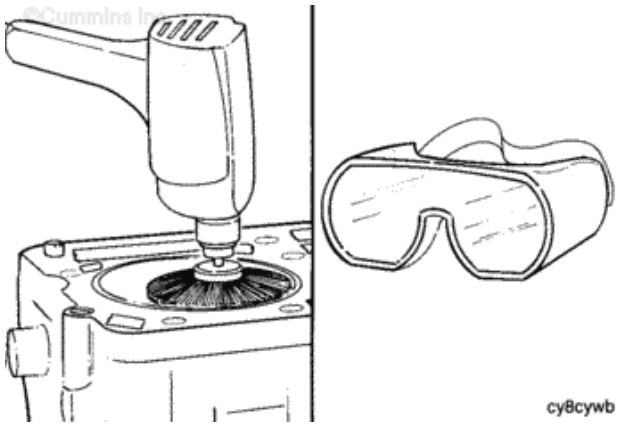
Wear appropriate eye and face protection when using a wire wheel to prevent serious personal injury.

An alternative method to remove the carbon ridge is to use a high quality-steel wire wheel installed in a drill.

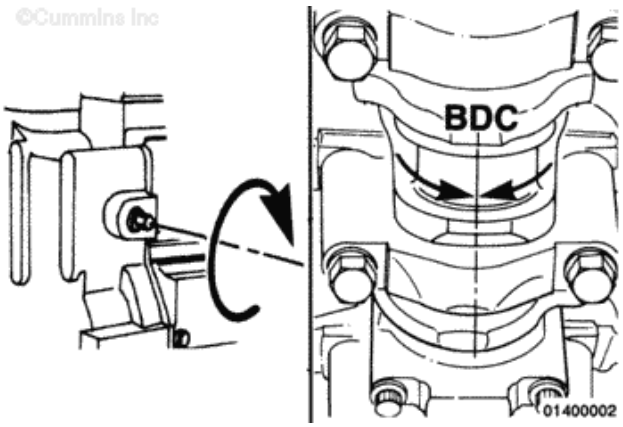
Do **not** use a steel wire wheel of inferior quality. The inferior wire wheel will lose steel bristles during operation and cause additional contamination.

NOTE: 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.

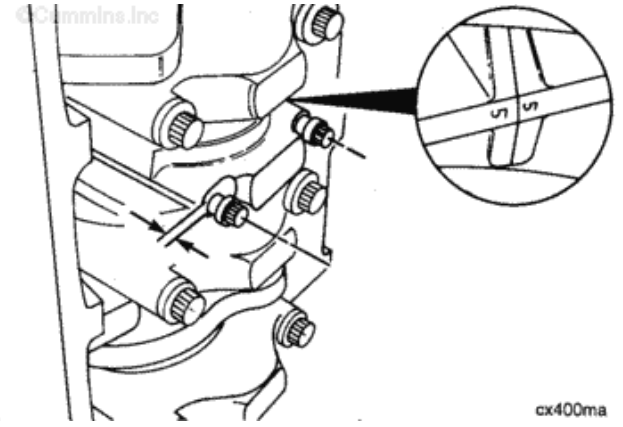


Use the barring mechanism to rotate the engine. Rotate the crankshaft to position the connecting rod at bottom dead center (BDC).



Connecting rods **must** have the cylinder number marked on both the connecting rod and the connecting rod cap on the side positioned toward the camshaft. Check the connecting rods for correct markings. Use a steel stamp and mark any rod that is **not** correctly marked.

Loosen the capscrews until there is 6 mm [¼ inch] of clearance between the connecting rod cap and the capscrew head.

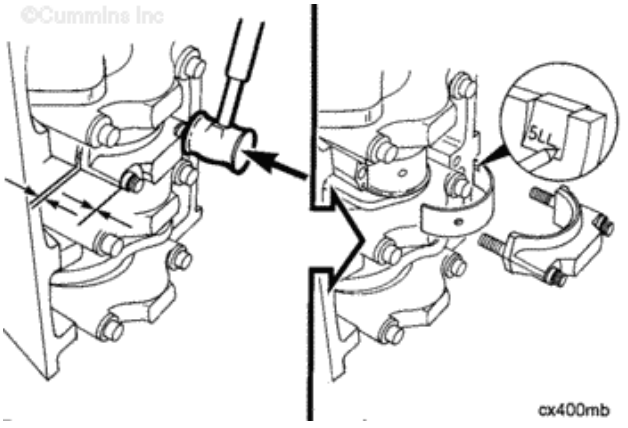


Use a mallet. Tap the connecting rod capscrews until the connecting rod cap and connecting rod separate. Remove the capscrews and the connecting rod cap.

Remove the lower rod bearing.

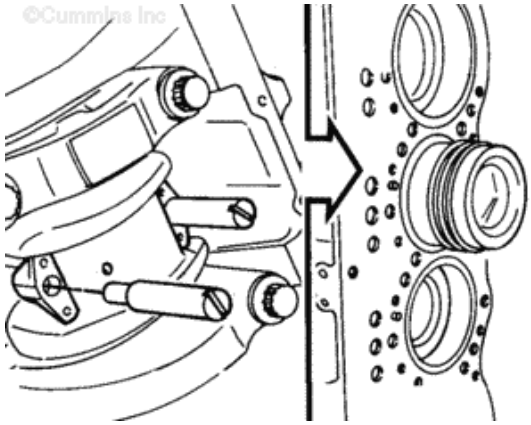
Use an awl to mark the bearing position in the tang area.

Mark the bearing for future identification or for possible failure analysis.



Install two connecting rod guide pins, Part Number 3375098, or equivalent, into the connecting rod.

Push the piston and connecting rod up until the piston rings are above the cylinder liner.



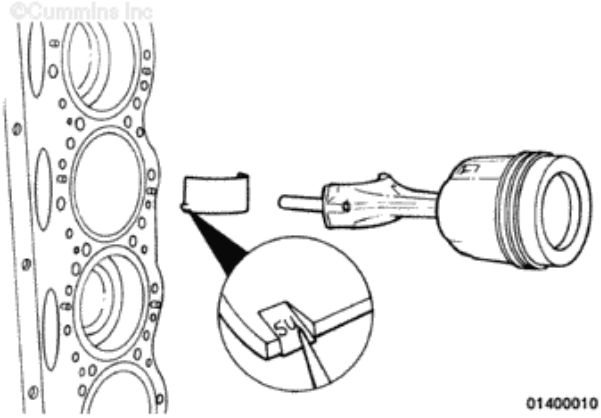
CAUTION

Place the piston and rod assembly in a rack to prevent damage to the piston and rod assembly.

Remove the piston and rod assembly.

Remove the upper connecting rod bearing.

Use an awl to mark the bearing position in the tang area.



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001-006 Bearings, Main

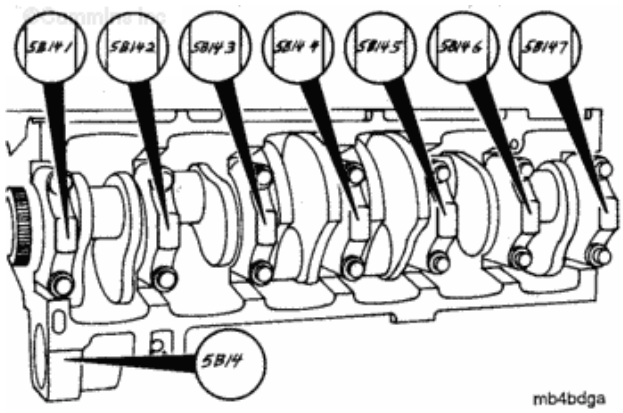
Remove

NOTE: Before removing the main bearings, refer to General Information step in this procedure.

The main bearings caps **must** be marked for position. The last number on each main bearing cap identifies the location and position in the cylinder block.

The cylinder block and main bearing cap identification numbers **must** be identical.

Use a steel stamp and mark any main bearing cap that is **not** marked correctly.



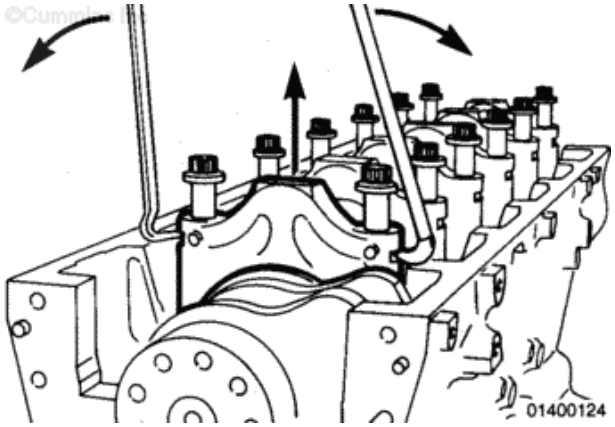
WARNING

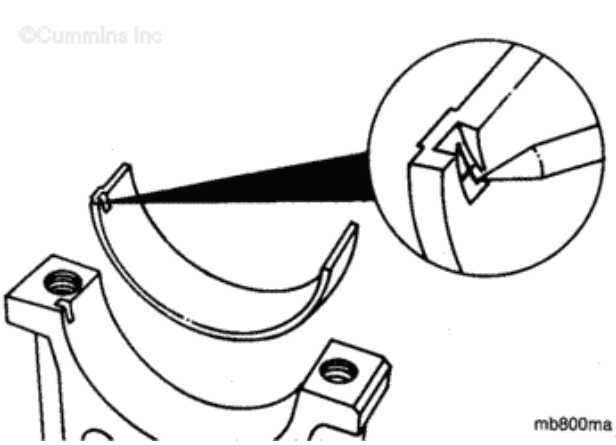
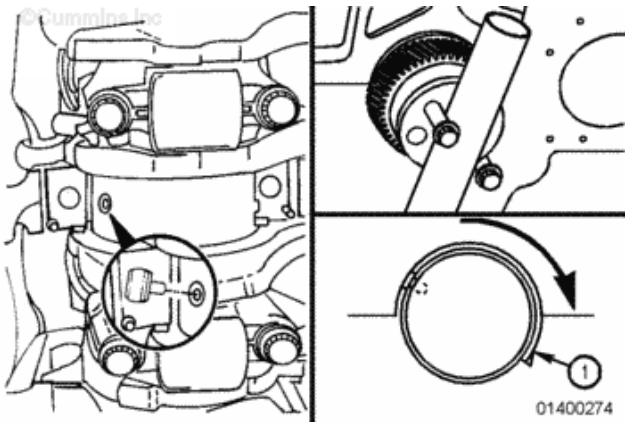
Remove the lower main bearings one pair at a time. Personal injury and damage to the crankshaft can result if the crankshaft falls.

Loosen the main bearing cap capscrews until there is approximately 13 mm [½ inch] between the capscrew head and the main bearing cap.

Install the pry bars in the notches at the sides of the main bearing cap and loosen it.

Remove the main bearing cap and capscrews.



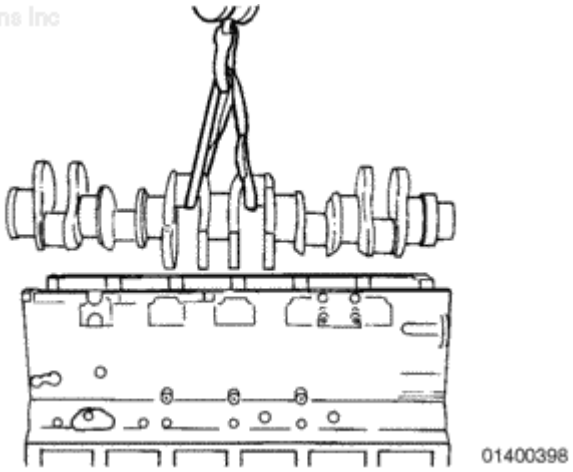
Mark the bearing position for future identification or for possible failure analysis. Remove the lower bearing. Use an awl and mark the bearing position in the tang area. Remove the crankshaft thrust bearings from the number 6 main bearing cap and the number 6 saddle in the cylinder block. Refer to Procedure 001-007.		
To remove the upper main bearing shell install the main bearing roll out tool, Part Number 3823818, into the crankshaft main bearing journal oil hole. Rotate the crankshaft so the tang (1) of the main bearing shell rolls out of the block first. Use the crankshaft adapter mounting bolts and slowly turn the crankshaft until the bearing shell is out of the block.		

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001-016 Crankshaft

Remove

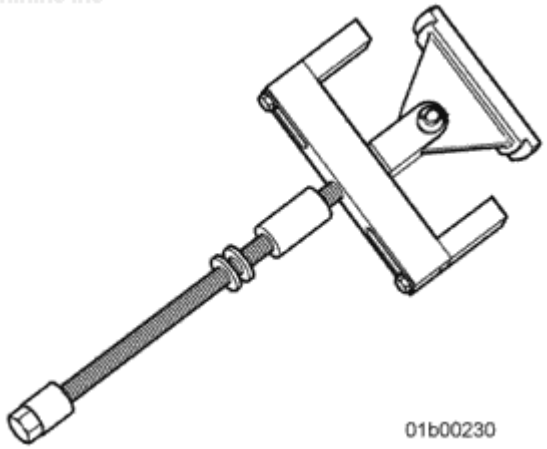
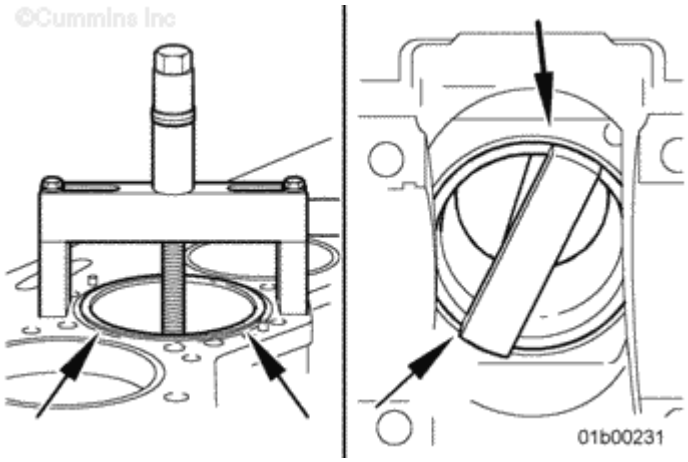
Support the weight of the crankshaft with a hoist or lifting device. Remove the crankshaft.		

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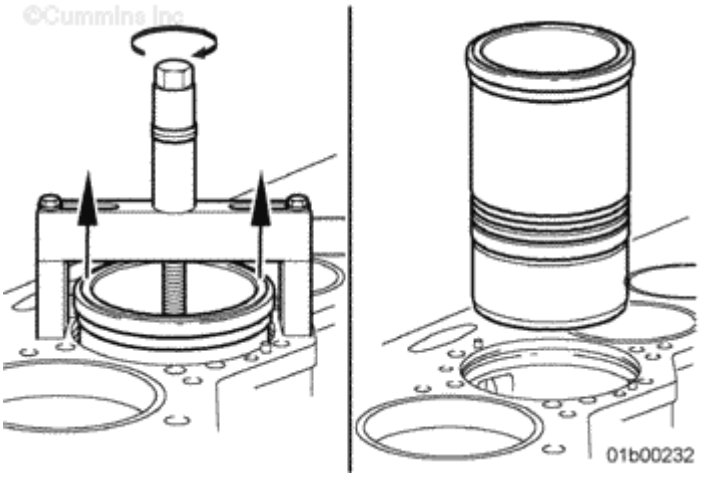
001-028 Cylinder Liner

Remove

Use the cylinder liner puller, Part Number 3163745, and puller plate, Part Number 3162886, to remove the cylinder liner. Wind down the threaded rod to extend the arm. Turn the arm to the side to enable passage through the liner.		
Install the cylinder liner puller, Part Number 3163745, in the cylinder liner. The puller feet **must not** touch the top of the liner. The puller arms **must** be positioned firmly on the bottom of the liner.		
Turn the puller		

screw until the liner loosens in the block.

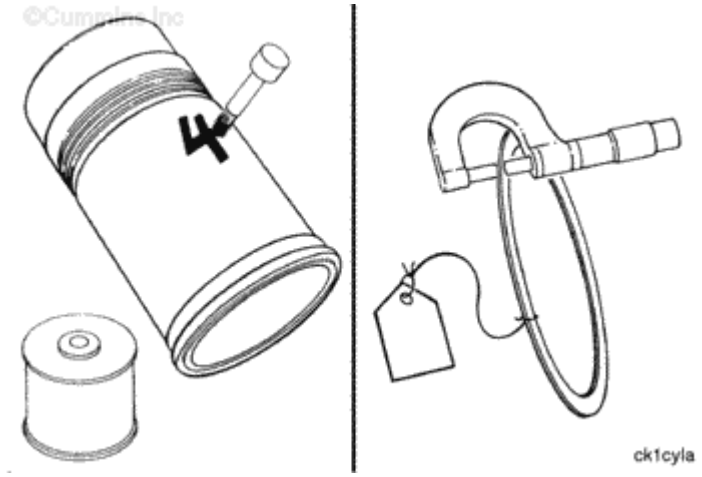
Remove the tool and the liner.

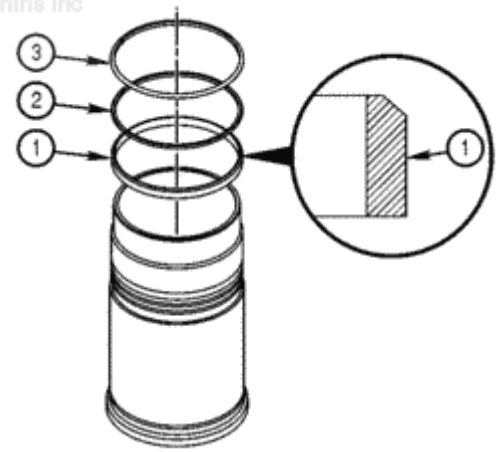


Use a liquid metal marker to mark the cylinder number and bank on each linter. Mark the cylinder liner on the camshaft side of the cylinder liner.

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 known when the liners are installed in the engine.



Remove and discard the two D-rings (1 and 2). Remove and discard the crevice seal (3).		

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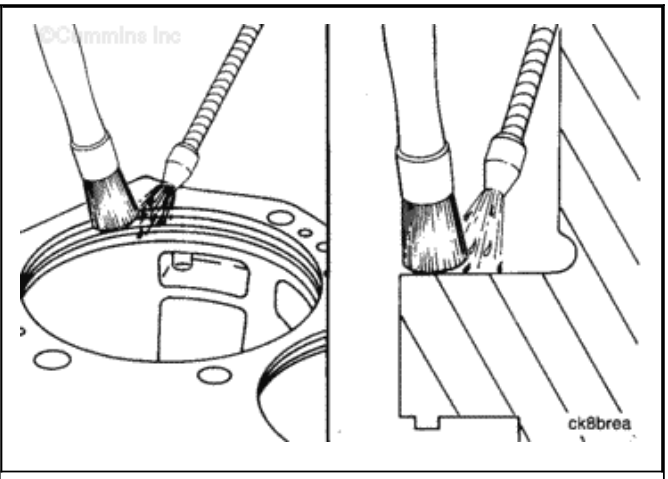
001-028 Cylinder Liner

Install

WARNING

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

Clean the bottom of the cylinder block cylinder liner flange with safety solvent.

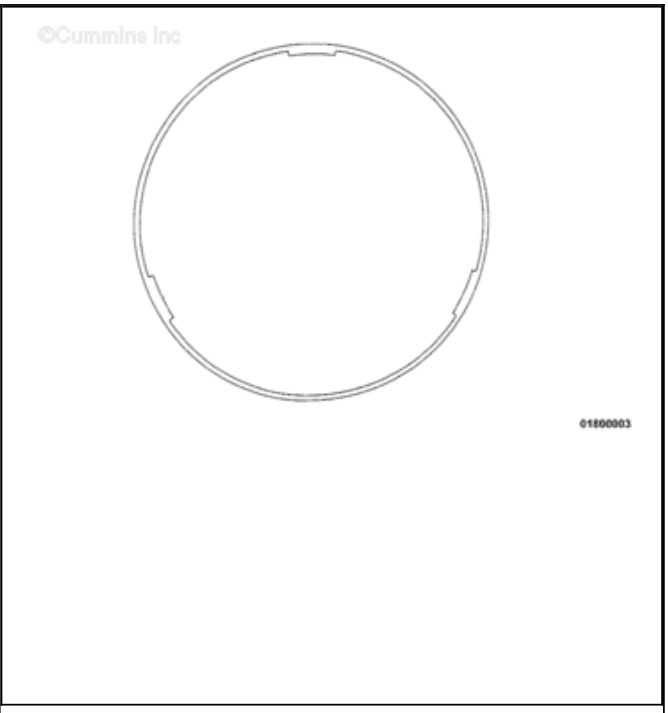


The seal rings have three locating tabs on the inside diameter. The tabs have an interference fit to the liner lower press fit diameter to hold the seal ring in place during liner installation.

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.



NOTE: 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.

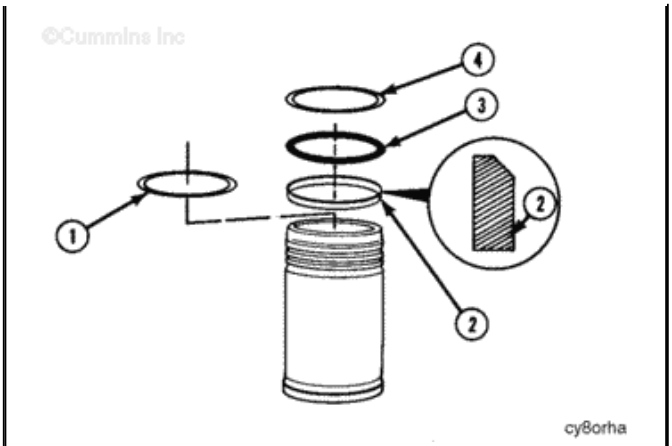
Install the liner, counter bore sealing ring (1).

If an upper crevice seal was used, install the upper crevice seal with the white side out.

Install the crevice seal. The beveled edge of the crevice seal (2) **must** be positioned as shown.

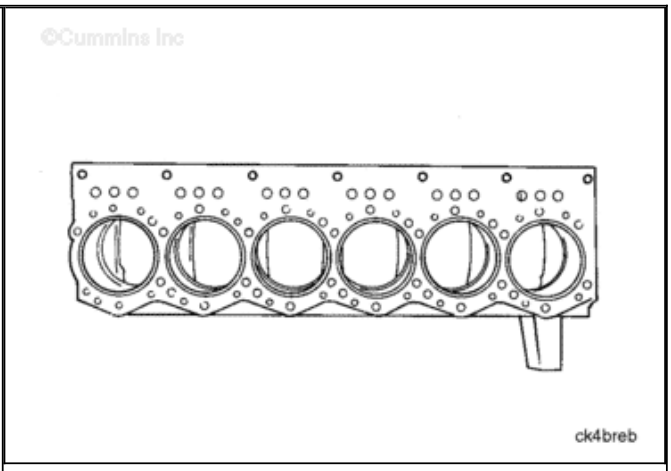
Install o-rings in the position shown. Use the mold mark on the o-ring to check if the o-ring is twisted.

- (3) Black o-ring
- (4) Red o-ring.



Use vegetable oil to lubricate the inside diameter of the packing ring bores.

Use hand pressure to push the cylinder liners into the block.



Use liner installation tool, Part Number 3375422, or equivalent, to install the bridge assembly and 2 cylinder head capscrews. Tighten the capscrews.

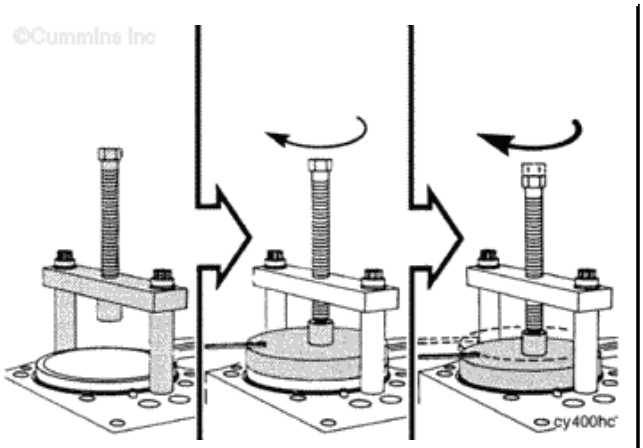
Torque
Value: 45 n.m [34 ft-lb]

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.

Do **not** use more than 65 N•m [50 ft-lb] of torque. Remove the tool.



NOTE: New cylinder liners can be 0.005 to 0.015 mm [0.0002 to 0.0006 in] smaller than the minimum specifications because of the Lubrite coating.

Use a dial bore gauge and measure the inside diameter of the liner at the top, bottom, and middle of the liner.

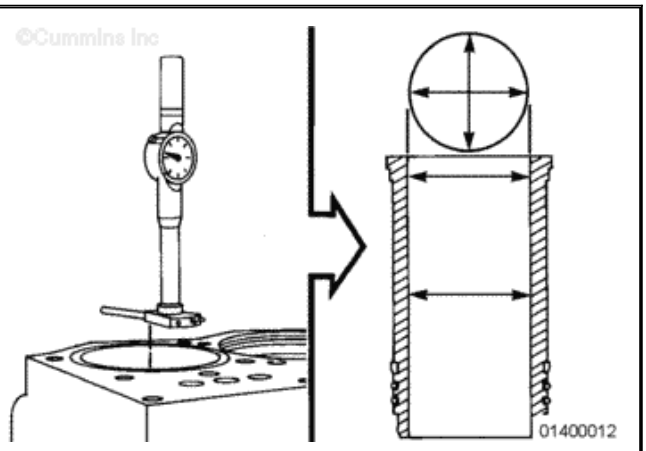
Perform two measurements at each location. The measurements **must** be 90 degrees apart.

New Cylinder Liner Inside Diameter

mm		in
158.737	MIN	6.250
158.775	MAX	6.251

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 0.05 mm [0.002 in] out-of-round in the bottom measurement location, the liner **must** be removed. Check for a twisted o-ring.



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001-016 Crankshaft

Install

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.

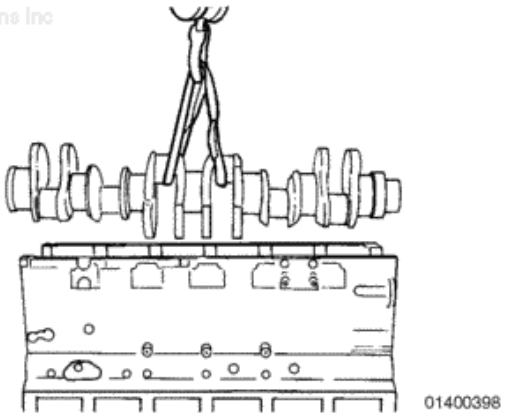
CAUTION

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.



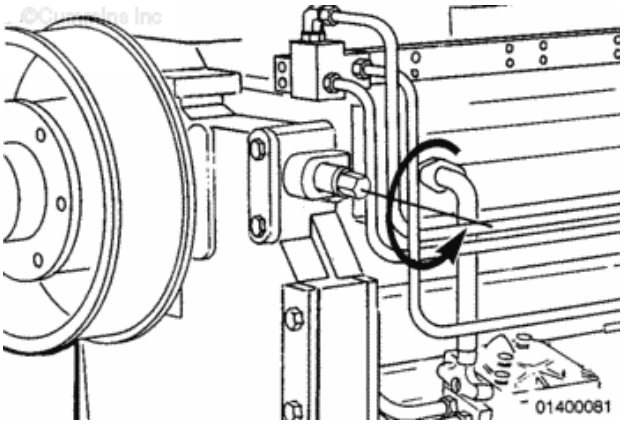
Rotation Check

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 correct procedure for inspection and replacement of internal engine components.



CAUTION

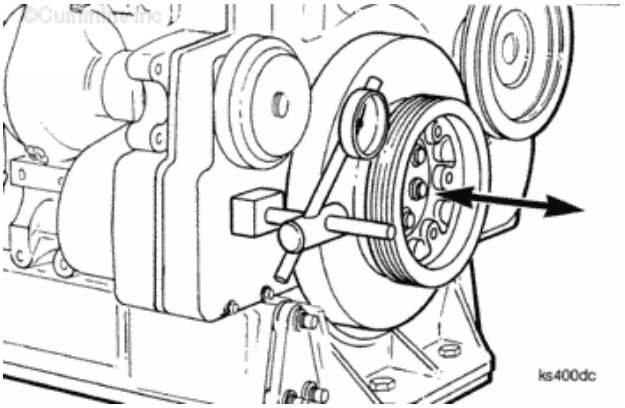
Extreme care must be used in prying against the viscous vibration damper. Sharp pry bars can damage the damper casing, resulting in a leak of the viscous vibration damper fluid and ultimate failure of the vibration damper.

Measure the crankshaft end clearance with a dial indicator.

Measure the end clearance.

Crankshaft End Clearance		
New Minimum	New Maximum	Worn Limit
0.10 mm [0.004 in]	0.43 mm [0.017 in]	0.56 mm [0.022 in]

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, contact a Cummins® Authorized Repair Location.		

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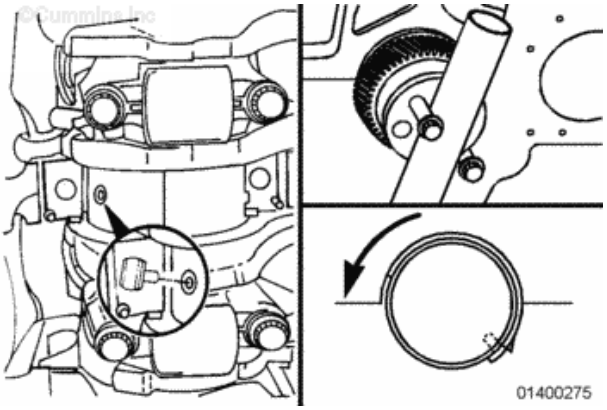
001-006 Bearings, Main

Install

Used bearings **must** be installed in their original location.

Install the upper main bearing shells using the same method that was used for the removal of the shells.

The bearing tang (1) **must** fit into the slot (2) in the bearing saddle to assure proper location of the bearing.



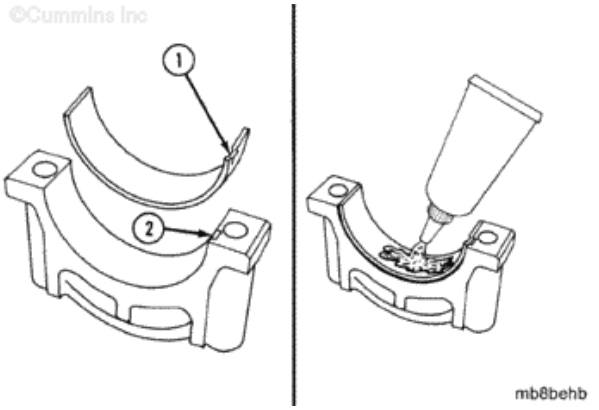
NOTE: Before installing the thrust bearings, refer to General Information step in this procedure and Procedure 001-007.

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.



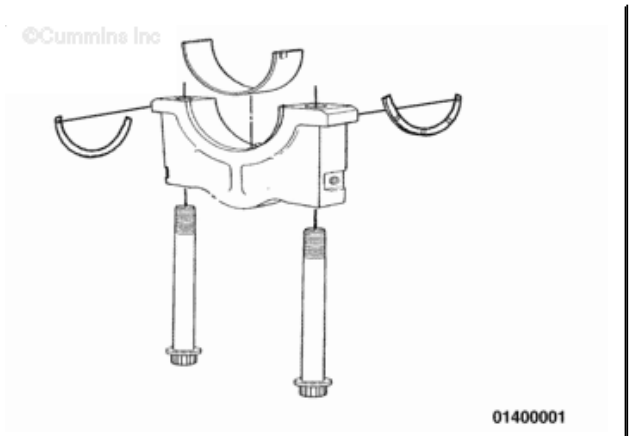
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust bearings must point toward the crankshaft. The dowels that secure the bearings must not protrude above the bearing.

Lubricate the capscrew head and threads with SAE EP 140W oil. Allow the excess oil to drip off of the capscrews before installing in the block.

Install the capscrews in the cap.

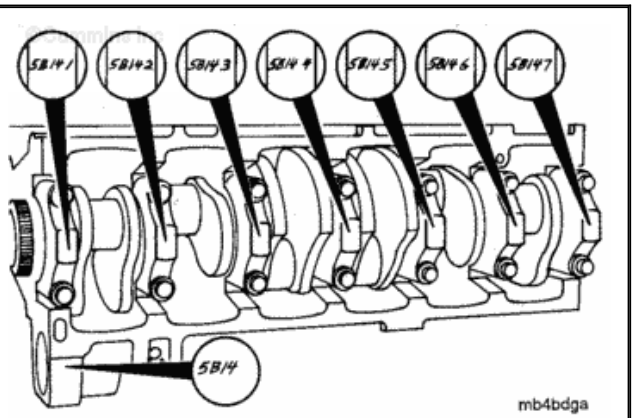
Install the two thrust bearings on the number 6 main bearing cap. Refer to Procedure 001-007.



CAUTION

To reduce the possibility of engine damage, the numbers on the main bearing caps must be the same as the numbers on the block.

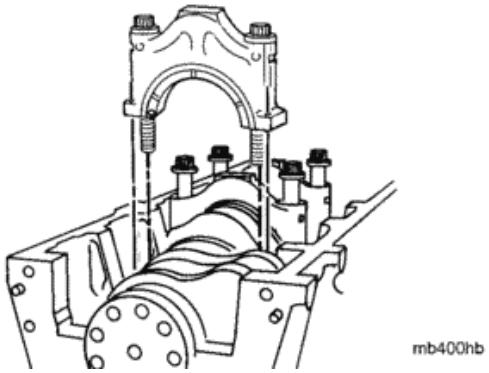
Check the number on the main bearing caps. The last digit of each number (1 through 7), indicates the correct location.



CAUTION

To reduce the possibility of engine damage, make sure the side of the cap and bearing with the bearing locating tang is toward the tang in the block.

Lubricate the bearing surface with engine oil. The bearing shells **must** be firmly seated in the cap and the correct capscrew, washer combination in position. Install the main bearing caps.



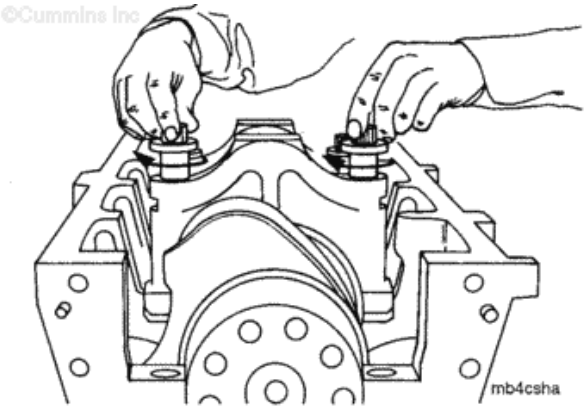
NOTE: Do not hit the main bearing caps with a hammer. The bearing shells can fall out.

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 caps.

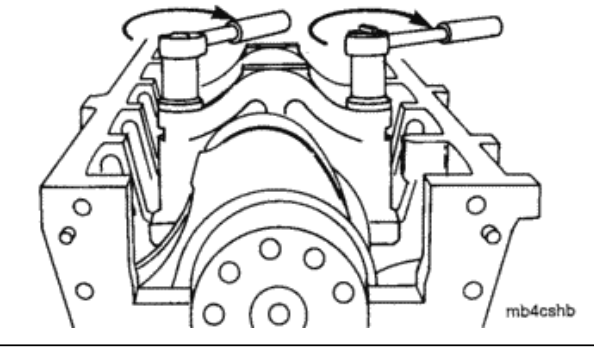


NOTE: Do not use an impact wrench. The main bearing shells can fall out.

Use both of the capscrews to pull the main bearing cap into position.

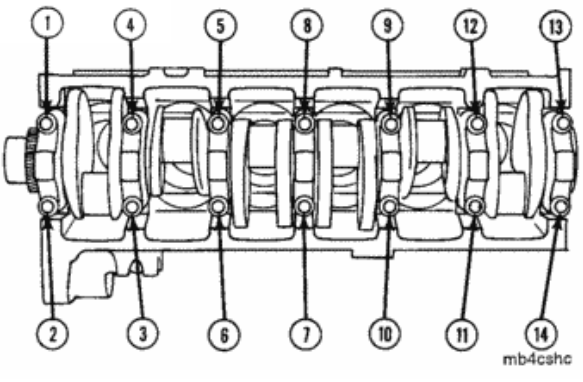
Use two wrenches and tighten both capscrews at the same time.

Check to be sure the number 7 cap is even with the back of the block.



Use the following steps and tighten the capscrews in the sequence shown.

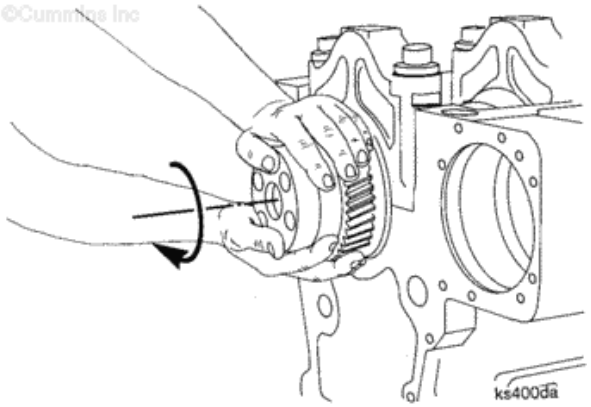
Torque Value:	Step 1	265 n.m	[195 ft-lb]
	Step 2	605 n.m	[445 ft-lb]
	Step 3	Loosen	
	Step 4	265 n.m	[195 ft-lb]
	Step 5	605 n.m	[445 ft-lb]



If the pistons are removed, turn the crankshaft by hand.

If the pistons are installed, use the barring mechanism.

The crankshaft will turn freely if the main bearings are installed correctly.



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001-054 Piston and Connecting Rod Assembly

Install

CAUTION

To reduce the possibility of engine damage, do not lubricate the back side of the bearing shells.

Clean the connecting rod and the bearing shells with a lint free cloth.

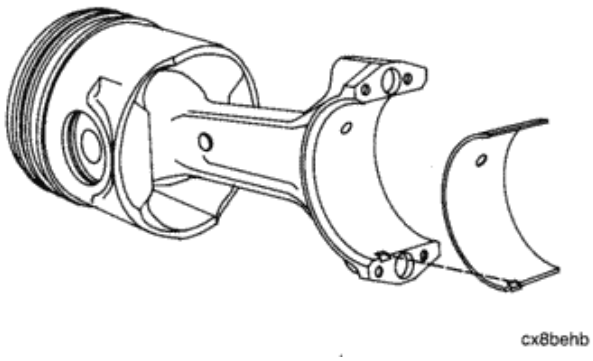
NOTE: All of the connecting rod bearings are identical.

NOTE: Do not reuse connecting rod bearings if either the connecting rod or crankshaft has been changed.

Install the connecting rod bearing. Be sure the tang is positioned as shown. The end of the bearing **must** be even with the cap mounting surface.

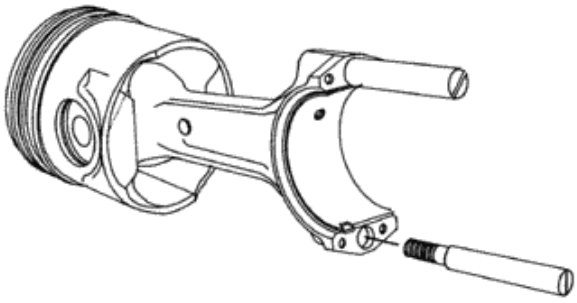
Lubricate the connecting rod bearing surface with clean engine oil.

The connecting rod bearings **must** be installed in their original locations if new connecting rod bearings are **not** used.



Install two connecting rod guide pins, Part Number 3375098, in the connecting rod. The guide pins will aid

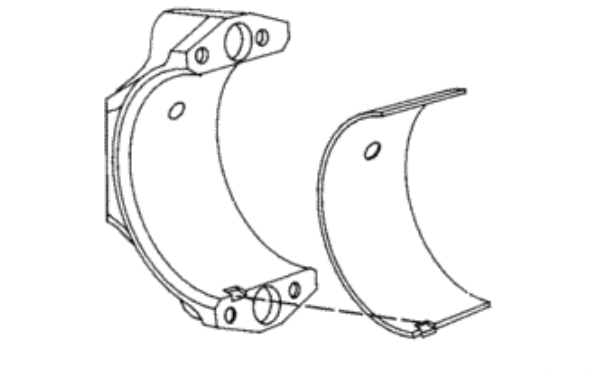
the assembly process and protect the crankshaft.



CAUTION

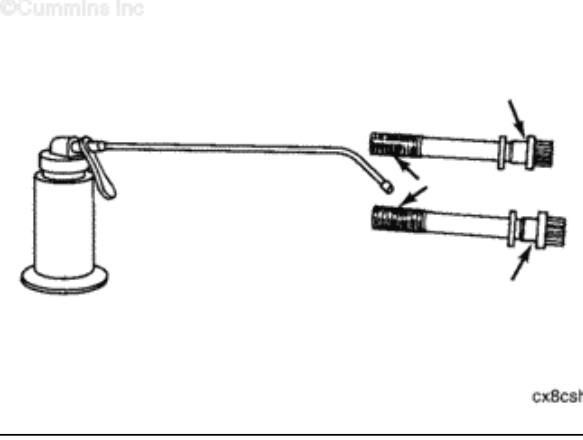
The connecting rods and connecting rod caps are not interchangeable. The connecting rods and the connecting rod caps are machined as an assembly. Damage to the engine will result if they are mixed.

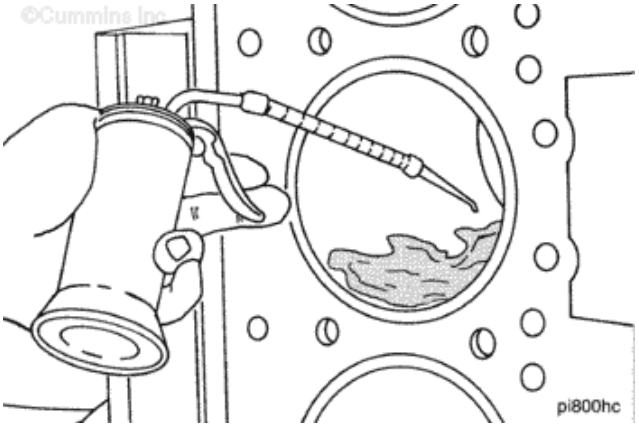
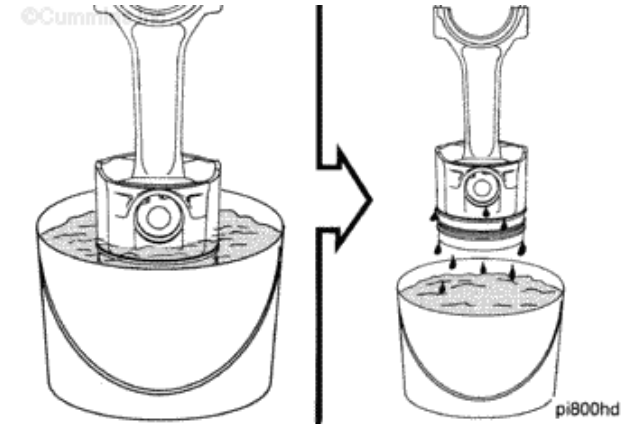
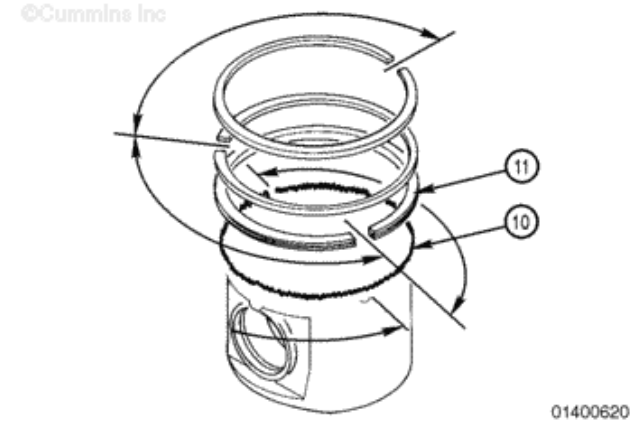
Install the lower bearing shell in the connecting rod cap. Be sure the tang of the bearing shell is in the slot of the connecting rod cap and the end of the bearing is even with the connecting rod cap surface.



Use clean lubricating oil to lubricate the connecting rod capscrews and washers as shown.

Install the washers and capscrews in the connecting rod caps.



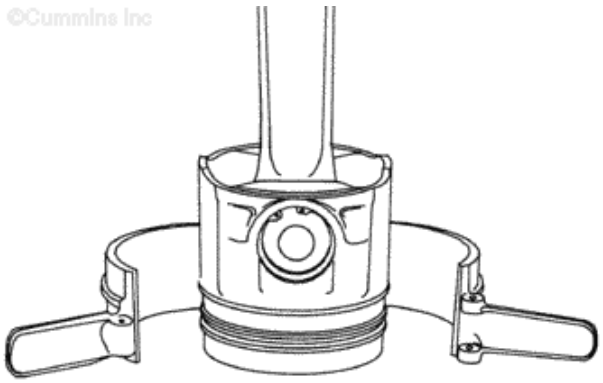
Lubricate the cylinder liner with clean engine oil. The entire bore **must** be lubricated.		
Immerse the piston in engine oil until the rings are covered. Allow the excess oil to drip off the assembly.		
Make sure the piston ring gap position is still correct.		

CAUTION

To reduce the possibility of engine damage, make sure the piston rings fit correctly in the piston.

Use a piston ring compressor, Part Number 3375342, or equivalent. Install the ring compressor on the piston.

NOTE: The ring compressor has a tapered bore. The small end of the taper must be positioned toward the piston skirt.

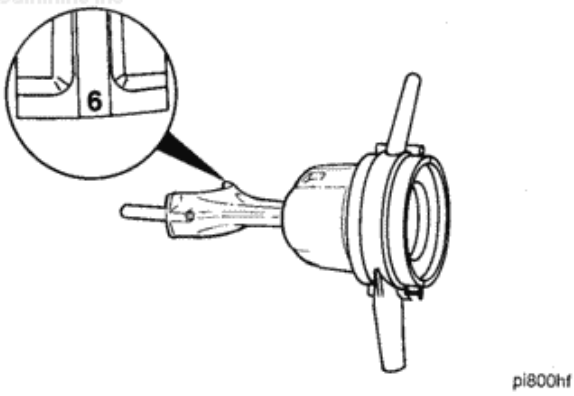


CAUTION

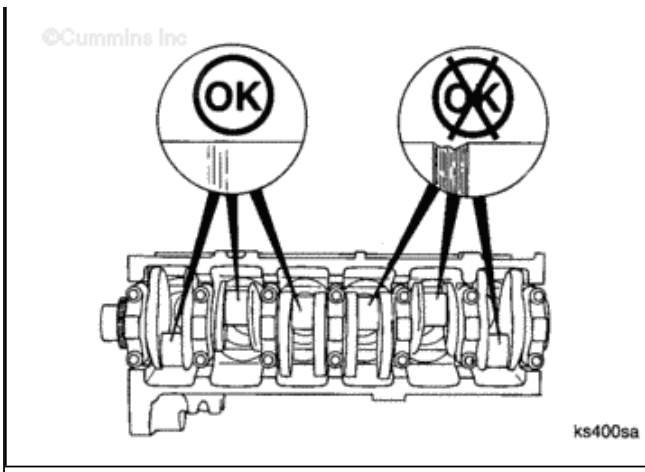
To reduce the possibility of engine damage, the cylinder number on the connecting rod and connecting rod cap must be the same and the side of the connecting rod with the cylinder number (bearing tang side) must be toward the camshaft.

Rotate the crankshaft until the journal for the rod being installed is at bottom dead center (BDC).

NOTE: If the engine has a crankshaft with bolt-on counterweights, the journal must be at top dead center (TDC).

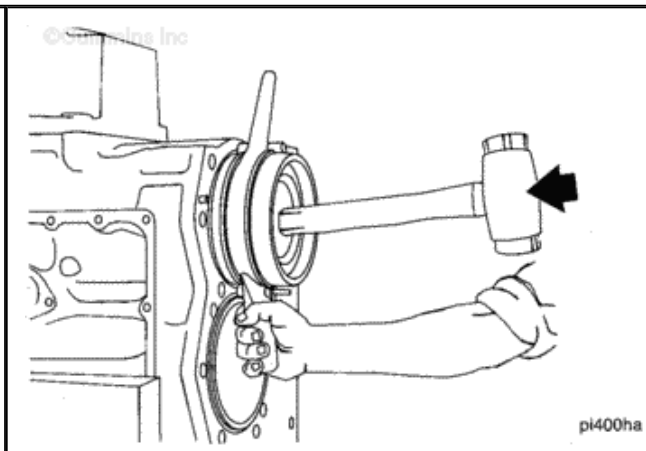


Check the crankshaft rod journals for damage.



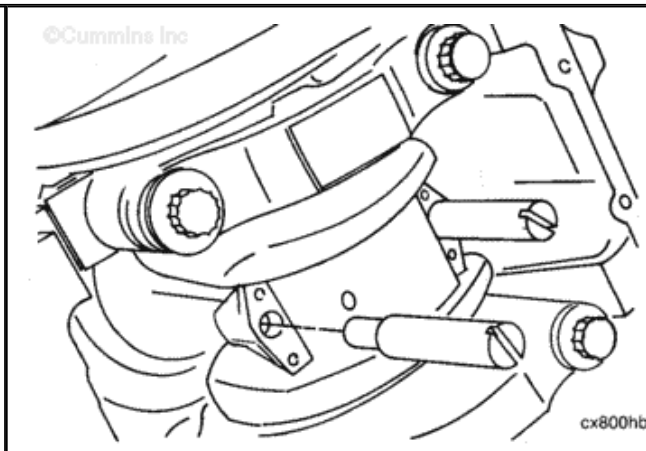
Install the connecting rod and piston until the ring compressor touches the block. Align the rod with the crankshaft journal.

Hold the ring compressor firmly against the block. Use a wooden hammer handle to push the piston into the liner.



Push the piston into the bore until the rod bearing contacts the crankshaft journal.

Remove the guide pins.



CAUTION

To reduce the possibility of engine damage, the cylinder number on the connecting rod and connecting rod cap must be the same and the side of the connecting rod with the cylinder number (bearing tang side) must be toward the camshaft.

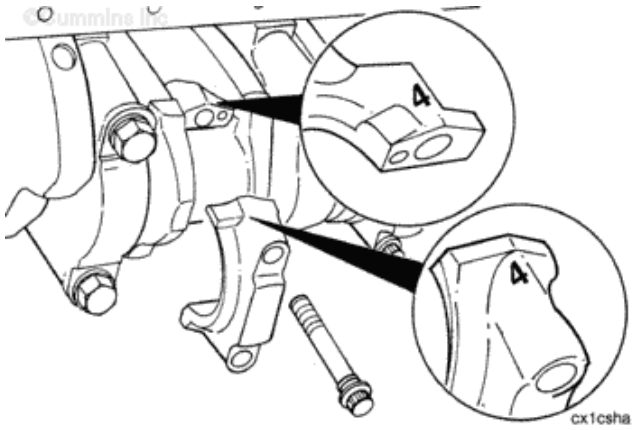
Install the connecting rod cap.

Tighten the capscrews alternately and evenly to pull the cap over the dowel pins. Use the following steps to tighten the capscrews.

Torque Value:

1. 102 n.m [75 ft-lb]
2. 197 n.m [145 ft-lb]
3. 292 n.m [215 ft-lb]
4. 366 n.m [270 ft-lb]
5. Loosen both capscrews to remove all tension.
6. 102 n.m [75 ft-lb]
7. 149 n.m [110 ft-lb]

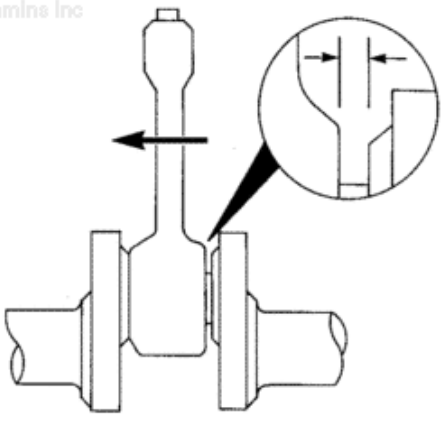
Plus 90° to achieve correct bolt stretch.



Check the side clearance between the rod and the crankshaft. The rod **must** move freely from side-to-side.

Measurements over 0.51 mm [0.020 in] **must** be measured with a dial indicator.

If the side clearance is greater than 0.51 mm [0.020 in], do **not** reuse the parts, unless the same connecting rod is used on the same crankshaft journal in the same engine. If the parts are reused on the same crankshaft



connecting rod journal in the same engine, the maximum allowable side clearance, measured with a dial indicator, is 5.08 mm [0.200 in].

Connecting Rod and Crankshaft Side Clearance, New or Remanufactured Parts

mm		in
0.20	MIN	0.008
0.35	MAX	0.014

Connecting Rod and Crankshaft Clearance, Used Parts

mm		in
0.51	MAX	0.020

Connecting Rod and Crankshaft Clearance, Same Connecting Rod and Crankshaft Reused on Same Journal of Crankshaft

mm		in
5.08	MAX	0.200

Last Modified: 10-Dec-2010

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016-006 Flywheel Housing

Install

WARNING

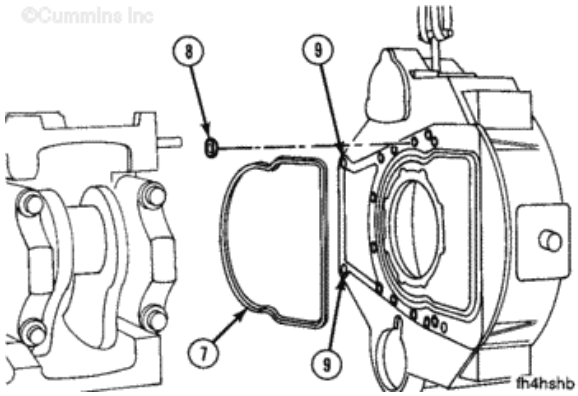
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance when lifting this component.

Make sure the flywheel housing dowels are installed in the block.

Install the sealing ring (7) in the groove on the housing. If a wet type is used, install the seals (8) in the counterbores as shown. The holes (9) do **not** require seals.

Use guide bolts to help during alignment.

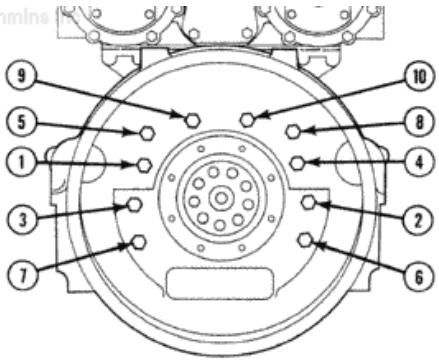
Install the housing and the capscrews.



Tighten the flywheel housing capscrews using the sequence shown.

Torque Value: Step 1 100 n.m [75 ft-lb]

Step 2 205 n.m [150 ft-lb]



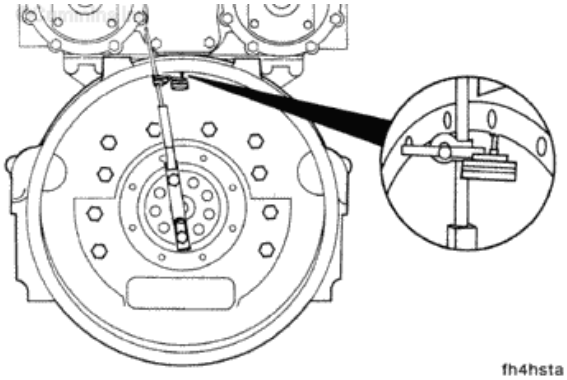
Measure the flywheel housing alignment.

The bore and the face of the housing **must** be in alignment with the

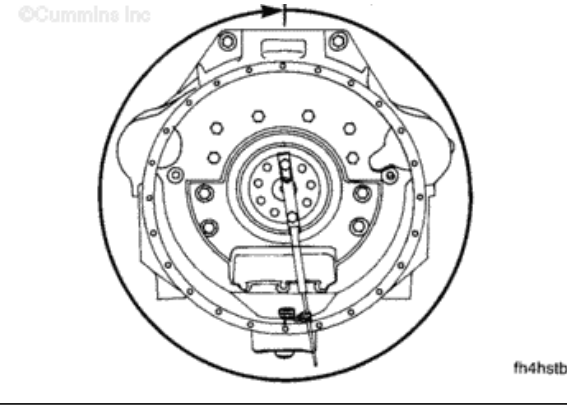
crankshaft.

The indicator arm **must** be rigid for an accurate reading. It **must not** sag.

Attach an indicator to the crankshaft as shown.

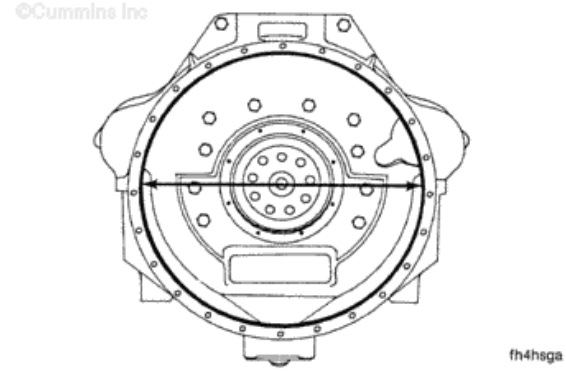


Position the indicator at the 12 o'clock position. Adjust the dial until the needle points to zero. Rotate the crankshaft one complete revolution (360 degrees). Record the total indicator runout.



The maximum allowable total indicator runout depends on the diameter of the bore.

Bore Diameter Maximum Total Indicator Runout		
SAE Number	**Size**	**Minimum/Maximum**
00	0.30 mm [0.012 in]	787.4 to 810.5 mm [31.00 to 31.91 in]
0	0.25 mm [0.010 in]	647.7 to 648.0 mm [25.50 to 25.51 in]
½	0.25 mm [0.010 in]	584.2 to 584.4 mm [23.00 to 23.008 in]
1	0.20 mm [0.008 in]	511.2 to 511.3 mm [20.125 to 20.13 in]

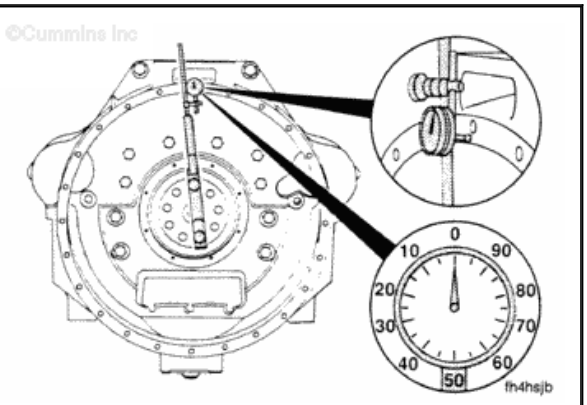


If the alignment is **not** within specifications and the bore is round, the housing can be shifted.

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.

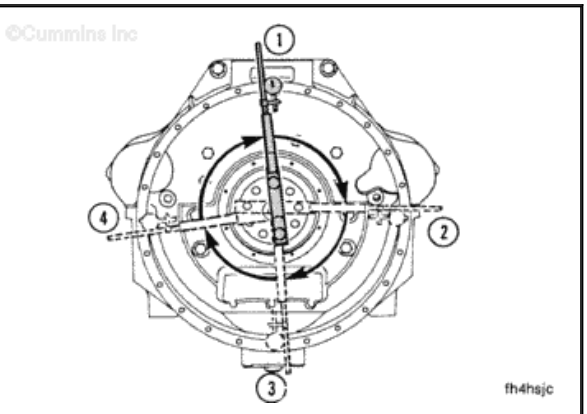


Record the indicator reading at three different points; 3 o'clock, 6 o'clock, and 9 o'clock.

Turn backward to the original position. Be sure the needle still points to zero. Determine the total indicator runout.

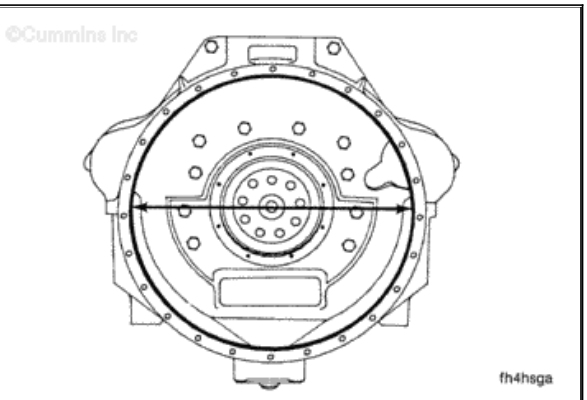
Example:

3 o'clock 0.00 mm [0.00 in] + 6 o'clock +0.08 mm [+0.003 in] + 9 o'clock -0.05 mm [-0.002 in] = 0.13 mm [0.005 in] total indicator runout.



The maximum allowable total indicator runout depends on the diameter of the bore.

Bore Diameter Maximum Total Indicator Runout		
SAE Number	**Size**	**Minimum/Maximum**
00	0.30 mm [0.012 in]	787.4 to 810.5 mm [31.00 to 31.91 in]
0	0.25 mm [0.010 in]	647.7 to 648.0 mm [25.50 to 25.51 in]



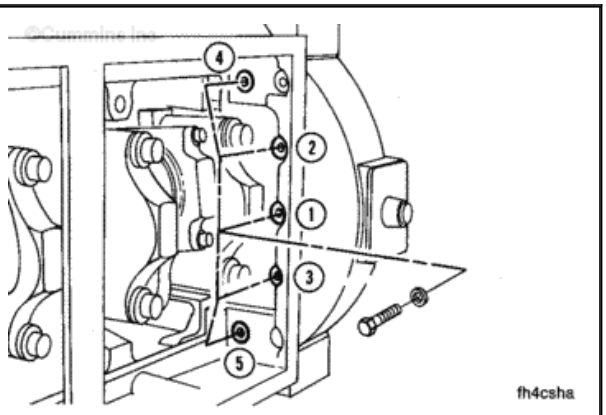
½	0.25 mm [0.010 in]	584.2 to 584.4 mm [23.00 to 23.008 in]
1	0.20 mm [0.008 in]	511.2 to 511.3 mm [20.125 to 20.13 in]

If the alignment is **not** within specifications, remove the housing. Check for nicks, burrs, or foreign material between the block and the housing. Check the alignment again. If the alignment is **not** within specifications, the block or the housing is **not** machined correctly.

Tighten the five [3/8-inch] washers and capscrews in the sequence shown.

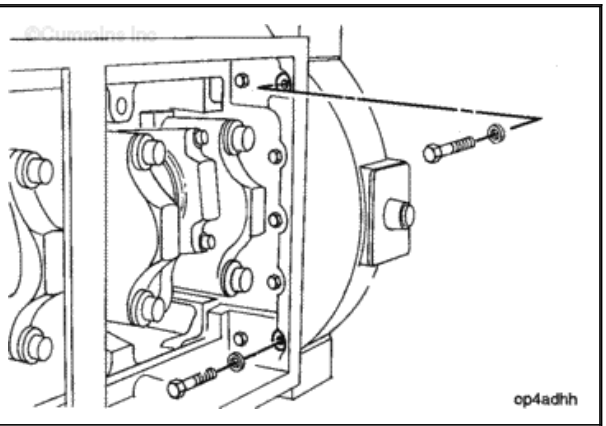
Torque Value:

Step 1	25 n.m	[20 ft-lb]
Step 2	40 n.m	[30 ft-lb]
Step 3	45 n.m	[35 ft-lb]



Install the two [7/16-inch] washers and capscrews as shown. Tighten the capscrews.

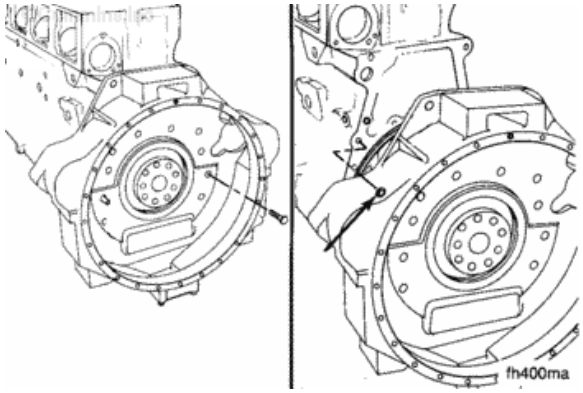
Torque Value: 65 n.m [50 ft-lb]



Install the flywheel housing mounting capscrews.

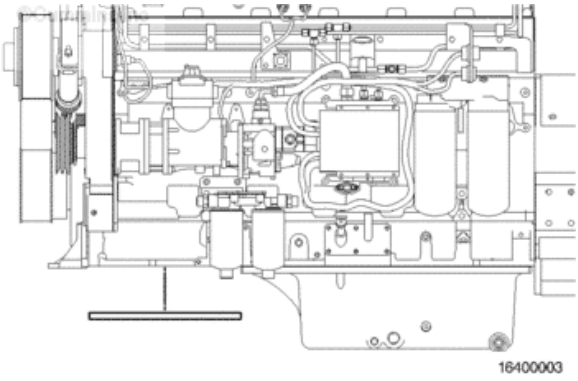
Tighten the capscrews.

Torque Value: 205 n.m [150 ft-lb]



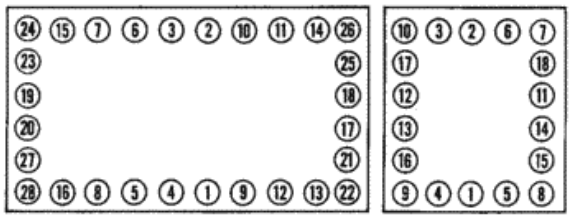
Gasket cement will prevent the gasket from sealing properly. Use a contact adhesive, such as 3M Spray 77 or 3M 1463, to hold the gasket in position.

Install the gasket, oil plate (or sump), washers, and capscrews.



Tighten the capscrews in the sequence shown.

Torque Value: 45 n.m [35 ft-lb]



Last Modified: 29-Nov-2004

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009-023 Rear Gear Drive (Lower Assembly)

Install

NOTE: If an SAE 1 flywheel housing option is used, there must be two [5/8-11 x 6 1/2 in] studs, Part Number 3065777, installed in the upper holes of the cylinder block.

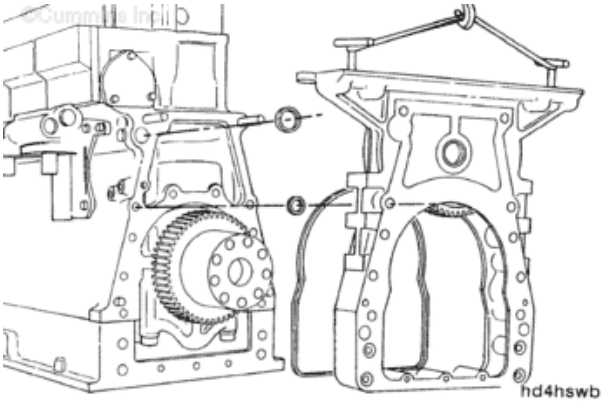
Apply a small amount of Lubriplate® 105 or gasket adhesive on the seal ring groove, the capscrew counterbores, and the dowel counterbores on the block side of the lower housing.

Install the new rectangular seal ring, with the joint at the top into the groove in the lower housing.

Install the ten new capscrew seals into the capscrew counterbores in the lower housing.

Use Lubriplate® 105 or equivalent on the main rifle seal.

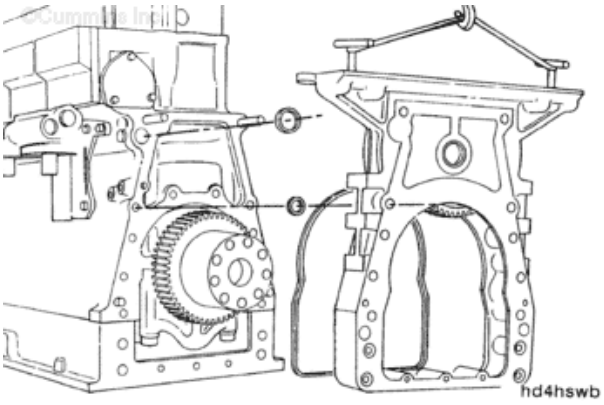
Install the main rifle seal into the counterbore surrounding the main rifle drilling.



WARNING

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

Install two 5/8-11 x 1/2 inch guide studs into the rear face of the cylinder block. Use a hoist, two tee handles, and a lifting



sling. Install the tee handles.

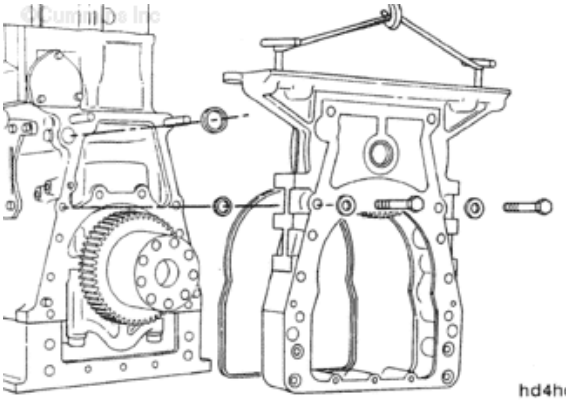
Lift the lower housing of the rear gear train.

Install the lower housing of the rear gear train onto the dowel pins.

Check the alignment of all capscrews seals, rectangular seal, and the main oil rifle seal.

Use two 5/8-11 x 5 inch capscrews with flat washers in the locations shown.

Tighten the capscrews alternately to pull the lower housing to the block.



Use a dial indicator. Be sure the two capscrews are holding the lower housing firmly against the cylinder block. Check the gear lash.

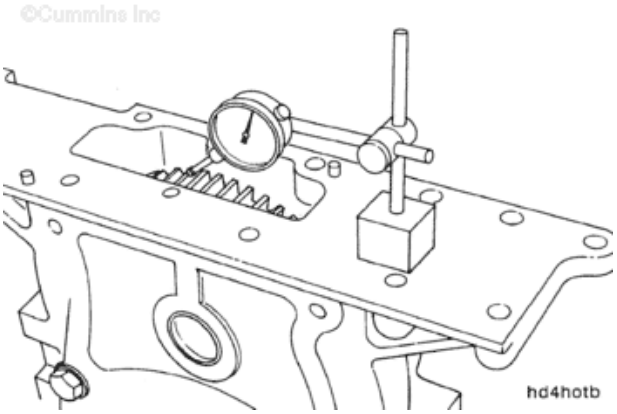
Lower Housing-To-Cylinder Block Gear Backlash

mm		in
0.05	MIN	0.002
0.51	MAX	0.015

If the gear lash is above acceptable limits, the rear gear train lower idler gear or crankshaft gear **must** be replaced.

NOTE: Replace the idler gear first.

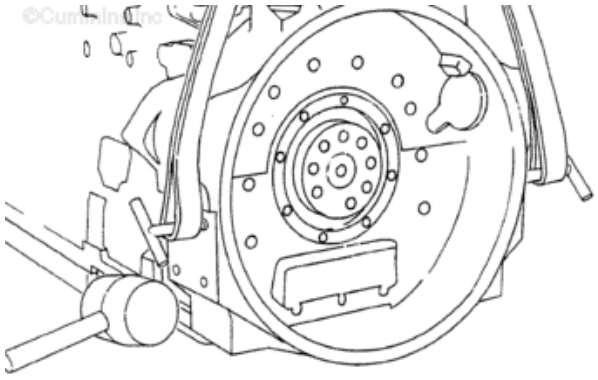
If the gear lash is below acceptable limits (or if the gear replacement does **not** correct the lash), replace the housing.



Use Lubriplate® 105 or gasket adhesive on the seal ring groove and the 10 capscrew counterbores on the rear gear train lower housing side of the flywheel housing.

Install the new rectangular seal ring, with the joint at the top, into the groove in the flywheel housing.

Install the new capscrew seals and dowel seals into the counterbores in the lower housing.

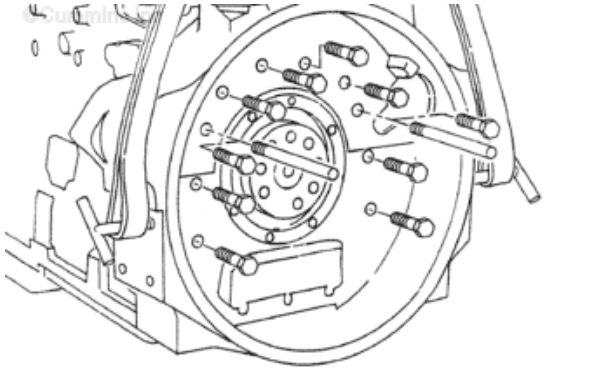


WARNING

The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to life the component.

Use two 5/8-11x6 1/2 inch guide studs. Use a hoist, tee handles, and a lifting sling. Install the flywheel housing onto the dowels in the rear gear train lower housing.

Install the lock washers, capscrews, and nuts.

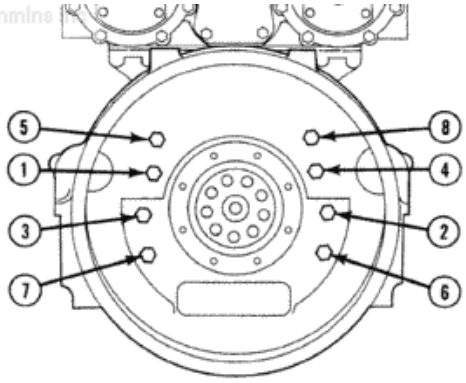


Use the following steps.

Tighten using the sequence shown.

Torque Value: Step 1 100 n.m [75 ft-lb]

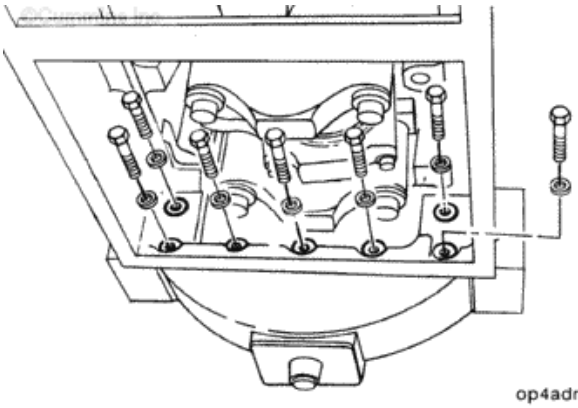
Step 2 205 n.m [150 ft-lb]



Install the two capscrews 7/16-

14 x 4 3/4 inch, Part Number 190799, and the five capscrews 3/8-16 x 4 3/4 inch, Part Number S106-C, with flat washers and lock washers.

3/8-16 inch	45 n.m	[35 ft-lb]
7/16-14 inch	65 n.m	[50 ft-lb]



Last Modified: 10-Dec-2004

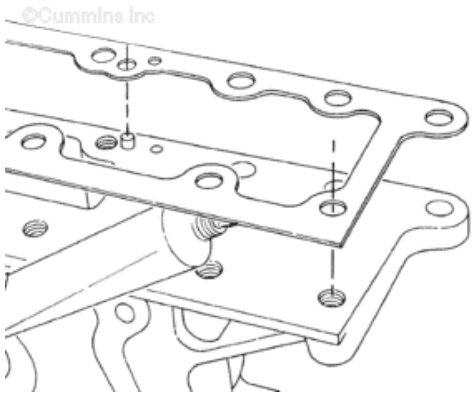
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009-024 Rear Gear Drive (Upper Assembly)

Install

Use gasket adhesive on the gasket. Do **not** use an excessive amount of adhesive on the gasket.

Align and install the rear gear train upper housing gasket to the rear gear train lower housing.

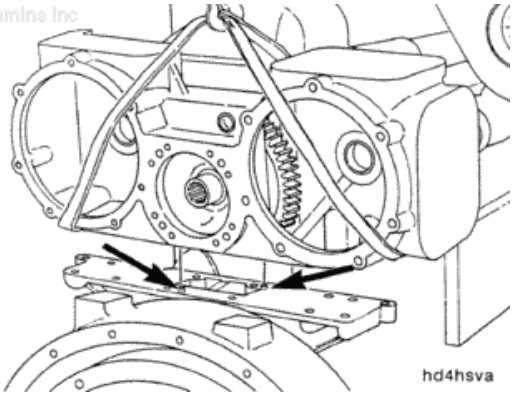


WARNING

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

NOTE: Use extra care when aligning the upper housing onto the lower housing to prevent gasket damage.

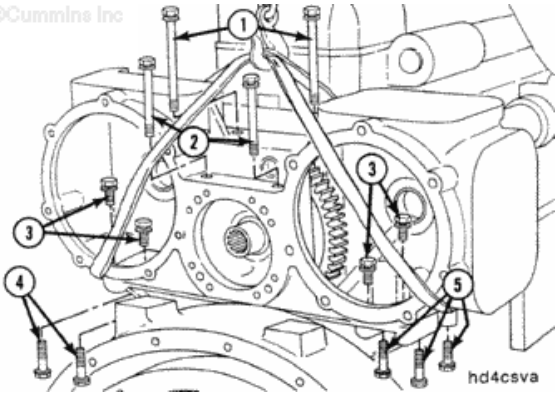
Use the dowel pins to align the upper housing onto the lower housing.



Use **only** SAE Grade 8 capscrews to install the upper housing. Install the following capscrews according to the table below.

Reference	Location	Size	Quantity
1	Top-Front	½-13 x 9¼	2

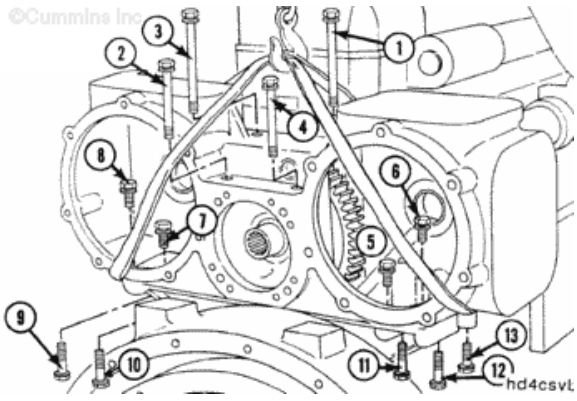
		in	
2	Top-Rear	½-13 x 7½ in	2
3	Internal	½ - 13 x 1¼ in	4
4	Bottom-Left Side	½-13 x 1¾ in	2
5	Bottom-Right Side	½-13 x 1¾ in	3



Tighten the capscrews in the sequence shown in the illustration the graphic.

Torque Value: Step 1 70 n.m [50 ft-lb]

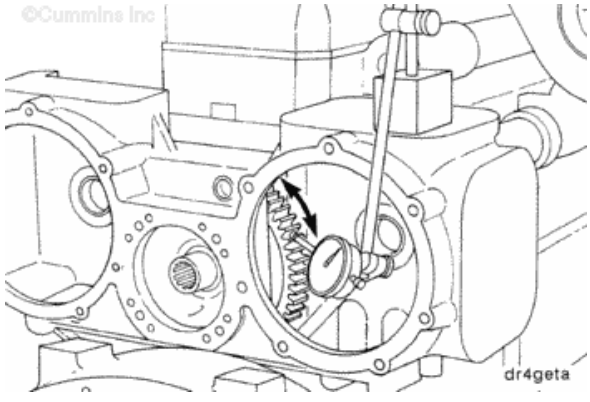
Step 2 150 n.m [110 ft-lb]



Make sure the lower idler gear is secure. If the gear is **not** secure, the indicator reading includes the lower idler gear to the crankshaft gear backlash.

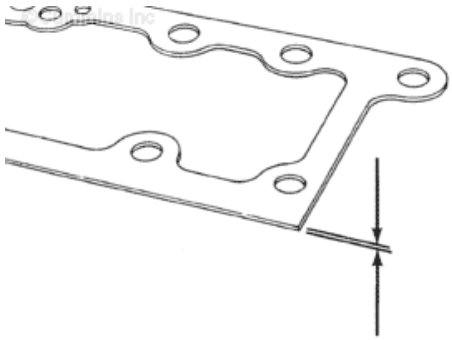
Measure the backlash between the center drive gear and the lower idler gear with a dial indicator

Idler Gear Backlash		
mm		in
0.05	MIN	0.002
0.51	MAX	0.020



If the gear lash is less than the specified limits, thicker gaskets are available. Do **not** use more than two gaskets to correct the backlash.

If the gear lash is greater than the specification and the thinnest gasket is used, the upper and lower gears **must** be replaced.

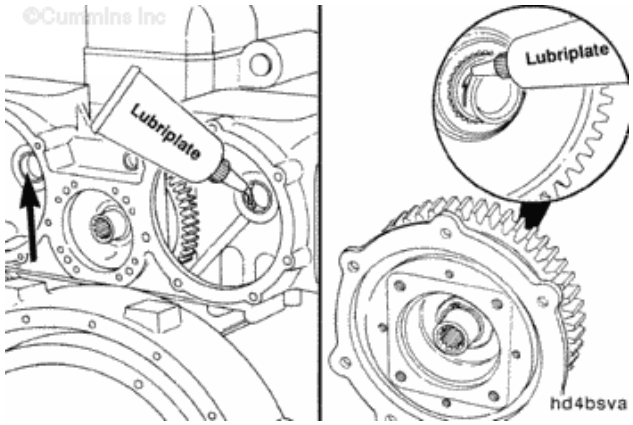
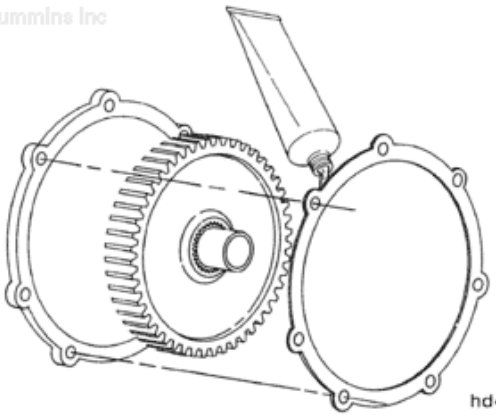


Last Modified: 10-Dec-2004

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009-036 Outer Hydraulic Pump Support Drive

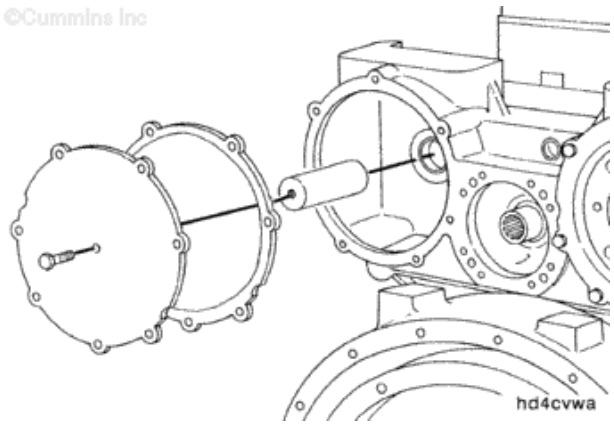
Install

Lubricate the outer hydraulic pump support bushings in the upper housing with Lubriplate® 105 or equivalent. Lubricate the bushing surfaces on both shafts in the outer hydraulic pump support drive assemblies.		
NOTE: Some engines will not have an outer hydraulic pump support drive. These engines require a cover plate and a non-splined shaft, but do not use a hydraulic gear. Apply a thin coat of gasket adhesive to the gaskets. Install the hydraulic support housing gaskets to both support mounting flanges on the outer hydraulic pump support drive assemblies.		
If using the outer hydraulic pump support cover plate, install the non-splined shaft onto the cover plate with a 3/8-16 x 1¼ inch capscrew. Tighten the capscrew.		

Torque
Value: 40 n.m [30 ft-lb]

Install the cover plate assembly and capscrews.

Tighten the capscrews.

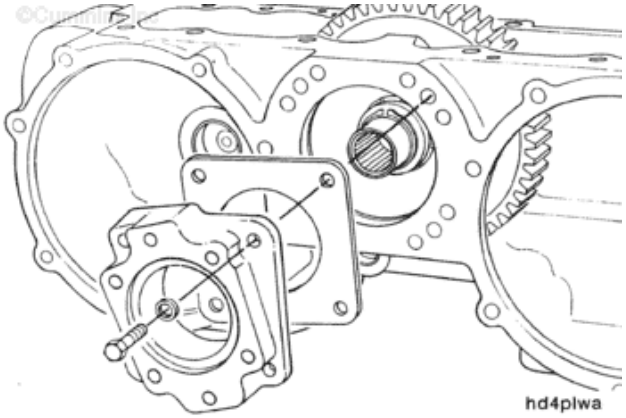


WARNING

This component weighs 23 kg [50 lb] or more. Tor reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Install three 7/16 - 14 x 4 guide studs.

Install one outer hydraulic pump support drive assembly.



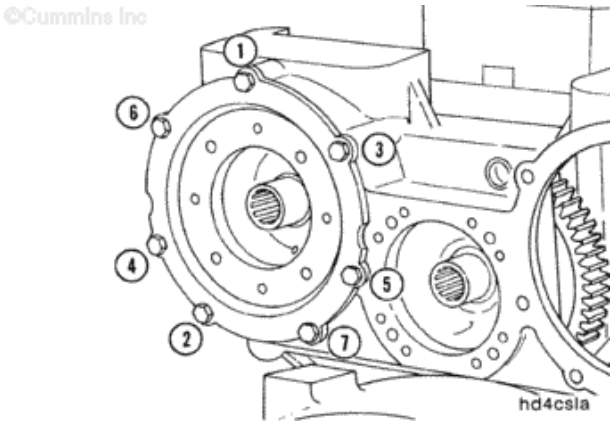
Install four capscrews.

Hand tighten the capscrews.

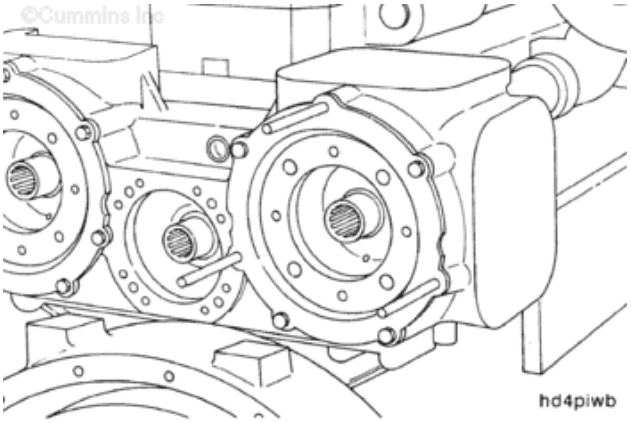
Install the remaining three capscrews.

Tighten the capscrews in sequence.

Torque
Value: 70 n.m [50 ft-lb]



Use the same procedure to install the remaining outer hydraulic drive assembly.



Last Modified: 11-Nov-2004

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007-027 Lubricating Oil Pan Adapter

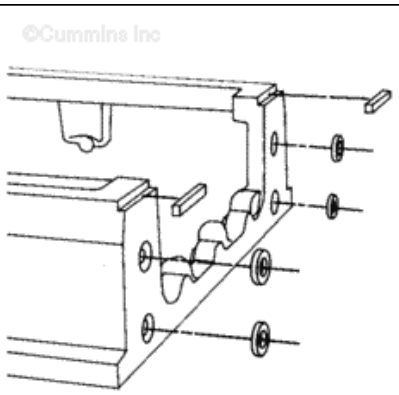
Install

Apply contact adhesive, such as 3M Spray 77 or 3M 4693, to the capscrew seals to hold them in position.

Install the four capscrew seals onto the lubricating oil pan adapter.

Use Cummins® sealant, Part Number 3823494, or equivalent on the oil pan adapter to hold the two rectangular seals in place before installing the seals on the oil pan adapter.

After the seals are in place, wipe off any excess sealant to keep the sealant out of the lubricating oil system.

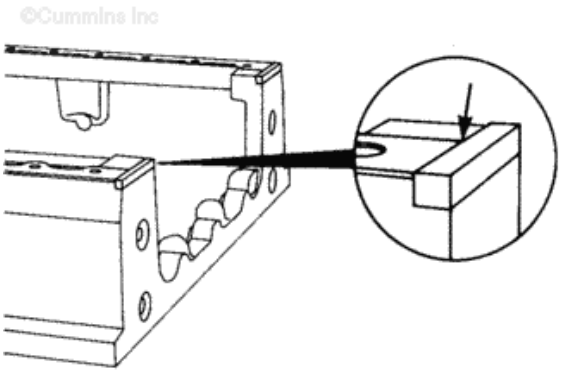


CAUTION

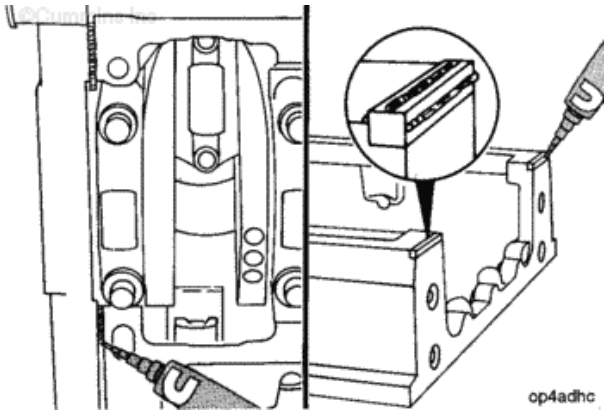
Do not use gasket cement. Gasket cement will prevent the gasket from sealing properly.

Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the pan adapter gasket to the pan adapter. Do **not** use the 3M Spray 77 or 3M 4693 adhesive on the rectangular seals.

Install the gasket onto the oil pan adapter. The flywheel end of the gasket **must** touch the rectangular seals as shown.



Apply sealant, Part Number 3164067, as illustrated in the graphic.



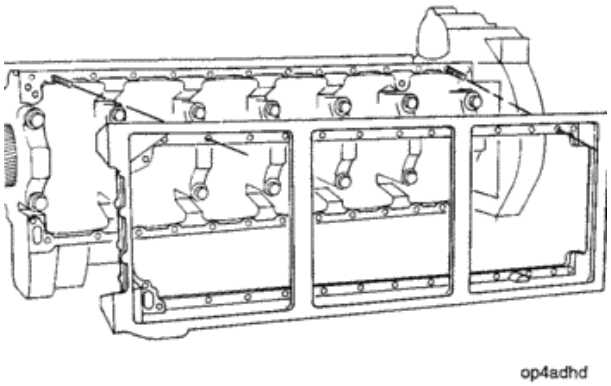
WARNING

This component weighs 23 kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Be sure to check the rectangular seal after the adapter has been set into place, and again when the adapter is tight. Seals **must** be checked prior to the sealant curing.

Position the oil pan adapter against the cylinder block and then move it back until it contacts the flywheel housing.

Install capscrews at the four corners of the oil pan adapter and hand-tighten.



The four capscrews shown in the graphic **must** be tightened alternately and evenly to make sure the adapter is pulled evenly to the block and flywheel housing.

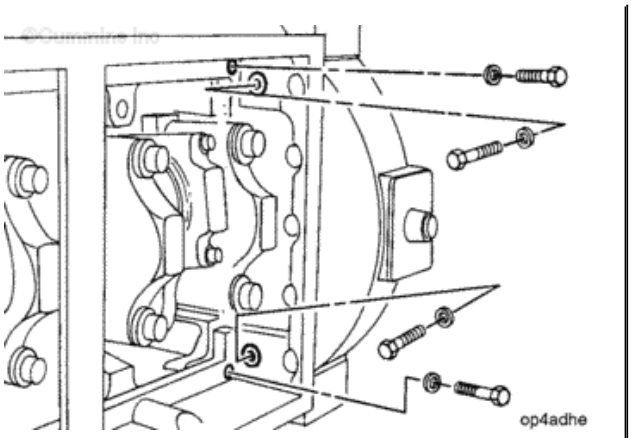
Install the four washers and capscrews.

Push the lubrication oil pan adapter towards the flywheel housing when tightening the

capscrews.

Tighten the capscrews.

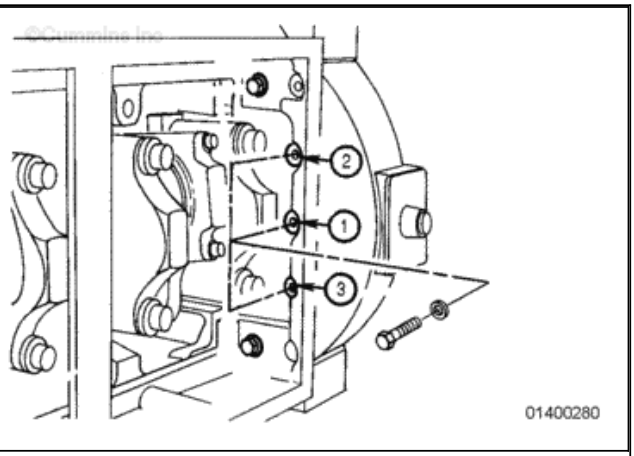
Torque Value:	Step 1	15 n.m [120 in-lb]
	Step 2	25 n.m [20 ft-lb]
	Step 3	40 n.m [30 ft-lb]
	Step 4	45 n.m [33 ft-lb]



Install the three capscrews located in the center of the flywheel housing.

Tighten the capscrews in the sequence illustrated in the graphic.

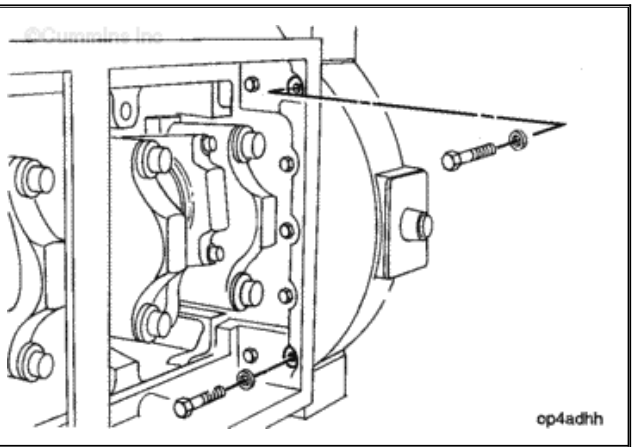
Torque Value:	Step 1	25 n.m [20 ft-lb]
	Step 2	40 n.m [30 ft-lb]
	Step 3	45 n.m [33 ft-lb]



Install the two 7/16-inch washers and capscrews illustrated in the graphic.

Tighten the capscrews.

Torque Value: 65 n.m [50 ft-lb]



Capscrews (24) through (28) thread into the front cover.

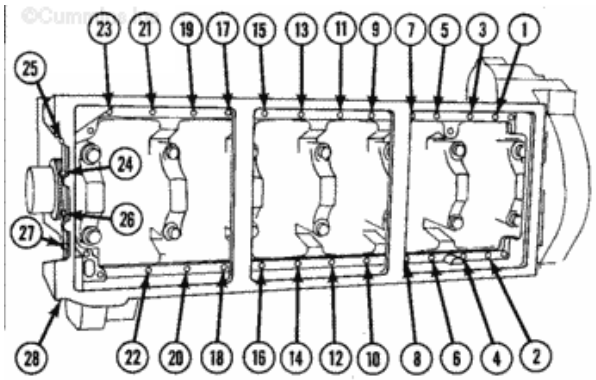
Install capscrews (24) through

(28).

Install the 3/8-inch capscrews (1) through (23).

Tighten the capscrews.

Capscrews (1) through (23)	60 n.m	[45 ft-lb]
Capscrews (24) through (28)	45 n.m	[33 ft-lb]

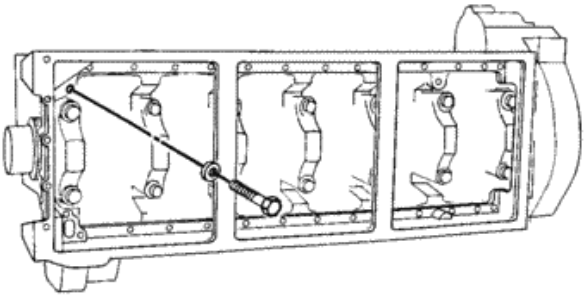


op4adhg

Install the 9/16-inch washer and capscrew.

Tighten the capscrew.

Torque Value: 150 n.m [110 ft-lb]


op4adhi

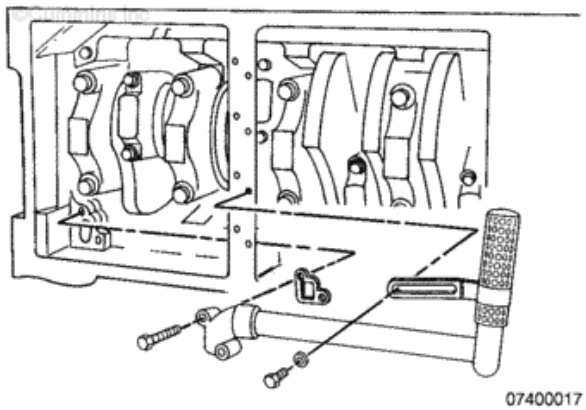
Install the gasket, oil pan suction tube, and capscrews.

Tighten the capscrews.

Torque Value: 60 n.m [45 ft-lb]

Tighten the clamp capscrew.

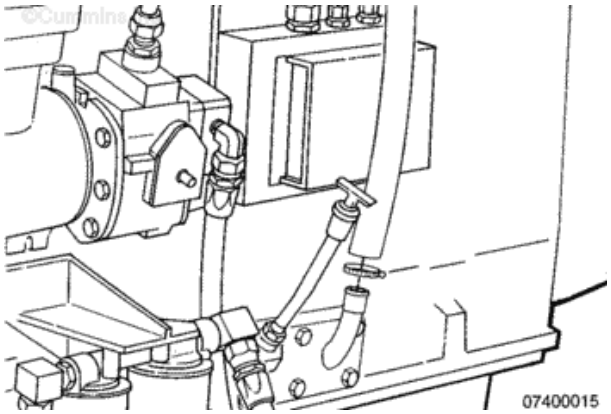
Torque Value: 35 n.m [25 ft-lb]


07400017

Install the breather vent hose onto the handhole cover.

Tighten the hose clamp.

Torque Value: 15 n.m [132 in-lb]



Last Modified: 24-Oct-2006

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007-026 Lubricating Oil Pan Adapter Cover Plate

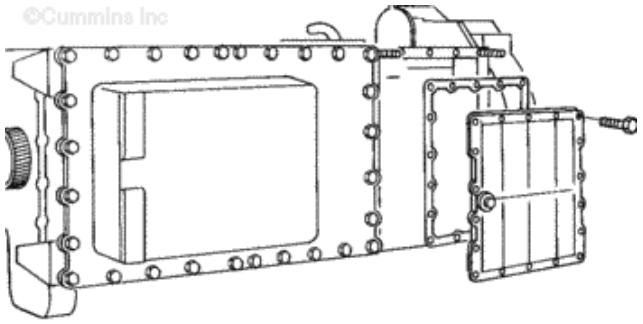
Install

CAUTION

Do not use gasket cement. Gasket cement will prevent the gasket from sealing properly.

Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the gasket in position.

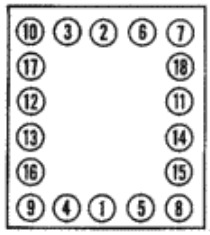
Install the gasket and lubricating oil pan adapter cover plate.



Install the capscrews.

Tighten the capscrews in sequence.

Torque
Value: 45 n.m [33 ft-lb]



Last Modified: 20-Dec-2004

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007-025 Lubricating Oil Pan

Install

All Applications Except Rail

WARNING

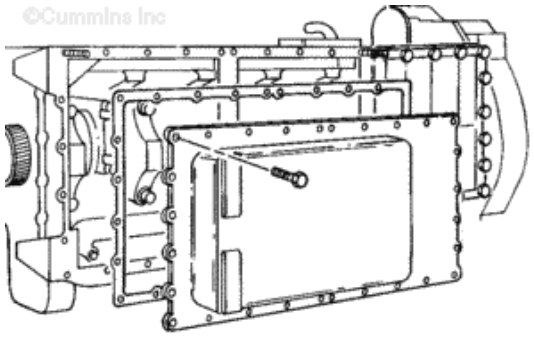
The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component.

CAUTION

Gasket cement will prevent the gasket from sealing properly.

Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the gasket in position.

Install the gaskets and lubricating oil pan.

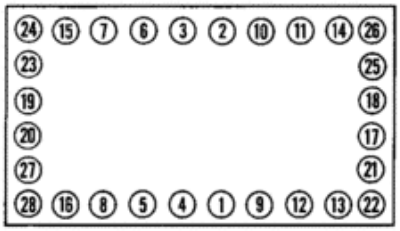


07400008

Install the capscrews.

Tighten the capscrews in sequence.

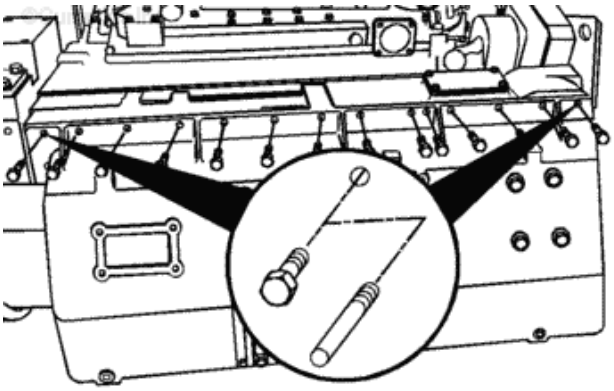
Torque
Value: 45 n.m [33 ft-lb]



07400009

Rail Applications

Install two 3/8 - 16 guide studs in the top row of capscrew holes.



WARNING

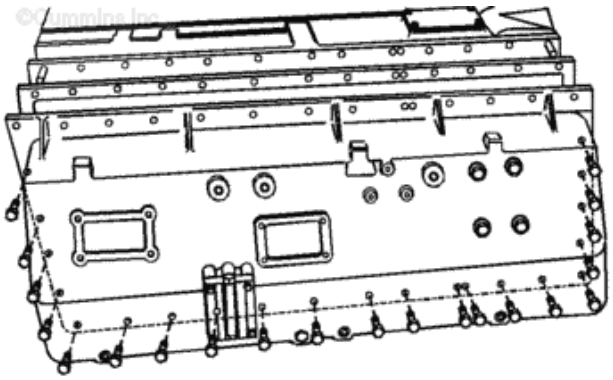
The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component.

CAUTION

Gasket cement will prevent the gasket from sealing properly.

Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the gasket in position.

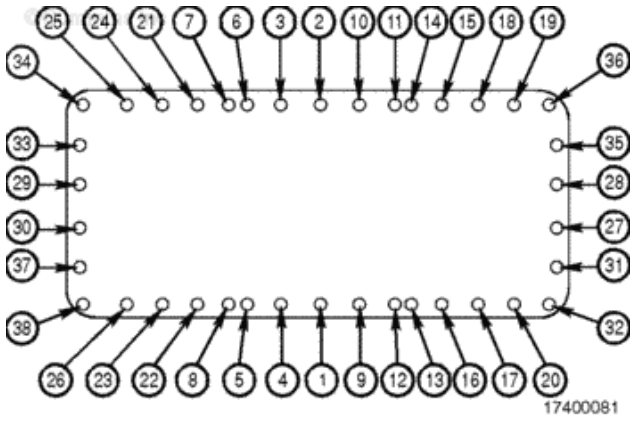
Install the gasket and lubricating oil pan.



Install the 38 capscrews.

Tighten the capscrews in the sequence shown.

Torque
Value: 45 n.m [33 ft-lb]



Last Modified: 08-Dec-2004

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001-067 Crankshaft Wear Sleeve, Rear

Install

CAUTION

Do not remove the seal from the wear sleeve. If the seal is removed from the wear sleeve it can be damaged during the installation process.

CAUTION

The wear sleeve and the seal must be installed simultaneously using a special tool. Attempting to install the assembly without the tool will result in failure of the seal and an oil leak.

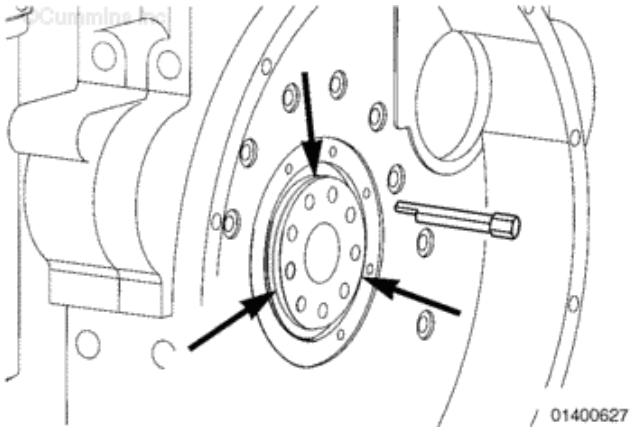
Install the seal and wear sleeve assembly into the mandrel.

Position the installation tool onto the crankshaft.

Install the capscrews.

Tighten the capscrews alternately approximately ½-turn at a time until the tool touches the gear cover.

Remove the installation tool.



Last Modified: 24-Sep-2004

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001-024 Crankshaft Seal, Rear

Install

Standard

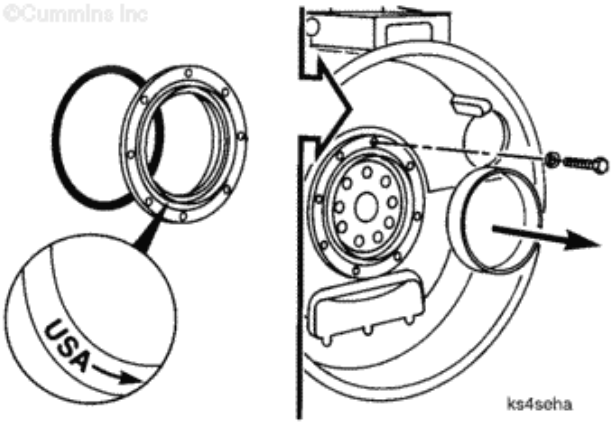
CAUTION

Do not lubricate the crankshaft or the seal lip. If the lip is exposed to oil to early, the risk of seal failure is increased.

Place the installation sleeve that comes with the seal onto the crankshaft.

Postion the seal as shown in the graphic and push the seal onto the crankshaft.

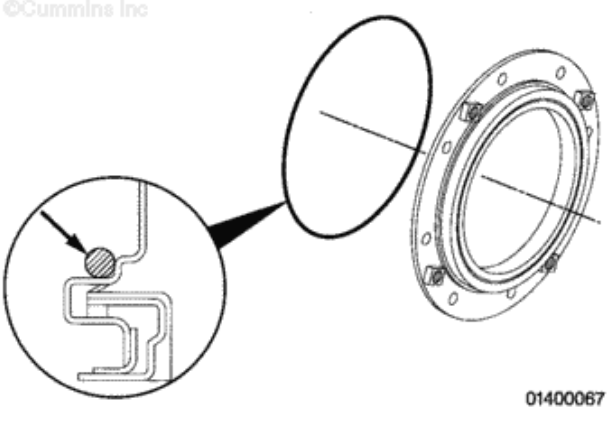
Remove the sleeve.



Non-REPTO Dry Unitized Seal

Install a new o-ring on the seal housing.

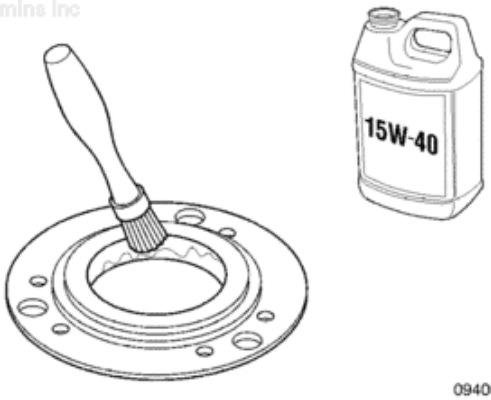
Lubricate the o-ring with vegetable oil.



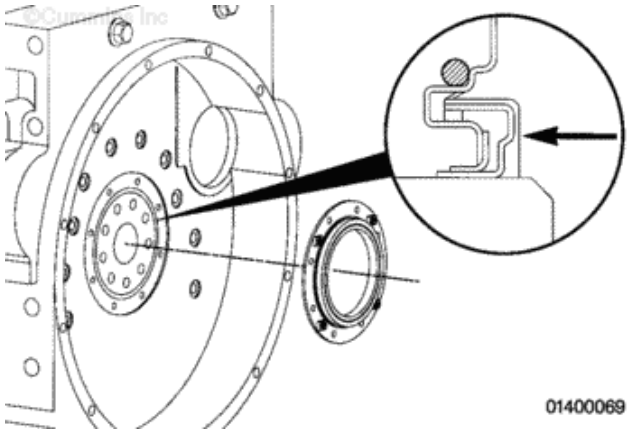
CAUTION

To reduce the possibility of damaging the sealing surfaces, do not allow oil to contact with any area other than the inside diameter of the seal case.

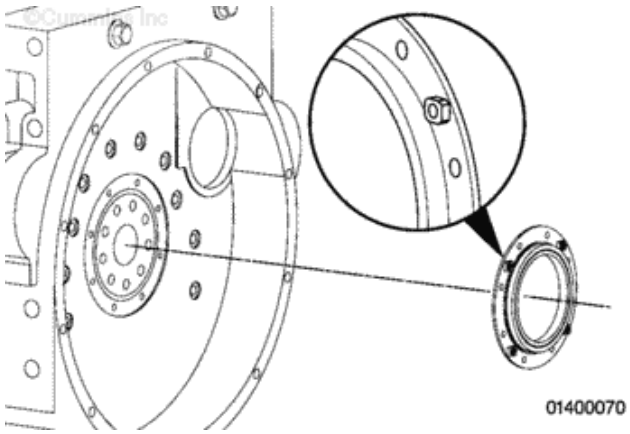
To aid in seal installation, use a small nonmetallic bristle brush to apply a thin film of 15W-40 oil to the inside diameter of the seal case.



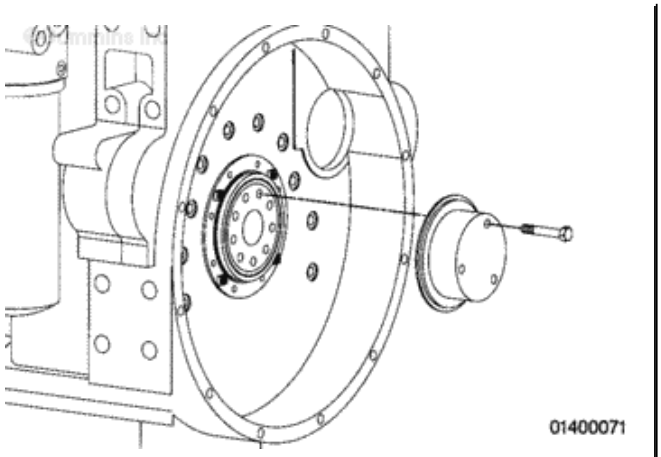
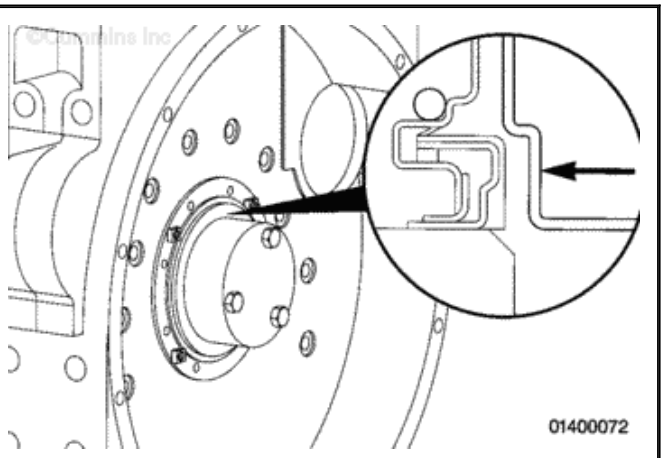
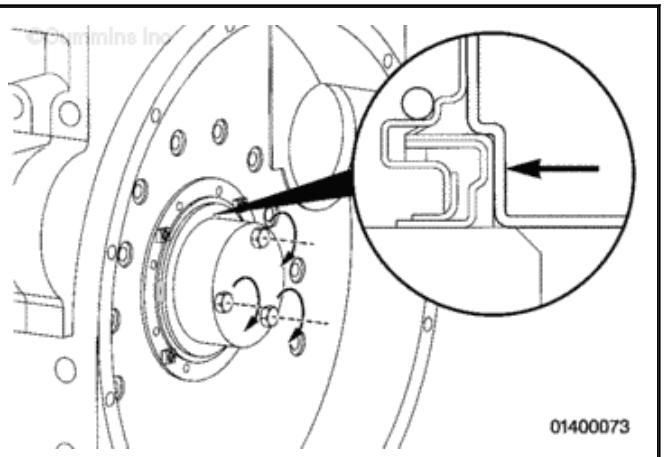
Use hand pressure to push the seal on the crankshaft as far as possible.

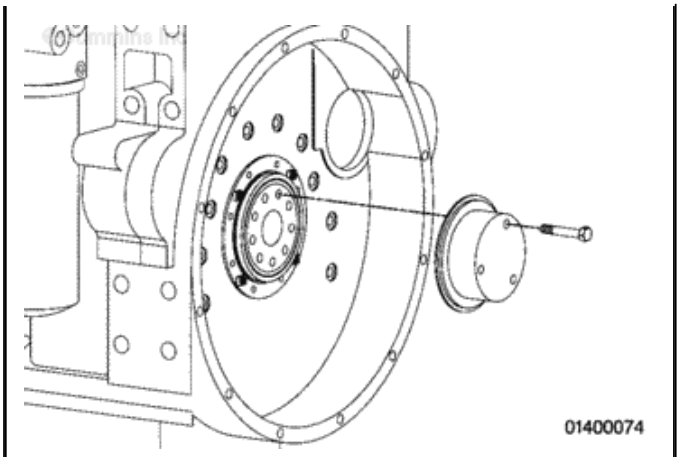


Use the pin supplied in the seal kit to align the seal mounting holes with the mounting capscrew holes in the flywheel housing.



Attach the seal installation tool that is supplied with the

seal, to the crankshaft, using three flywheel mounting capscrews.		
Align the installation tool with the pilot flange on the seal carrier.		
Tighten the three capscrews alternately in ½ turn increments until the seal carrier seats against the flywheel housing.		
Remove the seal installation tool.		



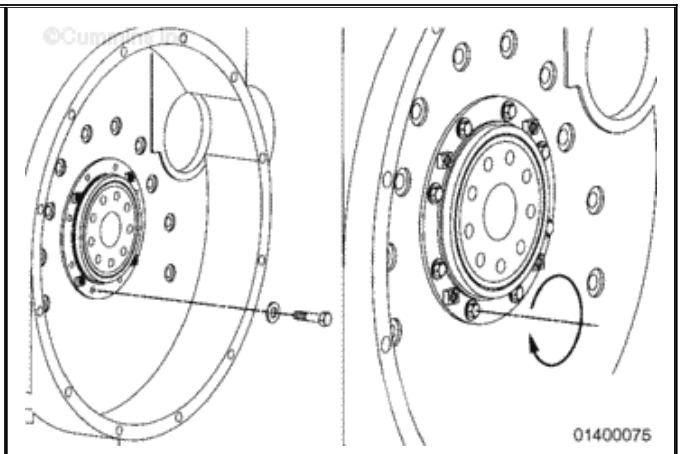
All Applications

Lubricate the threads of the capscrews with non-hardening sealant, Part Number 3375066.

Install the seal mounting capscrews.

Tighten the capscrews.

Torque
Value: 11 n.m [95 in-lb]



Last Modified: 29-Sep-2004

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001-025 Crankshaft Wear Sleeve, Front

Install

CAUTION

Do not remove the seal from the wear sleeve. If the seal is removed from the wear sleeve it can be damaged during the installation process.

CAUTION

The wear sleeve and the seal must be installed simultaneously using a special tool. Attempting to install the assembly without the tool will result in failure of the seal and an oil leak.

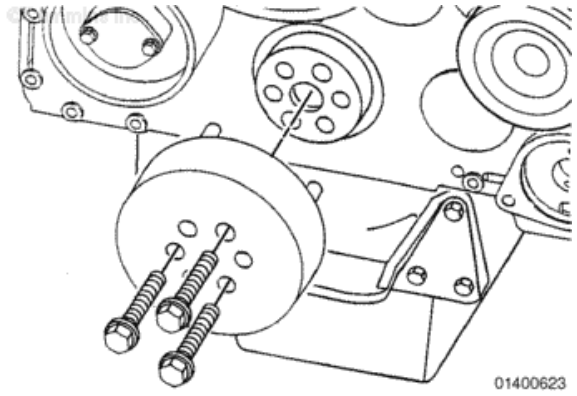
Insert the seal and wear sleeve assembly into the mandrel, Part Number 3824761.

Postion the mandrel onto the crankshaft.

Install the special puller capscrews, Part Number 3824762.

Tighten the capscrews alternately approximately ½-turn at a time until the tool touches the gear cover.

Remove the mandrel.



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001-023 Crankshaft Seal, Front

Install

Standard

CAUTION

Do not lubricate the seal or the crankshaft. The seal can fail prematurely if the seal lip is exposed to oil too soon.

CAUTION

Do not use a hammer to drive the tool. Damage to the threads will result. The tool can bind to the crankshaft because of narrow tolerances.

NOTE: If a wear sleeve needs to be installed the wear sleeve and seal is installed as an assembly. Refer to Procedure 001-025.

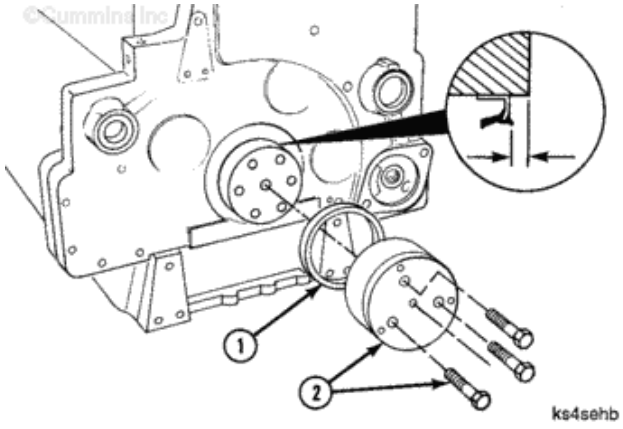
The standard seal contains a disposable expansion ring.

Place the expansion ring and seal over the end of the crankshaft.

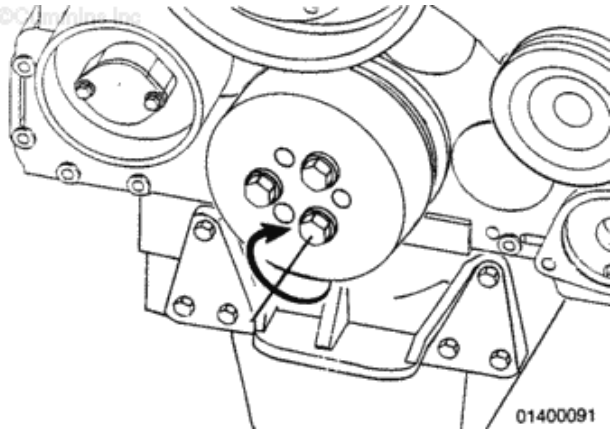
Use hand pressure to push the seal on the crankshaft as far as possible.

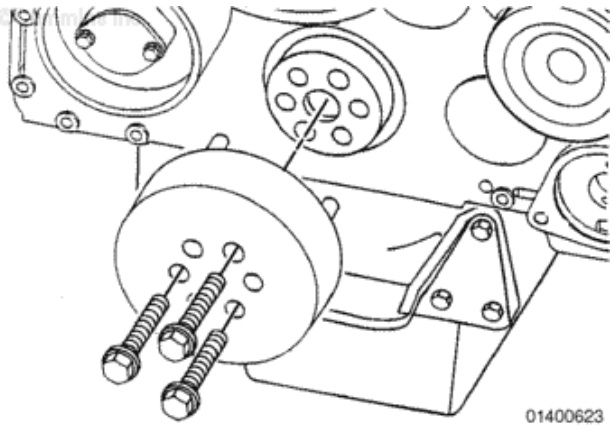
Remove and discard the expansion ring.

Place the mandrel, Part



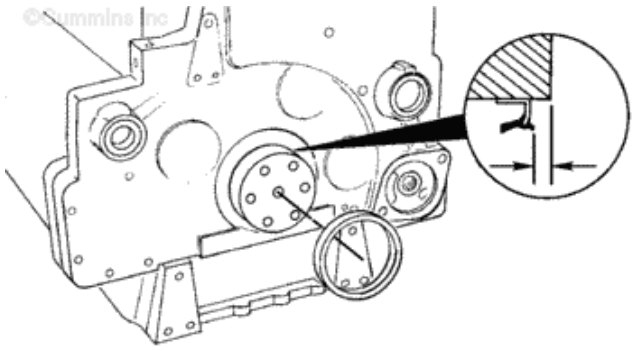
Number 3824761, from tool kit, Part Number 3824760, onto the crankshaft.		

CAUTION Do not continue to tighten the capscrews once the seal flange contacts the gear cover. Over-tightening will result in gear cover damage. Install three crankshaft mounting capscrews into the mandrel. Tighten the capscrew alternately and evenly in ½-turn increments until the seal flange contacts the gear cover.		

Remove the installation tool.		

POSE

Place the positive on shaft excluder (POSE) seal onto the crankshaft. Push the seal on the crankshaft until it rests against the seal case.		



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016-005 Flywheel

Install

WARNING

The flywheel mounting capscrews must be a minimum of SAE Grade 8 with rolled threads. The flywheel mounting washers are special hardened plain washers. Use identical replacements to avoid possible flywheel failure resulting in personal injury or property damage.

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 the component.

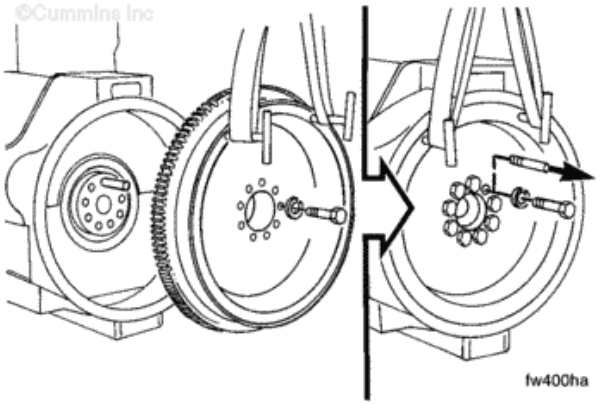
Lubricate the capscrews and washers with engine oil. Allow the excess oil to drip off the parts.

Do **not** lubricate the threads of the crankshaft.

A guide stud will help during assembly.

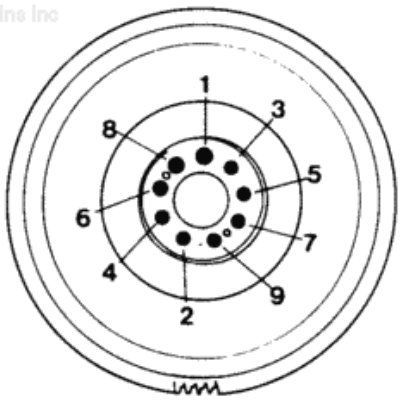
Install the flywheel, washers, and capscrews.

The flywheel **must** be firmly against the crankshaft.



Tighten the capscrews in sequence.

Torque Value:	Step 1	150 n.m [110 ft-lb]	
	Step 2	285 n.m [210 ft-lb]	



Measure

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 4 equally spaced points.

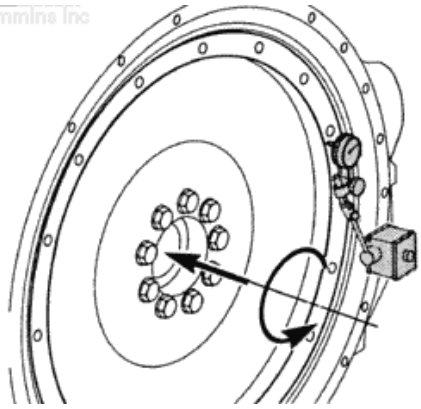
Measure the distance from the center of the crankshaft to the indicator tip. Multiply the distance to obtain the maximum runout.

The alignment specification is 0.025 mm [0.001 inch] per 25.4 mm [1.0 inch] distance from the center of the crankshaft.

Center of Crankshaft-To-Indicator Tip:

Multiply by 0.025 mm [0.001 inch] to obtain the center of crankshaft-to-indicator tip.

If the flywheel alignment is **not** within specifications, check for interference between the flywheel and the crankshaft.



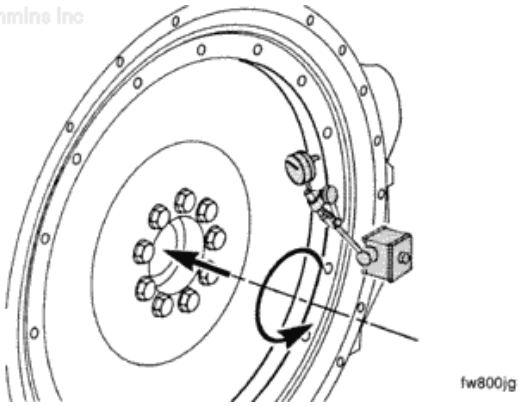
Attach an indicator as shown.

Observe the indicator while rotating the engine.

Measurements		
	mm	in
Maximum Radial Runout	0.13	0.005

If the 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.

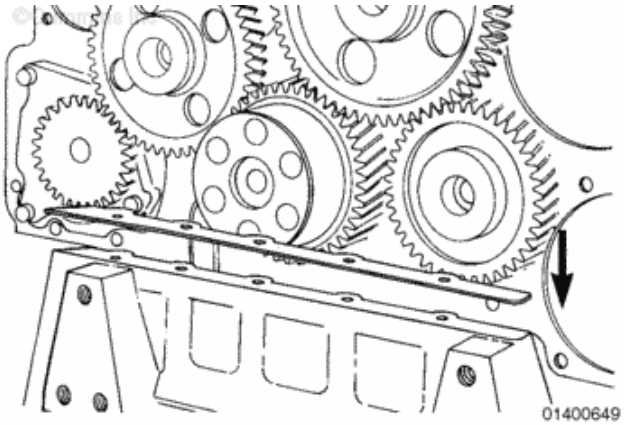
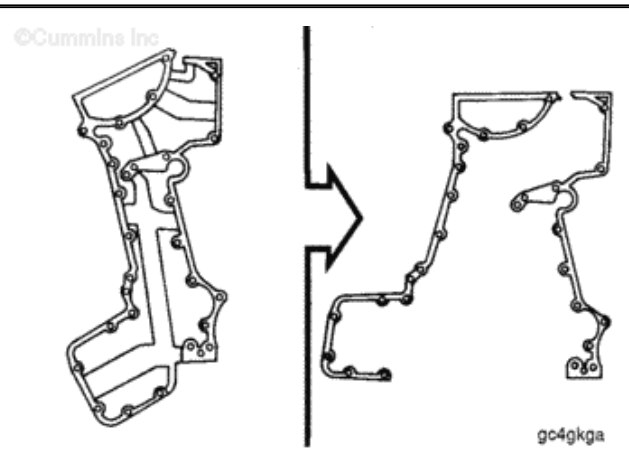


Last Modified: 29-Nov-2004

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001-033 Gear Housing, Front

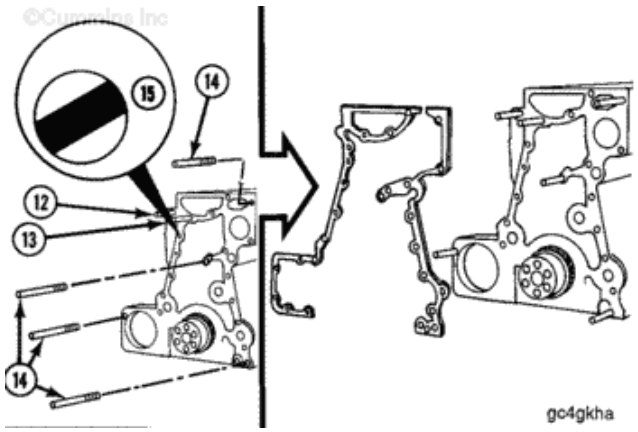
Install

Install the gasket piece onto the top of the oil pan adapter. Use a spray adhesive to hold it in position. Apply sealant, Part Number 3164067, or equivalent, to the joints of the gasket.		
Separate the gasket as illustrated in the graphic. Discard the center tab sections.		
If the engine has a belt driven fan hub, install two studs (12) and (13). The length of stud (12) is 140 mm [5½ in]. The length of stud (13) is		

152 mm [6 in].

The diamond dowel (15) **must** be installed with the flat surface turned towards the master dowel hole at the lower right hand corner of the block.

Guide studs (14) will help during installation.



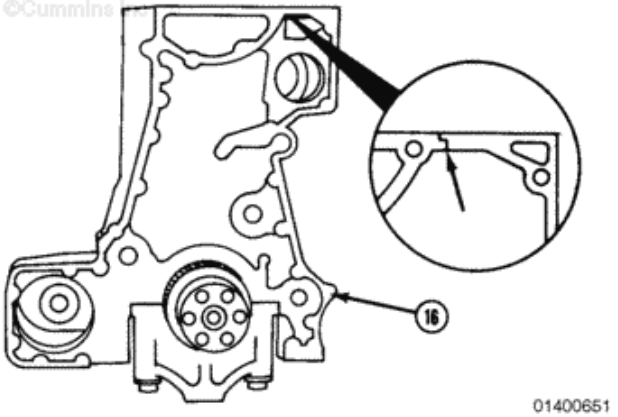
CAUTION

Do not use gasket cement. Damage to the gasket will result.

NOTE: The gasket illustrated in the graphic is used on old and new style blocks. When used on the old style block, there will be a capscrew hole (16) that is not used. It is not necessary to trim the gasket at this location.

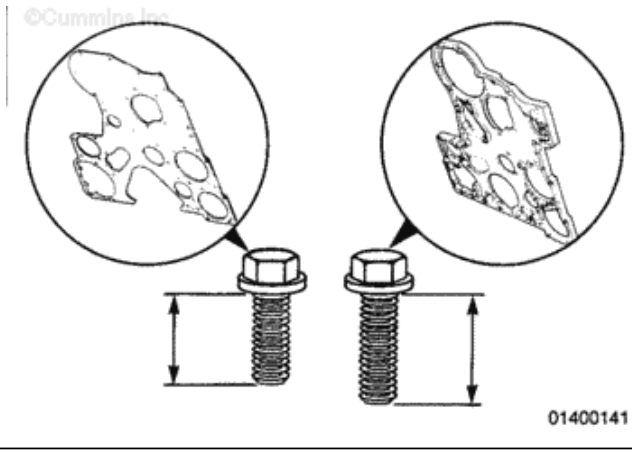
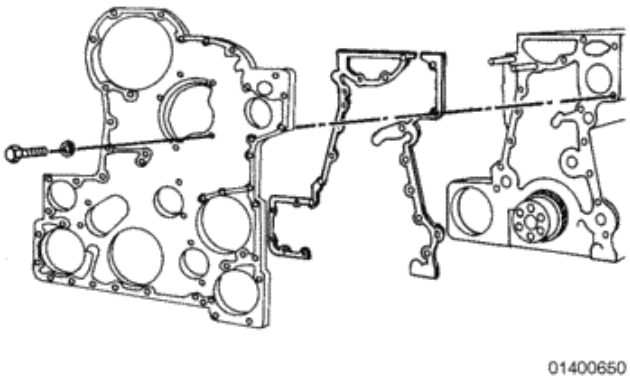
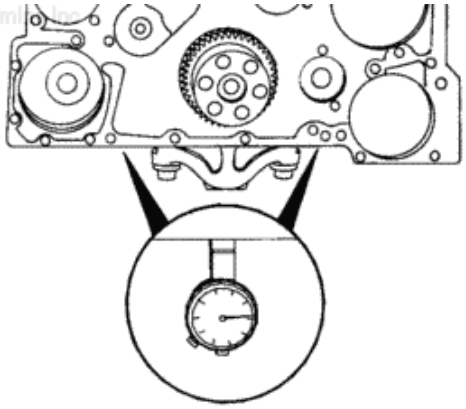
Apply a small amount of sealant, Part Number 3164067, or equivalent, to both sides of the gasket at the butt joint.

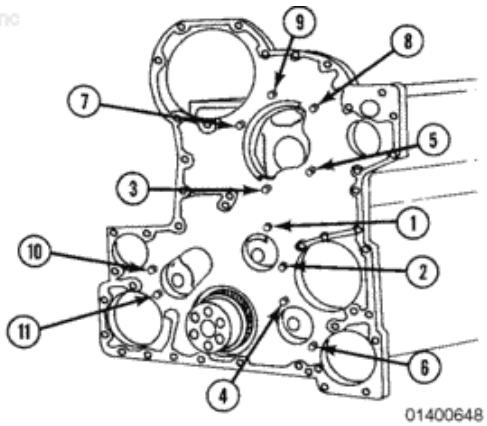
Install the gasket.

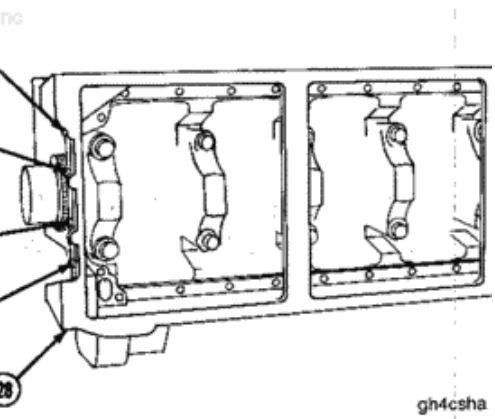


CAUTION

Special capscrews are required to attach the gear housing. The capscrews have a captive, cone shaped washer to maintain torque.

The capscrews for the gear housing are 28.575 mm [11/8 in] long.		
Install the gear housing. Install the capscrews and remove the guide studs.		
NOTE: If the oil pan adapter is removed, the gear housing alignment must be checked. If the oil pan adapter is installed the alignment does not need to be checked. Use depth gauge, Part Number 3164438, or equivalent to measure the distance from the bottom of the cylinder block to the bottom of the housing. The bottom of the housing **must** be within 0.05 mm [0.002 in] of the bottom of the block.		

Align the housing with the bottom of the block if necessary. Tighten the capscrews in the sequence shown. **Torque** **Value:** 45 n.m [33 ft-lb] Measure the housing to the block alignment to make sure it is within specifications.	 	

Install the remaining 3/8 inch washers and capscrews into the bottom of the gear housing. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]	 	

Last Modified: 08-Dec-2004

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016-002 Engine Support Bracket, Front

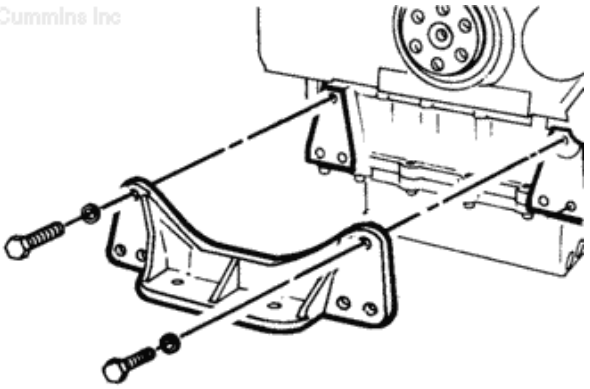
Install

WARNING

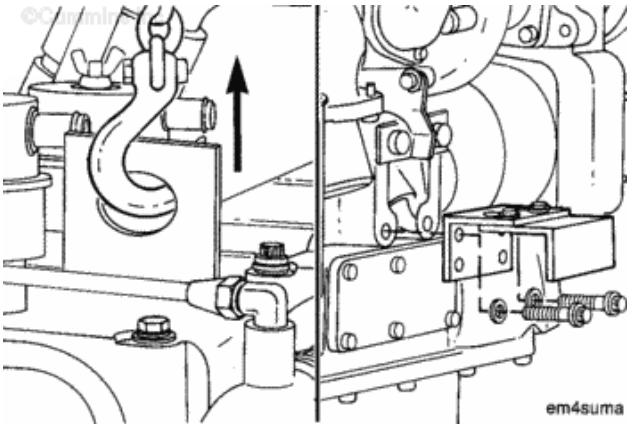
This component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

Install the support, washers, and capscrews. Tighten the capscrews.

Torque
Value: 195 n.m [145 ft-lb]

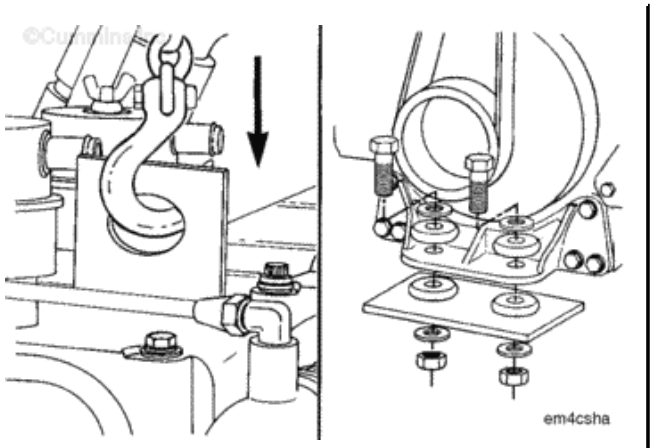


Raise the engine to remove the weight from the support brackets. Remove the support brackets.



Lower the engine until the front engine support is in position. Install and tighten the capscrews.

Refer to the equipment manufacturer's instructions.

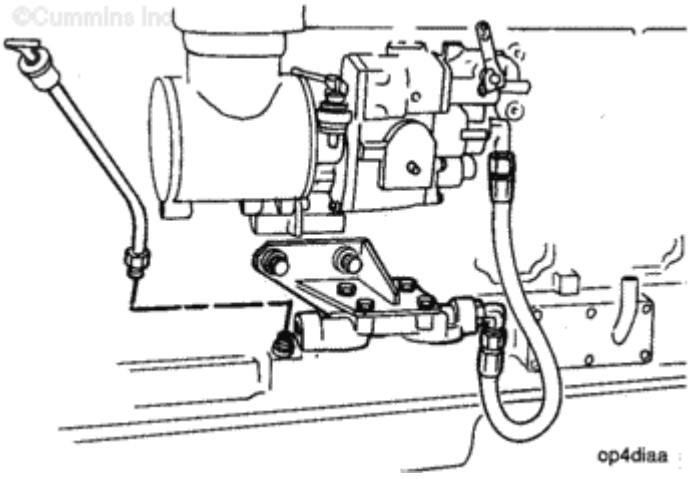


Last Modified: 28-Jul-2006

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007-011 Lubricating Oil Dipstick Tube

Install

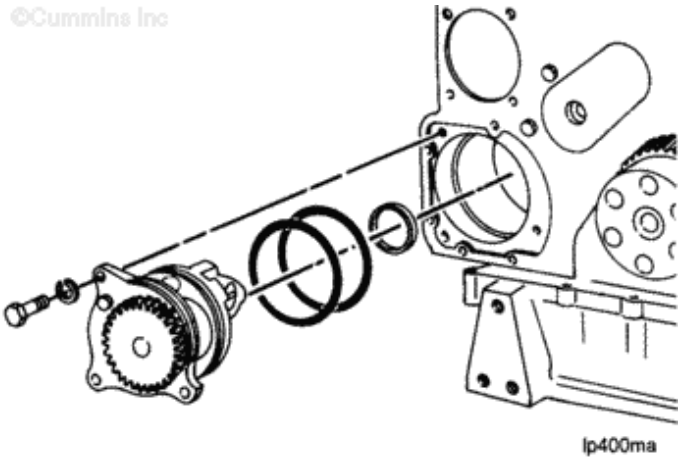
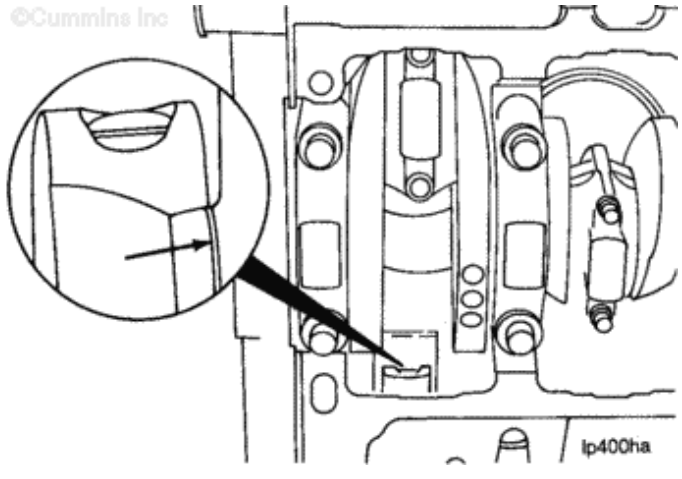
NOTE: The dipstick tube and fuel filter mounting locations vary depending on the application of the engine. Install the dipstick tube. Tighten the nut ¾ turn to 1 turn after contact with the ferrule.		

Last Modified: 29-Nov-2004

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007-031 Lubricating Oil Pump

Install

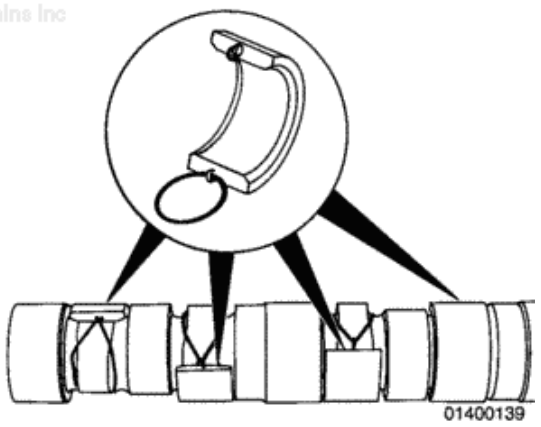
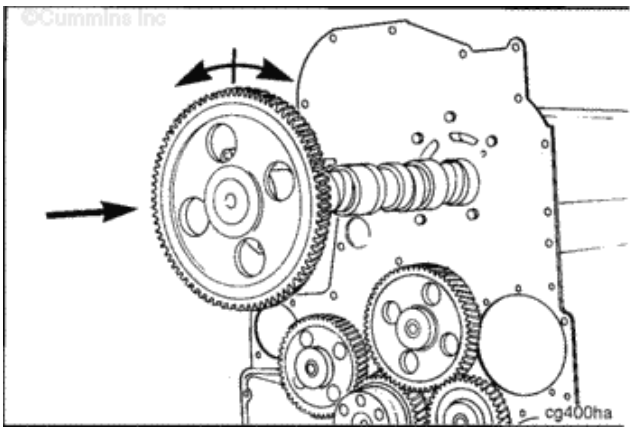
Apply a light coat of grease to the seal ring to hold it in place during assembly. Install the o-rings and the seal ring onto the pump. Lubricate the o-rings and bore in the block with vegetable oil. Install the pump and the capscrews. Tighten the capscrews. **Torque Value:** 45 n.m [33 ft-lb]		
Look between the number one and number two main bearing caps. The seal **must** be visible in the space between the rear of the pump and the engine block.		

Last Modified: 01-Dec-2004

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001-008 Camshaft

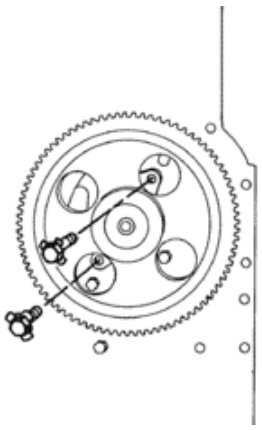
Install

Install the camshaft installation pilots, Part Number 3376280, onto the inner base circle of the valve lobes for the number 5 and 6 cylinders of the camshaft. Lubricate the camshaft and camshaft bushings with Lubriplate® 105 multipurpose lubricant, or equivalent.		
CAUTION If the installation pilots are not available. Be careful when installing the camshaft to prevent the camshaft lobes from damaging the bushings. Install the camshaft. Turn the camshaft backward and forward as it is being pushed. Keep the pilots turned downward to support the camshaft.		
If necessary, rotate the camshaft so the holes in the camshaft gear allow access to the capscrew holes in the thrust plate.		

Install the two capscrews and lockplates.

Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]

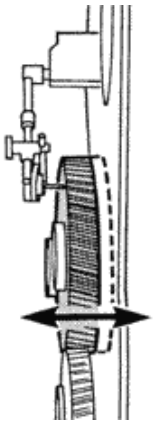


Measure the camshaft end clearance with a dial indicator.

Camshaft End Clearance

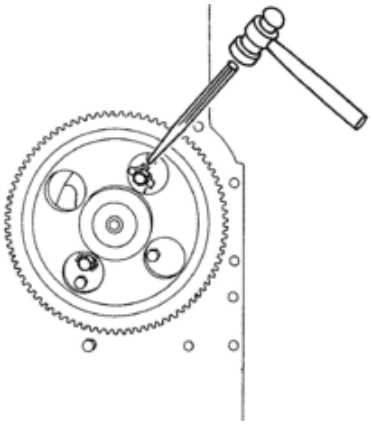
mm		in
0.15	MIN	0.006
0.33	MAX	0.013

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 hammer and a drift to bend one tab of the lockplate over the thrust plate, and the other tab over the capscrew.

Repeat the process for the other capscrew.



001-040 Idler Gear, Water Pump

Install

Bolt-On Type

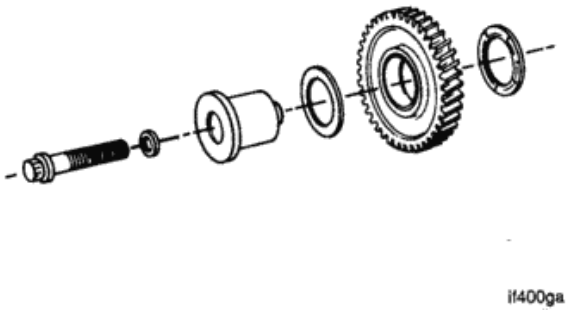
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washers must be turned toward the gear.

Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 316086, or equivalent.

Lubricate the capscrew with clean engine oil.

Assemble the parts.



CAUTION

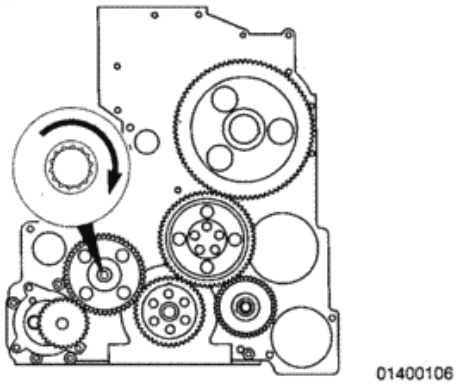
Do not allow the thrust washer to fall between the shaft and block or the will washer will be damaged and the gear end clearance will be to large.

Install the gear and shaft assembly.

Use the capscrew to pull the shaft into the cylinder block.

Tighten the capscrew.

Torque Value:	Step 1	185 n.m	[135 ft-lb]
	Step 2	Loosen completely	



Step 3	60 n.m [45 ft-lb]	
Step 4	Tighten 90 degrees	

Press-Fit Type

CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washers must, be turned toward the gear.

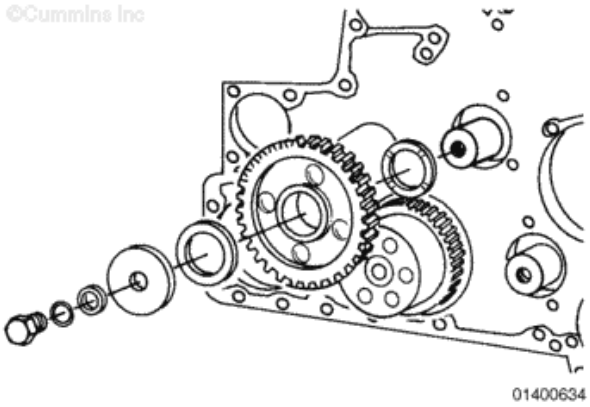
Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant or equivalent.

Lubricate the capscrew with clean engine oil.

Install the parts as illustrated in the graphic.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]

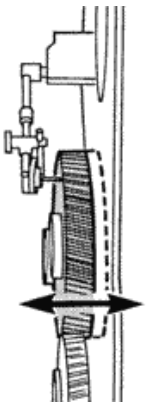


All Applications

Measure the idler gear end clearance with a dial indicator.

Water Pump Idler Gear End Clearance		
mm		in
0.10	MIN	0.004
0.36	MAX	0.014

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.



Jahan Compressor

Last Modified: 25-Aug-2004

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001-039 Idler Gear, Hydraulic Pump

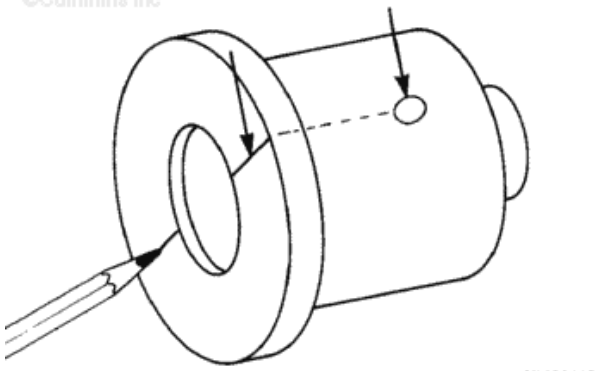
Install

Bolt-On Type

CAUTION

The holes in the hydraulic pump idler shaft and camshaft idler shaft must be installed in a specific orientation. If the shaft is not orientated correctly failure of the gear bushing can result.

Mark the flange of the shaft to show the oil hole orientation.



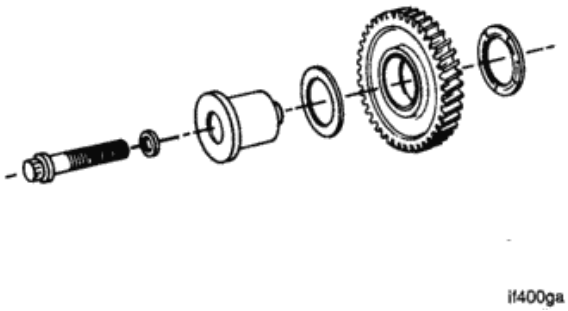
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washer must be turned toward the gear.

Lubricate the gear bushing, shaft and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrews with clean engine oil.

Assemble the parts.



CAUTION

Engines that contain a hydraulic

pump must have the oil holes in the hydraulic idler shaft oriented as illustrated in the graphic. Idler gear bushing failure will result if the oil holes are not aligned correctly.

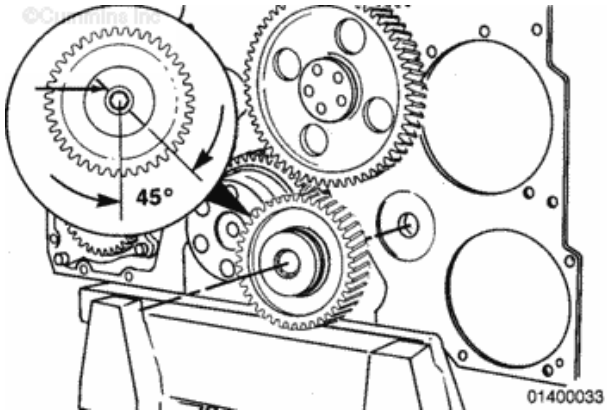
Align the oil holes in the shaft to an angle 45 degrees to the left of vertical.

Install the gear and shaft assembly, and the capscrew.

Use the capscrew to pull the idler shaft into the cylinder block bore.

Tighten the capscrew.

Torque Value:	Step 1	185 n.m [135 ft-lb]
	Step 2	Loosen completely
	Step 3	60 n.m [45 ft-lb]
	Step 4	Turn capscrew 90 degrees



Press-Fit Type

CAUTION

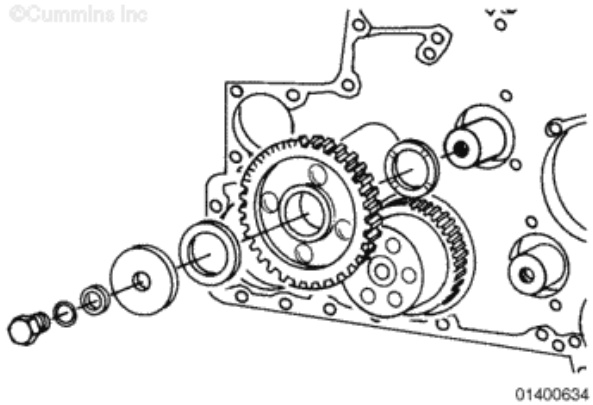
To reduce the possibility of engine damage, the grooves in the thrust washer must be turned toward the gear.

Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrews with clean engine oil.

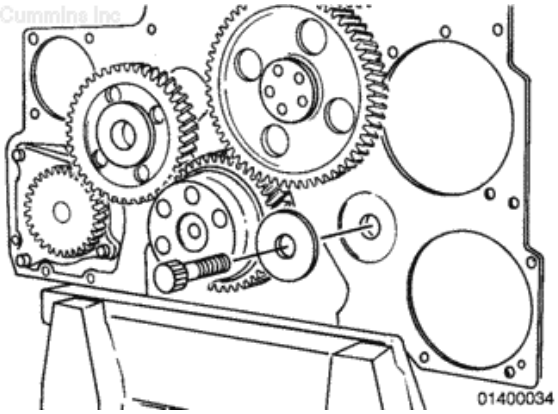
Install the parts as illustrated in the graphic.

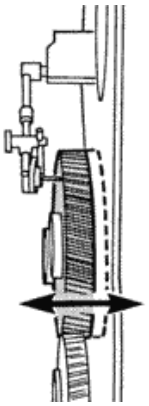
Tighten the capscrew.



Torque Value: 45 n.m [33 ft-lb]		

All Applications

CAUTION Engines that do not have a hydraulic pump drive must have a plug installed in place of the idler shaft. Low oil pressure will result if the plug is omitted. Install a 9/16 UNF-inch capscrew, lock washer, and plain washer that is larger than the cylinder block bore. Tighten the capscrew. **Torque Value:** 65 n.m [50 ft-lb]		

Measure the hydraulic pump idler gear end clearance with a dial indicator. Hydraulic Pump Idler Gear End Clearance mm MIN in 0.10 MIN 0.004 0.36 MAX 0.014 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.		

Last Modified: 04-Nov-2004

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001-036 Idler Gear, Camshaft

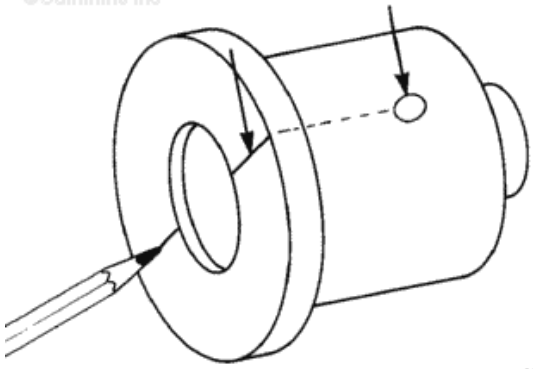
Install

Bolt-On Type

CAUTION

The oil holes in the camshaft idler shaft and hydraulic pump idler shaft must be installed at a specific orientation. If the shaft is not orientated correctly a failure of the gear bushing can result.

Mark the flange of the shaft to show the oil hole orientation.



CAUTION

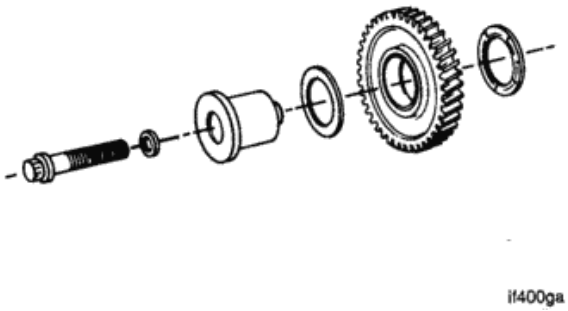
To reduce the possibility of engine damage, the grooves in the thrust washers mush be positioned toward the gear.

The timing marks on the camshaft idler gear **must** be visible when the gear is installed.

Lubricate the gear, bushing, shaft, and thrust washer with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrew with clean engine oil.

Assemble the parts as illustrated in the graphic.



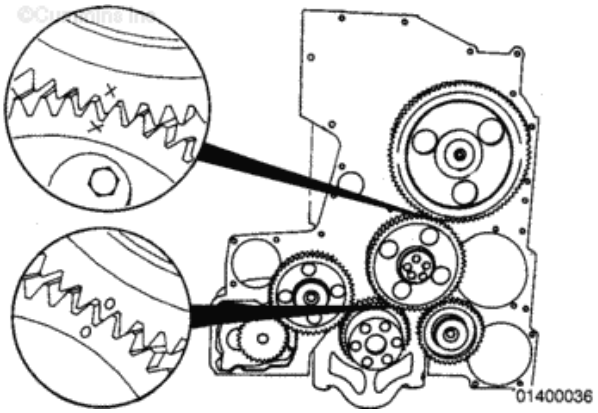
CAUTION

Do not allow the inner thrust washer to fall between the shaft and block or the washer will be damaged and the gear end clearance will be to large.

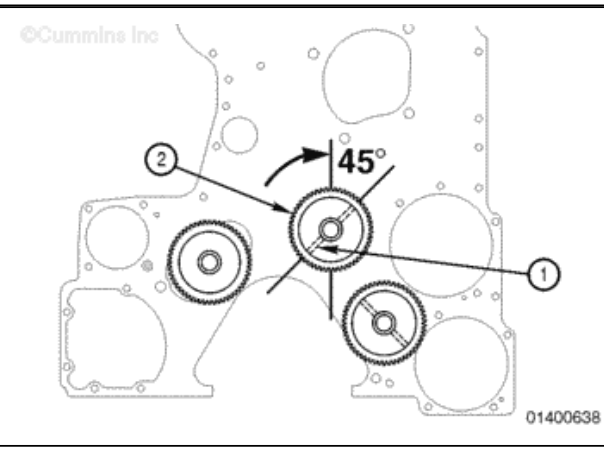
The camshaft idler gear is the **only** gear that has timing marks.

Install the gear and shaft assembly aligning the following:

- The “O” on the idler gear with the “O” on the crankshaft gear.
- The “X” on the idler gear with the “X” on the camshaft gear.



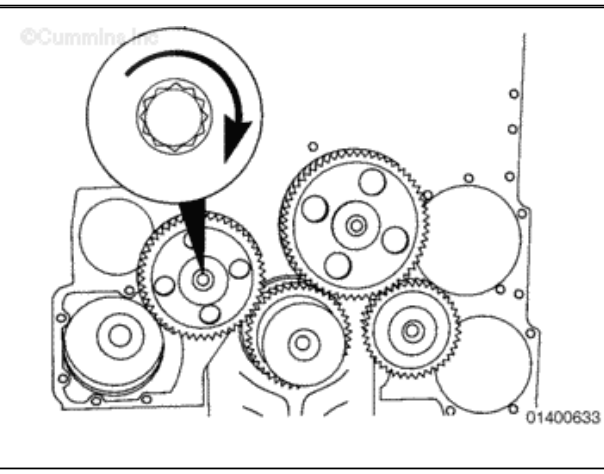
Align the camshaft idler shaft (2) so the oil drilling the shaft (1) is 45 degrees **clockwise** from vertical as shown.



Install the capscrew and use it to pull the shaft into the bore.

Tighten the capscrew.

Torque Value:	Step 1	185 n.m [135 ft-lb]
	Step 2	Loosen completely
	Step 3	60 n.m [45 ft-lb]
	Step 4	Tighten 90 degrees



Press-Fit Type

CAUTION

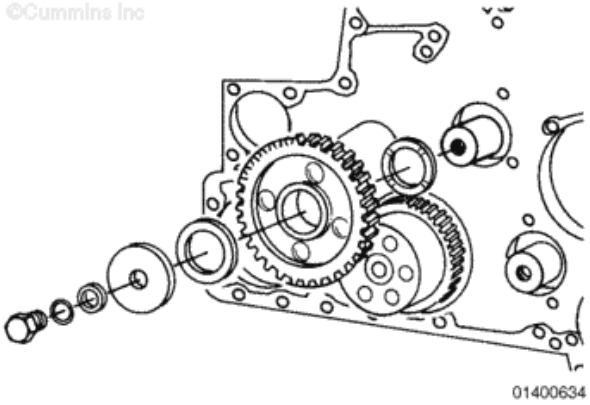
To reduce the possibility of engine damage, the grooves in the thrust washer must be positioned toward the gear.

Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrews with clean engine oil.

Assemble the parts as illustrated in the graphic.

Torque Value: 45 n.m [33 ft-lb]



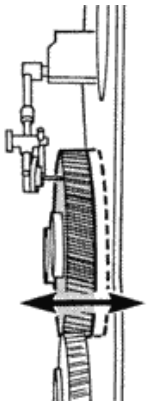
All Applications

Measure the camshaft idler gear end clearance.

Camshaft Idler Gear End Clearance		
mm		in
0.29	MIN	0.012
0.51	MAX	0.020

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.



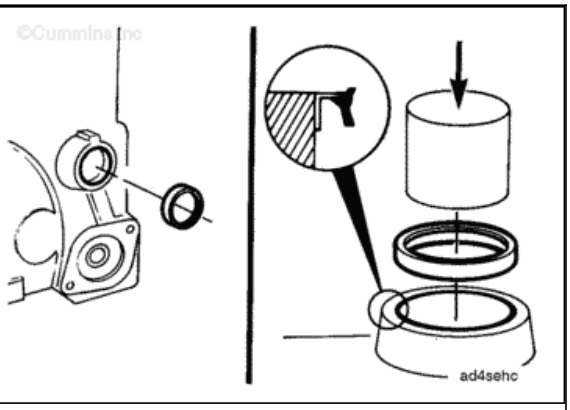
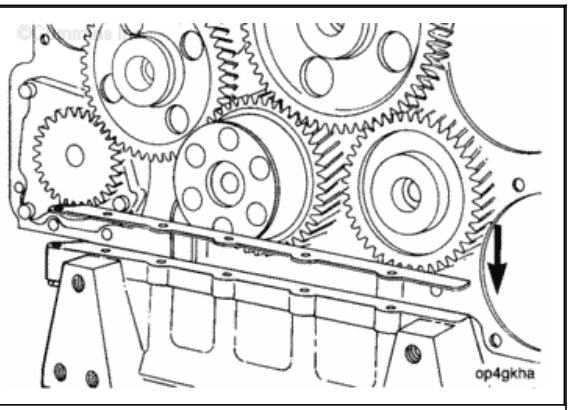
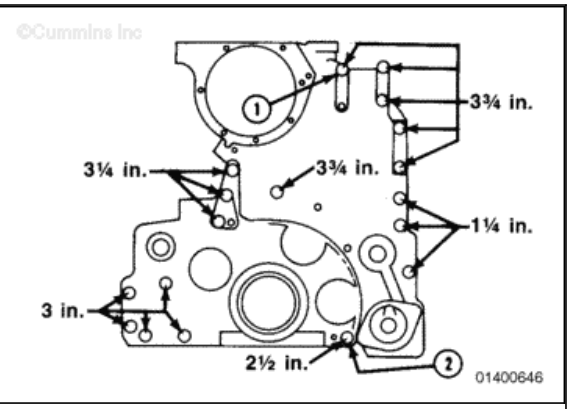
Last Modified: 25-Aug-2004

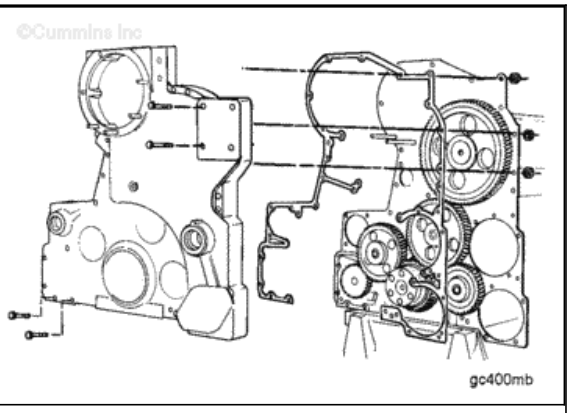
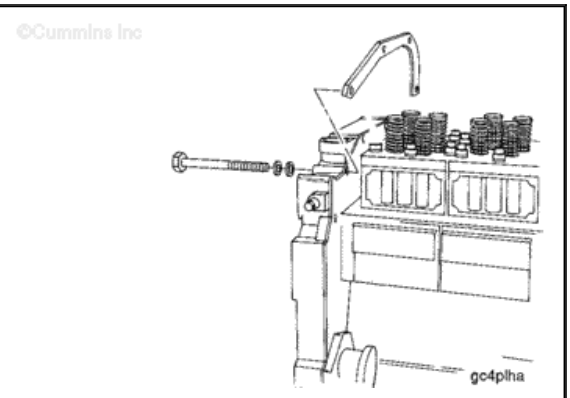
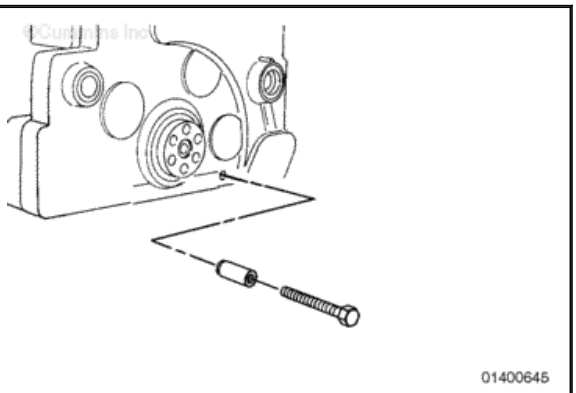
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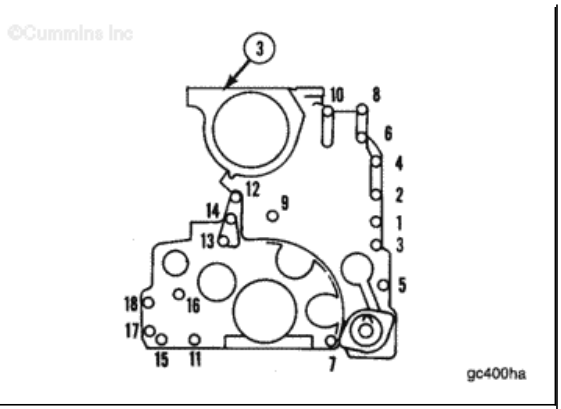
001-031 Gear Cover, Front

Install

One Piece Design, All Applications

Measure the height of the accessory drive seal boss. • If the height is 35 mm [13/8 in], the seal is installed even with the boss. • If the height is 38 mm [1½ in], the seal is installed 3 mm [1/8 in below the top of the boss. Install the accessory drive seal with a mandrel.		
Trim the gasket to the correct width. Install the gasket onto the top of the oil pan adaptor. Use a spray adhesive to hold the gasket in position. Apply sealant, Part Number 3164067, at the joints.		
The graphic illustrates the capscrew length requirements for the front cover. Capscrew (1) is installed in the front cover clamping plate. Capscrew (2) **must** be a 12-point style for head clearance.		

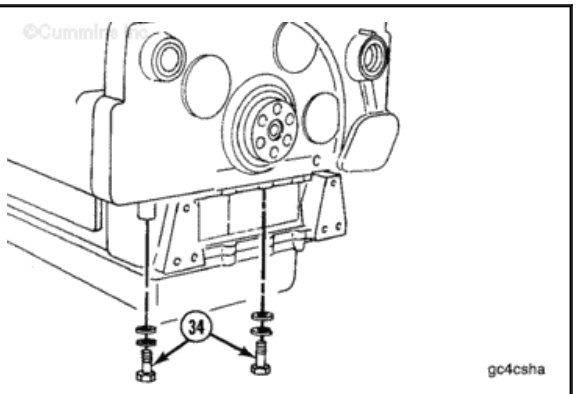
The use of guide bolts will aid in assembly. Instal the front cover gasket and the front cover. Install the front cover capscrews, but do **not** tighten them until the master dowel pin has been installed.		
Place the clamping plate into position and install the capscrew. Do **not** tighten the capscrew, the clamping plate **must** remain loose until the fan hub or the cover plate is installed.		
Thread a 5/16-8 x 3 in capscrew into the master dowel pin. Use a mallet to drive the master dowel pin into the cylinder block until it touches the bottom of the hole. Remove the capscrew.		
NOTE: Capscrews in sequence 1, 2, and 3 are located at the back of the spacer plate. Tighten the front cover capscrews (3) in sequence. **Torque Value:** 45 n.m [33 ft-lb]		



Install the five capscrews (34) at the bottom of the oil pan adapter.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]

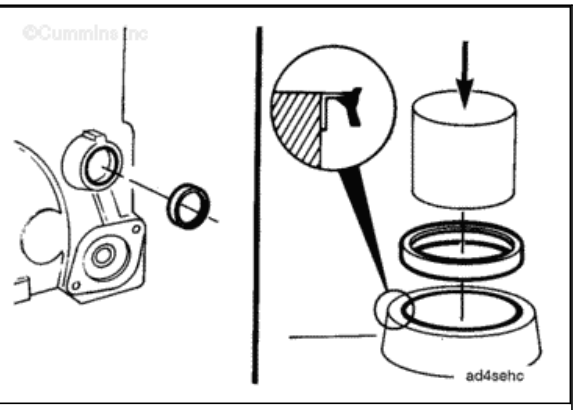


Two Piece Design, All Applications

Measure the height of the accessory drive seal boss.

- If the height is 35 mm [13/8 in], the seal is installed even with the boss.
- If the height is 38 mm [1½ in], the seal is installed 3 mm [1/8 in below the top of the boss.

Install the accessory drive seal with a mandrel.

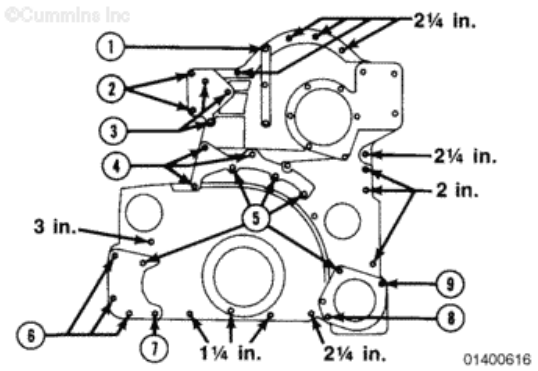


The common capscrew length requirements for all cast iron two-piece (marine) front gear cover are illustrated in the graphic.

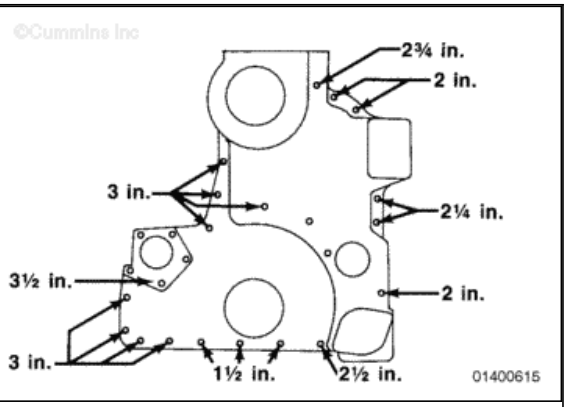
The capscrew lengths for (1) through (9) depend on the option used.

All capscrews are in US customary inches. All capscrews are 3/8 x 16 UNC.

Capscrew Lengths for Used Options				
Number	Front Power Take-off	Heat Exchanger	No Option	Both Options
(1)	3	3½	2	3½
(2)	3	3½	3	3½
(3)	3¾	4¼	4	4½
(4)	4½	3¾	4	4½
(5)	1¼	None	None	1¼
(6)	4½	3¾	4	4½
(7)	71/8	3¾	4	71/8
(8)	4½	None	None	4½
(9)	1¾	None	None	1¾

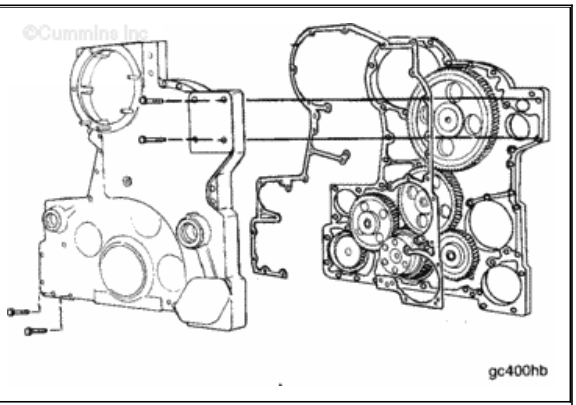


The graphic illustrates the capscrew length requirements for the aluminum two-piece front cover.



Install the guide stud.

Install the gasket, front cover and capscrews.



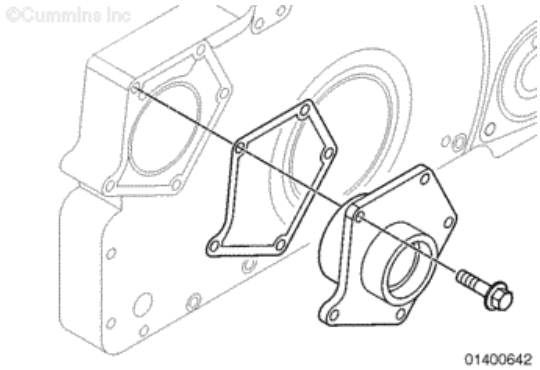
NOTE: It will possibly be necessary to freeze the drive support before installation. If the support does not fit into the cover without force freeze the cover at 0°C [32°F] for at least one hour.

Do not use capscrews to force the support in or the support will be broken.

Install the alternator drive support, gasket and capscrews.

Tighten the capscrews that are **not** part of the torque sequence.

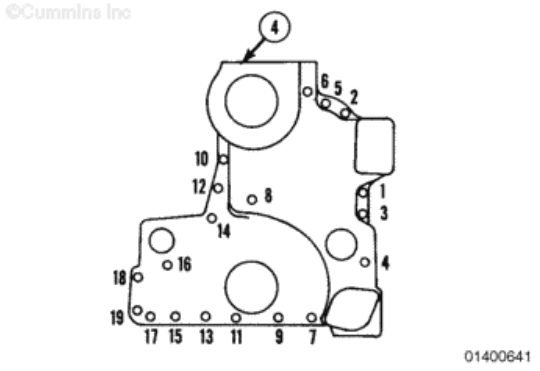
Torque Value: 45 n.m [33 ft-lb]



NOTE: The capscrew located in sequence number (4) is located at the rear of the gear housing.

Tighten the capscrews in the sequence shown.

Torque Value: 45 n.m [33 ft-lb]

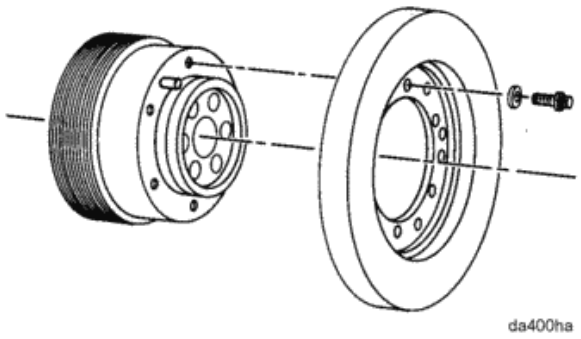
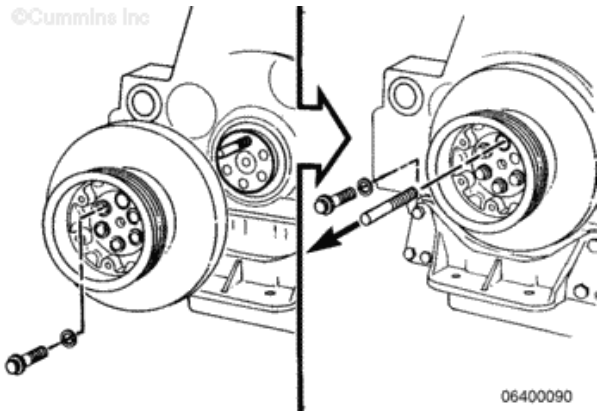


Last Modified: 07-Dec-2004

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001-052 Vibration Damper, Viscous

Install

Install the vibration damper on the crankshaft pulley or adapter (if equipped). Install the six washers and capscrews. Tighten the capscrews. **Torque Value:** 140 n.m [105 ft-lb]		
Install the guide stud in the crankshaft. Install the vibration damper assembly. The pilot **must** be aligned with the crankshaft correctly. Install the washers and capscrews. Tighten the capscrews. **Torque Value:** Step 1 230 n.m [170 ft-lb] Step 2 445 n.m [330 ft-lb]		

Last Modified: 23-Jul-2004

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001-046 Piston Cooling Nozzle

Install

One Piece Design, All Applications

Lubricate the o-ring with vegetable oil and install it onto the piston cooling nozzle.

Install the piston cooling nozzle, washer, and capscrew.

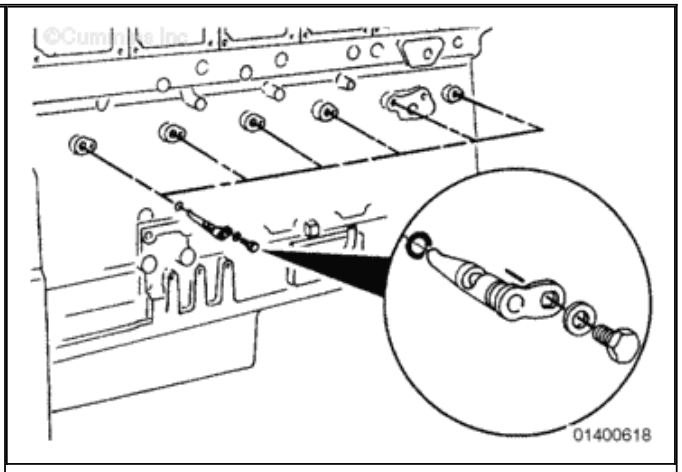
Tighten the capscrew.

Torque
Value: 13 n.m [115 in-lb]









Two Piece Design, All Applications

CAUTION

Use care when handling the piston cooling nozzle. Any damage to the piston cooling nozzle can result in major engine damage.

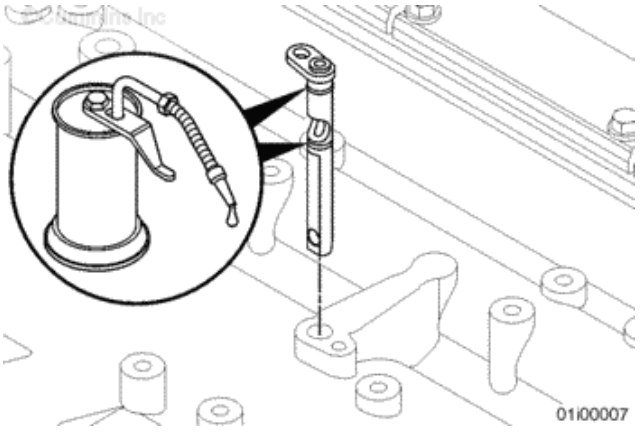
Lubricate the o-rings with vegetable oil.

Install the o-rings onto the piston cooling nozzle body.

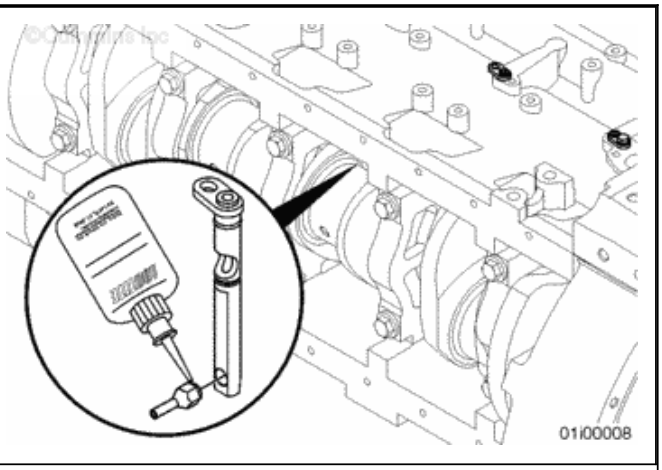
Install the the nozzle body into the cylinder block with the tip opening pointing toward the oil pan.

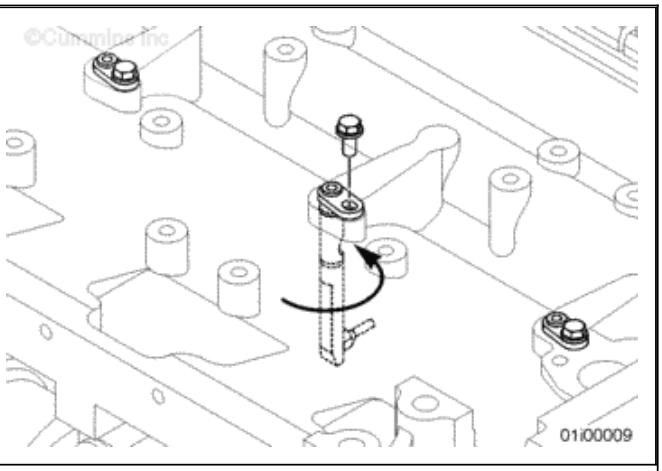






The nozzle body should rest on the inboard (bottom) o-ring.		

Apply Loctite™ 242, Part Number 3824041, onto the threads of the nozzle tip. Do **not** allow any Loctite™ to get inside the nozzle tip. Install the nozzle tip onto the nozzle body. Tighten the nozzle tip. **Torque** **Value:** 9 n.m [80 in-lb]		

Install the piston cooling nozzle the rest of the way into the cylinder block and rotate into position. Install and tighten the mounting capscrew. **Torque** **Value:** 14 n.m [124 in-lb]		

Last Modified: 30-Apr-2012

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009-016 Hydraulic Pump Drive

Install

The hydraulic pump drive or cover plate fro engines with a two-piece front cover **must** have an o-ring in addition to the gasket.

Lubricate the bushing in the front cover with clean engine oil.

Install the gasket, hydraulic pump drive, lock washers and capscrews.

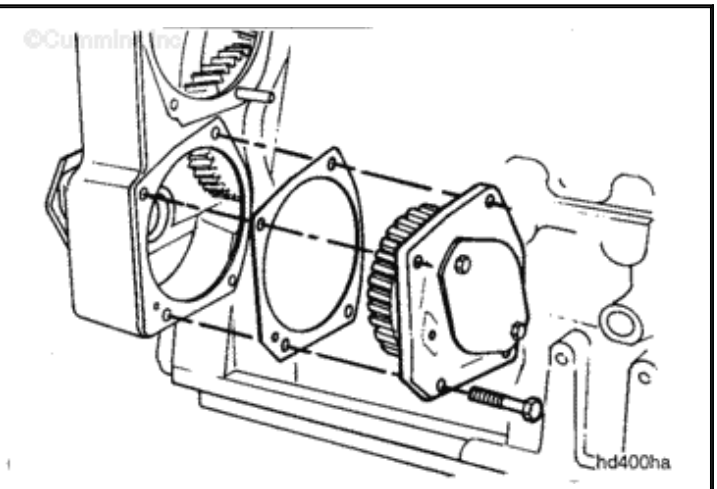
Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]







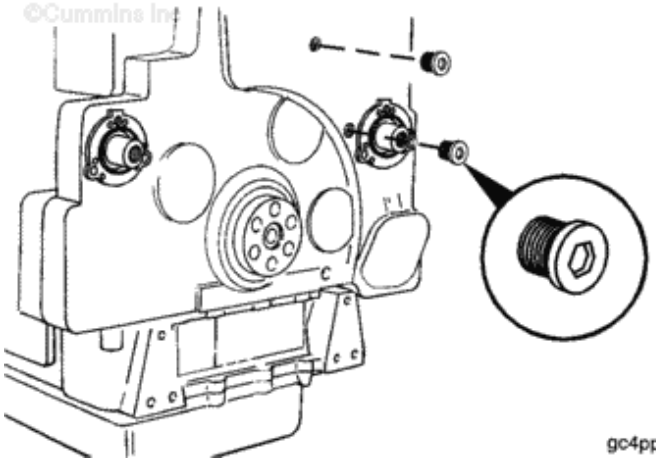
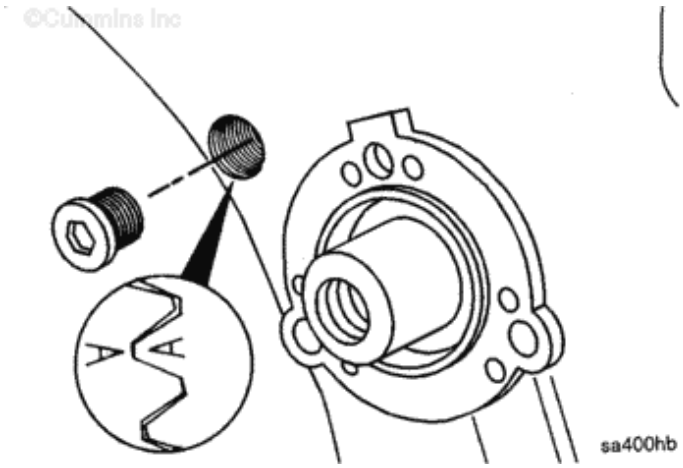


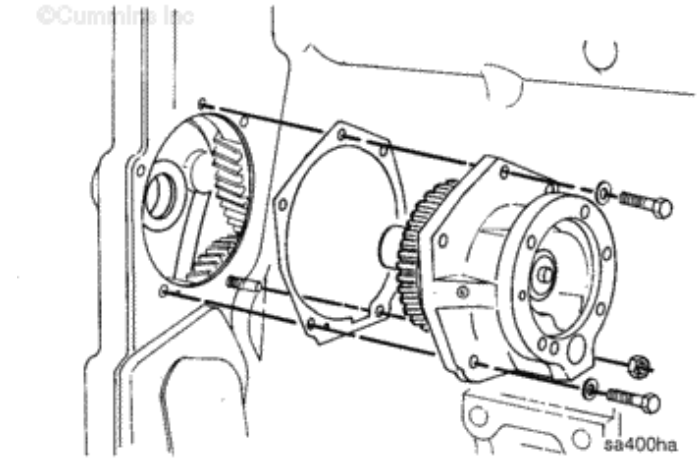
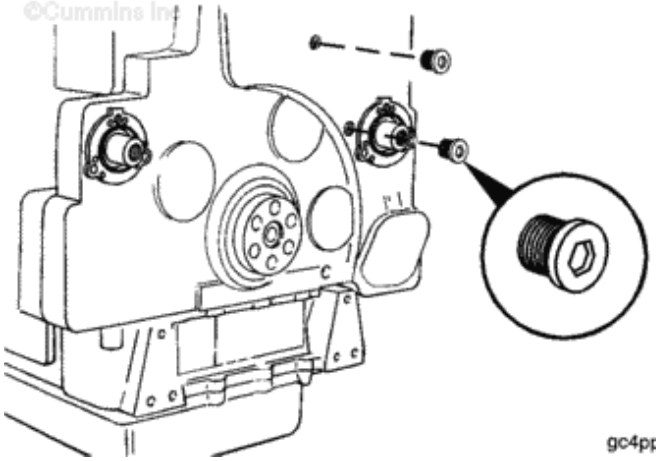
Last Modified: 01-Dec-2004

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009-011 Fuel Pump Drive

Install

Remove the two straight threaded o-ring plugs from the timing holes in the front cover. Check the index mark alignment.		
Do not use the “A” on the camshaft idler gear for the accessory drive alignment unless the “X” marks on the camshaft and the camshaft idler gears are aligned and centered in the upper timing plug hole. If the “X” marks are not visible in the upper plug hole, rotate the engine until the “X” marks on the camshaft gear and the camshaft idler gear are centered in the upper timing plug hole.		

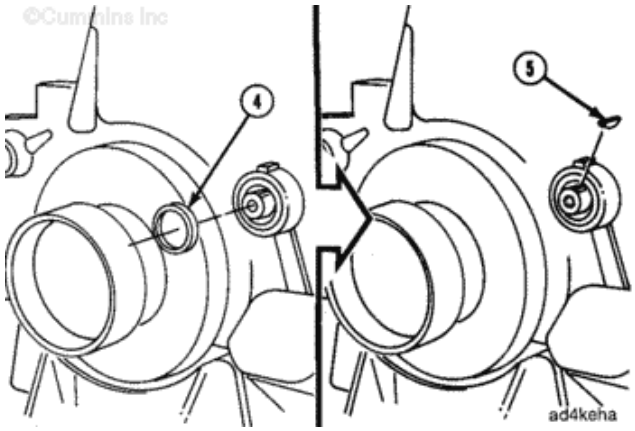
Install the fuel pump drive gasket. Install the fuel pump drive so the “A” on the fuel pump drive gear is centered in the lower timing plug. Install the capscrews and nut. Tighten the capscrews and nut. **Torque Value:** 45 n.m [33 ft-lb]		
Install the straight threaded o-ring plugs. Tighten the o-ring plugs. **Torque Value:** 25 n.m [20 ft-lb]		

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009-004 Accessory Drive Pulley

Install

Install the woodruff key (5).		

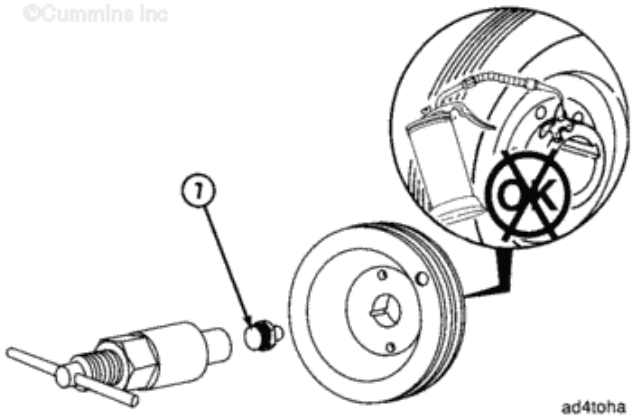
CAUTION

Do not use a hammer to drive the pulley into position. Damage to the thrust bearing will result.

Do **not** lubricate the pulley. The lips on the seal and the seal surface on the pulley wear sleeve **must** be clean and dry.

Use the pulley installation tool kit, Part Number 3376326.

Install the appropriate adapter (7) in the pusher.

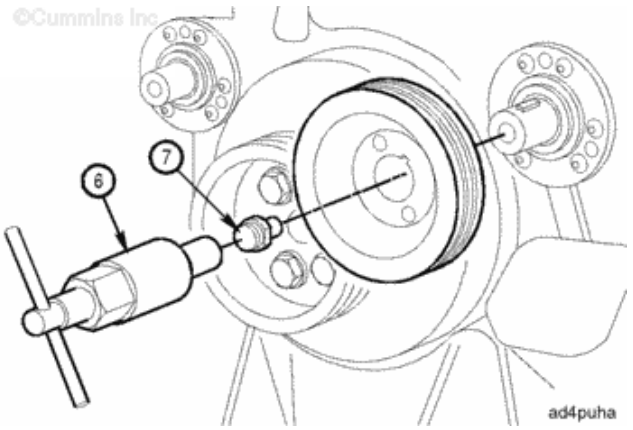


CAUTION

The dust lip on the accessory drive seal must be folded under when the pulley is installed. To reduce the possibility of the dust lip (yellow lip) from folding under, bend the lip outward by running a finger around it 8 to 10 times applying gentle pressure. Avoid touching the sealing lip. The dust lip will remain bent approximately one minute, then return slowly to the operating position.

Align the keyway in the pulley with the key in the shaft.

Use the tool to push the pulley onto the shaft until it touches the step on the shaft.



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012-014 Air Compressor

Install

Single Cylinder

WARNING

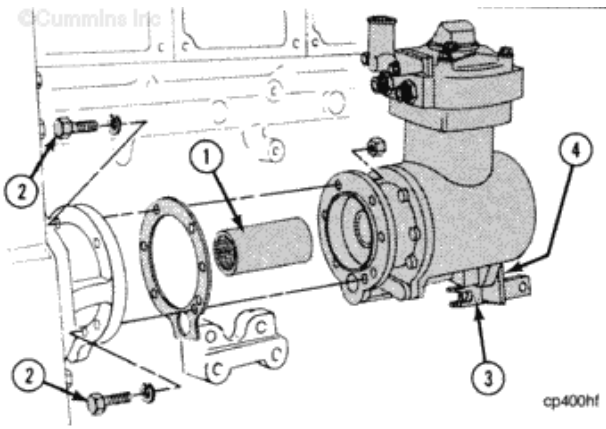
This component or assembly weighs greater than 23 kg [50 lbs]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Install the splined coupling (1) on the accessory drive shaft.

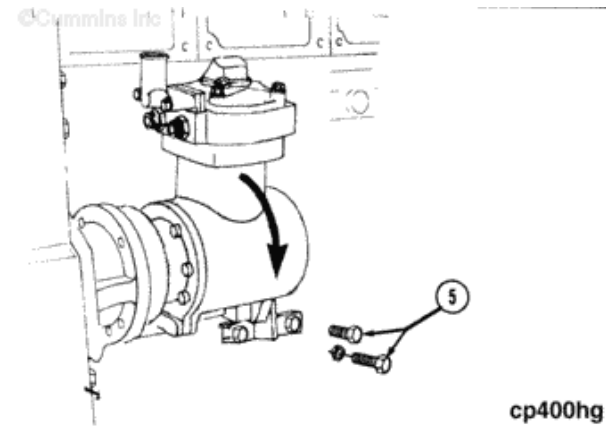
Be sure the gasket surfaces of the accessory drive and air compressor are clean and **not** damaged.

Use a new gasket to install the air compressor.

Install and **only** hand-tighten the four capscrews and nuts (2).



Install the two capscrews (5) for the bracket. The support bracket **must** be flat against the block. Turn the compressor until the bracket is flat against the block.



CAUTION

The bracket must be flat against the compressor. Failure to have the bracket flat can cause premature component failure.

Tighten the compressor to the accessory drive capscrews (2).

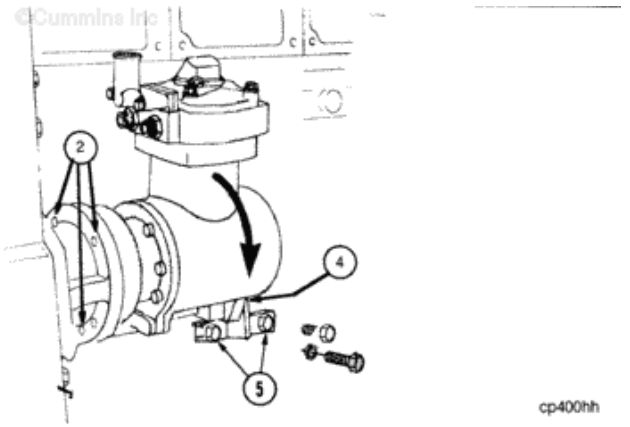
Torque
Value: 60 n.m [44 ft-lb]

Tighten the bracket to the block capscrews (5).

Torque
Value: 45 n.m [33 ft-lb]

Tighten the bracket to the compressor capscrew (4).

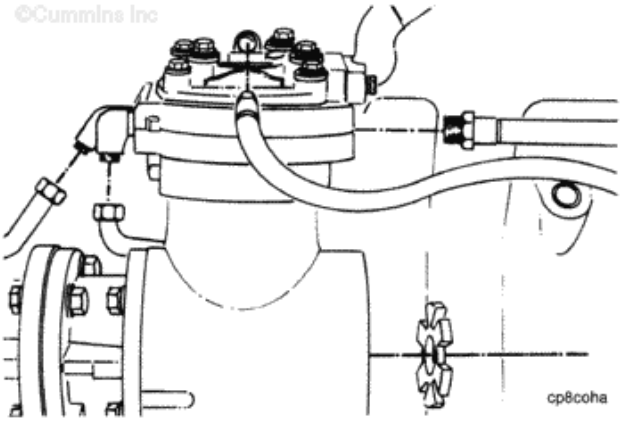
Torque
Value: 45 n.m [33 ft-lb]



NOTE: If rubber grommets are used on the coolant lines, be sure they are installed carefully to prevent cuts or tears to the grommets which cause coolant leaks. When flexible tubing is used, make sure that it does not rub any other surface.

Install the coolant and air lines to the air compressor and tighten.

Install the fuel pump drive coupling on the air compressor.



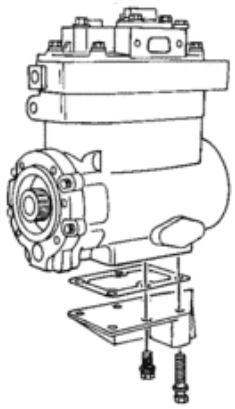
Twin Cylinder

WARNING

This component or assembly weighs greater than 23 kg [50 lbs]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

On twin cylinder compressors with a one piece bracket, install the gasket and the cover plate (support bracket) on the compressor.

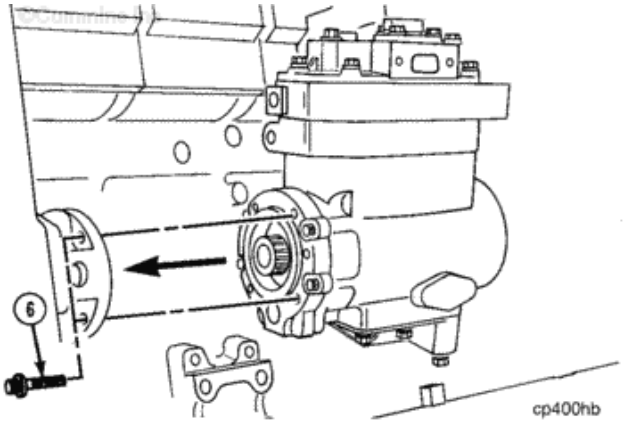
Do **not** tighten the six capscrews. The support **must** be adjusted.



NOTE: Do not install the splined coupling or the mounting gasket.

Install the compressor on the accessory drive.

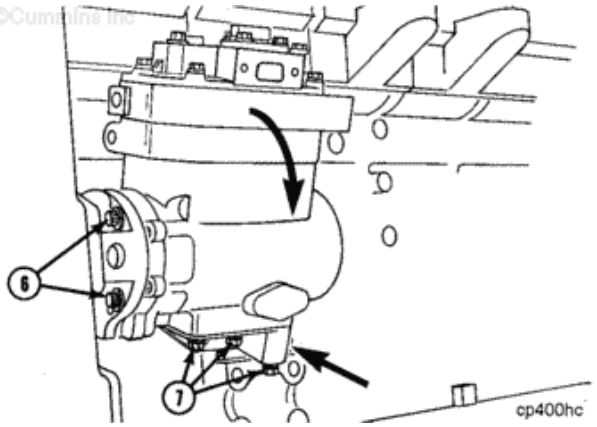
Install the four capscrews (6). **Only** tighten the capscrews enough to pull the compressor to the accessory drive. The compressor **must** be turned to align the support bracket.



CAUTION

The support must be flat against the block. Rotate the compressor until the support is aligned properly against the block. If the support is not flat, the compressor and/or accessory drive will fail.

Tighten the four capscrews (6).



Torque
Value: 60 n.m [44 ft-lb]

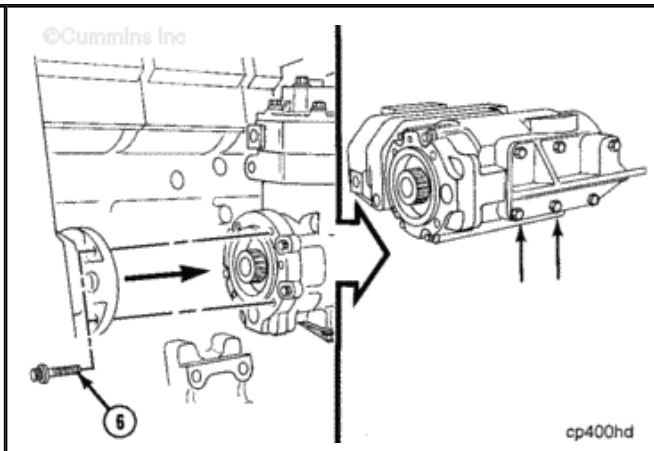
The bracket **must** remain flat against the block. Tighten the support capscrews (7) that are accessible.

Torque
Value: 45 n.m [33 ft-lb]

Remove the four capscrews (6). Remove the compressor.

Tighten the two remaining supports to the compressor capscrews.

Torque
Value: 45 n.m [33 ft-lb]



CAUTION

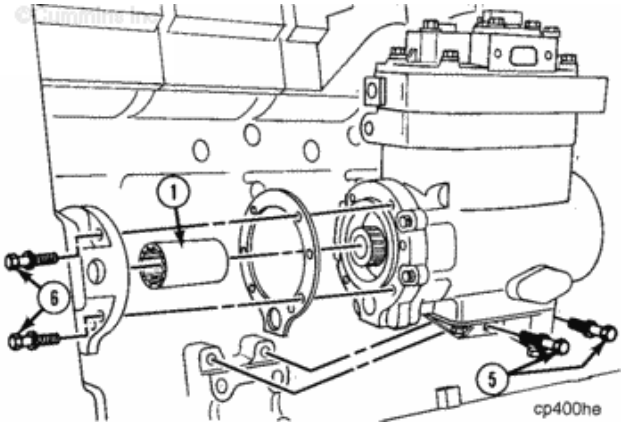
The support must be flat against the block. Rotate the compressor until the support is aligned properly against the block. If the support is not flat, the compressor and/or accessory drive will fail.

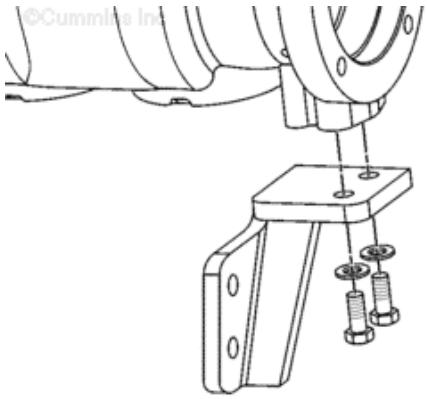
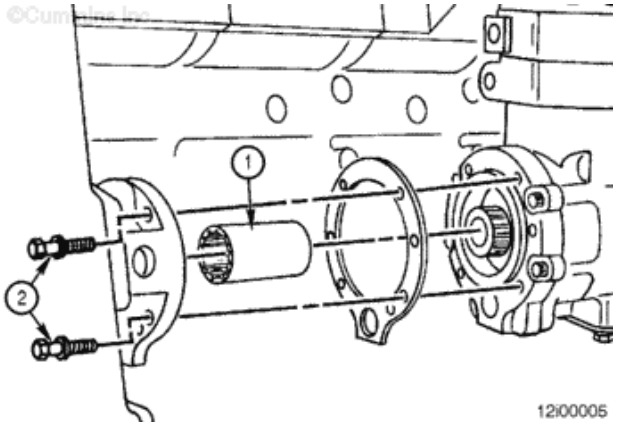
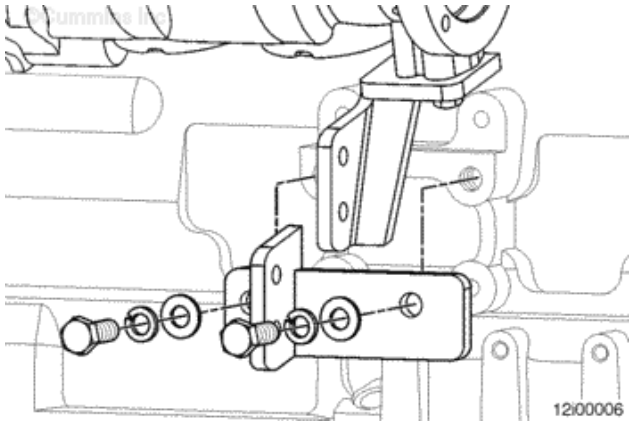
Install the splined coupling (1), gasket, and compressor.

Install the four capscrews (6) and two capscrews (5).

Torque Value:
Capscrew (6) 60 n.m [44 ft-lb]

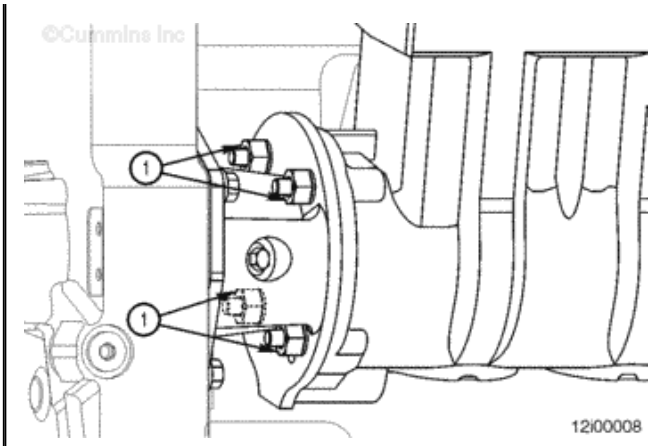
Torque Value:
Capscrew (5) 45 n.m [33 ft-lb]



On air compressors with the two-piece bracket, install the top bracket, washers, and capscrews onto the bottom face of the air compressor. Hand tighten the capscrews.		 12i00004
Install the splined coupling (1), gasket, and compressor. Install the four capscrews (2), but do **not** tighten to allow movement of the compressor for support bracket installation.		 12i00005
Position the bottom bracket behind the top bracket and install the capscrews, lock washers, and plain washers. Hand tighten the capscrews.		 12i00006
Tighten the four air compressor mounting capscrews (1).		

Torque Value:
Mounting
Capscrews 47 n.m [35 ft-lb]

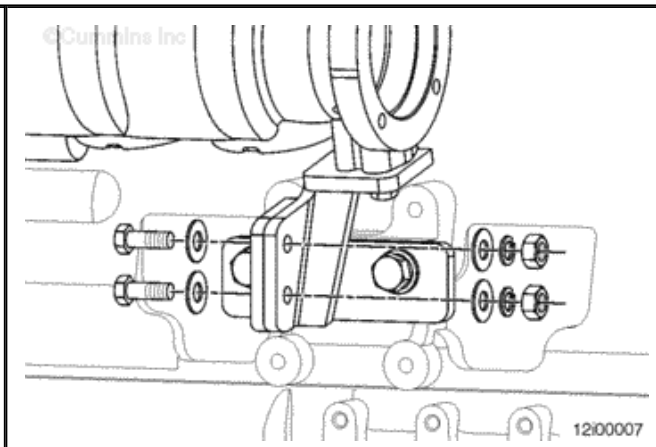
NOTE: The air compressor mounting brackets have slotted holes to allow for proper alignment when the air compressor is tightened.



Install the two capscrews through both brackets using two plain washers, one lock washer, and one nut on each capscrew.

Hand tighten the capscrews and nuts.

NOTE: Be sure the bracket mating surfaces are flush before tightening capscrews.



NOTE: Be sure brackets are flush against the compressor, block, and each other.

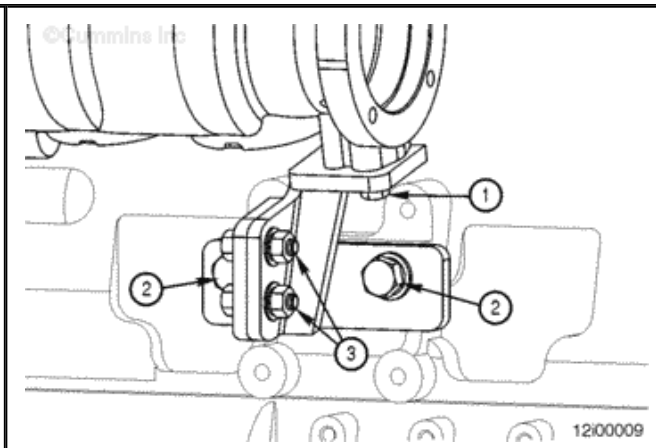
Tighten the capscrews to the compressor (1).

Torque Value:
Compressor
Capscrews 47 n.m [35 ft-lb]

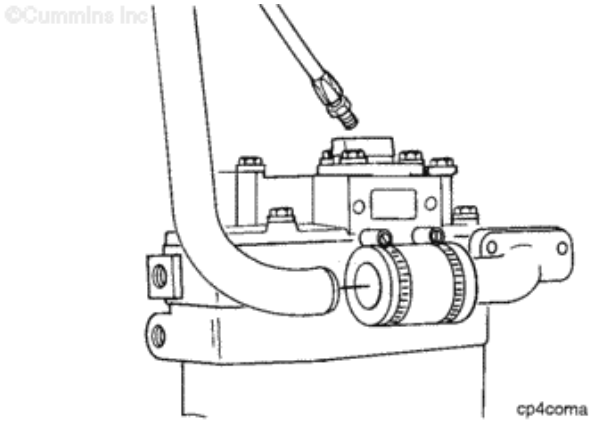
Tighten the capscrews to the block (2).

Torque Value:
Capscrews to
Block 135 n.m [100 ft-lb]

Tighten the capscrews and nuts (3).



Torque Value: Capscrews and Nuts 47 n.m [35 ft-lb]		

On the one-piece and two-piece brackets, install the air inlet and outlet connections to the air compressor. Tighten the clamps. **Torque Value:** 6 n.m [53 in-lb]		

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005-016 Fuel Pump

Install

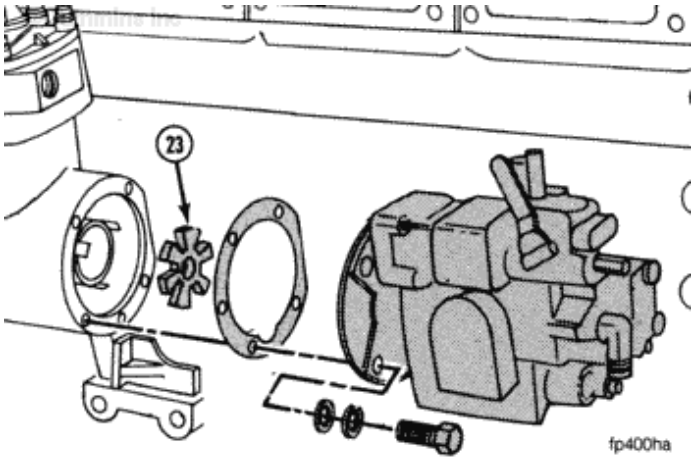
All K19 engines use a white nylon or light green fuel pump drive coupling.

Install the drive coupling (23).

Install the gasket, fuel pump and four capscrews.

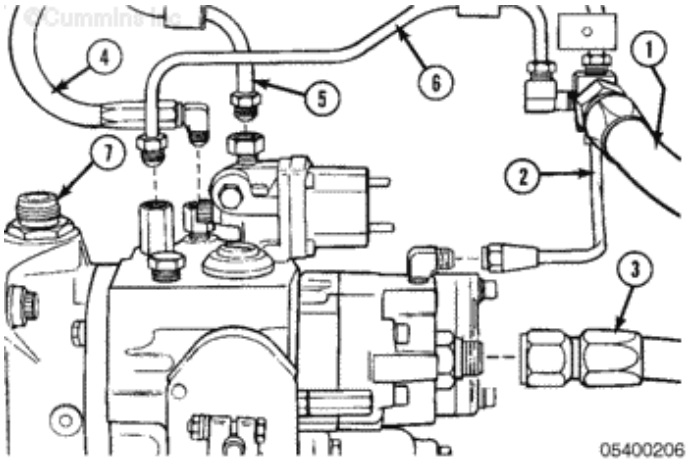
Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]

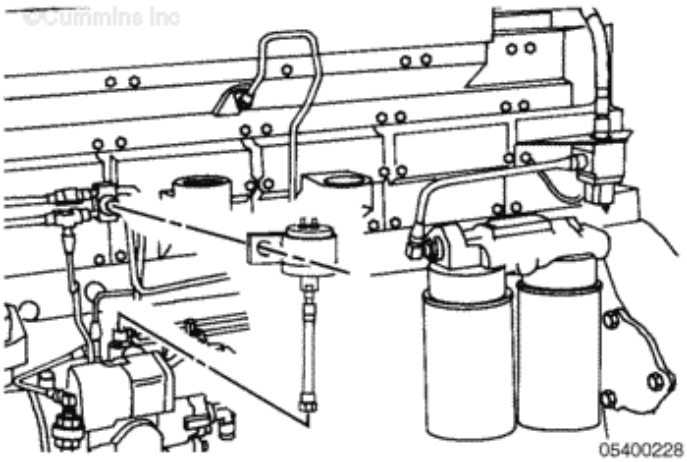


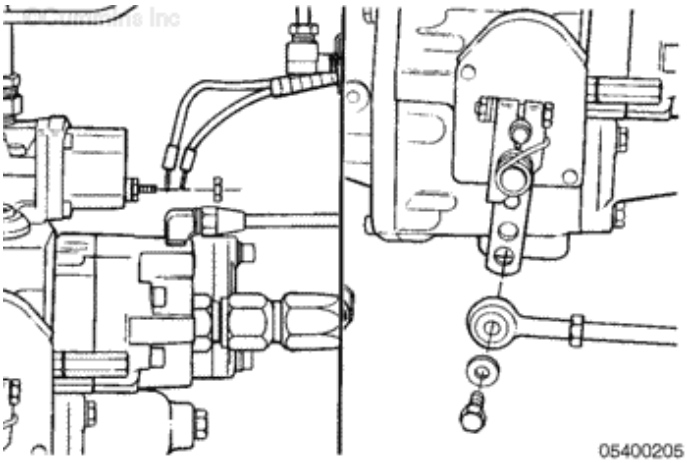
Install the following items:

- Fuel drain (1)
- Gear pump cooling drain (2)
- Gear pump suction line (3)
- AFC fuel drain (4)
- Fuel supply to the injectors (5)
- AFC air supply hose (6)
- Tachometer



cable (7).		

NOTE: This step applies only to engines equipped with STC. Install the STC pressure switch. Connect the hose to the switch and to the fuel pressure tube fitting on the fuel pump.		

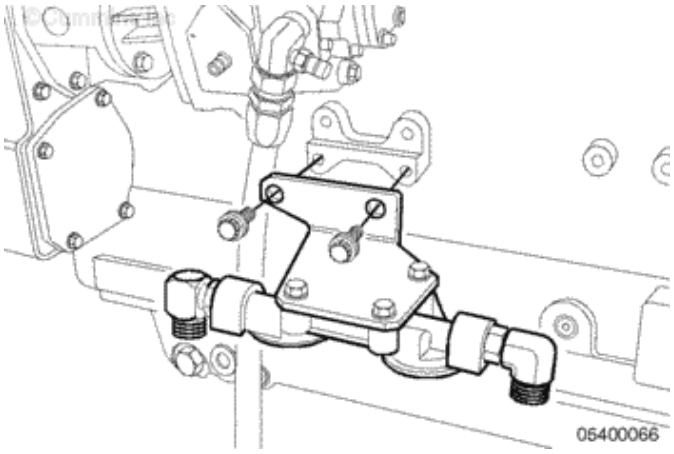
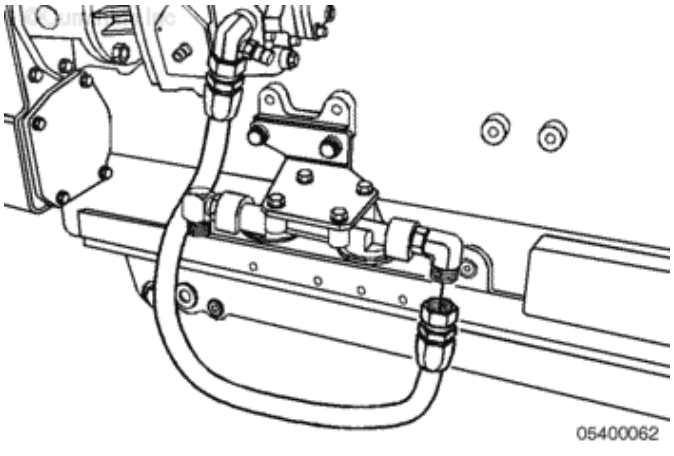
Make sure the wire connection nut and ground post are clean. Install the electric wire to the fuel shutoff valve. Tighten the nut. Install the linkage to the throttle lever.		

Last Modified: 31-Jul-2006

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006-017 Fuel Filter Head

Install

Install the fuel filter head. Install the two mounting capscrews. Tighten the capscrews. **Torque Value:** 55 n.m [40 ft-lb]		
Connect the fuel line to the fuel filter head.		

Last Modified: 04-Nov-2004

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004-001 Cam Follower Assembly

Install

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.

Service replacement cam followers are coated with a heavy preservative to prevent rust. This preservative **must** be removed completely with solvent before the cam followers are installed on the engine.

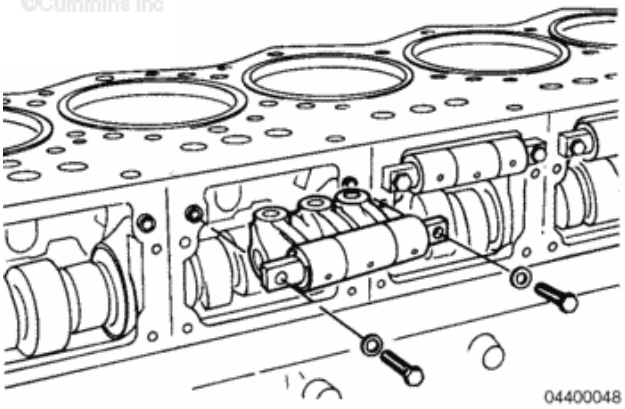
The cam follower mount capscrews are special. They have a slot that allows oil to flow to the cam follower assembly. The oil drilling intersects with the rear capscrew hole. Failure will result if standard capscrews are used.

Lubricate the camshaft and cam followers with clean engine oil.

Install the cam follower assembly.

The shaft **must** fit on both ring dowels.

Install and tighten the capscrews.



Cam Follower Mounting Capscrew Torque		
n.m		ft-lb
39	MIN	29
42	MAX	31

Last Modified: 20-Dec-2004

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004-002 Cam Follower Cover

Install

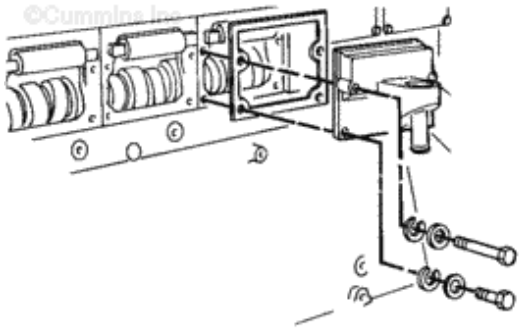
Two types of Gaskets Used on K19 Engines

- Gaskets **with** a raised bead of sealant material **must** be installed so the bead touches the cover.
- Gaskets **without** a bead of sealant are manufactured from a material that enlarges when exposed to engine oil. Do **not** use sealant on this type of gasket. These gaskets **must** be installed dry.

Only one of the camshaft follower covers contain an oil drain back tube. Install the camshaft follower cover with the crankcase ventilation hose in the number four position.

Install the gasket, camshaft follower cover, washers and capscrews.





04400054

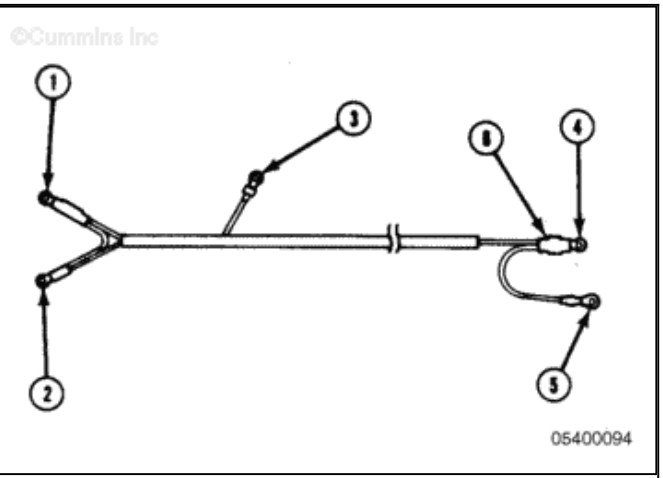
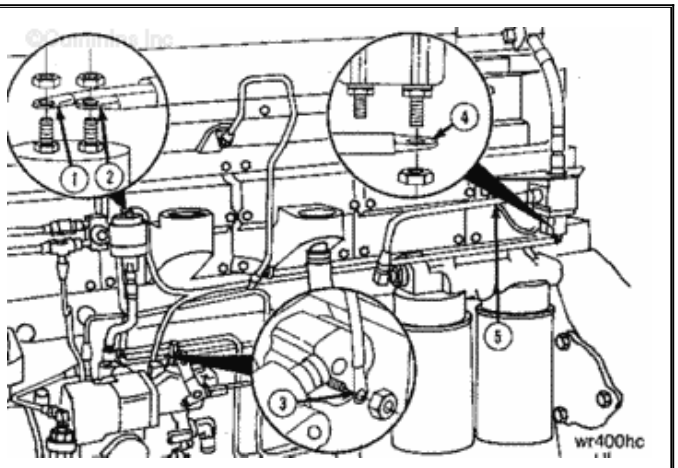
Tighten the capscrews. **Torque Value:** 25 n.m [20 ft-lb]		

Last Modified: 19-Dec-2011

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006-042 STC Wiring Harness

Install

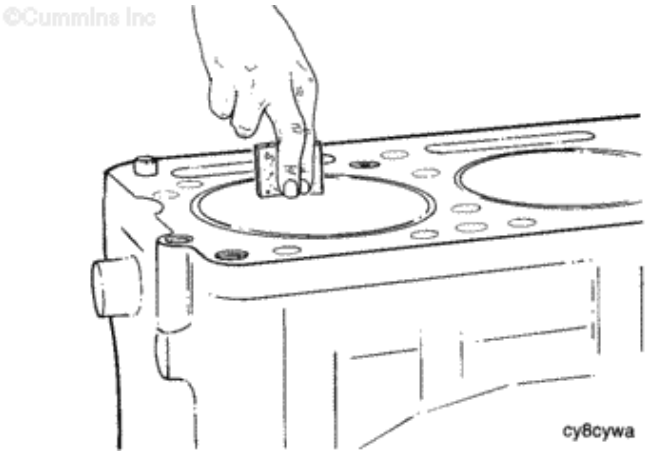
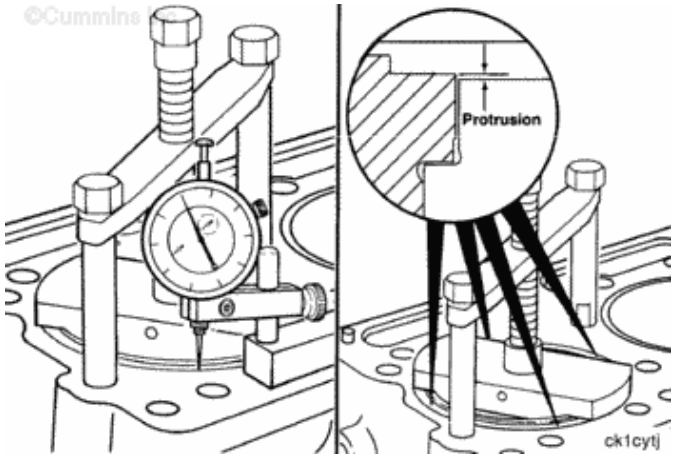
Identify the mounting location for each terminal of the STC wiring harness. (1) Fuel rail pressure switch (2) Fuel rail pressure switch (3) Fuel pump solenoid - positive terminal (4) Oil control switch - positive terminal (5) Ground.		
Install the wiring harness. Tighten the mounting nuts. **Torque** **Value:** 4 n.m [35 in-lb]	 	

Last Modified: 27-Oct-2004

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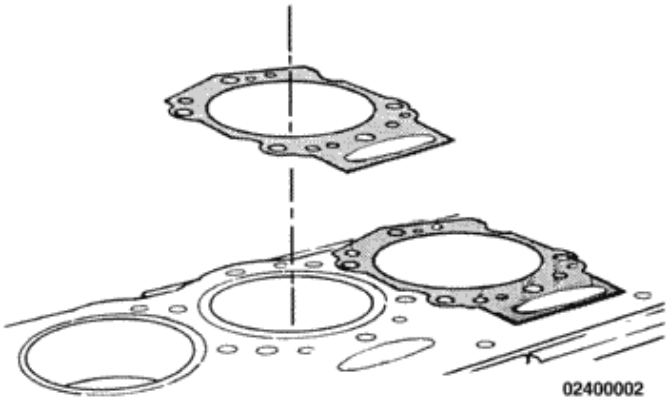
002-004 Cylinder Head

Install

Clean the top of the cylinder block and the cylinder liners.		
Measure the cylinder liner protrusion. Refer to Procedure 001-064 in Section 1.		
The word TOP, stamped on the top of the cylinder head gasket, **must** be		

visible after the gasket is installed.

Install the cylinder head gasket.



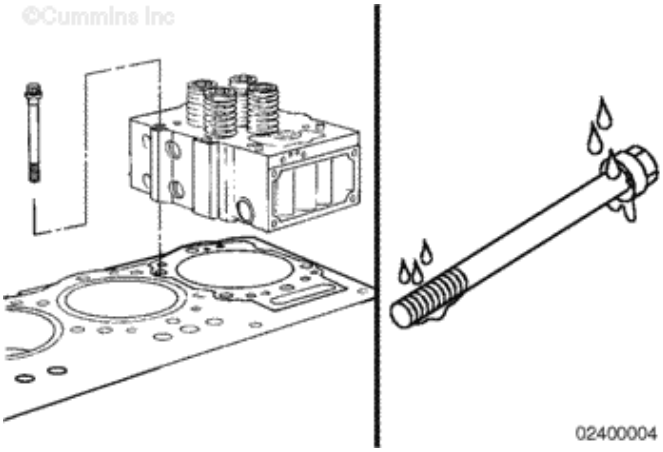
Install the cylinder head. It **must** slide easily over the groove pins.

Lubricate the cylinder head capscrew flange with SAE EP 140 weight oil.

Lubricate the cylinder head capscrew threads with clean engine oil.

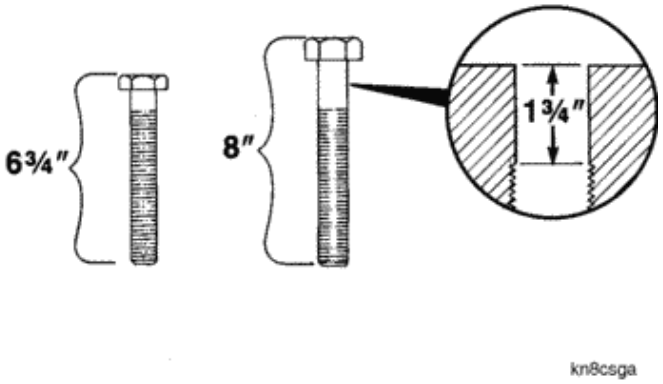
Allow the excess oil to drip off the capscrews before installing them into the block.

Install the capscrews.



CAUTION

The torque specification for the cadmium plated 170 mm [6¾ in] capscrews is lower than the torque specification for the lubrite coated (black) capscrews of the same length. Over-tightening of the cadmium plated capscrews causes



overload of the cylinder blocks, which can result in counterbore cracking or damaged threads. Do not mix cadmium plated capscrews with lubrite coated (black) capscrews on the same engine.

The original K19 cylinder head capscrews are 170 mm [6¾ in]. The capscrews can either be cadmium plated, producing a shiny chrome like finish, lubrite coated which appears black, or have a zinc phosphate coating, which is gray in color but can appear shiny after cleaning with a wire wheel. Make sure the correct torque is used when installing the capscrews.

All K19 engines with a serial number greater than 31103629 and all service blocks shipped since mid-1977 have used 203 mm [8 in] capscrews for the cylinder heads. The 203 mm [8 in] capscrews can be black or gray in color. Those that are gray in color have a zinc phosphate coating. The gray capscrews can appear shiny after cleaning with a wire wheel. There is **only** one torque specification for all capscrews that are 203 mm [8 in] in length.

Tighten the capscrews in the sequence illustrated in the graphic.

Torque Value:
Shiny Chrome 170 mm [6¾ in]

1. 65 n.m [48 ft-lb]

2. 160 n.m [118 ft-lb]
3. 250 n.m [184 ft-lb]
4. 345 n.m [254 ft-lb]

Torque Value:
Black 170 mm [6¾ in]

1. 65 n.m [48 ft-lb]
2. 200 n.m [148 ft-lb]
3. 340 n.m [251 ft-lb]
4. 490 n.m [361 ft-lb]

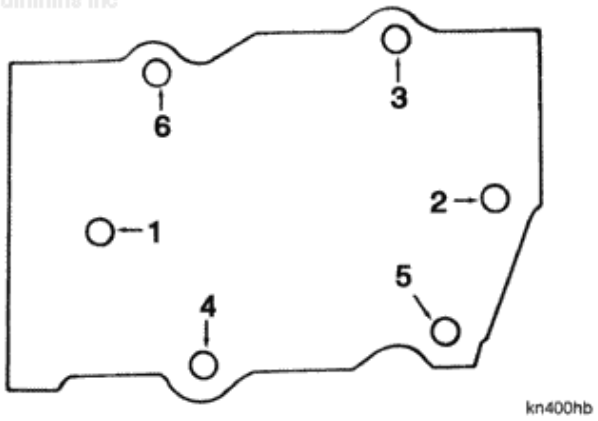
Torque Value:
Zinc Phosphate Gray 203 mm [8 in]

1. 65 n.m [48 ft-lb]
2. 200 n.m [148 ft-lb]
3. 340 n.m [251 ft-lb]
4. 490 n.m [361 ft-lb]

Torque Value:
Zinc Phosphate Gray 203 mm [8 in] (Alternate Method)

1. 65 n.m [48 ft-lb]
2. 200 n.m [148 ft-lb]
3. 300 n.m [221 ft-lb]
4. Advance 90 degrees

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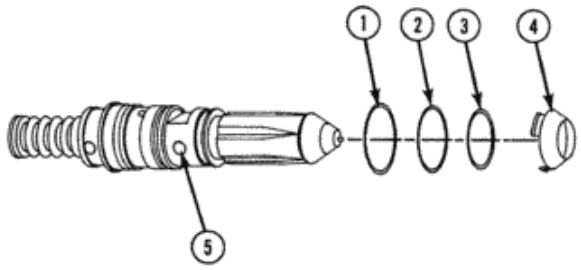
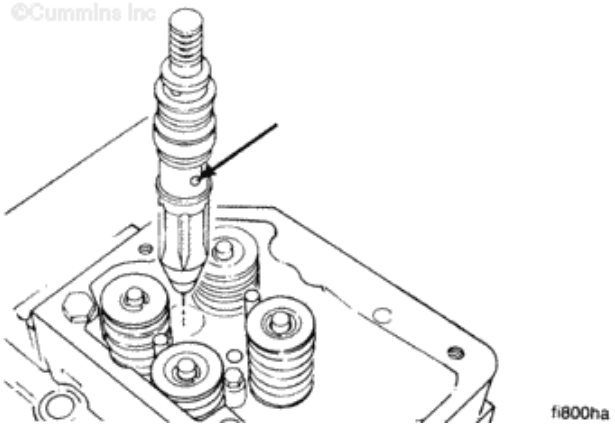


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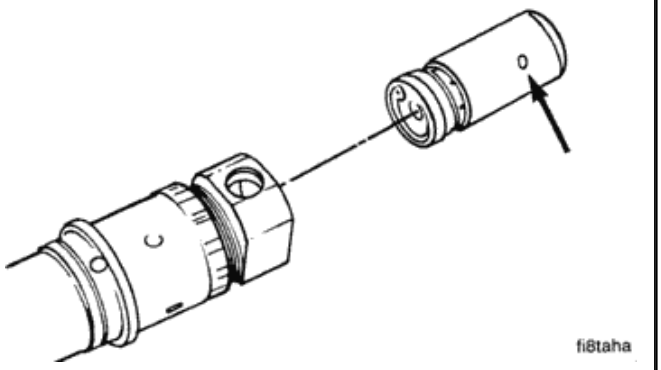
006-026 Injector

Install

Identify the o-rings so they can be installed in the correct groove. • O-ring (1) has a red dot or stripe and is dull gray in appearance. • O-ring (2) has no markings. • O-ring (3) has a green dot or stripe. The o-ring has a shiny black appearance. Lubricate the o-rings with vegetable oil and install them in the appropriate location. Install the proper size seal ring (4).		 fi4orga
Place the standard injector in the bore. Turn the injector so the screen points toward the hold-down capscrew hole on the intake side of the cylinder head.		 fi800ha
Do **not** allow the STC tappet		

fall out of the STC (top stop) injector. Damage can result.

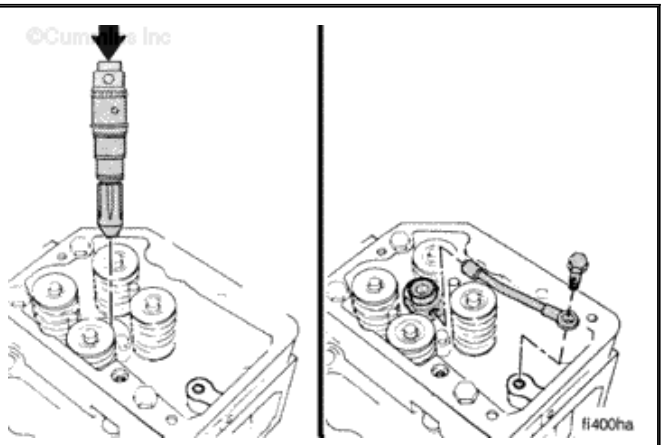
The STC tappet **must** be near the rocker lever assembly.



Do **not** push the injector on the seat until it is correctly aligned.

Place the STC injector in the bore. Turn the injector so the hole in the top stop screw points to the oil supply hole in the rocker lever housing.

Use the oil jumper tube and the connector screw as tools. Turn the injector until the holes are aligned. Remove the connector screw and the tube.

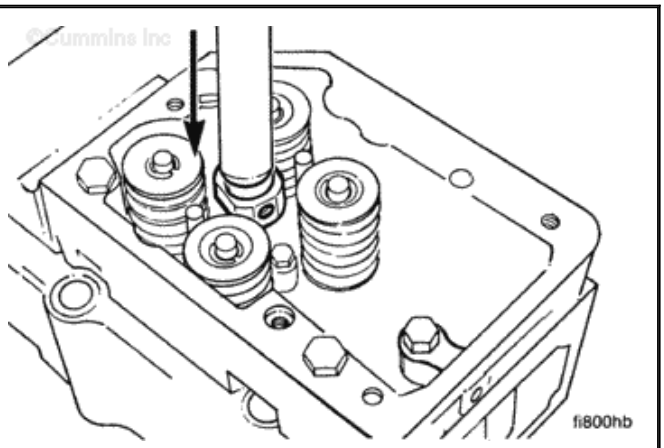


CAUTION

Do not use a wooden tool to push the injector onto the seat. Failure can result because of splinters falling into the tappet.

Apply a quick hard push with a blunt object that touches the top stop screw, to seat the injector.

A single snapping sound will be heard when the injector is seated properly.



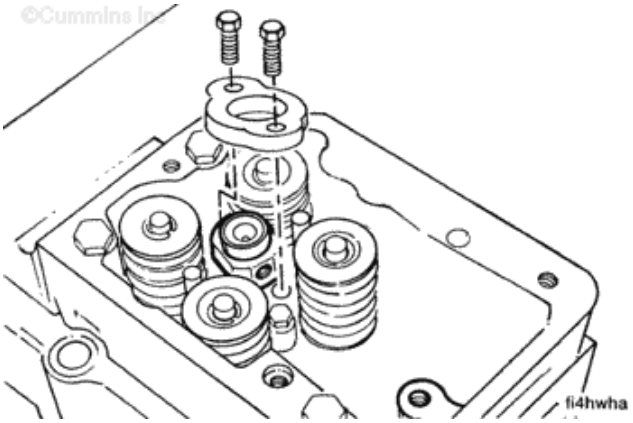
CAUTION

The injector hold-down clamp that is used on engines with STC requires capscrew that are 3 mm [1/8 in] longer than those on other K19 engines.

Install the hold-down clamp and the self-locking capscrews.

Alternately tighten the capscrews in sequence so the clamp is centered on the injector body.

Torque
Value: 16 n.m [145 in]

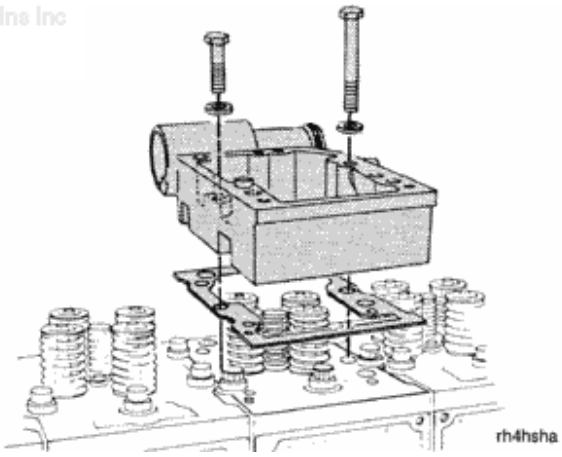
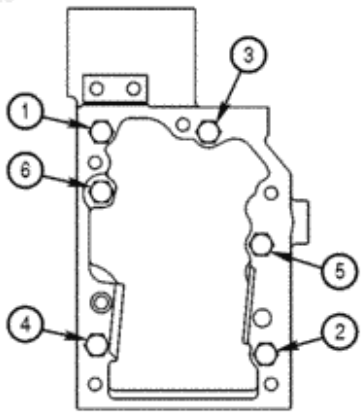


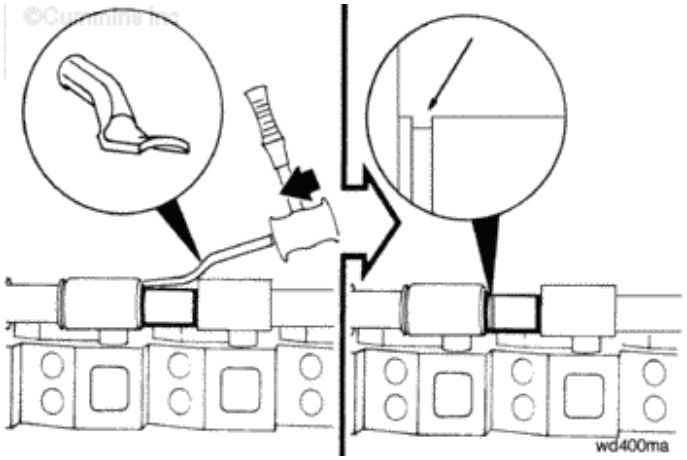
Last Modified: 13-Sep-2010

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003-013 Rocker Lever Housing

Install

Install the rocker lever housing gasket. Align the rocker lever housing with the dowels and install the housing. Check the threads of the rocker housing capscrews for damage. Check under the capscrew heads for cracks. Check for any deformation or necking of the capscrew. Install the six capscrews.		
Tighten the capscrews in the sequence illustrated in the graphic. **Torque** **Value:** 122 n.m [90 ft-lb]		

Drive the water tube into the adjacent housing until the tube is approximately centered, with water tube driver, Part Number ST-1319, and a hammer.		

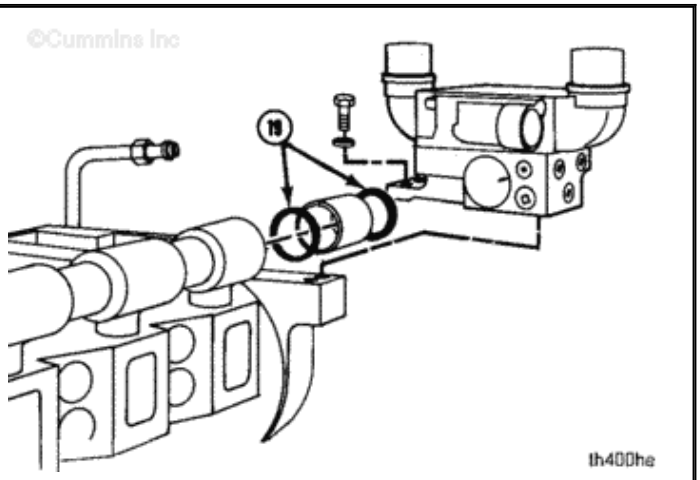
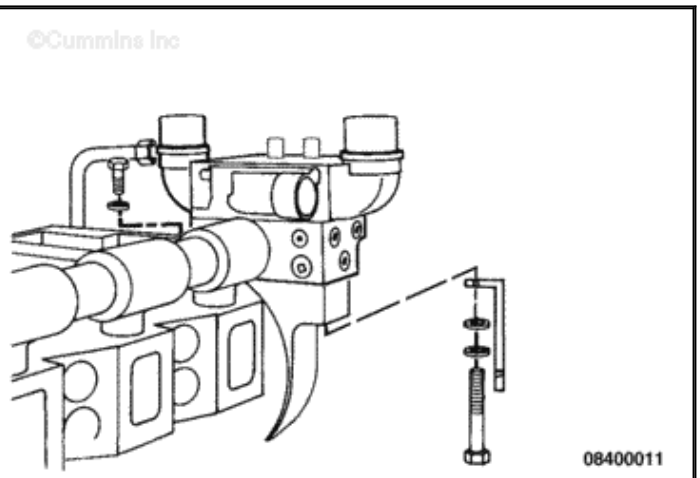
Last Modified: 28-Jun-2013

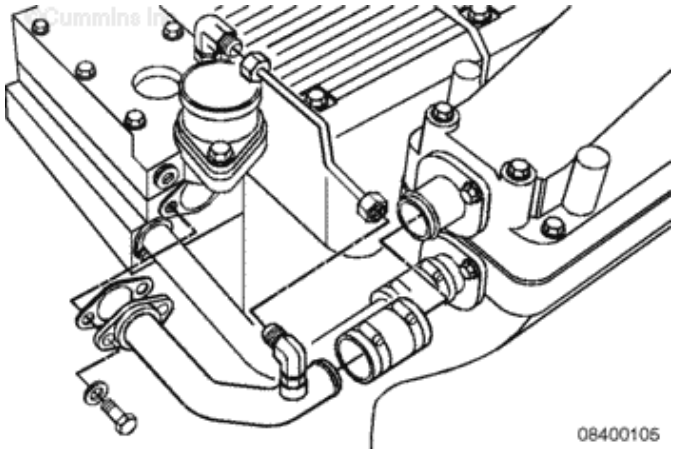
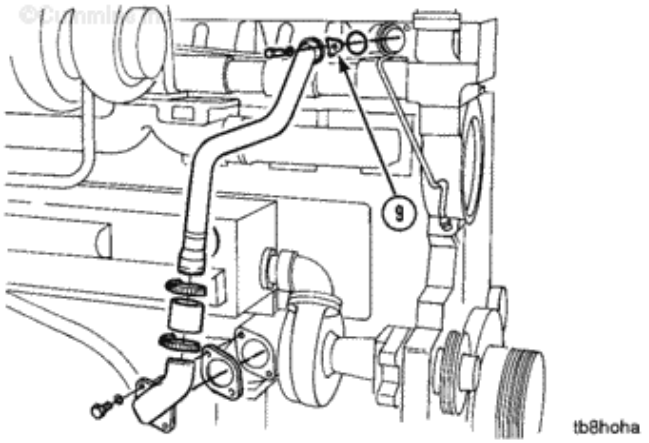
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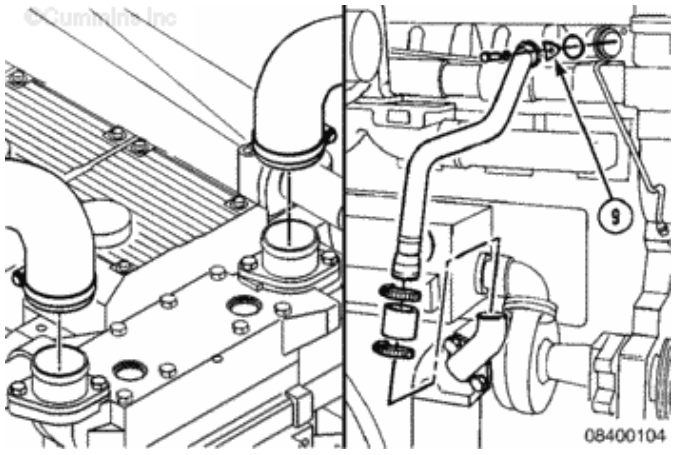
008-015 Coolant Thermostat Housing Support

Install

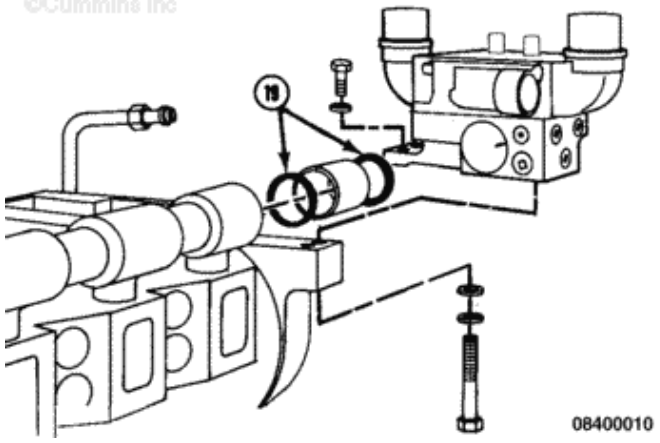
Aftercooled Engines

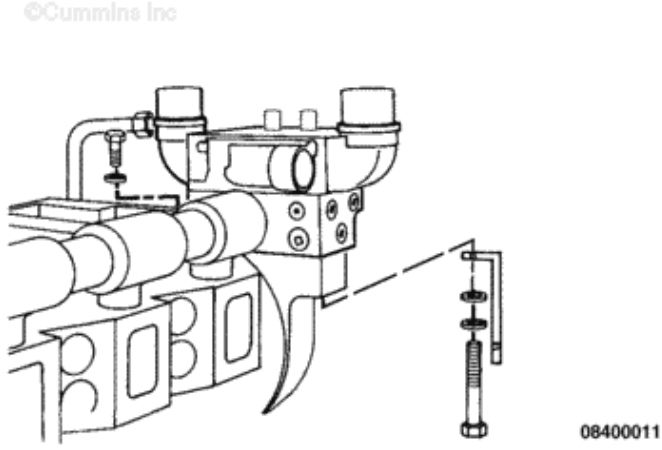
Install the o-rings (19) onto the water transfer tube. Lubricate the o-rings with vegetable oil. Install the transfer tube in the bore of the rocker lever housing. Align the bore in the thermostat housing support with the transfer tube. Push the support into position.		
The outside capscrew holds a clip for the aftercooler water inlet tube. Install the four lock washers and capscrews. Tighten the capscrews. **Torque Value:** 45 n.m [33 ft-lb]		

Connect the aftercooler coolant return tube, the aftercooler coolant supply tube, gaskets and hose(s) to the aftercooler. Install the gasket, coolant return tube, and capscrews. Tighten the capscrews. **Torque** **Value:** 6 n.m [50 in-lb] Connect the coolant temperature sensor wire. If the engine is equipped with an air compressor, install the air compressor coolant return tube.		
Install the o-ring onto the bypass tube. Lubricate the bypass tube o-ring with vegetable oil. Install the bypass tube. Tighten the capscrew. **Torque** **Value:** 45 n.m [33 ft-lb] Tighten the hose clamps. **Torque** **Value:** 6 n.m [50 in-lb]		

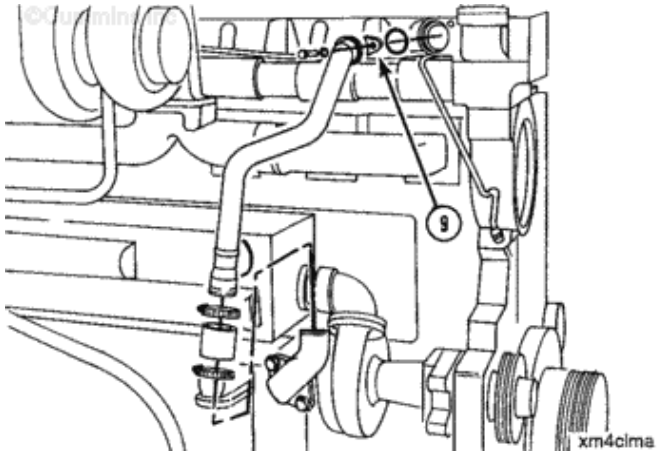
Install the two upper radiator hoses. Tighten the hose clamps. **Torque** **Value:** 6 n.m [50 in-lb] Install the vent lines.		

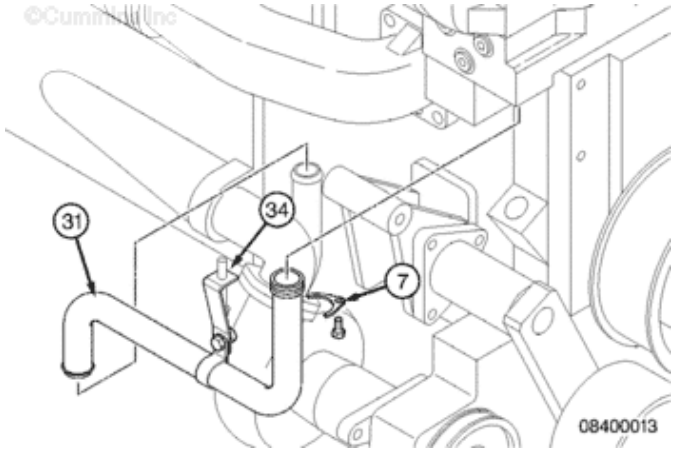
LTA

Install the o-rings (19) onto the water transfer tubes. Lubricate the o-rings with vegetable oil. Install the water transfer tube into the bore of the rocker lever housing. Align the bore in the thermostat housing support with the water transfer tube. Push the support into place.		

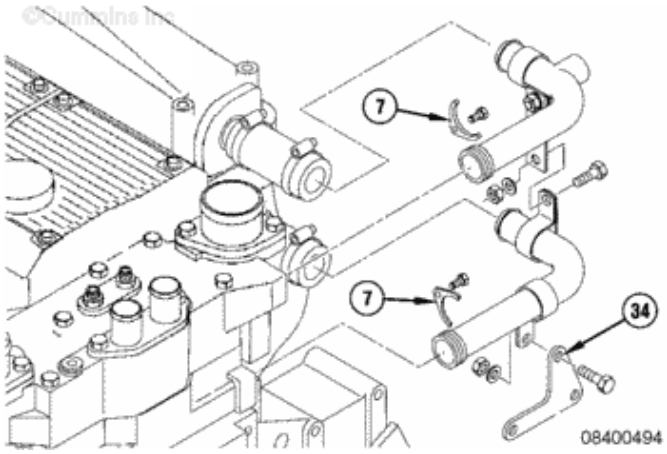
The outside capscrew holds a clip for the aftercooler water inlet tube. Install the four lock washers and capscrews. Tighten the capscrews. **Torque**		

Value: 45 n.m [33 ft-lb]		

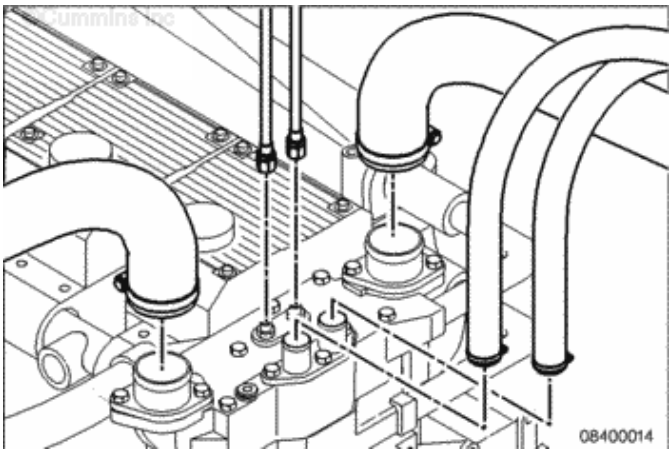
Install the o-ring onto the bypass tube. Lubricate the o-ring with vegetable oil. Install the retainer (9) and capscrew. Tighten the capscrew. **Torque** **Value:** 45 n.m [33 ft-lb] Tighten the hose clamps. **Torque** **Value:** 6 n.m [50 in-lb]		

The raised lip on the retainer (7) **must** point toward the thermostat housing. Lubricate the new o-rings with vegetable oil. Install the new o-ring on the aftercooler water supply tube (31). Install the aftercooler water supply tube into the bore of the thermostat housing. Install the retainer clips (7) and the capscrews. **Torque** **Value:** 20 n.m [15 ft-lb]		

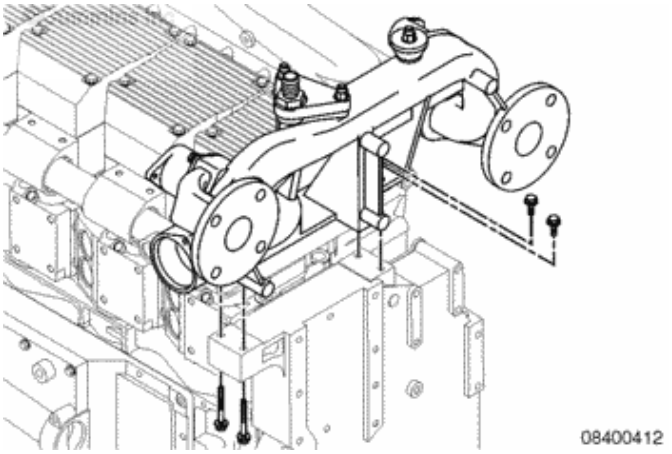
Tighten the hose clamps. **Torque** **Value:** 6 n.m [50 in-lb] Attach the support clip bracket (34).		

The raised lip on the retainer (7) **must** point toward the thermostat housing. Lubricate the new o-rings with vegetable oil. Install the o-rings on the aftercooler water inlet and outlet tubes. Install the aftercooler water inlet and outlet tubes, retainer clips (7) and capscrews. Tighten the capscrews. **Torque** **Value:** 20 n.m [15 ft-lb] Tighten the hose clamps. **Torque** **Value:** 6 n.m [50 in-lb] Attach the support clips to the bracket (34).		

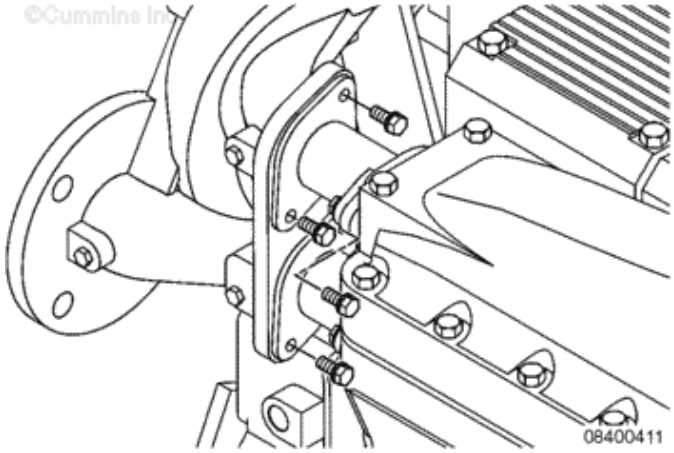
Install both of the radiator vent lines. Install the upper low temperature		

aftercooling radiator hose. Install both of the upper engine radiator hoses. Tighten the clamps. **Torque** **Value:** 6 n.m [50 in-lb]		

Marine Applications

Install the o-rings at the water rail flange and the aftercooler supply and return tubes. Install the thermostat housing to the top of the gear cover with four capscrews. Make sure the o-rings are in place. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb]		

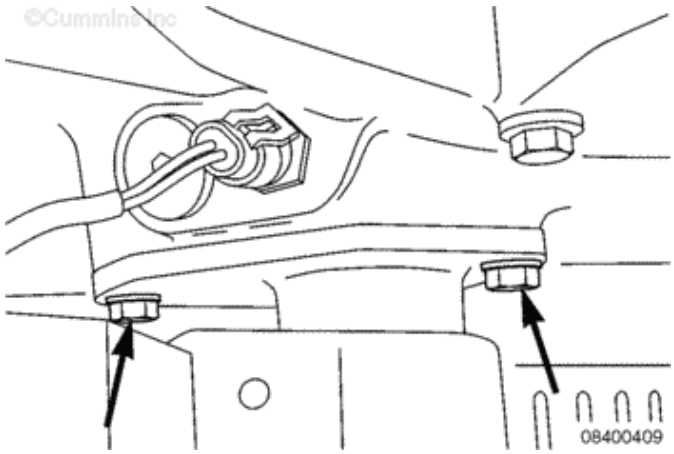
Install the four capscrews at the aftercooler supply and return tubes. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb]		



Install the two capscrews at the water rail flange to the thermostat housing.

Tighten the capscrews.

Torque Value: 40 n.m [30 ft-lb]



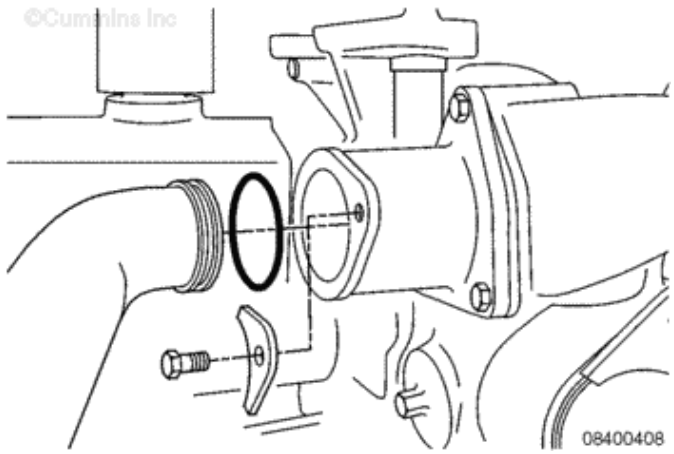
Install a new o-ring on the LTA supply pipe.

Insert the LTA supply pipe into the thermostat housing.

Install the upper and lower retaining clips.

Tighten the capscrews.

Torque Value: 40 n.m [30 ft-lb]



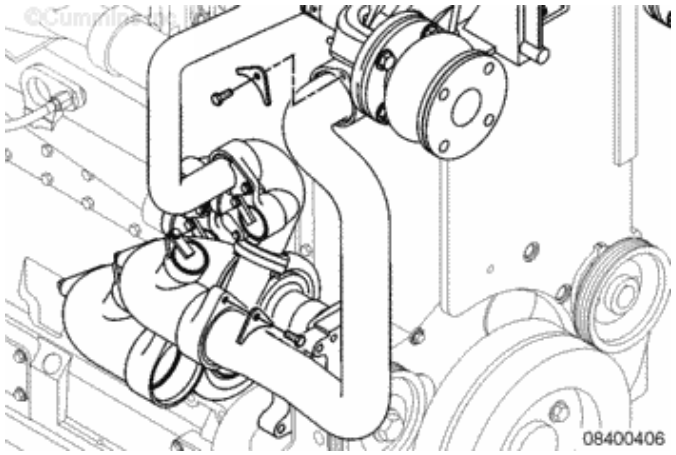
Install new o-rings on the water pump inlet pipe.

Insert the water inlet pipe into the water pump inlet and thermostat housing at the same time.

Install the upper and lower retaining clips.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

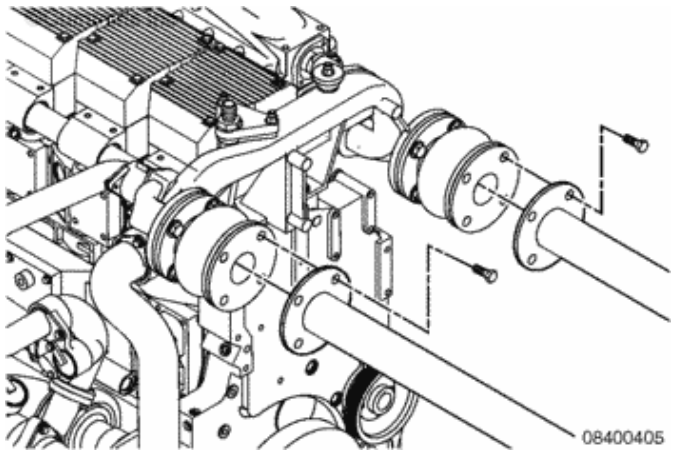


Install the flexible connections with four capscrews, if removed.

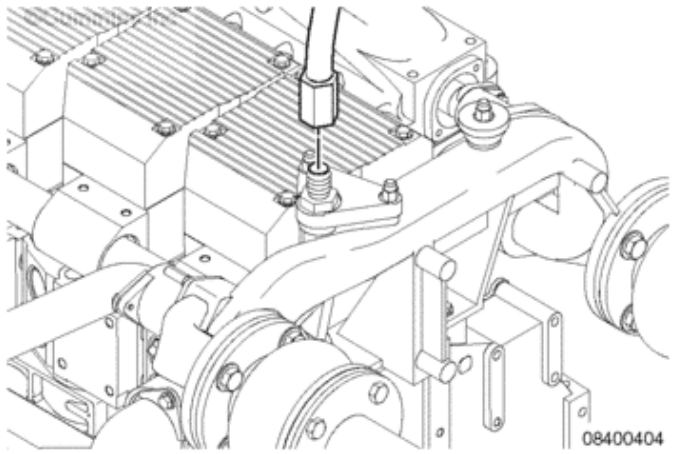
Tighten the capscrews.

Torque
Value: 180 n.m [135 ft-lb]

Connect the keel cooler supply and return pipes.



Connect the supply and vent hoses.

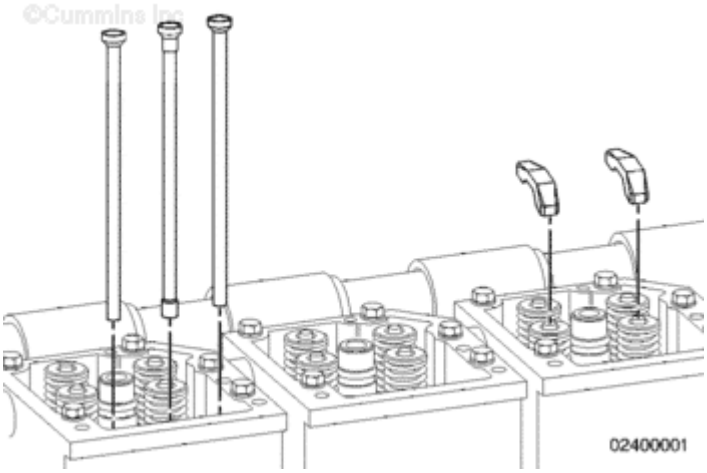


Last Modified: 19-Oct-2004

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004-014 Push Rods or Tubes

Install

The injector push rods are thicker in the middle. The valve push rods are the same thickness for both the intake and exhaust. Lubricate the sockets in the cam followers with clean engine oil. Install the push rods. Make sure the push rods are seated correctly in the cam followers. Install the crossheads.	 	

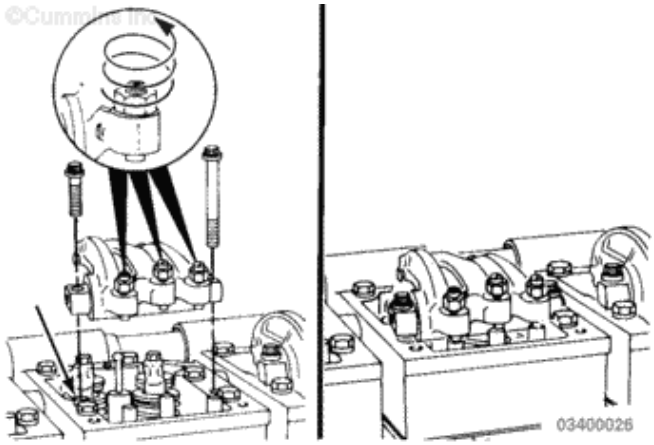
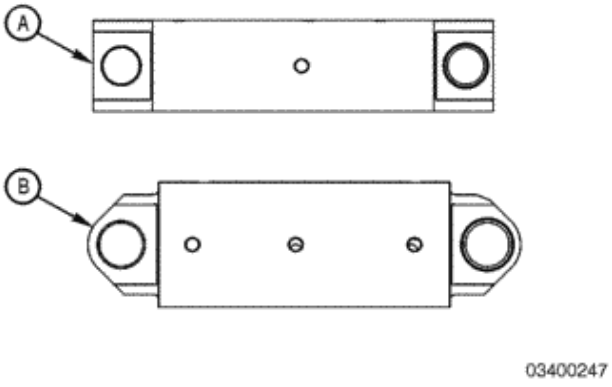
Last Modified: 23-Sep-2004

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View Related Topic

003-009 Rocker Lever Assembly

Install

Make sure the two dowels that align the rocker lever shaft are installed. Make sure the rocker lever adjusting screws are loose. Position the rocker lever assembly on the housing. Install the capscrews two or three revolutions. Align the push rod sockets with the adjusting screws.		
There are two different torque values, depending on the type of rocker lever shaft the engine has. For capscrews for rocker lever shaft A: **Torque** **Value:** 90 n.m [66 ft-lb] For capscrews for rocker lever shaft B: **Torque**		

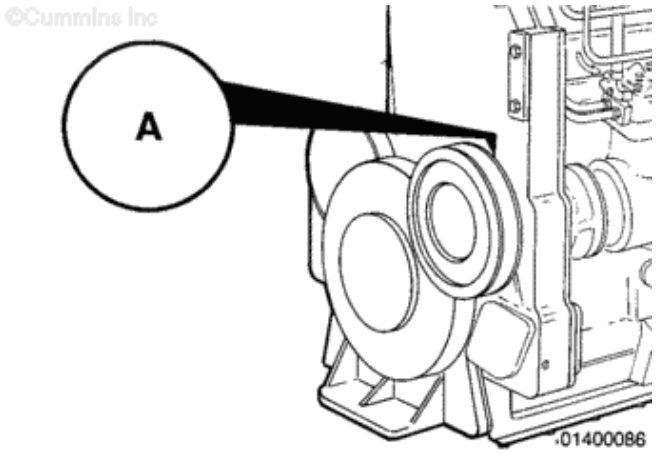
Value: 225 n.m [166 ft-lb]		

Last Modified: 17-Dec-2008

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003-006 Overhead Set (OBC)

Adjust

The barring device used on later engines with the one-piece front cover turns approximately two revolutions before the engine begins to turn. The device will **not** turn the engine opposite the direction of normal rotation. The barring device used on older engines with the two-piece front cover will turn the engine opposite the direction of normal rotation. Remove the clip and push the shaft in and turn the barring device **counterclockwise** until the “A” mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.		
Determine the cylinder in position for valve set. The valves will be adjusted on the cylinder that has all of the valves closed. Use the table to determine the cylinders		

for valve position.

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If Valve Set Mark Is:	Check Valve Position On:
A	1,6
B	2,5
C	3,4

fi400uz

If the rocker lever assemblies have been removed, use this step to determine the cylinder to be set.

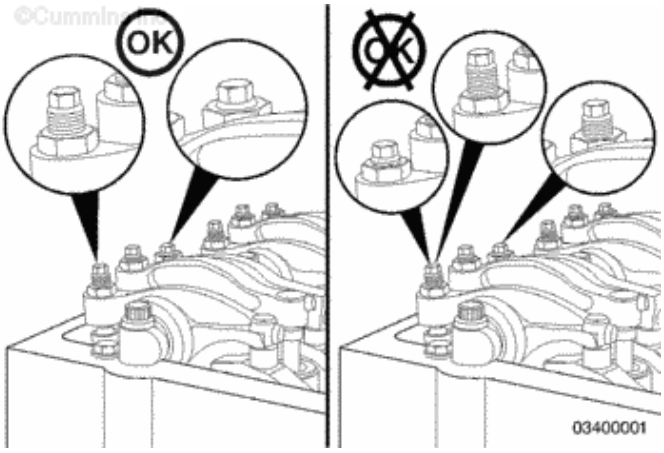
Lubricate the adjusting screw threads with clean engine oil prior to making valve and injector adjustments.

All adjusting screws **must** be loose on all cylinders, and the push rod **must** remain in alignment.

Perform this step on both cylinders to be checked.

Hold both rocker levers against the crossheads. Turn the adjusting screws until they touch the push rods. Turn the lock nuts until they touch the rocker levers.

The push rods will be the same height above the top of the rocker lever housing on the cylinder ready



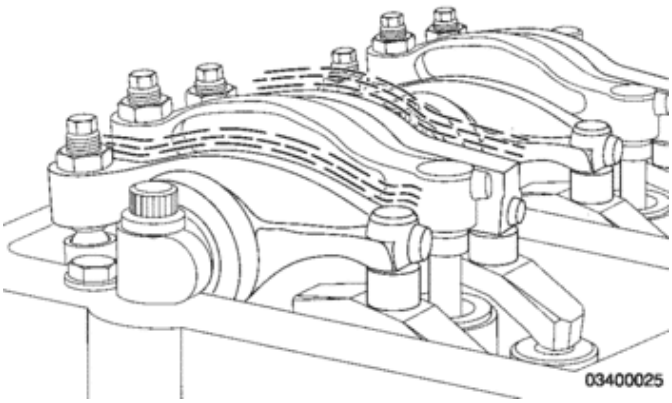
for valve adjustment.

CAUTION

There are two different procedures for adjusting the valves and injectors on K19 engines. Engines with fixed time are adjusted on the inner base circle of the camshaft using a dial indicator. Engines with STC (step timing control) or hydraulic variable timing are adjusted on the outer base circle using a torque wrench. Make sure to use the correct procedure for the engine being serviced, or all of the push rods can be bent.

If the rocker levers have **not** been removed, wiggle the valve rocker levers on the two cylinders in question.

Set the valves on the cylinder where both rocker levers feel loose.



Use the chart to determine the valve and injector that is ready to adjust.

Adjustment can begin on any valve set mark.

In the example, assume the A mark is aligned and the push rod heights indicate the valves on cylinder number 6 are closed, and one valve on cylinder 1 is fully open.

The chart shows the valves on cylinder

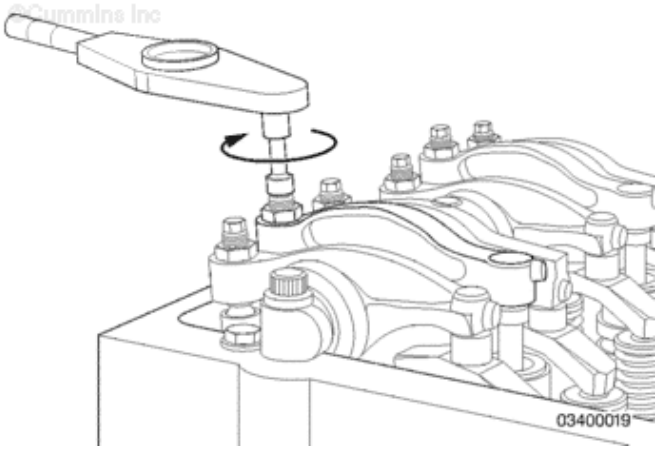
K19 OBC

	Valves Closed On	Set V	Set I
A	1	5	4
B	5	3	1
C	3	6	5
(A)	(6)	(2)	(3)
B	2	4	6
C	4	1	2

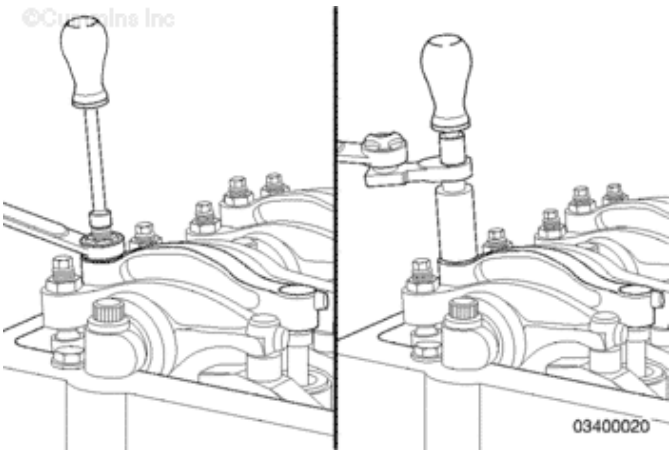
03400134

number 2 and injector on cylinder number 3 are ready to adjust. After the adjustment, bar the engine to the B set mark. Adjust the valves on cylinder number 4 and injector on cylinder number 6.		

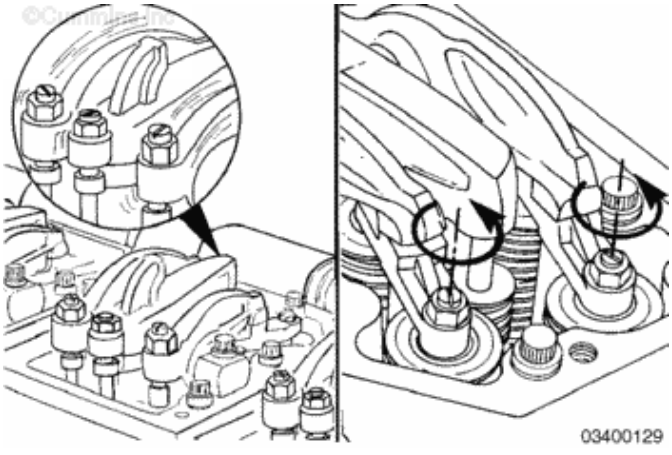
Injectors

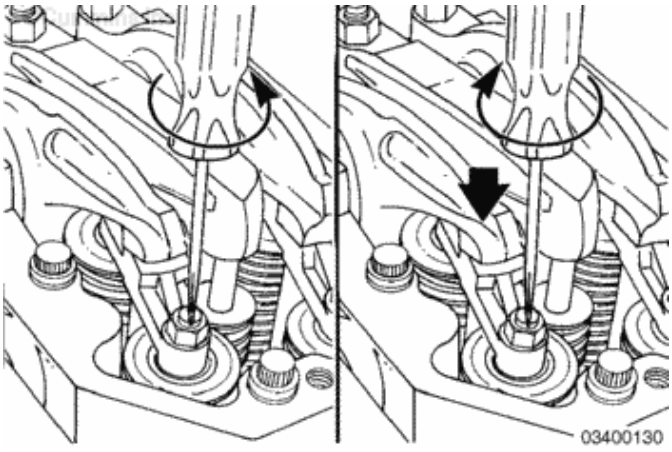
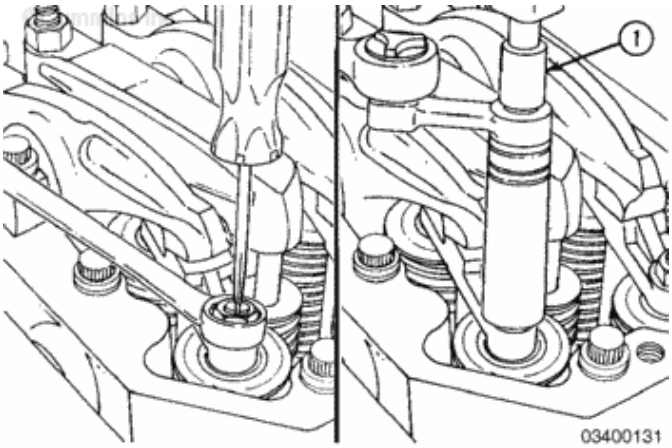
Use a dial-type torque wrench, Part Number 3164795, or equivalent, to tighten the injector rocker lever adjusting screw. If the screw chatters during setting, repair the adjusting screw and rocker lever as required. Position the torque wrench so the dial can be viewed in a direct line. This will enable the dial to be read accurately. Make sure the parts are in alignment and squeeze the oil out of the valve and injector train, while tightening the adjusting screw. This is an initial preload to the valve train and the injector. Tighten the adjusting screw. The torque wrench **must** be calibrated and have a resolution of 0.28 N•m [2.5 in-lb]. and have a range of 17 to 23 N•m [150 to 200 in-lb].		

Torque Value: 1. 11 n.m [100 in-lb] 2. Loosen adjusting screw 1 revolution 3. 10 n.m [90 in-lb]		

Hold the adjusting screw in position. The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut. **Torque Value:** With Torque Wrench Adapter, Part Number ST-669 1. 45 n.m [33 ft-lb] **Torque Value:** Without Adapter 1. 60 n.m [44 ft-lb]		

Crossheads

Crosshead adjustment **must always** be completed before attempting to adjust the valves. Adjust the crossheads on the cylinder that has both valves closed. Loosen the crosshead adjusting screw lock nuts on the intake and exhaust valve crossheads.		

Use this procedure to adjust both the intake and the exhaust crossheads. Turn the adjusting screw out a minimum of one turn. Hold the crosshead down against its mating valve stem. Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.		
Hold the adjusting screw in position. The adjusting screw **must not** turn when the lock nut is tightened to its torque value. Tighten the lock nut. Torque values are given when using and **not** using adapter, Part Number 3133196 (1). **Torque Value:** Without Jacobs® Brake (With Adapter) 1. 35 n.m [25 ft-lb] **Torque Value:** Without Jacobs® Brake (Without Adapter) 1. 40 n.m [30 ft-lb] **Torque Value:** With Jacobs®		

Brake (With Adapter) 1. 40 n.m [30 ft-lb] **Torque Value:** With Jacobs® Brake (Without Adapter) 1. 45 n.m [33 ft-lb]		

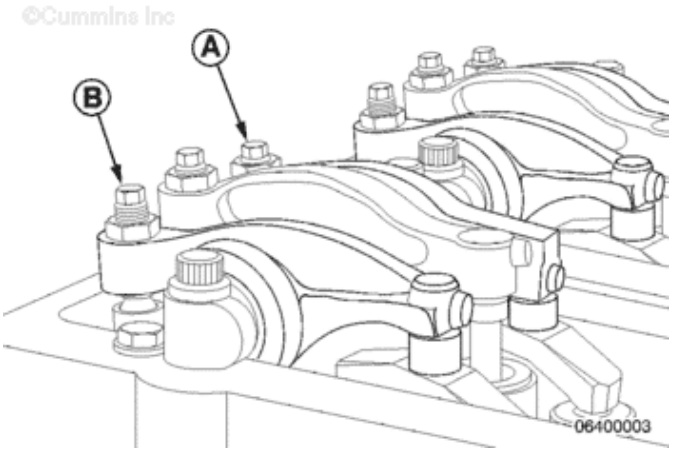
Valves

Use the table below to for valve adjustment initial set.

Valve Adjustment (Initial Set)	
Reference Point	**Valve**
A	Exhaust 0.69 mm [0.027 in]
B	Intake 0.36 mm [0.014 in]

The recheck limits are to be used when checking the overhead set during troubleshooting or periodic maintenance. The initial set specifications **must** be used when the valves are being adjusted.

Valve Recheck Limits	

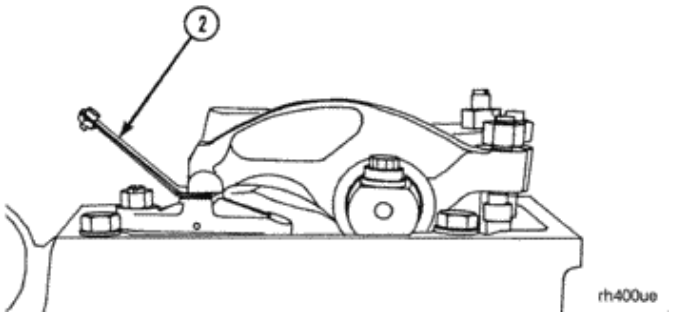


Reference Point	Valve
A	Exhaust minimum of 0.610 mm [0.024 in]
A	Exhaust maximum of 0.762 mm [0.030 in]
B	Intake minimum 0.279 mm [0.011 in]
B	Intake maximum 0.432 mm [0.017 in]

Make sure the crosshead is firmly in place on the valve stem tips.

Select a feeler gauge for the correct valve lash specification. Use service tool, Part Number 3163171 (intake) or Part Number 3163172 (exhaust).

Insert the feeler gauge between the rocker lever socket and crosshead.



There are two different methods for establishing valve lash clearance. Either method can be used. The torque wrench

method has proven to be the most consistent.

- Torque wrench method: Tightens the adjusting screw to 0.68 N•m [6 in-lb] against the feeler gauge, using torque wrench, Part Number 3376592.
- Feel method: Turns the adjusting screw until the lever touches the feeler gauge using a nut driver.

This step outlines the procedure for setting the valve lash using the torque wrench method.

Make sure the parts are in alignment and squeeze the oil out of the valve and injector train while tightening the adjusting screw.

Loosen the adjusting screw one revolution.

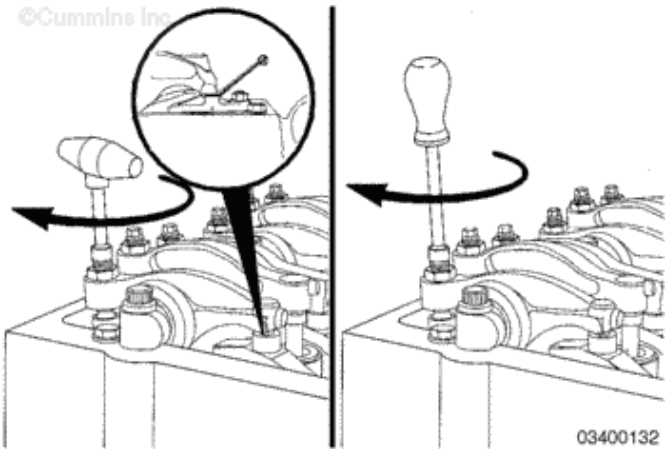
Insert the appropriate feeler gauge between the rocker lever and the crosshead.

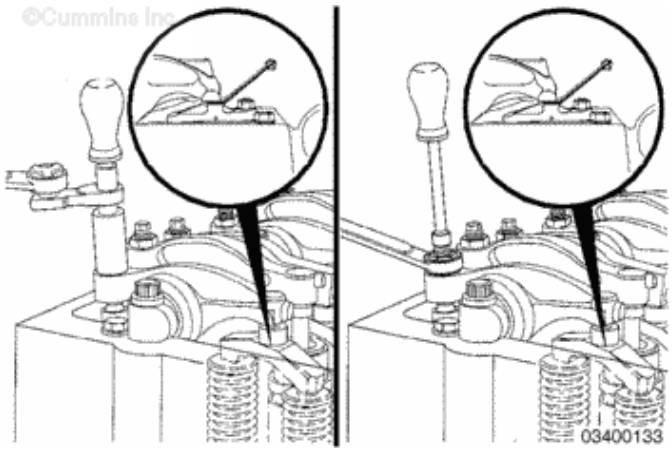
Tighten the adjusting screw.

Torque
Value: 0.68 n.m [6 in-lb]

Remove the feeler gauge.

The adjusting screw **must not** turn when the lock nut is



tightened. Tighten the lock nut. **Torque Value:** With Torque Wrench Adapter, Part Number ST-669 1. 45 n.m [33 ft-lb] **Torque Value:** Without Adapter 1. 60 n.m [44 ft-lb]		
This step outlines the procedure for setting the valve using the feel method. Make sure the parts are in alignment and squeeze the oil out of the valve and injector train while tightening the adjusting screw. Loosen the adjusting screw one revolution. Insert the appropriate feeler gauge between the rocker lever and crosshead. The feeler gauge **must** slide backward and forward with **only** a slight drag. The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut. **Torque Value:** With Torque Wrench Adapter,		

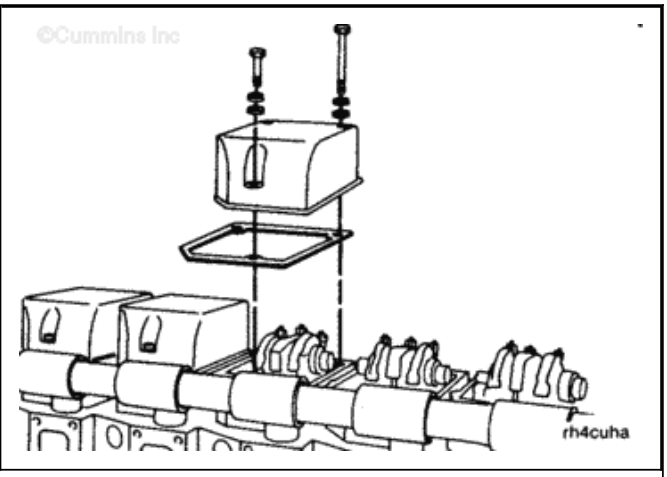
Part Number ST-669 1. 45 n.m [33 ft-lb] **Torque Value:** Without Adapter 1. 60 n.m [44 ft-lb] Attempt to insert a feeler gauge 0.03 mm [0.001 in] thicker than used for setting the valve lash. The valve lash is **not** correct if the feeler gauge will fit. Repeat the adjustment process until the clearance is correct on both the intake and exhaust valves.		

Last Modified: 16-Dec-2011

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003-007 Overhead Set (Travel Method)

Adjust



The valve and injector adjustment marks are found on the outside diameter of the accessory drive pulley or timing disk.

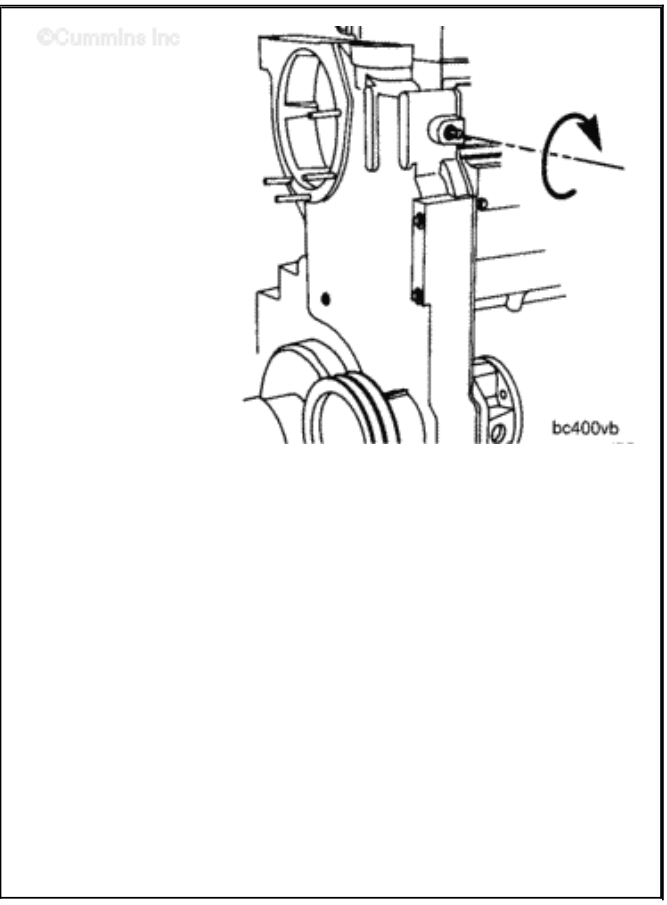
Some older engines have different index marks than A, B, and C.

On older engines:

- 1-6 VS is the same as A
- 2-5 VS is the same as B
- 3-4 VS is the same as C.

VS represents the valve set. Ignore any 1-6 TC mark during adjustment.

The barring device shaft turns approximately two revolutions before the engine begins to turn. The device will **not** turn the engine opposite the direction of normal rotation.

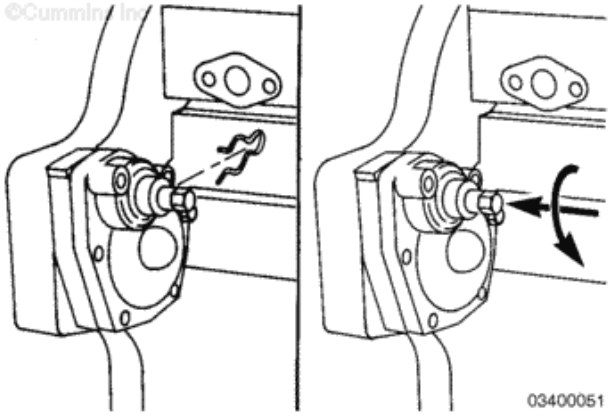


Push the shaft in and turn the barring device until the A mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.

On engines with a two-piece front cover:

- Remove the clip.
- Push the shaft in to engage the gears.
- Rotate the device shaft **counterclockwise** to turn the engine in the direction of normal rotation.

The alignment mark is also on the boss for the accessory drive seal.



The valves will be adjusted on the cylinder that has all of the valves closed. Use the table to determine the cylinders to check for valve position.

If Valve Set Mark Is:	Check Valve Position On:
A	1,6
B	2,5
C	3,4

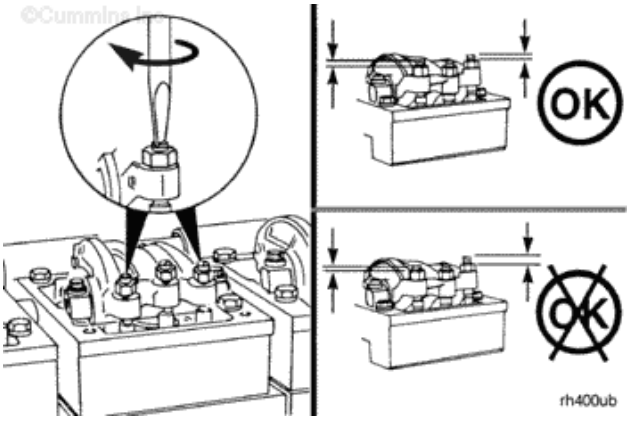
fi400uz

If the rocker lever assemblies have been removed, use this step to determine the cylinder to set.

All of the adjusting screws **must** be loose on all cylinders and the push rod **must** remain in alignment.

Perform this step on both of the cylinders to be checked.

Hold the rocker levers against



the crossheads. Turn the adjusting screws until they touch the push rods.

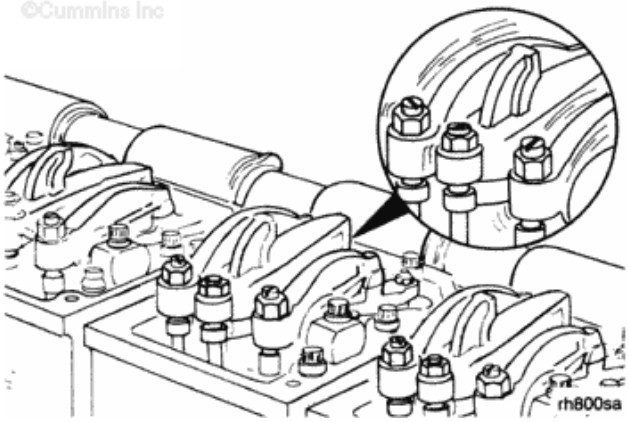
Turn the locknuts until they touch the rocker levers.

Compare the height of the adjusting screws above the locknut. The cylinder the adjusting screws are the same height are ready for valve adjustment.

The push rods will be the same height above the top of the rocker lever housing onto the cylinder ready for valve adjustment.

If the rocker levers have **not** been removed, wiggle the valve rocker levers on the two cylinders in question.

Set the valves on the cylinder where both levers feel loose.

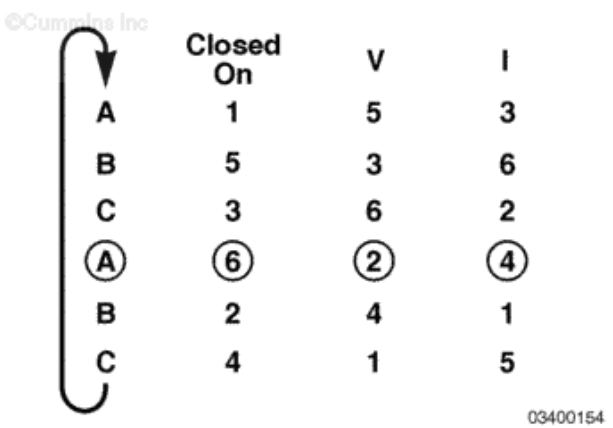


Use the chart to determine the injector that is ready to adjust.

Adjustment can begin on any valve set mark.

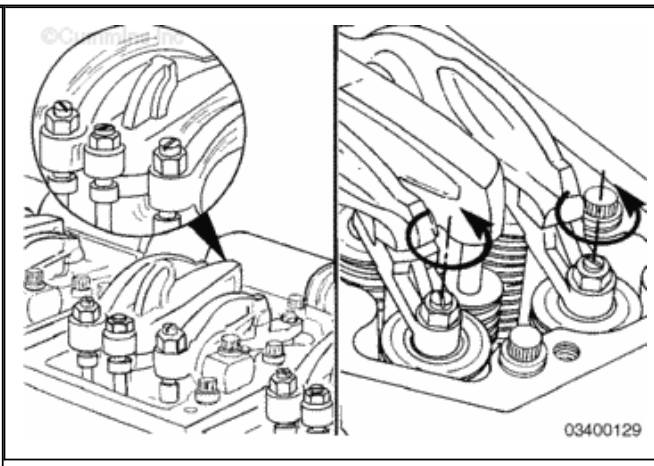
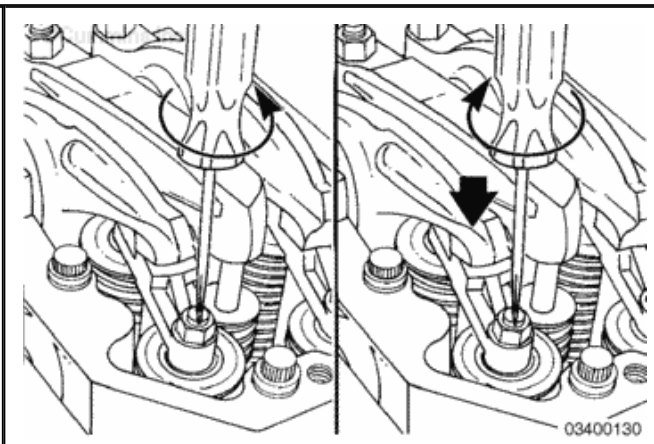
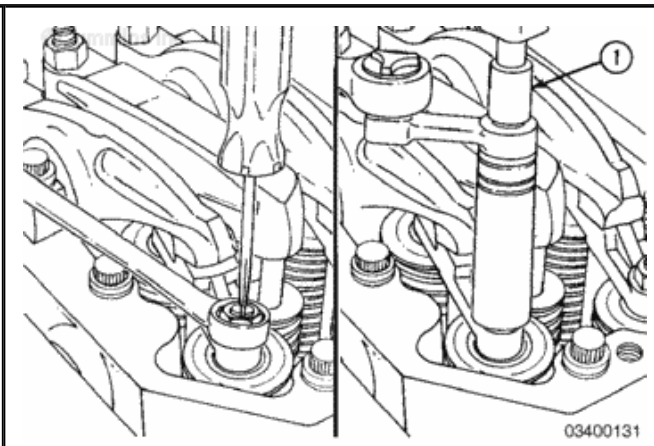
In the example, make sure the A mark is aligned and the adjusting screw height indicates the valves on cylinder number two are closed (ready to set). The chart shows the injector on cylinder number four is ready to adjust.

After the adjustment, bar the engine to the B set mark.



Adjust the valves on cylinder number four and the injector on cylinder number one.		

Crossheads

Crosshead adjustment **must always** be made before attempting to adjust the valves. Adjust the crossheads on the cylinder that has both valves closed. Loosen the crosshead adjusting screw lock nuts on the intake and exhaust valve crossheads.		
Use the following procedure to adjust both the intake and exhaust crossheads. Turn the adjusting screw out at least one turn. Hold the crosshead down against its mating valve stems. Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.		
The adjusting screw **must not** turn when the lock nut is tightened to its torque value. Hold the adjusting screw in position. Tighten the lock nut. The values are presented with and without the use of the torque wrench adapter (1), Part Number ST-669. **Torque Value:** Without Jacobs® Brake		

(With Adapter)

1. 35 n.m [25 ft-lb]

Torque Value:
Without Jacobs® Brake (Without Adapter

1. 40 n.m [30 ft-lb]

Torque Value:
With Jacobs® Brake (With Adapter)

1. 40 n.m [30 ft-lb]

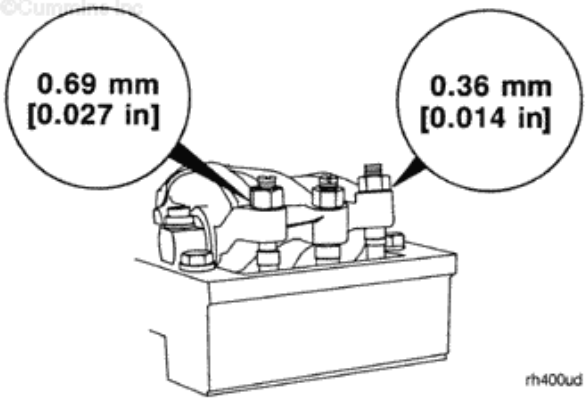
Torque Value:
With Jacobs® Brake (Without Adapter)

1. 45 n.m [33 ft-lb]

Valves

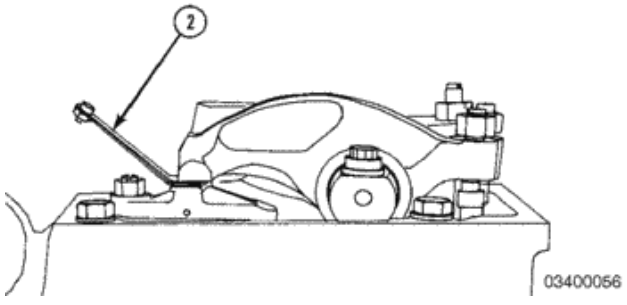
Use the table below to for valve adjustment initial set.

Valve Adjustment (Initial Set)	
Reference Point	**Valve**
A	Exhaust 0.69 mm [0.027 in]
B	Intake 0.36 mm [0.014 in]



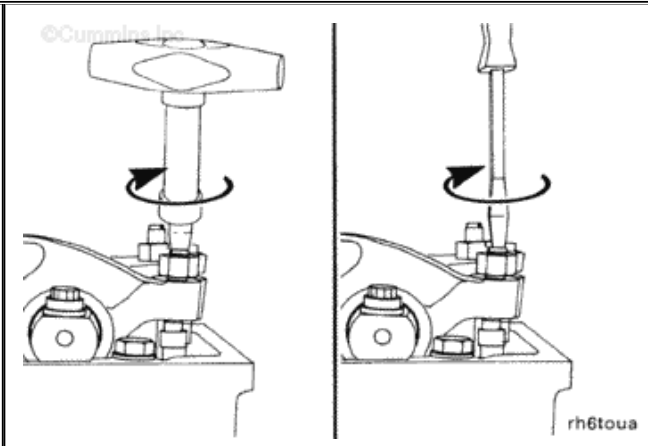
Select a feeler gauge for the correct valve lash specification. Use service tool, Part Number 3163171 (intake) or Part Number 3163172 (exhaust).

Insert the gauge (2) between the rocker lever and the crosshead.



There are two different methods for establishing valve lash clearance. Either method can be used; however, the torque wrench method has proven to be the most consistent.

- The torque wrench method uses an inch pound torque wrench, Part Number 3376592. The adjusting screw is tightened to 0.68 N•m [6 in-lb].
- The feel method uses a screw driver and the adjusting screw is turned **only** until the lever touches the feeler gauge.



The adjusting screw **must not** turn when the lock nut is tightened.

Tighten the locknut.

Torque Value:
With Torque Wrench Adapter, Part Number ST-669

1. 45 n.m [33 ft-lb]

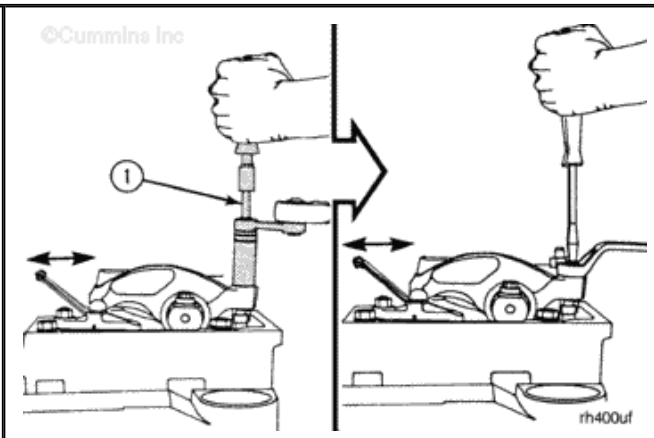
Torque Value:
Without Adapter

1. 60 n.m [44 ft-lb]

The feeler gauge **must** slide backward and forward with **only** a slight drag.

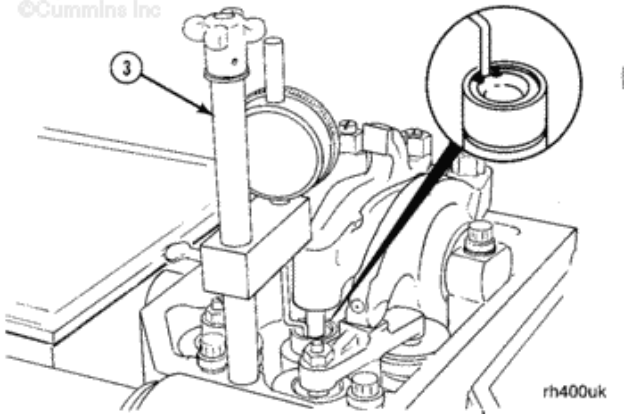
Attempt to insert a feeler gauge that is 0.03 mm [0.001 in] thicker. The valve lash is **not** correct when the thicker gauge will fit.

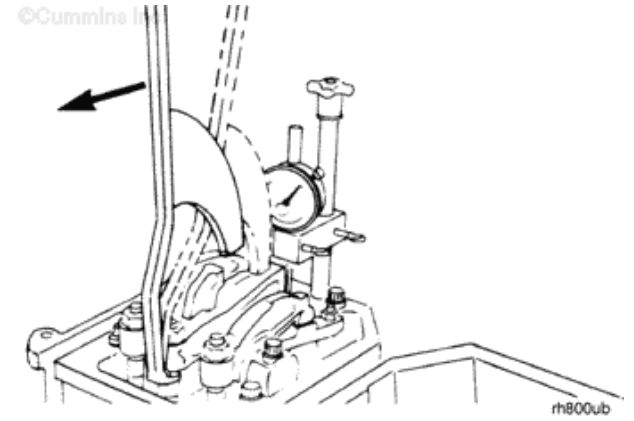
Adjust the slave cylinder clearance on the Jacobs Brakes. Refer to Procedure 020-999.



Repeat the adjustment process until the clearance is correct on both the intake and exhaust valves.		

Injectors

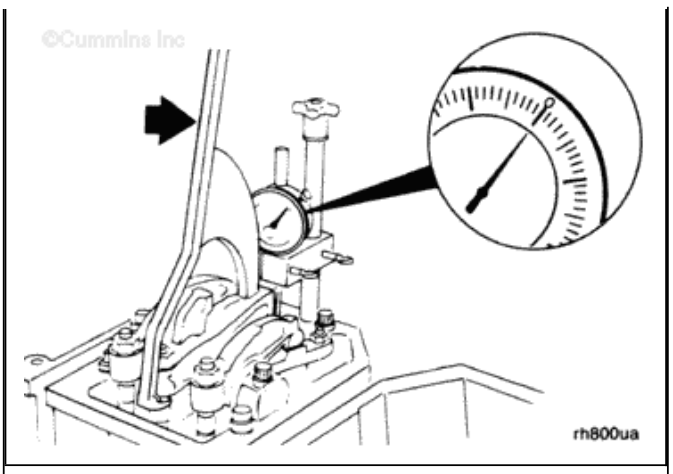
Assemble the parts of the injector and valve adjustment kit (3), Part Number 3375004, or equivalent. Install the adjustment kit on the cylinder to be adjusted as illustrated in the graphic. Adjust the indicator so the tip is touching the top of the injector plunger. Lower the indicator 12.7 mm [0.500 in] to allow for travel. Lock the indicator support to the post.		

WARNING The injector plunger is under spring tension. Do not allow the tool to slip. Personal injury can result. **CAUTION** Prevent damage to the indicator by allowing the lever to return slowly. Use a rocker lever actuator, Part Number 3376869, or equivalent, to depress the rocker lever until the injector bottoms two or three times. This will remove fuel and oil from the cup.		

Hold the lever with the injector plunger firmly bottomed in the cup. Set the		

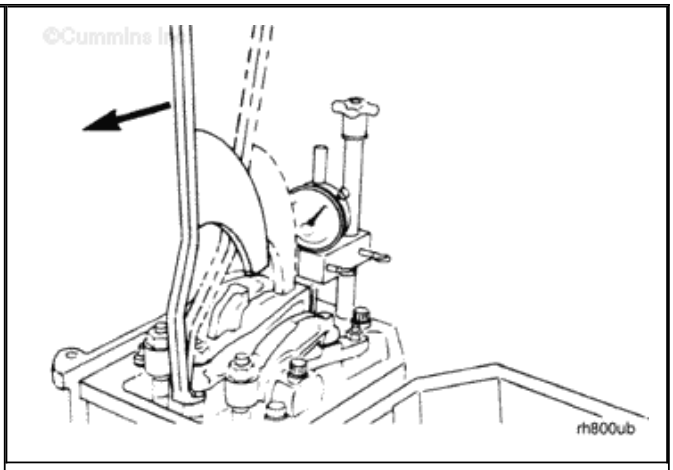
indicator to zero.

Raise and lower the lever a few time to confirm the zero.



Slowly release the lever and observe the travel of the gauge.

Press down or tap lightly on the adjusting screw to confirm the reading.

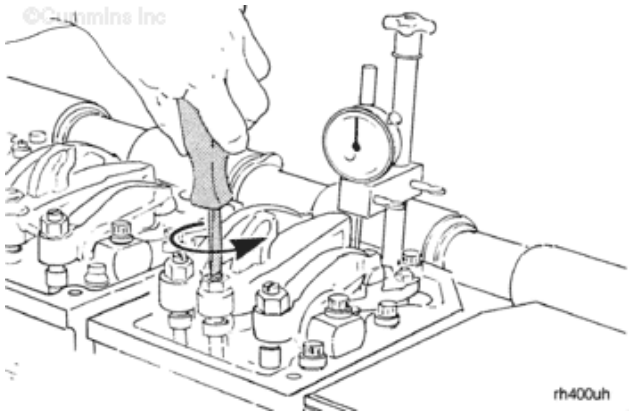


Turn the adjusting screw until the indicator reads the specified travel.

Injector Travel Specifications	
Model	**Specification**
All fixed time	7.72 mm [0.304 in]

Recheck limits are intended to be used on an engine already in service. It is **not** intended as a tolerance to be used when adjusting.

Recheck Limits
7.67 to 7.77 mm [0.302 to



0.306 in]

The adjusting screw **must not** turn when the lock nut is tightened.

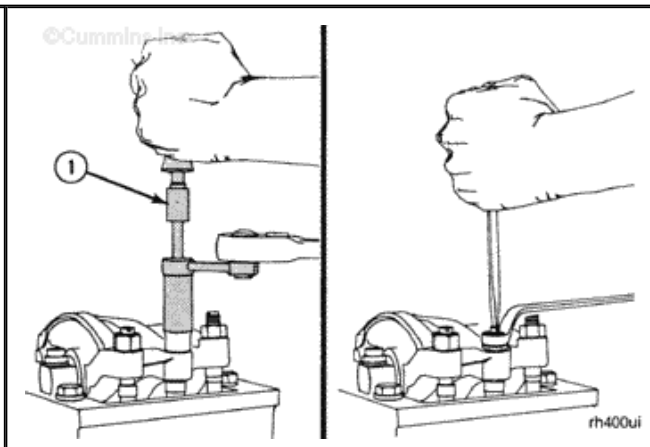
Tighten the lock nut.

Torque Value:
With Torque Wrench Adapter, Part Number ST-669

1. 45 n.m [33 ft-lb]

Torque Value:
Without Adapter

1. 60 n.m [44 ft-lb]



WARNING

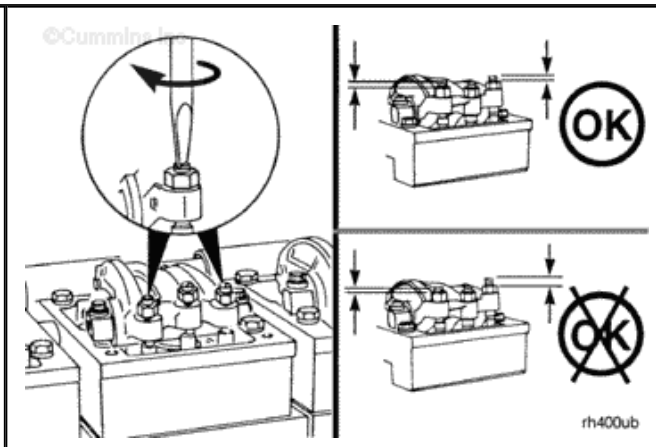
The injector plunger is under spring tension. Do not allow the tool to slip. Personal injury can result.

CAUTION

Prevent damage to the indicator by allowing the lever to return slowly.

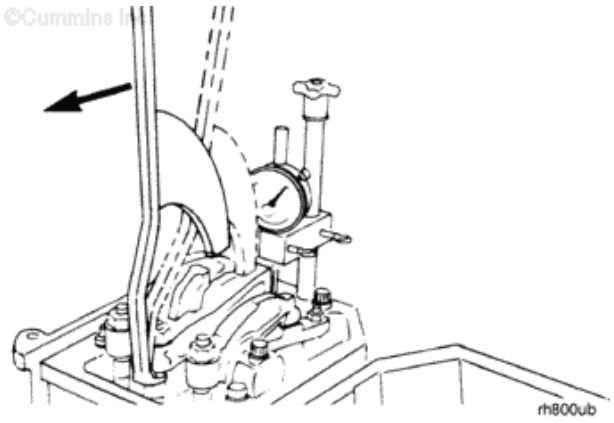
Check the injector adjustment. Use the rocker lever actuator. Bottom the injector plunger.

Confirm zero on the indicator.



Allow the rocker lever to return slowly.

Check the injector setting. Repeat the adjustment process if it is **not** within specification.

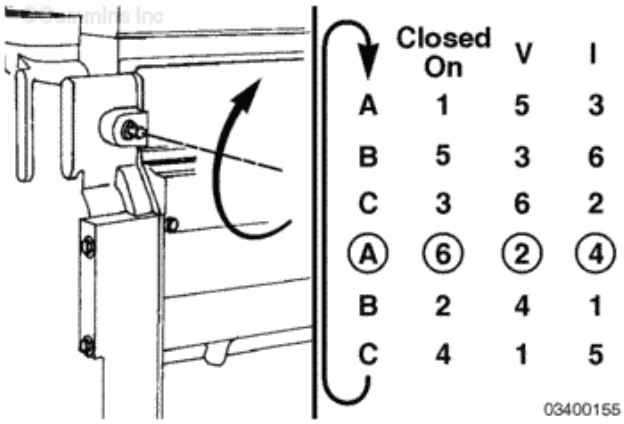


Rotate the engine.

Align the next mark.

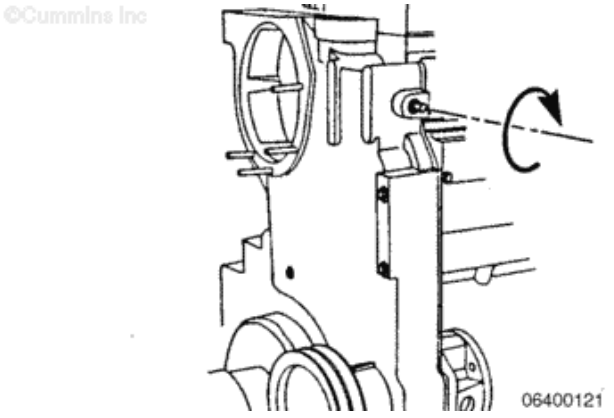
Adjust the appropriate valves and injectors.

Repeat the process to adjust all of the valves and the injectors correctly.



Turn the barring device in a **clockwise** direction to disengage the barring mechanism (worm gear).

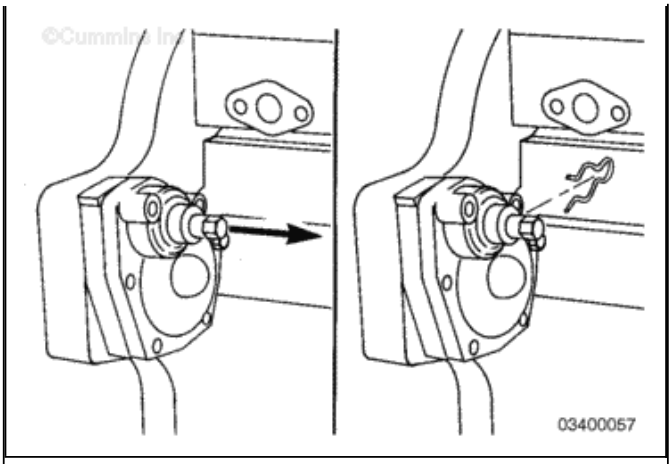
If the worm gear remains engaged during the engine start, the engine rotation will disengage the parts without damage.



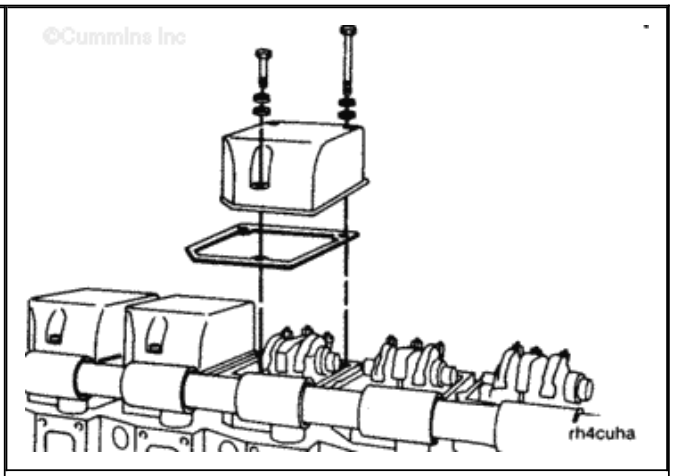
On engines with a two piece front cover:

- Pull the shaft out to

disengage the gears.
- Install the clip.







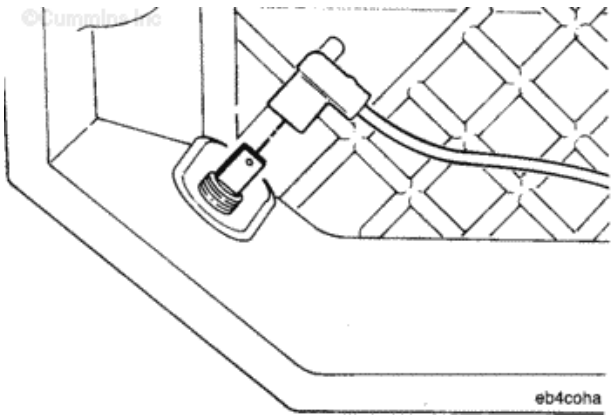
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003-011 Rocker Lever Cover

Install

If the engine has an engine brake, connect the solenoid wire to the terminal inside the cover.



CAUTION

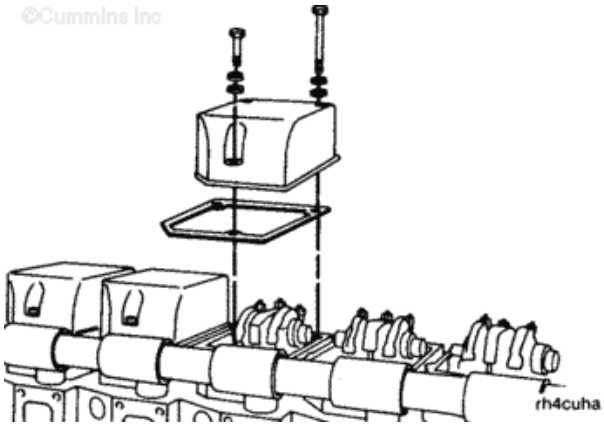
The use of gasket cement on the gasket will prevent the gasket from sealing properly.

Install the gasket and rocker lever cover.

Install the washers and capscrews.

Tighten the short capscrew first, then tighten the remaining capscrews.

Torque
Value: 45 n.m [33 ft-lb]

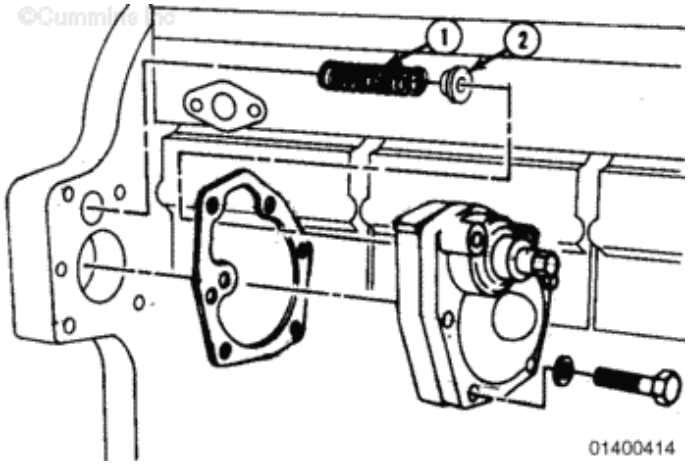


Last Modified: 17-Aug-2006

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009-035 Engine Barring Device

Install

Install the spring (1) and retainer (2). Install the gasket, barring mechanism, washers and capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]		

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View Related Topic

006-038 STC Oil Manifold

Install

Lubricate all o-rings with vegetable oil.

Install the o-rings, junction block, and capscrews.

Tighten the capscrews.

Torque
Value: 7 n.m [62 in-lb]

Install and tighten the STC oil manifold pipe plugs.

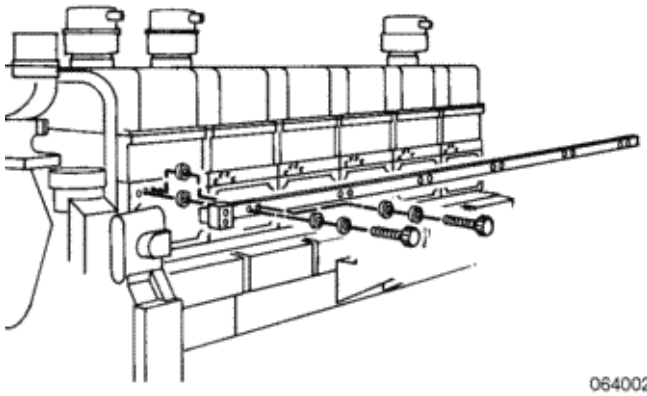
Torque
Value: 20 n.m [177 in-lb]

Apply Loctite™ 271, Part Number 3375068, or equivalent, to the capscrews.

Install the STC oil manifold, washers, and capscrews.

Begin tightening the capscrews at the center of the manifold and out to the ends.

Torque
Value: 16 n.m [142 in-lb]



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006-022 Fuel Manifold (Supply)

Install

NOTE: The fuel junction block on older engines can be toward the rear of the engine.

Lubricate the o-rings with vegetable oil.

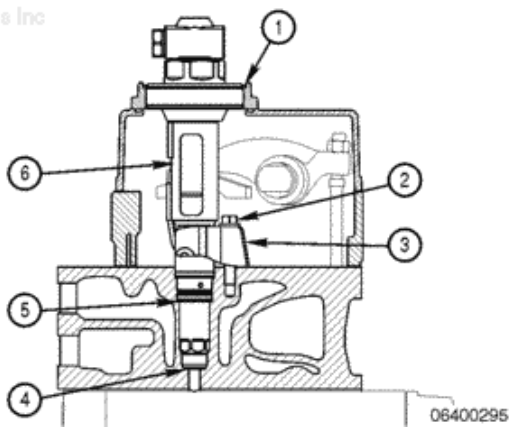
Install the o-rings onto the fuel manifold.

Install the fuel manifold, washers, and capscrews.

Start from the center of the fuel manifold work towards the outer edges tightening the capscrews.

Torque
Value: 10 n.m [89 in-lb]





CAUTION

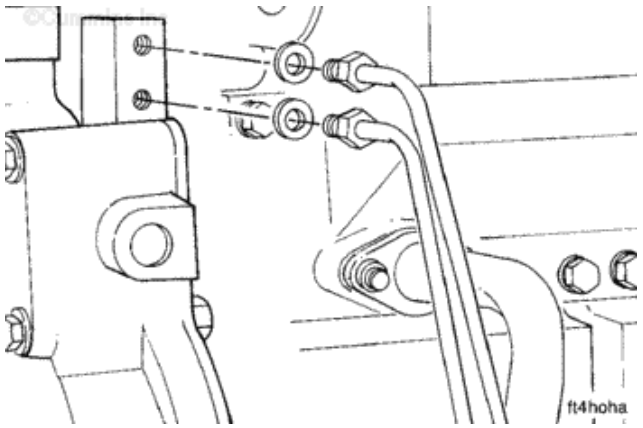
The seals must be installed on the tubes before the tubes are inserted into the junction block.

CAUTION

Do not over tighten the tube nuts and the junction block. Finger tighten the tube nuts into the junction block. Turn the tube nuts and additional ¾ to 1 turn past finger tight.

The fuel pressure tube is the





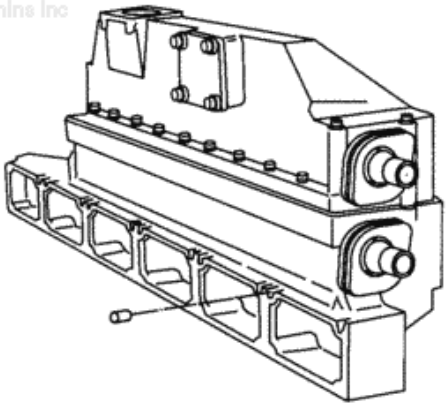
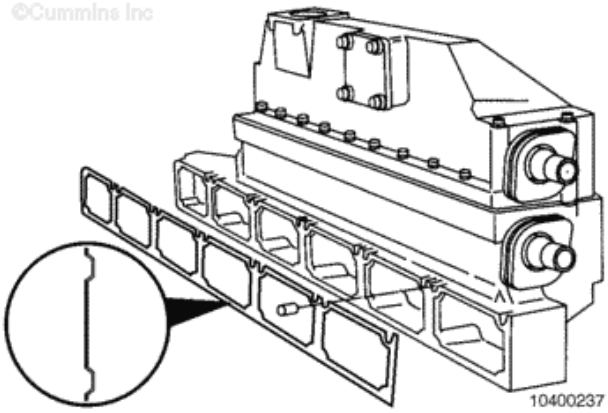
upper tube. The fuel drain tube is the lower tube. Install the tube nut and seals onto the fuel tubes. Connect, but do **not** tighten the fuel tubes to those already installed. Insert the fuel tubes into the junction block. Finger tighten the tube nuts in the junction block. Turn the nuts an additional ¾ to 1 turn beyond finger tight. Tighten the tubing nuts at their connection with the other tubes. Install the capscrew for the clamp and tighten. **Torque** **Value:** 45 n.m [33 ft-lb]		

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010-002 Aftercooler Assembly

Install

Install the bolt seals into the aftercooler housing.		
Use guide studs long enough to protrude beyond the installed part. Install 12 guide studs in the upper row of capscrew holes in the cylinder heads. Install the gasket onto the studs with the raised bead on the gasket toward the cylinder head.		
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		

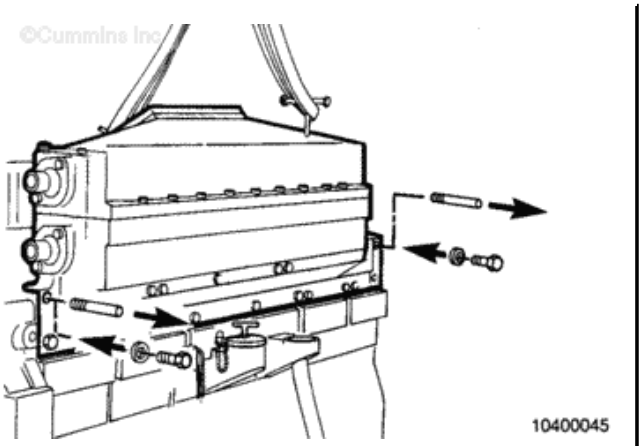
assembly.

Install the aftercooler and the bottom row of capscrews.

Tighten the capscrews **only** enough to hold the part.

Remove the guide studs and install the top row of capscrews.

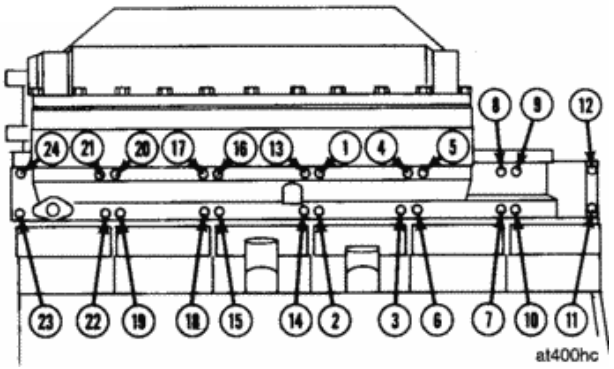
Remove the hoist, tee handles, and sling.



Tighten the capscrews in the sequence illustrated in the graphic.

Torque Value: Step 1 25 n.m [20 ft-lb]

Step 2 45 n.m [33 ft-lb]



NOTE: The AFC assembly is not used on all fuel pumps.

Connect the AFC tube to the fittings on the intake manifold and the fuel pump.

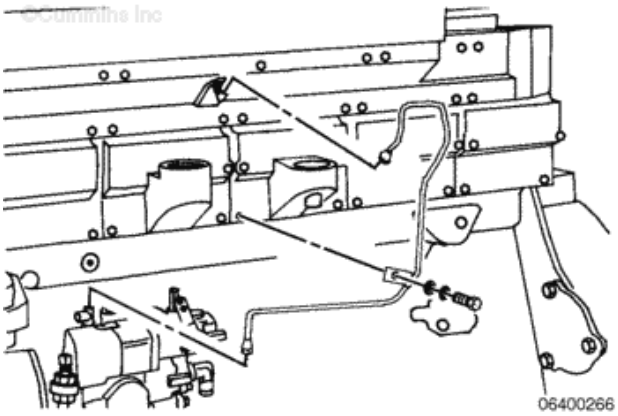
Install the tube clip and tighten the capscrew.

Torque Value: 45 n.m [33 ft-lb]

Install the oil fill cap.

Install any cam follower cover and gasket that were removed.

Tighten the capscrews.



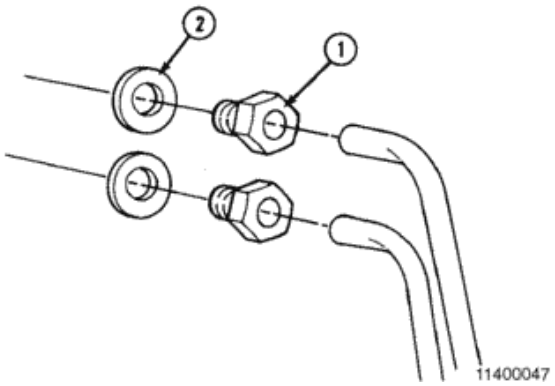
Torque
Value: 45 n.m [33 ft-lb]

CAUTION

The tube seals (2) must be installed on the tubes before the tubes are inserted into the junction block.

The fuel pressure tube is the lower tube and the fuel drain tube is the upper tube.

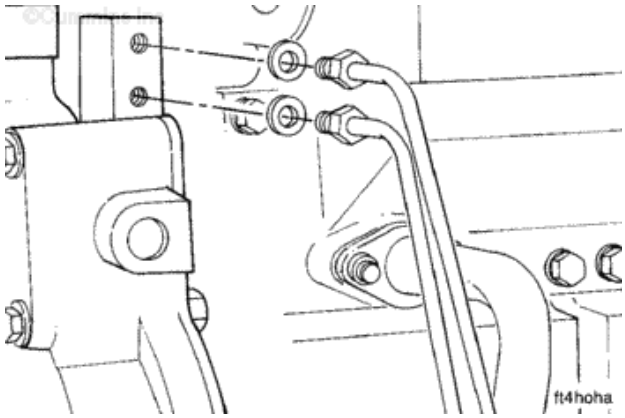
Install the tube nut (1) and the seals (2) on the fuel tubes.



CAUTION

Do not over tighten the tube nuts and the junction block. Finger tighten the tube nuts into the junction block. Turn the tube nuts an additional ¾ to 1 turn past finger tight.

Connect but do **not** tighten the fuel tubes to those that were **not** removed. Insert the fuel tubes into the junction block on the fuel manifold.



Tighten the tubing nuts at the connection with the other tubes.

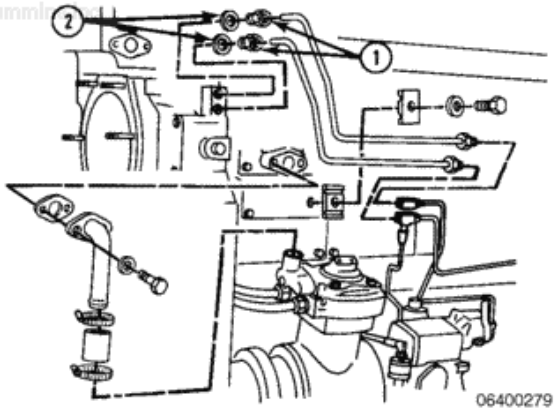
Install the tube clamp to the cam follower cover.

Torque
Value: 45 n.m [33 ft-lb]

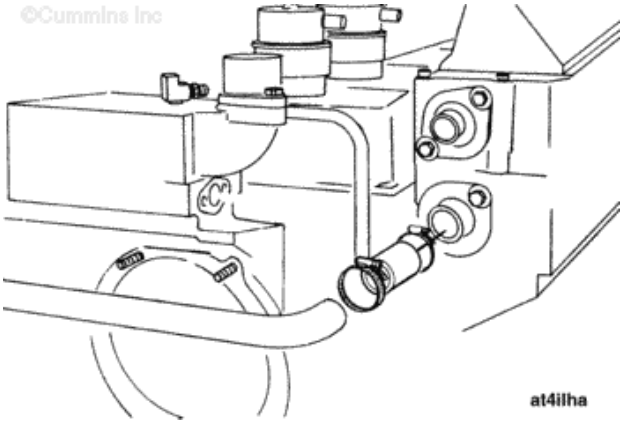
Install the air compressor inlet connection.

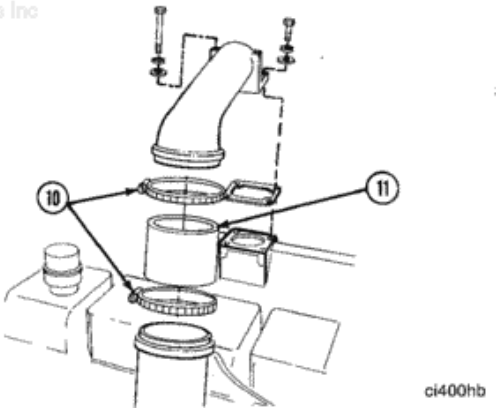
Tighten the capscrew.

Torque
Value: 45 n.m [33 ft-lb]

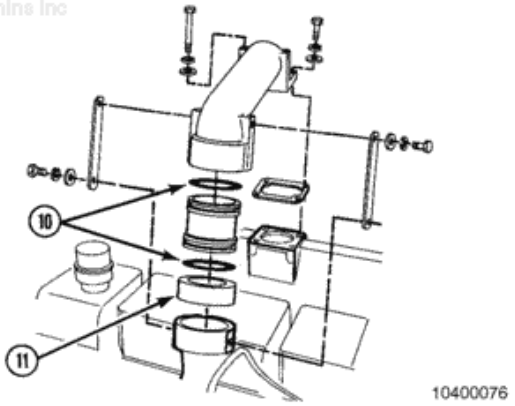


Tighten the air compressor inlet connection clamp. **Torque** **Value:** 6 n.m [50 in-lb]		

Connect the inlet hose. Tighten the clamps. **Torque** **Value:** 6 n.m [50 in-lb]		

Install the hose (connection type) air crossover. Install the hose (11) and the two clamps (10) onto the crossover tube. Install the air crossover. Slide the hose down over the turbocharger inlet. Install the gasket and capscrews. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb] Tighten the hose clamps. **Torque** **Value:** 8 n.m [75 in-lb]		

Install the (o-ring connections crossover). Lubricate the o-rings with vegetable oil and install them onto the tube.		

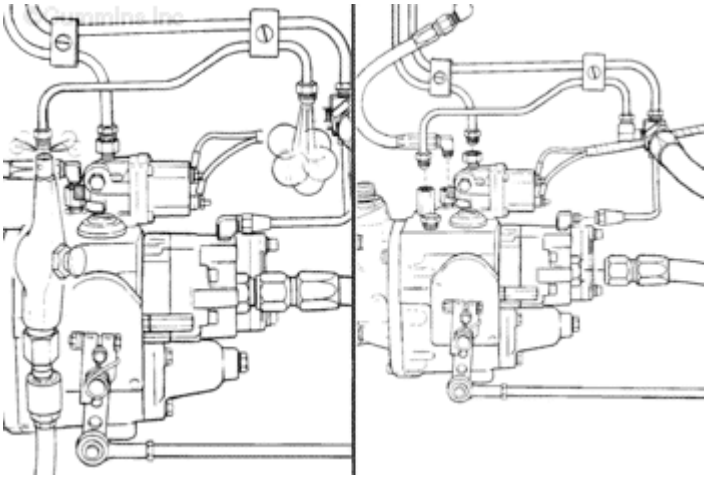
Install the tube into the crossover. Install the dust seal (11) onto the tube. Install the gasket, crossover and the capscrews. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb] Install the retainer straps, washers, and capscrews. Tighten the capscrews. **Torque** **Value:** 20 n.m [15 ft-lb]		©Cummins Inc 

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006-051 Injector Supply Lines (High Pressure)

Install

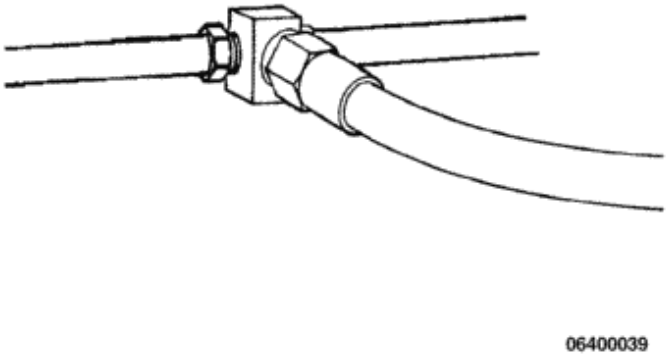
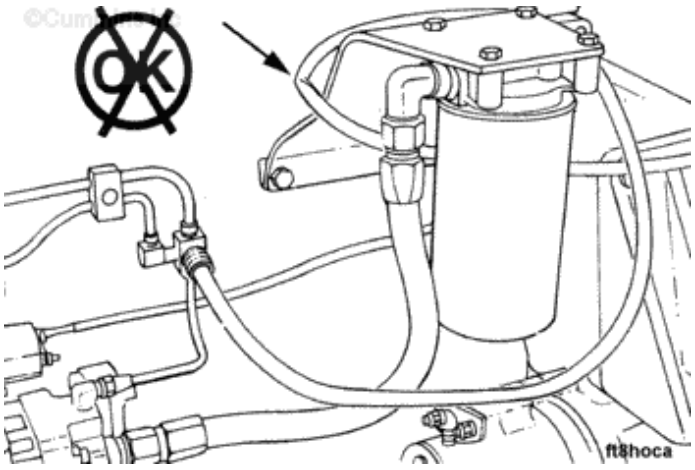
Flush the fuel lines with compressed air to remove any loose particles. Install the fuel lines.		

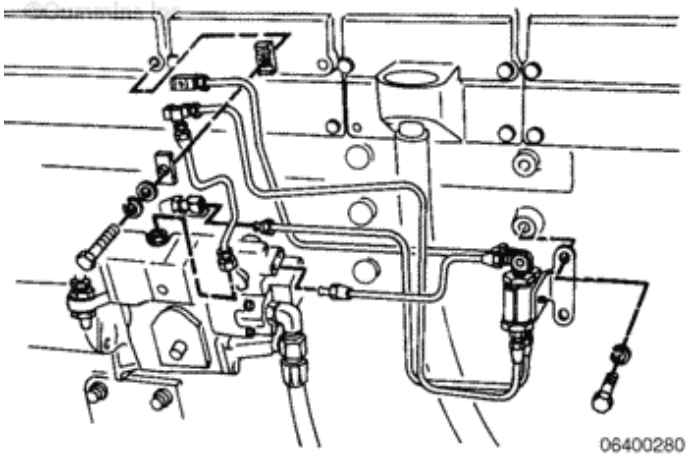
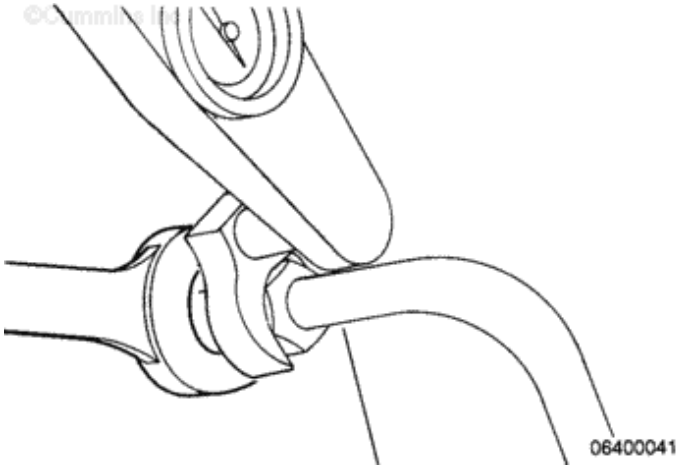
Last Modified: 29-Nov-2004

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006-013 Fuel Drain Lines

Install

Install and tighten the fuel drain hose. **Torque** **Value:** 75 n.m [55 ft-lb]		
Make sure the hose does **not** have pinches or loops that will obstruct fuel flow.		
Connect and tighten the fuel pump end of the		

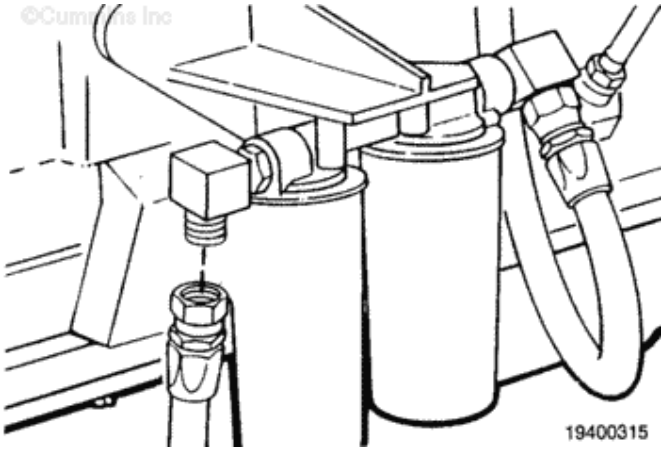
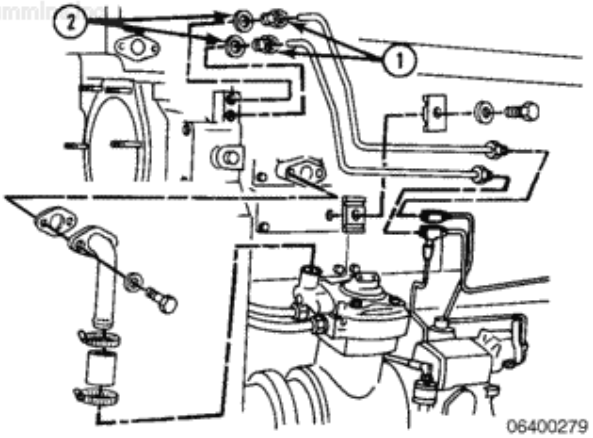
drain tube.		
Refer to Procedure 006-022 for the correct connection of the fuel tube to the manifold. Connect the fuel manifold end of the fuel drain tube.		

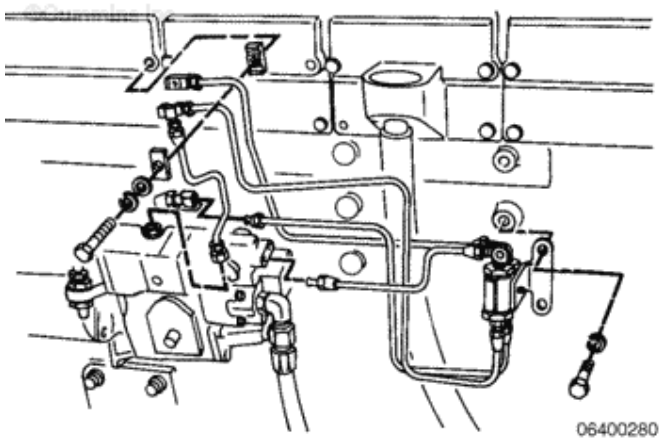
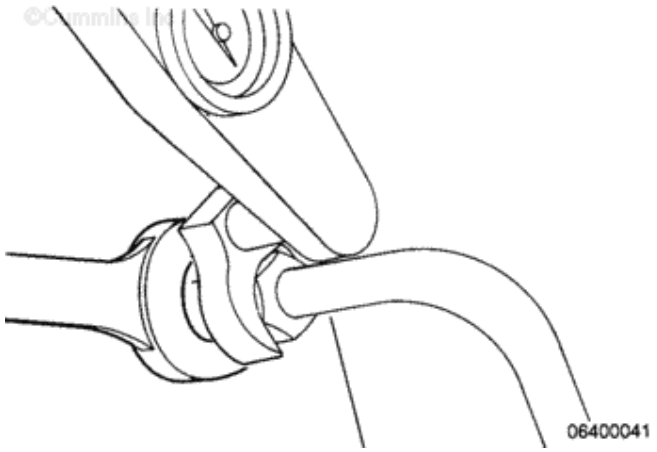
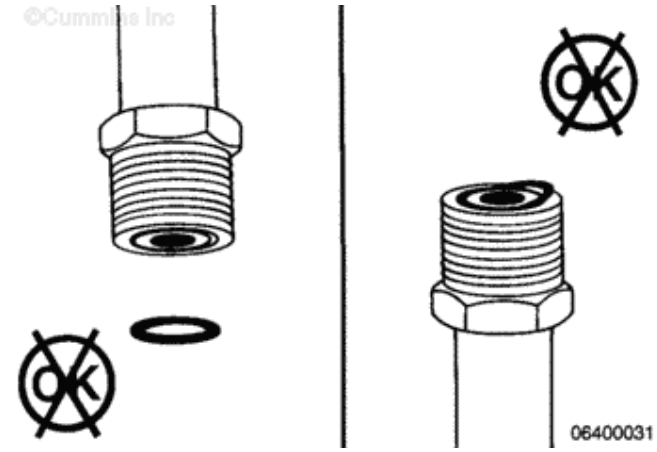
Last Modified: 19-Oct-2004

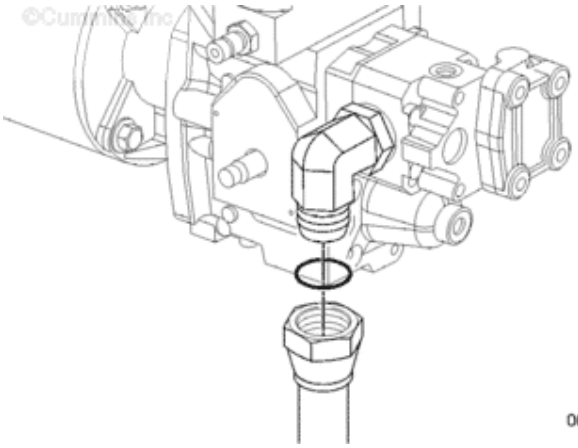
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006-024 Fuel Supply Lines

Install

Install the fuel tank to fuel filter fuel inlet hose. **Torque Value:** 115 n.m [85 ft-lb]		
Loosely assemble the fuel tubes and clamps. Connect the tube to the fuel manifold. Refer to Procedure 006-022 for the correct connection of the fuel tube to the fuel manifold. On engines equipped with an air compressor, install the air compressor air inlet connection with a new hose and gasket. Flange Capscrew 4 n.m [35 in-lb] Clamp 6 n.m [50 in-lb]		

Connect the tube to the fuel pump.		
Use two wrenches when tightening the fuel fittings. Support the fitting with a wrench and tighten the fuel tube nut with a crowfoot wrench and a torque wrench. **Torque** **Value:** 27 n.m [20 ft-lb]		
Install new o-rings on the fuel inlet fitting and fuel filter head outlet fitting. Make sure the o-rings are installed correctly.		

Install the hose at the fuel pump inlet and fuel filter head outlet fitting. Tighten the hose. **Torque** **Value:** 88 n.m [65 ft-lb]		

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View Related Topic

009-010 Alternator Drive Pulley

Install

CAUTION

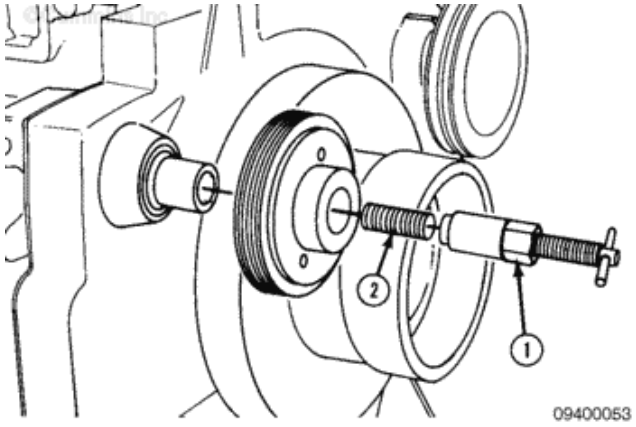
Do not use a hammer to drive the pulley into position. The thrust washers will be damaged.

Install the alternator drive seal. Refer to Procedure 001-001 in Section 1.

Insert the adapter (2), Part Number 3376089, into the shaft to prevent damage. The adapter is included with the pulley installation kit, Part Number 3376326.

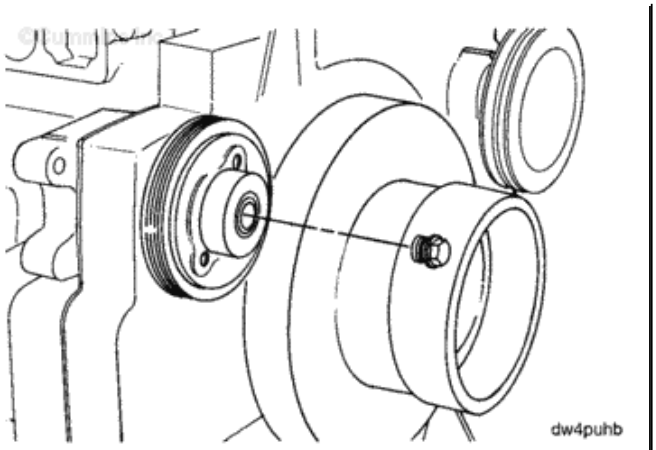
Press the pulley onto the shaft with the installation tool (1). The pulley **must** touch the step on the shaft.

Remove the tool (1) and adapter (2).



If a capscrew with the head ground was used instead of an adapter, remove the capscrew from the water pump drive.

Install the plastic plug that protects the threads.



Last Modified: 17-Dec-2008

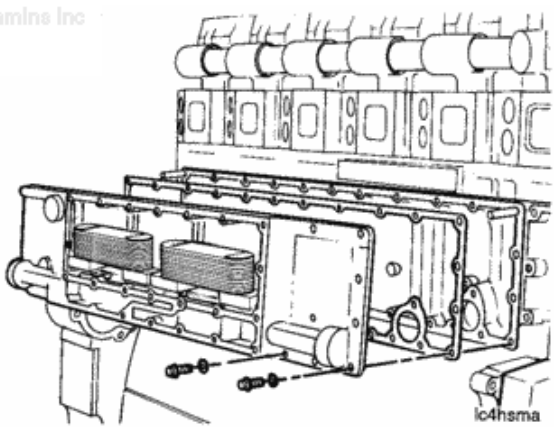
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007-046 Lubricating Oil Cooler Housing

Install

Install two guide studs.

Place the gasket and lubricating oil cooler housing into position.



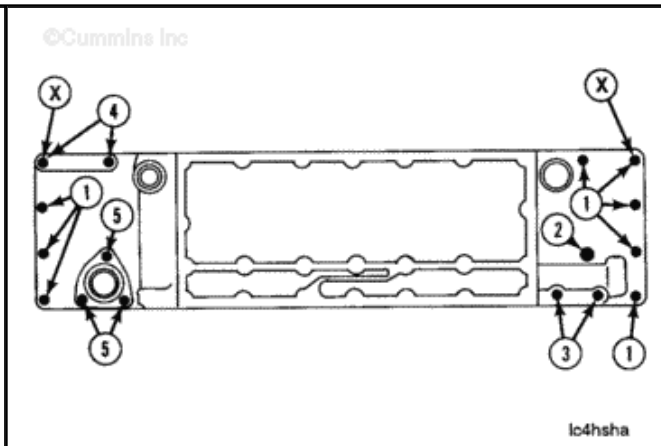
CAUTION

Two capscrew holes, marked with an (x) in the graphic, align with the cylinder head. The cylinder head capscrews will be damaged if the lubricating oil cooler capscrews are too long.

NOTE: Do not tighten the capscrews until the oil cooler cover, torque converter cooler, or marine gear oil cooler is installed.

Install the capscrews as illustrated in the graphic using the table below.

Lubricating Oil Cooler Housing Capscrew

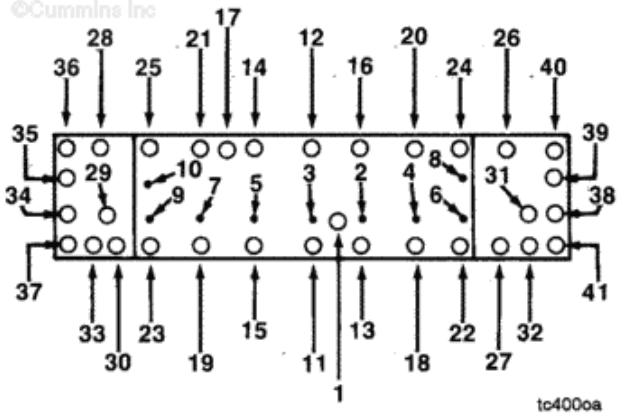


Lengths	
Illustration Call Out	**Without Oil Filter**
(1)	31.750 mm [1.250 in]
(2)	44.450 mm [1.750 in]
(3)	41.275 mm [1.625 in]
(4)	44.450 mm [1.450 in]
(5)	41.275 mm [1.625 in]

Install the oil cooler cover, torque converter cooler, or marine gear oil cooler. Refer to Procedure 007-045, 008-065, or 008-041.

Tighten the capscrews in the sequence illustrated in the graphic.

Torque Value: 45 n.m [33 ft-lb]



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007-018 Lubricating Oil Filter Head Adapter

Install

Threaded

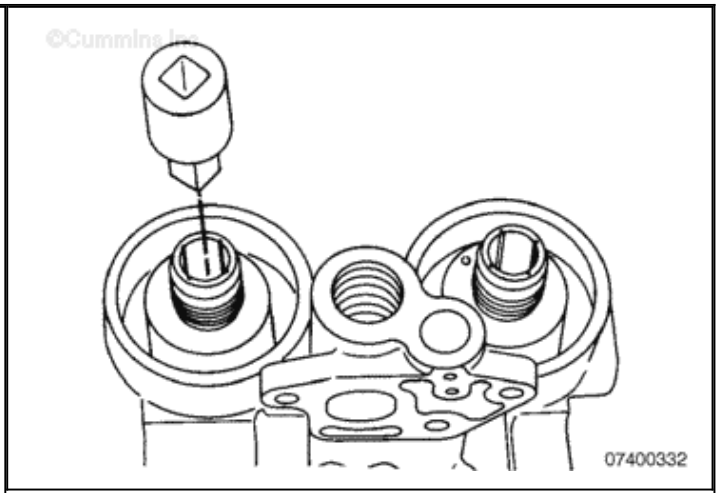
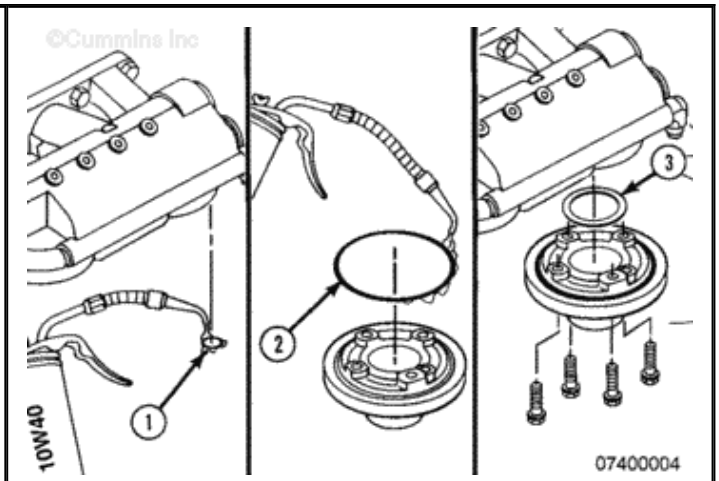
Apply Loctite® 609 or equivalent to the threads of the adapter. Install the adapter. Tighten the adapter. **Torque** **Value:** 135 n.m [100 ft-lb]		

Plate Type

Lubricate the o-ring (1) and install it into the oil filter head prior to installing the adapter. Lubricate o-rings (2 and 3) and install them into the adapter. Use the locating pin to align the oil filter head adapter and with the oil filter head and install the adapter. Install the capscrews.		

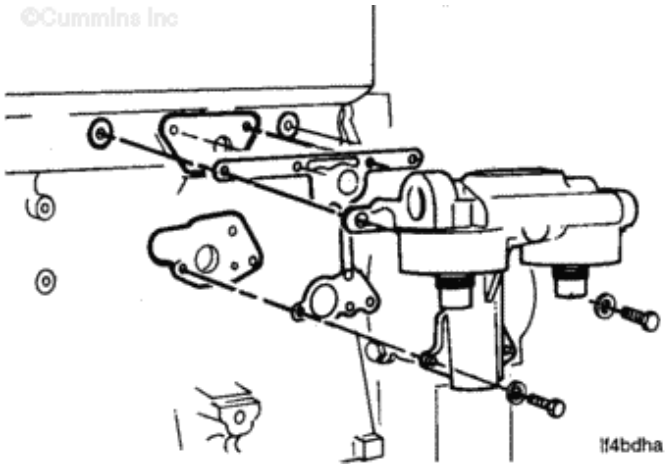
Tighten the capscrews. **Torque Value:** 23 n.m [17 ft-lb]		

Last Modified: 23-Jul-2004

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007-015 Lubricating Oil Filter Head

Install

Install the gasket, lubricating oil filter head, and capscrews. Tighten the capscrews. **Torque Value:** 45 n.m [33 ft-lb]		

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013-020 Starting Motor

Install

WARNING

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

NOTE: Not all engines use spacers.

NOTE: The wet type flywheel housing requires gaskets for the starting motor.

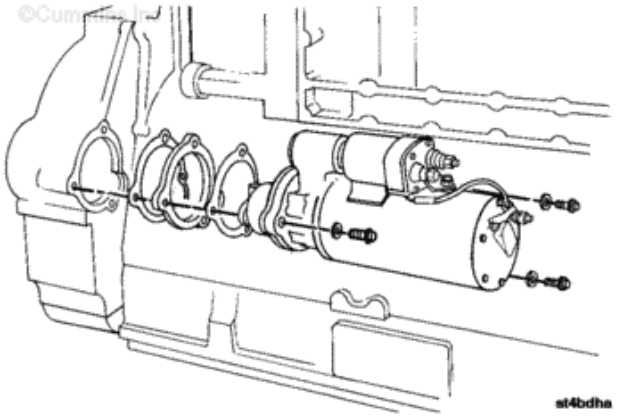
Lubricate the bushing with engine oil.

Install any spacer or gaskets.

Install the starting motor and capscrews.

Use the following to tighten the capscrews.

With Cast Iron Flywheel Housing	215 n.m	[160 ft-lb]
Without Aluminum Flywheel Housing	195 n.m	[145 ft-lb]

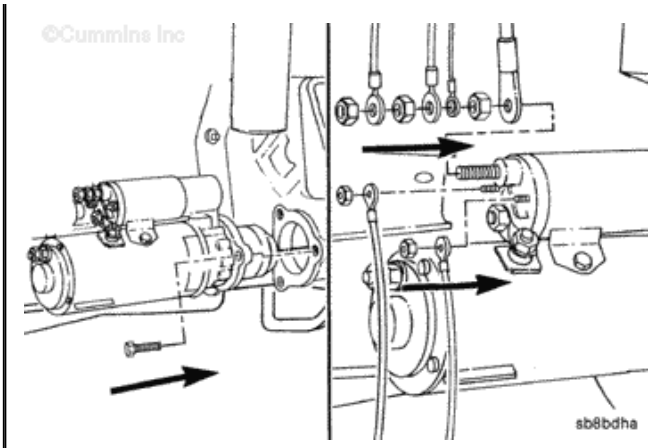


WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing 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.



Last Modified: 29-Nov-2004

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008-053 Heat Exchanger

Install

Tube Type

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.

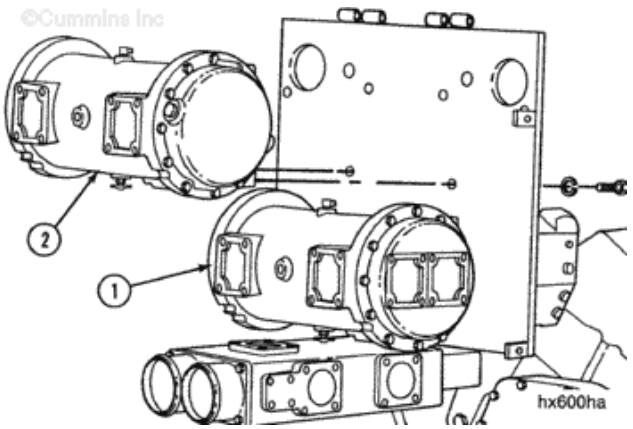
NOTE: All engines are not equipped with a upper and a lower heat exchanger option.

Install the lower heat exchanger (1) and the upper heat exchanger (2) as illustrated in the graphic.

Install four lock washers and capscrews in each heat exchanger.

Tighten the capscrews.

Torque
Value: 135 n.m [100 ft-lb]



The engine coolant pipes are **always** connected to the side of the heat exchanger.

Always tighten the capscrews before tightening the hose clamps.

Two clamps are installed on each end of each hose. Make sure the hose is centered over the gap

between the pipes. Tighten the capscrews for the pipe before tightening the clamps.

The upper heat exchanger and a portion of the heat exchanger support are **not** shown for clarity.

The engine outlet pipes (1) and (2) are different for the right bank and the left bank.

Install the outlet pipes (1) and (2) on the outlets of the thermostat housing, using hoses and clamps as shown.

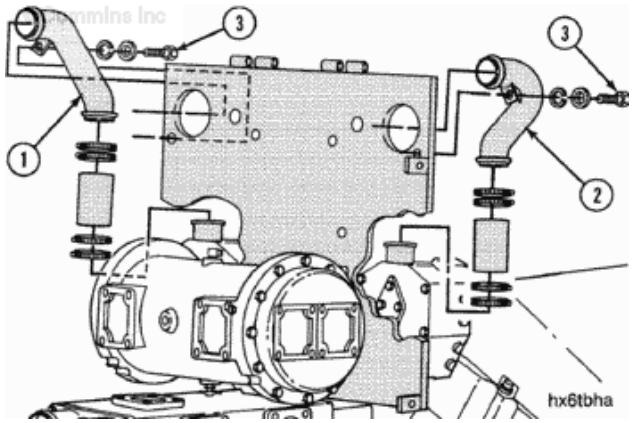
Install a flat washer, lock washer, and capscrew (3) through the tab on each pipe to the heat exchanger support.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 in-lb]



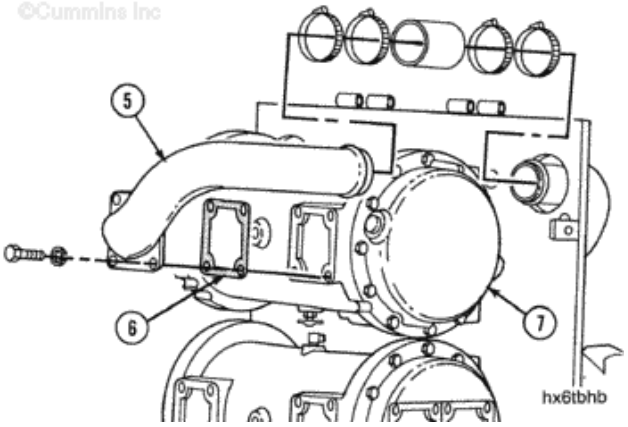
Connect the pipe (5) to the outlet pipe for the left bank as shown. Install the gasket (6), four lock washers, and capscrews to the upper heat exchanger (7) inlet.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 in-lb]



Connect the pipe (8) to the outlet pipe for the right bank as shown. Install the hose (9) and the pipe (10).

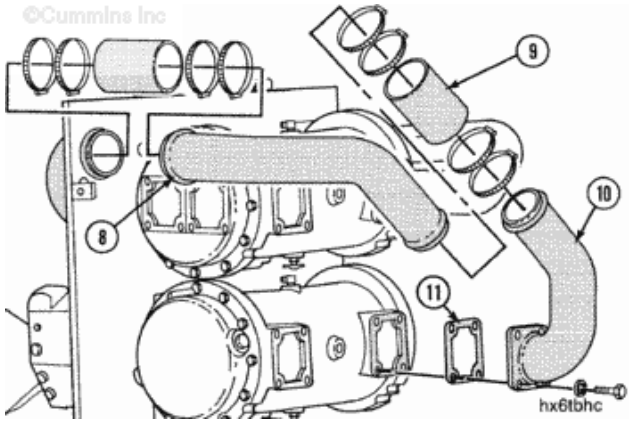
Install the gasket (11), four lock washers, and capscrews to the lower heat exchanger inlet.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 in-lb]



Install the gasket (15), upper heat exchanger outlet pipe (14), four lock washers, and capscrews to the upper heat exchanger outlet.

Install the hose (16), and the clamps on the lower heat exchanger outlet pipe (17). Install the hose on the upper heat exchanger outlet pipe.

Install the gasket (18), lock washers, and capscrews to the lower heat exchanger outlet (19).

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 ft-lb]

NOTE: A large pipe (not shown) with a flange and gasket must be installed to the lower heat exchanger outlet pipe (17) and to the engine water pump inlet. The pipe is not installed at this time because the pipe is routed under a crossmember of a base rail on engines equipped with base rails.

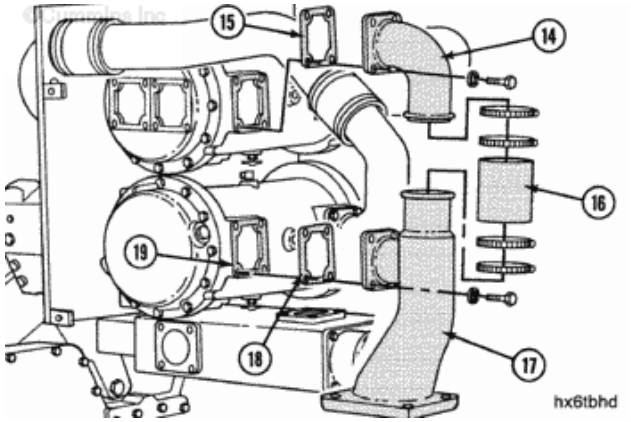
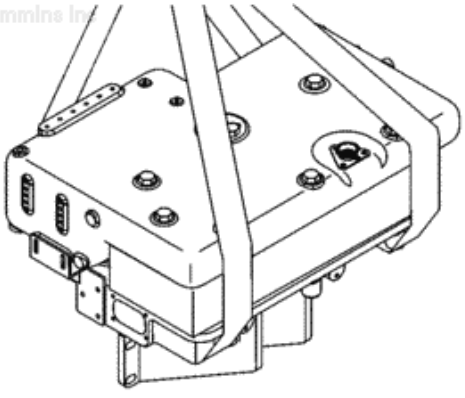


Plate Type

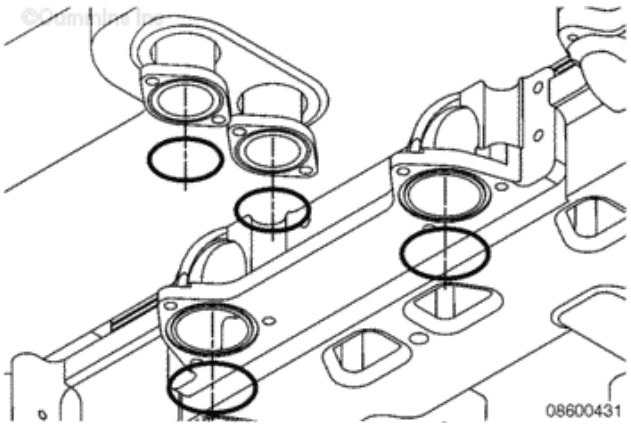
WARNING

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.

Use a chain fall or other lifting equipment to lift heat exchanger into position in front of the engine with the jacket water manifold over the thermostat housing.

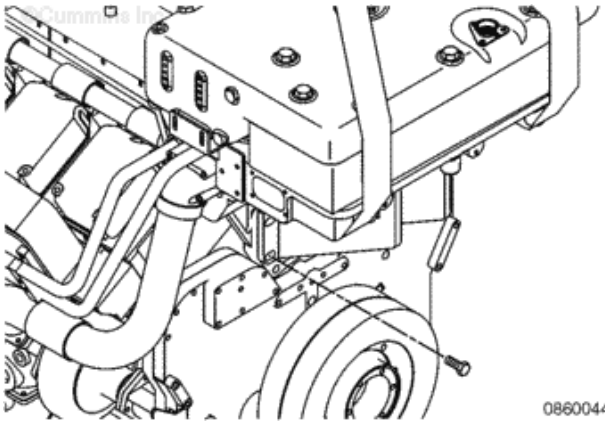


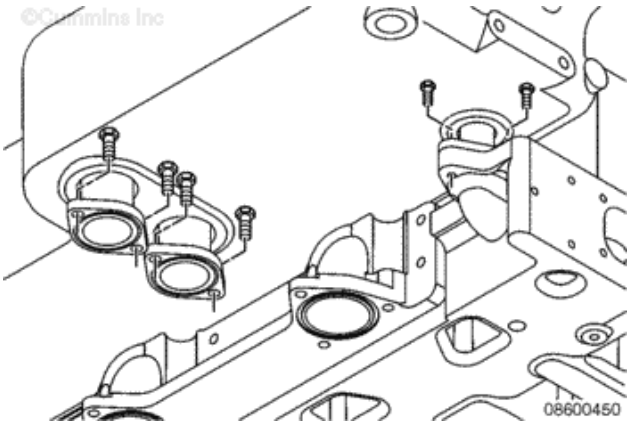
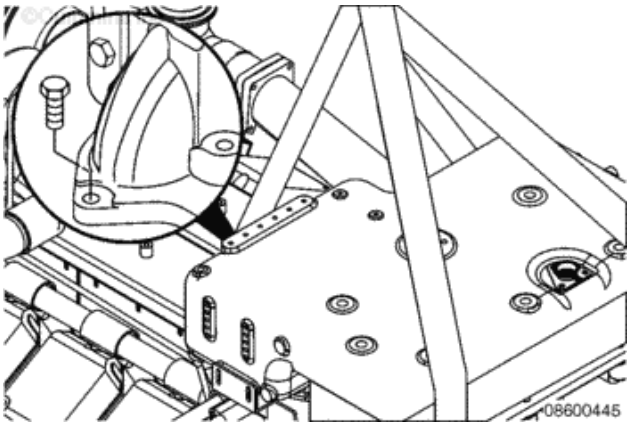
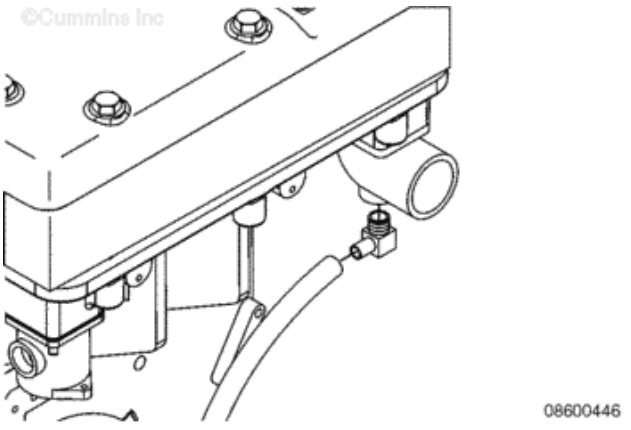
Install the o-rings onto the bottom flange of the LTA tubes and the jacket water manifold as the assembly is lowered into place.

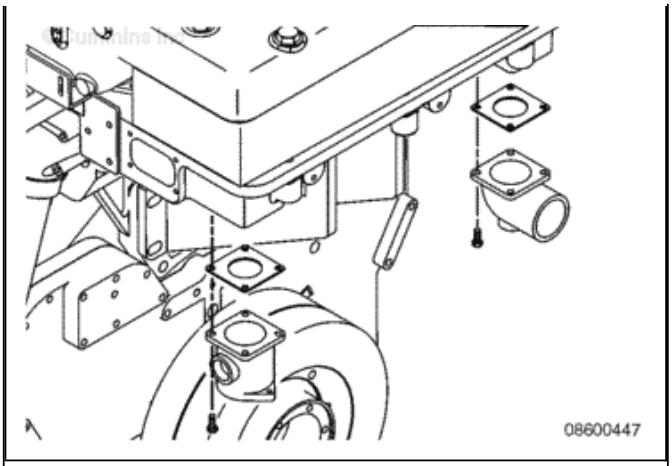
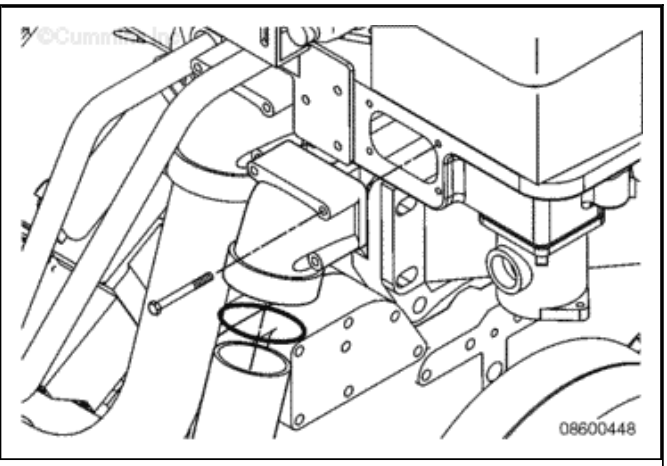
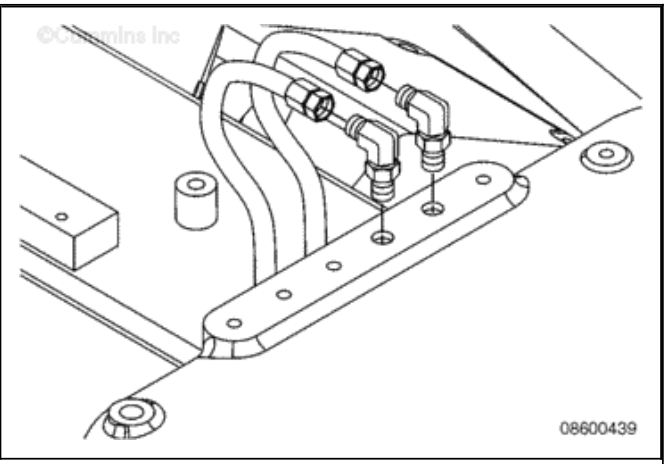


Install the lower mounting bracket capscrews that fasten the bracket to the engine block.

Torque
Value: 35 n.m [25 ft-lb]



Install the four capscrews that hold the Low Temperature Aftercooled (LTA) tube to the thermostat housing Tighten the capscrews. **Torque** **Value:** 78 n.m [57 ft-lb] Install the clips and bolt and tighten. Install the ring retainer clip from the drain pipe and tighten the clips. **Torque** **Value:** 17 n.m [144 in-lb]		
Install the jacket water manifold capscrews that fasten the manifold to the thermostat housing. Tighten the capscrews. **Torque** **Value:** 31 n.m [23 ft-lb]		
Connect the sea water pump prime discharge line from the heat exchanger sea water outlet connection.		

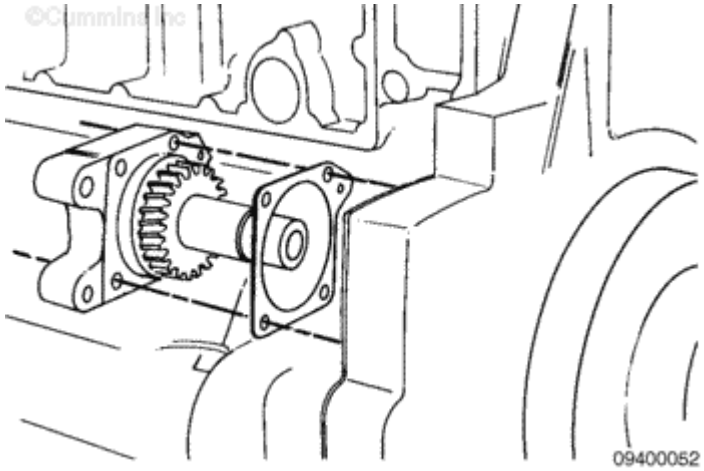
Connect the sea water inlet and outlet connections. Tighten the capscrews. **Torque** **Value:** 31 n.m [23 ft-lb]		
Connect the coolant outlet tube and connector. Tighten the capscrews. **Torque** **Value:** 31 n.m [23 ft-lb]		
Connect the vent lines to the expansion tank.		

Last Modified: 04-Nov-2004

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009-029 Water Pump Drive

Install

Install the water pump drive assembly gasket. Install the water pump drive assembly. The water pump drive assembly is secured in position by a stud.		

Last Modified: 10-Dec-2004

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008-057 Sea Water Pump

Install

WARNING

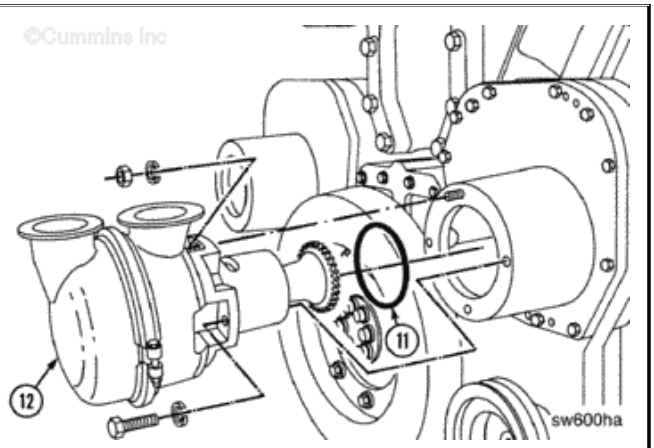
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Make sure the stud is installed as shown in the illustration.

Install the o-ring seal (11), pump (12), four lock washers, three capscrews, and the nut.

Tighten the capscrews and nut.

Torque Value: 60 n.m [44 ft-lb]

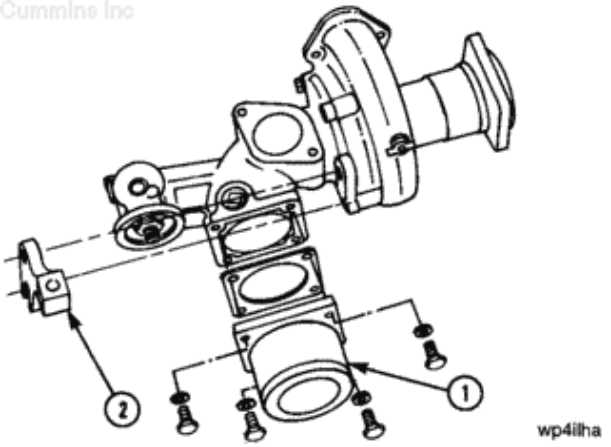
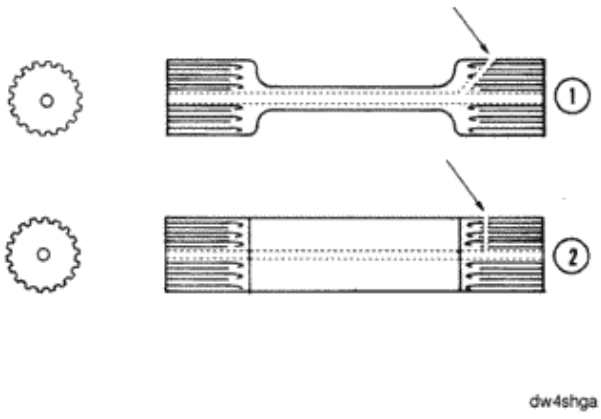


Last Modified: 01-Apr-2009

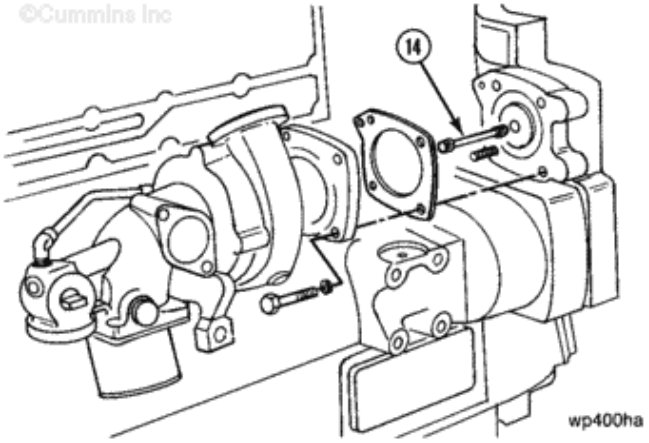
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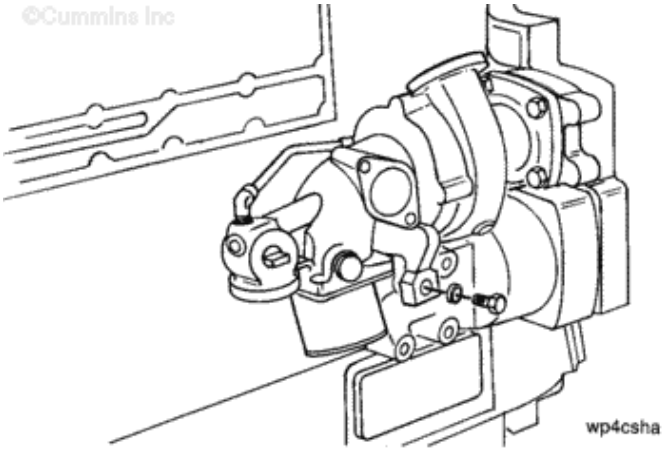
008-062 Water Pump

Install

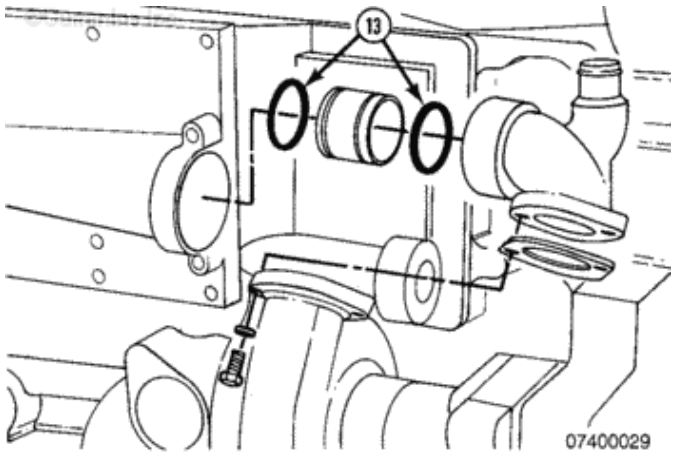
Install the gasket, inlet connection (1) and capscrews. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb] Do **not** tighten the support bracket until the water pump is assembled to the engine. Use a heavy, plain washer on the capscrew that attaches through the slotted hole.	 	©Cummins Inc 
Failure of the water pump drive shaft will result if the wrong shaft is used. The phenolic (plastic) plastic impeller has been discontinued. It is no longer available for production or service. The shaft (2) is also no longer available for production or service. Use shaft (1) with cast iron impeller pumps. Use shaft (2) with		©Cummins Inc 

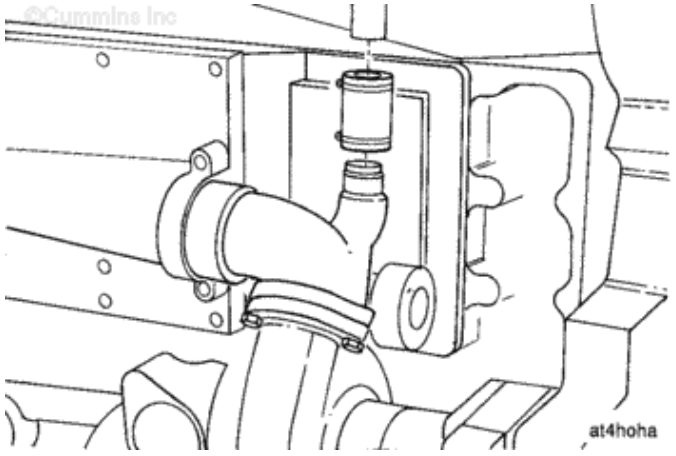
phenolic (plastic) impeller pumps. Install the shaft with the oil hole at the side of the shaft toward the water pump.		

Lubricate the shaft with clean engine oil. Install the shaft in the splined hole in the water pump drive. Do **not** tighten the capscrews and nut until the support bracket is aligned with the cylinder block. Install the gasket and water pump. Install the three capscrews and nuts. Tighten the capscrews and nuts. **Torque Value:** 45 n.m [33 ft-lb]		

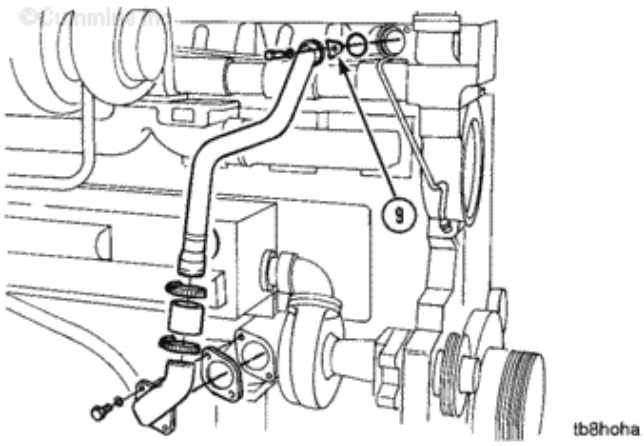
The support bracket **must** be flat against the water pump and the cylinder block. Align the bracket before tightening the capscrews. Install the capscrew through the bracket. Tighten the capscrew. **Torque Value:** 206 n.m [150 ft-lb]		

Check the alignment between the support bracket and the water pump. Loosen the capscrew and adjust if necessary. Tighten the capscrews holding the support bracket to the water pump. **Torque** **Value:** 45 n.m [33 ft-lb]		

Lubricate the o-rings (13) with vegetable oil and install them onto the transfer tube. Install the transfer tube into the water outlet connection. Install the water outlet connection assembly.		

Connect the water pump outlet connection to the aftercooler supply hose.		

Install the water		

bypass tube. Install the water bypass tube clamp and capscrew.		

Last Modified: 31-Jul-2006

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008-041 Marine Gear Oil Cooler

Install

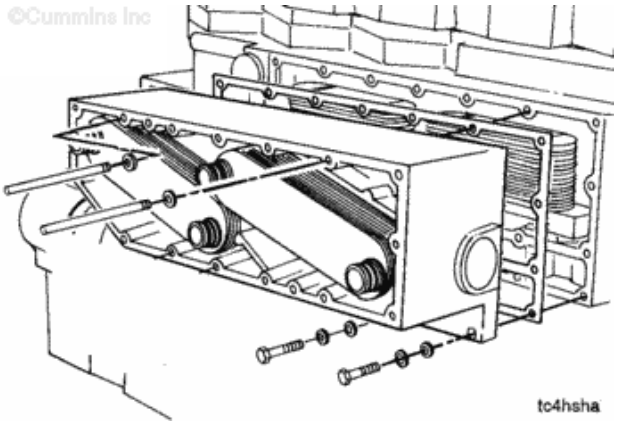
WARNING

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 two 3/8-16 x 12-in guide studs to support the housing during installation.

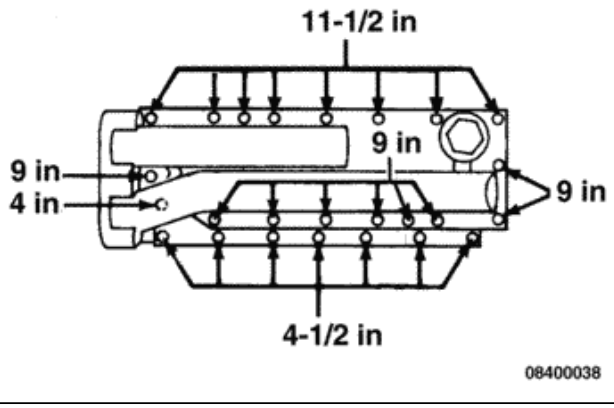
Install the gasket and the housing.

Install the capscrews in the bottom row of holes on the housing. These capscrews are all 101.6 mm [4 in] long.



The length and location of all the capscrews on the marine gear oil cooler and cover are shown. Make sure the capscrews are the correct length.

Do **not** tighten any of the capscrews until all of them have been installed.



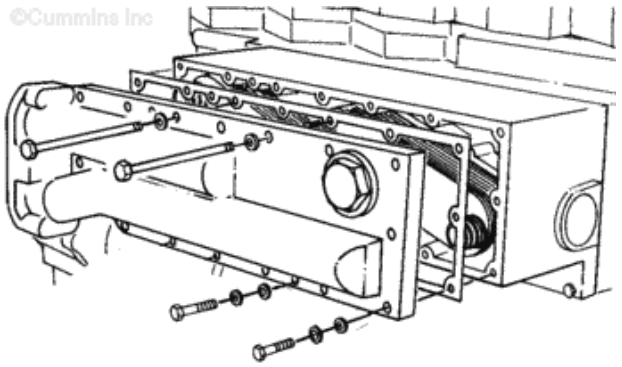
Make sure the capscrews are the correct length.

Lubricate the o-rings on the elements and the bores in the covers with vegetable oil.

Install the gasket and cover.

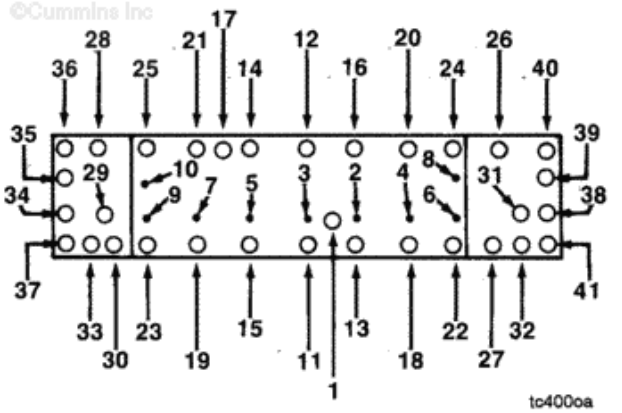
Push the cover over the o-rings until the cover is against the housing.

Install the remaining capscrews.



Tighten the capscrews in the sequence shown in the graphic.

Torque
Value: 45 n.m [33 ft-lb]



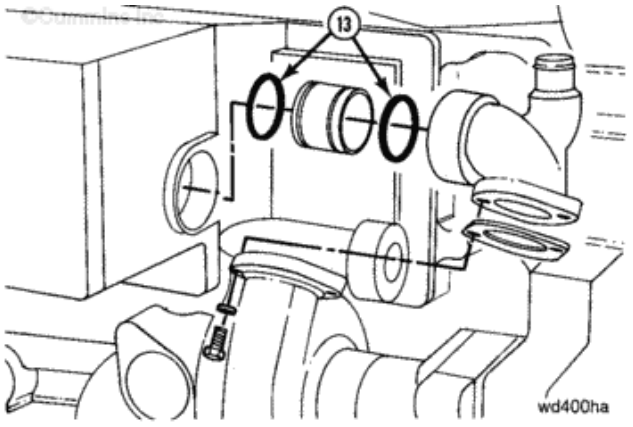
Lubricate the o-rings (13) with vegetable oil.

Install the transfer tube in the water pump outlet connection.

Install the water pump outlet connection, gasket, and capscrews.

Tighten the capscrews.

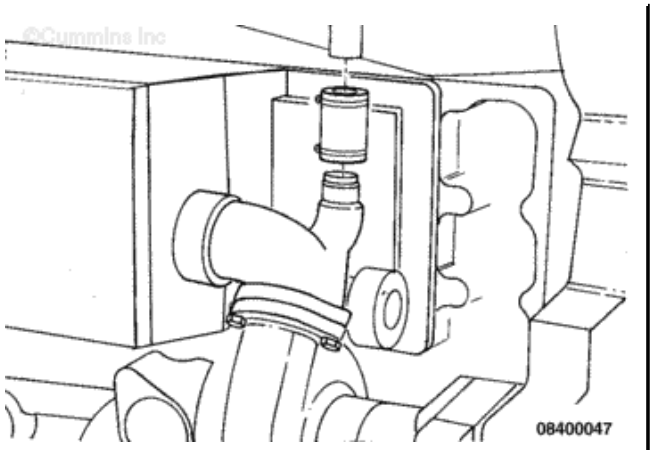
Torque
Value: 45 n.m [33 ft-lb]



Connect the aftercooler supply hose to the water pump outlet connection.

Tighten the clamps.

Torque
Value: 5.6 n.m [50 in-lb]



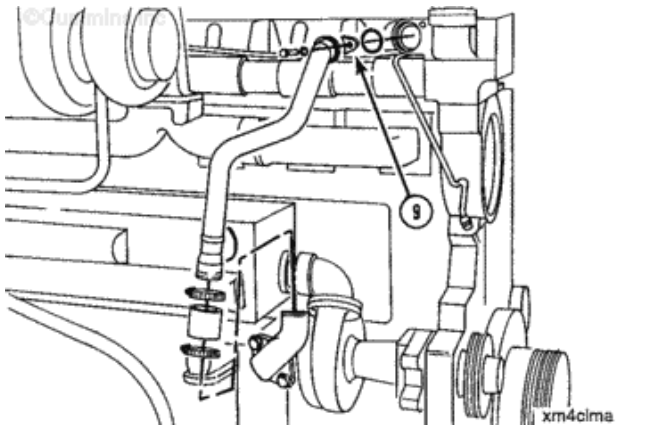
Lubricate the o-ring on the water bypass tube with vegetable oil.

Install the bypass tube.

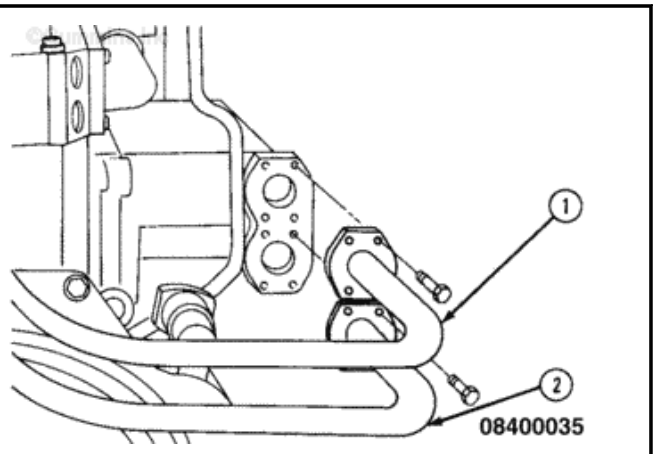
Install the retainer (9) and capscrew.

Tighten the capscrew and hose clamp.

Capscrew	45 n.m	[33 ft-lb]
Clamp	6 n.m	[50 in-lb]



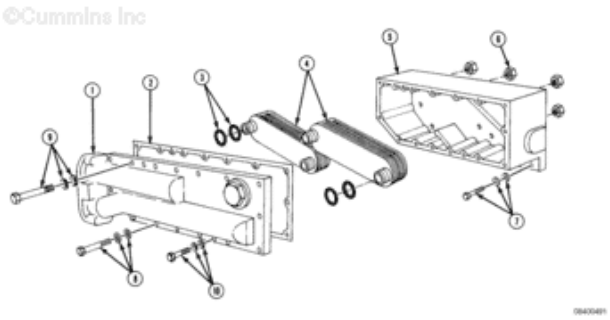
Connect the marine gear oil cooler oil tubes to the marine gear oil cooler.



Last Modified: 16-Aug-2004

008-065 Torque Converter Cooler

Exploded View



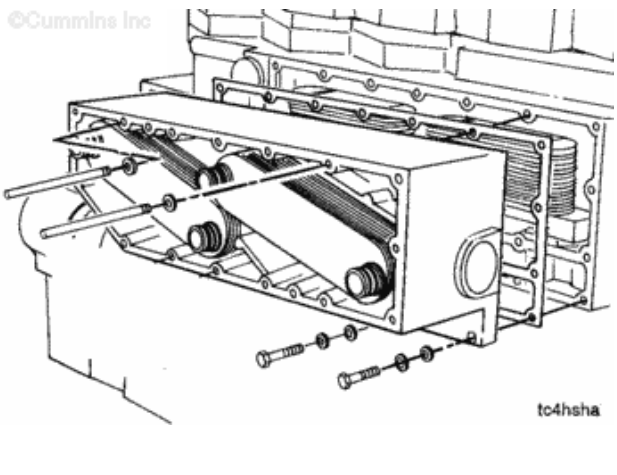
1. Torque converter oil cooler cover
2. Torque converter oil cooler cover gasket
3. O-ring
4. Torque converter oil cooler element
5. Torque converter oil cooler housing
6. Self-locking nut
7. Capscrew, lock washer, and plain washer
8. Capscrew and lock washer
9. Capscrew, lock washer, and plain washer
10. Capscrew, lock washer, and plain washer.

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 two 3/8-16 x 12-in guide studs to support the housing



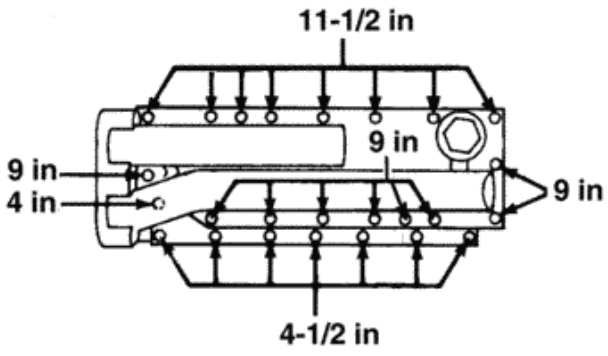
during installation.

Install the gasket and the housing.

Install the capscrews in the bottom row of holes on the housing. These capscrews are all 101.6 mm [4 in] long.

The length and location of all the capscrews on the torque converter cooler and cover are shown. Make sure the capscrews are the correct length.

Do **not** tighten any of the capscrews until all of them have been installed.



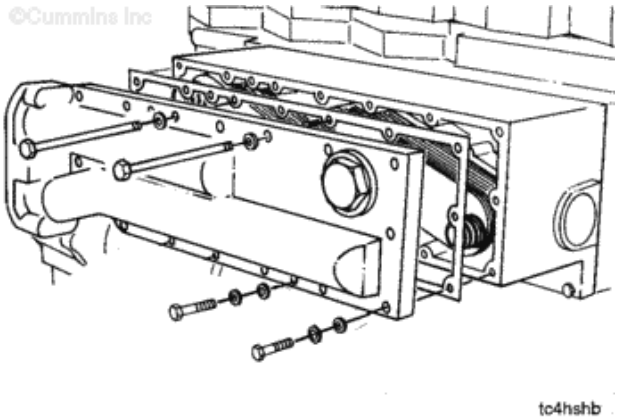
Make sure the capscrews are the correct length.

Lubricate the o-rings on the elements and the bores in the covers with vegetable oil.

Install the gasket and cover.

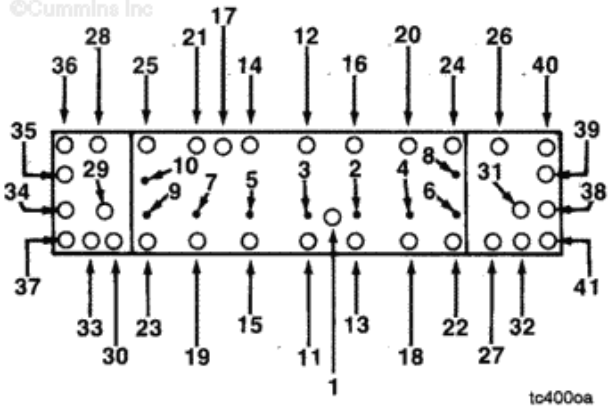
Push the cover over the o-rings until the cover is against the housing.

Install the remaining capscrews.



Tighten the capscrews in the sequence shown in the graphic.

Torque
Value: 45 n.m [33 ft-lb]



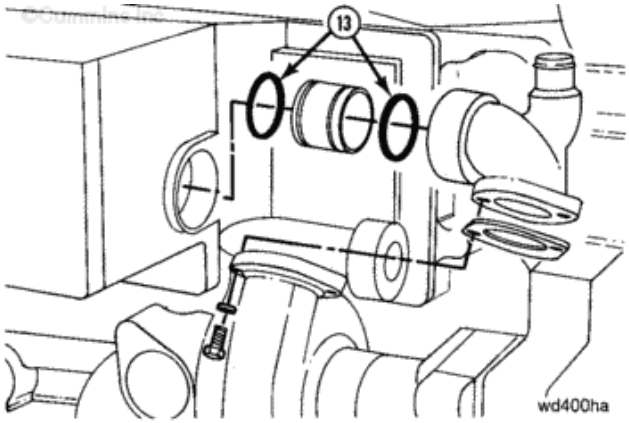
Lubricate the o-rings (13) with vegetable oil.

Install the transfer tube in the water pump outlet connection.

Install the water pump outlet connection, gasket, and capscrews.

Tighten the capscrews.

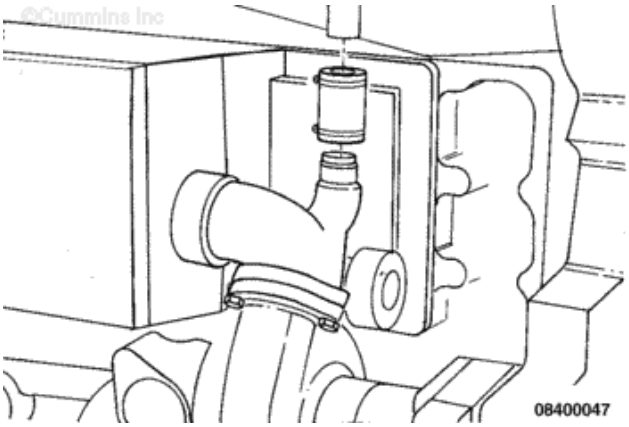
Torque
Value: 45 n.m [33 ft-lb]



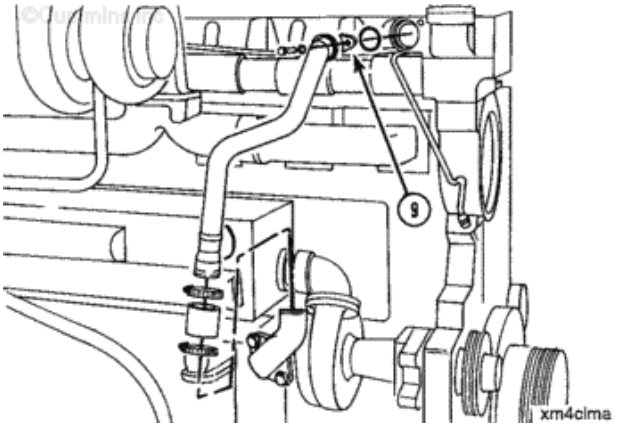
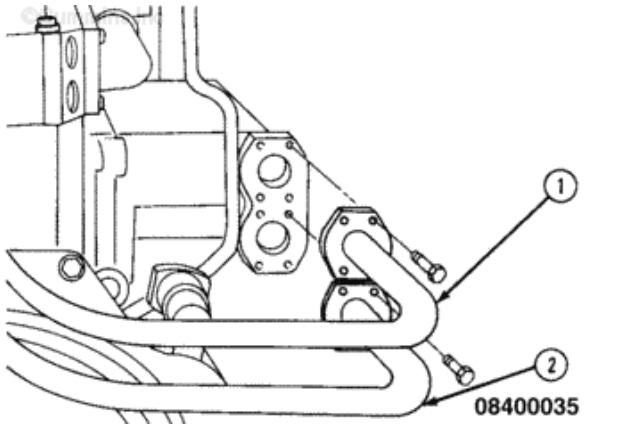
Connect the aftercooler supply hose to the water pump outlet connection.

Tighten the clamps.

Torque
Value: 5.6 n.m [50 in-lb]



Lubricate the o-ring on the water bypass tube with vegetable oil.

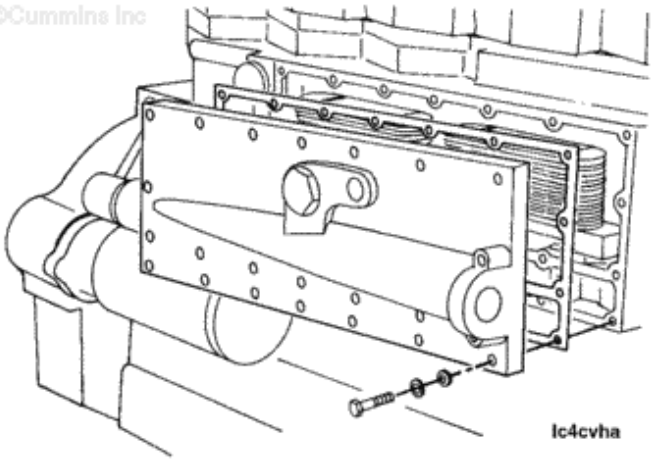
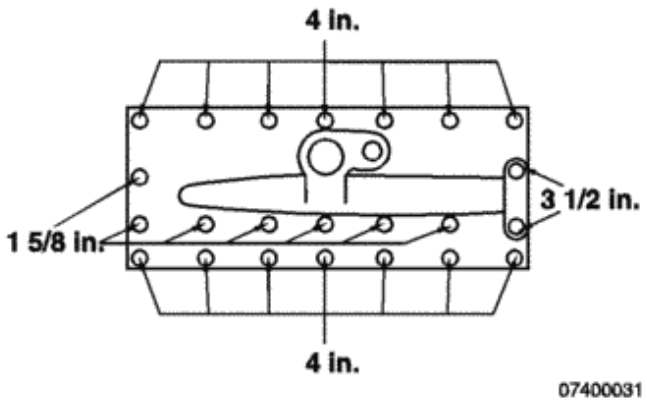
Install the bypass tube. Install the retainer (9) and capscrew. Tighten the capscrew and hose clamp. Capscrew 45 n.m [33 ft-lb] Clamp 6 n.m [50 in-lb]		
Connect the torque converter cooler oil tubes to the torque converter cooler.		

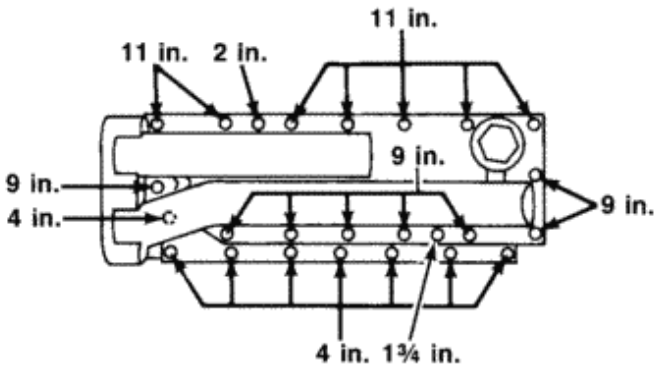
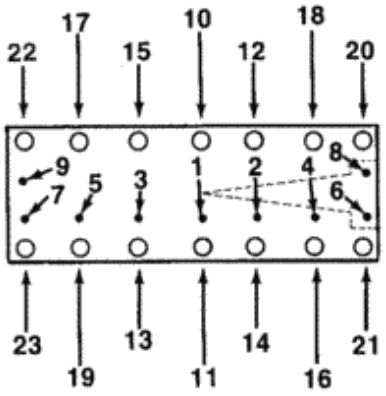
Last Modified: 19-Oct-2004

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007-045 Lubricating Oil Cooler Cover

Install

Install the lubricating oil cooler cover and gasket. Install several capscrews to secure the cover in position, but do **not** tighten the capscrews.		
Install the remaining lubricating oil cooler cover capscrews as illustrated in the graphic.		
If the engine has a torque converter cooler, install the		

lubricating oil cooler cover capscrews as illustrated in the graphic.		©Cummins Inc 
Tighten the capscrews in the sequence illustrated in the graphic. **Torque Value:** 45 n.m [33 ft-lb]		©Cummins Inc 

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011-007 Exhaust Manifold, Dry

Install

WARNING

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

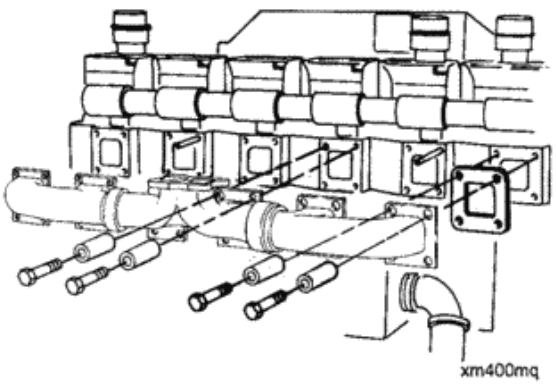
CAUTION

Do not use gasket cement when installing the exhaust manifold gasket. Use of gasket cement will cause the gasket to fail.

Install the guide studs used during removal.

Use contact adhesive and attach the gasket on the cylinder head exhaust ports.

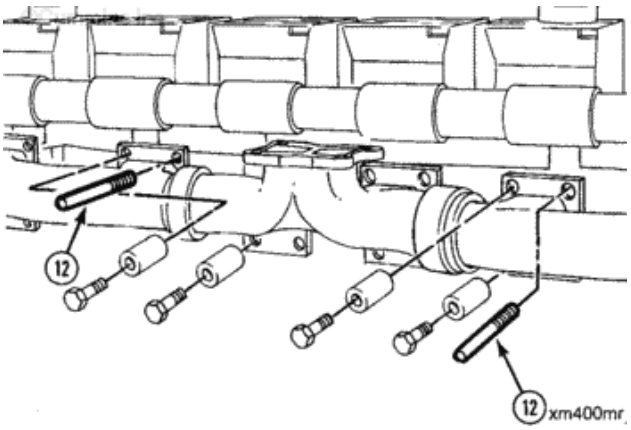
Install the exhaust manifold.

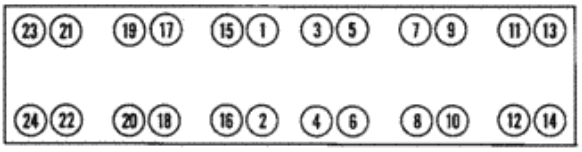
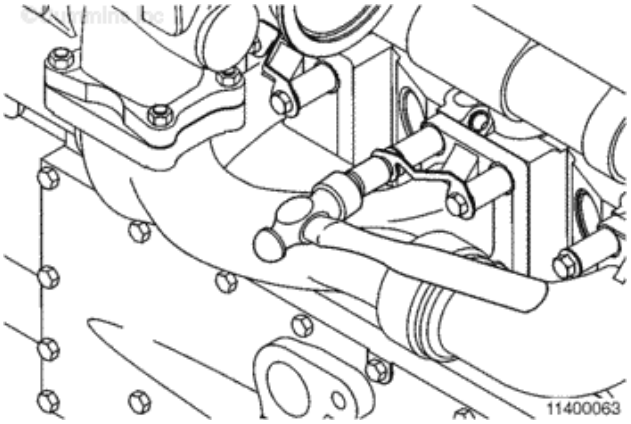


Apply an antiseize compound on the capscrew threads.

Install the capscrews.

Remove the two guide studs (12) and install the remaining capscrews.



Tighten the capscrews in the sequence illustrated in the graphic. **Torque** **Value:** 61 n.m [45 ft-lb]		©Cummins Inc  xm400oa
Align the lock plate with the top of both capscrews. Place the socket that was used to install the capscrew onto one of the capscrews and drive the lock plate down until it reaches the capscrew flange. Repeat the process on the remaining capscrews and lock plates.		

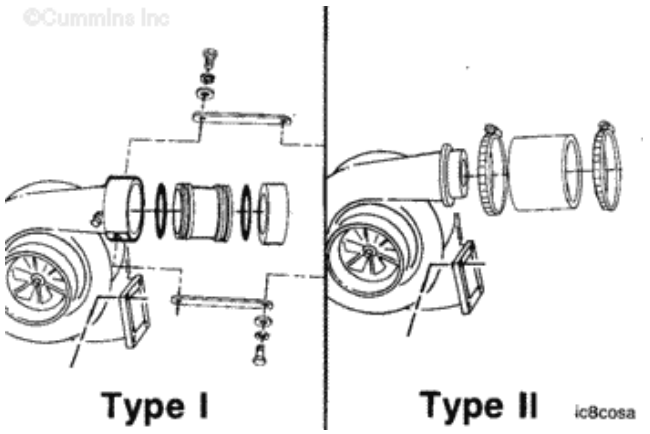
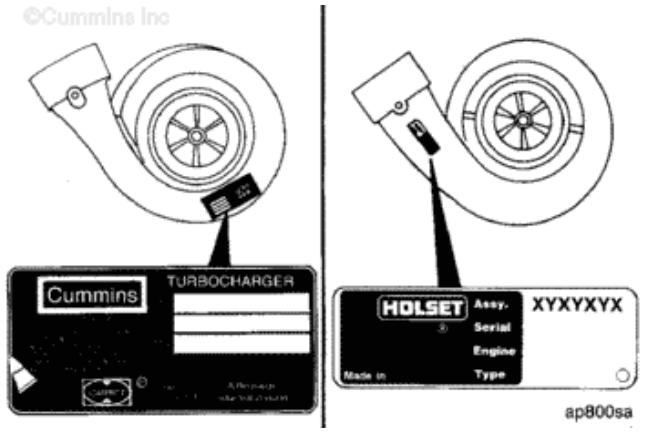
Last Modified: 19-Oct-2004

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010-033 Turbocharger

Install

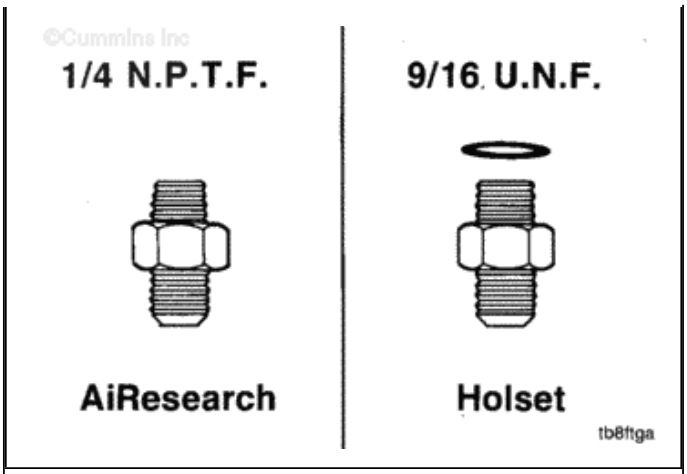
All Applications

Turbochargers are available with two types of compressor housings. Type 1 - requires two o-rings, dust seal, connector pipe, and two retainer straps. Type 2 - requires two hose clamps and a hose. Changing from one type to another requires a new air crossover.		
Two different turbochargers are used on the K19 engine; AiResearch™ and Holset®. Check the data tag on the turbocharger to determine the model. The name is also cast on the housing of each turbocharger.		
Two different types of oil supply fittings are used. The AiResearch™ turbocharger uses a ¼ NPTF		

(pipe plug) fitting.

The Holset® turbocharger uses a 9/16-18 UNF (straight thread) o-ring type fitting.

A new fitting is required if the model of turbocharger being installed is different from the original.



Single Turbocharger

Apply anti-sieze compound to the turbocharger mounting studs.

Install the gasket with the word OUT toward the turbocharger.

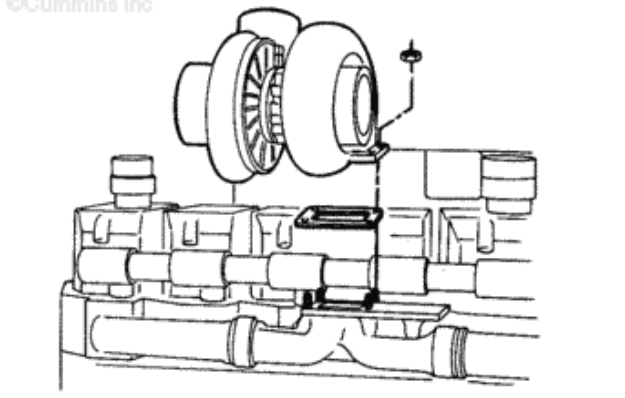
Install the turbocharger.

Install the washer and nuts.

Tighten the nuts.

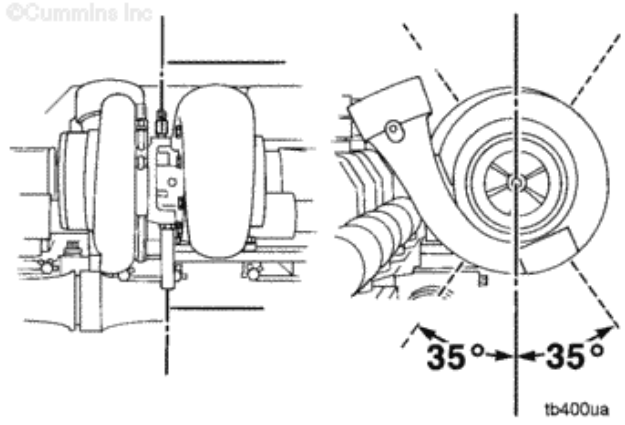
Torque
Value: 45 n.m [33 ft-lb]





Position the turbocharger drain tube. The drain tube **must** be within 35 degrees of vertical. Turn the bearing housing to align the tube, if necessary.

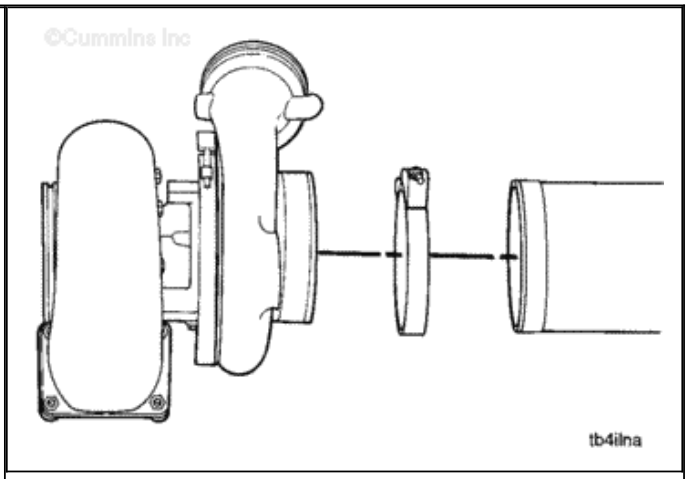
Some turbochargers use the through bolt style to attach the bearing housing to the turbine housing. Others use the clamp plate style.



Install the intake piping to the turbocharger.

Tighten the v-band clamp.

Torque
Value: 9 n.m [80 in-lb]



Connect the exhaust piping to the turbocharger.

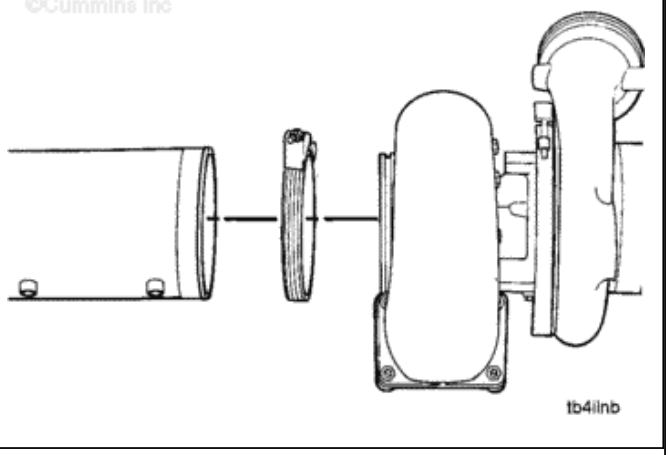
Tighten the v-band clamp.

Torque
Value: 4 n.m [35 in-lb]

Some engines contain a flanged exhaust connection.

Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]



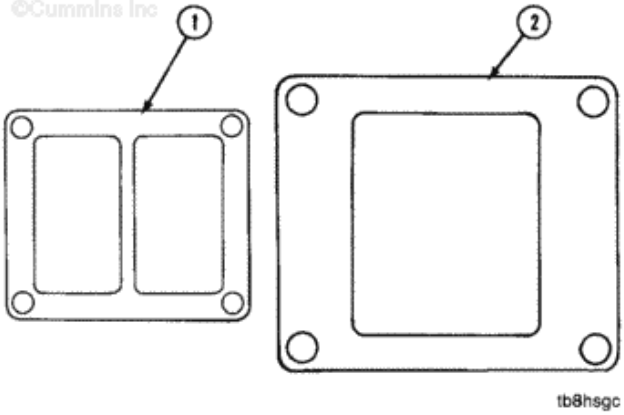
Multiple Turbochargers

CAUTION

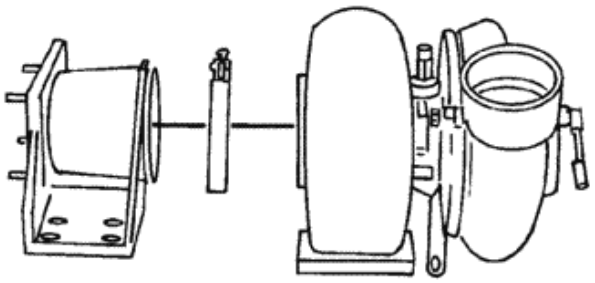
The turbochargers and components must be installed in the sequence given. Failure to do so can result in component failure.

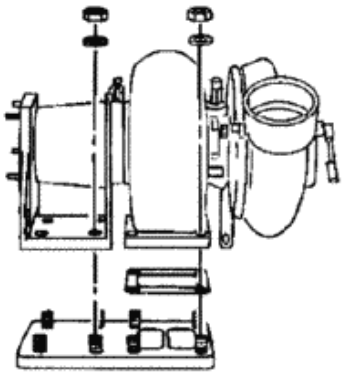
The high stage turbocharger (1) attaches directly to the exhaust manifold. This turbocharger has a divided turbine housing.

The mounting flange on the

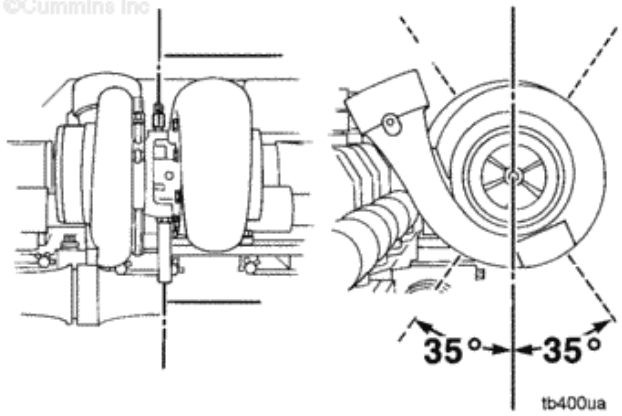


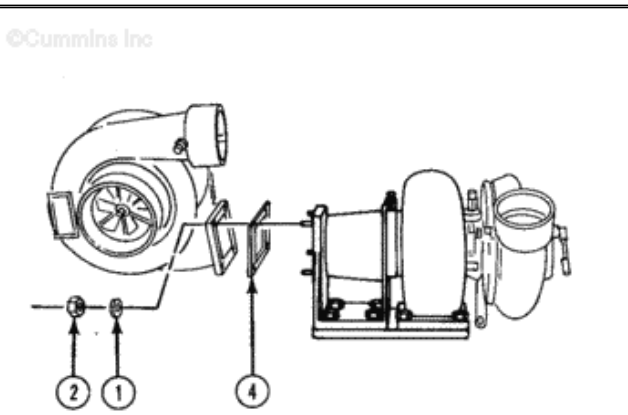
high stage turbocharger housing is much smaller than the low stage turbocharger.		

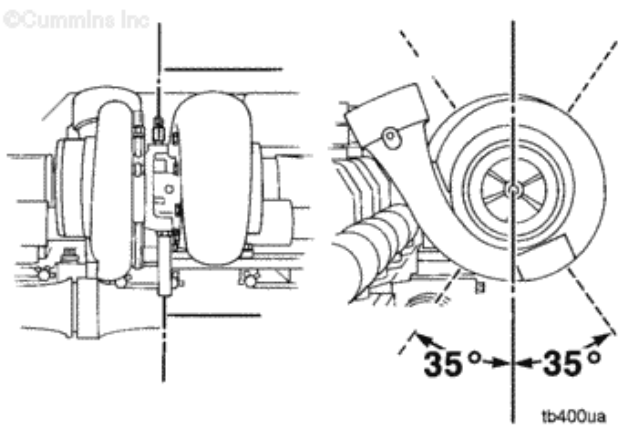
Install the mounting support and v-band clamp on the high stage turbocharger. Tighten the clamp enough to hold the parts together and allow them to rotate.		©Cummins Inc  10i00001

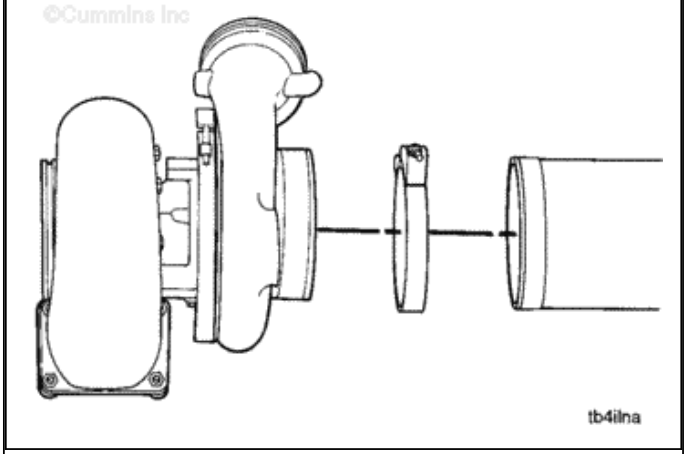
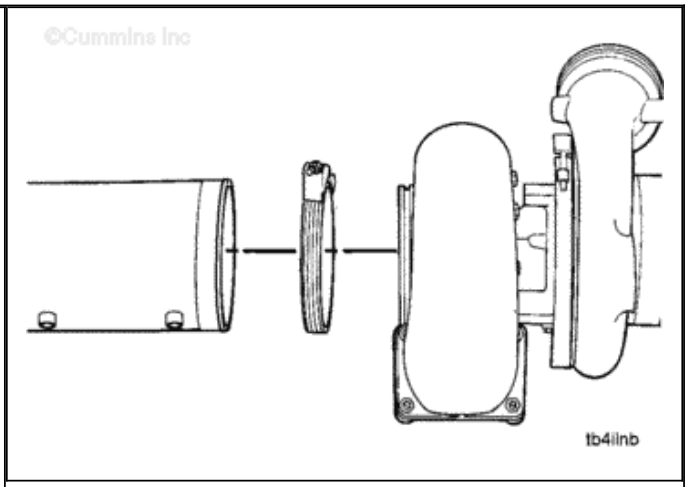
Do **not** use anti-seize compound on the mounting studs or nuts. Install the gasket on the exhaust manifold with the word OUT toward the turbocharger. Install the turbocharger and support on the manifold. Install the washers and nuts. Hand-tighten the nuts **only**. Check to make sure the turbocharger and the support fit flatly on the manifold. Remove the v-band clamp. Check the fit between the turbocharger and the support. Both parts **must** be in contact with the manifold and without gaps. Install the v-band clamp and tighten. **Torque Value:** AiReasearch™ 7 n.m [62 in]	 	©Cummins Inc  10400079

Torque Value: Holset® 14 n.m [124 in-lb]		

Check the oil drain tube angle. The turbocharger drain tube **must** be within 35 degrees of vertical.		

Do **not** use anti-seize compound on the studs or nuts. Install the gasket (4) on the support assembly with the word OUT toward the low stage turbocharger. Install the low stage turbocharger, washers, and nuts. Tighten the nuts. **Torque Value:** 45 n.m [33 ft-lb]	 	

Check the oil drain tube angle. The turbocharger drain tube **must** be within 35 degrees of vertical.		

Install the intake piping to the turbocharger. Tighten the v-band clamp. **Torque** **Value:** 9 n.m [80 in-lb]		
Connect the exhaust piping to the turbocharger. Tighten the v-band clamp. **Torque** **Value:** 4 n.m [35 in-lb] Some engines contain a flanged exhaust connection. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]		

Last Modified: 14-Sep-2011

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010-019 Air Crossover

Install

Lubricate the o-rings (10) with vegetable oil.

Install the o-rings onto the tube.

Install the tube into the crossover.

Install the dust seal (11) on the tube.

Install the gasket, air crossover, and capscrews.

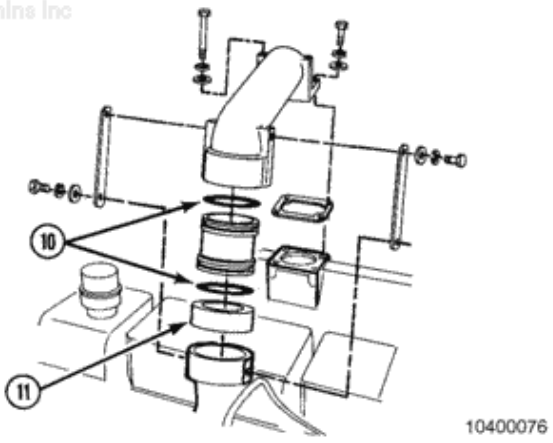
Tighten the capscrews.

Torque Value: 40 n.m [30 ft-lb]

Install the retaining straps, washers, and capscrews.

Tighten the capscrews.

Torque Value: 20 n.m [15 ft-lb]



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010-018 Air Connection Pipe (Turbocharger to Turbocharger)

Install

Use transfer tube (14) without o-rings, to check the alignment. The tube **must** slide easily onto both turbochargers.

Adjust the compressor housing on the low stage turbocharger to allow alignment if necessary.

Slide the dust seal (15), the clamps (16 and 17), on the pipe (14).

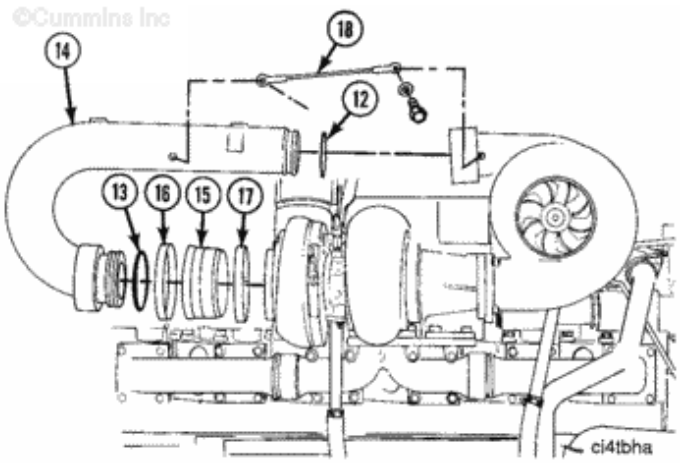
Lubricate the o-rings with vegetable oil and install them onto the pipe (14).

Install the pipe into the turbochargers. Install the dust seal and clamps.

Tighten the clamps.

Torque
Value: 6 n.m [50 in-lb]

Install the two adjusting links (15), washers, and the



capscrews. Tighten the capscrews **Torque Value:** 20 n.m [15 ft-lb]		

Last Modified: 29-Nov-2004

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010-045 Turbocharger Oil Drain Line

Install

CAUTION

These parts are safety related, make sure the parts are clamped correctly to prevent fretting.

Install the adapter elbow to the cylinder block.

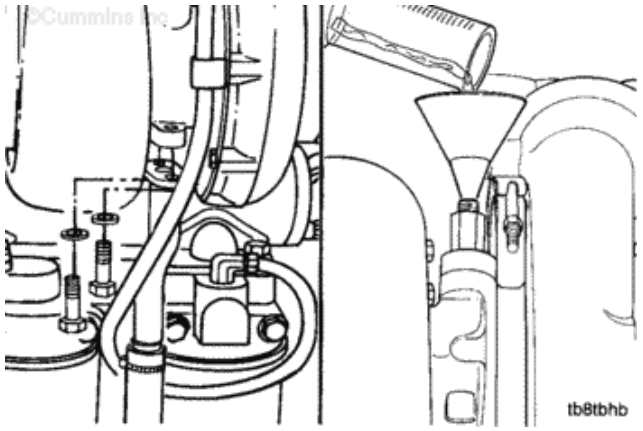
Connect the oil drain tube to the adapter.

Connect the oil drain tube to the turbocharger.

Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]

Pour 50 to 60 cc [2.0 to 3.0 oz] of clean engine oil into the oil supply fitting.

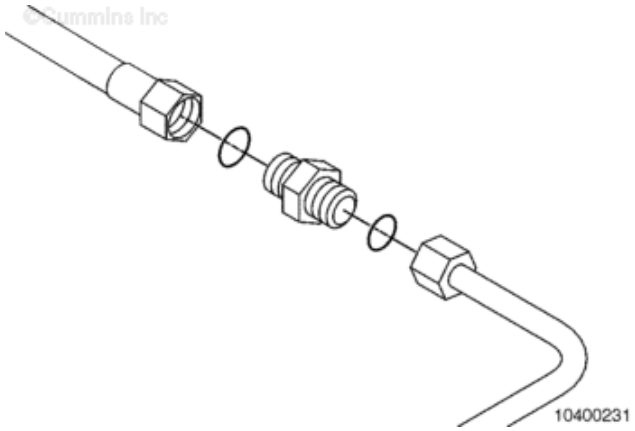


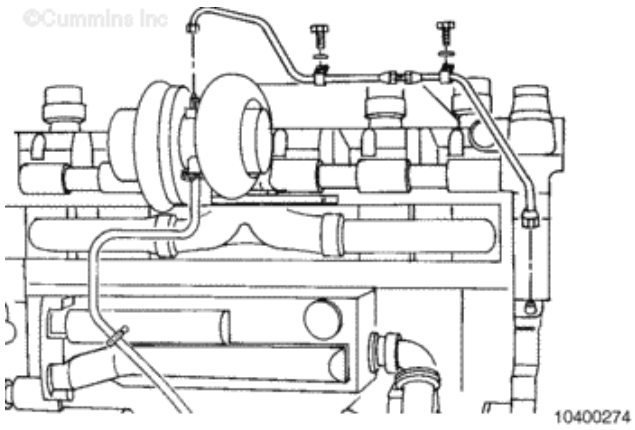
Last Modified: 29-Nov-2004

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010-046 Turbocharger Oil Supply Line

Install

Lubricate the o-rings with vegetable oil. Install o-rings. Connect the turbocharger oil supply hose to the oil supply tube.		

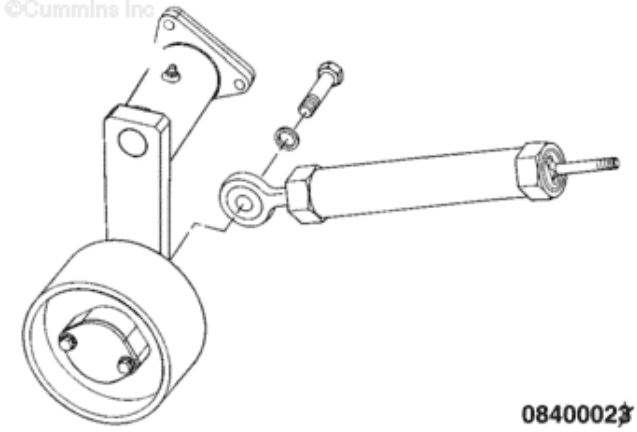
Make sure the turbocharger bearing housing has been filled with clean engine oil. Install the turbocharger oil supply hose. AiReasearch 45 n.m [33 ft-lb] Holset 20 n.m [15 ft-lb]		

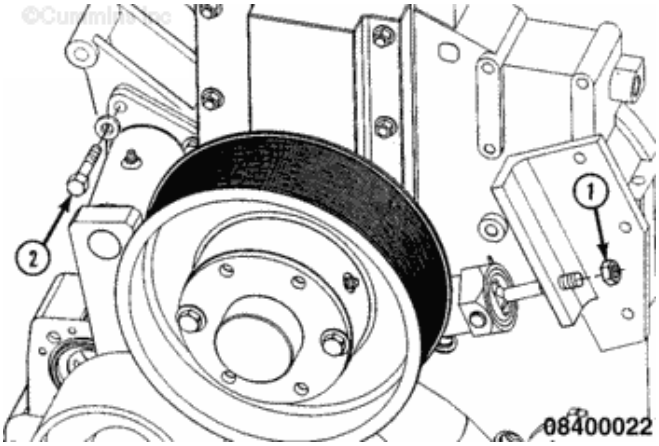
Last Modified: 29-Nov-2004

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008-029 Fan Drive Idler Arm Assembly

Install

Install the belt tensioner onto the idler arm. Tighten the capscrew. Enclosed Spring Style — 201 n.m [75 ft-lb] Shock Absorber and Control Rod with Spring Style — 45 n.m [33 ft-lb]		

Install the idler arm assembly and capscrews (2). Tighten the capscrews. **Torque Value:** 45 n.m [33 ft-lb] Install the belt tensioning nut (1). Do **not** tighten the nut.		

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008-036 Fan Hub, Belt Driven

Install

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.

If the studs have been removed check the protrusion.

Stud Protrusion From Front Cover		
mm		in
50.17	MIN	1.975
51.44	MAX	2.025

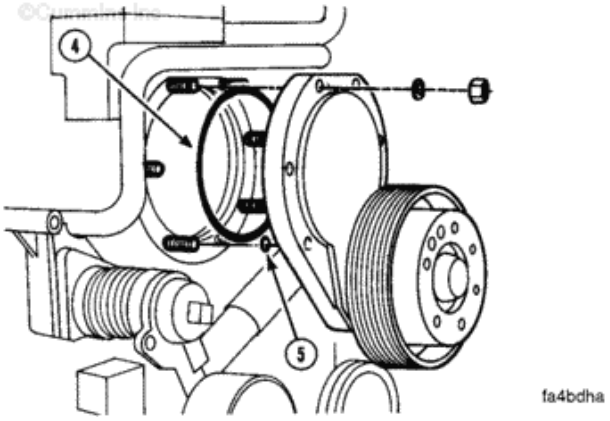
Lubricate the o-ring (4) and seal ring (5) with vegetable oil.

Install the o-ring and seal ring into the fan hub.

Install the fan hub and seven lock washers and nuts.

Tighten the nuts.

Torque Value: 35 n.m [25 ft-lb]



Last Modified: 31-Jul-2006

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008-037 Fan Hub, Gear Driven

Install

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.

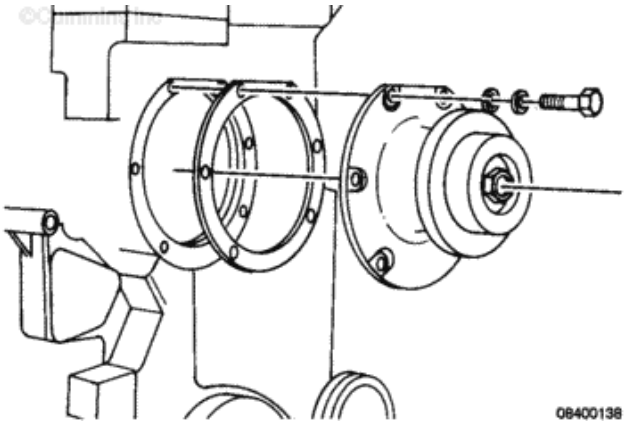
NOTE: For installation and operation of a clutch driven assembly, use the K-1150 Operation and Installation, Bulletin 3387082.

Align the hole in the gasket for the oil passage with the oil hole in the front cover.

Install the gasket, fan hub, and capscrews.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]

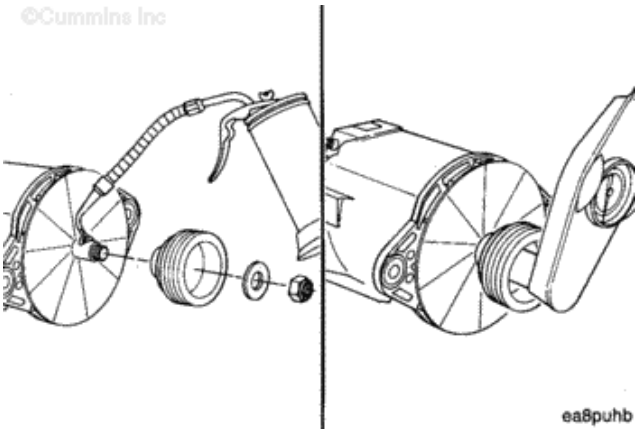
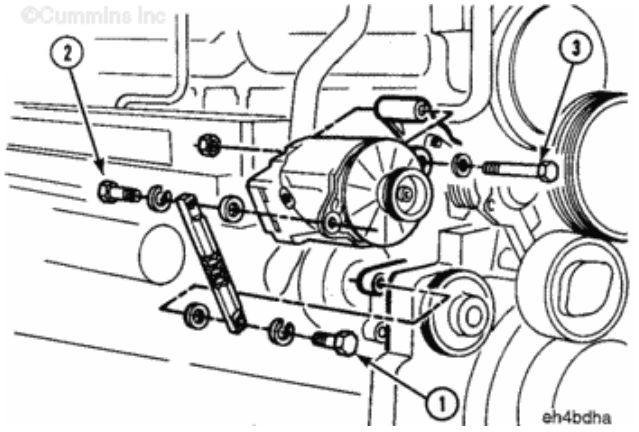


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013-001 Alternator

Install

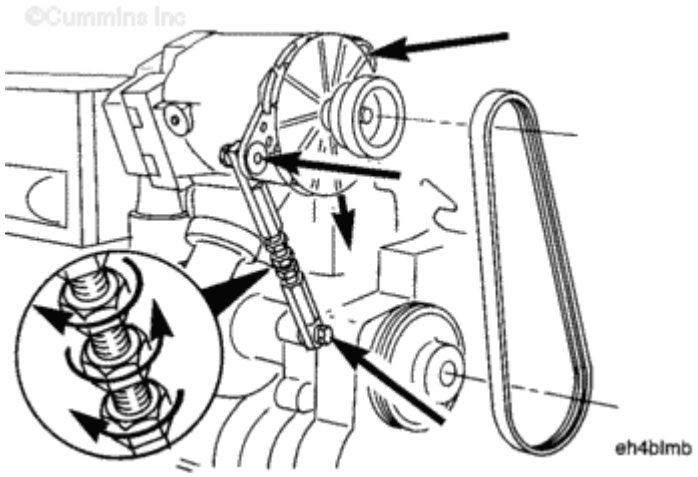
Lubricate the shaft with engine oil. Install the pulley and nut on the alternator shaft. Tighten the nut. **Torque** **Value:** 100 n.m [75 ft-lb]		
The belt **must** be adjusted before the capscrews are tightened. The end of the adjusting link with the largest area at the capscrew hole **must** be nearest to the alternator. Install the alternator and the adjusting link as shown. Connect the wiring to the alternator.		

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013-005 Drive Belt, Alternator

Install

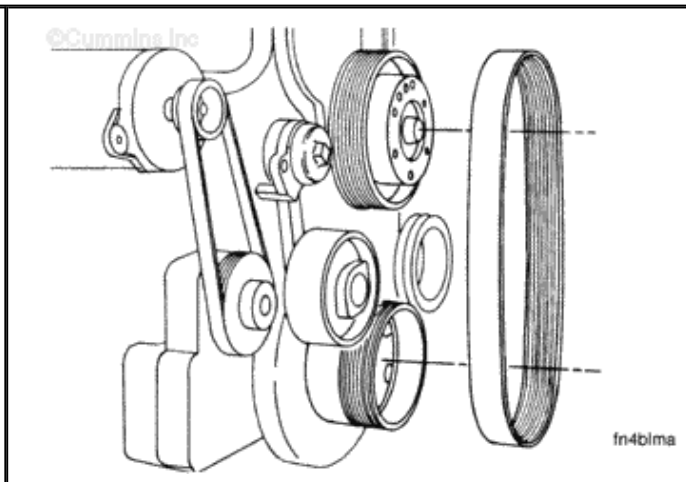
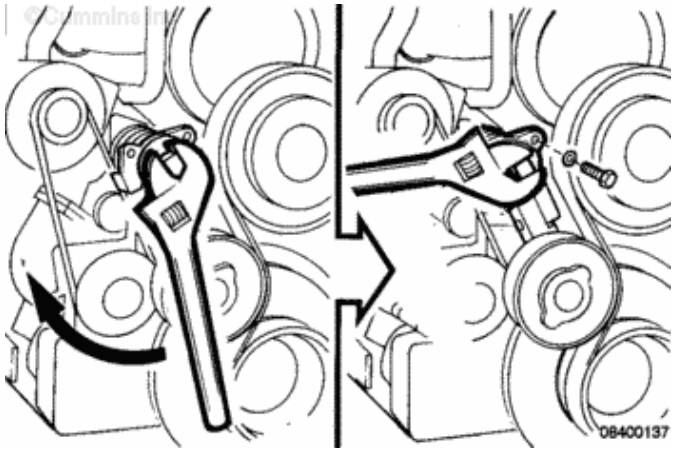
Do **not** attempt to pry the belt on the pulley. Turn the adjusting screw **counterclockwise** to shorten the link if necessary. Install the alternator belt.		

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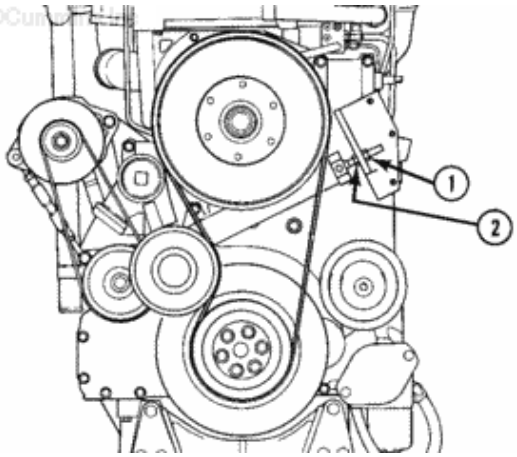
008-002 Drive Belt, Cooling Fan

Install

Install the fan belt.		
The shock absorber style of belt tensioner does **not** have an adjustment. For the shock absorber style, use an 8-point socket and a breaker bar or a large wrench on the lug on t he idler cap to rotate the idler against the spring tension until the capscrew holes are aligned. Install and tighten the capscrew. **Torque** **Value:** 45 n.m [33 ft-lb]		

Slowly turn the wrench until the idler is against the belt.		

Adjust

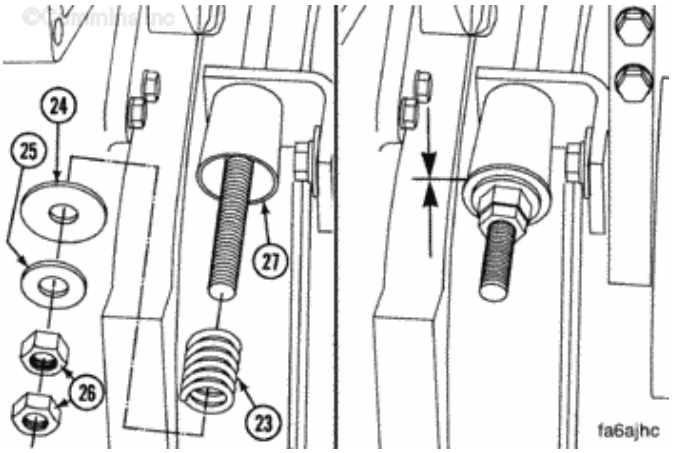
For the enclosed spring style of belt tensioner, pull the belt tensioner until the idler pulley contacts the fan belt. Tighten nut (1) finger-tight. Use a wrench to tighten nut (1) nine revolutions. Tighten nut (2). **Torque** **Value:** 81 n.m [60 ft-lb] If the fan belt was replaced, operate the engine for 10 minutes at high idle. Adjust the belt tension.		

CAUTION Do not tighten the inner jam nut more than one revolution after the spring retainer contacts the cup or the cup will be bent allowing a loose belt. Tighten the inner jam nut		

until the washer (24) contacts the cup on the bracket. Use two wrenches and tighten the outer jam nut to the inner jam nut.

For the control rod with spring belt tensioner, tighten the inner jam nut until the washer (24) contacts the cup on the bracket.

Use two wrenches and tighten the outer jam nut to the inner jam nut.



Last Modified: 28-Jul-2006

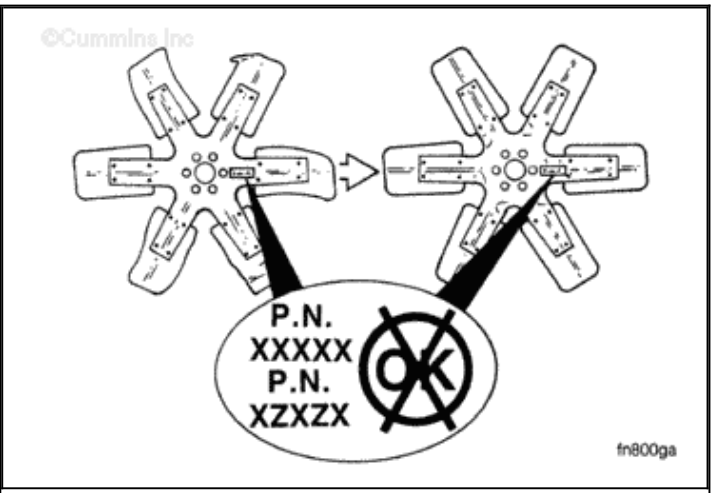
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008-040 Fan, Cooling

Install

CAUTION

To reduce the possibility of equipment damage, replace the original equipment fan with a fan of the identical part number. Cummins Inc. must approve of any fan changes.

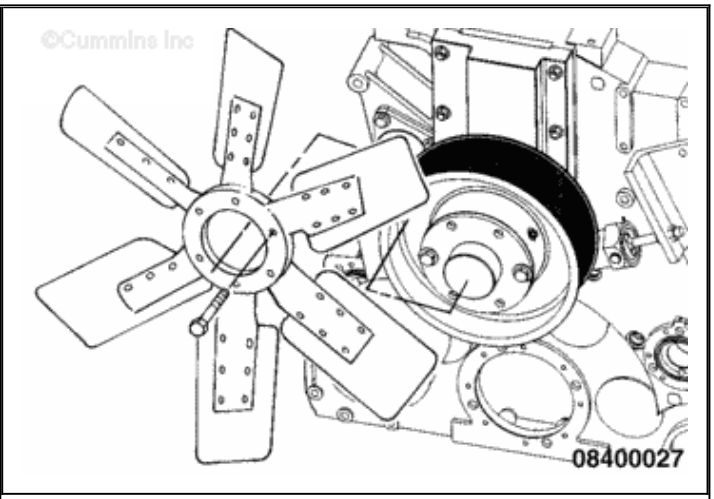


A minimum of 19.05 mm [¾ in] of capscrew threads **must** be engaged in the fan hub.

Install the spacer, fan, and capscrews.

Tighten the capscrews.

Torque
Value: 135 n.m [100 ft-lb]

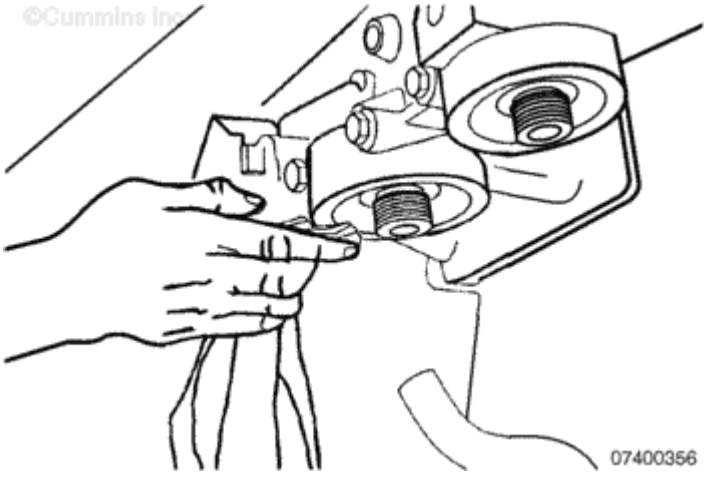
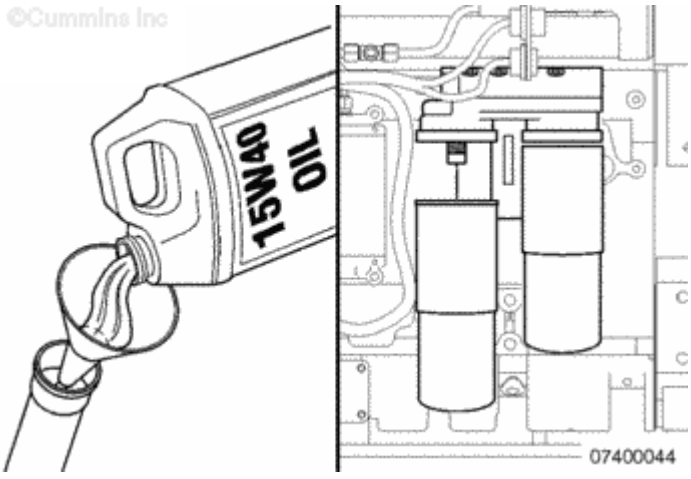


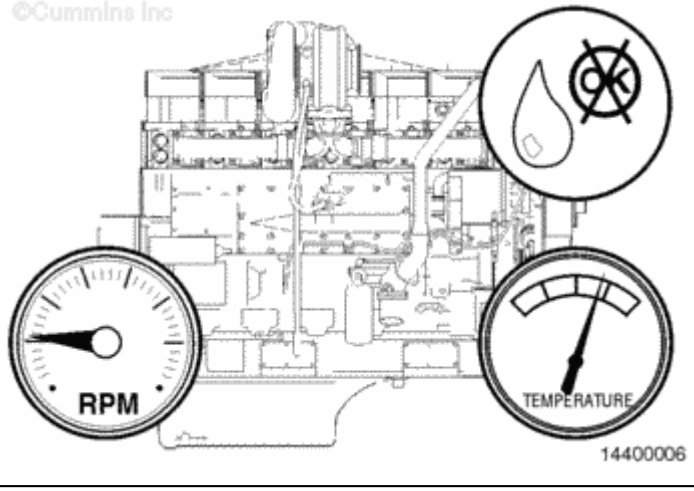
Last Modified: 20-Dec-2004

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007-013 Lubricating Oil Filter (Spin-On)

Install

Clean the oil filter head surface. Lubricate the gasket surface of the oil filter with clean engine oil.	 	
Fill the oil filters with clean 15W-40 oil. Install the oil filters on the oil filter head. Mechanical overtightening can distort the threads or damage the oil filter element seal. Turn the oil filter until the seal contacts the oil filter head.		

Turn an additional ¾ to 1 turn.		
Operate the engine until the oil temperature is at a minimum of 65°C [150°F]. Check for leaks.		

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006-011 Fuel Filter, Remote Mounted

Install

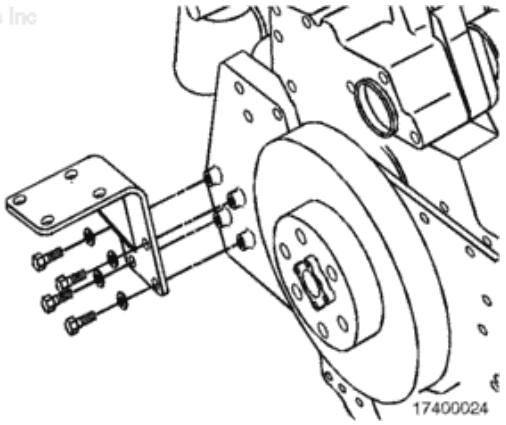
Rail Applications

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.

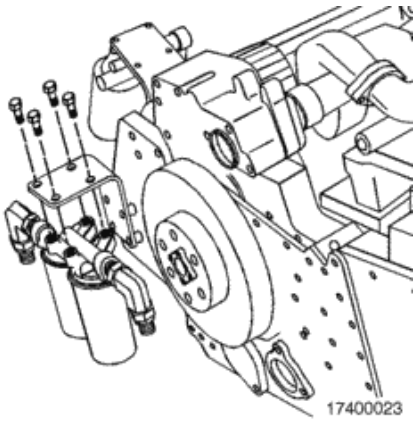
Install the bracket and four capscrews on the lubricating oil pan. Tighten the capscrews.

Torque Value: 75 n.m [55 ft-lb]



Install the fuel filter head and four capscrews on the bracket. Tighten the capscrews.

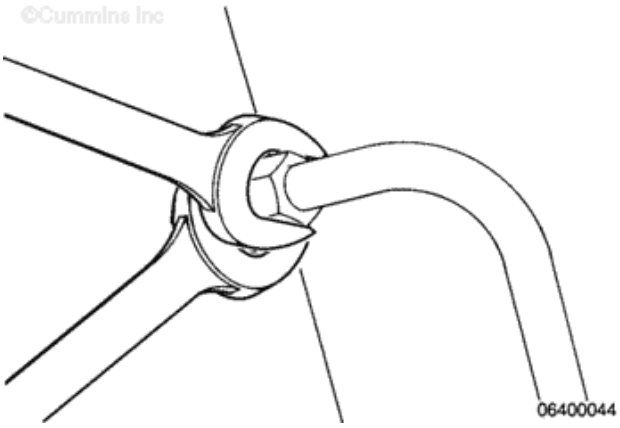
Torque Value: 25 n.m [20 ft-lb]



Install the two hoses and o-rings on the fuel filter head.

Tighten the fittings.		
Fitting - Fuel Tank to Fuel Filter	115 n.m	[85 ft-lb]
Fitting - Fuel Filter to Fuel Pump	90 n.m	[65 ft-lb]



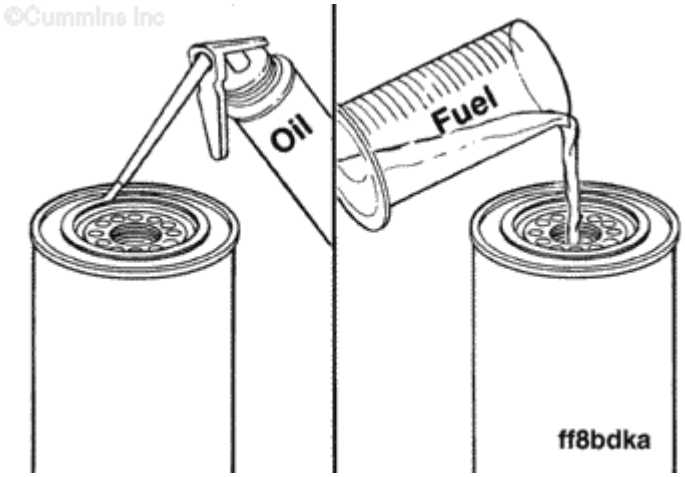
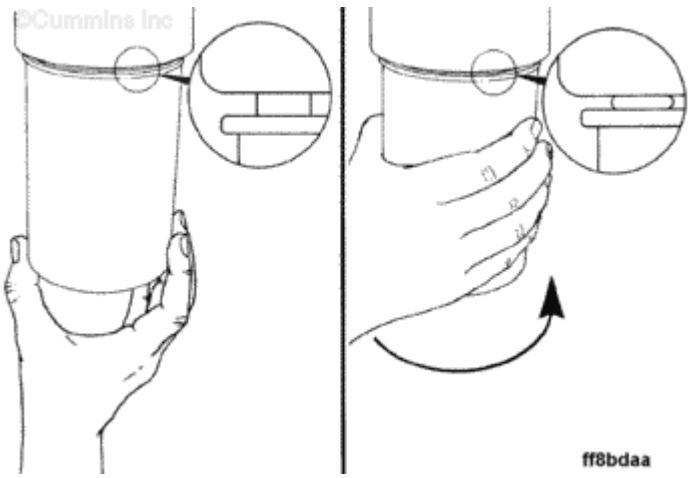


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006-015 Fuel Filter (Spin-On Type)

Install

Install a new thread adapter sealing ring supplied with the new filter. A fuel-water separator or fuel filter and water separator combination **must** be installed. 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 1/2 to 3/4 of a turn after the gasket touches the filter head surface.		

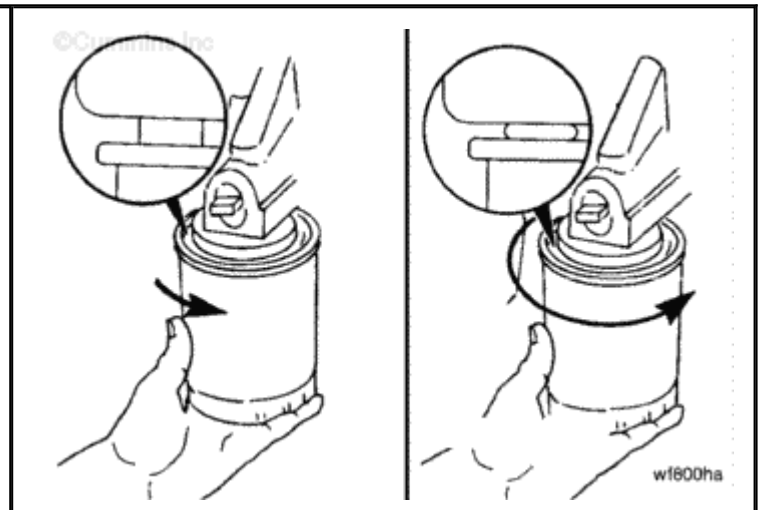
Open the fuel line shutoff valve and check for leaks.		

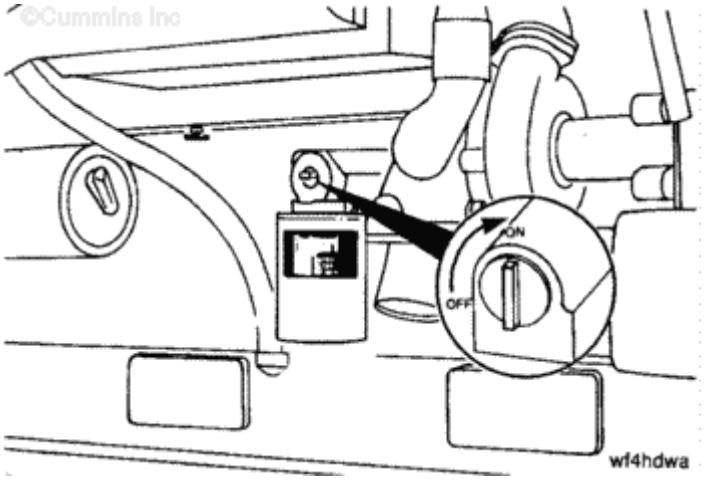
Last Modified: 28-Jul-2006

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008-006 Coolant Filter

Install

Do **not** allow oil to get in the filter. It will break down the SCA. Lubricate the seal on the filter with clean engine oil.		
Install the coolant filter. Turn the filter until the seal touches the filter head. Turn an additional ½ to ¾ of a turn after contact.		
Turn the valve to the ON position.		

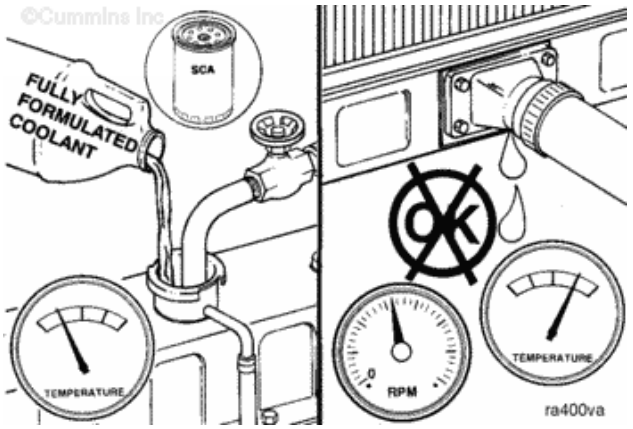


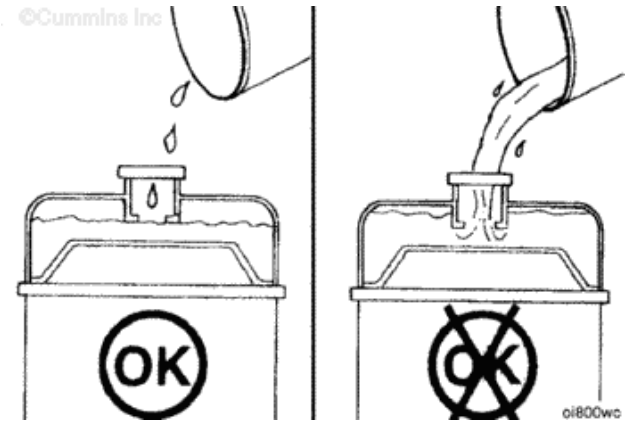
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008-018 Cooling System

Fill

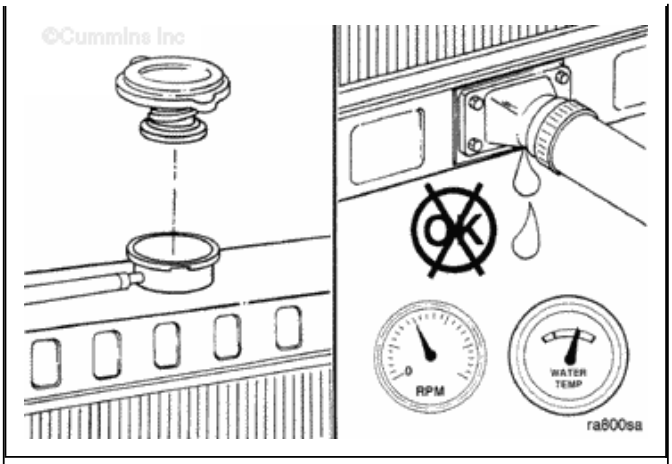
Close the radiator draincocks. Install the lower radiator hose(s). Tighten the hose clamps. **Torque** **Value:** 5 n.m [40 in-lb] Use fully formulated coolant to fill the coolant system.		

CAUTION If the coolant level is above the bottom of the fill neck there will not be enough space for the air that is in the system. If the air is not trapped at the top of the radiator it can travel to the water pump inlet causing low coolant flow because of impeller cavitation. The cavitation can result in overheating of the engine. Fill the cooling system with coolant to the bottom of the fill neck in the radiator or expansion tank.		

Replace the radiator or fill cap.		

Operate the engine until the coolant reaches a temperature of 70°C [160°F].

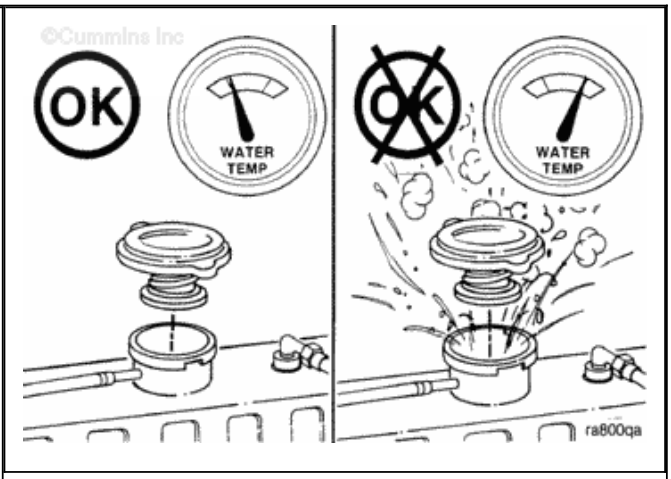
Check for leaks.



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, allow it to cool and check the coolant level.

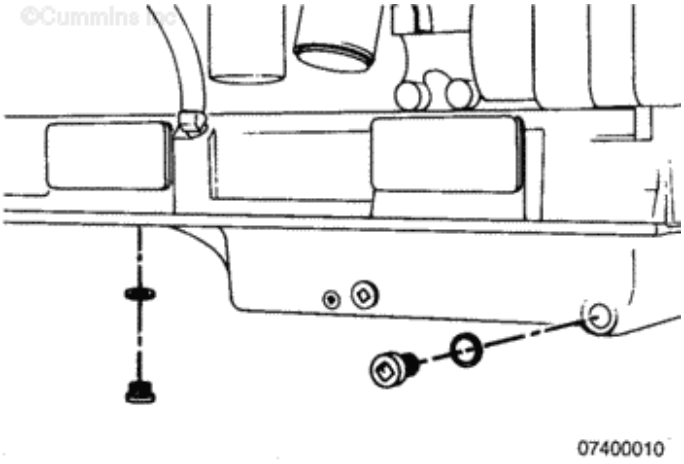
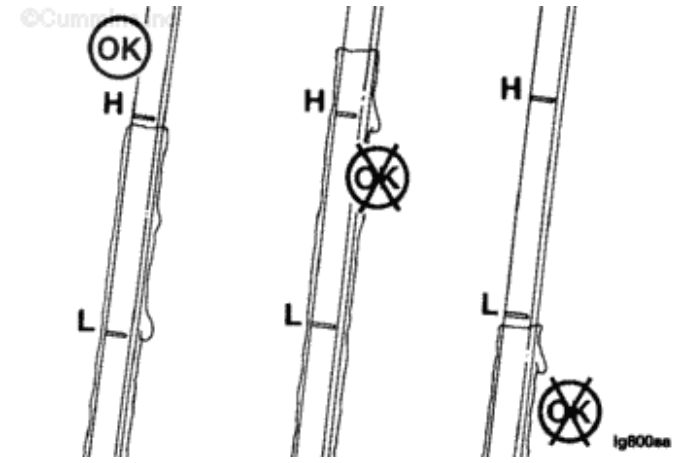


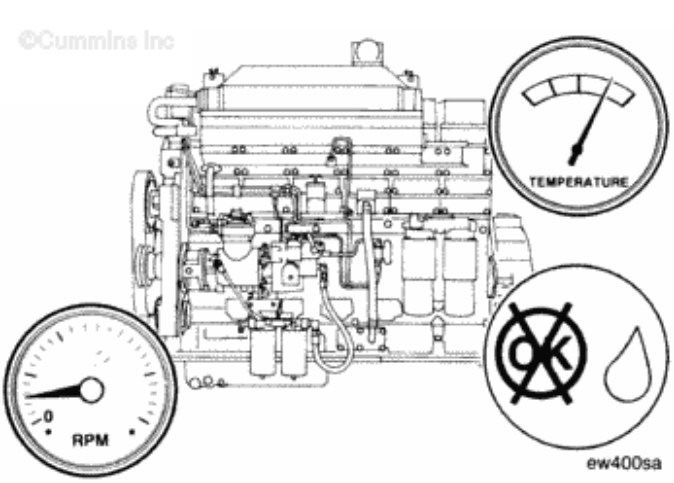
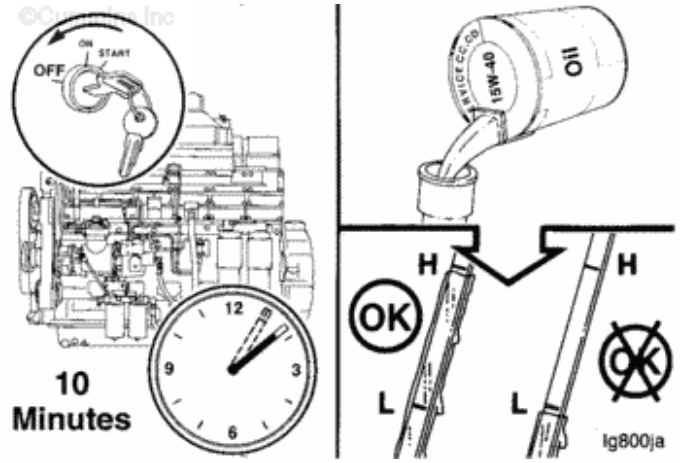
Last Modified: 31-Jul-2006

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007-037 Lubricating Oil System

Fill

Install the oil drain plugs and new copper washers into the oil sump and oil pan adapter cover plate. Tighten the oil drain plugs. **Torque** **Value:** 100 n.m [75 ft-lb] Fill the engine with clean 15W-40 oil. For oil pan capacities, refer to Procedure 018-017.		
Check the oil level on the dipstick. The level **must** be to the “H” (high) mark on the dipstick.		
Operate the engine to normal operating		

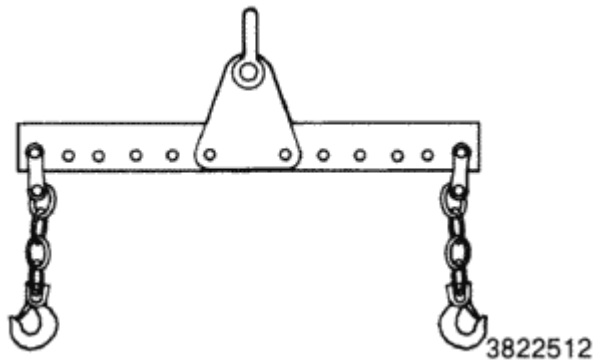
temperature and check for oil leaks.		
Shut the engine off and wait five to seven minutes to allow the oil to drain back into the oil pan. Check the oil level. Add oil as necessary to bring the level up to the “H” (high) mark on the dipstick.		

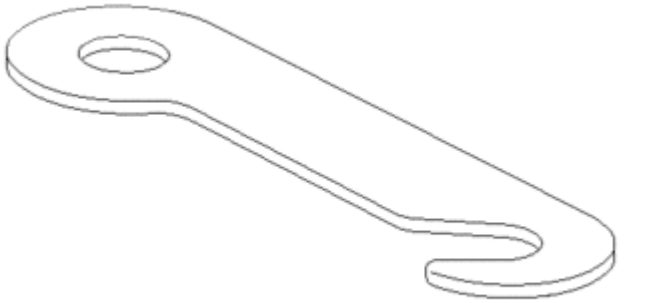
Last Modified: 23-Jul-2004

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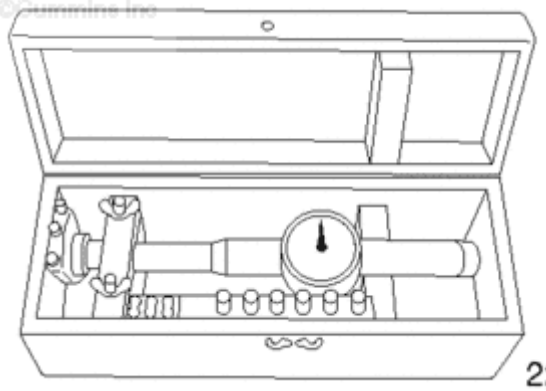
022-001 Service Tools

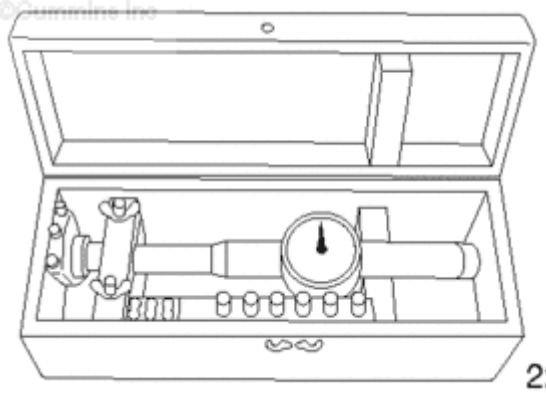
Cylinder Block

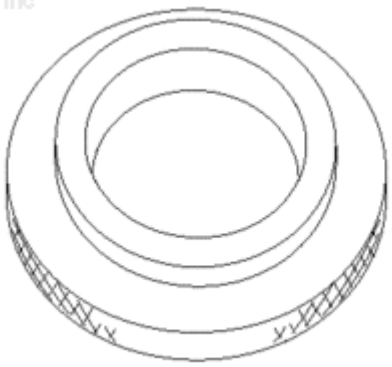
Tool Number		
3162871	**Engine Lifting Fixture** Designed to lift an engine up to 2722 kg [6000 lb].	

Tool Number		
3163091	**Lifting Hook** Designed to hook onto the lifting lugs of the cylinder heads. Use with Engine Lifting Fixture, Part Number 3162871 to attach to these lifting hooks to lift the engine as required.	

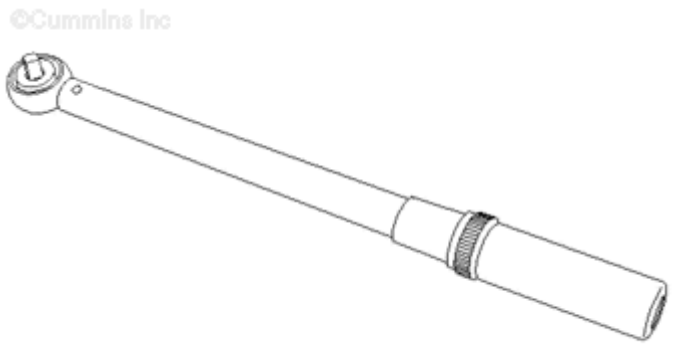
Tool Number		
	Dial Bore Gauge Kit (Short Handle) Used to measure the	

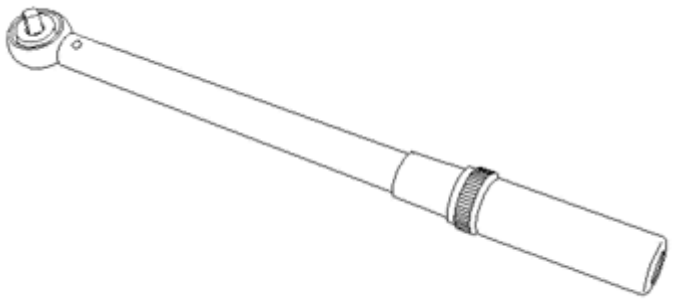
3375072	diameters of bores from three inches to 8 inches.	 22400225

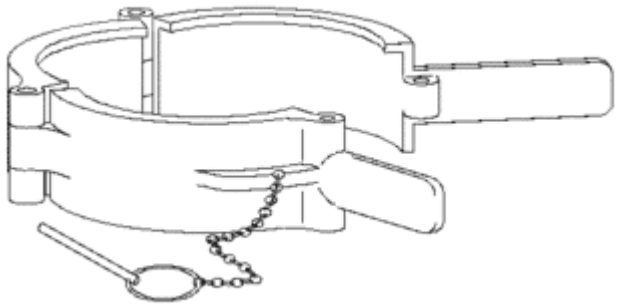
Tool Number 3376619	**Dial Bore Gauge Kit (Long Handle)** Used to measure the diameters of bores from three inches to 8 inches.	 22400225

Tool Number ST-1291	**Cylinder Liner Ring Gauge (6.251 K19, K38, K50)** Used for checking cylinder liner bores.	 22400226

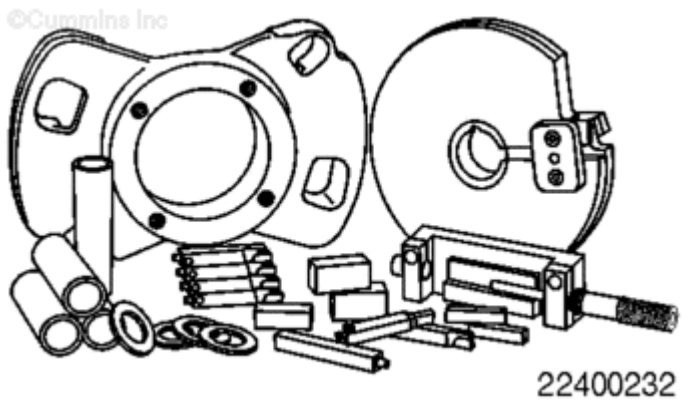
Tool Number	**Torque Wrench (30 to 250 ft-lb)**	

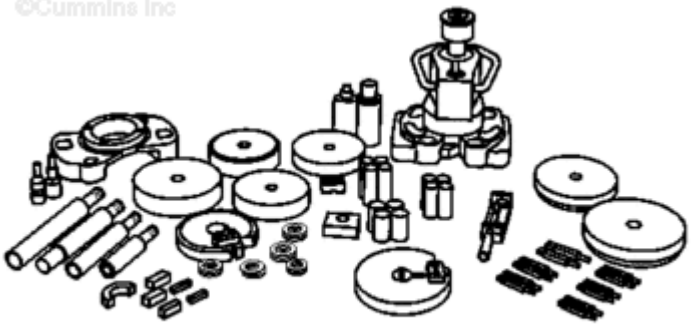
3164796	Used for general purpose when a specified torque is required.	 22400227

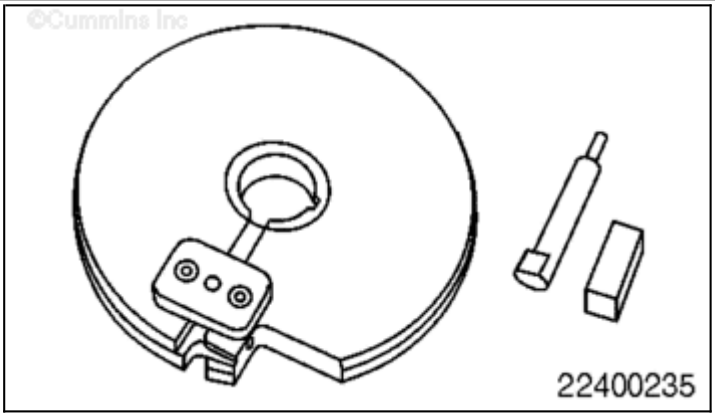
Tool Number 3164797	**Torque Wrench (100 to 600 ft-lb)** Used for general purpose when a specified torque is required.	 22400227

Tool Number 3823294	**Piston Ring Compressor** Used to compress the piston rings during piston installation.	 3163158

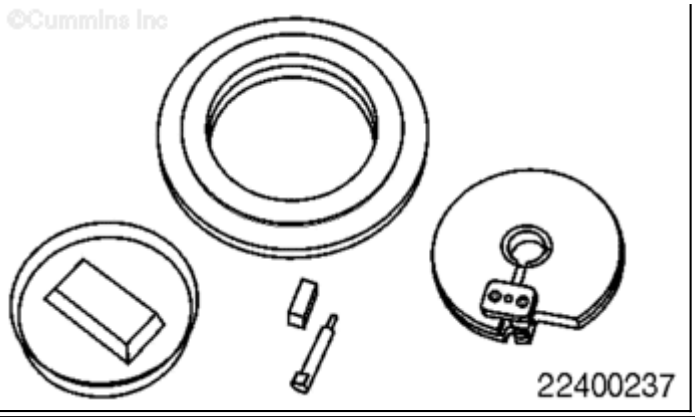
	Liner Counterbore Kit This kit is used to adapt older model	

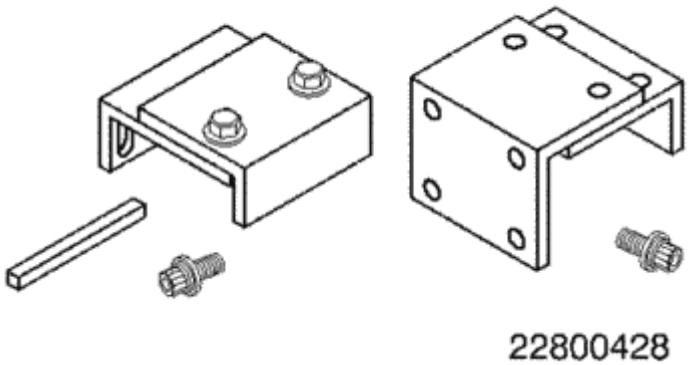
Tool Number 3375820	counterbore tools such as ST 1168 so that the tool will cut counterbores on K series cylinder blocks for oversize liners or repair sleeves. For more current tooling, refer to Counterbore Tool, Part Number 3377356 and various kits contained within.	

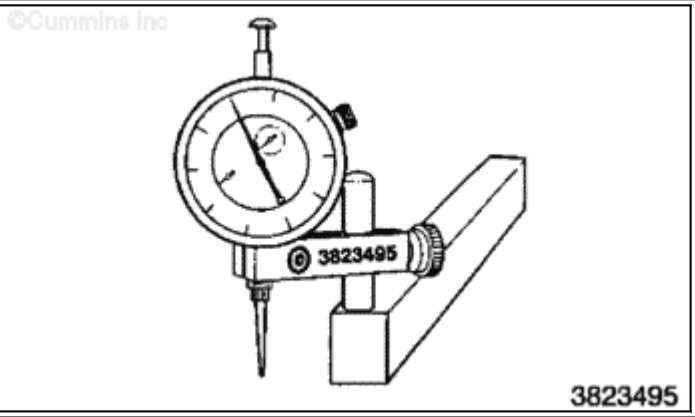
Tool Number 3377356	**Cylinder Liner Counterbore Tool (Upper Press Fit Liners)** This tool is used to bore the upper counterbore in the cylinder block for upper press fit repair sleeves or oversized liners.	

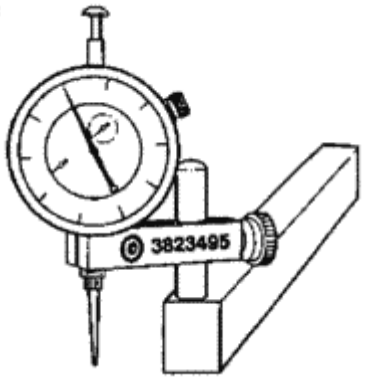
Tool Number 3824052	**Counterbore Cutter Plater O.S. Liners** Used in conjunction with components of Cylinder Liner Counterbore Tool, Part Number 3377356 for machining cylinder block liner counterbore for oversized liners.	

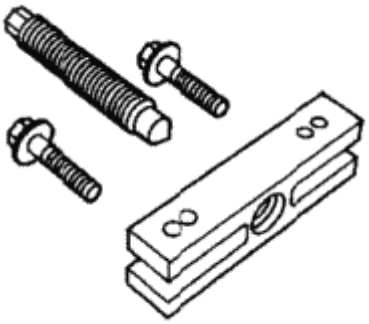
	Counterbore Salvage Kit This kit contains the	

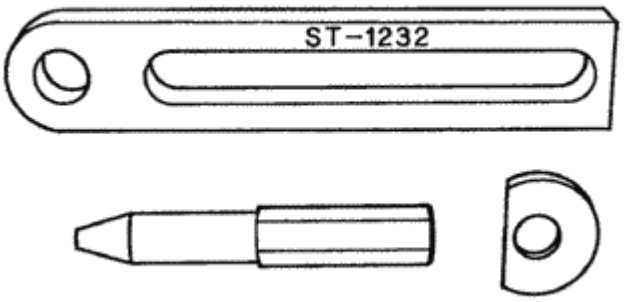
Tool Number 3824119	most needed tools for repairing counterbores in the K19 series engines. These are used in conjunction with components of Cylinder Liner Counterbore Tool, Part Number 3377356.	

Tool Number 3375272	**Engine Support Bracket Kit** Support the front of the engine to allow the front support or oil pan adapter to be removed.	

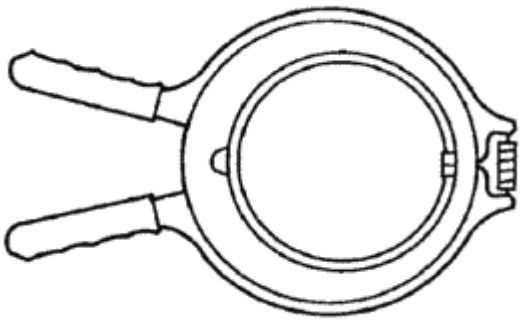
Tool Number 3164438	**Depth Gauge Assembly** Measure cylinder liner protrusion and cylinder liner counterbore ledge angle.	

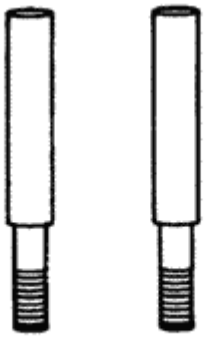
Tool Number 3823495	**Depth Gauge Assembly** Puller	 3823495

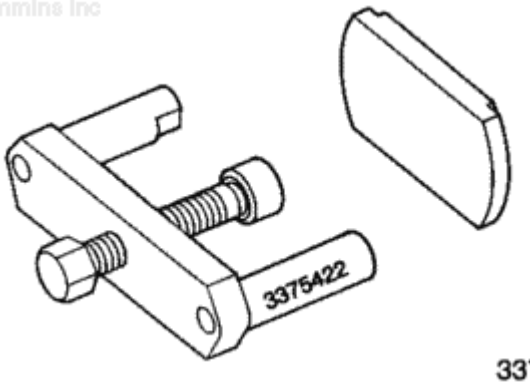
Tool Number ST-647	**Puller** Remove the alternator and accessory drive pulleys.	 ad8toga

Tool Number ST-1232	**Drill Ream Fixture** Machine dowel hole to install oversized dowels in cylinder block and flywheel housing. Use with drill, reamer, and the appropriate drill/ream bushing set.	 st-1232

Tool Number	**Piston Ring Expander**

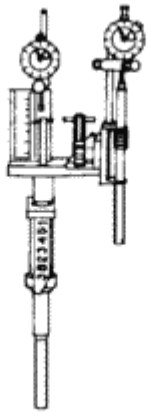
ST-1289	Designed to install piston rings on the piston without damaging or distorting the rings.	 pi8togd

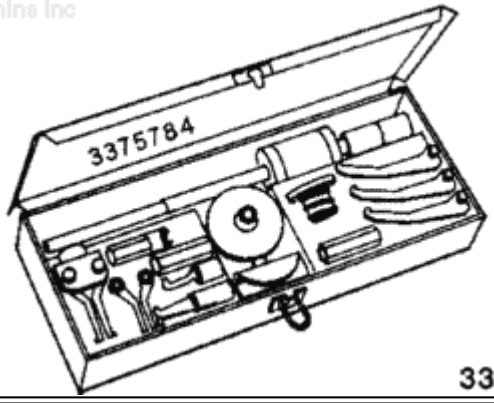
Tool Number 3375098	**Connecting Rod Guide Pins** Special nylon pins used to protect the crankshaft journals by guiding the connecting rod during installation and removal.	 cx8togg

Tool Number 3375422	**Liner Installation Tool** Install cylinder liner in engine.	 3375422

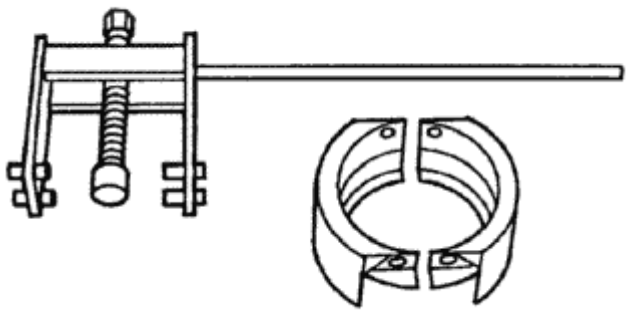
Tool Number	**Crack Detection Kit** Used to check for	

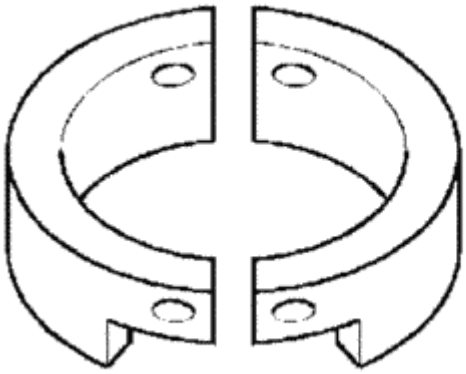
3375432	cracks in any engine component. It contains cleaner, developer, and penetrant.	©Cummins Inc  bp8togj

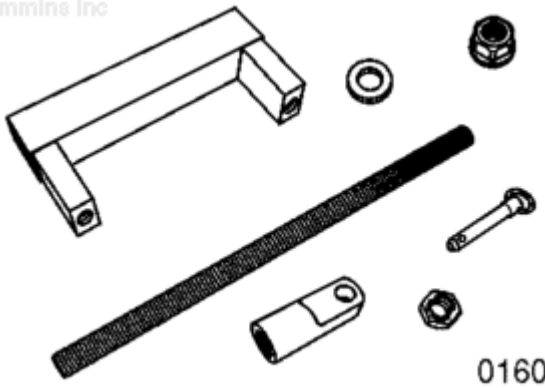
Tool Number 3824942	**Injection Timing Tool** Check injection timing. This timing fixture is designed to determine the push tube travel in relation to the piston travel.	©Cummins Inc  3823451

Tool Number 3375784	**Light Duty Puller Kit** Remove small bushings, oil seals, and bearings.	©Cummins Inc  3375784

Tool	**Puller Assembly**	

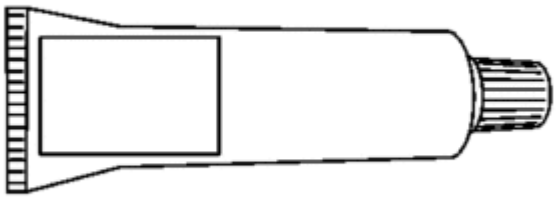
Number 3375834	Remove the crankshaft front gear from the crankshaft. Use with Puller Jaw, Part Number 3375835.	©Cummins Inc  ks8togd

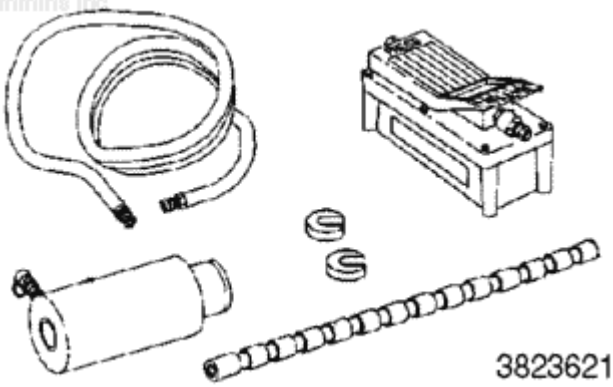
Tool Number 3375835	**Puller Jaw** Remove the crankshaft front gear from the crankshaft. Use with Puller Assembly, Part Number 3375834.	©Cummins Inc  3375835

Tool Number 3163745	**Liner Remover** Used with liner remover plate, Part Number 3162886, to remove the cylinder liner from the engine.	©Cummins Inc  01600269

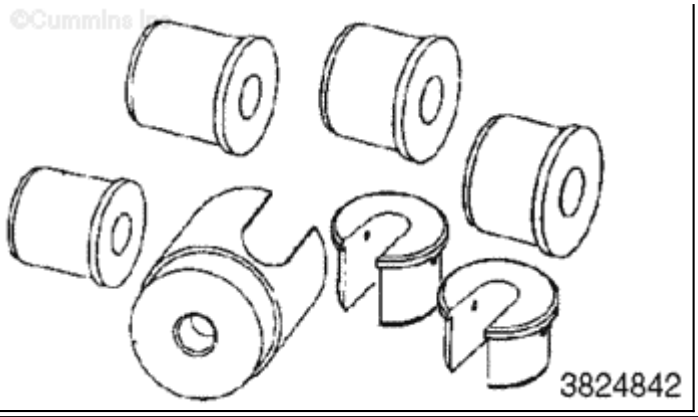
	Pulley Installation	

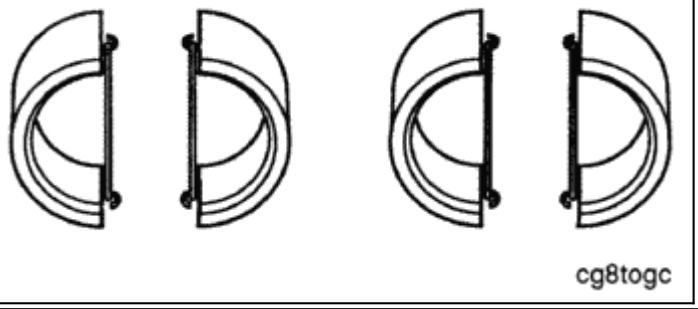
Tool Number 3376326	**Tool** Install the alternator and accessory drive pulleys.	 ad8togb

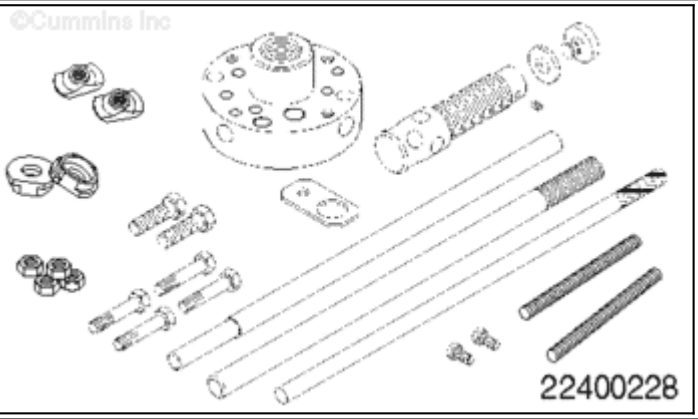
Tool Number 3164067	**Silicone Sealer** Silicone gasket maker. Room Temperature Vulcanizing (RTV), non-corrosive.	 07c00280

Tool Number 3823621	**Camshaft Bushing Installation/Removal Kit** Hydraulic ram provides the force to install/remove cam bushings when used with installation/removal kit.	 3823621

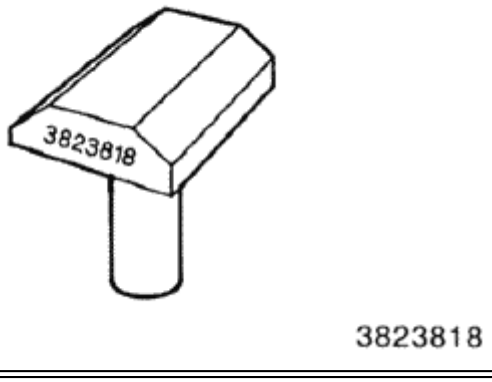
Tool Number	**Camshaft Bushing Installation/Removal Kit** Used with the	

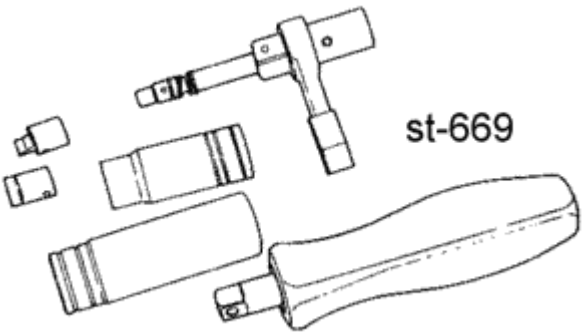
3823647	Camshaft Bushing Installation/Removal Kit, Part Number 3823621 to remove the camshaft bushings.	

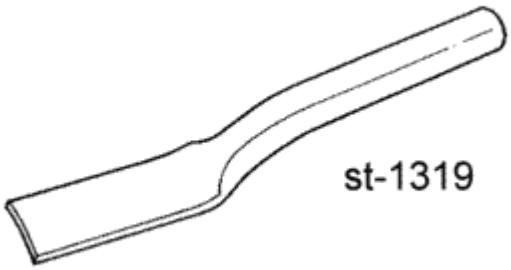
Tool Number 3376280	**Camshaft Pilot** Install camshaft without damaging the camshaft bushings or camshaft.	

Tool Number 3162895	**Camshaft Gear Puller Kit** Remove camshaft gear from camshaft without removing camshaft from engine.	

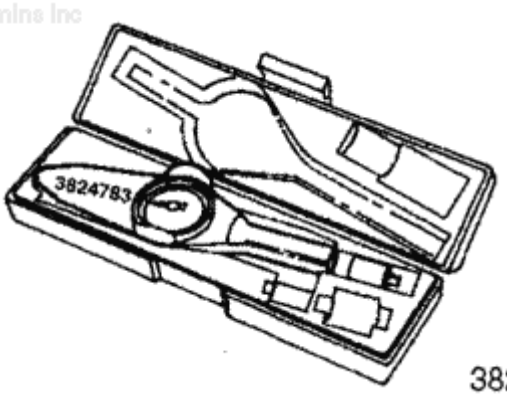
Tool Number	**Main Bearing Roll Out Tool** Used to remove and	

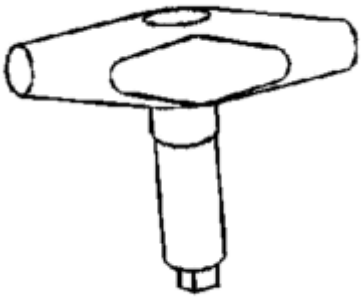
3823818	install the upper main bearing shell.	 3823818

Tool Number ST-669	**Torque Wrench Adapter** Secures the rocker lever adjusting screw while tightening the lock nut.	

Tool Number ST-1319	**Water Tube Driver** Used to install or remove the water transfer tubes from the rocker housing.	

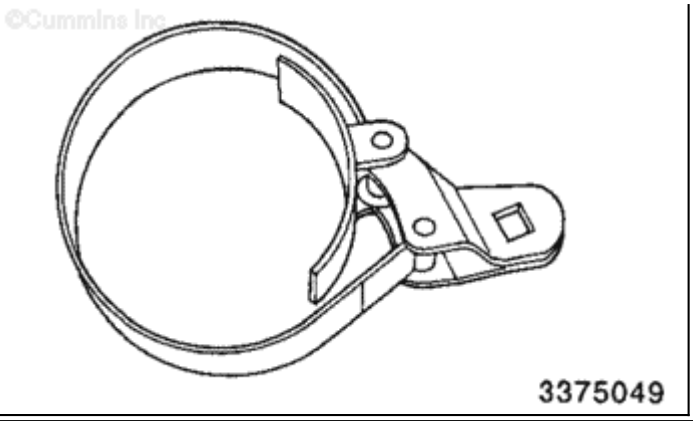
Tool Number	**Torque Wrench** A 3/8 drive, 300 inch-	

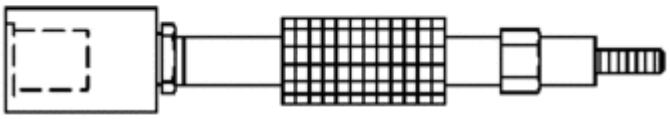
3164795	pound dial-type torque wrench used to accurately adjust injectors in inch-pounds.	©Cummins Inc  3824783

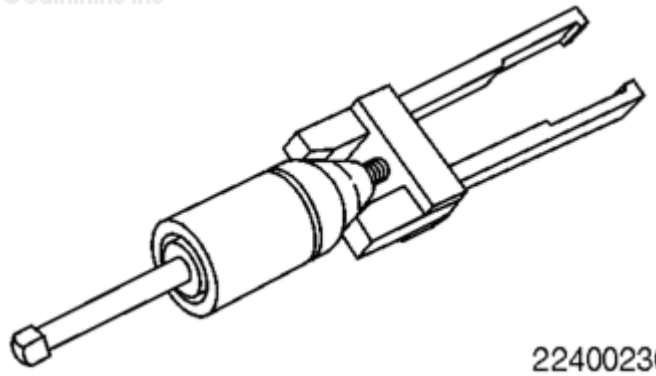
Tool Number 3376592	**Torque Wrench** Six inch-pound torque wrench used to tighten the valve lever adjusting screw. Does not require screwdriver attachment.	©Cummins Inc  3376592

Tool Number 3376845	**Fuel Pump/Air Compressor Ratchet Wrench** Used to reach nuts when removing or installing the fuel pump or air compressor.	©Cummins Inc  3376845

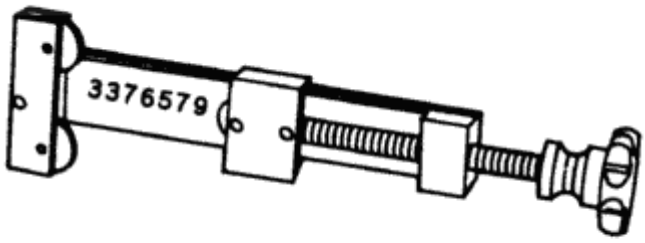
Tool Number	**Filter Wrench, Band Type 118 to 130 mm [4.65 to 5.12 inch]**	

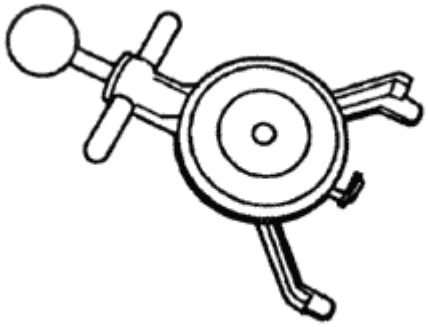
3400157	Used to remove spin on filters.	 3375049

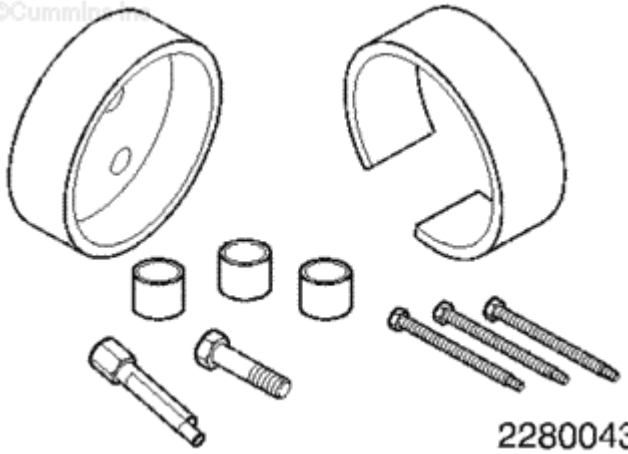
Tool Number 3824653	**Injector Puller** Used to remove and install injector. 3824653 must be used on STC injectors and can be used on non-STC injectors.	 22400229

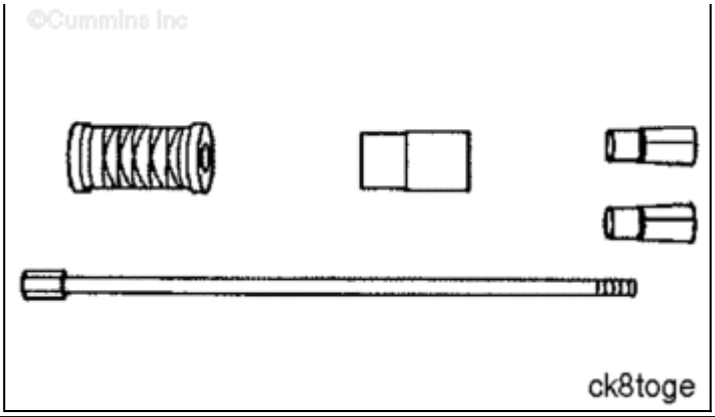
Tool Number 3823024	**Injector Puller** Used to remove and install injector. 3823024 is for standard PTD injectors.	 22400230

Tool Number	**Filter Cutter**	

3376579	Used to open spin-on full-flow filter for inspection.	 lf8togd

Tool Number ST-1293	**Belt Tension Gauge** Measure the accessory drive and alternator belt tension.	 fa8togc

Tool Number 3824760	**Oil Seal Remover/Installer** Used to remove small bushings, oil seals, and bearings.	 22800431

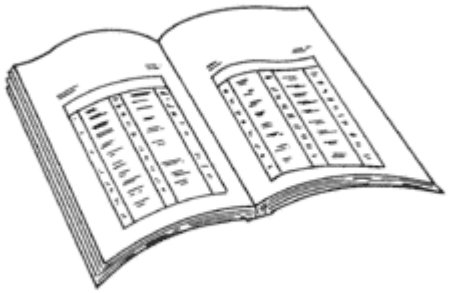
Tool Number ST-1134	**Dowel Pin Extractor** Remove dowel pins.	

Last Modified: 25-Oct-2004

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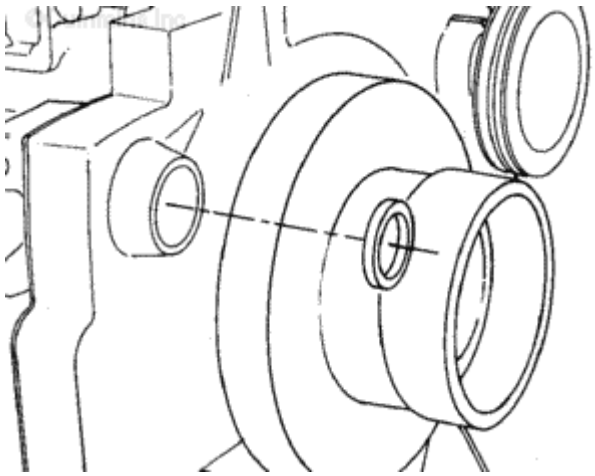
001-001 Alternator Drive Seal

Preparatory Steps

• Remove the alternator drive belt. Refer to Procedure 013-005. • Remove the water pump drive pulley. Refer to Procedure 009-032.		 ck800wa

Remove

Remove the alternator drive seal.		



Install

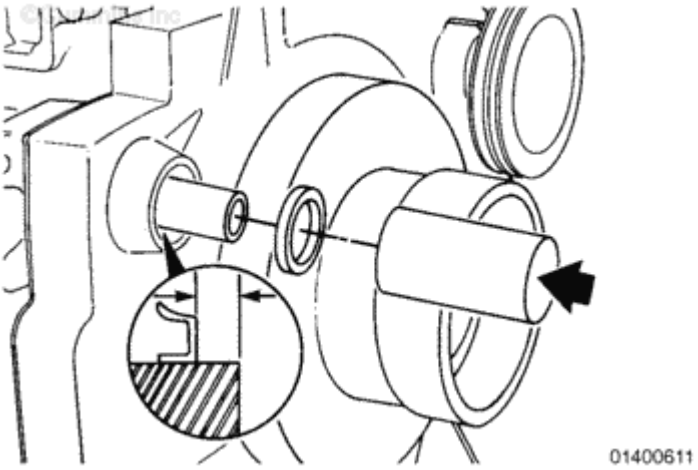
Do **not** lubricate the seal or the shaft. The seal and the surface of the shaft **must** be clean and dry.

An installation sleeve is provided with the seal.

Position the seal and installation sleeve over the shaft.

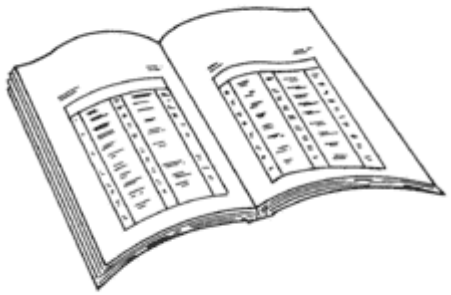
Push the seal onto the step on the shaft.

Remove the installation sleeve.



Use a mandrel to push the seal into the bore until the seal is 3.18 mm [0.125 in] below the surface of the gear cover.		

Finishing Steps

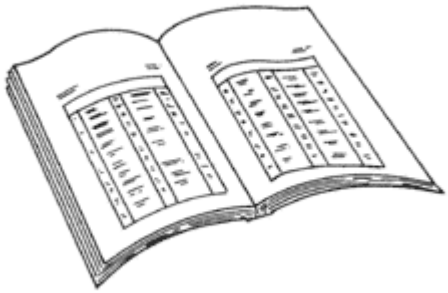
• Install the water pump drive pulley. Refer to Procedure 009-032. • Install the alternator drive belt. Refer to Procedure 013-005.		

Last Modified: 12-Jan-2005

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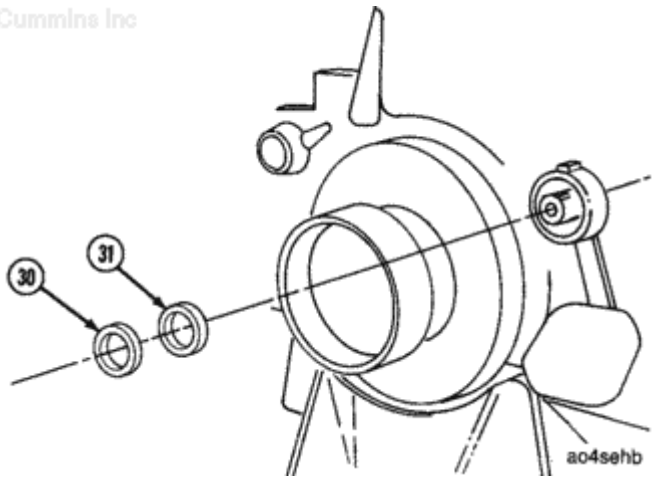
001-003 Accessory Drive Seal

Preparatory Steps

• Remove the accessory drive pulley. Refer to Procedure 009-004.		©Cummins Inc  ck800wa

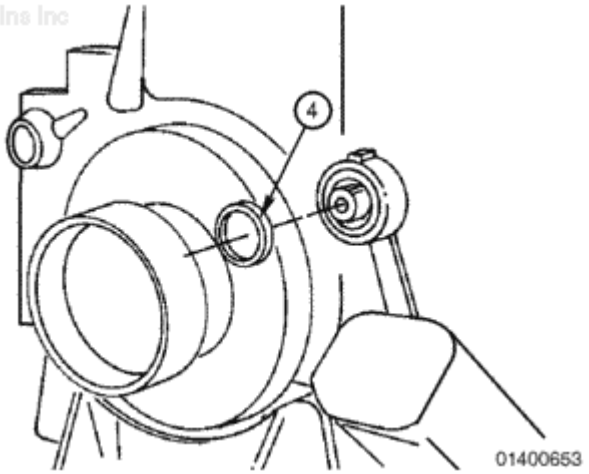
Remove

Remove the seal (30) and the oil slinger (31).		



Install

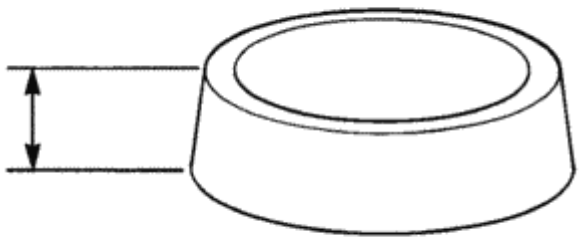
Install the oil slinger (4).



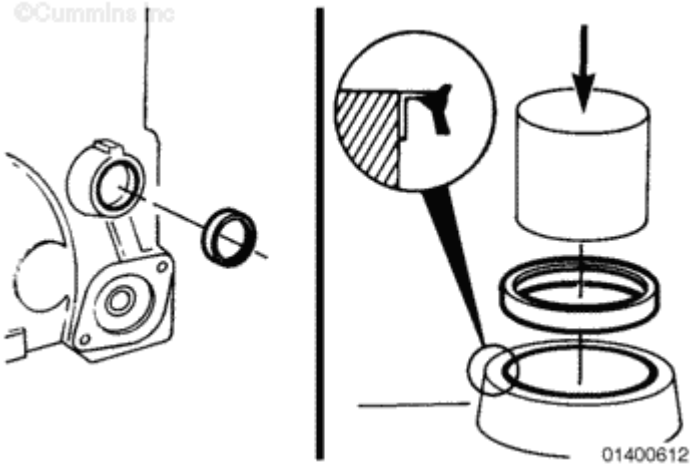
Measure the height of the accessory drive seal boss.

Height	Seal Installation Depth

36 mm [1.375 in]	Even with top of boss
38 mm [1.500 in]	3 mm [0.118 in] recess into top of boss

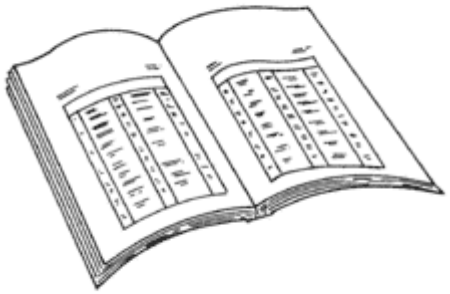


Install the accessory drive seal into the gear cover or housing with a mandrel to the seal installation depth.



Finishing Steps

- Install the accessory drive pulley. Refer to Procedure 009-004.



ck800wa

Last Modified: 20-Dec-2004

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001-005 Bearings, Connecting Rod

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

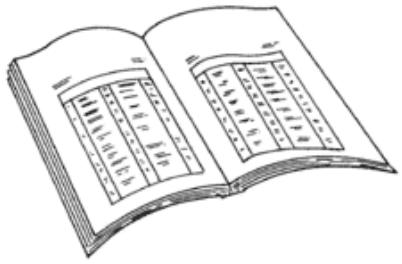
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the



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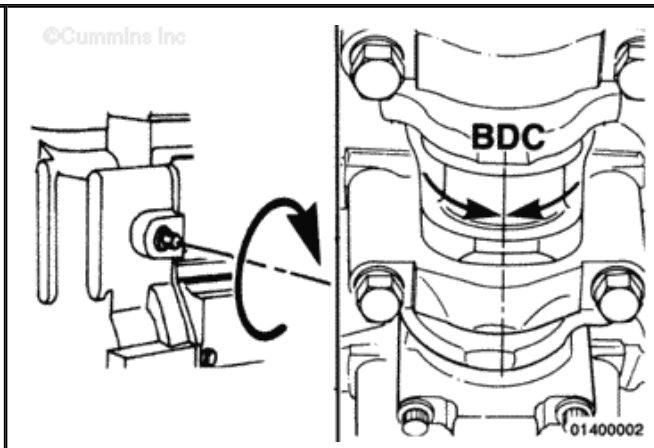
ck800wa

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. Refer to Procedure 013-009 in Section 13.
- Drain the lubricating oil system. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the lubricating oil pan adapter cover. Refer to Procedure 007-026 in Section 7.
- Remove the oil suction tube. Refer to Procedure 007-027 in Section 7.

Remove

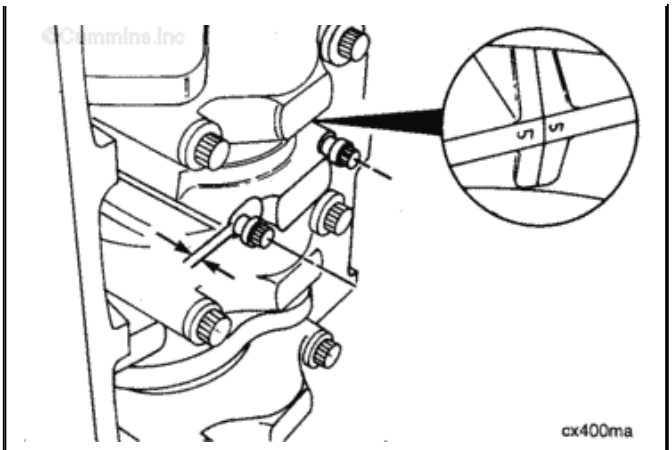
Use the barring mechanism to rotate the engine. Rotate the crankshaft to position a connecting rod at Bottom Dead Center (BDC).



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 connecting rods for correct markings. Use a steel stamp and mark any connecting rod that is **not** correctly marked.

Loosen the capscrews until there is 6 mm [1/4 inch] of clearance between the connecting rod cap and the capscrew head.

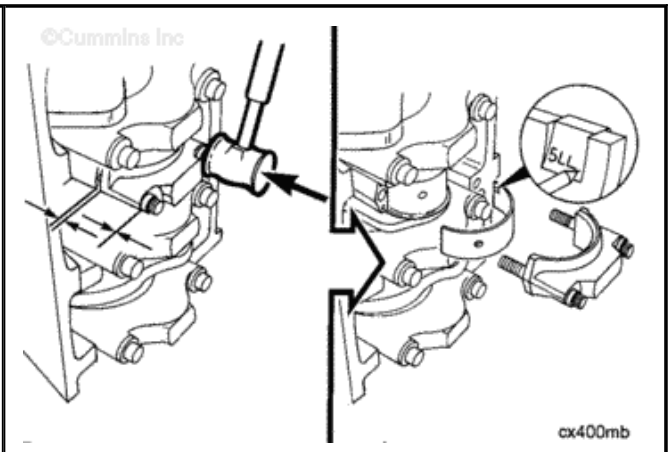


Use a mallet. Tap the connecting rod capscrews until the connecting rod cap and rod separate.

Remove the capscrews and the connecting rod cap.

Remove the lower connecting rod bearing. Use an awl and mark the bearing position in the tang area.

Mark the cylinder number and the letter “L” in the flat surface of the bearing tangs.

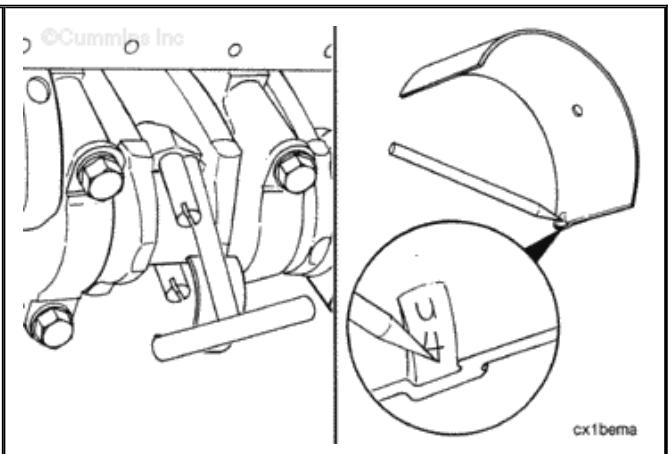


Install two guide pins, Part Number 3375098, in the connecting rod.

Push the connecting rod up far enough to allow the upper bearing shell to be removed.

Use a “T handle” piston pusher to push the connecting rod away from the crankshaft.

Remove the bearing shell, and mark the cylinder number and the letter “U” in the flat surface of the bearing tangs.



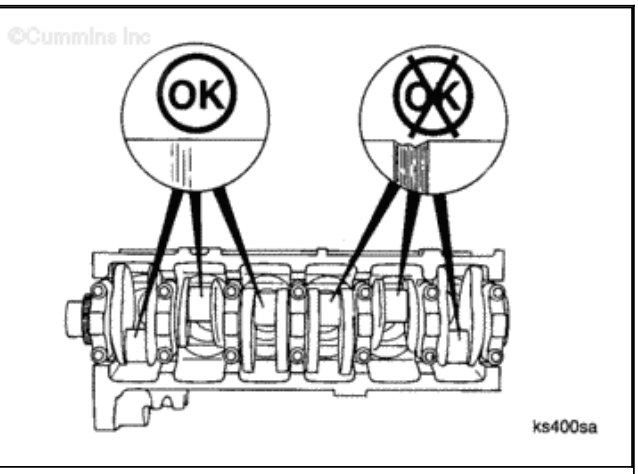
Clean and Inspect for Reuse

Use a clean, lint free paper towel to clean the connecting rod bore, the connecting rod cap, the bearings, and the crankshaft connecting rod journal.

Inspect the crankshaft connecting rod journals for damage.

If damage is found on the connecting rod, connecting rod cap, or the crankshaft journal, the bearing **must** be replaced.





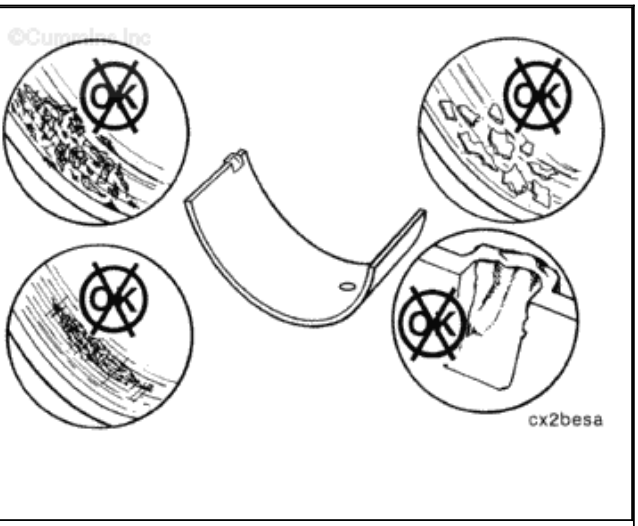
Clean the connecting rod bearing shells with a lint free cloth.

Inspect the bearing face on the front and back for:

- Nicks
- Cracks
- Burrs
- Scratches
- Scrapes
- Gouges
- Embedded particles
- Fretting.

If any damage is found, the bearing **must** be replaced.





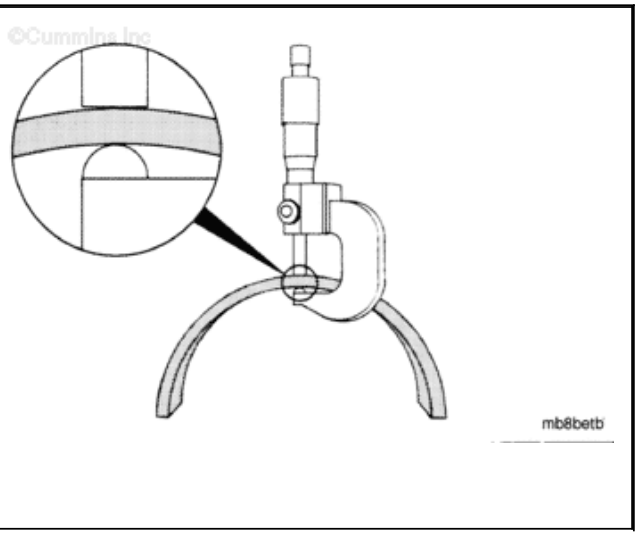
Use a ball-end micrometer to measure the thickness od the bearing in the wear area.

Use the following table for allowable dimensions of the various sizes of connecting rod bearings.

Connecting Rod Bearing Thickness

	mm		in
Standard	3.1250	MIN	0.1230
	3.1750	MAX	0.1250





0.010 Oversize	3.2520	MIN	0.1280
	3.3020	MAX	0.1300
0.020 Oversize	3.3790	MIN	0.1330
	3.4290	MAX	0.1350
0.030 Oversize	3.5060	MIN	0.1380
	3.55620	MAX	0.1400

If the bearings are **not** within specification, they **must** be replaced.

Install

CAUTION

To reduce the possibility of engine damage, do not lubricate the back of the bearing shells.

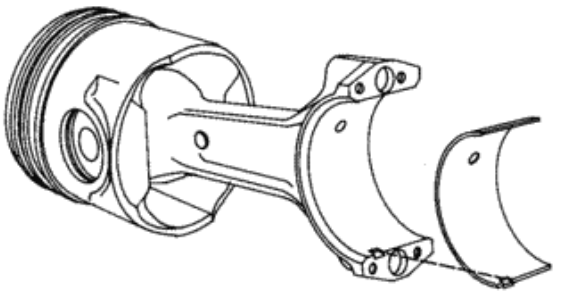
CAUTION

Do not reuse connecting rod bearings if either the connecting rod or crankshaft has been damaged.

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

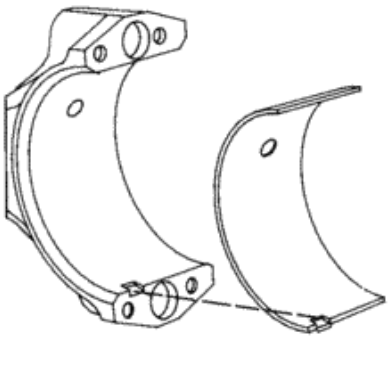
Lubricate the bearing shell with engine oil.

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



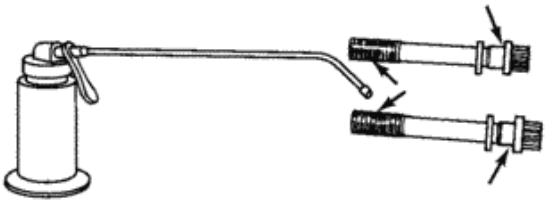
Install the lower bearing shell in the connecting rod cap.

Be 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 engine oil, as shown.

Install the washers and capscrews in the connecting rod caps.

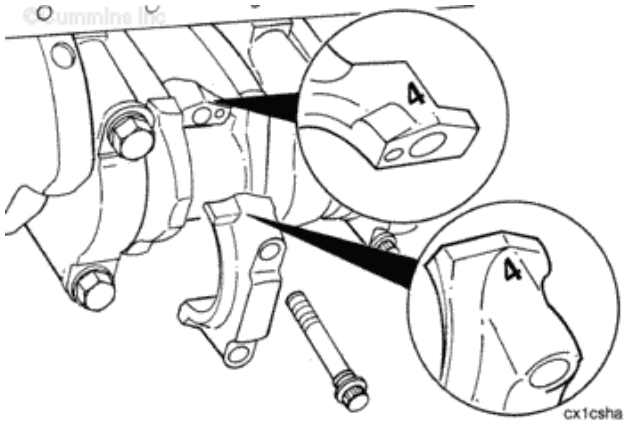


CAUTION

The connecting rods and connecting rod caps are not interchangeable. The connecting rods and the connecting rod caps are machined as an assembly. Failure will result if the parts are mixed.

CAUTION

The cylinder number on the connecting rod and connecting rod cap must be the same. Failure will result if the parts are mixed.



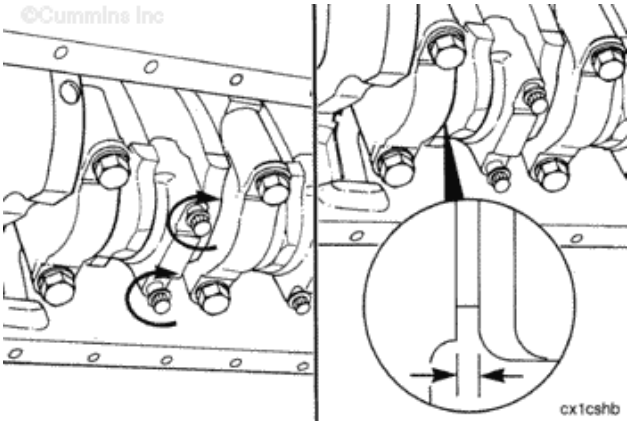
CAUTION

The side of the connecting rod 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. Refer to Procedure 001-054 in Section 1.

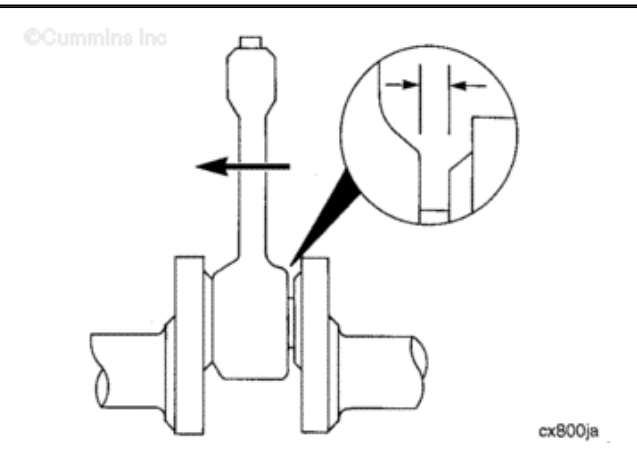




Check the side clearance between the connecting rod and the crankshaft. Refer to Procedure 001-054 in Section 1.







Finishing Steps

WARNING

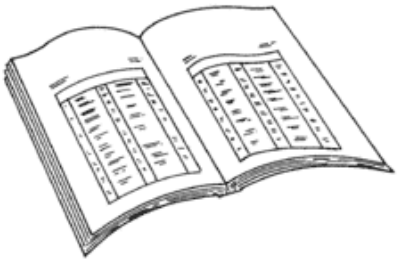
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

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.

- Install the oil suction tube. Refer to Procedure 007-027 in Section 7.
- Install the lubricating oil pan adapter cover. Refer to Procedure 007-026 in Section 7.
- Install the lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Fill the lubricating oil system. Refer to Procedure 007-037 in Section 7.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for leaks.

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Last Modified: 11-May-2010

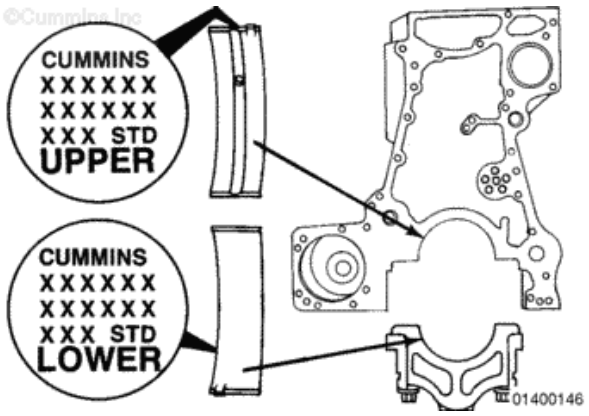
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001-006 Bearings, Main

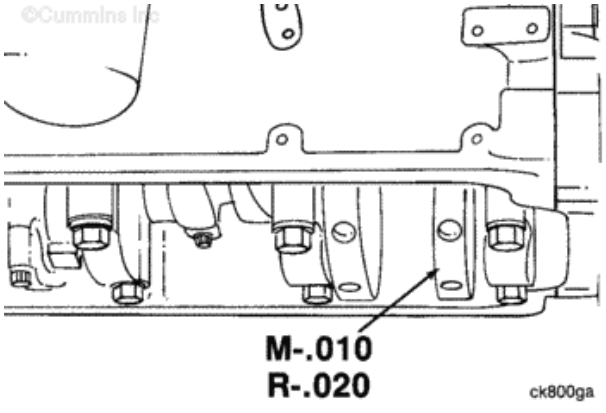
General Information

NOTE: The upper bearings contain an oil hole. The lower bearings do not have an oil hole. Both bearings are marked on the back side indicating location (UPPER or LOWER) and size (STANDARD [STD] or OVERSIZE [OS]). The amount of OS is indicated in U.S. customary inches.

Use the same size bearing [STD, 0.010, 0.020, or 0.030] that was removed.

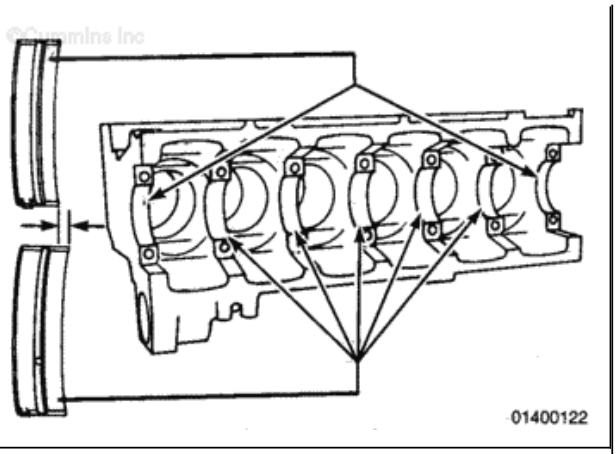


The crankshaft will be stamped on the end of the number one counterweight to indicate if it has been ground under size. Thrust bearing size is stamped on a crankshaft counterweight adjacent to the thrust location.



The location number of the main bearing caps, beginning at the front, are numbers 1 through 7.

The main bearings are two widths. The narrow main bearings fit locations number 1 and number 7. The wide bearings fit the remaining locations.



Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

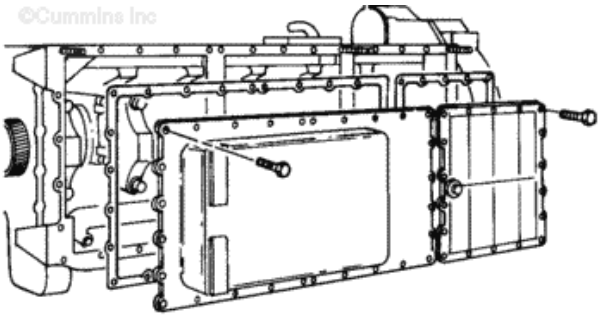
WARNING

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 hoist or get assistance to lift this component.





- Drain the lubricating oil. Refer to Procedure 007-037.
- Remove the oil filter elements. Refer to Procedure 007-013.
- Remove the lubricating oil pan. Refer to Procedure 007-025.
- Remove the lubricating oil pan adapter cover. Refer to Procedure 007-026.
- Remove the oil suction tube and oil pan adapter. Refer to Procedure 007-027

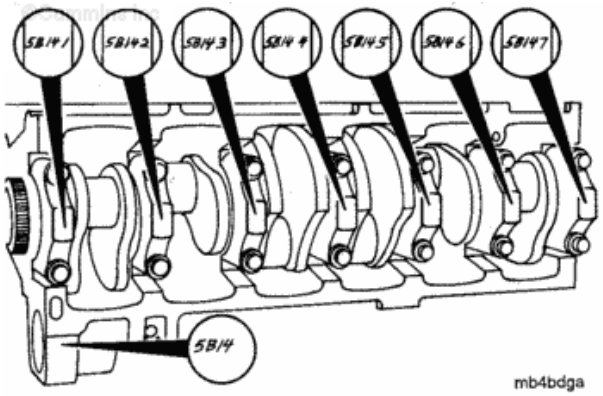
Remove

NOTE: Before removing the main bearings, refer to General Information step in this procedure.

The main bearings caps **must** be marked for position. The last number on each main bearing cap identifies the location and position in the cylinder block.

The cylinder block and main bearing cap identification numbers **must** be identical.

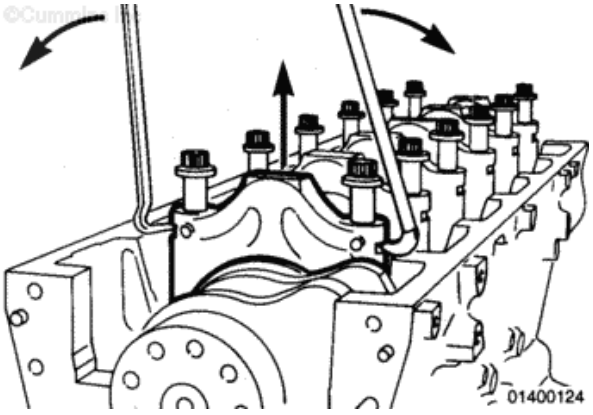
Use a steel stamp and mark any main bearing cap that is **not** marked correctly.



WARNING

Remove the lower main bearings one pair at a time. Personal injury and damage to the crankshaft can result if the crankshaft falls.

Loosen the main bearing cap capscrews until there is approximately 13 mm [½ inch]



between the capscrew head and the main bearing cap.

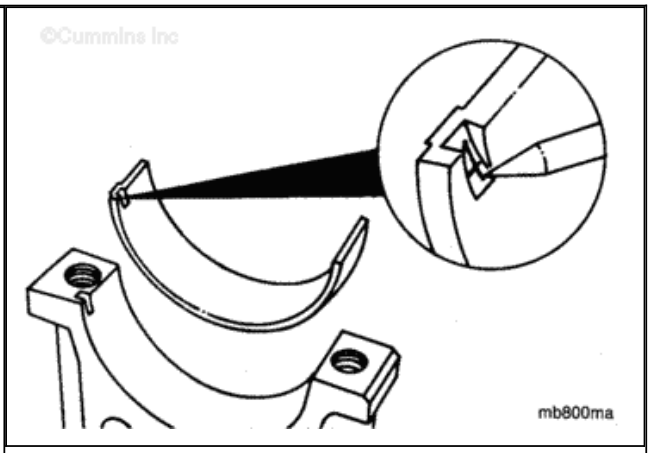
Install the pry bars in the notches at the sides of the main bearing cap and loosen it.

Remove the main bearing cap and capscrews.

Mark the bearing position for future identification or for possible failure analysis.

Remove the lower bearing. Use an awl and mark the bearing position in the tang area.

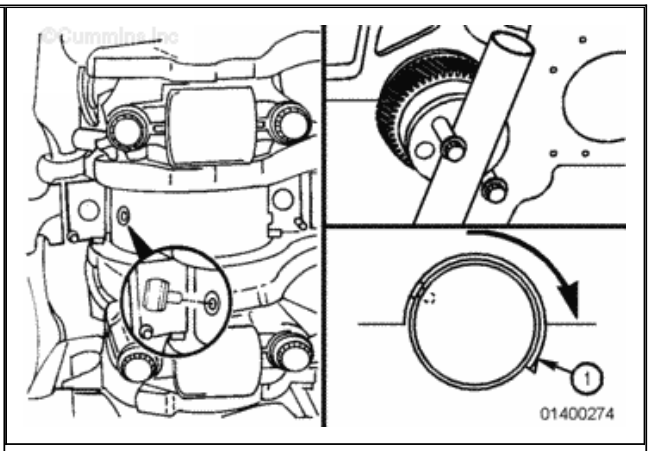
Remove the crankshaft thrust bearings from the number 6 main bearing cap and the number 6 saddle in the cylinder block. Refer to Procedure 001-007.



To remove the upper main bearing shell install the main bearing roll out tool, Part Number 3823818, into the crankshaft main bearing journal oil hole.

Rotate the crankshaft so the tang (1) of the main bearing shell rolls out of the block first.

Use the crankshaft adapter mounting bolts and slowly turn the crankshaft until the bearing shell is out of 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.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

To reduce the possibility of bearing damage, do not use a scraper or a wire brush.

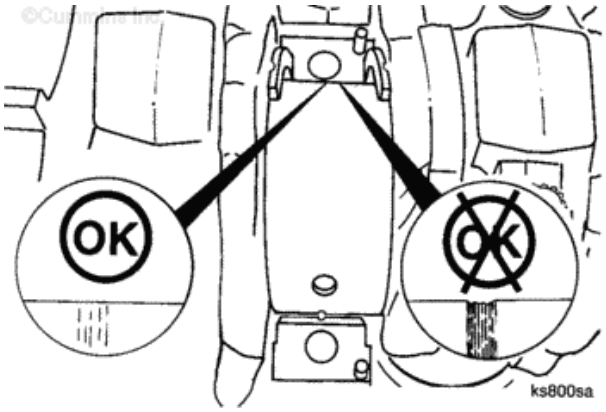
NOTE: Be sure the bearings are marked for location. The bearings must be installed in the original location if they are to be reused.

Use a lint-free cloth. Clean the crankshaft journals, and connecting rods, and main bearings.

Check the crankshaft journal for damage.

If the crankshaft journal is damaged, the crankshaft **must** be repaired or repalced.

Clean the bearings with solvent and dry with compressed air.

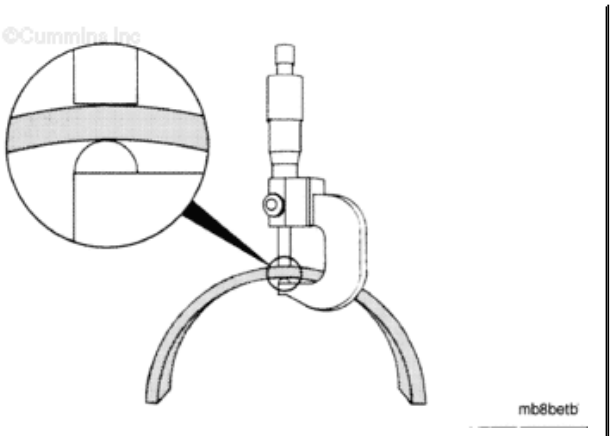


Use ball-end micrometer. Measure the bearing thickness at the wear location.

Main Bearing Thickness Standard or Oversize (OS)			
	mm		in
Standard	4.280	MIN	0.1685
	4.336	MAX	0.1707
0.010	4.407	MIN	0.1735

(OS)		
	4.463 MAX 0.1757	
0.020 (OS)	4.534 MIN 0.1785	
	4.590 MAX 0.1807	
0.030 (OS)	4.661 MIN 0.1835	
	4.717 MAX 0.1857	
0.040 (OS)	4.788 MIN 0.1885	
	4.884 MAX 0.1907	

If the bearing is **not** within specifications, it **must** be replaced.

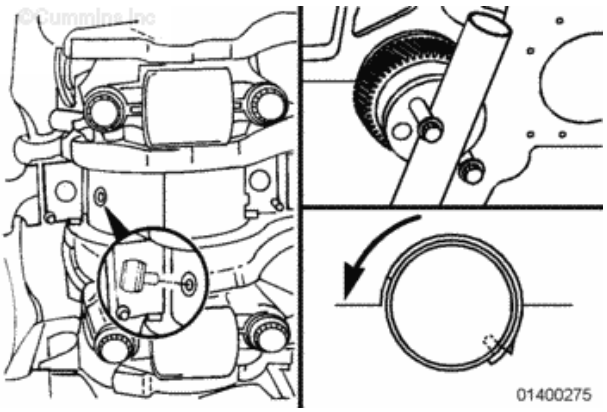


Install

Used bearings **must** be installed in their original location.

Install the upper main bearing shells using the same method that was used for the removal of the shells.

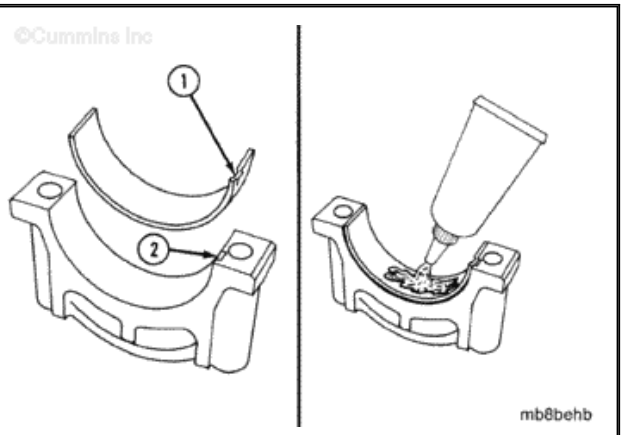
The bearing tang (1) **must** fit into the slot (2) in the bearing saddle to assure proper location of the bearing.



NOTE: Before installing the thrust bearings, refer to General Information step in this procedure and Procedure 001-007.

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.

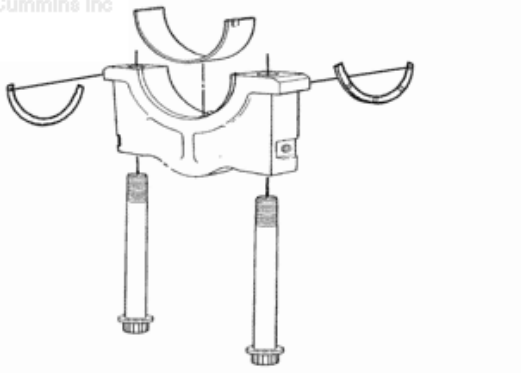
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust bearings must point toward the crankshaft. The dowels that secure the bearings must not protrude above the bearing.

Lubricate the capscrew head and threads with SAE EP 140W oil. Allow the excess oil to drip off of the capscrews before installing in the block.

Install the capscrews in the cap.

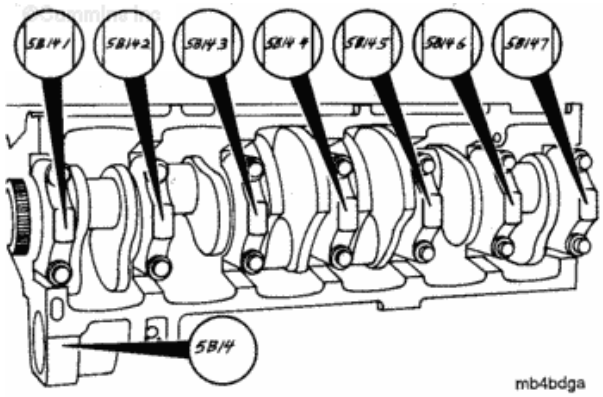
Install the two thrust bearings on the number 6 main bearing cap. Refer to Procedure 001-007.



CAUTION

To reduce the possibility of engine damage, the numbers on the main bearing caps must be the same as the numbers on the block.

Check the number on the main bearing caps. The last digit of each number (1 through 7), indicates the correct location.



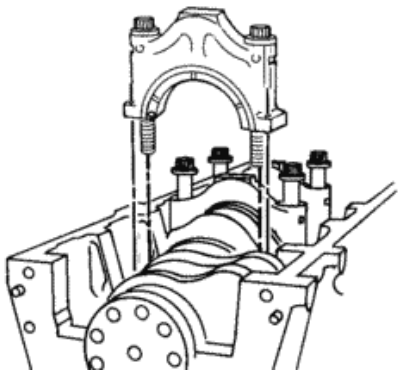
CAUTION

To reduce the possibility of

engine damage, make sure the side of the cap and bearing with the bearing locating tang is toward the tang in the block.

Lubricate the bearing surface with engine oil. The bearing shells **must** be firmly seated in the cap and the correct capscrew, washer combination in position. Install the main bearing caps.

NOTE: Do not hit the main bearing caps with a hammer. The bearing shells can fall out.

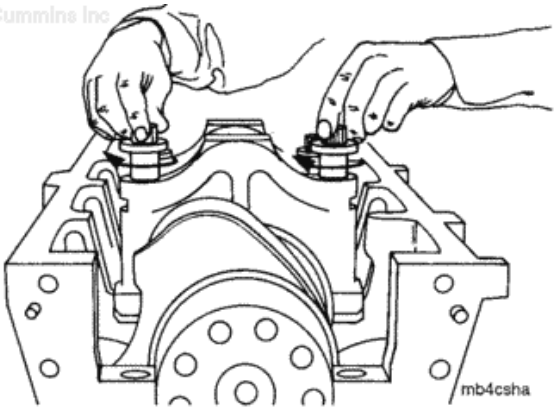


CAUTION

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 caps.

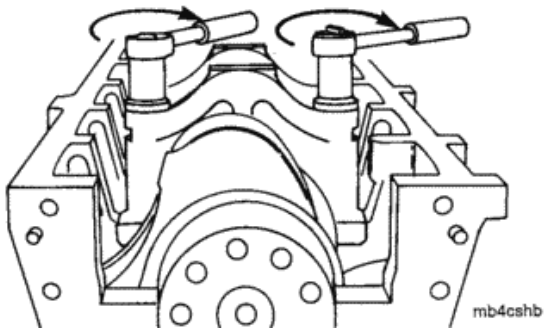


NOTE: Do not use an impact wrench. The main bearing shells can fall out.

Use both of the capscrews to pull the main bearing cap into position.

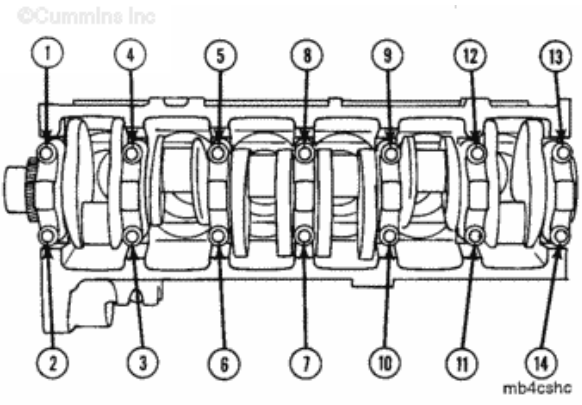
Use two wrenches and tighten both capscrews at the same time.

Check to be sure the number 7 cap is even with the back of the block.



Use the following steps and tighten the capscrews in the sequence shown.

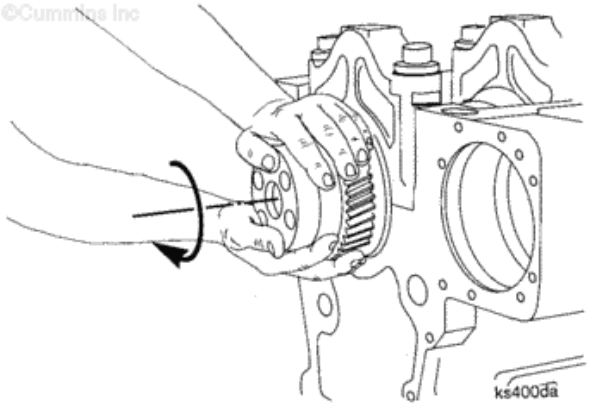
Torque Value:	Step 1	265 n.m	[195 ft-lb]
	Step 2	605 n.m	[445 ft-lb]
	Step 3	Loosen	
	Step 4	265 n.m	[195 ft-lb]
	Step 5	605 n.m	[445 ft-lb]



If the pistons are removed, turn the crankshaft by hand.

If the pistons are installed, use the barring mechanism.

The crankshaft will turn freely if the main bearings are installed correctly.

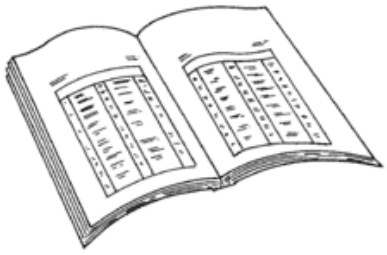


Finishing Steps

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.

- Check the crankshaft end clearance. Refer to Procedure 001-016.
- Install the lubricating oil pan adapter and the oil suction tube. Refer to 007-



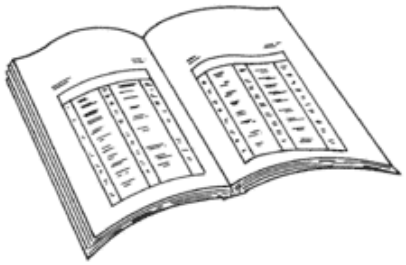
027. • Install the lubricating oil pan adapter cover. Refer to Procedure 007-026. • Install the lubricating oil pan. Refer to Procedure 007-025. • Install new lubricating oil filter elements. Refer to Procedure 007-013. • Fill the engine with lubricating oil. Refer to Procedure 007-037. • Operate the engine to 70° C [160°F] coolant temperature and check for leaks.		

Last Modified: 10-Dec-2004

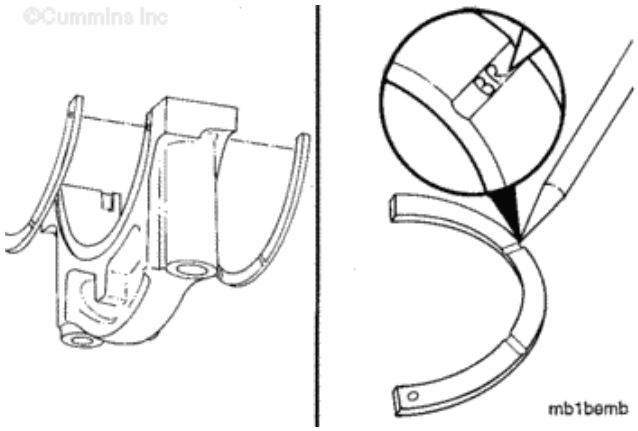
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001-007 Bearings, Thrust

Preparatory Steps

• Remove main bearing caps. Refer to Procedure 001-006.		 ck800wa

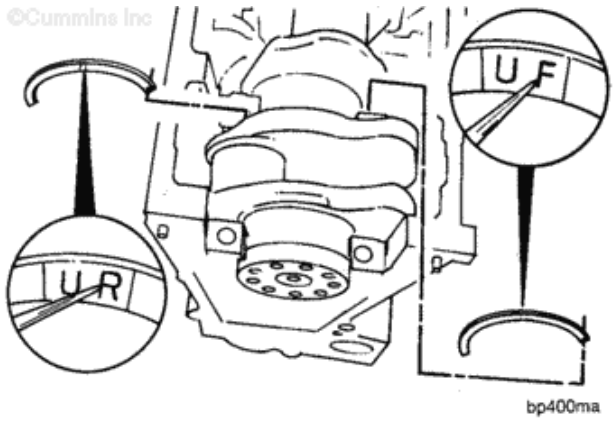
Remove

The number 6 main bearing cap contains two thrust bearings. Remove and mark them for position in the notched area.		 mb1bemb

NOTE: If necessary, slide the crankshaft to the front or to the rear to allow the thrust bearings to be removed.

Remove the two upper thrust bearings from the cylinder block at the number 6 location.

Mark the thrust bearings, in the notched area for position.



Inspect for Reuse

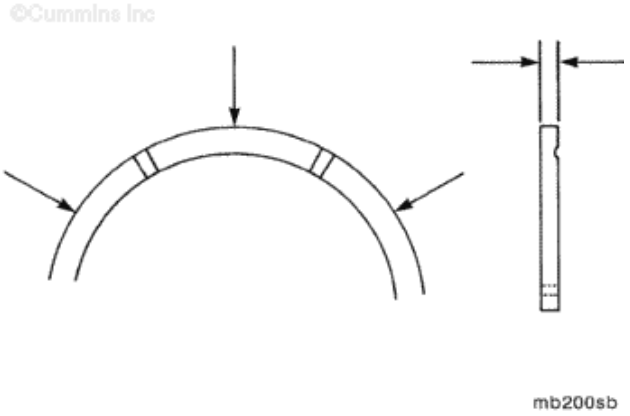
The thrust bearing thickness is **not** uniform. Measure at each of the points shown in the illustration. If the bearings are used the thickest points will be indicated by shiny or brighter areas.

Thrust bearings are available in three sizes: [STD, 0.010, 0.020] OS. The upper and lower thrust bearings **must** be the same size. The front and rear can be different sizes.

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.

Measure the thickness of the thrust bearings.

Thrust Bearing Thickness, Standard and



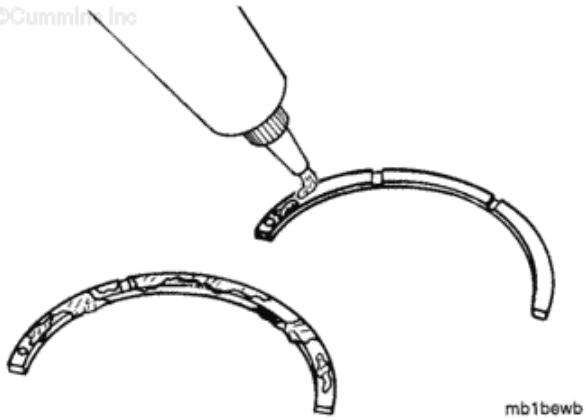
Oversize (OS)			
	mm		in
Standard	3.82	MIN	0.151
	3.90	MAX	0.154
0.010 OS	4.08	MIN	0.161
	4.15	MAX	0.164
0.020 OS	4.33	MIN	0.171
	4.41	MAX	0.174

NOTE: If the thrust bearing is not within specifications, it must be replaced.

Install

NOTE: Before installing the thrust bearings, refer to General Information step, in Procedure 001-006.

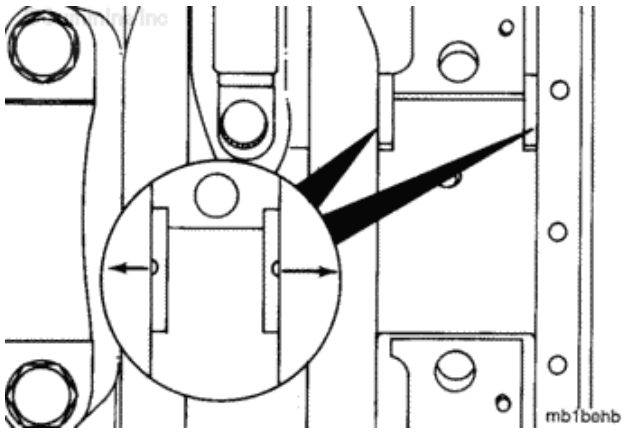
Lubricate the upper thrust bearings with engine oil.



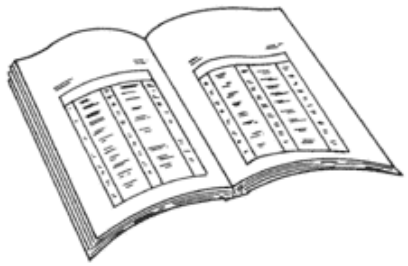
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust bearings must point toward the crankshaft.

Install the bearings in the number 6 location.

Move the crankshaft to the front or to the rear to so the second thrust bearing to be installed.		

Finishing Steps

• Install the main bearing cap and the lower thrust bearings. Refer to Procedure 001-006. • Measure the crankshaft end clearance. Refer to Procedure 001-016.		

Last Modified: 07-Dec-2004

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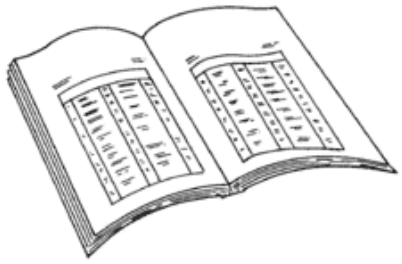
001-008 Camshaft

Preparatory Steps

NOTE: The barring device shaft turns approximately two revolutions before the engine begins to turn. The device will not turn the engine opposite the direction of normal rotation.

- Push the shaft in and turn the barring device counterclockwise until the I-6TC mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.
- Remove the gear cover and all related components. Refer to Procedure 001-031 in Section 1.
- Remove all of the cam follower assemblies. Refer to Procedure 004-001 in Section 4.
- Remove the number 1 cylinder injector, to allow timing to be checked. Refer to Procedure 006-026 in Section 6.
- Remove the camshaft idler gear. Refer to Procedure 001-036 in Section 1.





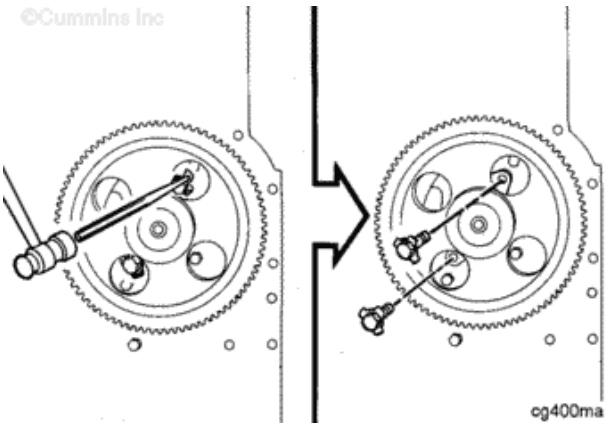
ck800wa

Remove

Use a hammer and a drift to bend the lockplates off of the two mounting capscrews.

Remove the capscrews and lockplates.

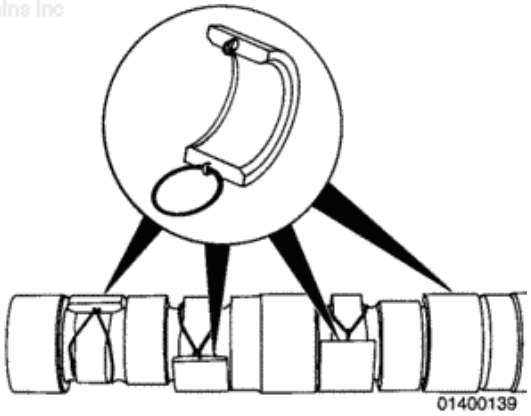
Discard the lockplates.



CAUTION

Pilots must be used to prevent damage to the camshaft and the bushings. Be sure the hooks do not damage the camshaft bushings.

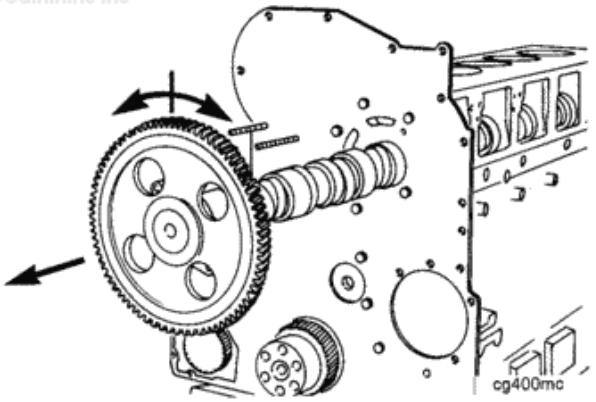
Place camshaft installation pilots, Part Number 3376280, on the inner base circle of the valve lobes for the number 5 and 6 cylinders before removing the camshaft from the block.



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.

Rotate the camshaft during removal so that one of the pilots is always on the downward side to support the camshaft.



Clean and Inspect for Reuse

WARNING

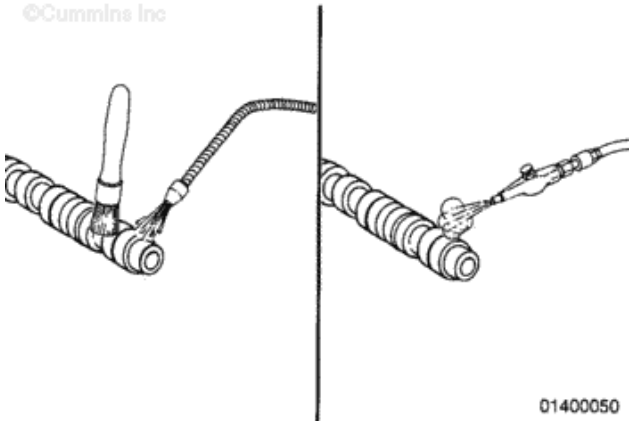
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

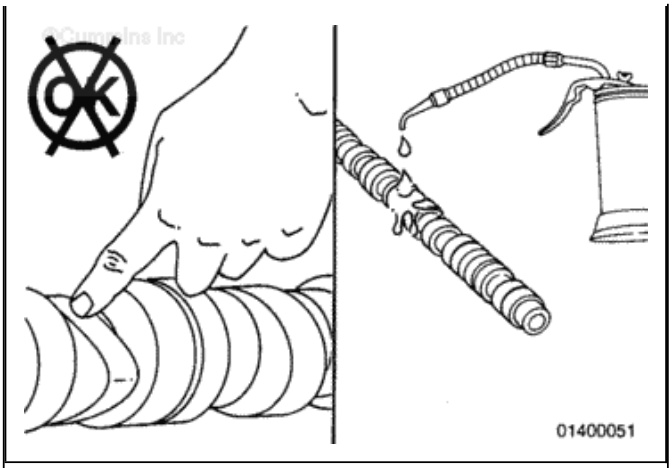
NOTE: The following illustrations show the camshaft with the camshaft gear removed. The camshaft gear does not need to be removed to clean and inspect the camshaft for reuse if the camshaft gear must be removed. Refer to Procedure 001-013 in Section 1.

Clean the camshaft with solvent and dry with compressed air.



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 oil before handling.



CAUTION

Do not attempt to repair the camshaft by grinding the valve or the injector lobes.

Inspect the camshaft.

Check the valve and the injector lobes for damage. Refer to the Camshaft Reuse Guidelines for Cummins® Engines with Roller Followers or Roller Tappets, Bulletin 3666052.

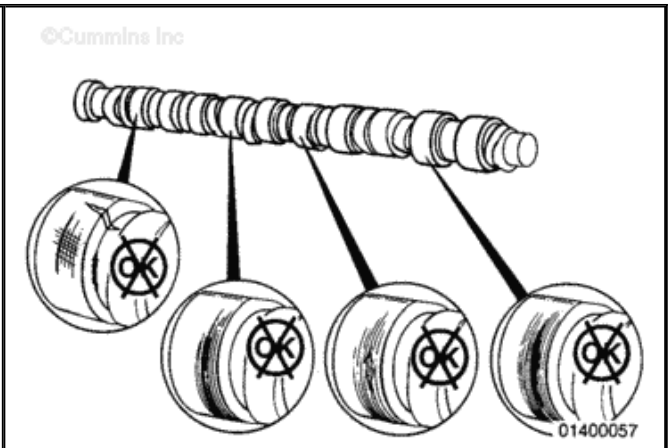
Measure each of the seven bushing journals.

Measure the outside diameter.

Camshaft Bushing Journal Outside Diameter

mm		in
76.07	MIN	2.995
76.12	MAX	2.997

If the outside diameter is **not** within specifications, the camshaft **must** be replaced.

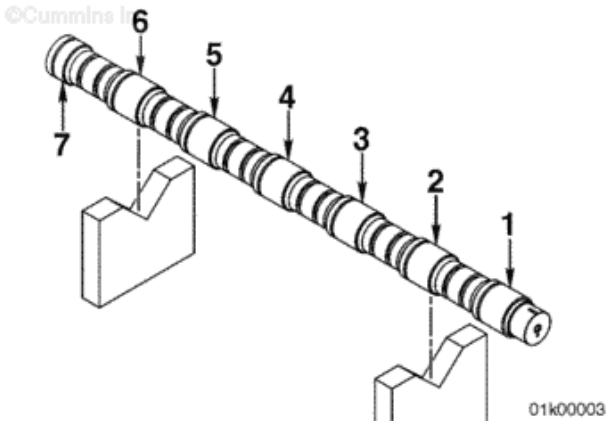


WARNING

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 vee blocks on a flat surface.

Support the camshaft on the vee blocks at journals 2 and 6, as shown in the illustration.



Position a dial indicator so the stem touches the center line of the journal. Rotate the camshaft and measure the total indicator runout for each journal.

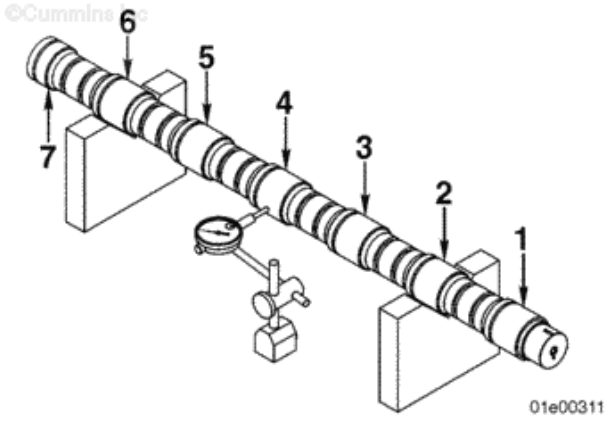
The dial indicator **must** be positioned at the centerline of any journal that is measured.

Maximum Journal Runout	
0.08 mm	0.003 in

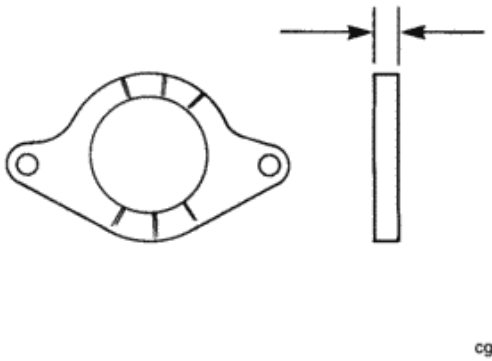
If the camshaft is **not** within specification, it **must** be replaced.

NOTE: The maximum journal runout applies to each journal.

NOTE: The two supported journals do not need to be measured.



Inspect the camshaft thrust bearing. Refer to Procedure 001-056 in Section 1.



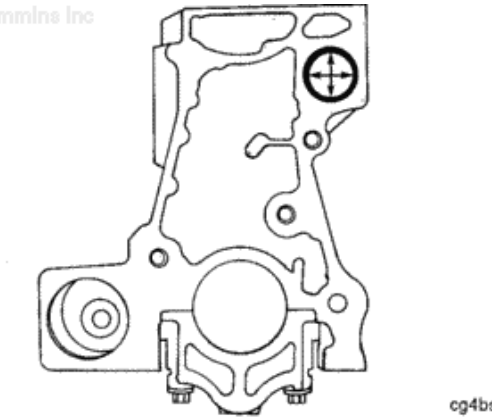
Inspect the amount of copper exposure on the camshaft bushing. If it extends more than 180 degrees around the bushing, the bushing **must** be replaced.

Measure the inside diameter.

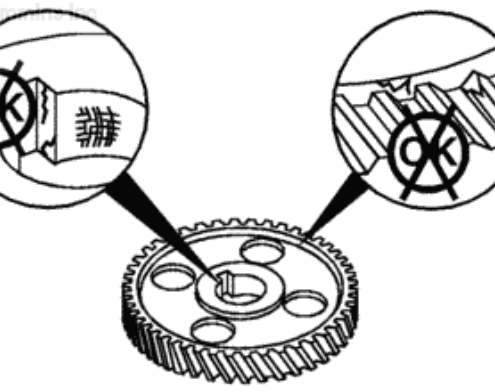
Camshaft Bushing Inside Diameter

mm		in
76.200	MIN	3.0000
76.289	MAX	3.0035

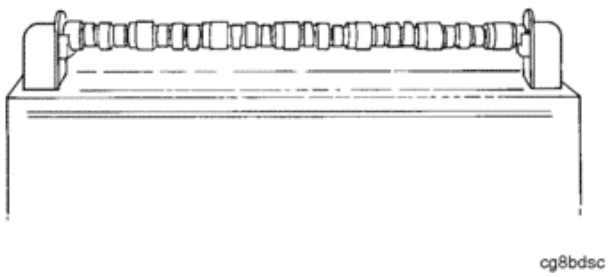
If the bushing is **not** within specifications, the bushing **must** be replaced.



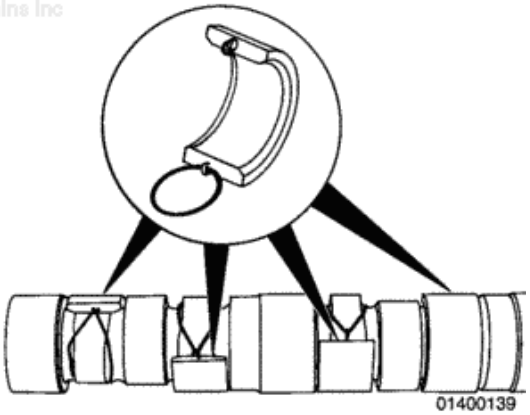
If the camshaft requires replacement, inspect the camshaft gear for reuse. Refer to Procedure 001-012 in Section 1.



Magnetic Crack Inspect

The gear and the thrust plate **must** be removed before performing this check. Refer to Procedure 001-013 in Section 1. Use a magnetic particle testing machine. Use the head shot method. Adjust the machine to 2000 ampere D.C. or rectified A.C. Use the continuous method. Do **not** wet more than one third of the camshaft at a time. Check the camshaft for cracks.		 cg8bdsc

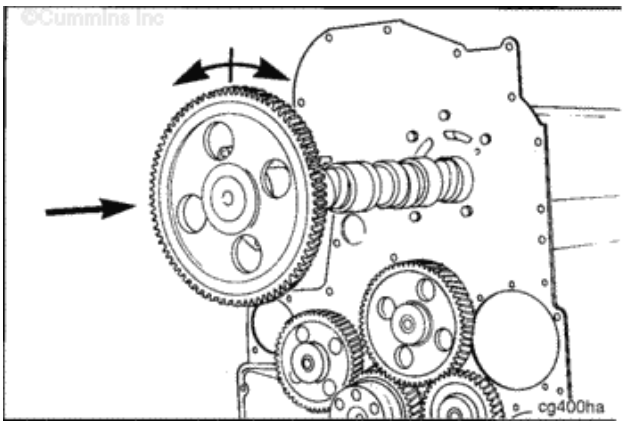
Install

Install the camshaft installation pilots, Part Number 3376280, onto the inner base circle of the valve lobes for the number 5 and 6 cylinders of the camshaft. Lubricate the camshaft and camshaft bushings with Lubriplate® 105 multipurpose lubricant, or equivalent.		 01400139

CAUTION

If the installation pilots are not available. Be careful when installing the camshaft to prevent the camshaft lobes from damaging the bushings.

Install the camshaft. Turn the camshaft backward and forward as it is being pushed. Keep the pilots turned downward to support the camshaft.

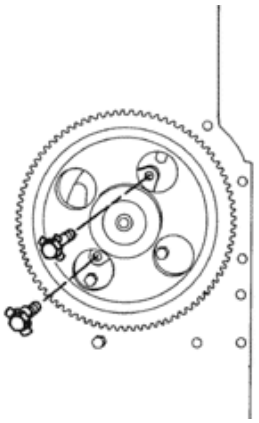


If necessary, rotate the camshaft so the holes in the camshaft gear allow access to the capscrew holes in the thrust plate.

Install the two capscrews and lockplates.

Tighten the capscrews.

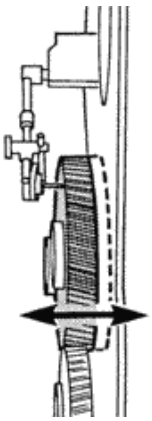
Torque
Value: 45 n.m [33 ft-lb]



Measure the camshaft end clearance with a dial indicator.

Camshaft End Clearance		
mm		in
0.15	MIN	0.006
0.33	MAX	0.013

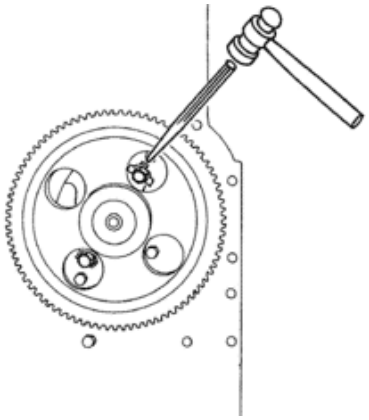
If the clearance is **not** within specifications, check for foreign material or a piece of gasket between the thrust plate and the block.



Use a hammer and a drift to bend one tab of the lockplate over the thrust plate, and the

other tab over the capscrew.

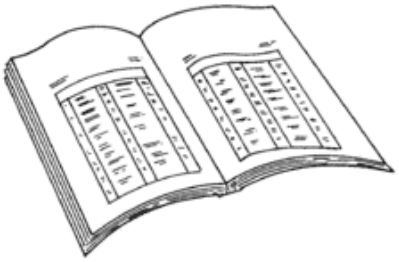
Repeat the process for the other capscrew.



Finishing Steps

- Install the camshaft idler gear. Refer to Procedure 001-036 in Section 1.
- Make sure the index marks on the camshaft and crankshaft are in alignment with the timing marks on the idler gear.
- Measure the gear train backlash. Refer to Procedure 001-055 in Section 1.
- The reason for installing **only** one camshaft follower assembly at this time is to save time, if the camshaft has to be removed to adjust the injection timing. Install the camshaft follower assembly on cylinder number 3. Refer to Procedure 004-001 in Section 4.
- Measure the injection timing. Refer to Procedure 006-025 in Section 6.
- Install the remaining





camshaft follower assemblies and related components. Refer to Procedure 004-001 in Section 4. • Install the gear cover and related components. Refer to Procedure 001-031 in Section 1. • Operate the engine and check for proper operation.		

Last Modified: 15-Nov-2011

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001-010 Camshaft Bushings

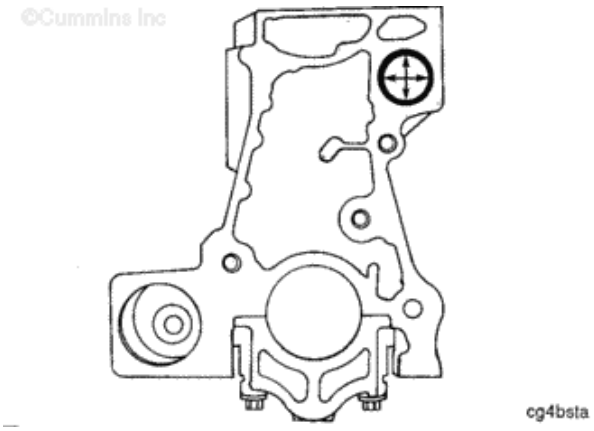
Initial Check

Inspect the amount of copper exposure on the camshaft bushing. If it extends more than 180 degrees around the bushing, the bushing **must** be replaced.

Measure the inside diameter.

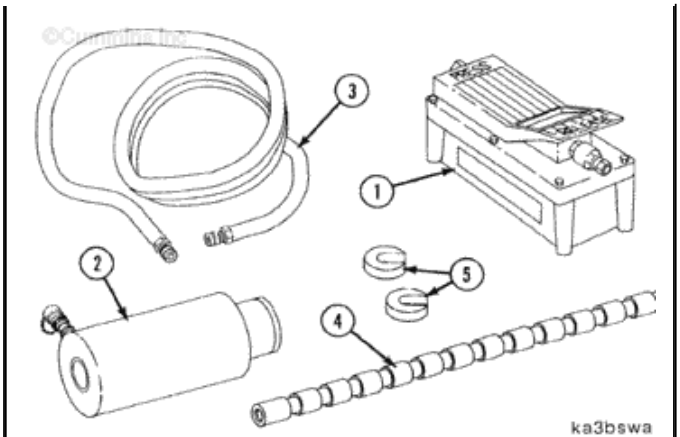
Camshaft Bushing Inside Diameter		
mm		in
76.200	MIN	3.0000
76.289	MAX	3.0035

If the bushing is **not** within specifications, the bushing **must** be replaced.



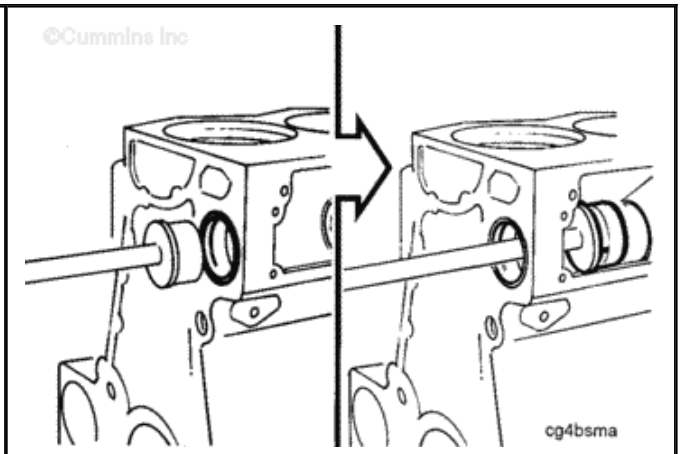
Remove

Use hydraulic actuator kit, Part Number 3823621, and camshaft bushing installation/removal kit, Part Number 3823647, to remove the camshaft bushings.



Remove the camshaft bushings.





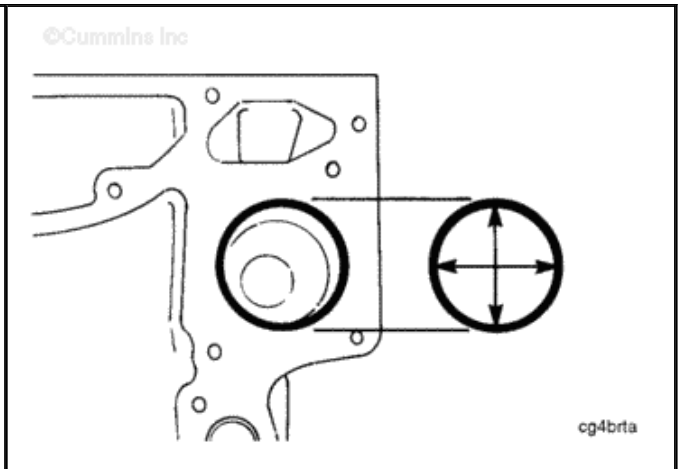
Inspect for Reuse

Clean and inspect the camshaft bushing bore.

Camshaft Bushing Bore in the Block		
mm		in
82.639	MIN	3.2535
82.665	MAX	3.2545

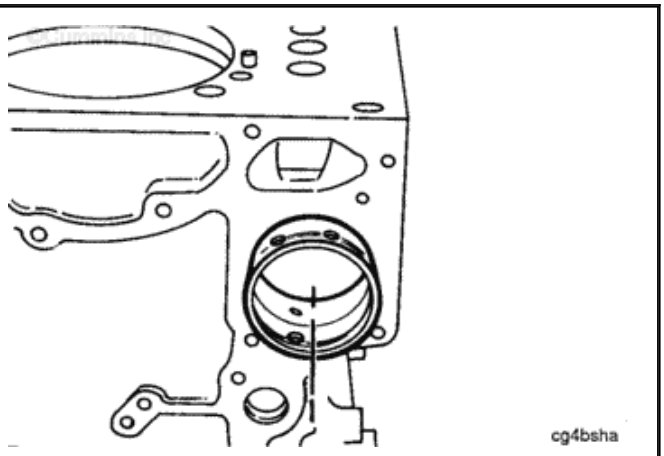
If the inside diameter is **not** within specifications, install a repair sleeve. Refer to the

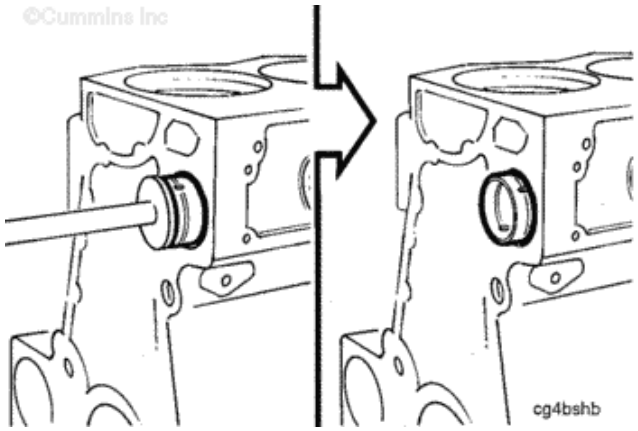




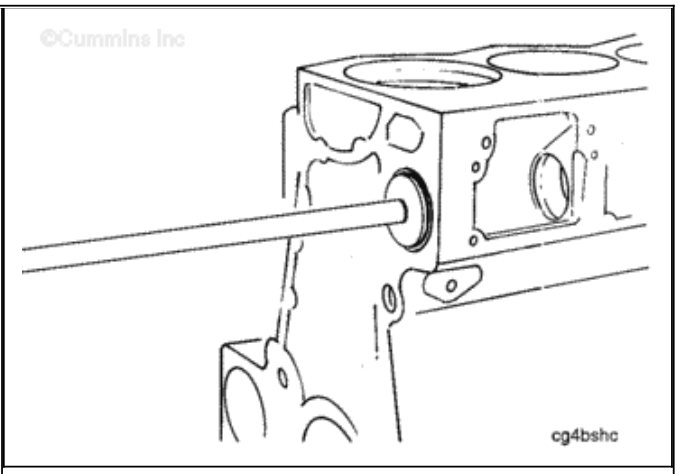
Alternative Repair Manual, Bulletin 3379035, for repair and sleeve information.		

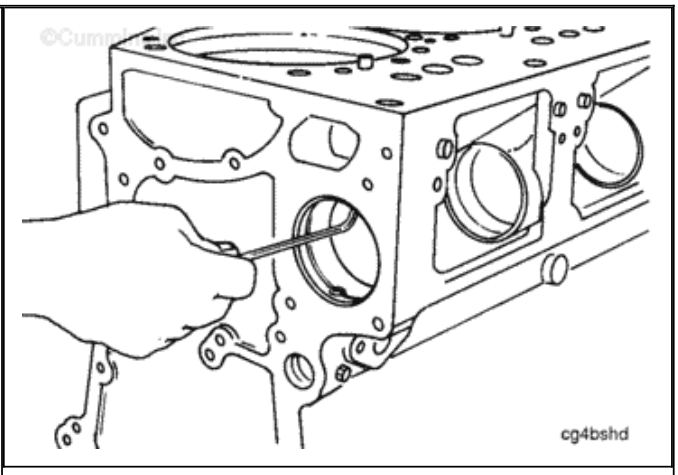
Install

Align the oil holes in the bushing with the oil drillings in the block. The notch in the bushing **must** be positioned 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. Use the camshaft bushing driver assembly, Part Number 3376637 , and the specified driver kit (mandrel): 3.188” Cam bore driver kit, Part Number 3376634. 3.254” Cam bore driver kit, Part Number 3376635. 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. Install the bushing until the oil holes are aligned.		

Use a 7 mm [¼-in] Allen wrench to check the alignment of the bushing oil holes. There are three holes in each bushing. All holes **must** be aligned, except on the front bushing. There are no drillings to align with the upper holes on the front bushing.		

Last Modified: 21-Oct-2008

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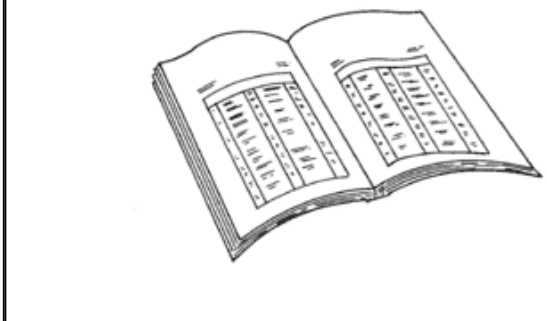
001-012 Camshaft Gear (Camshaft Installed)

Preparatory Steps

NOTE: The barring device shaft turns approximately two revolutions before the engine begins to turn. The device will not turn the engine opposite the direction of normal rotation.

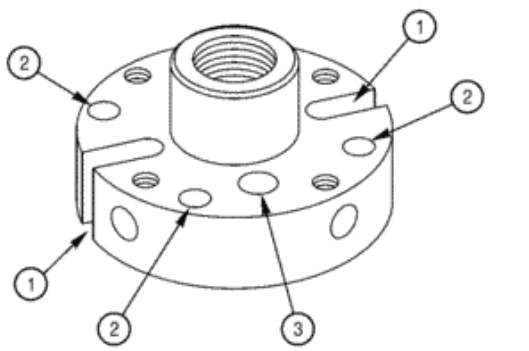
- Remove the rocker lever cover on number one cylinder. Refer to Procedure 003-011.
- Push the shaft in and turn the barring device counterclockwise until the “I-6TC” mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.
- If both the intake and exhaust number 1 cylinder rocker levers wiggle and the mark on the accessory pulley align with the “I-6TC” mark, Number 1 cylinder is on its compression stroke. If the marks are **not** aligned, rotate the crankshaft one full revolution to place number 1 cylinder on its compression stroke.
- Remove the gear cover and all related components. Refer to Procedure 001-031.
- Remove the camshaft idler gear. Refer to Procedure 001-036.





ck800wa

Remove

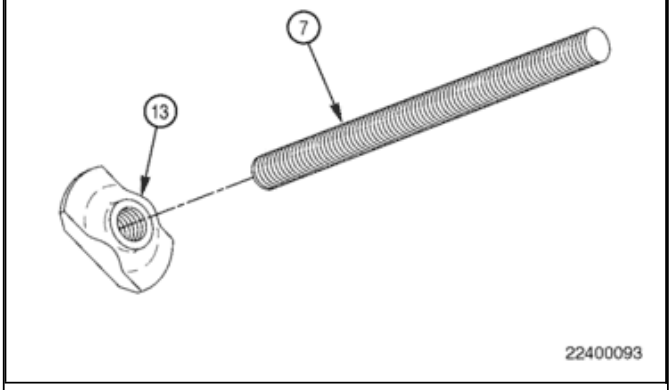
Use the camshaft gear puller kit, Part Number 3162895, for the removal of the camshaft gear. The mounting holes in the remover plate, Part Number 3162997, are **not** marked for identification. Refer to the graphic for identification. 1) L10, M11, ISM, QSM, K19, K38, and K50 series engines 2) QSK45, QSK60, and QSK78 series engines 3) QSK19 series engines. **NOTE: Hydraulic gear remover kit, Part Number 3164375, can also be used with kit, Part Number 3164376, to remove the camshaft gear.**		 22400092

Apply anti-seize or heavy duty grease onto the threads of the remover screw (3). Install the remover screw (3) into the remover plate assembly (2). lubricate the thrust washer (17) with anti-seize or heavy duty grease. Assemble the thrust washer (17) and the remover screw adapter (14) to the remover screw (3), and secure it with the socket setscrew (15). Install plate (11) on the remover plate assembly (2) with one capscrew (8). Tighten the capscrew.		

Install the remover jaw (13)		

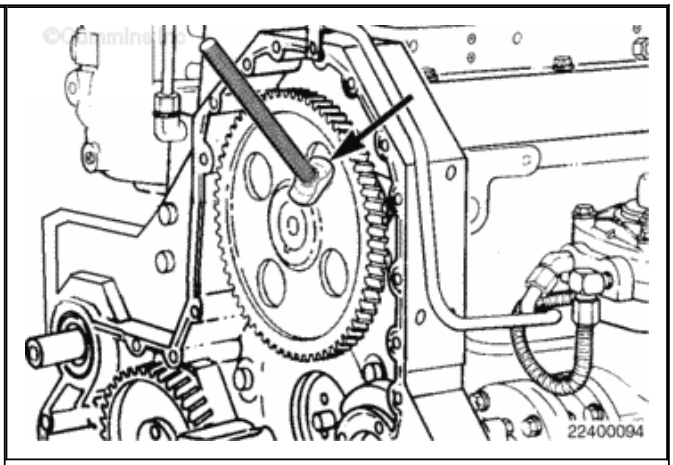
onto the end of the stud (7).

Make certain the end of the stud is flush with the bottom of the jaw.



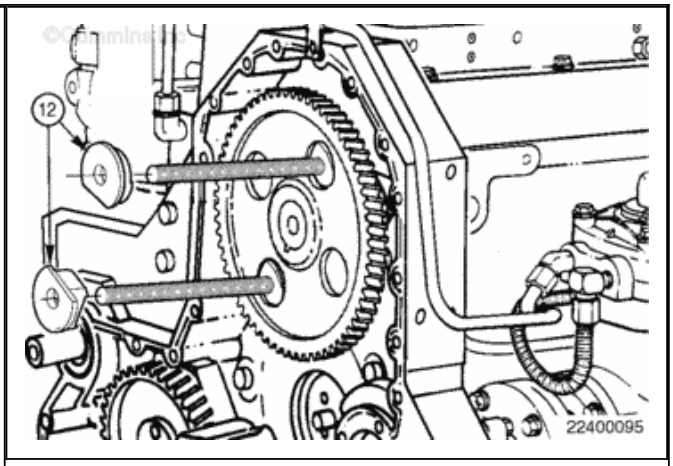
Tilt the remover jaw and stud assembly through a round blanking hole, and maneuver it sideways until the remover jaw is inserted.

Install the other remover jaw and stud assembly in the opposite round blanking hole.



Position the flat face of the retainer flange toward the camshaft.

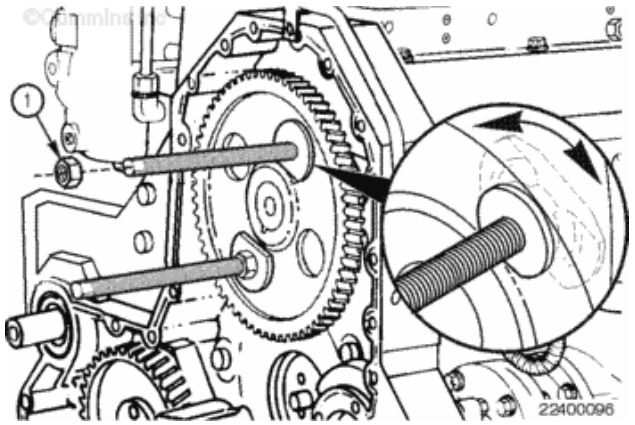
Slide the retainer (12) down the stud until it is positioned into the camshaft gear blanking hole and engages with the remover jaw.



Make sure the flat face of the retainer flange sits against the radius of the camshaft gear hub. This will

locate the remover jaw correctly at the back of the camshaft gear.

Adjust the retainer if necessary, and uniformly hand-tighten the nuts (1) onto the studs.



WARNING

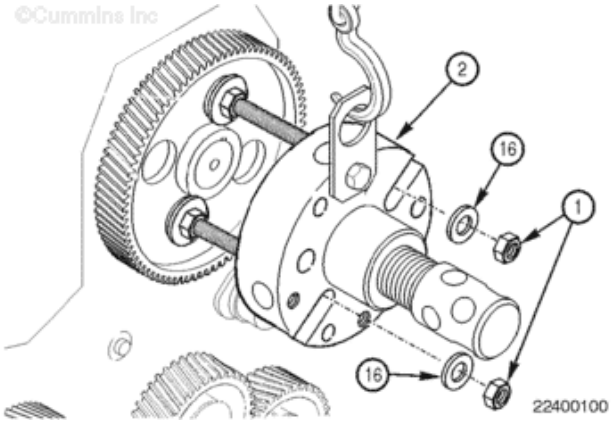
The remover is heavy and the gear can come loose suddenly causing the gear and gear remover assembly to fall. To reduce the possibility of personal injury and component damage, use a hoist or other lifting device when using the gear remover.

Using a lifting device, slide the remover plate (2) over the studs and position it close to the camshaft gear.

Make sure the pilot of the old remover screw adapter is properly engaged with the camshaft.

Install the washers (16) and nuts (1) onto the studs.

Uniformly hand tighten the nuts.



CAUTION

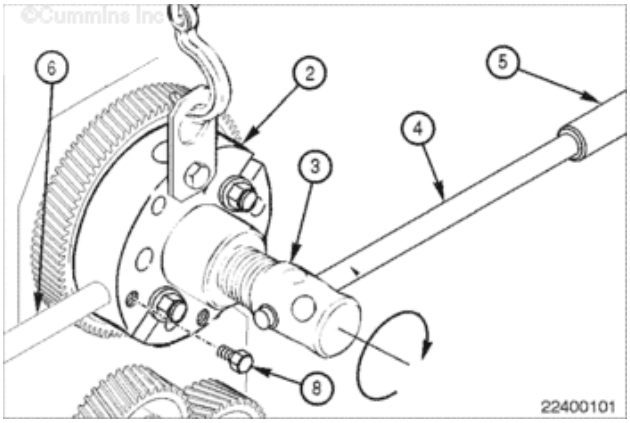
Do not attempt to alter the camshaft gear remover assembly for use with any

kind of impact wrench. Do not exceed 890 N [200 lb] of force on the end of the handle. The threads on the remover can gall and seize.

Make sure anti-sieze or heavy duty grease was applied to the remover screw threads (3).

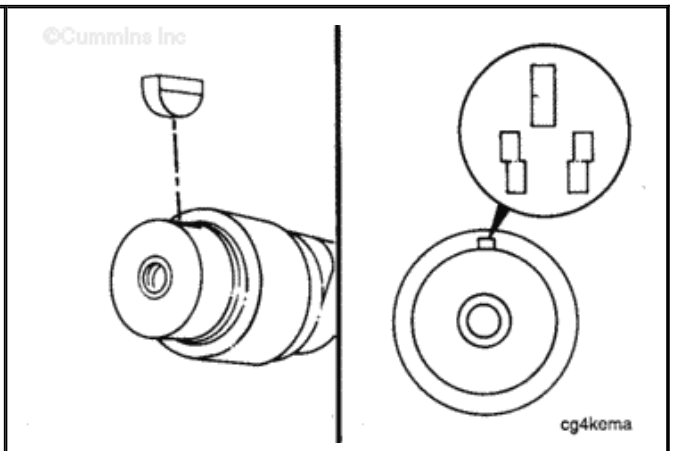
Install handle (6) into the remover plate assembly (2) and secure it with one capscrew (8).

Using handles (4) and (5), and holding handle (6) turn the remover screw (3) **clockwise** to remove the camshaft gear from the camshaft.



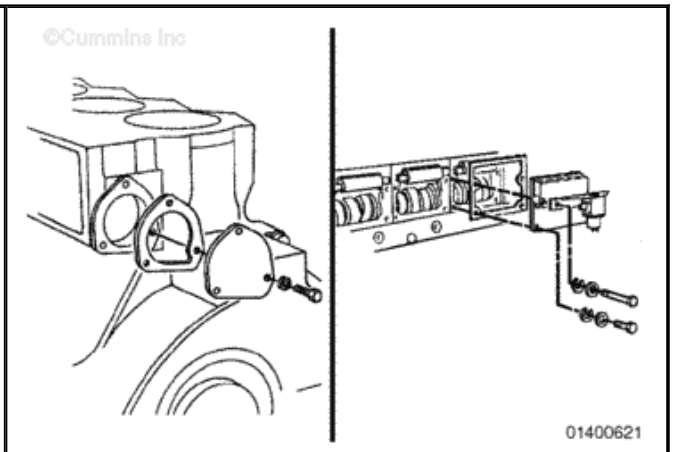
Check and record the direction of the key offset when compared to the camshaft gear rotation (same or opposite).

Remove the key.



Remove the camshaft cover at the rear of the block.

If the camshaft cover is **not** accessible, remove a cam follower cover.

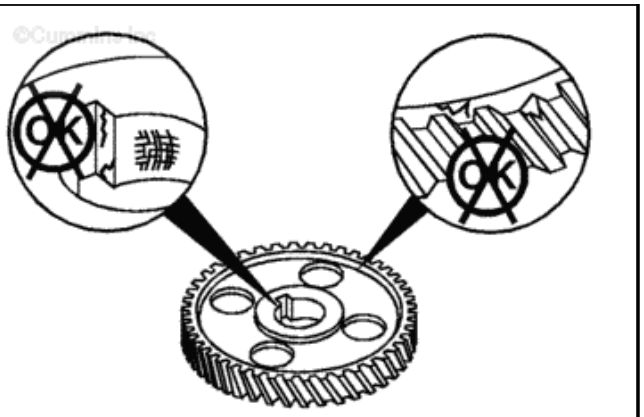


Inspect for Reuse

Inspect the camshaft gear for cracks, chipped or broken teeth.

Inspect the bore of the gear for fretting or burrs.

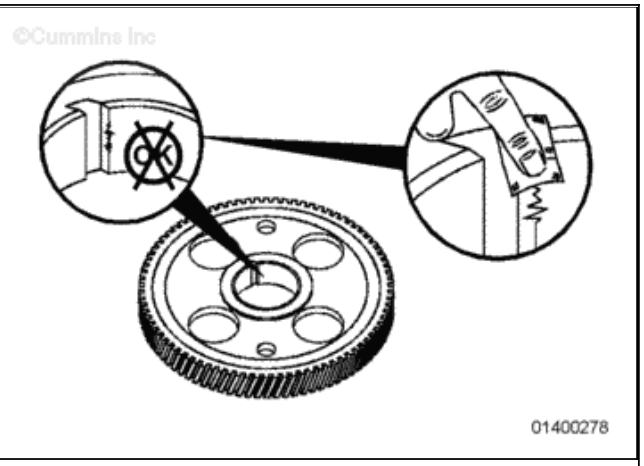
Replace camshaft gear if damaged.



Inspect the gear keyway for burrs.

Remove any burrs with fine crocus cloth.

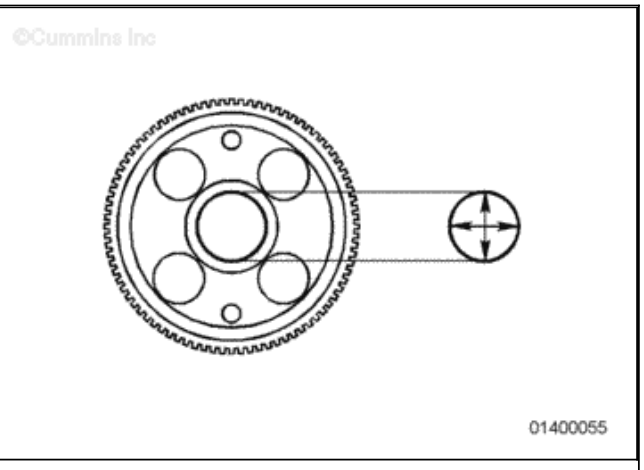
If the keyway is damaged or it is **not** possible to remove the burrs with fine crocus cloth, the gear **must** be replaced.



Measure the inside diameter of the camshaft gear.

Camshaft Gear Inside Diameter		
mm		in
57.124	MIN	2.249
57.150	MAX	2.250

If the camshaft gear is **not** within specifications, it **must** be replaced.



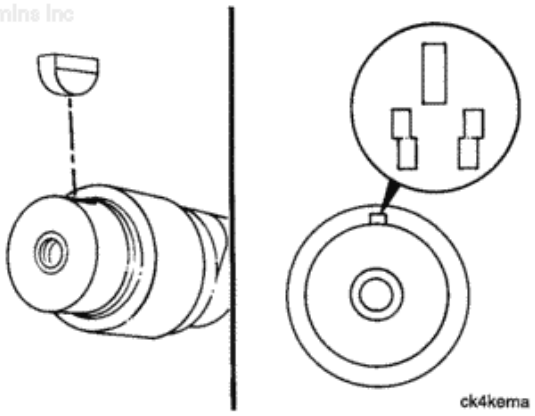
Install

Camshaft keys are available in different sizes (amount of offset). The injection timing is controlled by:

- Selection of the camshaft key
- Direction of the key offset when compared to the camshaft gear rotation
- Amount of offset.

Refer to Procedure 006-025 for further information on camshaft key selection.

Install the same part number key in the same orientation as the key that was removed.



WARNING

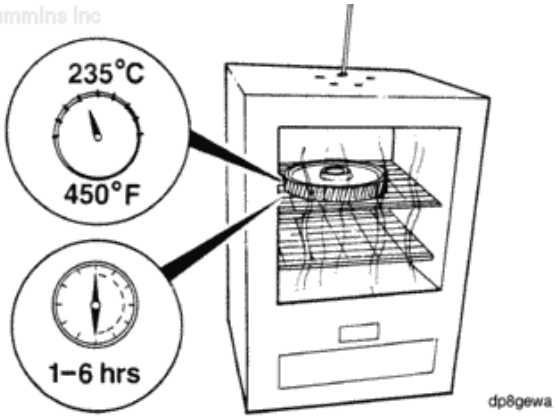
To reduce the possibility of severe burns, Wear protective gloves when installing the camshaft gear.

CAUTION

Do not exceed the specified time or the temperature. Damage to the gear and the gear teeth will result.

CAUTION

To reduce the possibility of gear and camshaft damage, 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** longer than 6 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 camshaft gear.

CAUTION

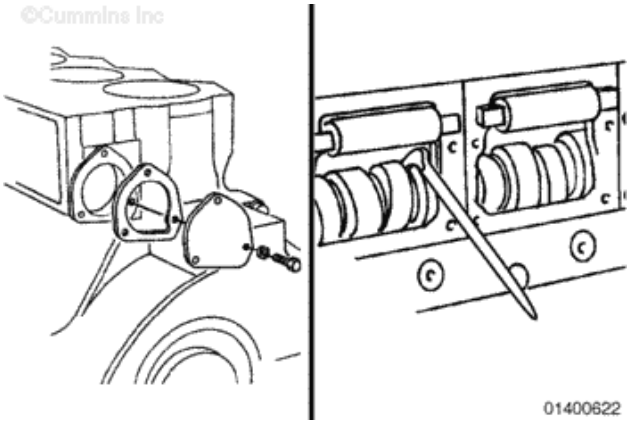
Allow the gear to cool slowly. Do not use water or oil to reduce the cooling time. This will cause the gear to crack.

The timing mark on the camshaft gear **must** be visible from the front of the gear after it is installed on the camshaft.

During the gear installation it will be necessary to apply force forward on the camshaft to make sure the camshaft remains in position against the thrust plate.

A second person is required to secure the camshaft through the hole in the rear of the block or at the cam follower location.

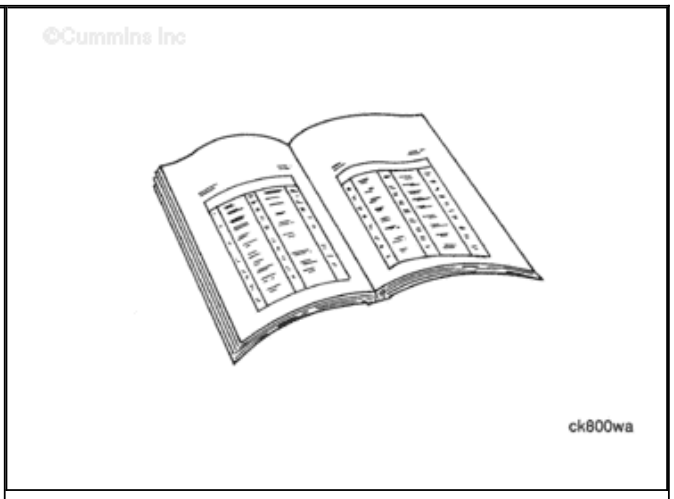
Remove the gear from the oven and install it on the camshaft. The keyway in the gear **must** be aligned with the key in the camshaft.



Finishing Steps

- Measure the camshaft end clearance. Refer to Procedure 001-008.
- Install the camshaft idler gear. Refer to Procedure 001-036.
- Measure the injection timing. Refer to Procedure 006-025.
- Install the gear cover and all related components. Refer to Procedure 001-031.
- Install the rocker lever cover for the number one cylinder. Refer to Procedure 003-011.





Last Modified: 24-Sep-2004

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001-013 Camshaft Gear (Camshaft Removed)

Remove

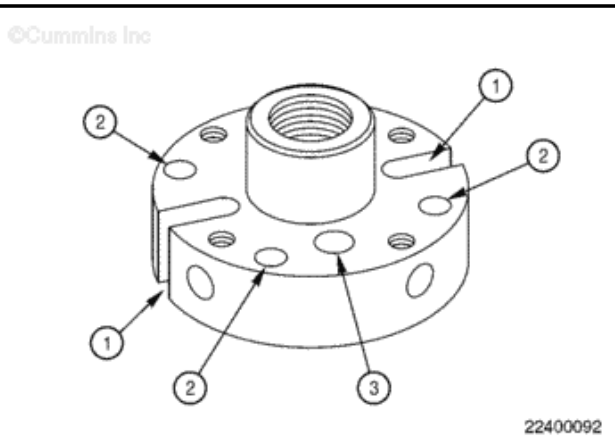
Use the camshaft gear puller kit, Part Number 3162895, for the removal the camshaft gear.

The mounting holes in the remover plate, Part Number 3162997, are **not** marked for identification.

Refer to the graphic for identification.

1) L10, M11, ISM, QSM, K19, K38, and K50 series engines
2) QSK45, QSK60, and QSK78 series engines
3) QSK19 series engines.

NOTE: Hydraulic gear remover kit, Part Number 3164375, can also be used with kit, Part Number 3164376, to remove the camshaft gear.



Apply anti-seize or heavy duty grease onto the threads of the remover screw (3).

Install the remover screw (3) into the remover plate assembly (2).

lubricate the thrust washer (17) with anti-seize or heavy duty grease.

Assemble the thrust washer (17) and the remover screw adapter (14) to the remover screw (3), and secure it ith the socket setscrew (15).

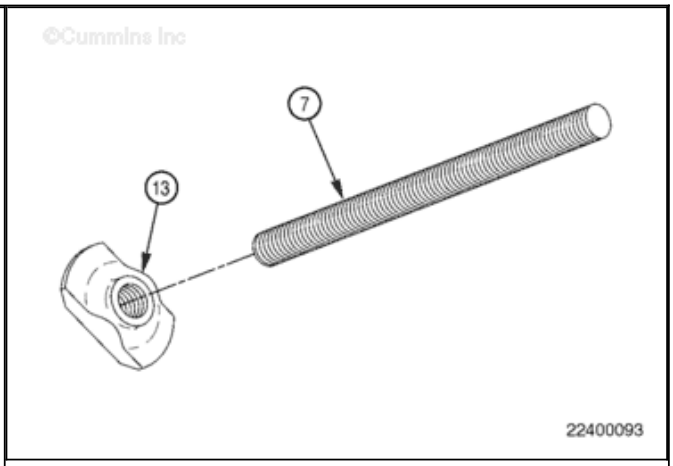
Install plate (11) on the remover plate assembly (2) with one capscrew (8).

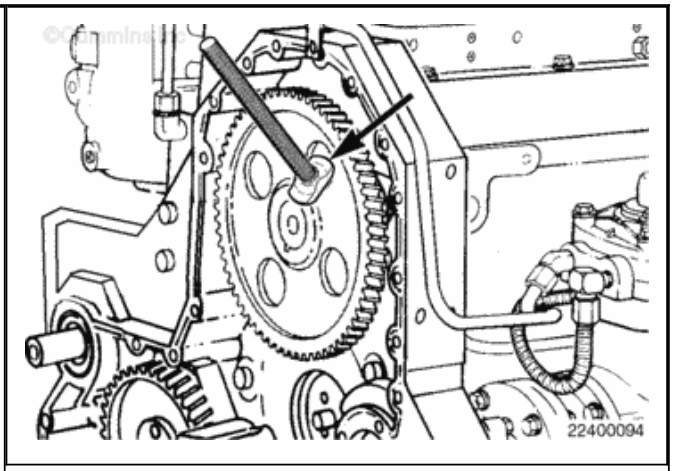


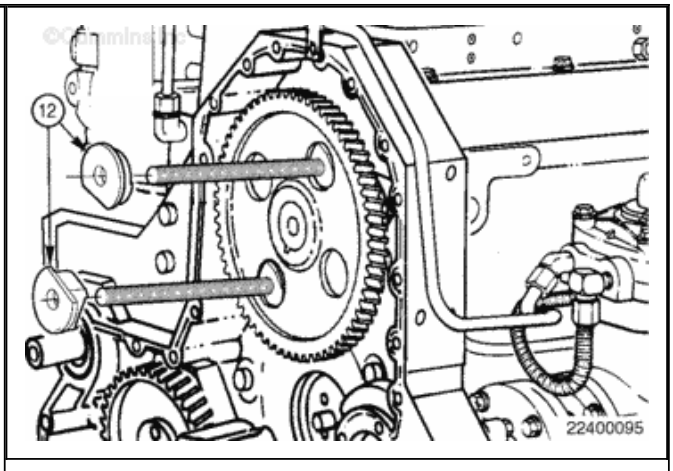




Tighten the capscrew.		

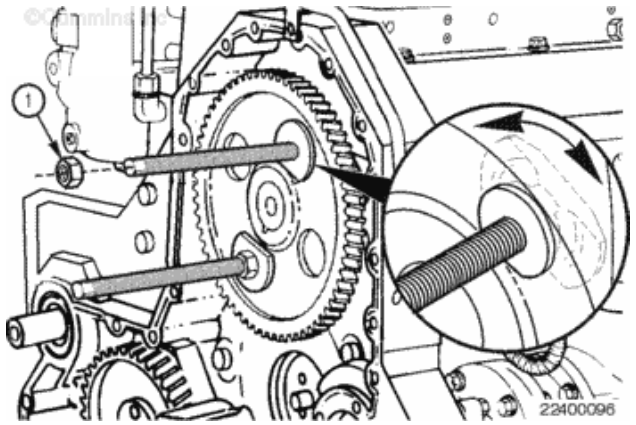
Install the remover jaw (13) onto the end of the stud (7). Make certain the end of the stud is flush with the bottom of the jaw.		

The round blanking holes in the camshaft gear **must** be aligned in the 1-o'clock and 7-o'clock positions to insert the remover jaw assembly. Tilt the remover jaw and stud assembly through a round blanking hole, and maneuver it sideways until the remover jaw is inserted. Install the other remover jaw and stud assembly in the opposite round blanking hole.		

Position the flat face of the retainer flange toward the camshaft. Slide the retainer (12) down the stud until it is positioned into the camshaft gear blanking hole and engages with the remover jaw.		

Make sure the flat face of the retainer flange sits against the radius of the camshaft gear hub. This will locate the remover jaw correctly at the back of the camshaft gear.

Adjust the retainer if necessary, and uniformly hand-tighten the nuts (1) onto the studs.



WARNING

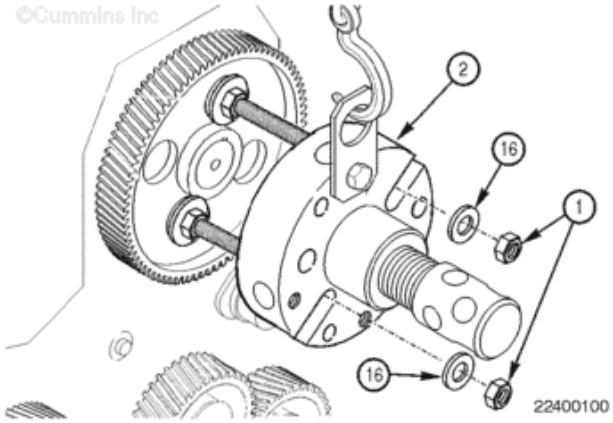
The remover is heavy and the gear can come loose suddenly causing the gear and gear remover assembly to fall. To reduce the possibility of personal injury and component damage, use a hoist or other lifting device when using the gear remover.

Using a lifting device, slide the remover plate (2) over the studs and position it close to the camshaft gear.

Make sure the pilot of the old remover screw adapter is properly engaged with the camshaft.

Install the washers (16) and nuts (1) onto the studs.

Uniformly tighten hand tighten the nuts.



CAUTION

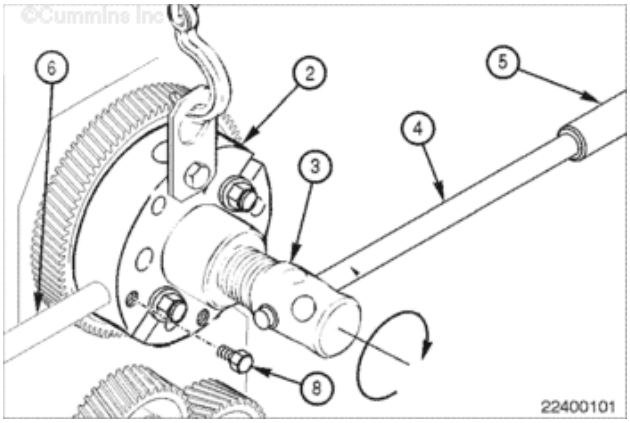
Do not attempt to alter the camshaft gear remover assembly for use with any

kind of impact wrench. Do not exceed 890 N [200 lb] of force on the end of the handle. The threads on the remover can gall and seize.

Make sure anti-sieze or heavy duty grease was applied to the remover screw threads (3).

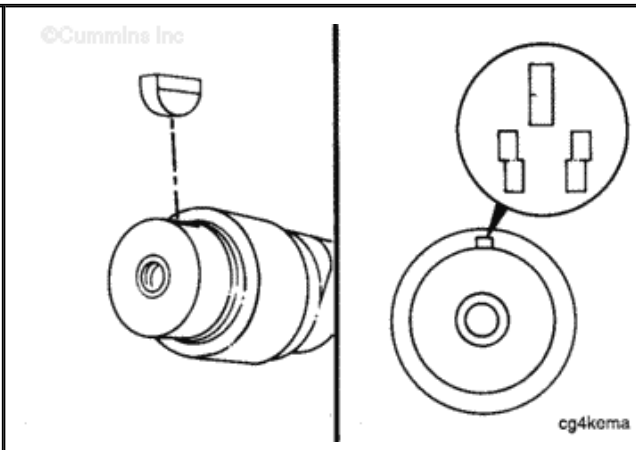
Install handle (6) into the remover plate assembly (2) and secure it with one capscrew (8).

Using handles (4) and (5), and holding handle (6) turn the remover screw (3) **clockwise** to remove the camshaft gear from the camshaft.



Check and record the direction of the key offset when compared to the camshaft gear rotation (same or opposite).

Remove the key.



Clean and Inspect for Reuse

Clean the camshaft gear and the camshaft.

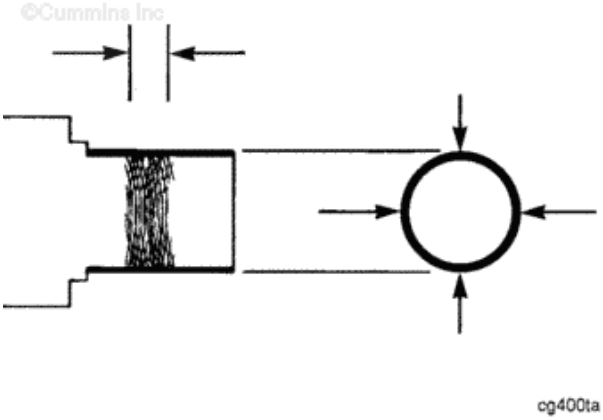
Inspect the camshaft and camshaft gear for reuse. Check for fretting damage. The camshaft **must** be replaced if the fretting damage is more than 3 mm

[1/8 inch] wide.

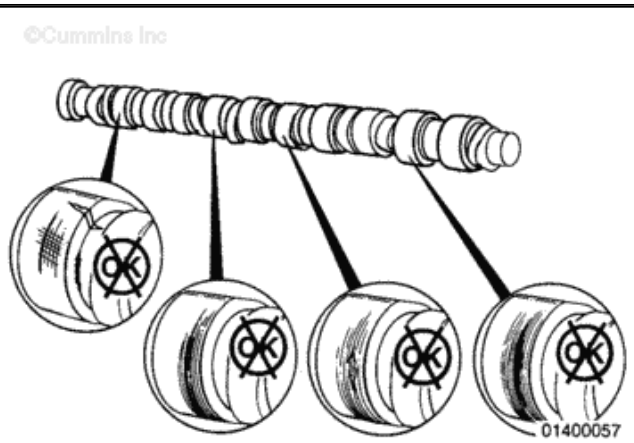
Measure the outside diameter of the camshaft.

Camshaft Outside Diameter (Gear Location)		
mm		in
57.200	MIN	2.2520
57.210	MAX	2.2525

If the camshaft **not** within specifications, it **must** be replaced.



Inspect the camshaft. Refer to Procedure 001-008.



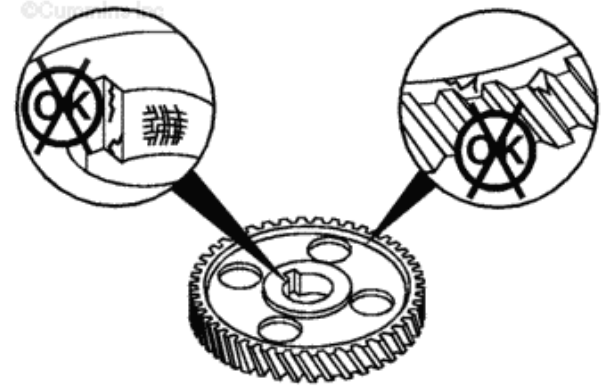
Inspect the camshaft gear for cracks, chipped or broken teeth.

Inspect the bore of the gear for fretting or burrs. Refer to Procedure 001-012.

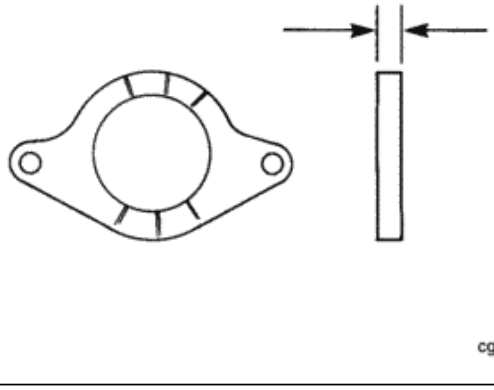
Measure the camshaft gear inside diameter.

Camshaft Gear Inside Diameter		
mm		in
57.200	MIN	2.2520
57.210	MAX	2.2525

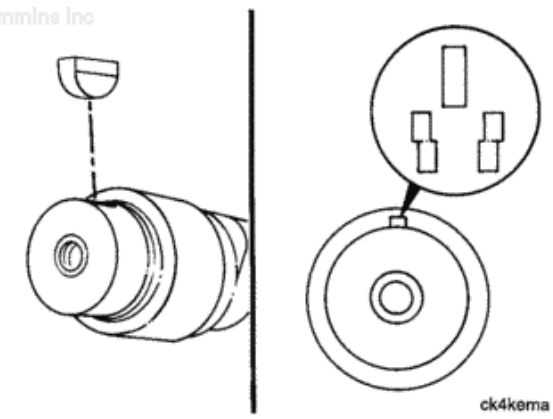
If the camshaft gear is **not** within specifications, it **must**



be replaced.		

Inspect the thrust bearing for damage and measure the thickness, refer to Procedure 001-056.		

Install

Camshaft keys are available in different sizes (amount of offset). The injection timing is controlled by: • Selection of the camshaft key • Direction of the key offset when compared to the camshaft gear rotation • Amount of offset. Refer to Procedure 006-025 for further information on camshaft key selection. Install the same part number key in the same orientation as the key that was removed.		

WARNING To reduce the possibility of		

severe burns, Wear protective gloves when installing the camshaft gear.

CAUTION

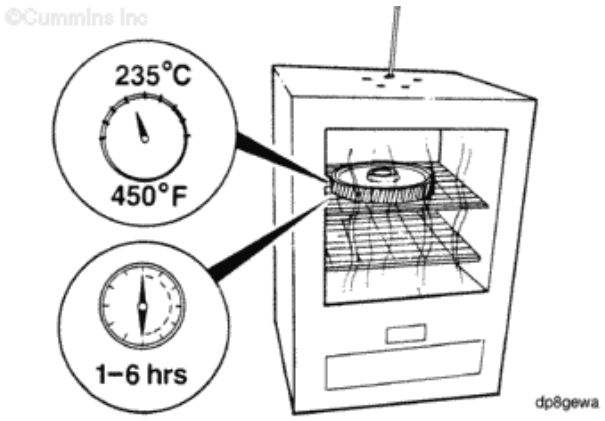
Do not exceed the specified time or the temperature. Damage to the gear and the gear teeth will result.

CAUTION

To reduce the possibility of gear and camshaft damage, 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** than a **maximum** of 6 hours.

The inside diameter of the gear will become larger and will simplify installation.



WARNING

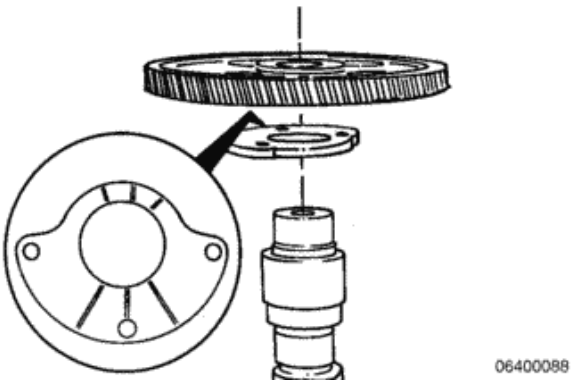
To reduce the possibility of severe burns, Wear protective gloves when installing the camshaft gear.

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.

The timing marks **must** be visible on the front of the gear after it is installed. The keyway in the gear **must** be aligned with the key.

Install the thrust plate. Install



the camshaft gear.		

Last Modified: 24-Sep-2004

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001-014 Connecting Rod

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

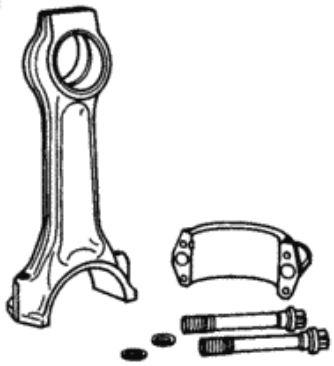
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

The number on the connecting rod must be the same as the number on the connecting rod cap. To reduce the possibility of engine damage never assemble a new connecting rod cap to a old connecting rod or an old connecting rod cap to a new connecting rod.

Remove the capscrews, washers, and the connecting rod cap from the connecting rod.

Clean the parts with solvent



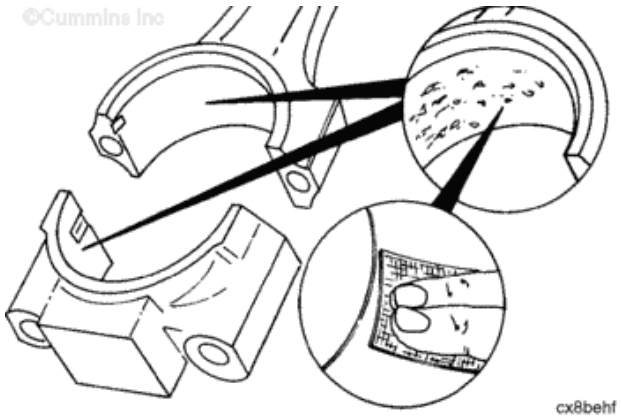
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and dry with compressed air.

Inspect the connecting rod caps, and capscrews for nicks, cracks, burrs, scratches or fretting.

The connecting rod and connecting rod cap **must** be replaced as an assembly if any fretting damage is visible on either piece.

Inspect the bearing seating surface for nicks or burrs. If it is **not** possible to remove any nicks or burrs with a fine crocus cloth, the connecting rod **must** be replaced.



Check the threads of the connecting rod capscrews for damage. Check under the capscrew heads for cracks.

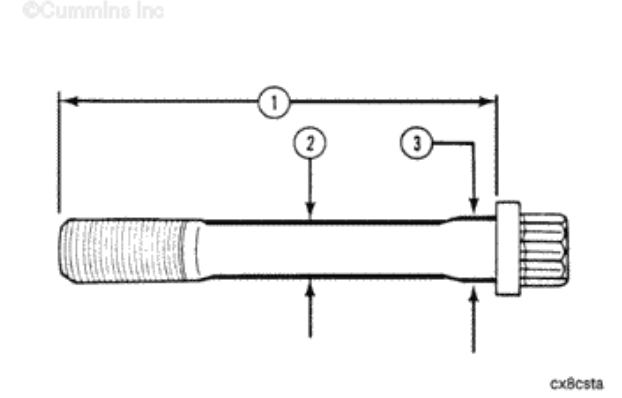
Measure the connecting rod capscrews.

Capscrew Length (1)		
mm		in
117.09	MIN	4.610
117.86	MAX	4.640

Capscrew Outside Diameter (2)		
mm		in
15.26	MIN	0.601
15.37	MAX	0.605

Capscrew Outside Diameter (3)		
mm		in
17.35	MIN	0.683
17.45	MAX	0.687

If the capscrews are **not** within specifications, the capscrews **must** be replaced.



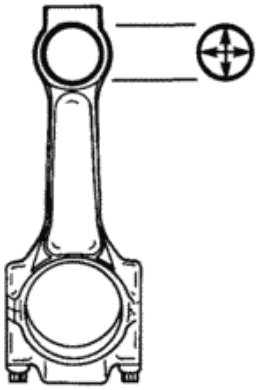
Measure the connecting rod wrist pin inside diameter.

Connecting Rod Wrist Pin

Bearing Inside Diameter		
mm		in
60.99	MIN	2.401
61.02	MAX	2.403

The bushing **must** be precision machined after installation. If machining capability is available, the bushing can be replaced. Refer to the Alternate Repair Manual, Bulletin 3379035.

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Calibrate

CAUTION

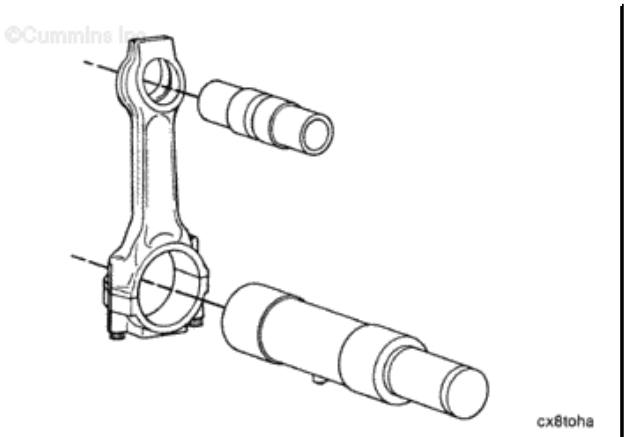
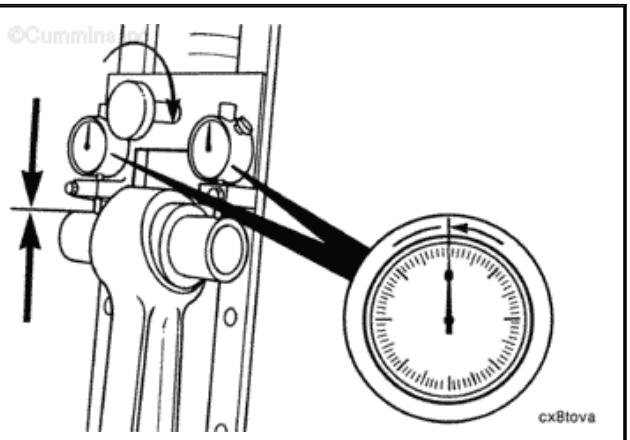
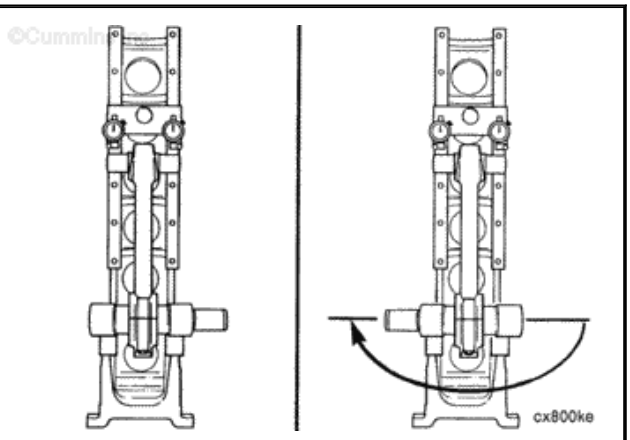
The connecting rod **must** be installed and torqued to specification or the measurement will be incorrect.

A connecting rod of known length, bend and twist, called a master connecting rod, is required to calibrate the fixture. A new connecting rod with a known distance from center of the crank pin to the center of the piston pin end (connecting rod length), can also be used.

Install the appropriate mandrel in the piston pin end of the master connecting rod.

NOTE: Be sure the locating pin in the mandrel for the crank pin end is touching the connecting rod cap directly opposite the beam of the connecting rod.

Install the mandrel in the

crank pin bore of the master connecting rod. Tighten the mandrel so it is centered in the bore correctly.		
Install the master 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 **master** connecting rod in and out to confirm the "0" setting.		
Remove the master connecting rod from the fixture. Rotate the connecting rod 180 degrees horizontally and install it in the checking fixture.		

CAUTION

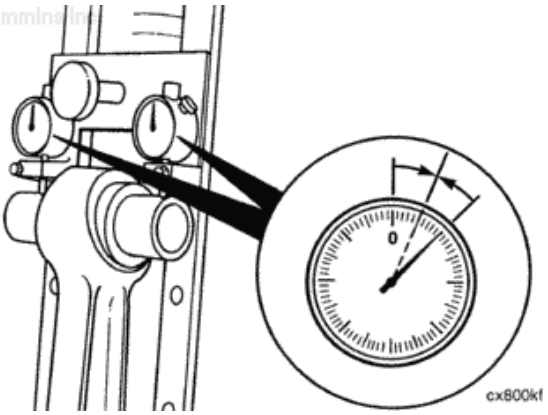
Do **not** adjust the indicators during this step of the procedure or the measurement will be incorrect.

Be sure the indicators are at "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.

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 master connecting rod is **not** damaged.

After completing the calibration of the fixture, remove the mandrels from the master connecting rod.



Bend and Twist Inspect

CAUTION

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

CAUTION

The number on the connecting rod must be the same as the number on the connecting rod cap. To reduce the possibility of engine damage never assemble a new connecting rod cap to a old connecting rod or an old connecting rod cap to a new connecting rod.

CAUTION

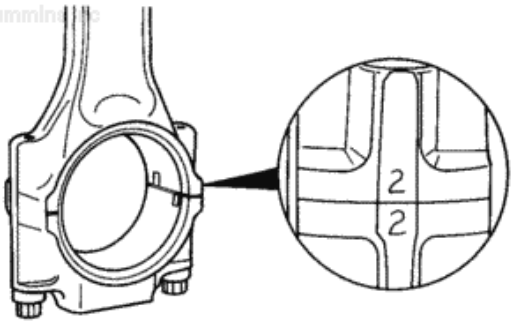
To reduce the possibility of engine damage, the connecting rod must be assembled with the capscrews tightened to specifications before stamping the cylinder identification number on the connecting rod. Always stamp a new connecting rod with the cylinder number of the connecting rod being replaced.

Lubricate the connecting rod capscrews with clean engine oil.

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

Tighten the capscrews.

Refer to Procedure 001-054 in Section 1 for proper torque values.



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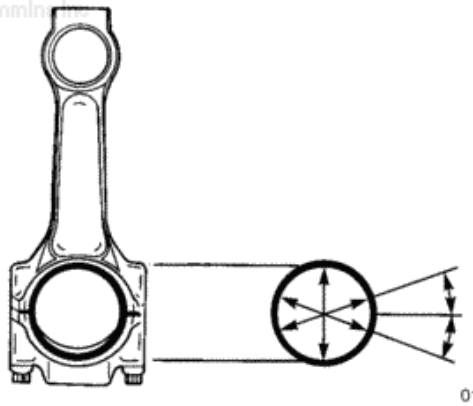
Use a dial bore indicator to measure the inside diameter within a 20 degree arc from each side of the parting line.

Measure the inside diameter at 90 degrees from the parting line.

Connecting Rod Bearing Bore Inside Diameter

mm		in
107.995	MIN	4.252
108.005	MAX	4.253

If any of the three measurements are **not** within specifications, the connecting rod **must** be repaired or replaced.



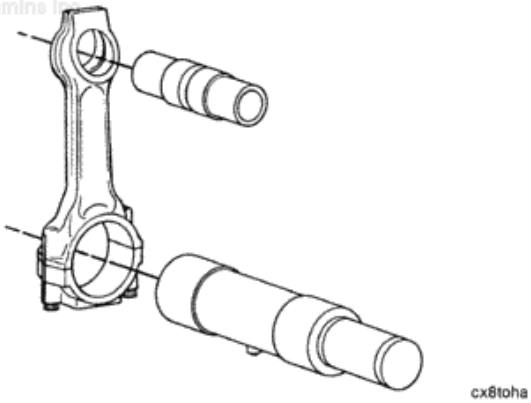
CAUTION

The connecting rod cap must be installed an tightened to specification or the measurements will not be correct.

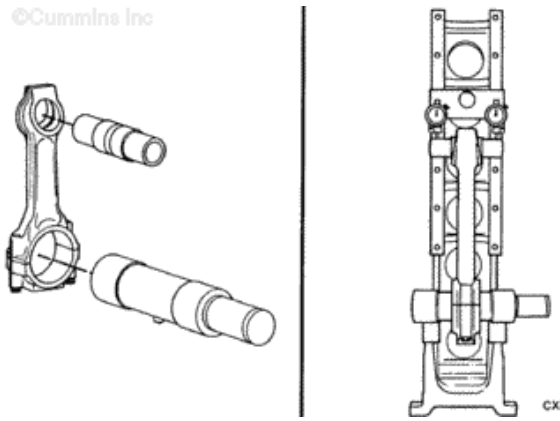
Install the appropriate mandrel in the piston pin end of the connecting rod.

Make sure the locating pin in the mandrel for the crank pin end is touching the connecting rod cap, directly opposite the beam of the connecting rod.

Install the mandrel in the crank pin bore of the connecting rod. Center the mandrel in the bore and tighten it.



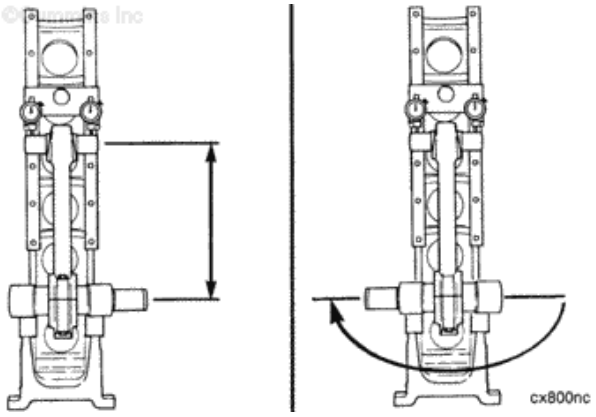
Install the connecting rod into the fixture.



Record the indicator reading. The difference of the calibrated “0” of the indicators **must** be added or subtracted from the known length of the master connecting rod to determine the length of the connecting rod being measured.

Connecting Rod Length		
mm		in
289.69	MIN	11.405
289.74	MAX	11.407

If the connecting rod length is **not** within specifications, the connecting rod **must** be replaced or the piston pin bushing replaced and machined.



CAUTION

Never attempt to straighten a connecting rod using heat or force. The rod will break eventually and cause extensive engine damage.

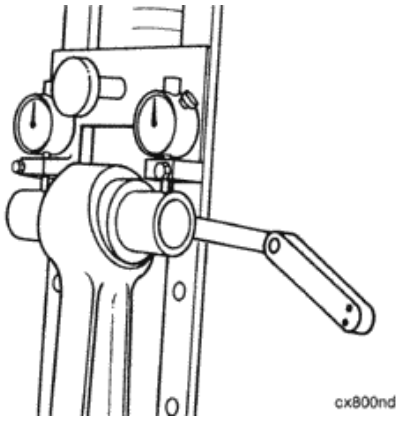
Record indicator readings.

Remove the connecting rod from the fixture. Turn the connecting rod 180 degrees horizontally.

Compare the indicator readings with those recorded in the previous step. The difference between the indicator reading is the amount of bend in the connecting rod.

Connecting Rod Bend		
mm		in
0.010	MIN	0.004
0.203	MAX	0.008

If the connecting rod bend is **not**



within specification with the bushing installed, the bushing can be removed and bend measured again. If the connecting rod is **not** within specifications with the bushing removed, the connecting rod **must** be replaced.

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 connecting rod twist.

Maximum Connecting Rod Twist				
	mm		in	
Bushing Installed	0.25	MIN	0.010	
Bushing Removed	0.51	MAX	0.020	

If the connecting rod twist is **not** within specifications with the bushing installed, the bushing can be removed. If the connecting rod twist is **not** within specifications with the bushing removed, the connecting rod **must** be replaced.

Magnetic Crack Inspect

Use a magnetic particle testing machine. The connecting rod and		

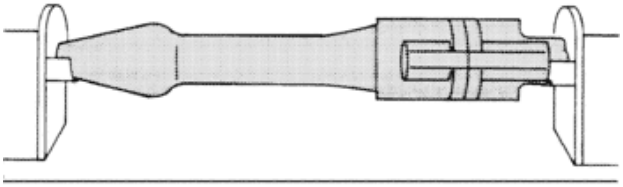
connecting rod cap **must** be assembled during this check.

Use the residual method and apply head shot amperage.

Adjust the amperage to 1500 ampere VDC or rectified VAC.

Check for cracks.

If the connecting rod is cracked, it **must** be replaced.



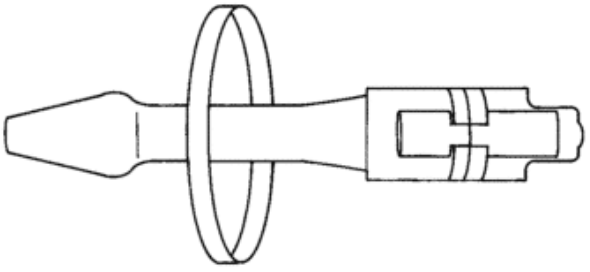
Use the residual method and apply coil shot amperage.

Amperage (Ampere Turns)	
Minimum	2600 VDC or Rectified VAC
Maximum	2600 VDC or Rectified VAC

An ampere turn is an electrical current of one ampere flowing through the coil, multiplied by the number of turns in the coil.

Check for cracks.

If the connecting rod is cracked, it **must** be replaced.

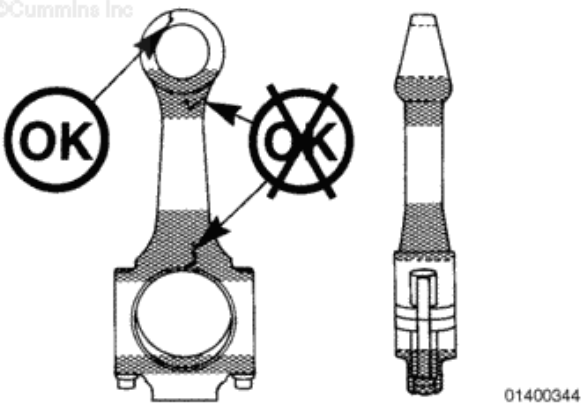


WARNING

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.

WARNING

When using a steam



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

CAUTION

The connecting rod must be demagnetized completely and cleaned thoroughly. Any small particles will cause engine damage.

Demagnetize the connecting rod.

Clean the connecting rod with solvent or steam.

Last Modified: 23-Jan-2009

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001-016 Crankshaft

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

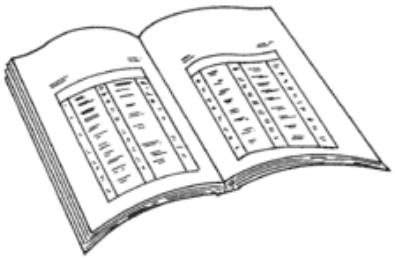
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapor, ingestion, and prolonged contact with used engine oil. If not reused dispose of in accordance with local environmental regulations.

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.

- Drain the lubricating oil. Refer to Procedure 007-037 in Section 7.
- Remove the oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the connecting rod caps. Refer to Procedure 001-054 in Section 1.

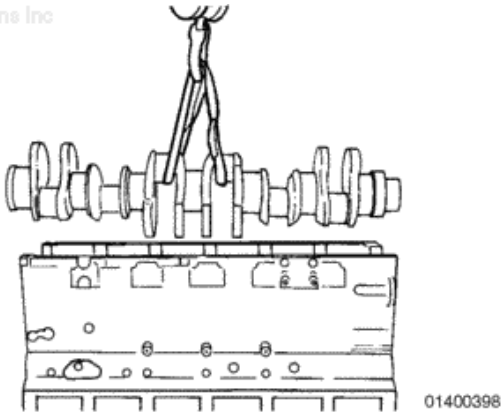




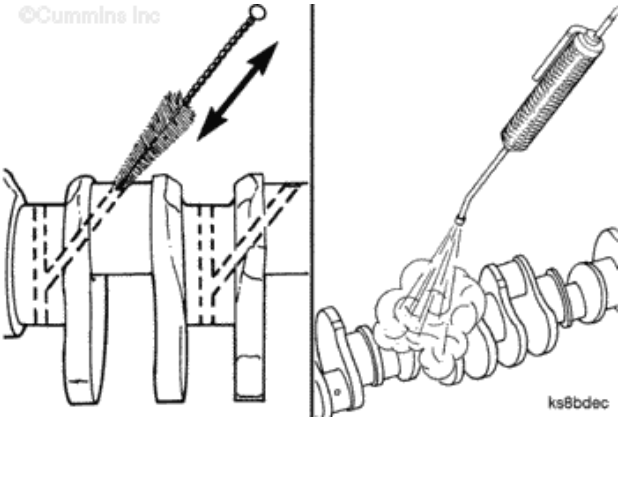
ck800wa

• Remove the main bearing caps and bearings. Refer to Procedure 001-006 in Section 1. • Remove the thrust bearings. Refer to Procedure 001-007 in Section 1.		

Remove

Support the weight of the crankshaft with a hoist or lifting device. Remove the crankshaft.		

Clean and Inspect for Reuse

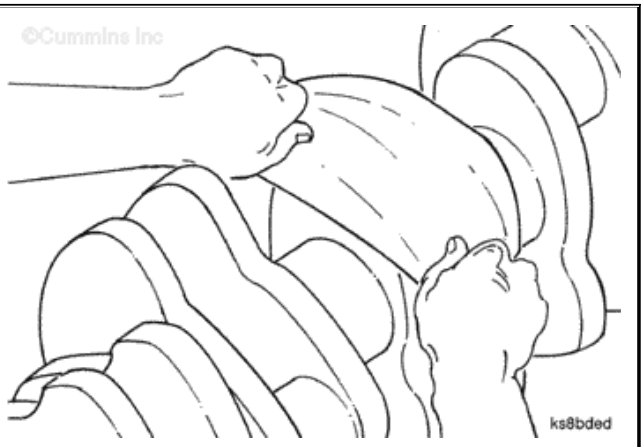
WARNING When using solvents, acids or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.		

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.

Use crocus cloth or a Scotch-Brite™ pad to remove discoloration or light scratches from the machined surfaces.



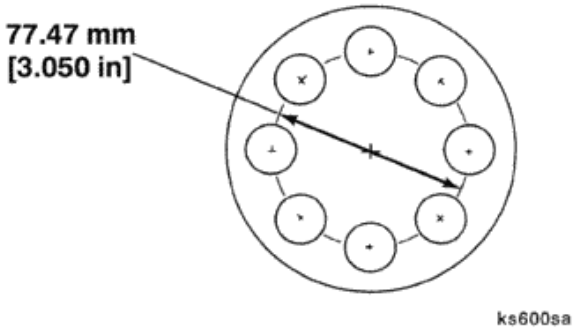
WARNING

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.

To clean the ROLLED threads, flush with solvent, and dry with compressed air.

If additional cleaning is required, brush with a nylon bristle brush.

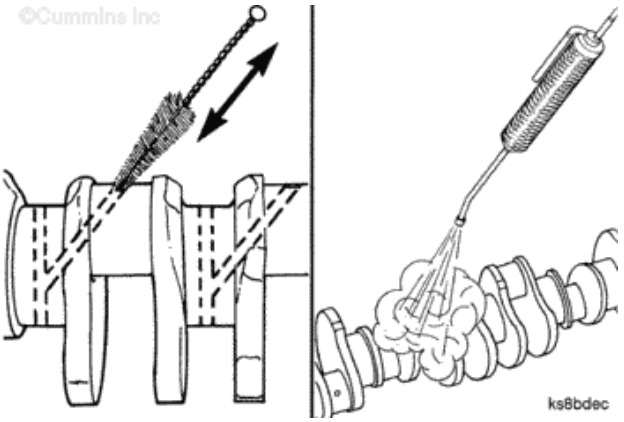
Place tape over the threaded capscrew holes.

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.

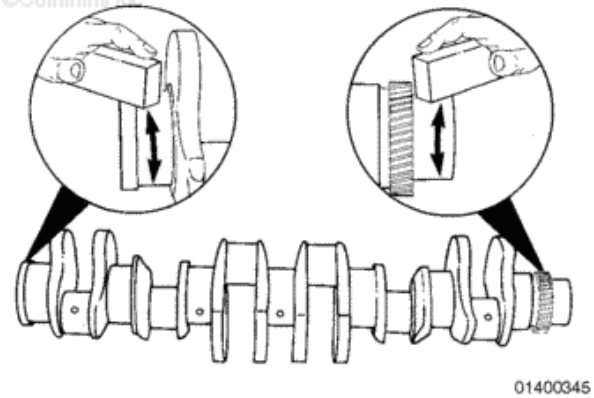
Use a light preservative oil to lubricate the crankshaft to prevent the formation of rust.



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.

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.

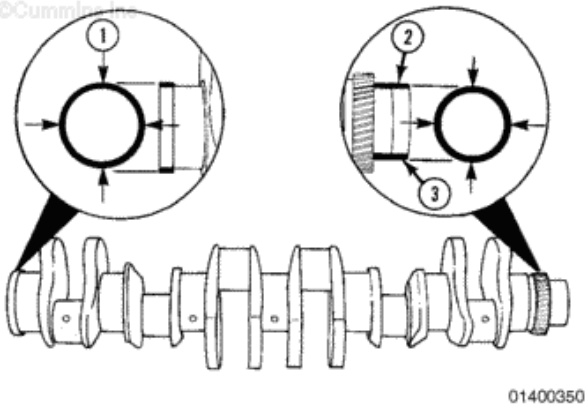
Use a honing stone to polish the outside diameter of the front and rear oil seal locations, the flywheel mounting location, and the vibration damper location. Remove all small scratches and grooves.

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)	152.35	MIN	5.998
	152.40	MAX	6.000
Location (2)	111.07	MIN	4.373
	111.13	MAX	4.375
Location (3)	110.74	MIN	4.360
	110.77	MAX	4.361

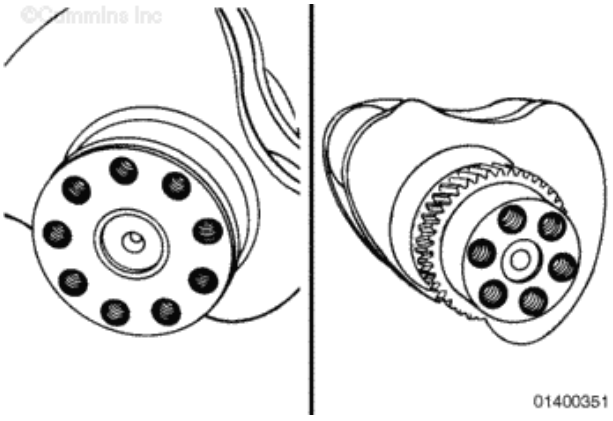


CAUTION

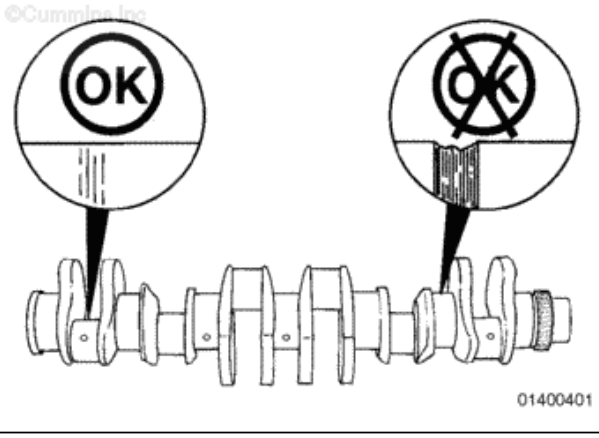
Do not chase threads on the crankshaft. Severe engine damage can occur.

Check the threads for damage at both ends of the crankshaft.

If necessary, refer to the Alternative Repair Manual, Bulletin 3379035, for repair instructions.



Check the main bearing journals and rod bearing journals for damage or excessive wear. Minor scratches are acceptable.



Measure the outside diameter.

Rod Bearing Journal Outside Diameter (4)

mm		in
101.524	MIN	3.997
101.600	MAX	4.000

Main Bearing Journal Outside Diameter (5)

mm		in
139.637	MIN	5.4975
139.700	MAX	5.5000

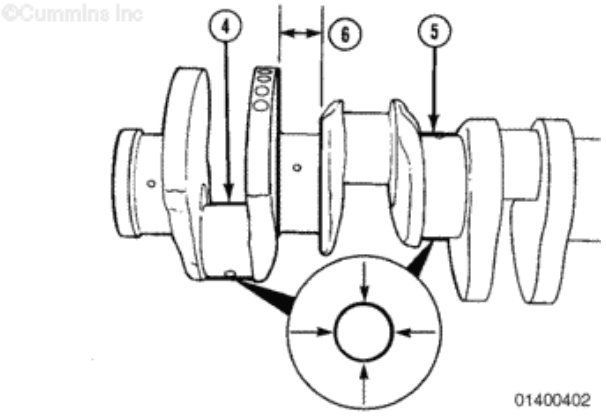
Measure the thrust distance between the thrust faces on the number 6 main bearing journal.

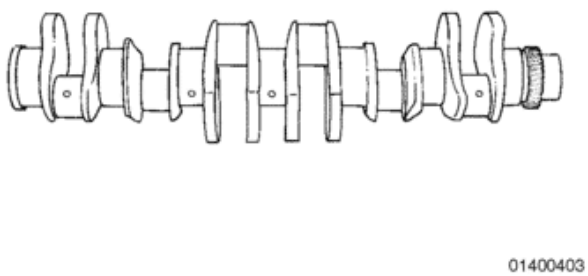
Thrust Distance (6)

mm		in
60.30	MIN	2.374
60.33	MAX	2.375

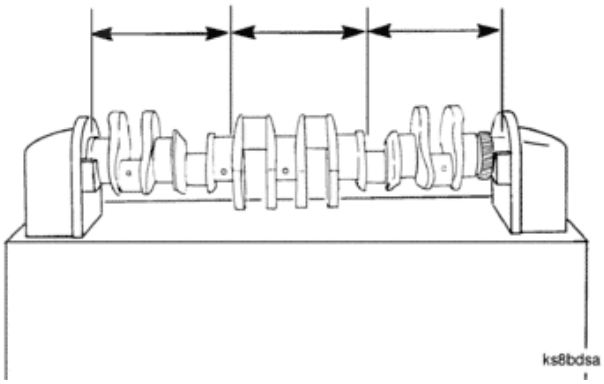
The crankshaft can be ground undersize if the outside diameter is **not** within specifications. **Always** grind all of the journals when one is **not** within specifications.

Oversize rod bearings and main bearings are available. Refer to the Alternate Repair Manual, Bulletin 3379035, for grinding specifications and instructions.



Oversize thrust bearings are available if the thrust distance is **not** within specifications. A 0.25 mm [0.010 in] and a 0.51 mm [0.020 in] oversize thrust bearing are available. If the crankshaft **must** be machined to use an oversize thrust bearing, refer to the Alternate Repair Manual, Bulletin 3379035, for instructions. 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.		

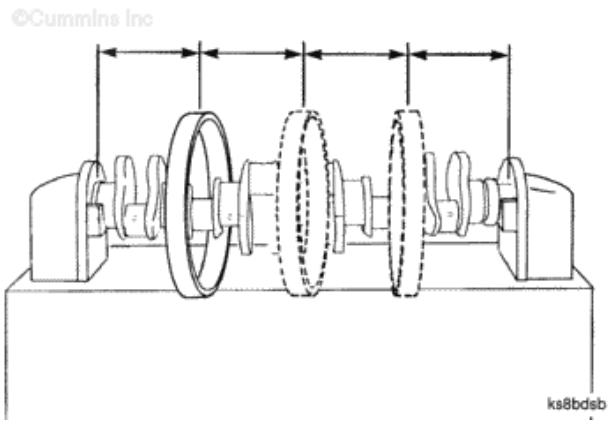
Magnetic Crack Inspect

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 VDC or rectified alternating current	5000 VDC or rectified alternating current

Ampere turn is an electrical current of ampere flowing through the coil, multiplied by the number of turns in the coil.

Check the crankshaft for cracks.

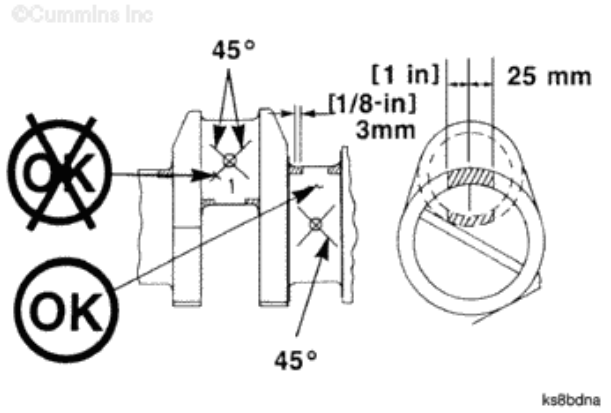


An open indication is visible after the wetting operation has been completed. An indication below the surface is **not** visible after the wetting operation has been completed. An indication below the surface can be seen with the use of the ultraviolet light.

Do **not** use the crankshaft if:

Limits of Acceptance - Open Indications

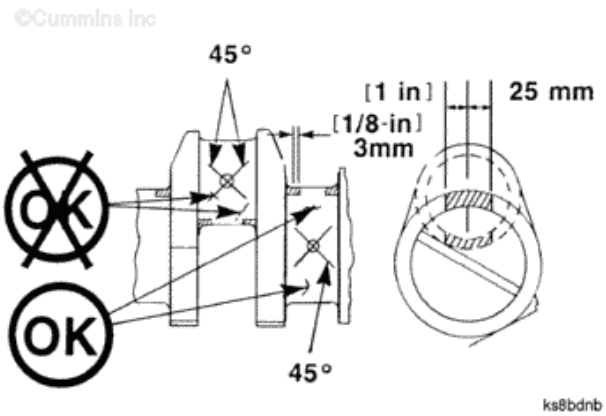
- There is an indication in the fillet or in the shaded area.
- There is an indication that passes through the 45 degree diagonal from the oil hole or goes into the oil hole chamfer.
- There is an indication that is longer than 6 mm [0.250 in].
- There are more than four indications on one journal.



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.

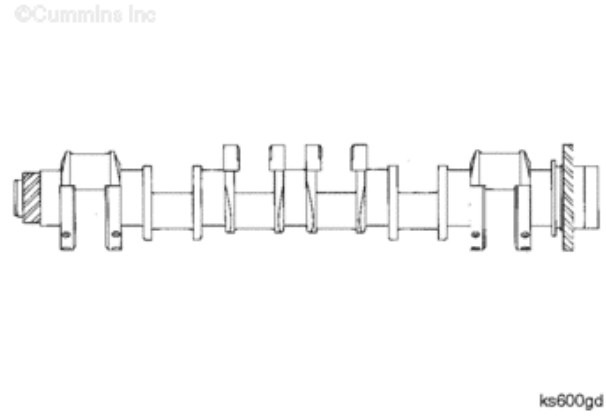
CAUTION

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.

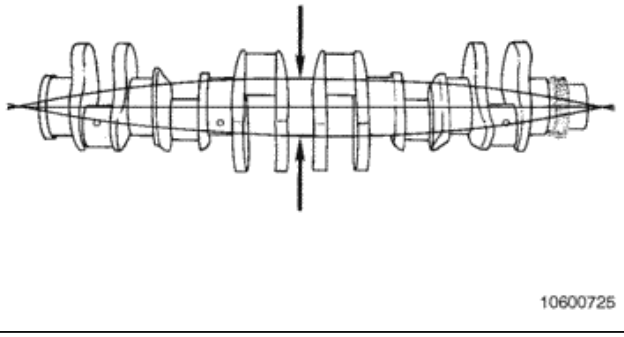
Use a heavy preservative oil if the crankshaft is **not** going to be installed immediately. Protect the part with a cover to prevent dirt from sticking to the oil.



Bend and Twist Inspect

The crankshaft straightness is determined by the amount of total runout and the adjacent journal runout.

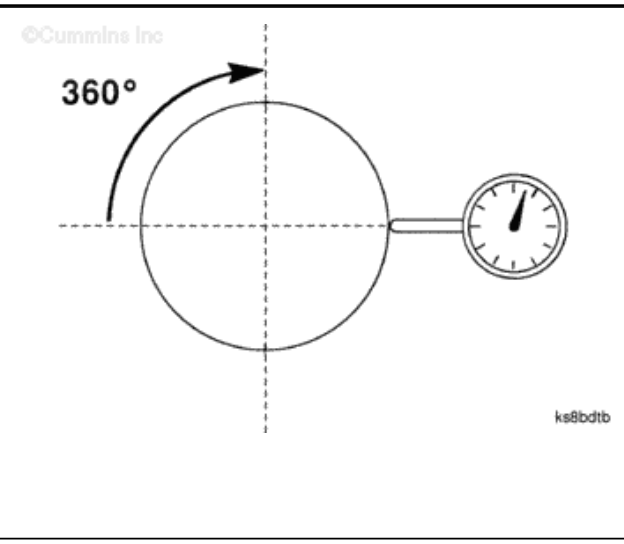
Total runout is defined as the total indicator runout measured at the middle bearing journal when the crankshaft is supported on the two end journals. Total runout is often referred to as the bend or full length alignment.



Journal runout is defined as, the total indicator run out (total sweep of the needle) of the main bearing journals the crankshaft is rotated one complete revolution (360 degrees).

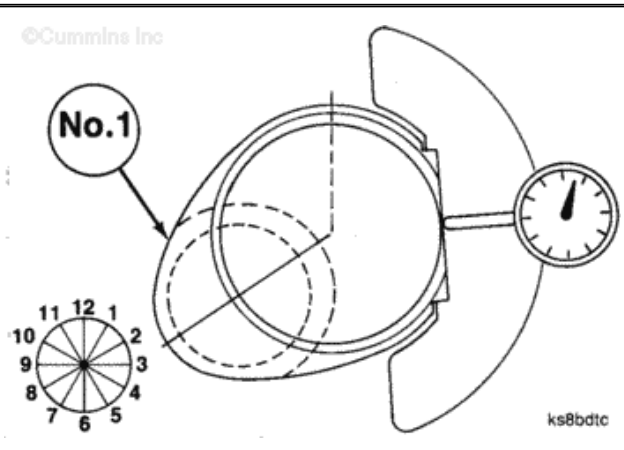
Adjacent journal runout is defined as the relationship of the total indicator runout of a main bearing journal as it is rotated on a common axis to the total indicator runout of an adjacent journal.

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.

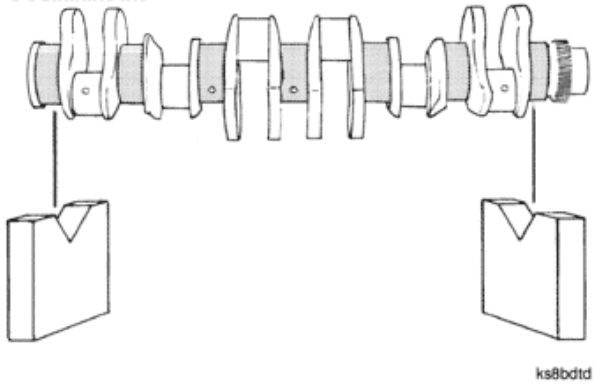


WARNING

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

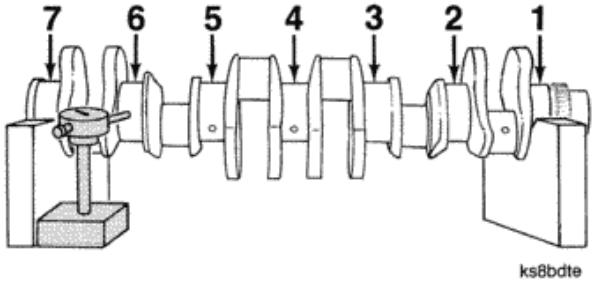
Place two vee-blocks on a flat surface.

Support the crankshaft on the vee-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 measure,d (1) through (7).



Rotate the crankshaft and measure the total indicator runout 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

ks8bdtf

A fully fillet hardened crankshaft **must** be discarded

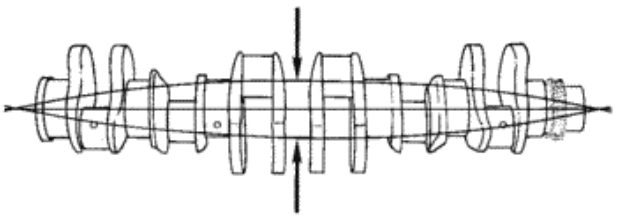
if the total runout is **not** within specifications.

Position the dial indicator stem to the center main bearing journal.

Rotate the crankshaft a complete revolution.

Crankshaft Total Runout		
mm		in
0.230	MAX	0.009

If the crankshaft is **not** within specifications. It **must** be replaced.



For each journal, plot the total indicator run out value at its clock position illustrated on the polar chart.

The end journals, supported by vee-blocks, **must** be plotted at the center of the chart.

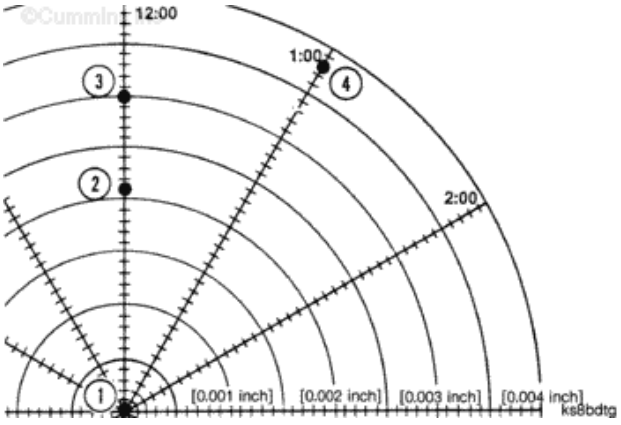
The graphic illustrates the plot points.

Journal	Total Indicator Run Out	Clock Position
(1)	0	0
(2)	0.002	12
(3)	0.003	12
(4)	0.004	1

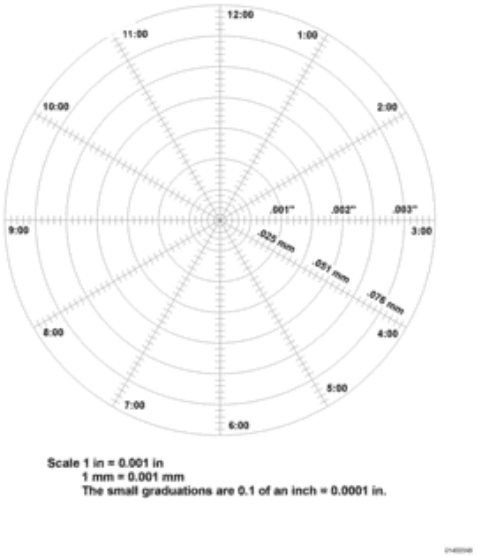
Draw a straight line between the plotted points. From journal number one to journal number two from journal number two to journal number three until all journals are plotted on the chart.

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 0.08 mm [0.003 in]. If the crankshaft is **not** within specifications. It **must** be replaced.		



Polar Chart

Polar chart

Install

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.

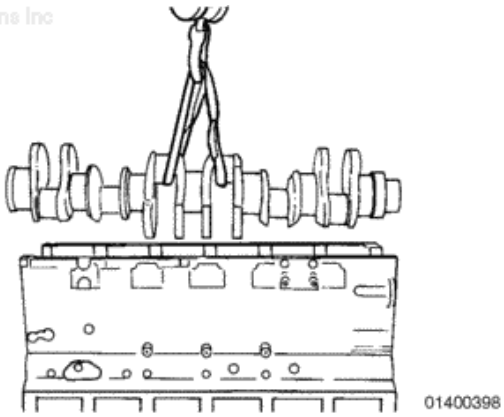
CAUTION

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.

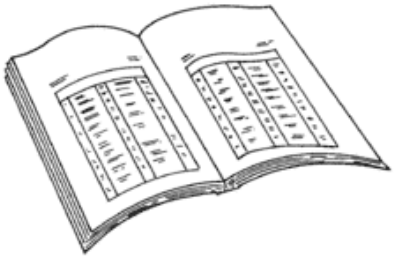


Finishing Steps

WARNING

This component 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 thrust bearings. Refer to Procedure 001-007 in Section 1.
- Install the main bearings and caps. Refer to Procedure 001-006.
- Install the connecting rod caps. Refer to Procedure 001-054.
- Install the oil pan. Refer to Procedure 007-025.
- Fill the engine with lubricating oil. Refer to Procedure 007-037.

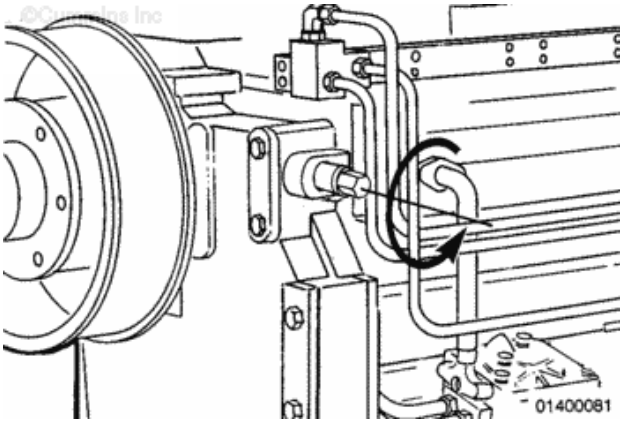


Rotation Check

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 correct procedure for inspection and replacement of internal engine components.



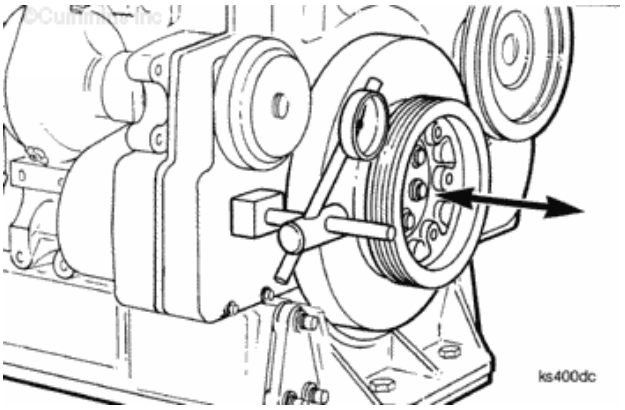
CAUTION

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.

Crankshaft End Clearance		
New Minimum	New Maximum	Worn Limit
0.10 mm [0.004 in]	0.43 mm [0.017 in]	0.56 mm [0.022 in]



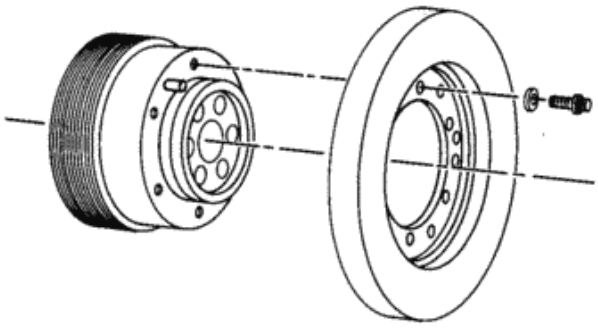
The check can be made by attaching a dial indicator resting against the vibration damper or pulley while prying against the front cover and inner part of the pulley or vibration damper. End clearance **must** be in specification with the engine mounted in the unit and assembled to the transmission or converter. If the clearance is **not** within specifications, contact a Cummins® Authorized Repair Location.		

Last Modified: 11-Nov-2010

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001-017 Crankshaft Adapter

Disassemble

Remove the capscrews and vibration damper from the crankshaft adapter or pulley.		

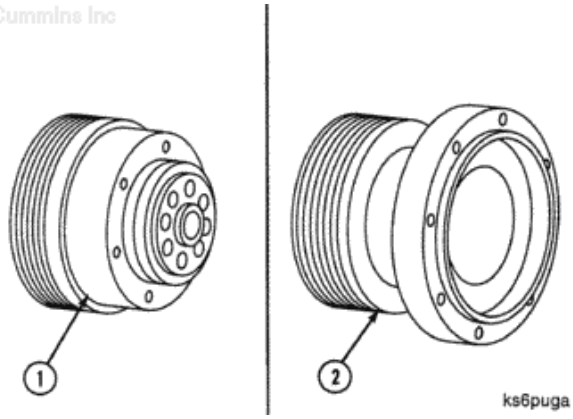
Clean and Inspect for Reuse

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 personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

The mounting pilots and surfaces control the center and spacing of the pulleys. Do not repair the part by machining. It will cause an out-of-balance condition or a crankshaft failure.

Clean the crankshaft adapter or pulley with solvent or steam and dry with compressed air.

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 crankshaft adapter or pulley outside diameter.

Crankshaft Adapter or Pulley Outside Diameter		
mm		in
134.78	MIN	5.311
135.04	MAX	5.312

If the crankshaft adapter or pulley outside diameter is **not** within specifications, the crankshaft adapter or pulley **must** be replaced.

Measure the crankshaft adapter or pulley inside diameter.

Crankshaft Adapter or Pulley Inside Diameter		
mm		in
110.780	MIN	4.361
110.806	MAX	4.362

If the crankshaft adapter or pulley inside diameter is **not** within specifications, the crankshaft adapter or pulley **must** be replaced.

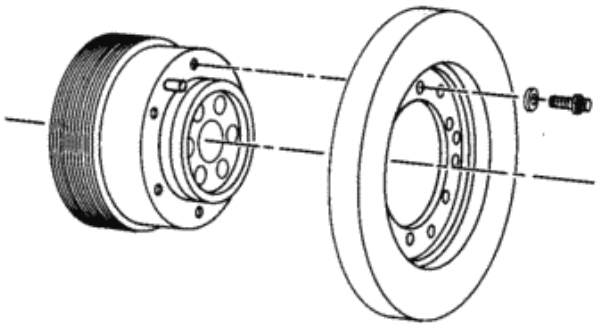
Assemble

Place the vibration damper onto the crankshaft adapter or pulley.

Install the capscrews into the vibration damper.

Tighten the capscrews.

Torque
Value: 140 n.m [105 ft-lb]



Last Modified: 23-Jul-2004

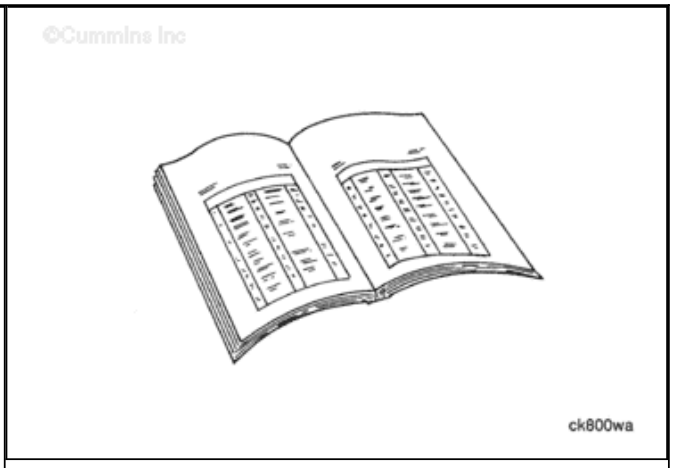
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001-018 Crankshaft Gear, Front (Crankshaft Installed)

Preparatory Steps

- Remove the gear cover and all related components. Refer to Procedure .

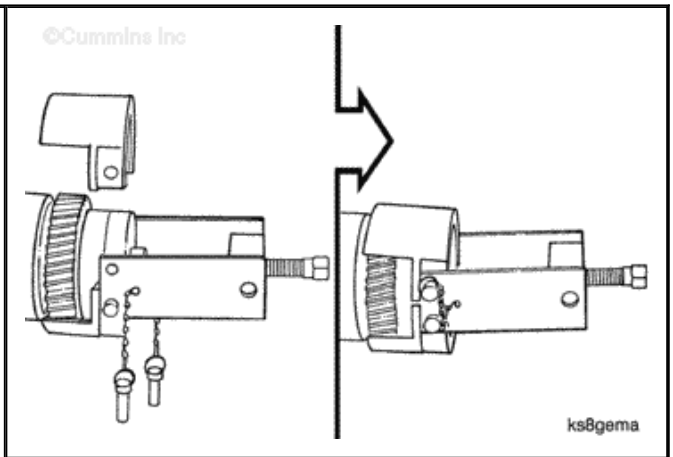




Remove

Only remove the gear when the crankshaft or the gear is damaged.

Use gear remover, Part Number 3165049, and remover jaw, Part Number 3375835, 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.

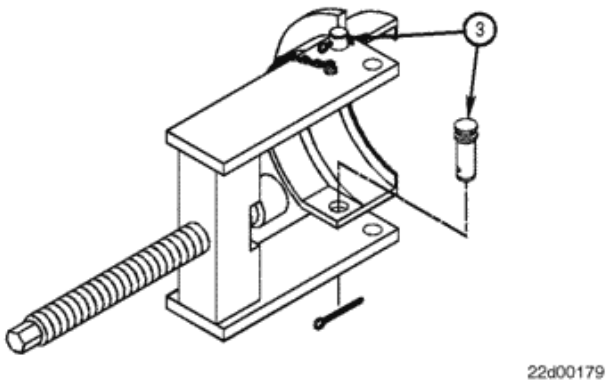
CAUTION

To reduce the possibility of tool and crankshaft damage, do not exceed 475 N•m [350 ft-lb] of torque when turning the jackscrew.

Lubricate the replacer screw assembly with Lubriplate® multipurpose lubricant, Part Number 3163086, Part Number 3163087, or a suitable grease.

Install the clevis pins (3) from inside of the appropriate remover jaw and the gear remover assembly.

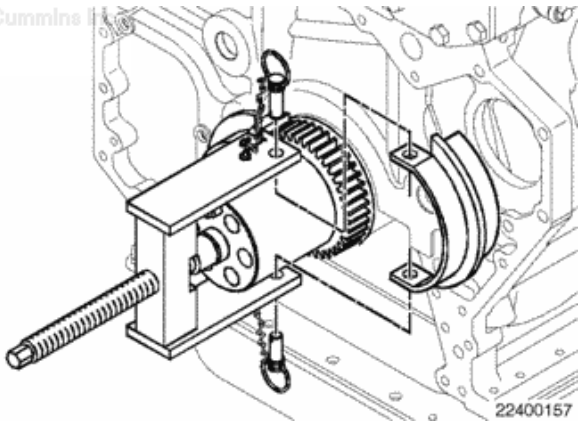
Install the cotter pins into the clevis pin holes.



Place the remover jaw knife edge behind the gear.

Install the other appropriate remover jaw behind the gear and align the mounting hole with the mounting hole in the gear remover assembly.

Install the straight pins through the gear remover assembly and the remover jaw.



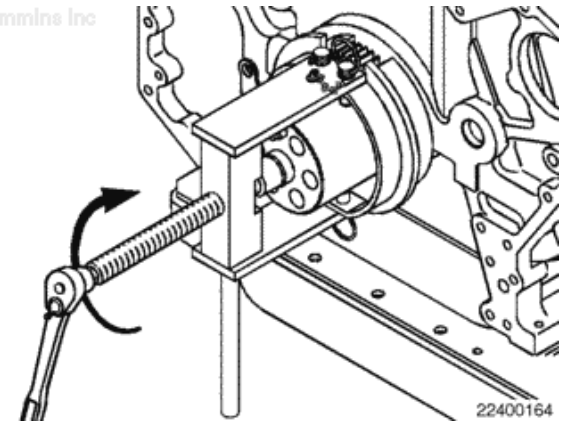
CAUTION

Do not use an impact wrench or air tools. Doing so can damage the engine.

Install the handle into the gear remover assembly.

Hold the handle to prevent rotation of the assembly.

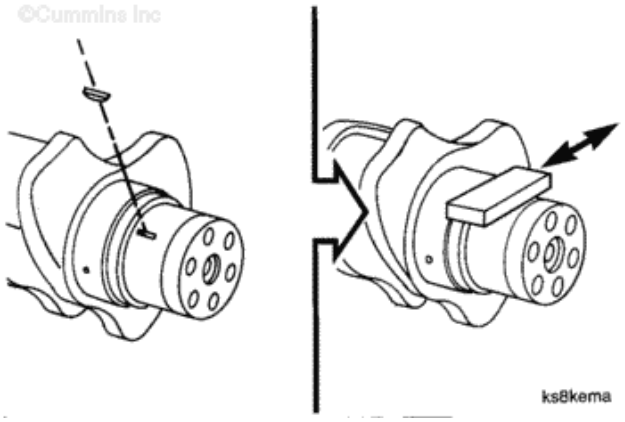
Rotate the remover screw **clockwise** until the crankshaft gear is removed.



Remove the key.

Use a hone stone to polish the outside diameter of the crankshaft.

Remove all of the small scratches, burrs, and small grooves.

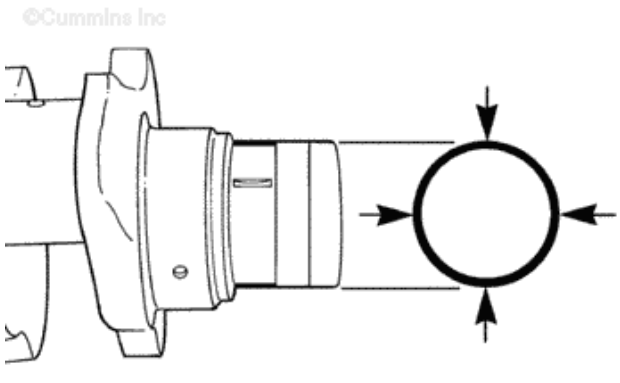


Clean and Inspect for Reuse

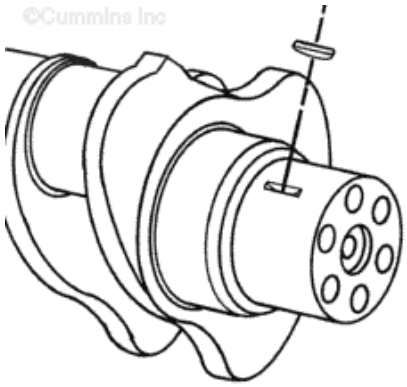
Clean and inspect the crankshaft for reuse.

Measure the outside diameter of the crankshaft at the gear location.

Crankshaft Outside Diameter (Gear Location)	
mm	in

111.25 MIN 4.380 111.28 MAX 4.381		

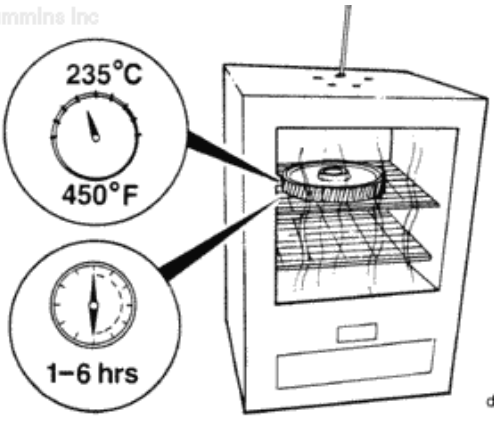
Install

Install the key.		

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the crankshaft gear.

CAUTION



Do not exceed the specified time or the temperature. Damage to the gear and the gear teeth will result.

CAUTION

to reduce the possibility of crankshaft and gear damage 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 a **maximum** of six hours. The inside diameter of the gear will become larger and will simplify installation.

WARNING

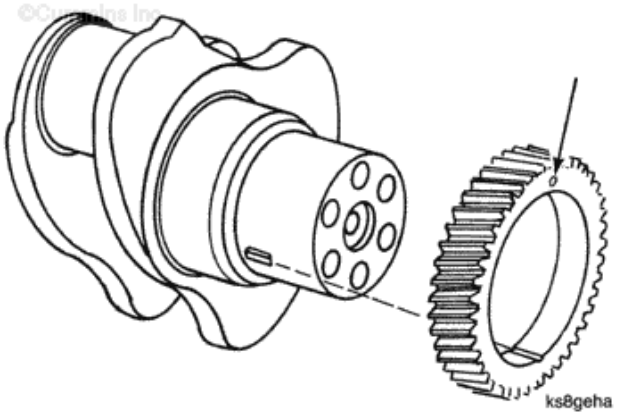
To reduce the possibility of severe burns, wear protective gloves when installing the crankshaft gear.

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.

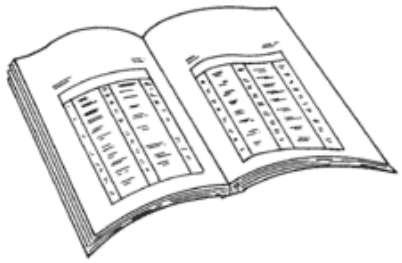
The timing mark on the crankshaft gear **must** be visible from the front of the gear after it is installed on the crankshaft.

Lubricate the outside diameter of the crankshaft with Lubriplate® Number 105 multipurpose lubricant, or equivalent. Remove the gear from the oven and install it on the crankshaft. The keyway in the gear **must** be aligned with



the key in the crankshaft.		

Finishing Steps

• Install the gear cover and related components. Refer to Procedure 001-031.		 ck800wa

Last Modified: 24-Sep-2004

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001-021 Crankshaft Gear, Rear (Crankshaft Removed)

Remove

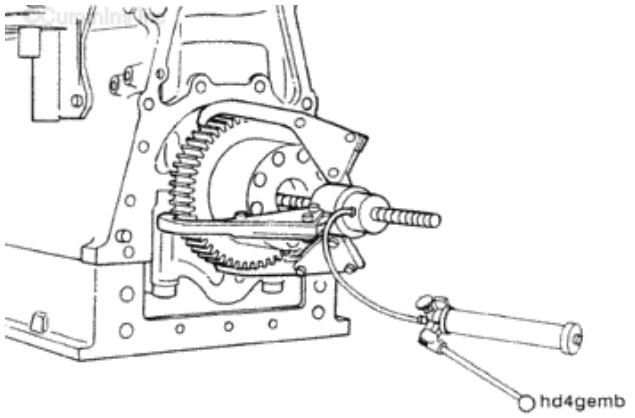
CAUTION

Do not use a cutting torch to remove the gear if the gear is to be used again. Excessive heat from a cutting torch will damage the heat treatment of the gear.

A three-jaw puller that has a hydraulic ram with a capacity of nine tons (10 short tons) is recommended.

Evenly applied heat can be used to help remove the gear.

Use a three-jaw puller and remove the gear.

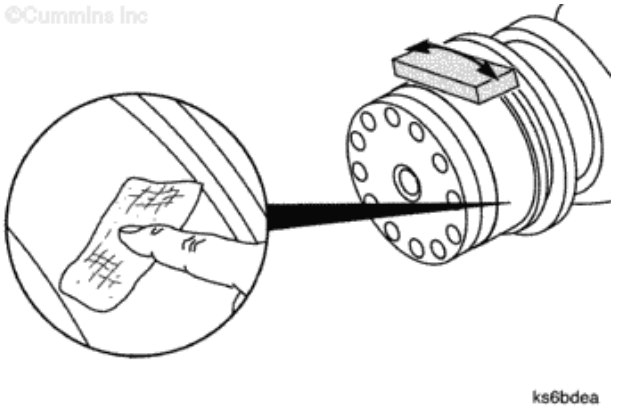


Clean and Inspect for Reuse

Inspect the rear gear press location of the crankshaft for small scratches, burrs, or grooves.

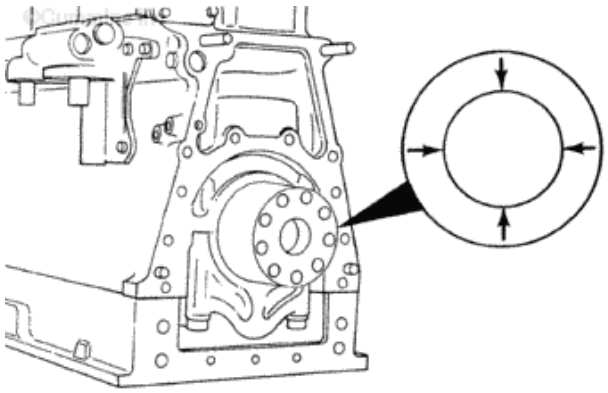
Remove any small scratches, burrs, or grooves with a hone stone.

Polish the outside diameter.



Measure the crankshaft outside diameter at the rear gear press location.

Crankshaft Outside Diameter (Rear Gear Press Location)		
mm		in
153.62	MIN	6.030
153.19	MAX	6.031



Install

WARNING

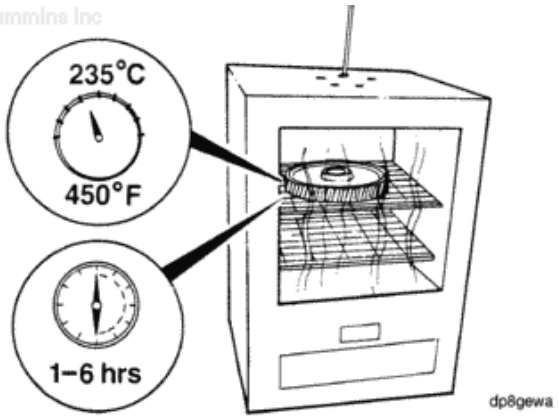
To reduce the possibility of severe burns, wear protective gloves when installing the heated crankshaft gear. Do not attempt to install the gear without heat.

CAUTION

Do not exceed the specified time or the temperature. Damage to the gear and gear teeth will result.

Heat the gear in an oven, with the temperature adjusted to 235°C [450°F], for a minimum of one hour and a maximum of six hours.

The inside diameter of the gear will become larger and will



simplify the installation of the gear on the crankshaft.

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated crankshaft gear. Do not attempt to install the gear without heat.

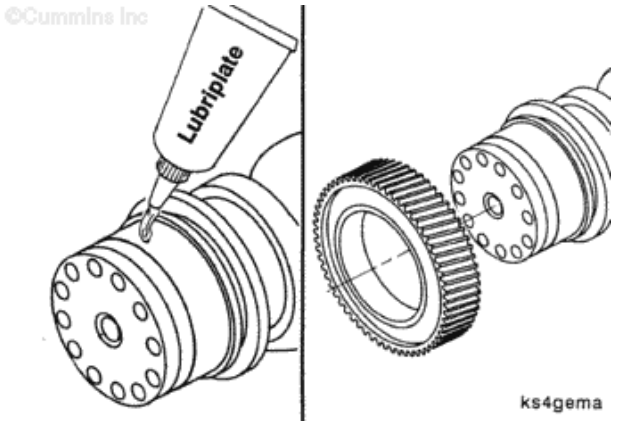
CAUTION

Allow the air to cool the gear. Do not use water or oil ot reduce the cooling time. The use of water or oil can cause the gear to crack.

Lubricate the outside diameter of the crankshaft in the gear location with Lubriplate® 105.

The gear can be installed with either side out.

Remove the gear from the oven and install it onto the crankshaft.



Last Modified: 20-Dec-2004

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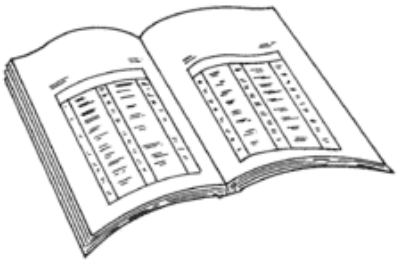
001-023 Crankshaft Seal, Front

Preparatory Steps

- Remove the cooling fan. Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the vibration damper. Refer to Procedure 001-052.







Remove

Use a drill, sheet metal screw, and the following from the light duty pulley kit, Part Number 3375784:

- Slide hammer
- Hook.

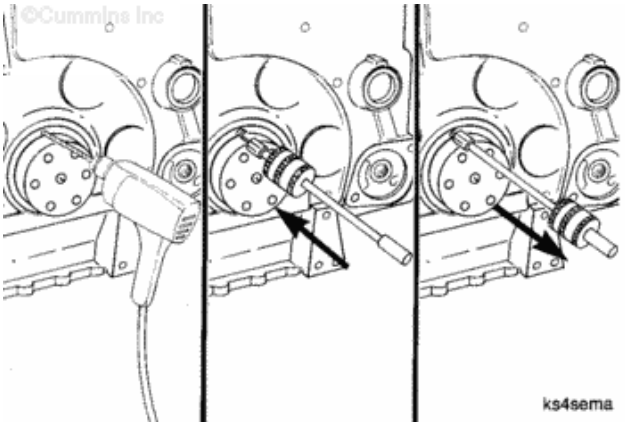
Drill a hole in the seal and install a sheet metal screw.

Use the hook and the slide hammer to remove the seal.

NOTE: If a service seal with a wear sleeve has been installed the wear sleeve must be removed

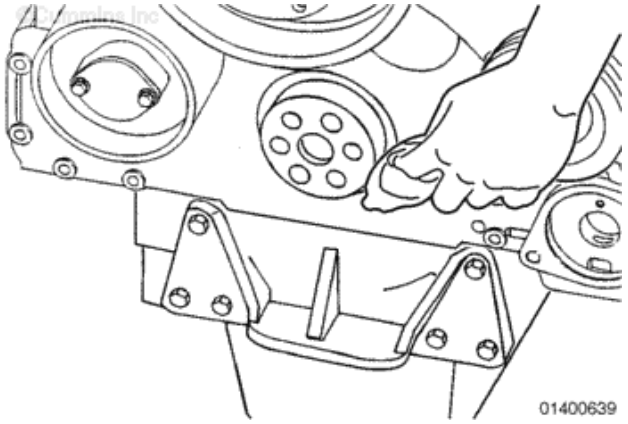


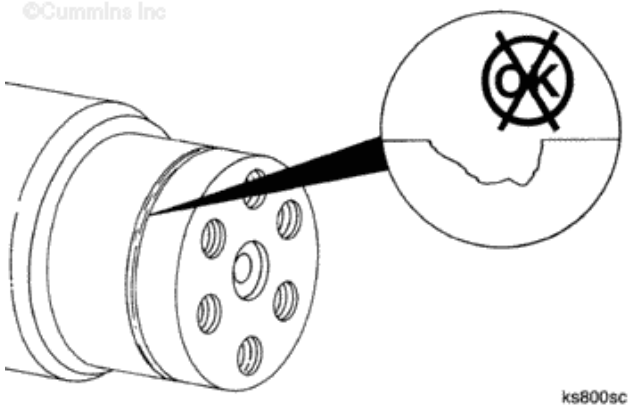




from the crankshaft. Refer to Procedure 001-025.		

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 nose of the crankshaft and the bore in the front gear housing with a clean cloth and contact cleaner, Part Number 3824510.		

Check for damage on the seal area of the crankshaft. If the crankshaft is grooved, the service seal that contains a wear sleeve and special oversized seal **must** be installed. Refer to Procedure 001-025 wear sleeve and seal assembly installation.		

Install

Standard

CAUTION

Do not lubricate the seal or the crankshaft. The seal can fail prematurely if the seal lip is exposed to oil too soon.

CAUTION

Do not use a hammer to drive the tool. Damage to the threads will result. The tool can bind to the crankshaft because of narrow tolerances.

NOTE: If a wear sleeve needs to be installed the wear sleeve and seal is installed as an assembly. Refer to Procedure 001-025.

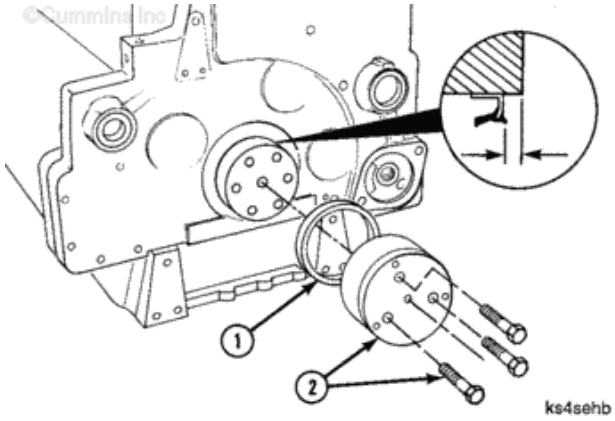
The standard seal contains a disposable expansion ring.

Place the expansion ring and seal over the end of the crankshaft.

Use hand pressure to push the seal on the crankshaft as far as possible.

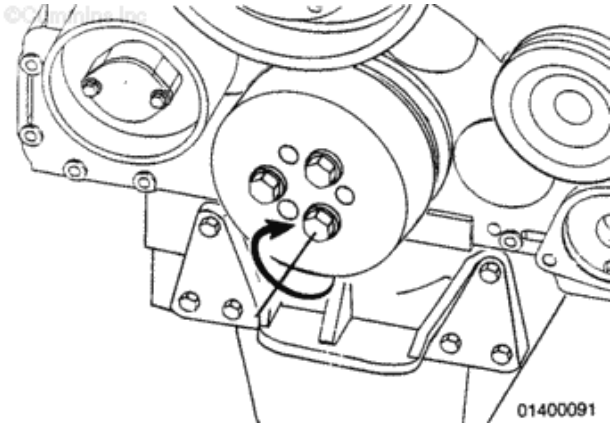
Remove and discard the expansion ring.

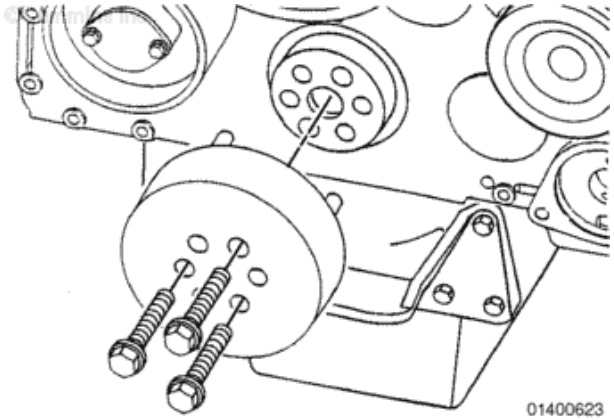
Place the mandrel, Part Number 3824761, from tool kit, Part Number 3824760, onto the crankshaft.



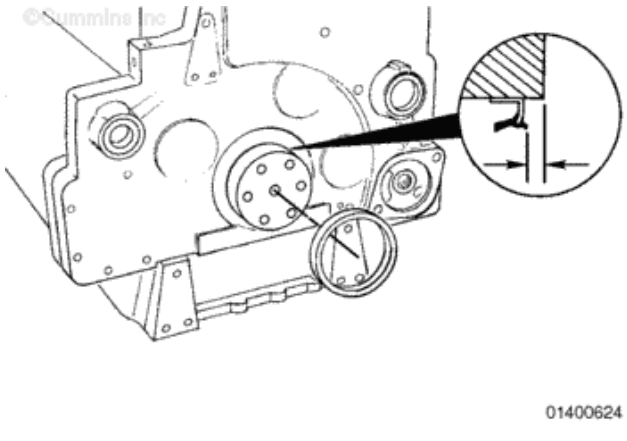
CAUTION

Do not continue to tighten the capscrews once the seal flange contacts the gear cover. Over-tightening will result in gear cover damage.

Install three crankshaft mounting capscrews into the mandrel. Tighten the capscrew alternately and evenly in ½-turn increments until the seal flange contacts the gear cover.		

Remove the installation tool.		

POSE

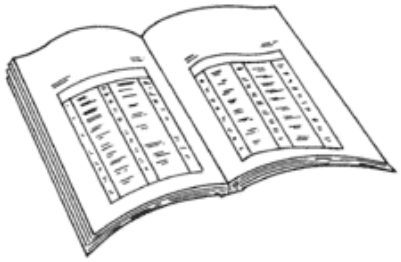
Place the positive on shaft excluder (POSE) seal onto the crankshaft. Push the seal on the crankshaft until it rests against the seal case.		

Finishing Steps

- Install the vibration damper. Refer to Procedure 001-052.
- Install the fan belt. Refer to Procedure 008-002.
- Install the cooling fan. Refer to Procedure 008-040.







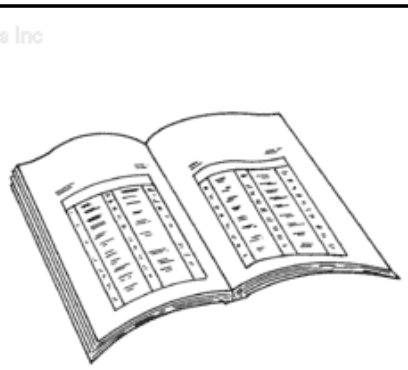
Last Modified: 24-Sep-2004

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001-024 Crankshaft Seal, Rear

Preparatory Steps

- Remove the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.
- Remove the flywheel. Refer to Procedure 016-005.



Remove

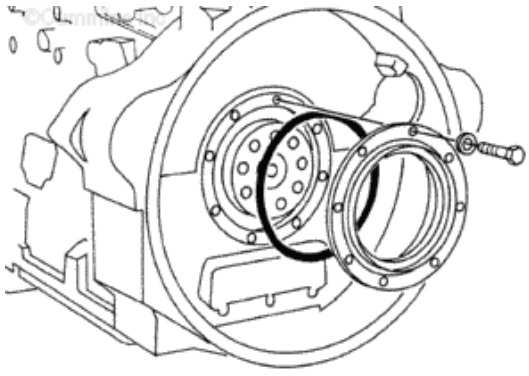
NOTE: If a service seal with a wear sleeve has been installed the wear sleeve must be removed from the crankshaft. Refer to Procedure 001-025.

The seal removal and installation procedures are the same for the wet type seal as for the dry type seal.

Remove the seal mounting capscrews.

Remove the seal and o-ring.

Discard the o-ring.

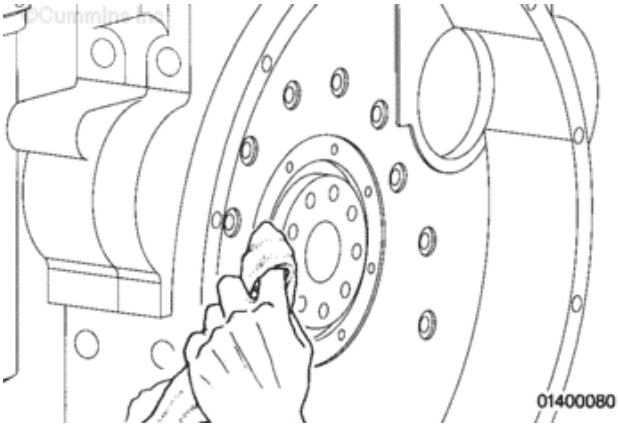


Clean and Inspect for Reuse

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.

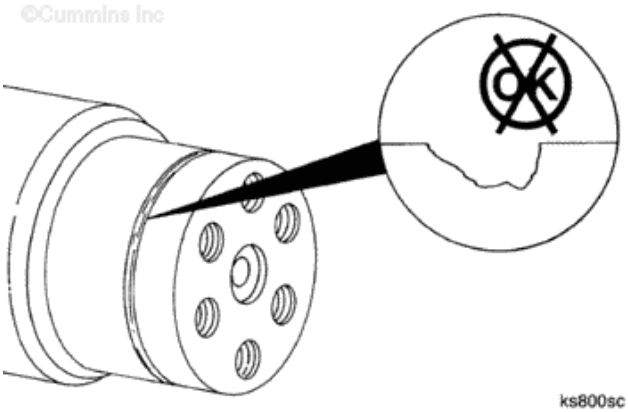
Clean the crankshaft and seal mounting area with a clean cloth and contact cleaner, Part Number 3824510.



Check for damage on the seal contact area of the crankshaft.

If the crankshaft is grooved, there are two options available.

- If the engine was built after October 1997, it has a “step” or two diameters on the rear. For these engines or engines rebuilt with the newer crankshaft, the unitized seal for the QSK19 series engine can be used.
- If the crankshaft does **not** have the “step” then a service seal with a wear sleeve as an assembly is available.



Install

Standard

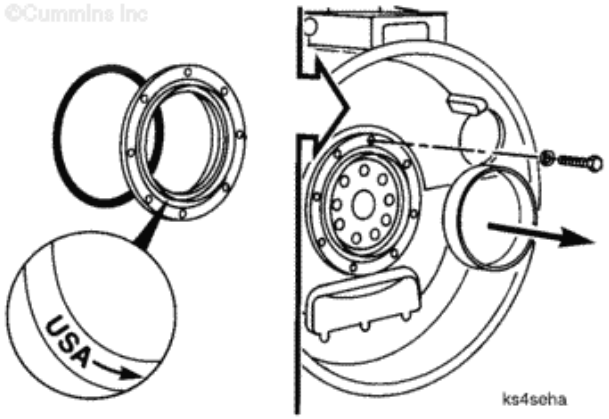
CAUTION

Do not lubricate the crankshaft or the seal lip. If the lip is exposed to oil to early, the risk of seal failure is increased.

Place the installation sleeve that comes with the seal onto the crankshaft.

Postion the seal as shown in the graphic and push the seal onto the crankshaft.

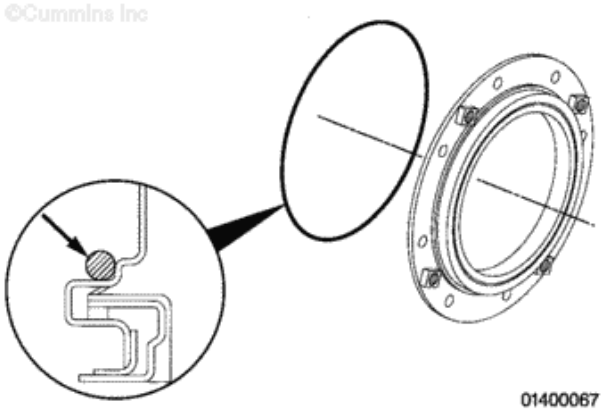
Remove the sleeve.



Non-REPTO Dry Unitized Seal

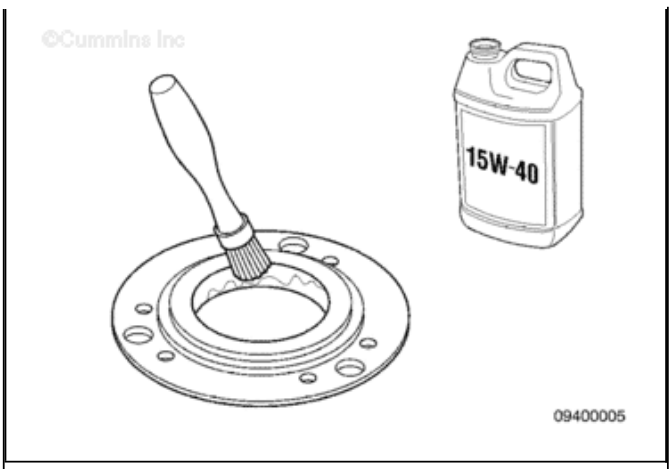
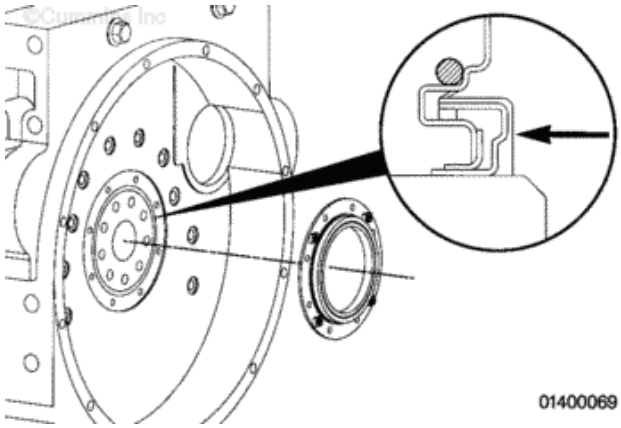
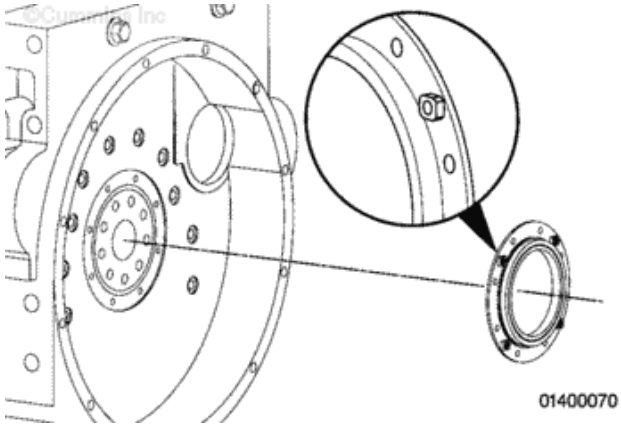
Install a new o-ring on the seal housing.

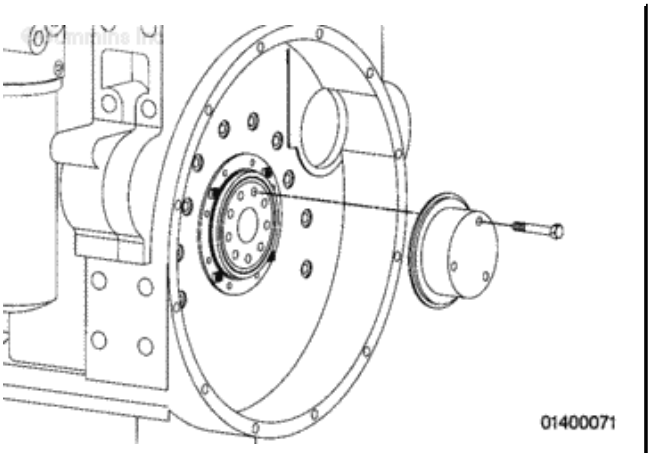
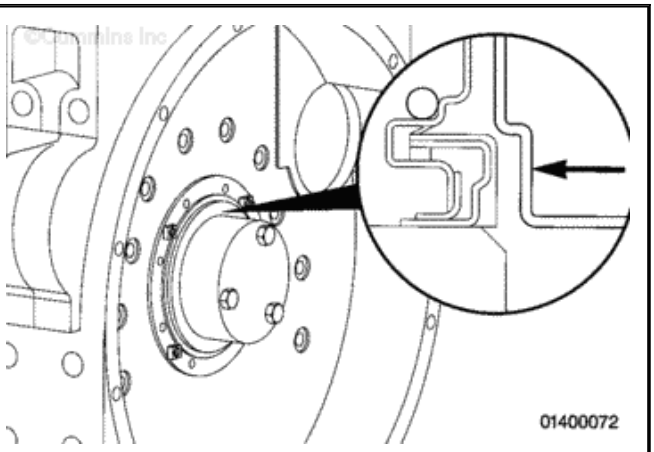
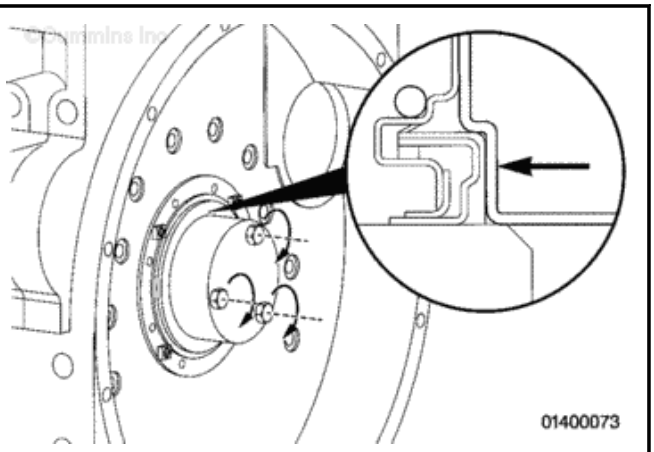
Lubricate the o-ring with vegetable oil.

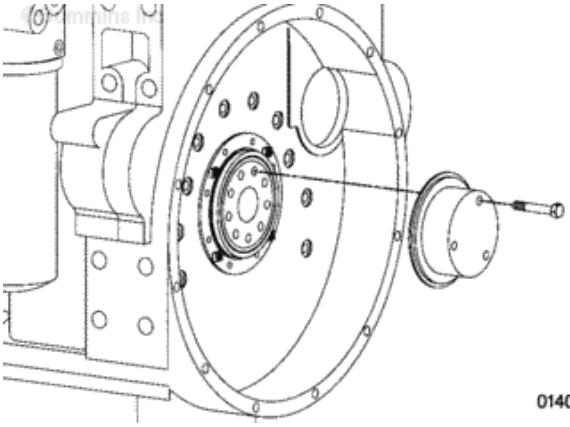


CAUTION

To reduce the possibility of damaging the sealing surfaces, do not allow oil to contact with any area other than the inside diameter of the seal case.

To aid in seal installation, use a small nonmetallic bristle brush to apply a thin film of 15W-40 oil to the inside diameter of the seal case.		
Use hand pressure to push the seal on the crankshaft as far as possible.		
Use the pin supplied in the seal kit to align the seal mounting holes with the mounting capscrew holes in the flywheel housing.		
Attach the seal installation tool that is supplied with the seal, to the crankshaft, using three flywheel mounting		

capscrews.		
Align the installation tool with the pilot flange on the seal carrier.		
Tighten the three capscrews alternately in ½ turn increments until the seal carrier seats against the flywheel housing.		
Remove the seal installation tool.		



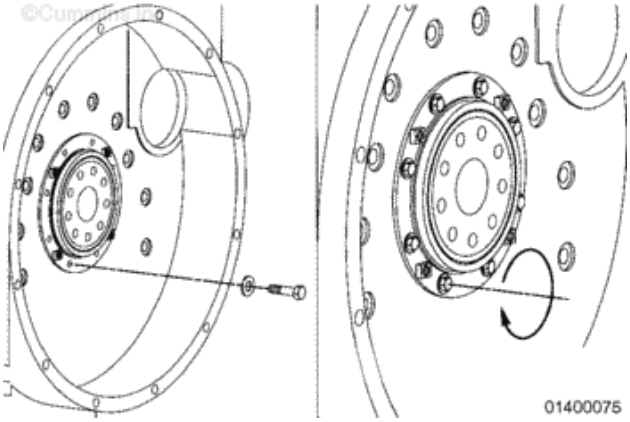
All Applications

Lubricate the threads of the capscrews with non-hardening sealant, Part Number 3375066.

Install the seal mounting capscrews.

Tighten the capscrews.

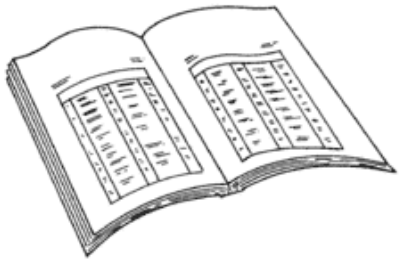
Torque
Value: 11 n.m [95 in-lb]



Finishing Steps

- Install the flywheel. Refer to Procedure 016-005.
- Install the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.

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ck800wa

Last Modified: 29-Sep-2004

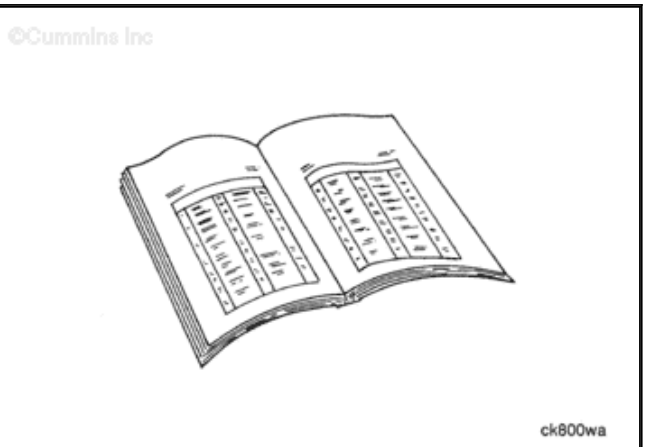
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001-025 Crankshaft Wear Sleeve, Front

Preparatory Steps

- Remove the cooling fan. Refer to Procedure 008-040.
- Remove the fan belt. Refer to Procedure 008-002.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the front crankshaft seal. Refer to Procedure 001-023.

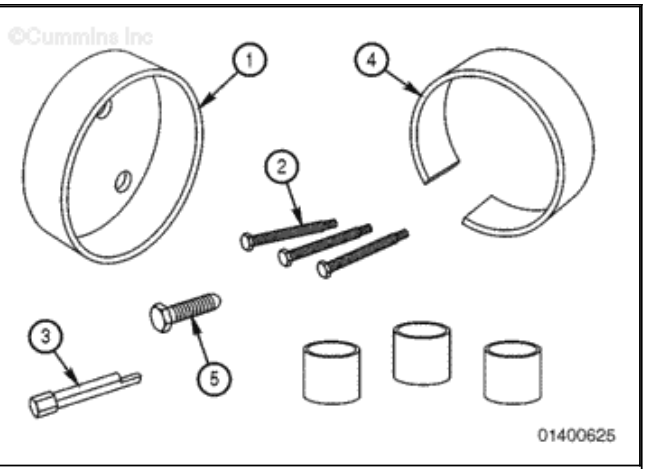




Remove

The parts contained in the Oil Seal/Wear Sleeve Installer/Puller, Part Number 3824760 are:

(1) Mandrel, Part Number 3824761
(2) Special puller screws, Part Number 3824762
(3) Expander (chisel), Part Number 3824763
(4) Protective sleeve, Part Number 3824764
(5) Center puller screw, Part Number 3375099.



CAUTION

It is not necessary to completely cut the wear sleeve. If the sleeve is completely cut the crankshaft can be damaged.

If a service seal with a wear sleeve has been installed the wear sleeve **must** be removed from the crankshaft.

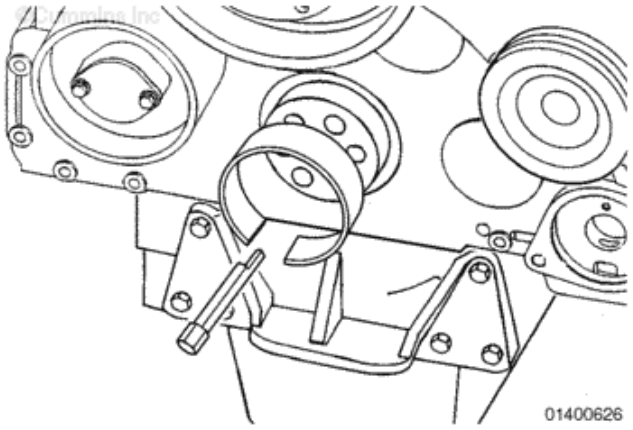
Install the protective sleeve, Part Number 3824764, in the seal bore of the front gear cover. The protective sleeve will protect the front gear cover bore from damage.

Insert the expander (chisel), Part Number 3824763, between the wear sleeve and protective sleeve.

Turn the expander (chisel) so the nose deforms the sleeve. Repeat this procedure at three or four points around the sleeve.

The sleeve press fit will be reduced and can be lifted off of the crankshaft.

Remove the protective sleeve from the gear cover.



Install

CAUTION

Do not remove the seal from the wear sleeve. If the

seal is removed from the wear sleeve it can be damaged during the installation process.

CAUTION

The wear sleeve and the seal must be installed simultaneously using a special tool. Attempting to install the assembly without the tool will result in failure of the seal and an oil leak.

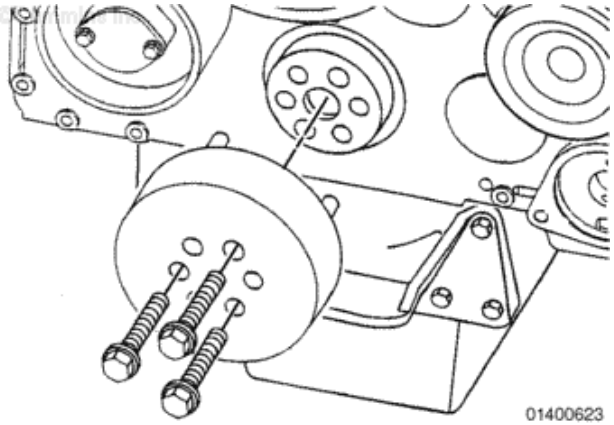
Insert the seal and wear sleeve assembly into the mandrel, Part Number 3824761.

Postion the mandrel onto the crankshaft.

Install the special puller capscrews, Part Number 3824762.

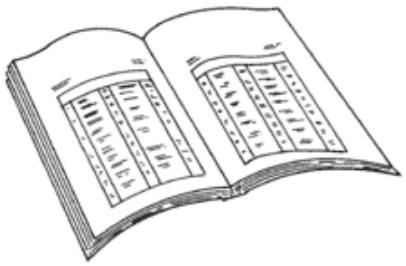
Tighten the capscrews alternately approximately ½-turn at a time until the tool touches the gear cover.

Remove the mandrel.



Finishing Steps

- Install the vibration damper. Refer to Procedure 001-052.
- Install the fan belt. Refer to Procedure 008-002.
- Install the cooling fan. Refer to Procedure 008-040.



ck800wa

Last Modified: 07-Dec-2004

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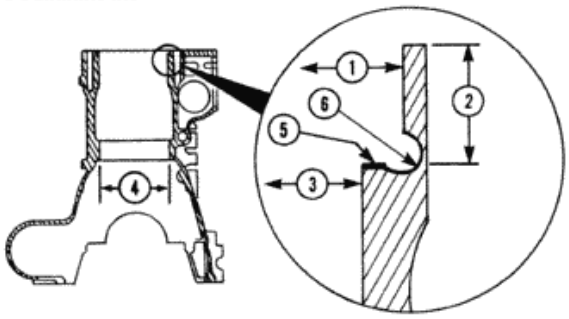
001-026 Cylinder Block

General Information

There are seven variations of K19 cylinder blocks and oversize liners now in the field. Use the following information to identify the parts that are used. Make sure the correct parts are used with the correct block.

Definition of counterbore features:

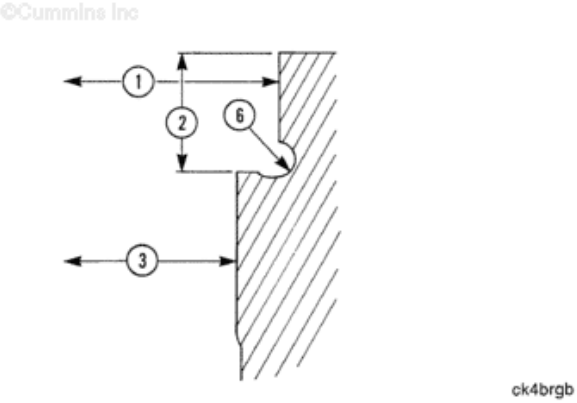
(1) Upper counterbore inside diameter, called upper press fit inside diameter
(2) Counterbore depth
(3) Lower counterbore inside diameter, called lower press fit inside diameter
(4) Packing ring bore
(5) Counterbore ledge
(6) Counter bore radius (graphic illustrates double undercut radius).



ck4brgl

The thick flanged block has:

(1) The upper press fit inside diameter of the bore is machined at the factory and referred to as standard. The inside diameter of the standard bore is 188.16 to 188.21 mm [7.408 to 7.410 in].
(2) The counterbore standard depth for some engines built between September 1994, engine serial number 37155415 and June 1995 engine serial number 37158125 and after is 13.754 to 13.805 mm [0.5412 to 0544 in]. The counterbore standard depth for all engines built June 1995, engine serial number 37158125 is 13.754 to 13.805 mm [0.542 to 0.544 in]. The counterbore standard depth for all blocks manufactured from February 1981 to September 1994, engine serial number 37155415 is



ck4brgb

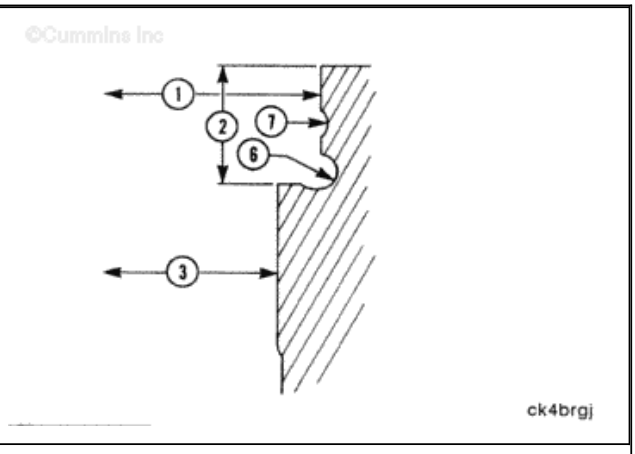
13.23 to 13.28 mm [0.521 ot 0.523 in].
(3) Lower press fit inside diameter of the bore is machined at the factory and referred to as standard. The inside diameter of the standard bore is 180.07 to 180.14 mm [7.090 to 7.092 in].
(6) The thick flange block has the double undercut radius.

Most engines with an engine serial number greater than 311216 70 (February 1981) contain this type of block.

All K19 engines with engine serial number that begins with 37 (December 1986) and engines with a serial number that begins with a 66, have this type of block.

The thin flange factory modified block is the same as the thick flange block except for the groove (7) which has no function.

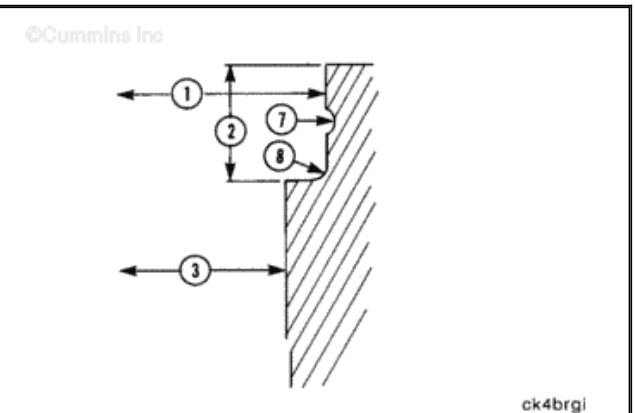
This block is treated exactly the same as the thick flange block.



The thin flange field modified to thick flange block will be referred to as the ex-thin flange block.

(1) The upper press fit inside diameter varies with the upper press fit oversized liner used during the modification.
(2) The depth is 13.23 to 13.28 mm [0.521 to 0.523 in].
(3) The lower press fit inside diameter is the same as the thick flange block.
(8) It has a 1.73 to 1.85 mm [0.068 to 0.073 in] radius that is **not** undercut.

This type block is found on engines with engine serial number between

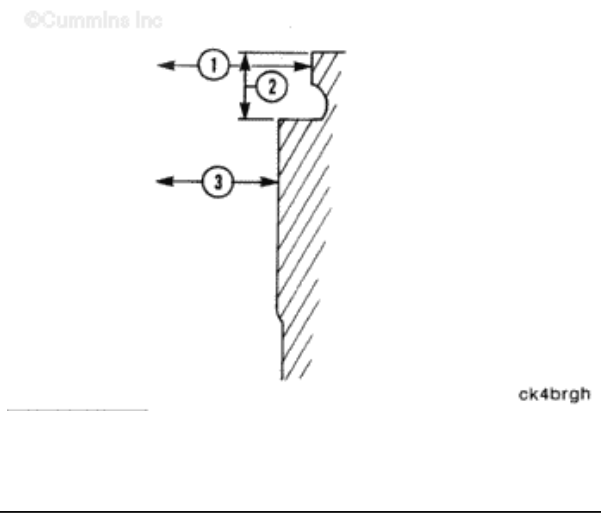


31103629 (November 1976) and 31121670 (February 1981). as they were originally built with thin flange blocks.

The thin flange block has:

(1) A upper press fit inside diameter that can vary depending on the type of the upper press fit oversized thin flange liner used. Standard thin flanged liners are available. Oversized thin flange liners are no longer available.
(2) Counterbore depth is 7.62 to 7.67 mm [0.300 ot 0.302 in].
(3) Lower press fit inside diameter is the same as the thick flange type.

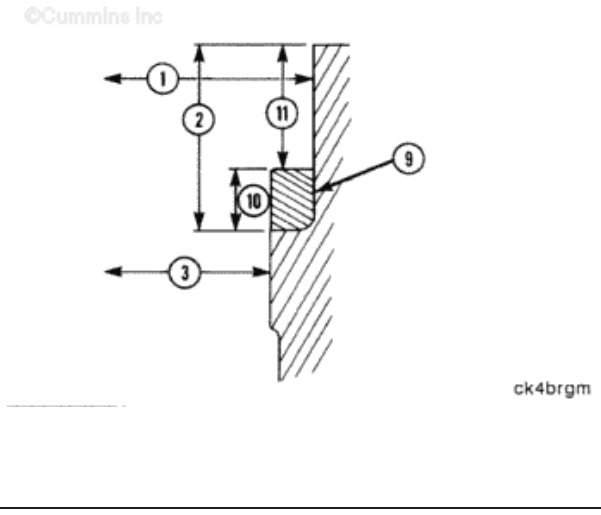
The radius is double undercut. This type of block is found on engines with an engine serial number range of 31103629 to 31121669.



The counterbore ring thick flange (8) is identified by the counter bore ring.

Depth (2), depth (11) and the inside diameter (3) are the same as present K38 and K50 engines thus use standard and oversized K38 and K50 liners. This type is **not** lower press fit. That is, by design there was **not** always a press fit below the liner flange (3). There is no recommended salvage for the inside diameter (3) on these blocks.

This type block is found on engines with an engine serial range between 31101150 (August 1975) to 31103628 (November 1976).



The original K19:

- (1) Upper press fit inside diameter is the same as the present K38 and K50 engines.
- (2) Depth is the same as the present K38 and K50 engines.
- (3) Lower counterbore is the same as the present K38 and

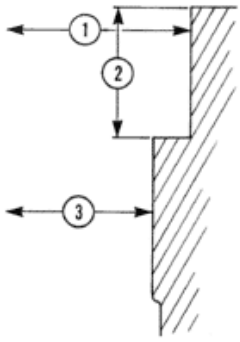
K50, but will probably **not** provide press fit to the liner.

There is no recommended salvage for the inside diameter (3) on this type block.

This type of block is found on engines with an engine serial number range of 31100101 (July 1974) to 31101149 (August 1975).

Cummins Inc. recommends this style block **not** be reused.

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ck4brgg

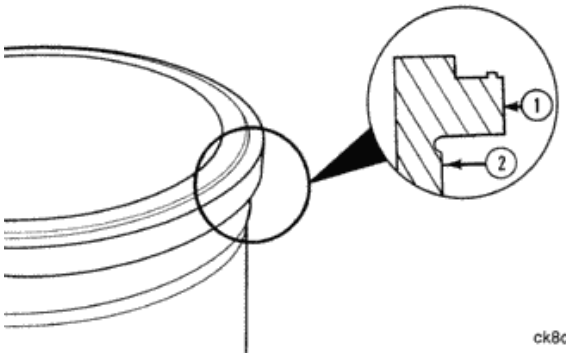
The cylinder liners are:

(1) Flange outside diameter referred to as the upper press fit outside diameter.
(2) Referred to as lower press fit outside diameter.

The standard K19 liners are those liners used in new production K19 engines. Oversized liners have dimensions that are oversized with respect to the standard liner.

For example, 20/20 OS means the upper press fit outside diameter (1) is 0.020 inch larger than the standard liner and the lower press fit outside diameter is 0.020 in larger than the standard liner.

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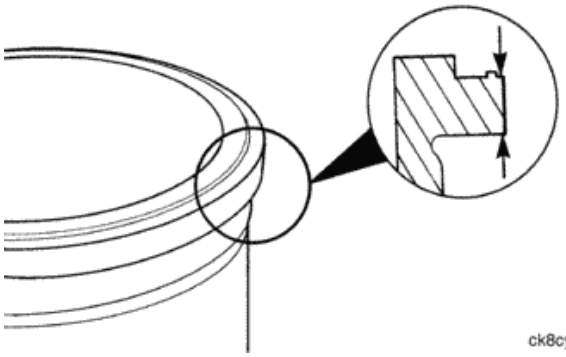


ck8cytc

The specification for the liner flange thickness on all K19 liners, standard and oversized is the same, 13.360 to 13.365 mm [0.526 to 0.527 in].

The K38 and K50 liner is referred to as the liner used to in new production K38 and K50 engines. The K38 and K50 production liner upper press fit outside diameter is normally 2.16 mm [0.085 in] larger and the lower press fit outside diameter is normally 1.65 mm [0.065 in] larger than the respective outside diameter on the standard K19 liner.

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ck8cyta

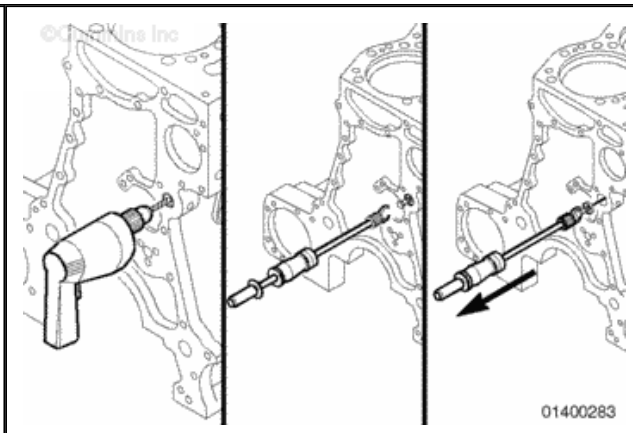
The K38 and K50 liner can be described as 85/65 oversized with respect to the K19. The use of K38 and K50 oversized upper press fit liners to repair K19 counterbores is **not** recommended.

The use of standard K38 and K50 liners in a properly machined K19 block is authorized.

Disassemble

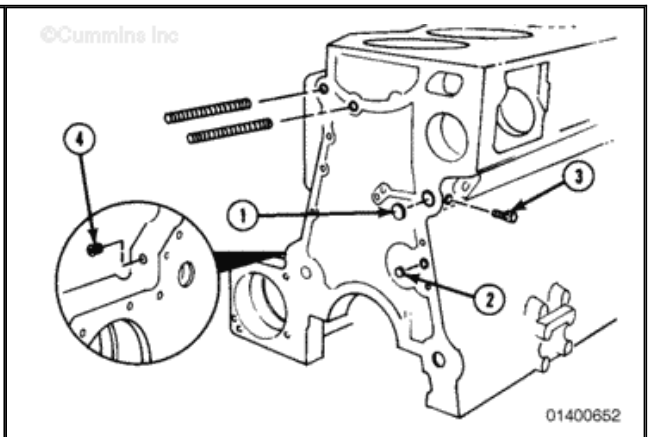
Use a drill, a sheet metal screw, and the listed parts from the light duty puller kit, Part Number 3375784:

- Slide hammer
- Hook.



Remove the listed plugs:

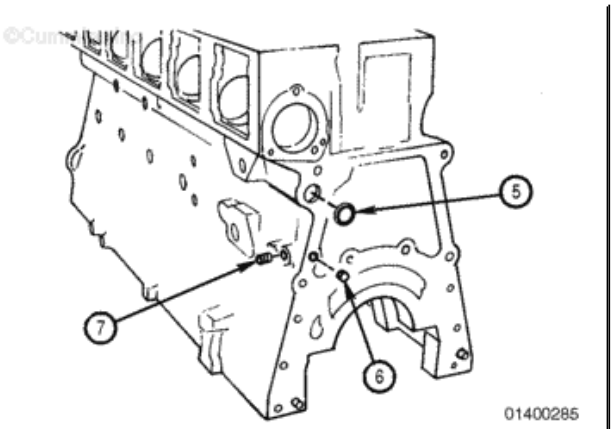
(1) Main oil passage cup plug
(2) Piston cooling oil passage cup plug
(3) Main oil passage pipe plug
(4) Water pump idler oil passage plug.



NOTE: Engines equipped with a rear gear drive must not have a plug in the main oil passage.

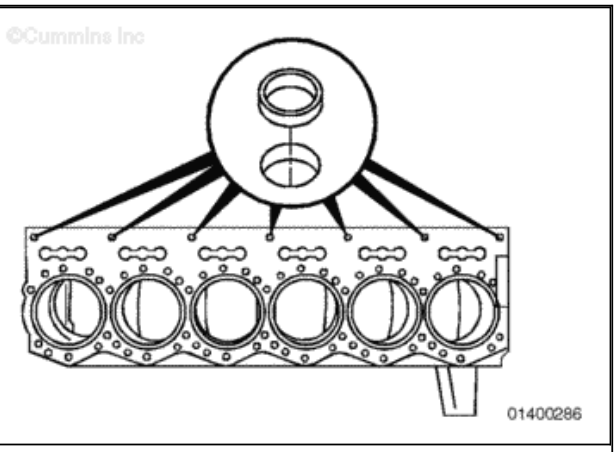
Remove the listed plugs:

(5) Main oil passage cup plug
(6) Piston cooling rifle cup plug
(7) Piston cooling oil passage pipe plug.



Remove the seven cup plugs from the camshaft oil passages.

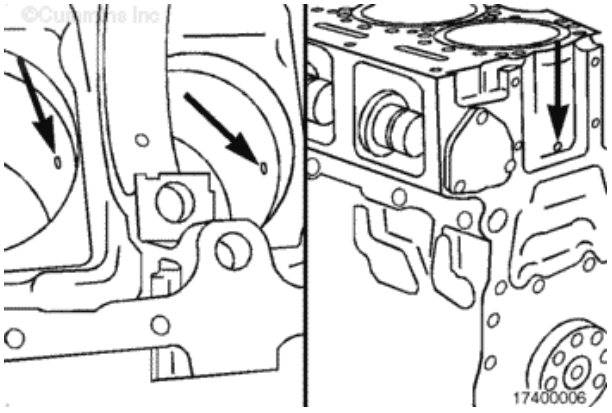
These passages extend through the camshaft bores to the main bearing bores. The passage for the number six main rifle contains a steel tube that has an interference fit with the drilled passage.



To allow for the proper coolant flow and air removal of the cylinder head and engine block on a horizontally mounted K19 engine, a coolant drilling runs the entire length of the cylinder block and passes through the center of each cylinder liner cavity.

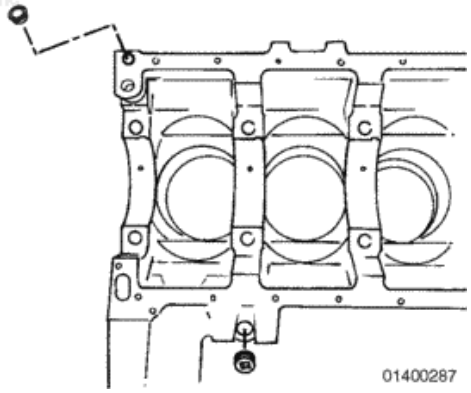
The drilling is plugged by a ¼ pipe plug.

It is **not** necessary to remove the cup plug at the end of the block unless it is leaking.



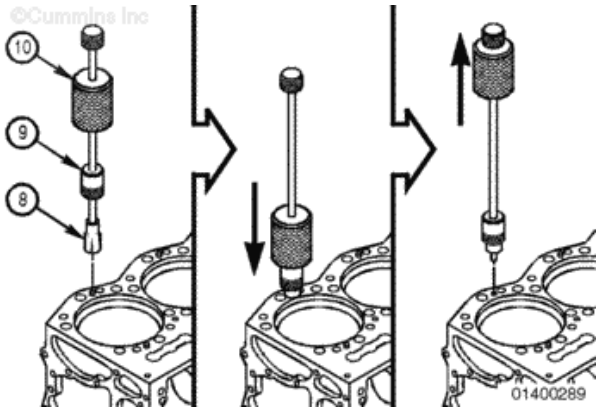
Remove the cup plug from the hydraulic pump idler oil passage.

Remove the pipe plug from the lubricating oil pump oil passage.



Use dowel pin extractor, Part Number 3163720, or equivalent to perform the listed steps to remove the 12 cylinder head groove pins.

1. Place the split collet (8) over the groove pin.
2. Slide the extractor collar (9) over the split collet.
3. Use the slide hammer (10) to push the extractor collar over the split collet tightly.
4. Use the slide hammer to remove the groove pin.

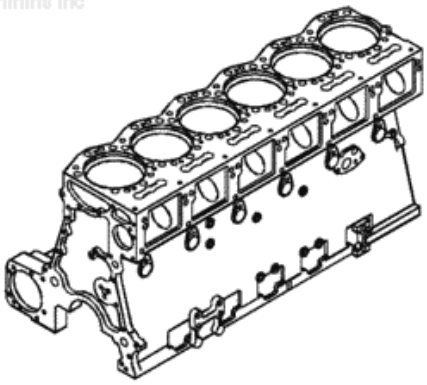


Clean and Inspect for Reuse

CAUTION

To reduce the possibility of leaks and engine damage, do not damage the machine gasket surfaces or the camshaft bushings.

Use a scraper, a wire brush, or hand pad, Part Number 3823258, to clean all of the heavy dirt deposits off of the cylinder block and clean:



- All gasket surfaces
- All mounting surfaces
- Cylinder liner counterbore ledge and press fit areas
- Cylinder liner packing ring bore
- Top of block
- Main bearing saddle and caps
- All cup plug bores.

Clean all of the oil passages with a long handle bottle brush.

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

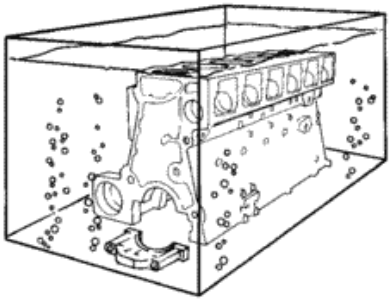
A cleaning solution must be used that will not harm camshaft bearings.

Cummins Inc. does **not** recommend any specific cleaning solution. Refer to the General Cleaning Instructions Procedure 204-008.

Follow the instructions of the manufacturer of the cleaning tank and the manufacturer of the cleaning solution.

Remove the bock from the engine stand and place it into a tank of cleaning solution.

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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.

CAUTION

To reduce the possibility of damage to the cylinder block, make sure all of the water is removed from the capscrew holes and the oil passages.

Remove the block from the cleaning tank.

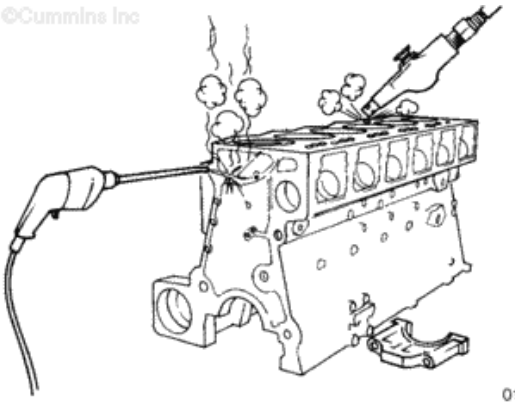
Steam clean the block.

Make sure all of the oil passages are clean.

Dry the block with compressed air.

If the cylinder block is **not** going to be used immediately, apply a coating of preservative oil to prevent rust.

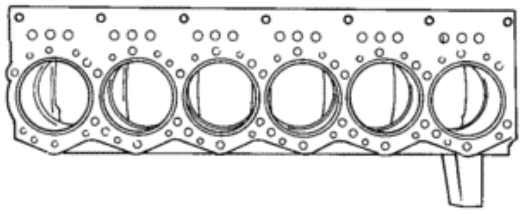
Cover the block to prevent dirt from sticking to the oil.



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 if it does **not** change the protrusion measurement of the counterbore or liner.

A newly machined surface **must** be flat within 0.05 mm [0.002 in] under a cylinder head. Waves on the surface are acceptable as long as they are **not** more than



0.018 mm [0.0007 in] high, and the high and low points of the waves are **not** closer than 25 mm [1.0 in].

A newly machined surface **must** meet the specifications for block height. The top of the surface of the cylinder liner counterbore **must** be machined.

The parting line of the main bearing cap is **not** at the same height as the centerline of the main bearing bore.

Measure the cylinder block height.

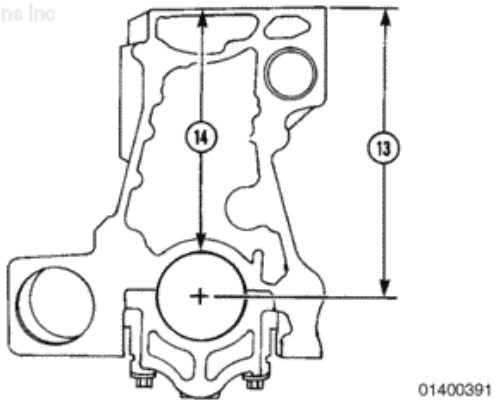
If the checking ring or the centering ring is **not** available, the height of the block can be measured from top of the bearing saddle (14)

Cylinder Block Height		
	mm	in
(13) Center Line Main Bearing Bore	481.91 MIN	18.974
	482.76 MAX	19.007
(14) Top of Main Bearing Saddle	407.70 MIN	16.051
	408.53 MAX	16.084

If the height of the block from the crankshaft centerline is less than 482.42 mm [18.993 in] a 0.51 mm [0.020 in] oversize head gasket **must** be used.

If the height of the block from the main bearing bore is less than 408.20 mm [16.071 in] a 0.51 mm [0.020 in] oversize head gasket **must** be used.

The height of the block **must not** vary more than 0.05 mm [0.002 in] from end to end of the block. If the block height is **not**



within specifications, the top surface of the block **must** be machined or the block replaced.

If the top surface of the block is machined, ledge depth of the cylinder liner counterbore **must** be machined.

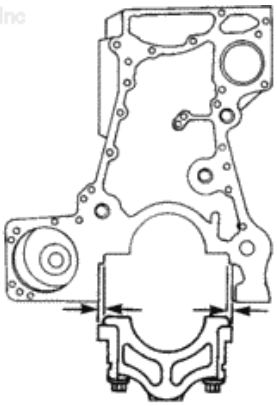
Check the main bearing caps that are loose.

The main bearing cap **must** be repalced if:

- The clearance causes the main bore alignment **not** to be within specifications.
- The clearance between the block and the cap is more than 0.17 mm [0.007 in] on either side of the cap when the cap is installed and tightened to specifications.
- There is fretting or heat damage to the cap.

On new or reconditioned blocks, the main bearing cap is 0.00 to 0.13 mm [0.00 to 0.010 in] larger than the block. Force **must** be used to install the caps.

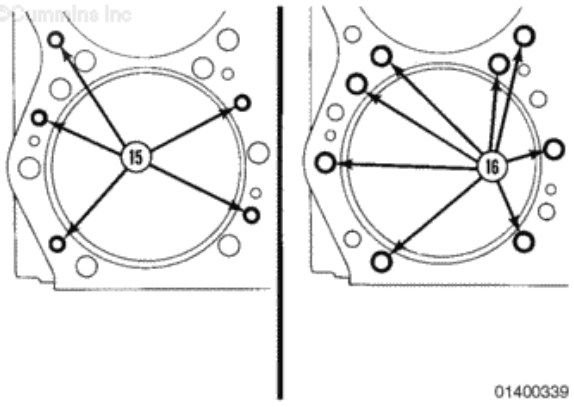
Service caps do **not** have the bore machined to a final specification. If the cap is machined, use the correct parts of the main bearing boring tool, Part Number ST-1177.



Check the water holes (15). If erosion or pitting is more than 0.08 mm [0.003 in] deep or extends more than 2.4 mm [0.095 in] from the edge of the water hole, the water hole **must** be repaired.

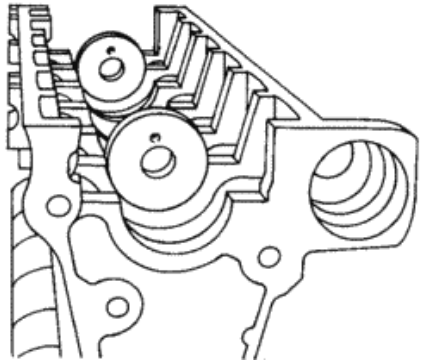
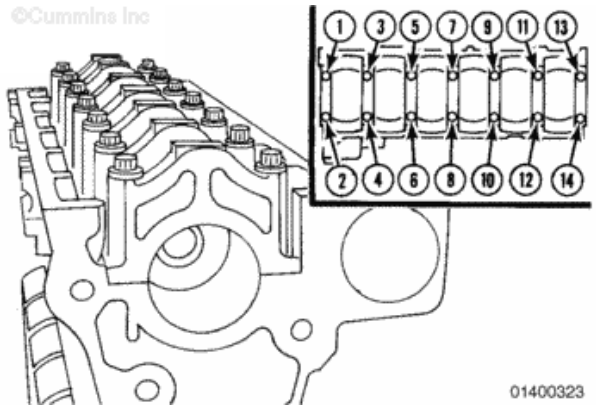
Use the coolant passage repair kit, Part Number 3824047 or the water hole surface repair kit, Part Number 3824066 to repair the water hole.

Check the threads of the capscrew holes (16) for damage. Use a threaded insert if a damaged hole **must** be



repaired.		

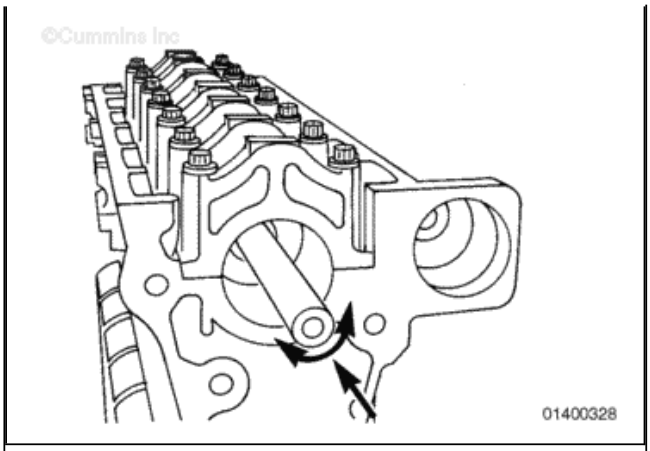
Main Bearing Bore

Place two centering rings, Part Number ST-1177-54 in the number two and number six main bearing locations.		
The main bearing caps are numbered one through seven. Install each cap in the correct location. The slot in the cap for the bearing tang **must** be on the same side as the slot in the block. Position the main bearing caps in the cylinder block. Install the capscrews, making sure they are positioned correctly. Use a mallet to drive the caps down until they touch the block. If any of the caps do **not** require force during installation, mark the cap to check the side clearance. Tighten the capscrews for the main bearing caps. **Torque Value:** Step 1 270 n.m [200 ft-lb] Step 2 610 n.m [450 ft-lb]		
Lubricate the inside diameter of the two centering rings. Install the alignment/boring bar, Part Number ST-1177-16, in the two centering rings.		

The bar **must** turn easily.

If the bar does **not** turn easily, make sure the main bearing caps are installed correctly.

If the main bearing caps appear to be installed correctly, move the centering ring to another bearing location.

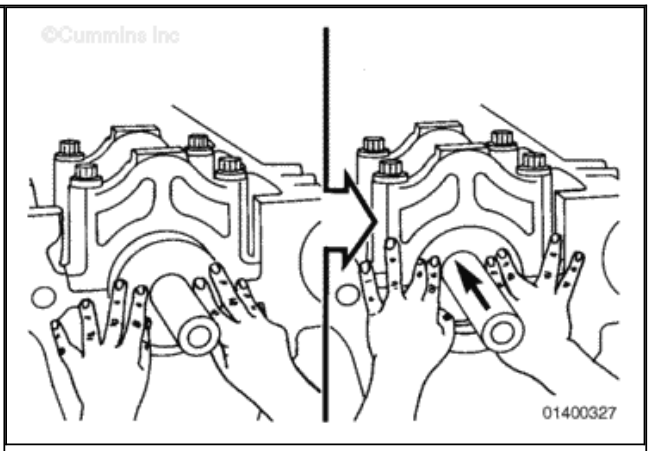


Install the checking ring into the main bearing bore by hand.

If the ring will **not** slide through the, check the bore for burrs.

Remove any burrs in the bore.

If the checking ring still will **not** slide through the bore, the bore is undersized and **must** be repaired. Refer to the Alternate Repair Manual, Bulletin 3379035.



Use a 0.075 mm [0.003 in] feeler gauge that is **not** more than 13 mm [0.5 in] wide.

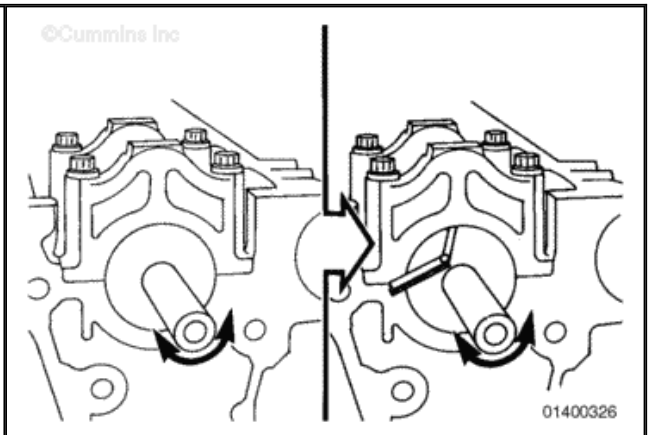
Center the checking ring in the bore.

Attempt to insert the feeler gauge between the checking ring and the bore.

Rotate the gauge in the bore at both sides of the checking ring.

The bore alignment of the main bearing is acceptable if:

- The gauge does **not** enter at any point.
- The gauge will enter, but will **not** slide through or around the bore, and the alignment bar will rotate with the gauge inserted.



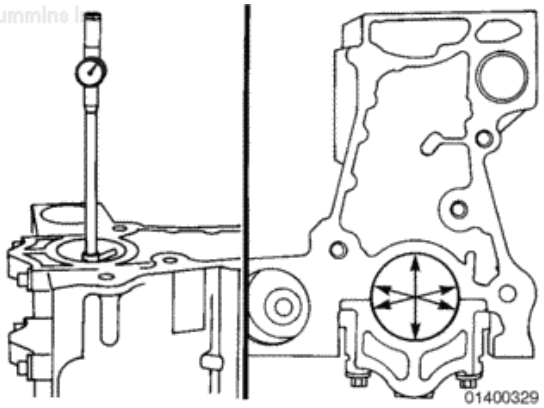
The bore alignment of the main bearing is **not** acceptable if:

- The gauge enters and slides around the bore. This indicates the bore is oversize and **must** be repaired.
- The gauge will enter on one side **only**, but can slide around the bore. This indicates the bore is tapered and **must** be repaired.

If the tools to check the main bearing bore alignment are **not** available, use a dial bore indicator.

Support the rear portion of the block on a flat surface to obtain the most accurate measurement of the inside diameter.

Measure the inside diameter in the three positions illustrated in the graphic. The inside diameter **must** be completely round within 0.013 mm [0.0005 in].



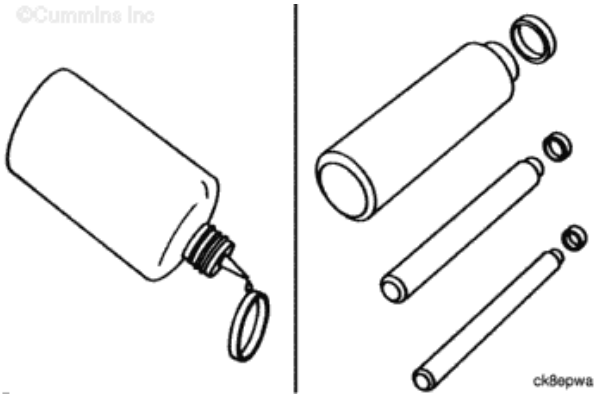
Assemble

CAUTION

Do not install any cup plugs or pipe plugs in the block until the inspect and any necessary repair procedures are completed. This will prevent dirt from being trapped in any oil passages.

Apply a thin coat of pipe Loctite sealant, Part Number 3375068, or equivalent, to the pipe or cup plugs.

Install the pipe plugs.



Use cup plug driver, Part Number 3164085 or 3376795 with all cup plug drivers to install the cup plugs.

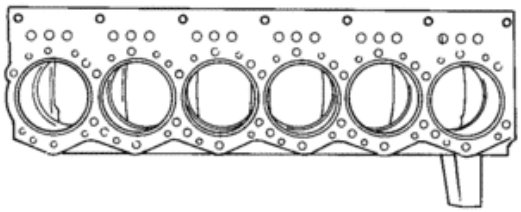
Cup Plug Driver Part Number	Cup Plug Size
3822372	0.375 in
3376793	0.500 in
3376813	0.875 in
3376812	1.125 in
3376814	1.625 in

Crack Detection Test

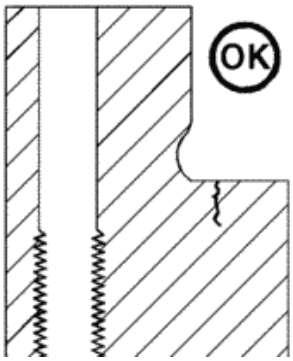
WARNING

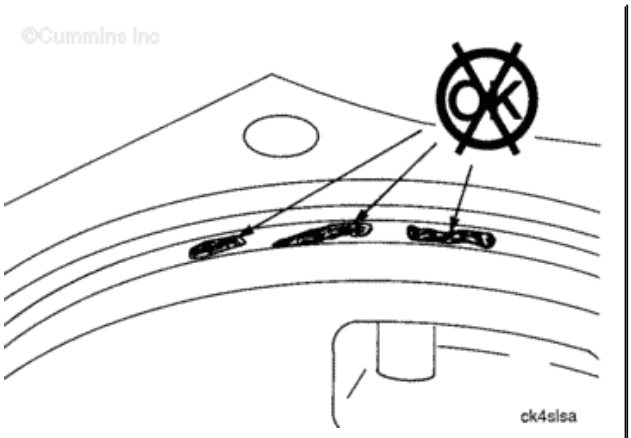
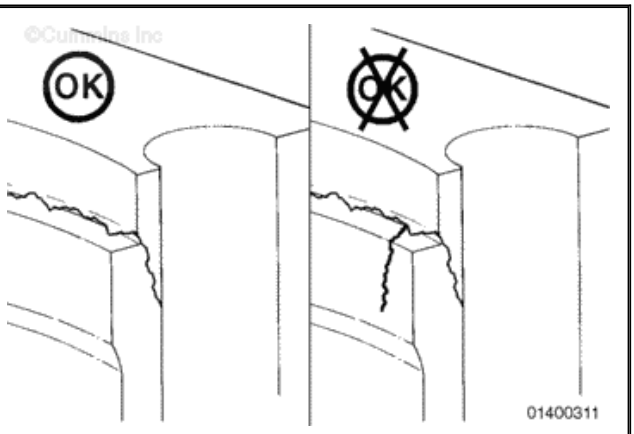
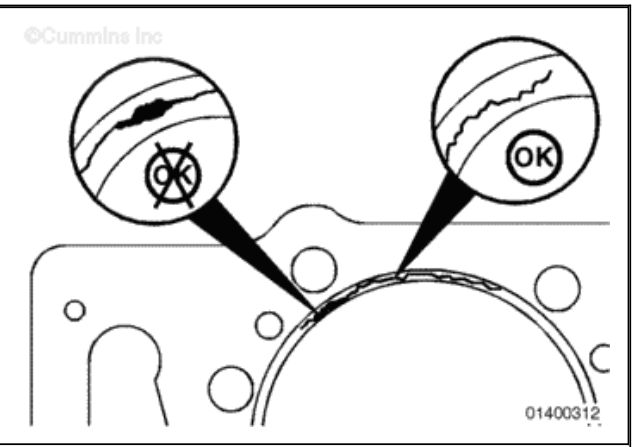
When using solvents, acids or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

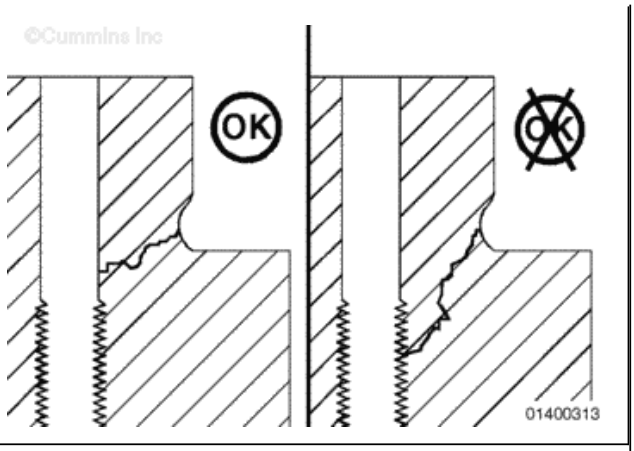
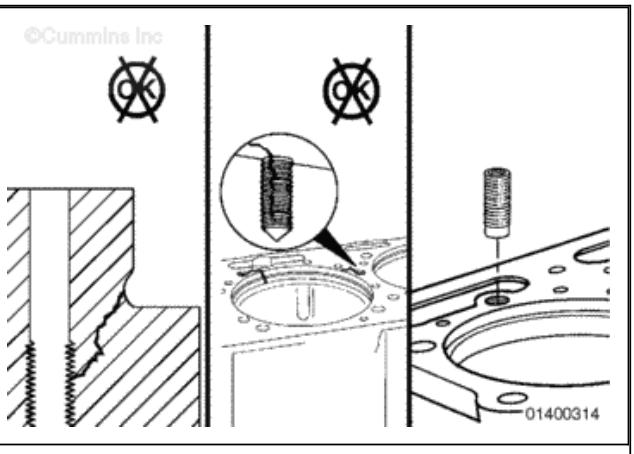
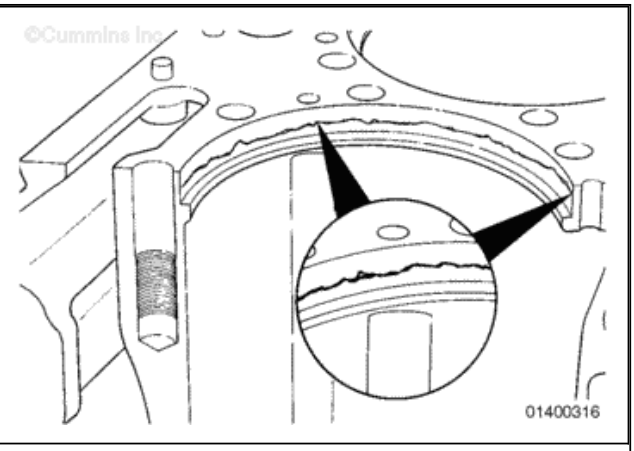
Clean the counterbore area with safety solvent.



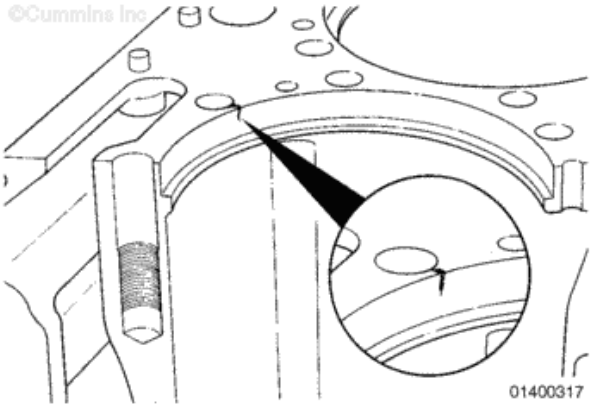
Metallurgical analysis of cross sections of counterbores having circumferential cracks has revealed the cracks are surfaced initiated on the top of the counterbore ledge, and normally do **not** propagate vertically through the counterbore ledge into the coolant passage around the cylinder liner.



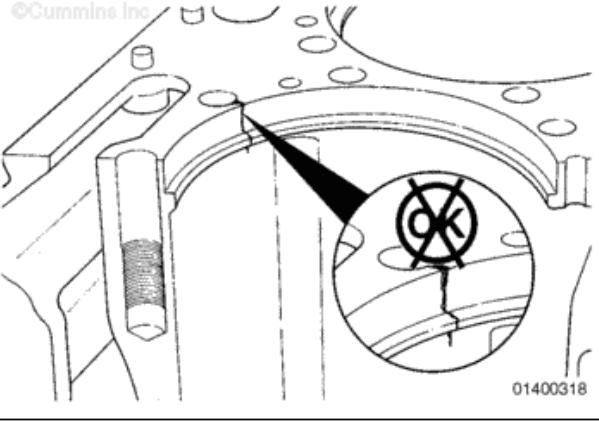
Pitting on the liner seat is **not** acceptable. The illustration in the graphic is an example of pitting in a damaged area. This block requires machining before it can be used. Refer to Procedure 001-028 for the machine depth for the seal ring.		
Check the counterbore ledge for cracks with crack detection kit, Part Number 3375432, or equivalent. Circumferential cracks of the counterbore ledge are acceptable if the cracks do **not** extend to or over the edge of the ledge as shown in the illustration. Circumferential cracks in the radius are acceptable if they do **not** extend more than 90 degrees around the radius.		
It is **not** necessary to machine the block in an effort to remove acceptable cracks. If cracks that are **not** acceptable are found during the initial inspection, the counterbore **must** be machined. If a crack that is **not** acceptable remains after the machining repair procedure is completed, the block is **not** acceptable for use.		
Check the capscrew holes for cracks. Cracks that extend from the counter bore wall to the capscrew hole are acceptable		

for use **only** if they do **not**extend into the threaded portion of the hole.		
Cracks that extend into the threaded portion of the capscrew hole require repair with a blind-end thread insert. Use the thread salvage kit, Part Number 3164021 or 3376208 to repair the insert.		
Check for cracks running horizontally around the vertical wall of the counterbore. All coolant passages that are closest to the bore **must** be repaired with coolant passage threaded inserts.		
Check for cracks that run vertically to a coolant passage or a capscrew hole. Those passages **must** be repaired with coolant passage		

threaded inserts.



Cylinder block with vertical cracks that extend from a coolant passage down over the counterbore ledge can **not** be repaired.

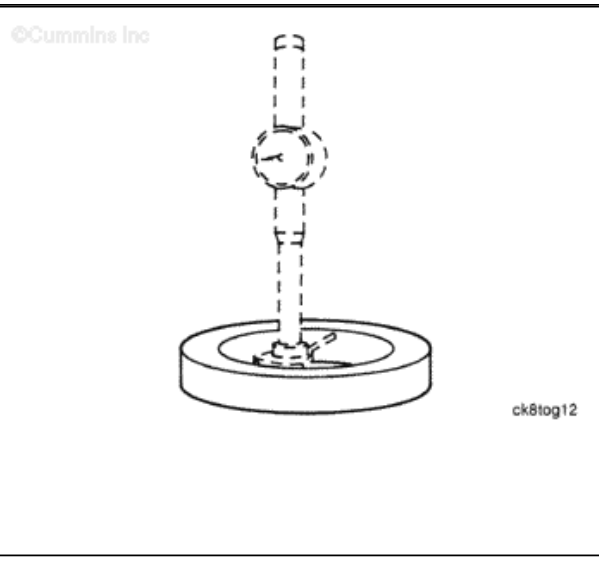


Measure

Two dial bore gauge setting rings have been released to support salvage of the lower press fit bore in a K19 cylinder block.

Both rings have steps:

- Standard/0.020 - The inside diameter of the bores in the gauge are:
  Small inside diameter (Standard K19) - 180.11 mm [7.091 in]
  Large inside diameter (0.020 oversized) - 180.619 mm [7.111 in]



- 0.065/0.85 - The inside diameter of the bores in the gauge are are:
  Small inside diameter (0.065 oversized) - 181.765 mm [7.156 in]
  Large inside diameter (0.085 oversized) - 182.270 mm [7.176 in]

The 0.065 oversize ring for the k19 is the same a s the new production lower press fit ring on the K38 and K50 engines.

Both of the setting rings are included in counterbore salvage kit, Part Number 3824119.

The following lower press fit bore specifications apply to the thick flange, thin flange factory modified, ex-thin and thin flange type blocks.

(3) New Block Lower Press Fit Specifications		
mm		in
180.07	MIN	7.090
180.14	MAX	7.092

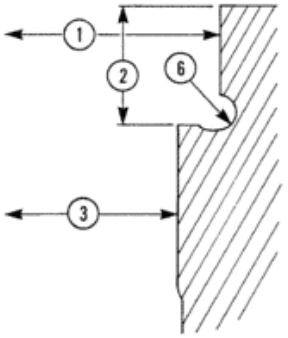
New Block Maximum Out of Round		
mm		in
0.05	MAX	0.002

In Service Lower Press Fit Specifications		
mm		in
180.07	MIN	7.090
180.16	MAX	7.093

In Service Maximum Out of Round		
mm		in
0.08	MAX	0.003

There **must** be a minimum of 0.025 mm [0.001 in] press fit all around between the lower press fit outside diameter of the liner and the lower press fit inside diameter of the block. Often, the new standard K19 liners can be sorted by measuring to find a liner that will provide adequate press fit without machining the lower press fit inside diameter of

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ck4brgb

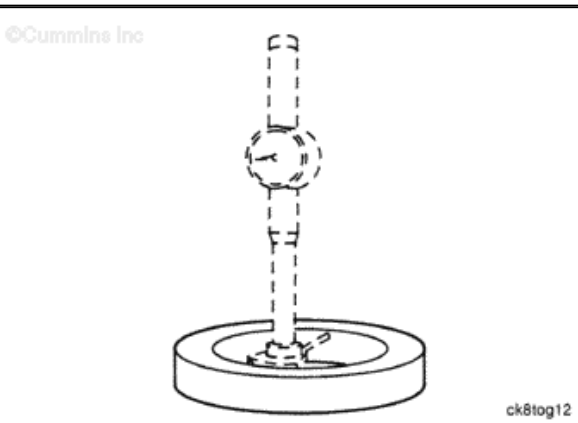
the block.

If the lower press fit inside diameter is **not** within specifications, it **must** be machined to accept either an oversized lower press fit K19 liner or K38 or K50 liner.

Use a dial bore gauge, Part Number 3376619 or 3375072, or equivalent. Other measuring devices such as inside diameter micrometers or calipers are **not** as accurate as a dial bore gauge and can cause unnecessary machining of cylinder blocks.

Ring gauge, Part Number 3376831, has an inside diameter of 112.014 mm [7.410 in]. Use this gauge when setting up the dial bore gauge to measure thick flange, factory modified thin flange and ex-thin flange blocks that have **not** been machined for oversized upper press fit K19 liners.

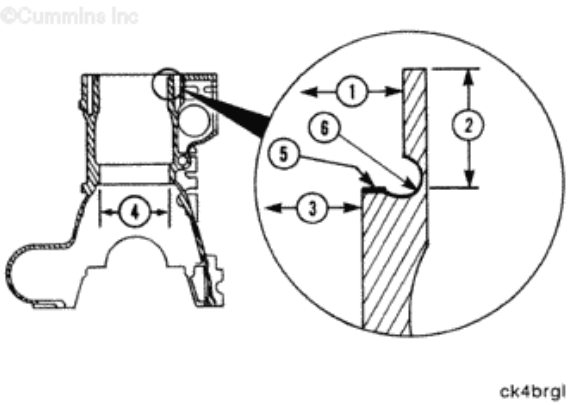
Ring gauge, Part Number 3376832, has an inside diameter of 190.335 mm [7.4935 in]. Use this gauge when setting up the dial bore gauge to measure blocks that have been machined for 83/Standard oversized upper press fit liners or K38 and K50 standard liners.



The specification for the upper press fit inside diameter (1) is dependent on whether or **not** the block has been machined for oversized upper press fit liners.

For blocks in service, the upper press fit inside diameter **must** be **not** more than the 0.076 mm [0.003 in]. Smaller than 0.076 mm [0.003 in], larger than the liner flange outside diameter on the liner that is to be installed in that bore. This bore can be as much as 0.15 mm [0.006 in] out of round.

When machining the block to accept the oversized lower press fit or K38 and K50 liners the inside diameter (1) needs to be



the same size as the 0.076 mm [0.003 in], larger than the liner to be installed in that bore. Use a depth micrometer. When measuring a ex-thin flange block make sure the end of the gauge tip is **not** contacting the ledge radius. Measure the depth at four points. The four measures **must not** vary more than 0.25 mm [0.001 in]. The maximum depth for any K19 block, except the counterbore ring type, is 158.8 mm [0.625 in]. This maximum depth also applies if the block deck height is at the minimum specifications.		

Counterbore Repair Matrix - Thick Flange and Factory Modified Type Blocks			
Liner Removed	**Lower Press Fit in Specification**	**Upper Press Fit in Specification**	**Recommended Counterbore Repair**
Standard	Yes	Yes	Machine depth for seal ring, use standard liner
Standard	Yes	No	Machine for 20/20 liner and seal ring
Standard	No	Yes	Machine for 20/20 liner and seal ring
Standard	No	No	Machine for 20/20 liner and seal ring
20/Standard	Yes	Yes	Machine depth fro seal ring, Use 20/standard oversize upper press fit liner
20/Standard	Yes	No	Machine for 40/standard liner and seal ring
20/Standard	No	Yes	Machine for 20/20 liner and seal ring
20/Standard	No	No	Machine for 60/20 liner and seal ring
40/Standard	Yes	Yes	Machine depth for seal ring, use 40/standard oversize upper press fit liner
40/Standard	Yes	No	Machine for 40/standard liner and seal ring
40/Standard	No	Yes	Machine for 60/20 liner and seal ring
40/Standard	No	No	Machine for 60/20 liner and seal ring
60/Standard	Yes	Yes	Machine depth for seal ring, use 60 standard oversize upper press fit liner
60/Standard	Yes	No	Machine for K38 and K50 liner and seal ring
60/Standard	No	Yes	Machine for 60/20 liner and seal ring

60/Standard	No	No	Machine for K38 and K50 liner and seal ring
83/Standard	Yes	Yes	Machine depth for seal ring, use 83/standard oversize upper press fit liner
83/Standard	Yes	No	None, upper press fit already over K38 and K50 standard
83/Standard	No	Yes	Machine for K38 and K50 liner and seal ring
83/Standard	No	No	None, bores already over K38 and K50 standard
95/Standard	Yes	Yes	Machine depth for seal ring, Use 95/standard oversize upper press fit liner
95/Standard	Yes	No	None, upper press fit already over K38 and K50 standard
95/Standard	No	Yes	None, upper press fit already over K38 and K50 standard
95/Standard	No	No	None, bores already over K38 and K50 standard
20/20	Yes	Yes	Machine depth for thicker seal ring, use 20/20 liner
20/20	Yes	No	Machine for 60/20 and thicker seal ring
20/20	No	Yes	Machine for K38 and K50 standard and thicker seal ring
20/20	No	No	Machine for K38 and K50 standard and thicker seal ring
60/20	Yes	Yes	Machine for thicker seal ring, use 60/20 liner
60/20	Yes	No	Machine for K38 and K50 standard and thicker seal ring
60/20	No	Yes	Machine for K38 and K50 standard and thicker seal ring
60/20	No	No	Machine for K38 and K50 standard and thicker seal ring
K38 and K50	Yes	Yes	Machine for thicker seal ring, use K38 and K50 standard liner
K38 and K50	Yes	No	None, upper press fit already over K38 and K50 standard
K38 and K50	No	Yes	None, upper press fit already over K38 and K50 standard
K38 and K50	No	No	None, bores already over K38 and K50 standard

Counterbore Repair Matrix - Ex-Thin Type Blocks			
Liner Removed	**Lower Press Fit in Specification**	**Upper Press Fit in Specification**	**Recommended Counterbore Repair**
			Machine depth for seal ring, use

60/Standard	Yes	Yes	60/standard oversize upper press fit liner
60/Standard	Yes	No	Machine for K38 and K50 liner and seal ring
60/Standard	No	Yes	Machine for 60/20 oversize and seal ring
60/Standard	No	No	Machine for K38 and K50 liner and seal ring
83/Standard	Yes	Yes	Machine depth for seal ring, use 83/standard of upper press fit liner
83/Standard	Yes	No	None, upper press fit already over K38 and K50 liner
83/Standard	No	Yes	Machine for K38 and K50 liner and seal ring
83/Standard	No	No	None, bores already over K38 and K50 standard
95/Standard	Yes	Yes	Machine depth for seal ring, use 95/standard oversize upper press fit liner
95/Standard	Yes	No	None, upper press fit already over K38 and K50 standard
95/Standard	No	Yes	None, upper press fit already over K38 and K50 standard
95/Standard	No	No	None, bores already over K38 and K50 standard
60/20	Yes	Yes	Machine for thicker seal ring, use 60/20 liner
60/20	Yes	No	Machine for K38 and K50 standard and thicker seal ring
60/20	No	Yes	Machine for K38 and K50 standard and thicker seal ring
60/20	No	No	Machine for K38 and K50 standard and thicker seal ring
K38 and K50	Yes	Yes	Machine for thicker seal ring, use K38 and K50 standard liner
K38 and K50	Yes	No	None, upper press fit already over K38 and K50 standard
K38 and K50	No	Yes	None, lower press fit over K38 and K50 standard
K38 and K50	No	No	None, bores already over K38 and K50 standard

Counterbore Repair Matrix - Thin Flange Type Blocks			
Liner Removed	**Lower Press Fit in Specification**	**Upper Press Fit in Specification**	**Recommended Counterbore Repair**
Thin flange	Yes	Yes	Machine depth for seal ring, use thin flange liner
Thin flange	Yes	No	Machine for 60/standard liner and seal ring

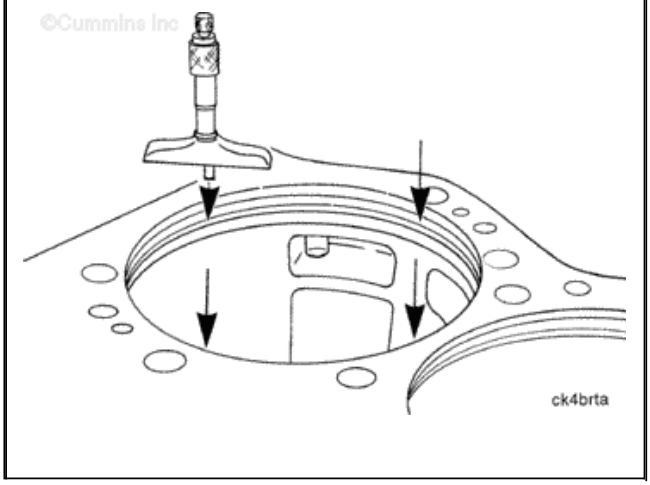
Thin flange	No	Yes	Machine for 60/20 liner and seal ring
Thin flange	No	No	Machine for 60/20 liner and seal ring

Counterbore Machining Specifications				
Liner Upper Press Fit/Lower Press Fit	Upper Press Fit Bore Inside Diameter		Lower Press Fit Bore Inside Diameter	
Oversize/Oversize	Minimum mm [in]	Maximum mm [in]	Minimum mm [in]	Maximum mm [in]
Standard/Standard	188.16 [7.408]	188.21 [7.414] [1]	180.07 [7.090]	180.14 [7.093] [2]
20/20	188.67 [7.431]	188.72 [7.434]	180.59 [7.110]	180.64 [7.112]
60/20	189.69 [7.471]	189.76 [7.474]	180.59 [7.110]	180.64 [7.112]
K38/K50	190.30 [7.495]	190.39 [7.498]	181.73 [7.155]	181.78 [7.157]
20/Standard	188.67 [7.431]	188.72 [7.434]	180.07 [7.090]	180.14 [7.093] [2]
40/Standard	189.26 [7.451]	189.33 [7.454]	180.07 [7.090]	180.14 [7.093] [2]
60/Standard	189.76 [7.471]	189.84 [7.474]	180.07 [7.090]	180.14 [7.093] [2]
83/Standard	190.30 [7.495]	190.39 [7.498]	180.07 [7.090]	180.14 [7.093] [2]
95/Standard	190.65 [7.506]	190.73 [7.509]	180.07 [7.090]	180.14 [7.093] [2]
Thin flange/Standard	188.01 [7.402]	188.09 [7.405] [1]	180.07 [7.090]	180.14 [7.093] [2]
[1] Maximum inside diameter blocks in service.				
[2] Maximum inside diameter blocks in service. **Must** be a minimum of 0.03 mm [0.001 in] press fit between liner and block.				

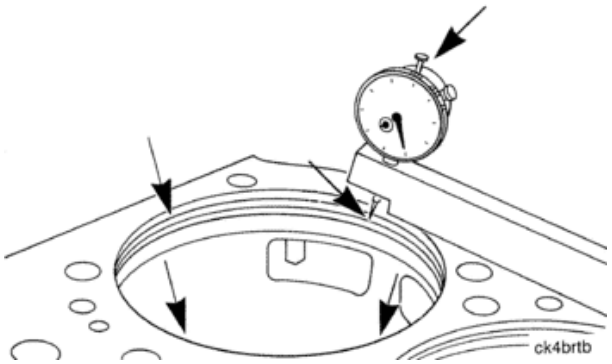
Measure the counterbore depth at the four locations illustrated in the graphic with a depth micrometer.

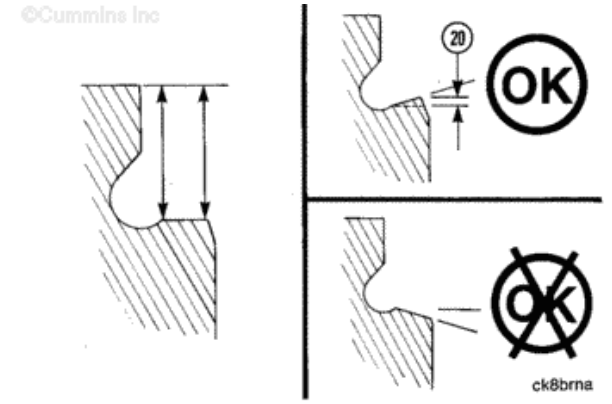
Make sure the micrometer contacts the flat surface of the ledge. It**must not** touch the radius.

Counterbore Depth		
mm		in
13.755	MIN	0.5415



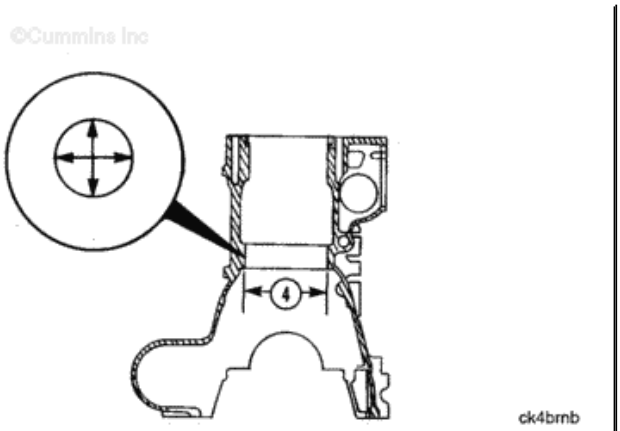
13.805 MAX 0.5435 The four measurements **must not** vary more than 0.25 mm [0.001 in]. If the measurements exceed the specifications, the counterbore ledge **must** be machined.		

Be 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 or 3823495, or equivalent, to measure the angle of the counterbore ledge at four places 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 (12) of the counterbore ledge is acceptable if the measurement near the counterbore is the same or no more than 0.36 mm [0.0014 in] shorter than the measurement near the counterbore radius. If the measurement near the counterbore ledge is greater than the measurement near the counterbore radius, the ledge **must** be machined.		

Measure the chamfer at the top of the packing ring bore. Excessive pitting **must** be repaired. (4) Packing Ring Bore mm in 177.34 MIN 6.982 177.40 MAX 6.984 If the packing ring bore is **not**		

within specifications, it **must** be repaired. Refer to the Alternate Repair Manual, Bulletin 3379035.



Last Modified: 25-Oct-2004

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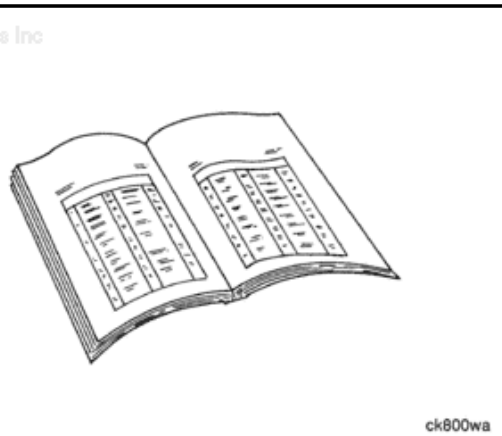
001-028 Cylinder Liner

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.

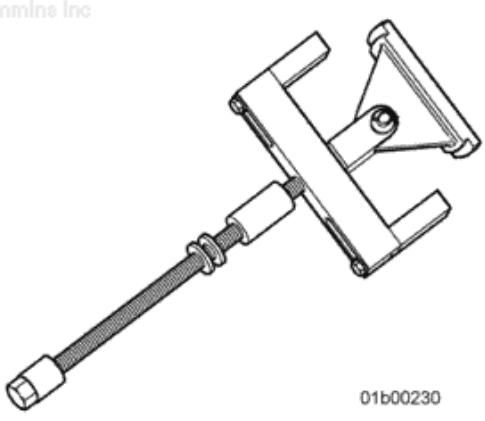
- Remove the cylinder head. Refer to Procedure 002-004 in Section 2.
- Remove the piston and connecting rod assembly. Refer to Procedure 001-054 in Section 1.

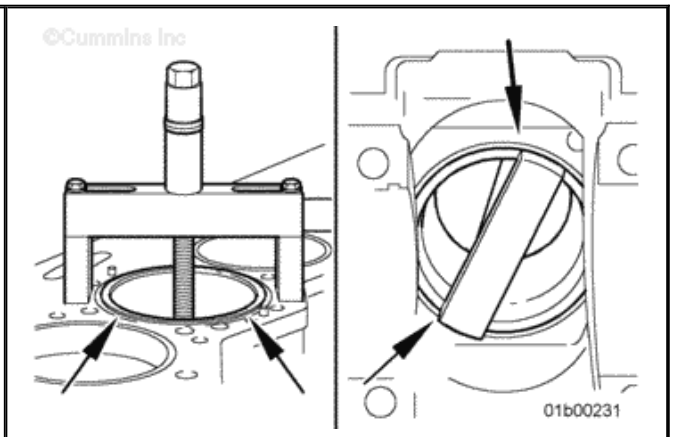


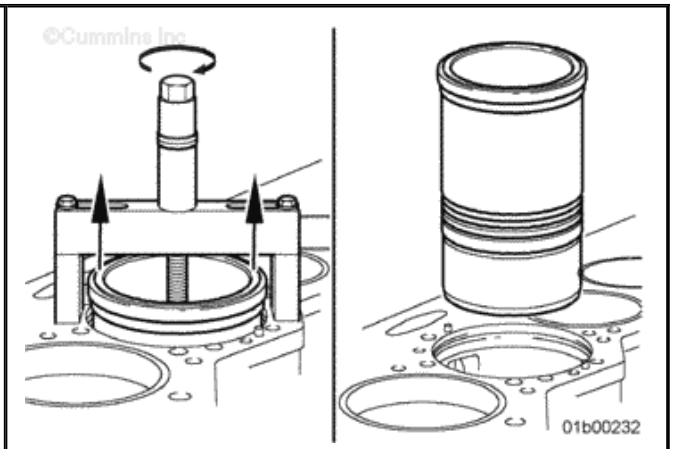
Remove

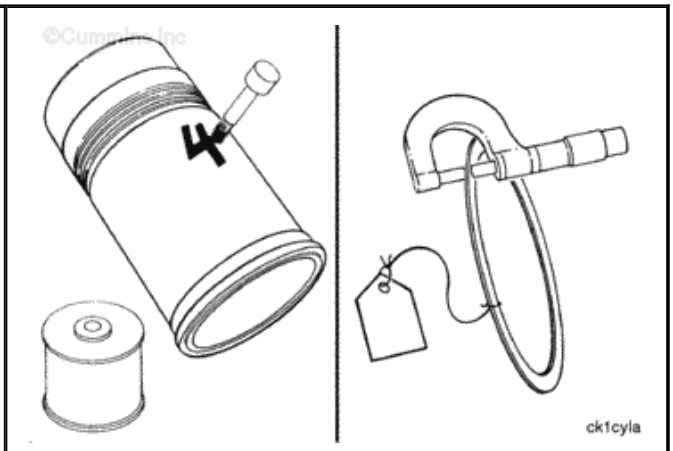
Use the cylinder liner puller, Part Number 3163745, and puller plate, Part Number 3162886, to remove the cylinder liner.

Wind down the threaded rod to extend the arm. Turn the arm to the side to enable passage through the liner.

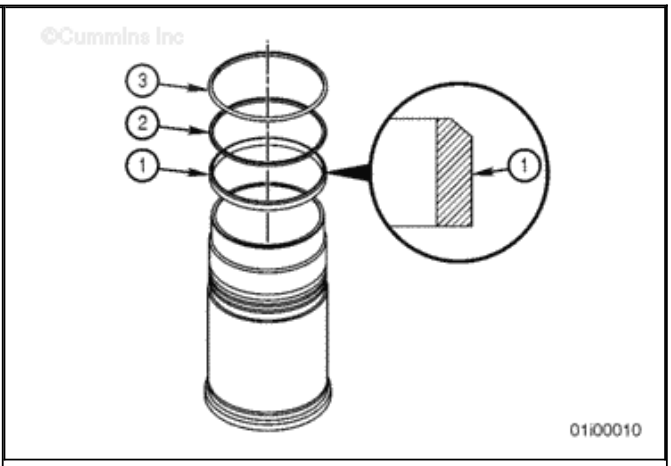


Install the cylinder liner puller, Part Number 3163745, in the cylinder liner. The puller feet **must not** touch the top of the liner. The puller arms **must** be positioned firmly on the bottom of the liner.		

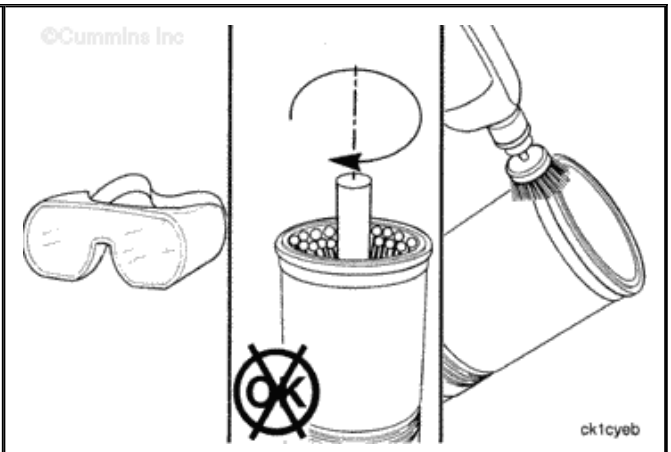
Turn the puller screw until the liner loosens in the block. Remove the tool and the liner.		

Use a liquid metal marker to mark the cylinder number and bank on each linter. 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 known when the liners are installed in the		

engine.		

Remove and discard the two D-rings (1 and 2). Remove and discard the crevice seal (3).		

Clean and Inspect for Reuse

WARNING To reduce the possibility of personal injury wear appropriate eye and face protection. Make sure the wire brush is rated for the RPM being used if the brush is motor driven. **CAUTION** Do not use a hone, deglazing, or prebrushing 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.		

WARNING

When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious 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.

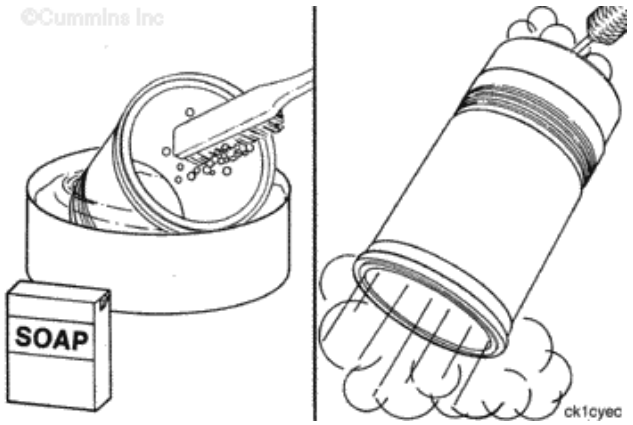
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use a nonmetallic bristle brush, detergent soap, and warm water to clean the inside of the liner.

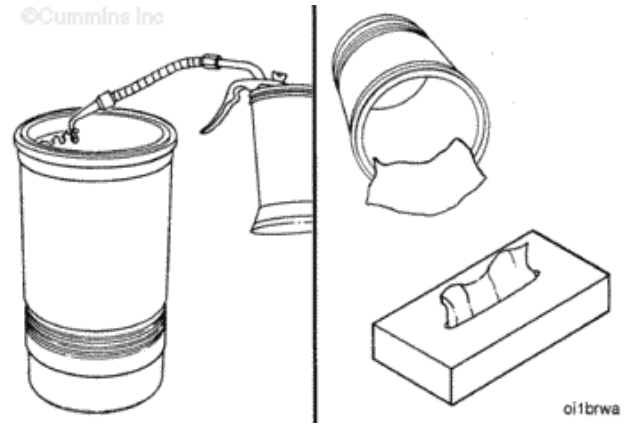
Use a steam cleaner or solvent tank to clean the liners.

Dry with compressed air.



Lubricate the inside diameter of the cylinder liner with clean engine oil.

Allow the liner to soak for five to 10 minutes.

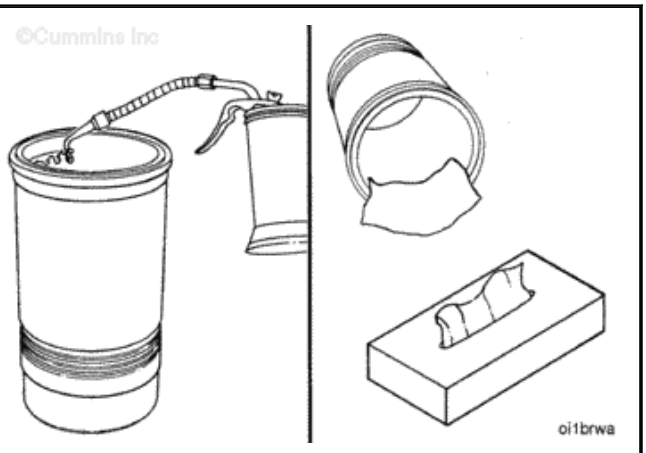


CAUTION

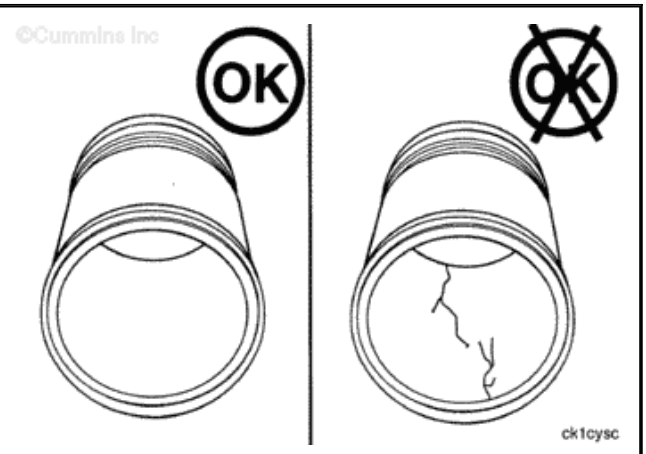
Do not use a cloth towel. Lint will cause severe engine damage.

Clean the inside diameter of the cylinder liner with a paper towel.

Repeat the cleaning steps until the paper towel does **not** show gray or black residue.

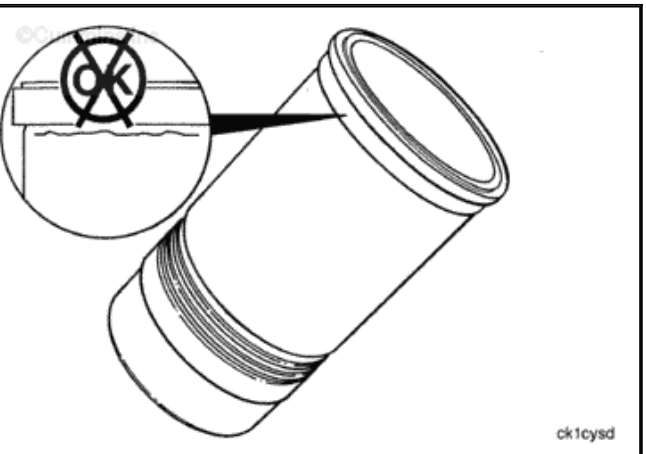


Inspect the liners for cracks on the inside and the outside diameters.



Inspect for cracks under the flange.

NOTE: Cracks can also be detected by using either magnetic inspection or the dye method.

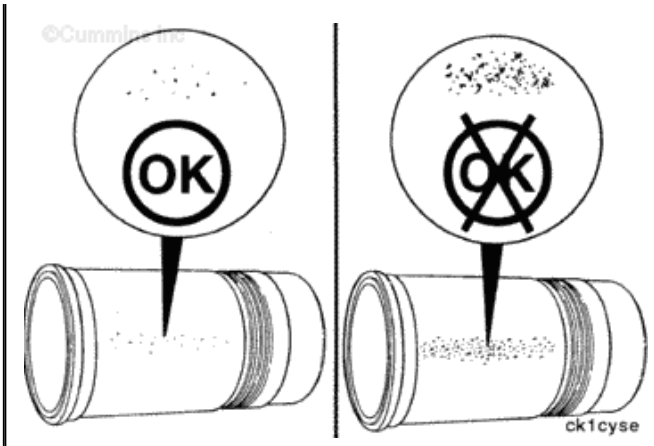


Inspect the outside diameter for excessive corrosion or

pitting.

Pits **must not** be more than 1.6 mm [0.063 in] deep.

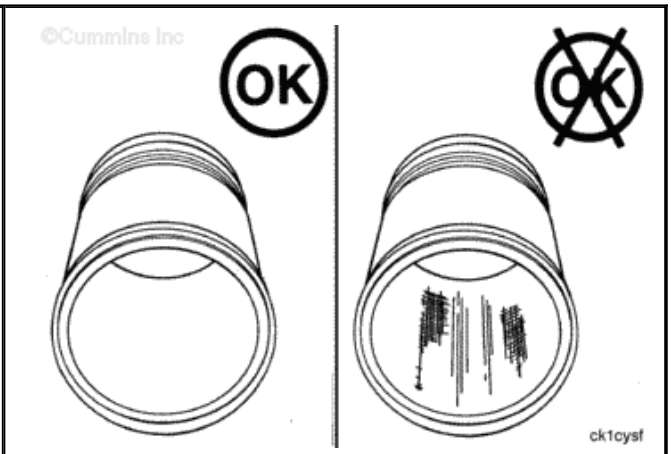
Replace the liner if the pits are too deep or if the corrosion can **not** be removed with an abrasive pad.



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.

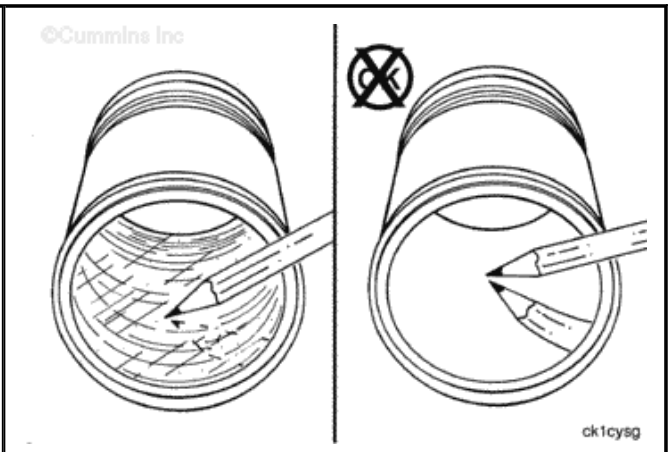


Inspect the inside diameter for liner bore polishing.

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.

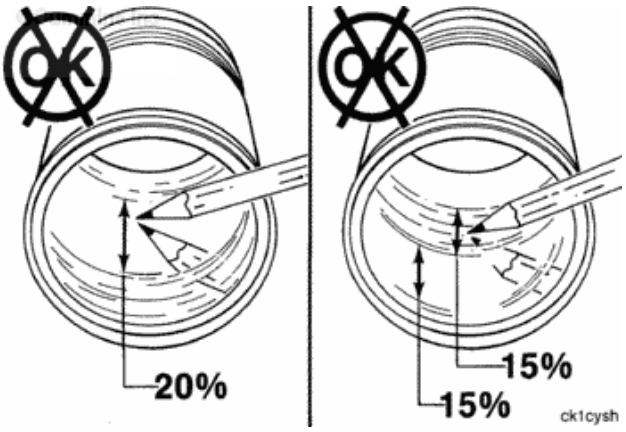
A heavy polish produces a bright mirror finish in the worn area with no traces of hone marks or an etch pattern.

Reference Parts Reuse Guidelines, Bulletin Number 3810303, for further information on liner bore polishing.



Replace the liner:

- If a heavy polish is present over 20 percent of the piston ring travel area.
- If 30 percent of the piston ring travel area has both moderate and heavy polish, with one-half of the 30 percent (15 percent) consisting of heavy polish.



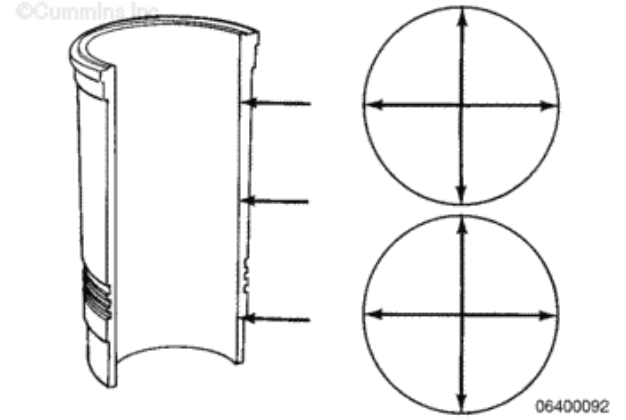
Use a dial bore gauge to measure the inside diameter of the liner at the top, the bottom, and the middle of the piston ring travel area.

Perform two measurements at each location. The measurements **must** be 90 degrees apart.

Cylinder Liner Inside Diameter		
mm		in
158.737	MIN	6.250
158.877	MAX	6.251

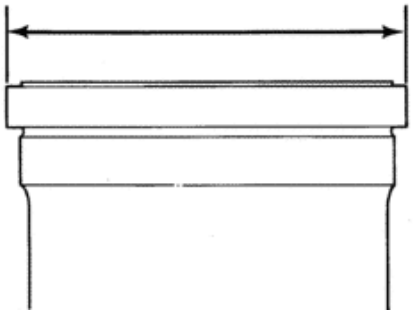
NOTE: The inside diameter of a new cylinder liner can be 0.015 mm [0.0006 in] smaller than specifications because of the Lubrite coating.

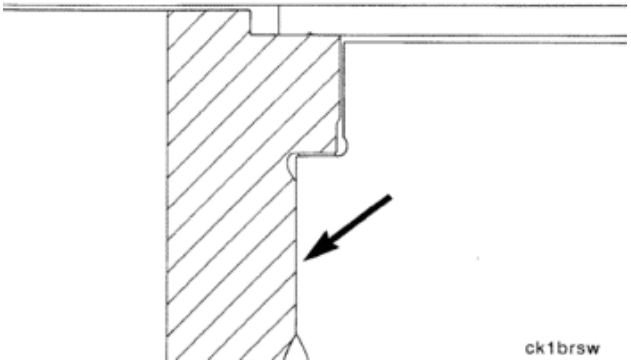
If the cylinder liner is **not** within specifications, the cylinder liner **must** be replaced.

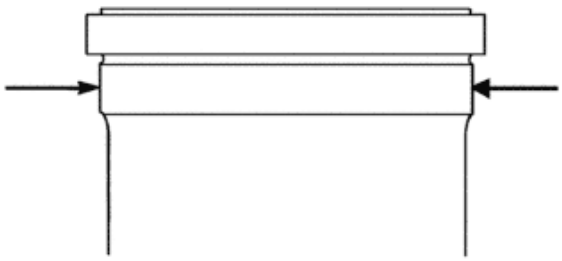


Measure the cylinder liner flange outside diameter.

Upper Press Fit Cylinder Liner Flange Diameter			
	mm		in
Standard	188.19	MIN	7.409

188.24 MAX 7.411 Oversize 188.70 MIN 7.429 20/20 188.75 MAX 7.431 If the cylinder liner is **not** within specifications, the cylinder liner **must** be replaced.		©Cummins Inc 

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. Cylinder liners with standard and oversize press fit diameters are available.		©Cummins Inc **Lower Press Fit** 

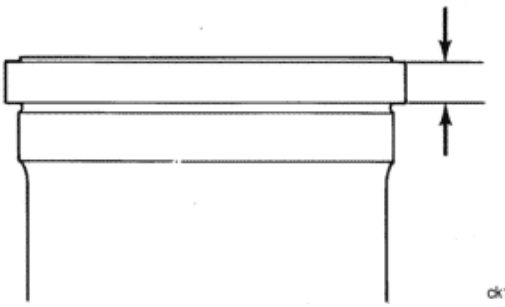
Measure the cylinder liner lower press fit diameter. Cylinder Liner Lower Press Fit Area Outside Diameter mm in Standard 180.16 MIN 7.093 180.21 MAX 7.095 Oversize 180.67 MIN 7.113 20/20 180.72 MAX 7.115 If the cylinder liner is **not** within specifications, the cylinder liner **must** be replaced.		©Cummins Inc 

Measure the cylinder liner flange thickness.		

Cylinder Liner Flange Thickness

mm		in
13.398	MIN	0.528
13.424	MAX	0.529

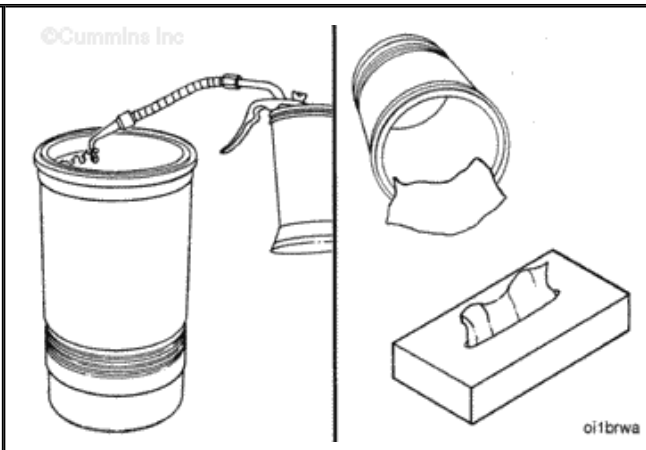
If the cylinder liner is **not** within specifications, the cylinder liner **must** be replaced.



Apply a thick film of clean 15W-40 oil to the bores of the liners for final cleaning. Leave the oil on for five 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.

Do **not** place the liners in an area where dirty air flow can contaminate the liners.

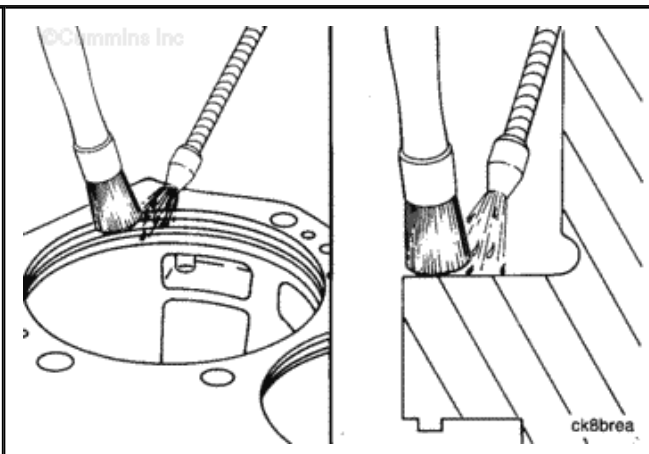


Install

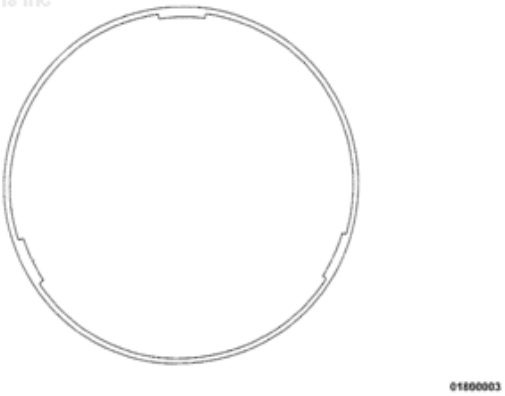
WARNING

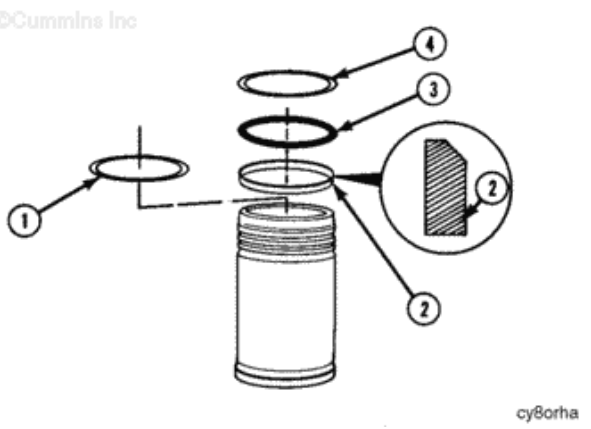
When using solvents, acids, or alkaline material for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

Clean the bottom of the



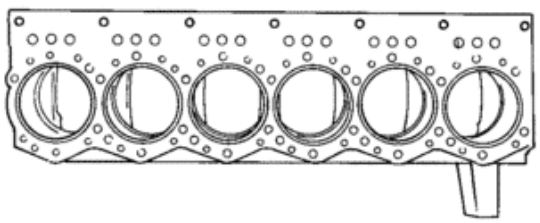
cylinder block cylinder liner flange with safety solvent.		

The seal rings have three locating tabs on the inside 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.		

NOTE: 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 liner, counter bore sealing ring (1). If an upper crevice seal was used, install the upper crevice seal with the white side out. Install the crevice seal. The beveled edge of the crevice seal (2) **must** be positioned as shown. Install o-rings in the position shown. Use the mold mark on the o-ring to check if the o-ring is twisted. • (3) Black o-ring • (4) Red o-ring.		

Use vegetable oil to lubricate the inside diameter of the packing ring bores.

Use hand pressure to push the cylinder liners into the block.



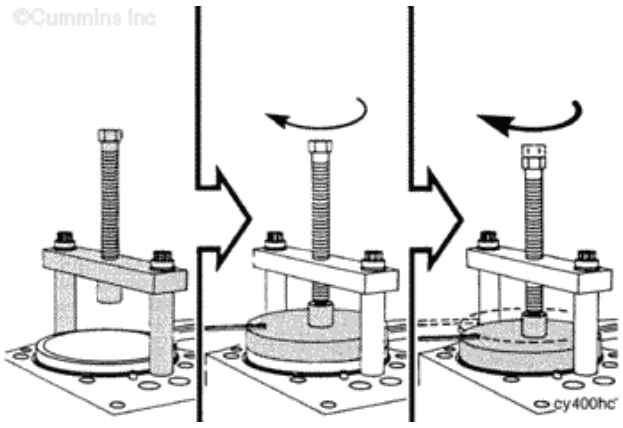
Use liner installation tool, Part Number 3375422, or equivalent, to install the bridge assembly and 2 cylinder head capscrews. Tighten the capscrews.

Torque
Value: 45 n.m [34 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.

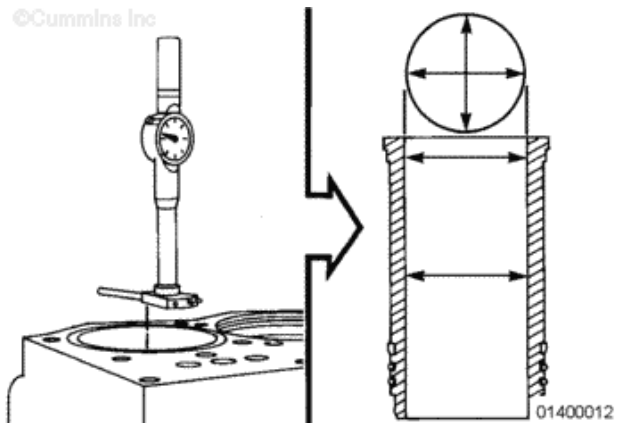
Do **not** use more than 65 N•m [50 ft-lb] of torque. Remove the tool.



NOTE: New cylinder liners can be 0.005 to 0.015 mm [0.0002 to 0.0006 in] smaller than the minimum specifications because of the Lubrite coating.

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
158.737	MIN	6.250
158.775	MAX	6.251

The inside diameter **must not** be more than 0.076 mm [0.003 in] out-of-round at the top two measurements.

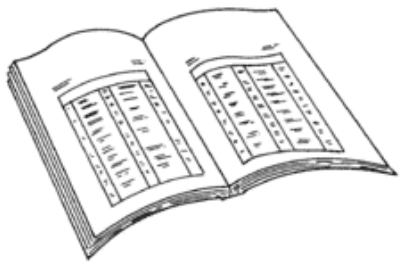
If the inside diameter is more than 0.05 mm [0.002 in] out-of-round in the bottom measurement location, the liner **must** be removed. Check for a twisted o-ring.

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.

- Measure the cylinder liner protrusion. Refer to Procedure 001-064 in Section 1.
- Install the piston and connecting rod assembly. Refer to Procedure 001-054 in Section 1.
- Install the cylinder head. Refer to Procedure 002-004 in Section 2.



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Last Modified: 25-Jun-2012

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001-029 Gear Cover Spacer Plate

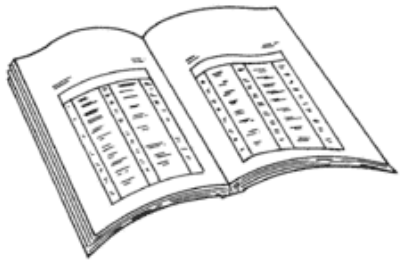
Preparatory Steps

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.

- Remove the gear cover and related components. Refer to Procedure 001-031.
- Place the number one cylinder on compression stroke.
- Rotate the engine, using the crankshaft until the index marks on the camshaft gear and the crankshaft gear are pointing at each other.
- Remove the water pump idler gear. Refer to Procedure 001-040.
- Remove the camshaft idler gear. Refer to Procedure 001-036.
- Remove the hydraulic pump idler gear, if equipped. Refer to Procedure 001-039.
- Remove the camshaft gear. Refer to Procedure 001-012.





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Remove

WARNING

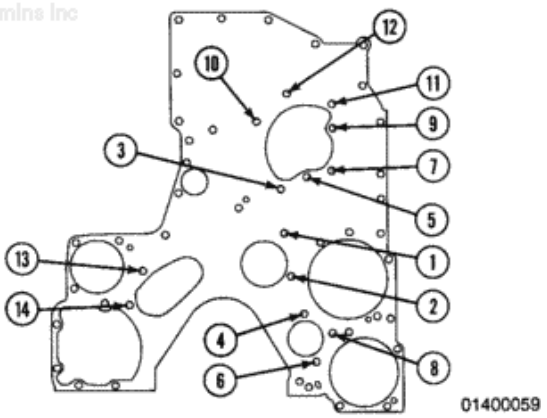
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Remove the 14 mounting capscrews from the spacer plate.

Tag the special capscrews for future identification.

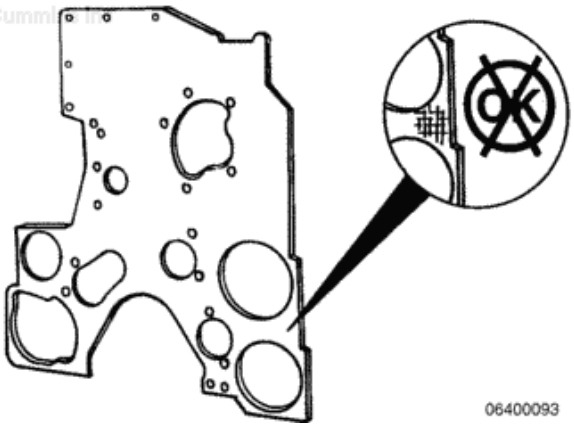
Remove the spacer plate and the gasket.

Discard the gasket.



Inspect for Reuse

Check the spacer plate for fretting or damage on both sides of the gasket surface.



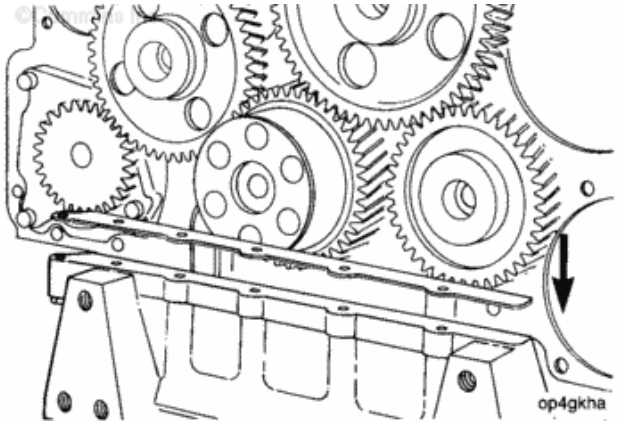
Install

The oil pan adapter gasket is designed to be removed at the perforations. It is a steel core gasket and can **not** be cut without causing damage to the oil pan adapter surface.

Remove the oil pan adapter gasket at the perforations.

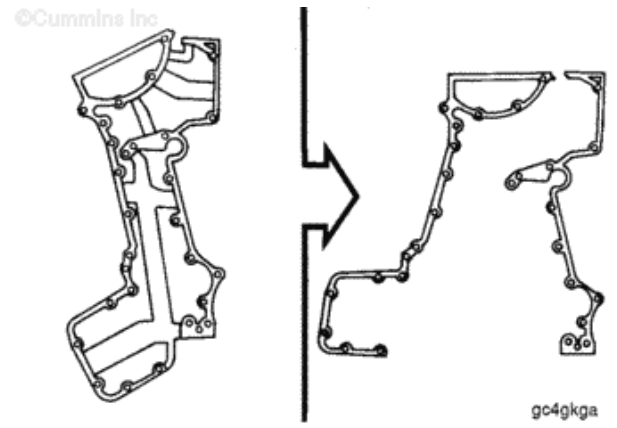
Install the oil pan adapter gasket onto the top of the oil pan adapter. Use spray adhesive to hold it in position.

Apply Cummins sealant, Part Number 3164067, to the joints of the gasket.



Separate the gasket as illustrated in the graphic.

Discard the center tab sections.

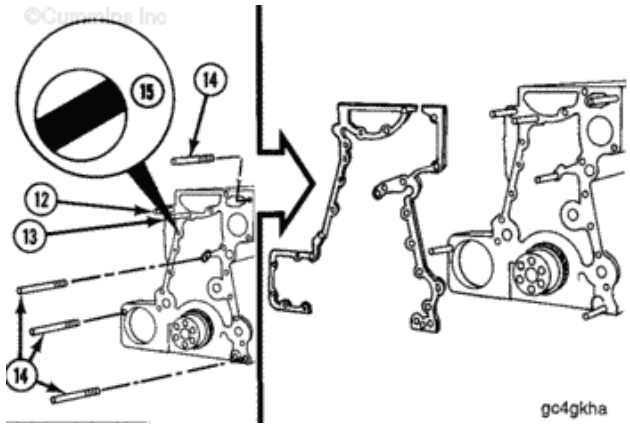


CAUTION

Do not use gasket cement on the gasket. Damage to the gasket will result.

The diamond dowel (15) **must** be installed with the flat surface turned toward the master dowel hole at the lower right hand corner of the cylinder block.

Install guide studs (14) into the cylinder block.



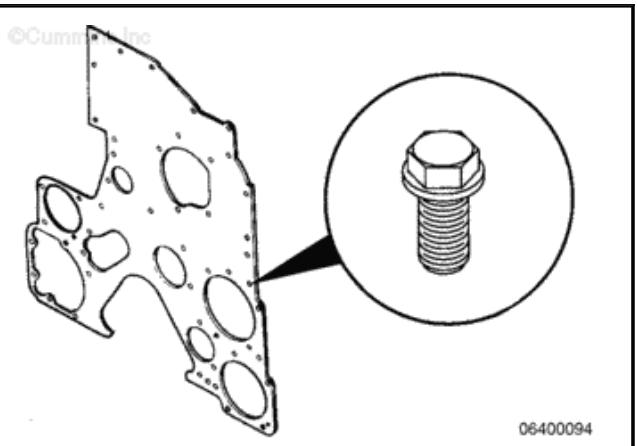
Apply a small amount of Cummins sealant, Part Number 3164067, or equivalent, to both sides of the gasket at the butt joint.

Install the gasket.

The gasket **must** be even with the bottom of the cylinder block and the spacer plate.

Special capscrews are required to attach the spacer plate and the gear housing.

The capscrews have a captive cone-shaped washer to maintain torque.



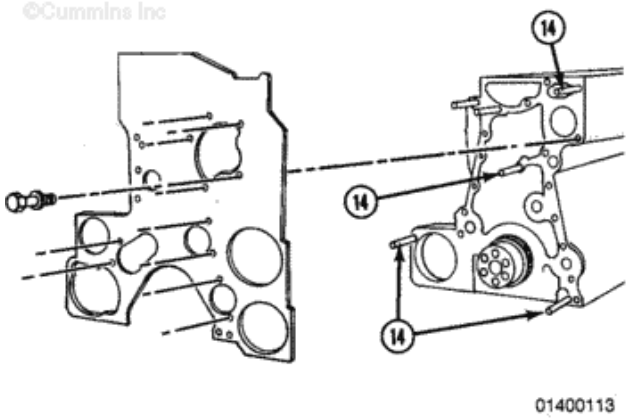
WARNING

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 spacer plate and 11 capscrews.

Remove the guide studs (14).

Install the remaining capscrews.



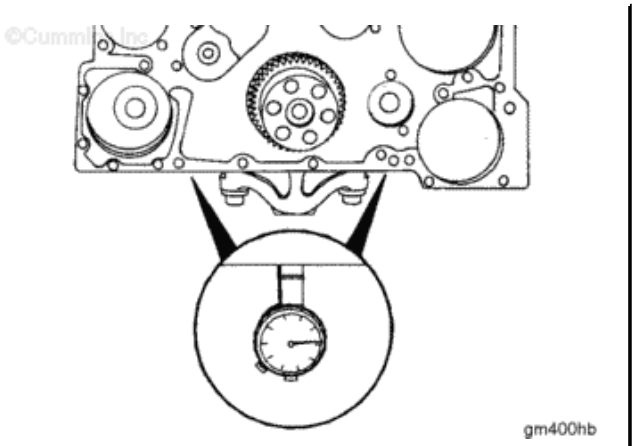
NOTE: If the oil pan adapter is removed, the spacer plate alignment must be checked. If the oil pan adapter is installed, the spacer plate alignment

does not need to be checked.

Measure the distance from the bottom of the cylinder block to the bottom of the spacer plate with a depth gauge, Part Number 3164438, or equivalent.

The bottom of the spacer plate or housing **must** be within 0.05 mm [0.002 in] of the bottom of the cylinder block.

Align the spacer plate or housing with the bottom of the cylinder block if necessary.



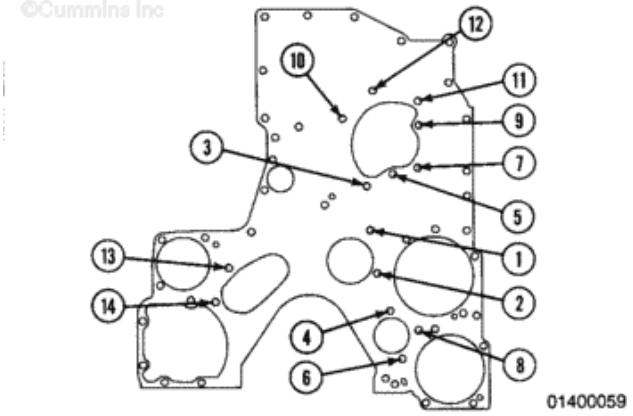
Tighten the capscrews in the sequence shown in the graphic.

Torque
Value: 45 n.m [33 ft-lb]

Measure the spacer plate or the housing to the cylinder block alignment again to make sure it is within specifications.

Tighten the capscrews in sequence again.

Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

WARNING

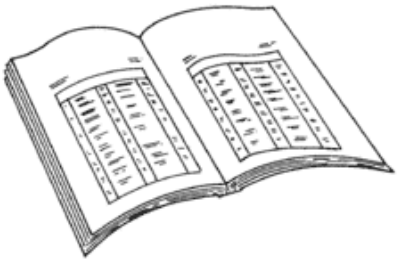
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal

injury, use a hoist or get assistance to lift this component.

NOTE: Make sure to check the end clearance on all gears after they have been installed.

- Install the camshaft gear. Refer to Procedure 001-012.
- Install the hydraulic pump idler gear. Refer to Procedure 001-039.
- Install the water pump idler gear. Refer to Procedure 001-040.
- Install the camshaft idler gear. Refer to Procedure 001-036.
- Perform the static injection timing check. Refer to Procedure 006-025.
- Install the gear cover and related components. Refer to Procedure 001-031.

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Last Modified: 07-Dec-2004

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001-031 Gear Cover, Front

Preparatory Steps

One Piece Design, All Applications Except Marine

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

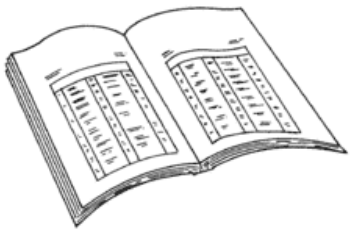
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

NOTE: Two different front cover designs have been used. The latest design "one piece" consists of an aluminum or cast iron front cover that is approximately 51 mm [2 in] thick. The older design, "two piece" consists of a gear cover and a gear housing that are both slightly over 25.4 mm [1 in] thick.

- Disconnect the batteries or air starter to prevent accidental starting.
- Drain the cooling system. Refer to Procedure 008-018.
- Remove the cooling fan. Refer to Procedure 008-040.
- Remove the cooling fan drive belt. Refer to Procedure 008-002.
- Remove the alternator drive belt. Refer to Procedure 013-005.
- Remove the alternator. Refer to



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Procedure 013-001.
- Remove the gear driven fan hub. Refer to Procedure 008-037.
- Remove the belt driven fan hub. Refer to Procedure 008-036.
- Remove the belt driven fan hub idler assembly. Refer to Procedure 008-030.
- Remove the water pump. Refer to Procedure 008-062.
- Remove the aftercooler water tubes. Refer to Procedure 010-002.
- Remove the thermostat housing. Refer to Procedure 008-015.
- Remove the alternator drive pulley. Refer to Procedure 009-010.
- Remove the water pump drive. Refer to Procedure 009-029.
- Remove the fuel pump. Refer to Procedure 005-016.
- Remove the air compressor. Refer to Procedure 012-014.
- Remove the accessory drive pulley. Refer to Procedure 009-004.
- Remove the fuel pump drive. Refer to Procedure 009-011.
- Remove the hydraulic pump drive. Refer to Procedure 009-016.

One Piece Design, Marine Applications

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.

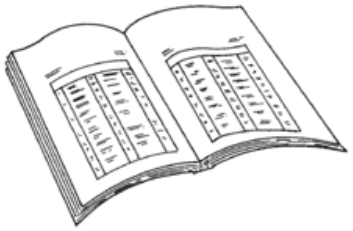
WARNING

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 starter to prevent accidental starting.
- Drain the cooling system. Refer to



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Procedure 008-018.
- Remove the alternator drive belt. Refer to Procedure 013-005.
- Remove the alternator. Refer to Procedure 013-001.
- Remove the sea water expansion tank. Refer to Procedure 008-052.
- Remove the heat exchanger. Refer to Procedure 008-053.
- Remove the sea water pump. Refer to Procedure 008-057.
- Remove the aftercooler water tubes. Refer to Procedure 010-002.
- Remove the thermostat housing. Refer to Procedure 008-015.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the alternator drive pulley. Refer to Procedure 009-010.
- Remove the water pump drive. Refer to Procedure 009-029.
- Remove the fuel pump. Refer to Procedure 005-016.
- Remove the air compressor. Refer to Procedure 012-014.
- Remove the accessory drive pulley. Refer to Procedure 009-004.
- Remove the fuel pump drive. Refer to Procedure 009-011.
- Remove the hydraulic pump drive. Refer to Procedure 009-016.

Two Piece Design, All Applications Except Marine

WARNING

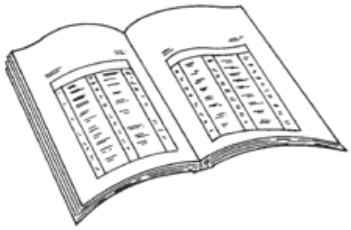
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative battery cable last.

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.



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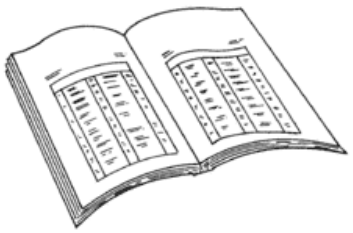
- Disconnect the batteries or air starter to prevent accidental starting.
- Drain the cooling system. Refer to Procedure 008-018.
- Remove the cooling fan. Refer to Procedure 008-040.
- Remove the cooling fan drive belt. Refer to Procedure 008-002.
- Remove the alternator drive belt. Refer to Procedure 013-005.
- Remove the alternator. Refer to Procedure 013-001.
- Remove the gear driven fan hub. Refer to Procedure 008-037.
- Remove the belt driven fan hub. Refer to Procedure 008-036.
- Remove the belt driven fan hub idler assembly. Refer to Procedure 008-030.
- Remove the aftercooler water tubes. Refer to Procedure 010-002.
- Remove the thermostat housing. Refer to Procedure 008-015.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the alternator drive pulley. Refer to Procedure 009-010.
- Remove three capscrews from the water pump drive, the nut does **not** have to be removed from the stud. Refer to Procedure 009-029.
- Remove the accessory drive pulley. Refer to Procedure 009-004.
- Remove the four capscrews that mount fuel pump drive to the front gear cover. The nut does **not** need to be removed from the stud which is located on the bottom of the drive closest to the cylinder block. Refer to Procedure 009-011.
- Remove the three capscrews from the hydraulic pump drive. The capscrew nearest to the top of the drive mounting flange that is closest to the cylinder block does **not** need to be removed. Refer to Procedure 009-016.

Two Piece Design, Marine Applications

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.

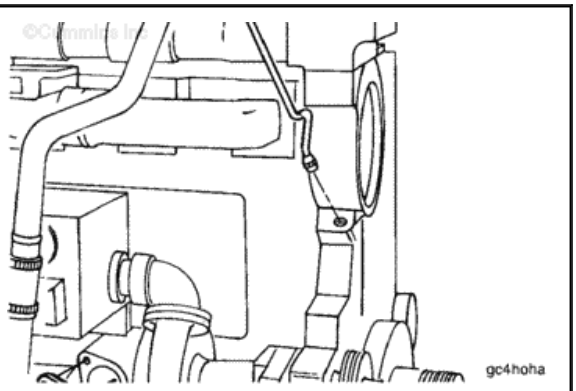
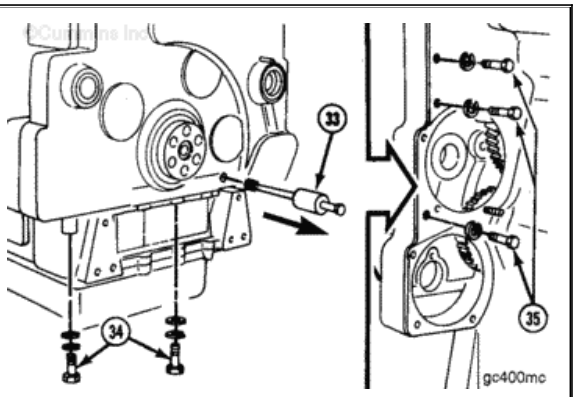
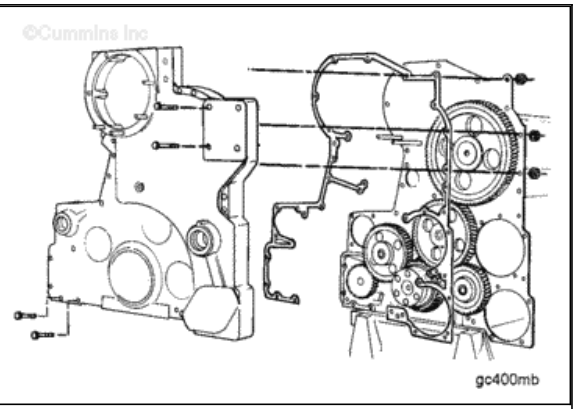
WARNING

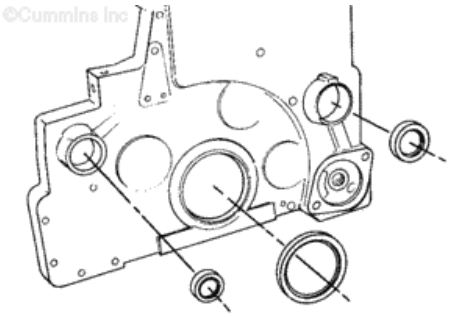
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

- Disconnect the batteries or air starter to prevent accidental starting.
- Drain the cooling system. Refer to Procedure 008-018.
- Remove the alternator drive belt. Refer to Procedure 013-005.
- Remove the alternator. Refer to Procedure 013-001.
- Remove the sea water expansion tank. Refer to Procedure 008-052.
- Remove the heat exchanger. Refer to Procedure 008-053.
- Remove the sea water pump. Refer to Procedure 008-057.
- Remove the aftercooler water tubes. Refer to Procedure 010-002.
- Remove the thermostat housing. Refer to Procedure 008-015.
- Remove the vibration damper. Refer to Procedure 001-052.
- Remove the alternator drive pulley. Refer to Procedure 009-010.
- Remove three capscrews from the water pump drive, the nut does **not** have to be removed from the stud. Refer to Procedure 009-029.
- Remove the accessory drive pulley. Refer to Procedure 009-004.
- Remove the four capscrews that mount fuel pump drive to the front gear cover. The nut does **not** need to be removed from the stud which is located on the bottom of the drive closest to the cylinder block. Refer to Procedure 009-011.
- Remove the three capscrews from the hydraulic pump drive. The capscrew nearest to the top of the drive mounting flange that is closest to the cylinder block does **not** need to be removed. Refer to Procedure 009-016.

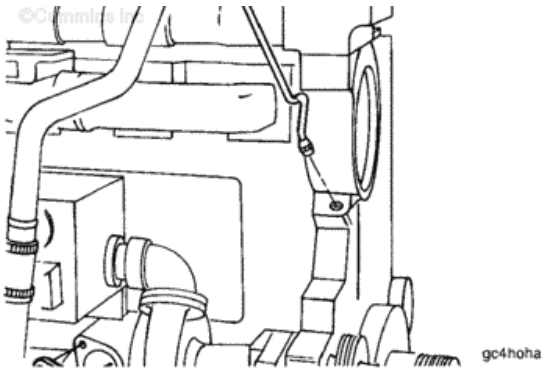
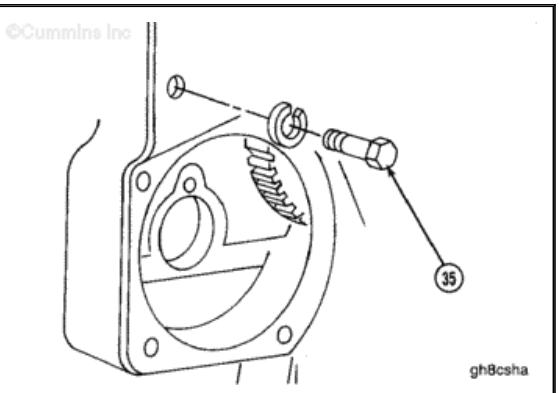
Remove

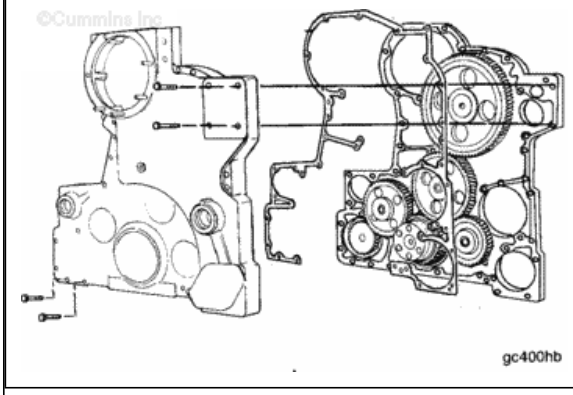
One Piece Design, All Applications

Disconnect the turbocharger oil supply line from the front cover.		
The master dowel **must** be removed before the gear cover can be removed. Use a slide hammer (33) or a 5/16-18 inch capscrew or threaded rod and an old piston pin to remove the dowel. The front cover contains five capscrews on the bottom (34) and three capscrew on the back (35). Remove the bottom capscrews (34) and the back capscrews (35).		
Remove the 15 capscrews located in the front of the front cover. Remove the front cover and gasket. Discard the gasket.		
Remove the oil seals with a mandrel or drift and a mallet.		

Two Piece Design, All Applications

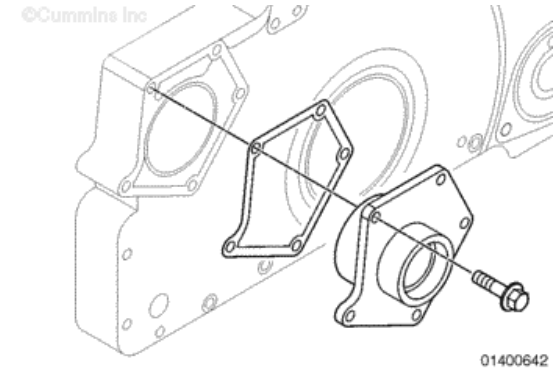
Disconnect the turbocharger oil supply line from the front cover.		
There is one capscrew that **must** be removed from the back of the housing. Remove the capscrew (35).		
Remove the 18 capscrews from the front cover. Remove the front cover and gasket. Discard the gasket.		



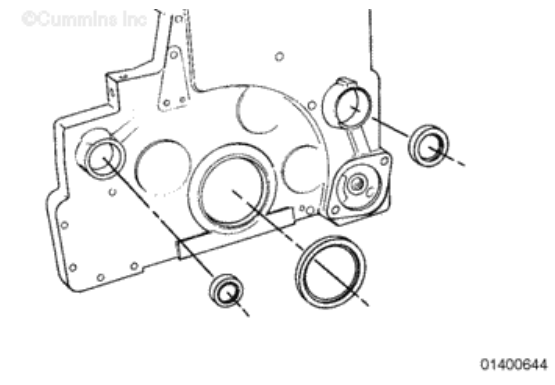
NOTE: It is not necessary to remove the alternator support from the gear cover unless the gasket is leaking. It is not necessary to remove the alternator support to replace the bushing or seal.

Some alternator supports are slightly larger than the machined area of the front gear cover. These supports **must** be frozen prior to installation into the cover. Do **not** attempt to drive the cover into place or both parts will be damaged beyond reuse.

If needed, remove the five capscrews, the support, and the gasket from the cover.



Use a mandrel and drift to remove the oil seals from the front cover and/or alternator drive support.



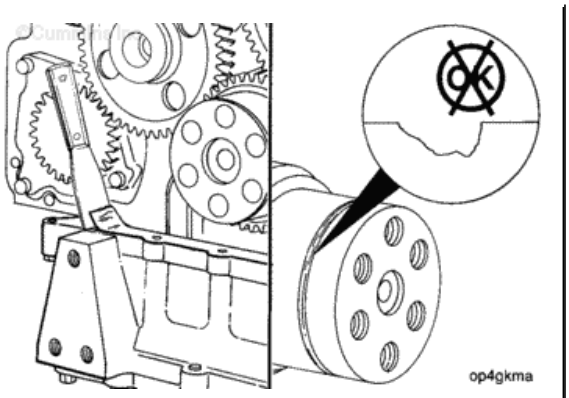
Clean and Inspect for Reuse

One Piece Design, All Applications

Remove the gasket from the top of the oil pan adapter, but do **not** remove the gasket under the spacer plate.

Check the crankshaft for damage in the oil seal location. Refer to Procedure 001-023.





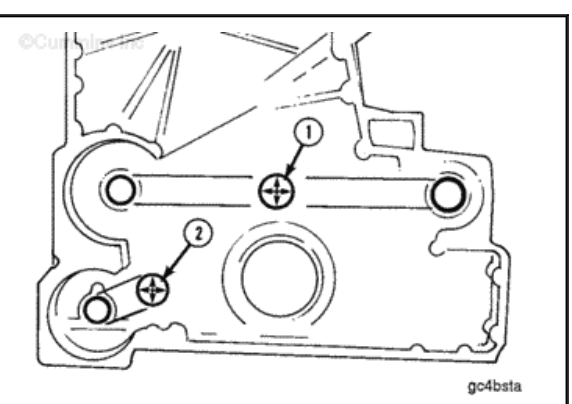
Clean all gasket surfaces.

Measure the inside diameter of accessory drive and hydraulic drive bushings.

Front Gear Cover Bushing Inside Diameter				
	mm		in	
Accessory Drive and Water Pump Drive (1)	39.75	MIN	1.565	
	39.90	MAX	1.571	
Hydraulic Pump Drive (2)	38.13	MIN	1.501	
	38.25	MAX	1.506	

If the bushings are **not** within specifications, they **must** be replaced.





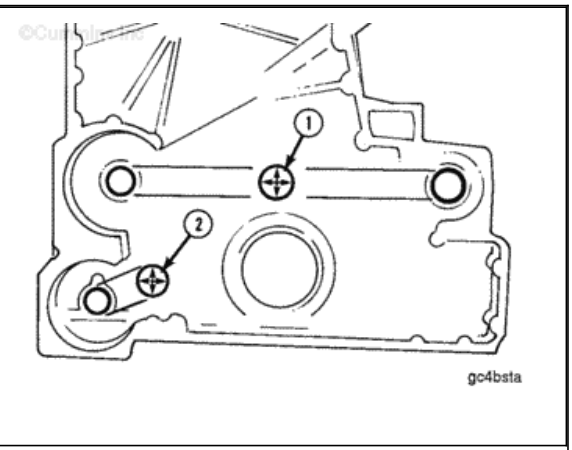
Two Piece Design, All Applications

Clean the gasket areas of the front cover.

Measure the inside diameter of the accessory drive and hydraulic drive bushings.

Front Gear Cover Bushing Inside Diameter				
	mm		in	
Accessory Drive and Water Pump Drive (1)	39.75	MIN	1.565	
	39.90	MAX	1.571	
Hydraulic Pump Drive (2)	38.13	MIN	1.501	
	38.25	MAX	1.506	



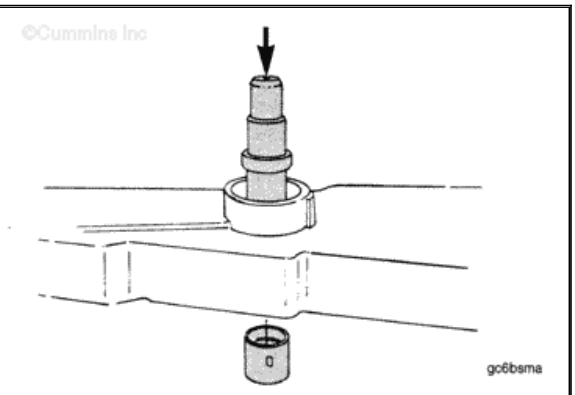


Disassemble

One Piece Design, All Applications

Use the bushing mandrel, Part Number ST-598 to remove the accessory drive and water pump drive bushings.

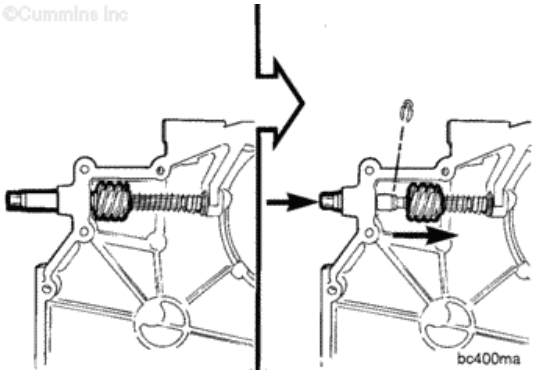
Use an appropriate mandrel or blind hole puller to remove the hydraulic pump drive bushing.



Push the engine barring mechanism shaft in and hold it in position.

Slide the worm gear until the spring is compressed.

Use a screwdriver to remove the retaining ring.



WARNING

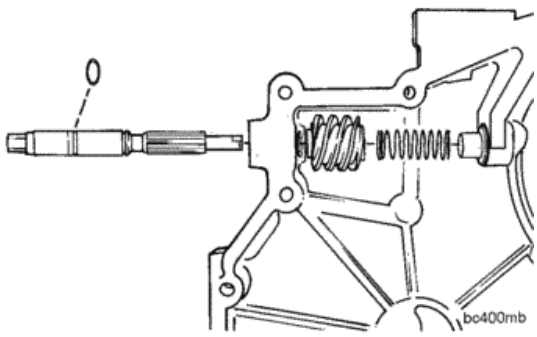
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

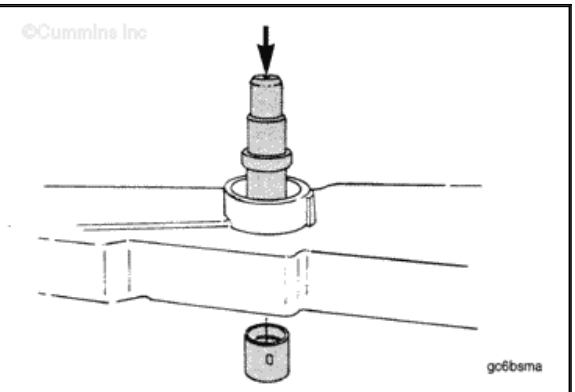
Remove the following parts:

- Shaft
- Spring
- Worm gear.



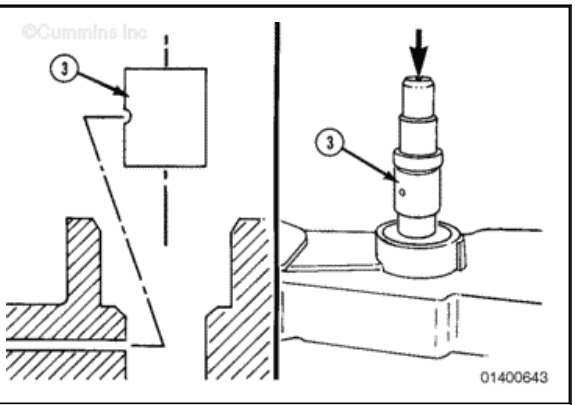
Remove the o-ring from the shaft and discard the o-ring. Clean the parts with solvent, Part Number 3824421, or equivalent. Flush the oil drillings. Dry with compressed air. Inspect the parts for damage. If any part is damaged it **must** be replaced.		

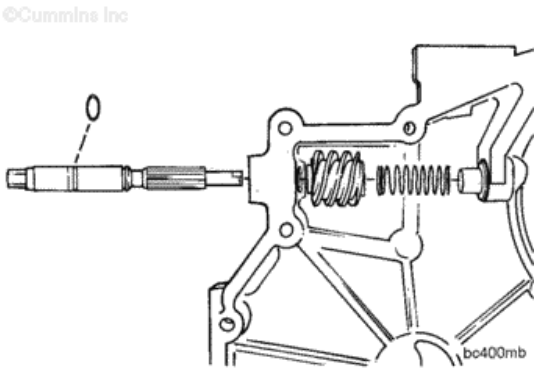
Two Piece Design, All Applications

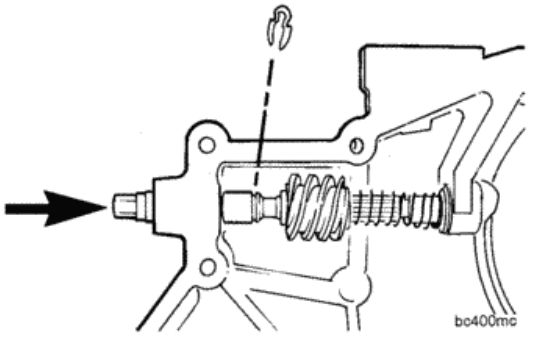
Use the bushing mandrel, Part Number ST-598 to remove the accessory drive and water pump drive bushings. Use an appropriate mandrel or blind hole puller to remove the hydraulic pump drive bushing.		

Assemble

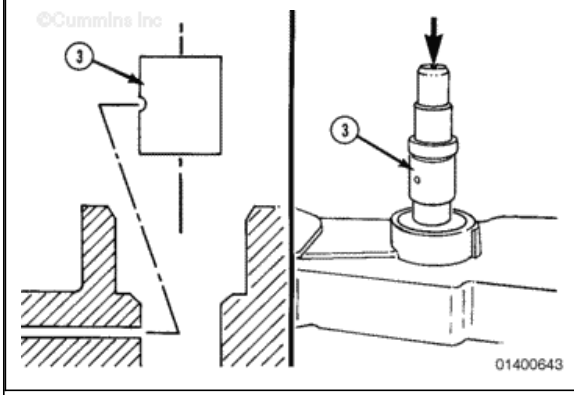
One Piece Design, All Applications

Install the accessory drive and water pump bushing with bushing mandrel, Part Number ST-598. Align the oil hole in the hydraulic pump drive bushing (3) with the oil drilling in the front cover. Install the bushing with the appropriate mandrel and an arbor press or mallet. Use a 3 mm [1/8 in] allen wrench to check the bushing oil hole to the front cover oil drilling alignment.		
Lubricate the o-ring with vegetable oil. Install the o-ring onto the barring shaft.		

Install the following parts • Worm gear • Spring • Shaft.		

Install the retaining ring. Rotate the shaft to check for correct assembly.		

Two Piece Design, All Applications

Install the accessory drive and water pump bushing with bushing mandrel, Part Number ST-598. Align the oil hole in the hydraulic pump drive bushing (3) with the oil drilling in the front cover. Install the bushing with the appropriate mandrel and an arbor press or mallet. Use a 3 mm [1/8 in] allen wrench to check the bushing oil hole to the front cover oil drilling alignment.		

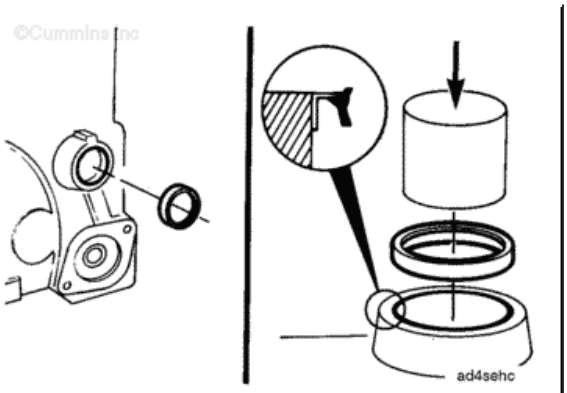
Install

One Piece Design, All Applications

Measure the height of the accessory drive seal boss.

- If the height is 35 mm [13/8 in], the seal is installed even with the boss.
- If the height is 38 mm [1½ in], the seal is installed 3 mm [1/8 in below the top of the boss.

Install the accessory drive seal with a mandrel.

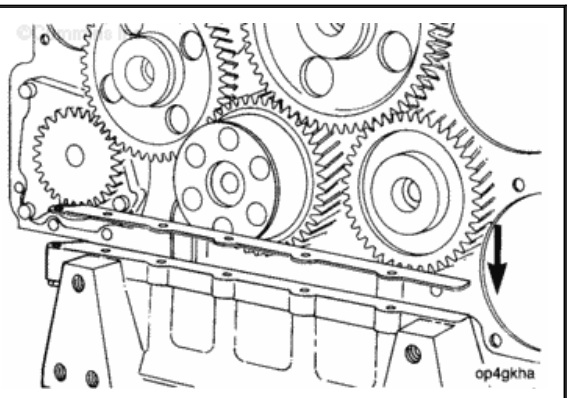


Trim the gasket to the correct width.

Install the gasket onto the top of the oil pan adaptor.

Use a spray adhesive to hold the gasket in position.

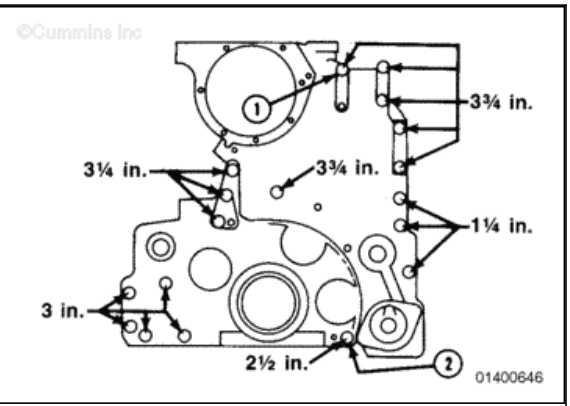
Apply sealant, Part Number 3164067, at the joints.



The graphic illustrates the capscrew length requirements for the front cover.

Capscrew (1) is installed in the front cover clamping plate.

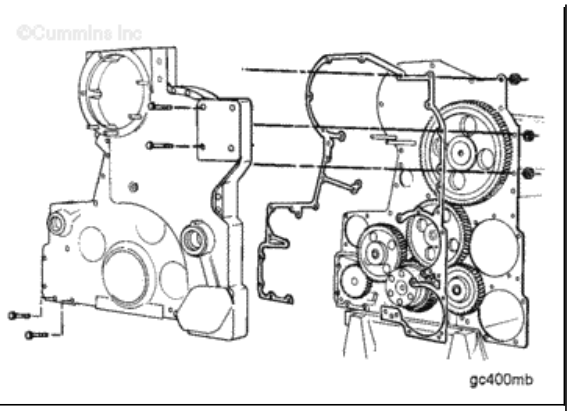
Capscrew (2) **must** be a 12-point style for head clearance.



The use of guide bolts will aid in assembly.

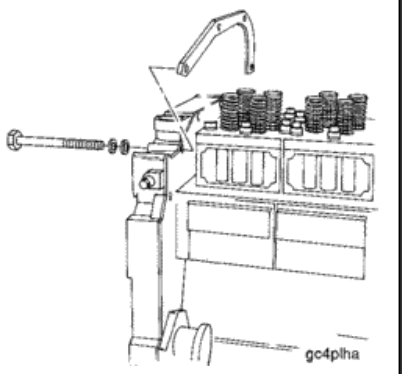
Instal the front cover gasket and the front cover.

Install the front cover capscrews, but do **not** tighten them until the master dowel pin has been installed.



Place the clamping plate into position and install the capscrew.

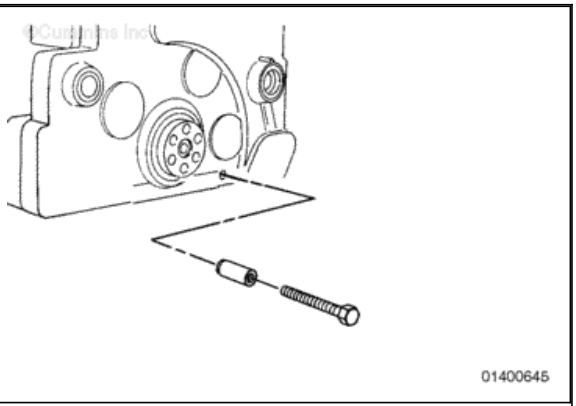
Do **not** tighten the capscrew, the clamping plate **must** remain loose until the fan hub or the cover plate is installed.



Thread a 5/16-8 x 3 in capscrew into the master dowel pin.

Use a mallet to drive the master dowel pin into the cylinder block until it touches the bottom of the hole.

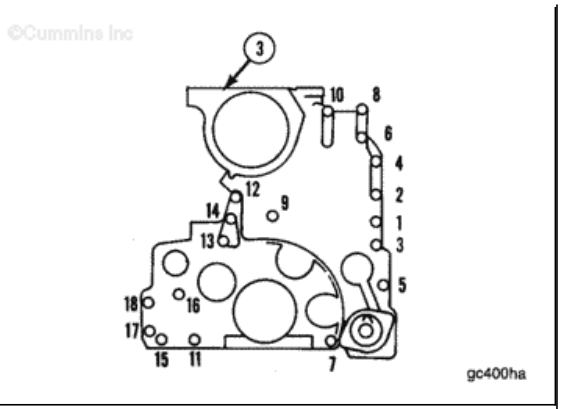
Remove the capscrew.



NOTE: Capscrews in sequence 1, 2, and 3 are located at the back of the spacer plate.

Tighten the front cover capscrews (3) in sequence.

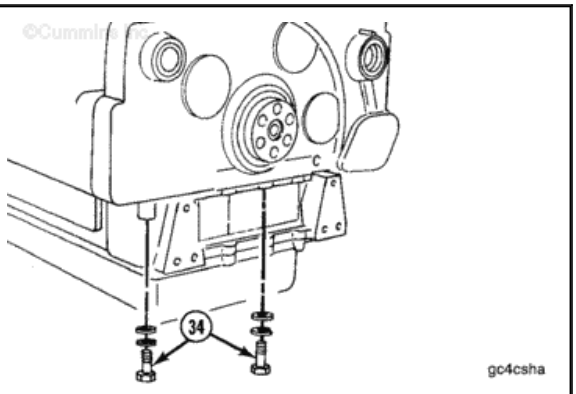
Torque Value: 45 n.m [33 ft-lb]



Install the five capscrews (34) at the bottom of the oil pan adapter.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]

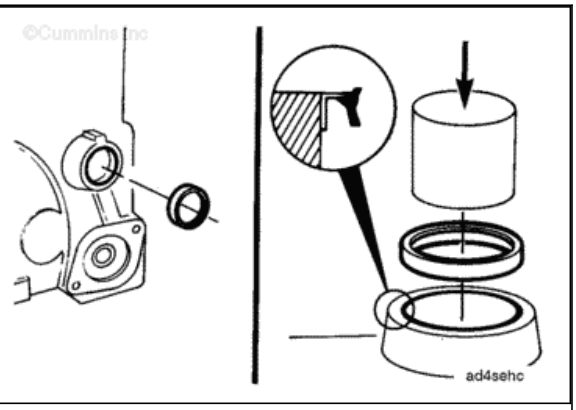


Two Piece Design, All Applications

Measure the height of the accessory drive seal boss.

- If the height is 35 mm [13/8 in], the seal is installed even with the boss.
- If the height is 38 mm [1½ in], the seal is installed 3 mm [1/8 in below the top of the boss.

Install the accessory drive seal with a mandrel.

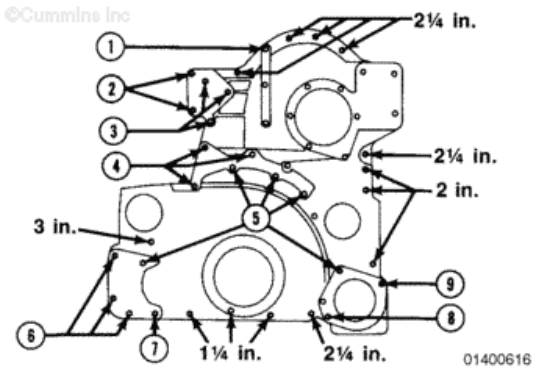


The common capscrew length requirements for all cast iron two-piece (marine) front gear cover are illustrated in the graphic.

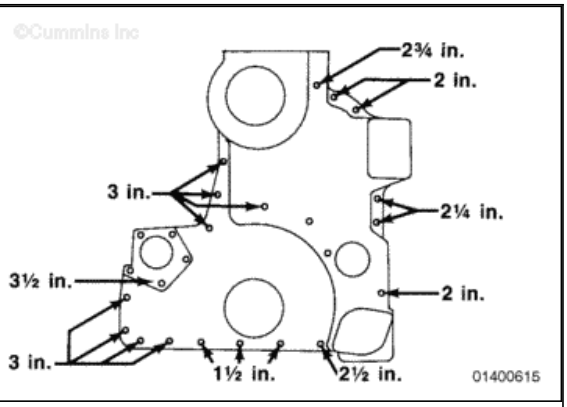
The capscrew lengths for (1) through (9) depend on the option used.

All capscrews are in US customary inches. All capscrews are 3/8 x 16 UNC.

Capscrew Lengths for Used Options				
Number	Front Power Take-off	Heat Exchanger	No Option	Both Options
(1)	3	3½	2	3½
(2)	3	3½	3	3½
(3)	3¾	4¼	4	4½
(4)	4½	3¾	4	4½
(5)	1¼	None	None	1¼
(6)	4½	3¾	4	4½
(7)	71/8	3¾	4	71/8
(8)	4½	None	None	4½
(9)	1¾	None	None	1¾

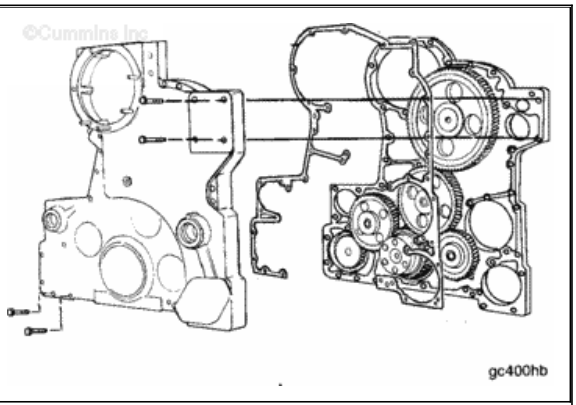


The graphic illustrates the capscrew length requirements for the aluminum two-piece front cover.



Install the guide stud.

Install the gasket, front cover and capscrews.



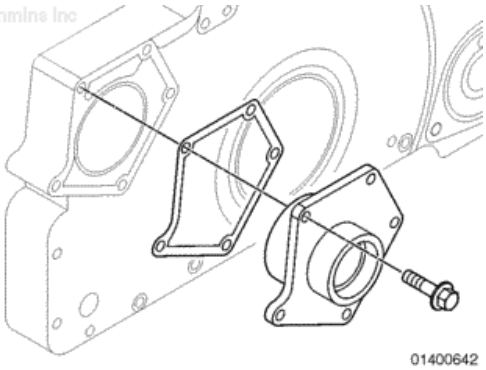
NOTE: It will possibly be necessary to freeze the drive support before installation. If the support does not fit into the cover without force freeze the cover at 0°C [32°F] for at least one hour.

Do not use capscrews to force the support in or the support will be broken.

Install the alternator drive support, gasket and capscrews.

Tighten the capscrews that are **not** part of the torque sequence.

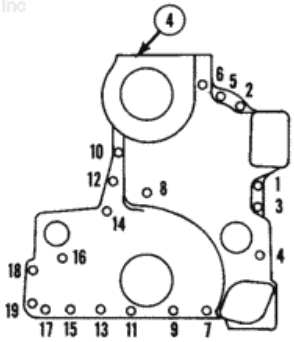
Torque Value: 45 n.m [33 ft-lb]



NOTE: The capscrew located in sequence number (4) is located at the rear of the gear housing.

Tighten the capscrews in the sequence shown.

Torque Value: 45 n.m [33 ft-lb]



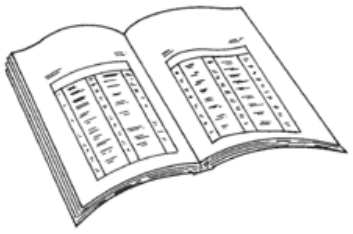
Finishing Steps

One Piece Design, All Applications Except Marine

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 hydraulic pump drive. Refer to Procedure 009-016.
- Install the fuel pump drive. Refer to Procedure 009-011.
- Install the accessory drive pulley. Refer to Procedure 009-004.
- Install the air compressor. Refer to Procedure 012-014.



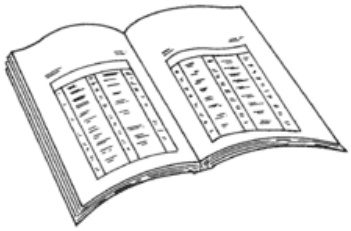
- Install the fuel pump. Refer to Procedure 005-016.
- Install the water pump drive. Refer to Procedure 009-029.
- Install the alternator drive pulley. Refer to Procedure 009-010.
- Install the thermostat housing. Refer to Procedure 008-015.
- Install the aftercooler water tubes. Refer to Procedure 010-002.
- Install the water pump. Refer to Procedure 008-062.
- Install the belt driven fan hub idler assembly. Refer to Procedure 008-030.
- Install the belt driven fan hub. Refer to Procedure 008-036.
- Install the gear driven fan hub. Refer to Procedure 008-037.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator drive belt. Refer to Procedure 013-005.
- Install the cooling fan drive belt. Refer to Procedure 008-002.
- Fill the cooling system. Refer to Procedure 008-018.
- Connect the batteries or air starter.

One Piece Design, Marine Applications

WARNING

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- Install the fuel pump. Refer to Procedure 005-016.
- Install the water pump drive. Refer to Procedure 009-029.
- Install the alternator drive pulley. Refer to Procedure 009-010.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the thermostat housing. Refer to Procedure 008-015.
- Install the aftercooler water tubes. Refer to Procedure 010-002.
- Install the sea water pump. Refer to Procedure 008-057.



ck800wa

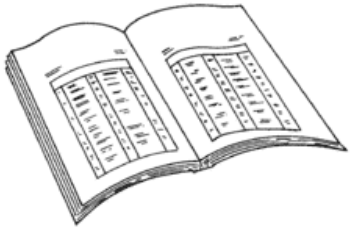
- Install the heat exchanger. Refer to Procedure 008-053.
- Install the sea water expansion tank. Refer to Procedure 008-052.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator drive belt. Refer to Procedure 013-005.
- Fill the cooling system. Refer to Procedure 008-018.
- Connect the batteries or air starter.

Two Piece Design, All Applications Except Marine

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 three capscrews from the hydraulic pump drive. Refer to Procedure 009-016.
- Install the four capscrews that mount fuel pump drive to the front gear cover. Refer to Procedure 009-011.
- Install the accessory drive pulley. Refer to Procedure 009-004.
- Install three capscrews from the water pump drive. Refer to Procedure 009-029.
- Install the alternator drive pulley. Refer to Procedure 009-010.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the thermostat housing. Refer to Procedure 008-015.
- Install the aftercooler water tubes. Refer to Procedure 010-002.
- Install the belt driven fan hub idler assembly. Refer to Procedure 008-030.
- Install the belt driven fan hub. Refer to Procedure 008-036.
- Install the gear driven fan hub. Refer to Procedure 008-037.
- Install the alternator. Refer to Procedure 013-001.
- Install the cooling fan drive belt. Refer to Procedure 008-002.
- Install the cooling fan. Refer to Procedure 008-040.
- Fill the cooling system. Refer to Procedure 008-018.
- Connect the batteries or air starter.



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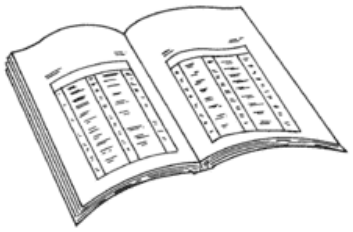
Two Piece Design, Marine Applications

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.

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- Install the accessory drive pulley. Refer to Procedure 009-004.
- Install three capscrews from the water pump drive. Refer to Procedure 009-029.
- Install the alternator drive pulley. Refer to Procedure 009-010.
- Install the vibration damper. Refer to Procedure 001-052.
- Install the thermostat housing. Refer to Procedure 008-015.
- Install the aftercooler water tubes. Refer to Procedure 010-002.
- Install the sea water pump. Refer to Procedure 008-057.
- Install the heat exchanger. Refer to Procedure 008-053.
- Install the sea water expansion tank. Refer to Procedure 008-052.
- Install the alternator. Refer to Procedure 013-001.
- Install the alternator drive belt. Refer to Procedure 013-005.
- Fill the cooling system. Refer to Procedure 008-018.
- Connect the batteries or air starter.

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001-033 Gear Housing, Front

Preparatory

WARNING

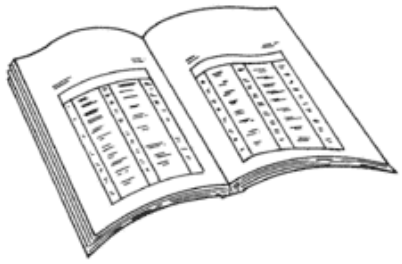
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

- Remove the accessory drive pulley. Refer to Procedure 009-004.
- Remove the front gear cover. Refer to Procedure 001-031.
- Drain lubricating oil. Refer to Procedure 007-037.
- Remove the engine barring device. Refer to Procedure 009-035.
- Remove the fuel pump. Refer to Procedure 005-016.
- Remove the air compressor. Refer to Procedure 012-014.
- Remove the fuel pump drive. Refer to Procedure 009-011.

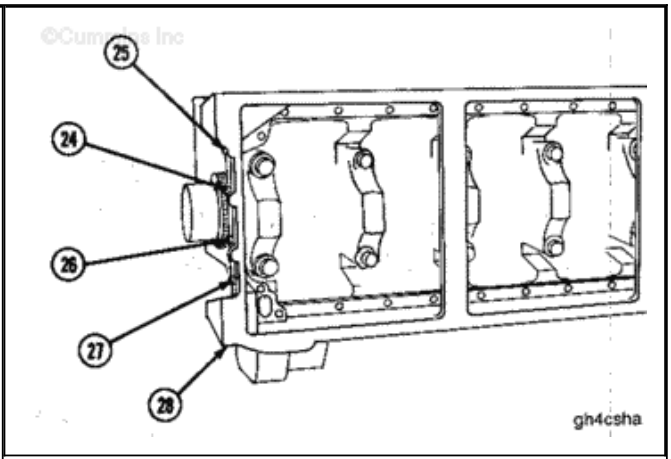




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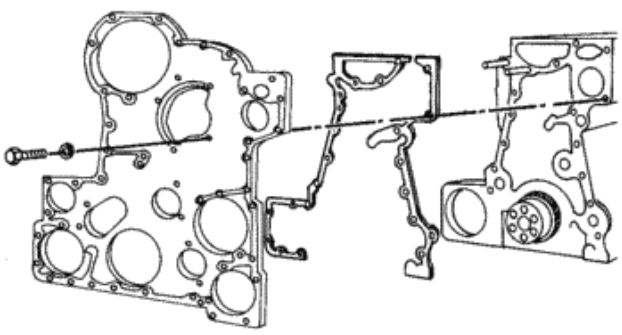
• Remove the hydraulic pump drive. Refer to Procedure 009-016. • Bar the engine, by turning the crankshaft, until the index marks on the camshaft gear and the crankshaft gear are in alignment. • Remove the camshaft idler gear. Refer to Procedure 001-036. • Remove the water pump idler gear. Refer to Procedure 001-040. • Remove the hydraulic pump idler gear, if equipped. Refer to Procedure 001-039. • Remove the camshaft gear or camshaft. Refer to Procedure 001-012 or 001-008. • Remove the oil pan or oil pan adapter cover. Refer to Procedure 007-025. or 007-026.		

Remove

Remove the five capscrews that attach the bottom of the gear housing to the oil pan adapter.		
Remove and tag the 11 gear housing capscrews.		

Remove the gear housing and gasket.

Discard the gasket.



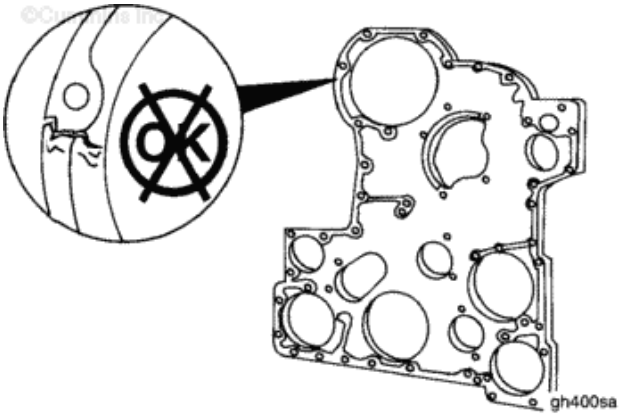
Clean and Inspect for Reuse

Clean the gear hosing.

Check both sides of the gear housing gasket surfaces for fretting damage.

Inspect the gear housing for cracks.

If the gear housing is cracked or damaged it **must** be repaired or replaced.

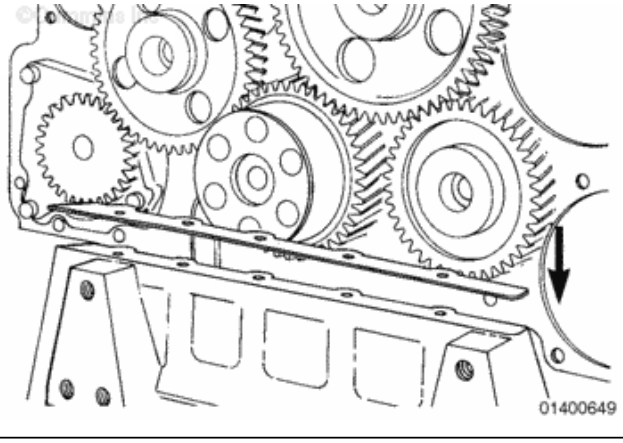


Install

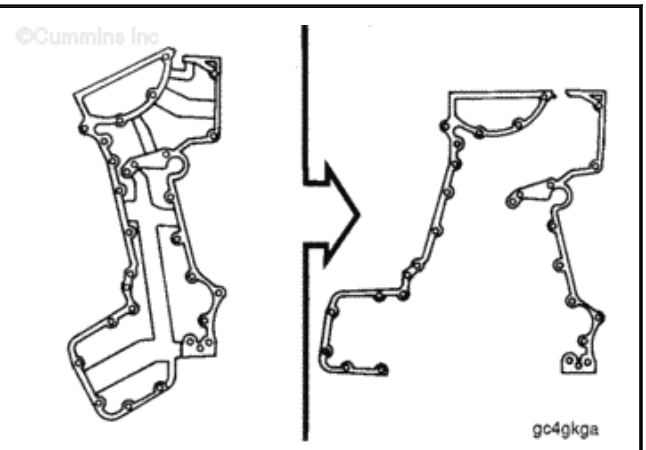
Install the gasket piece onto the top of the oil pan adapter.

Use a spray adhesive to hold it in position.

Apply sealant, Part Number 3164067, or equivalent, to the joints of the gasket.



Separate the gasket as illustrated in the graphic. Discard the center tab sections.



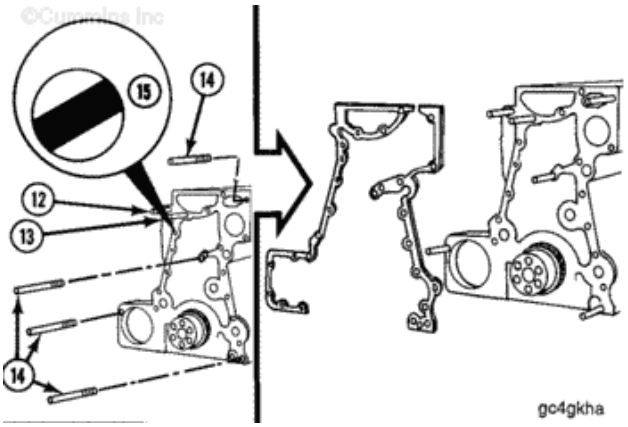
If the engine has a belt driven fan hub, install two studs (12) and (13).

The length of stud (12) is 140 mm [5½ in].

The length of stud (13) is 152 mm [6 in].

The diamond dowel (15) **must** be installed with the flat surface turned towards the master dowel hole at the lower right hand corner of the block.

Guide studs (14) will help during installation.



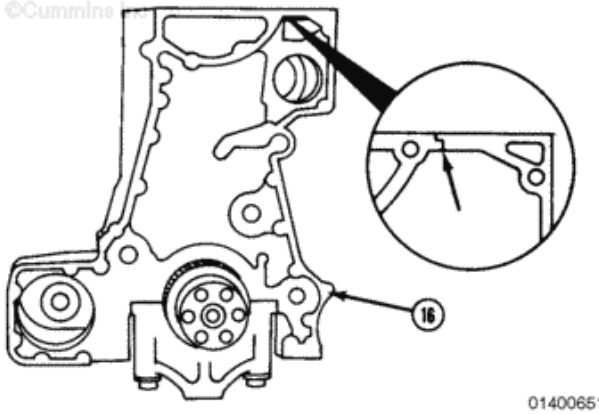
CAUTION

Do not use gasket cement. Damage to the gasket will result.

NOTE: The gasket illustrated in the graphic is used on old and new style blocks. When used on the old style block, there will be a capscrew hole (16) that is not used. It is not necessary to trim the gasket at this location.

Apply a small amount of sealant, Part Number 3164067, or equivalent, to both sides of the gasket at the butt joint.

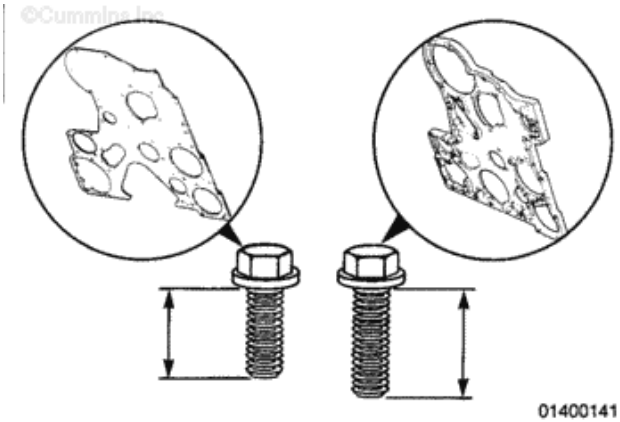
Install the gasket.



CAUTION

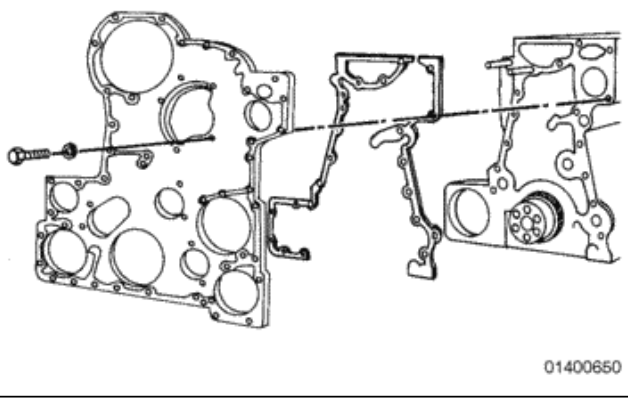
Special capscrews are required to attach the gear housing. The capscrews have a captive, cone shaped washer to maintain torque.

The capscrews for the gear housing are 28.575 mm [11/8 in] long.



Install the gear housing.

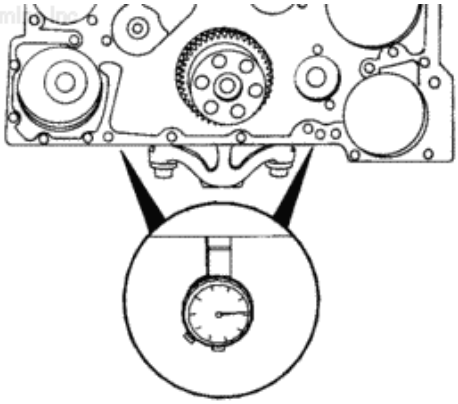
Install the capscrews and remove the guide studs.



NOTE: If the oil pan adapter is removed, the gear housing alignment must be checked. If the oil pan adapter is installed the alignment does not need to be checked.

Use depth gauge, Part Number 3164438, or equivalent to measure the distance from the bottom of the cylinder block to the bottom of the housing.

The bottom of the housing **must** be within 0.05 mm [0.002 in] of the bottom of the block.

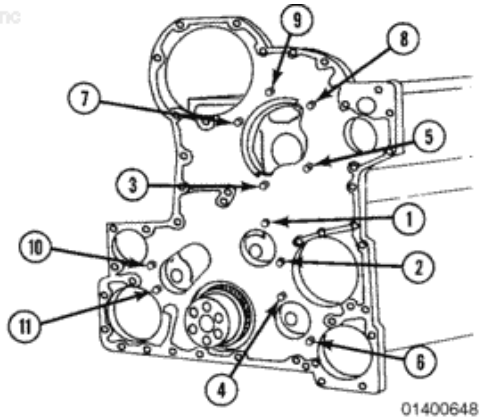


Align the housing with the bottom of the block if necessary.

Tighten the capscrews in the sequence shown.

Torque
Value: 45 n.m [33 ft-lb]

Measure the housing to the block alignment to make sure it is within specifications.

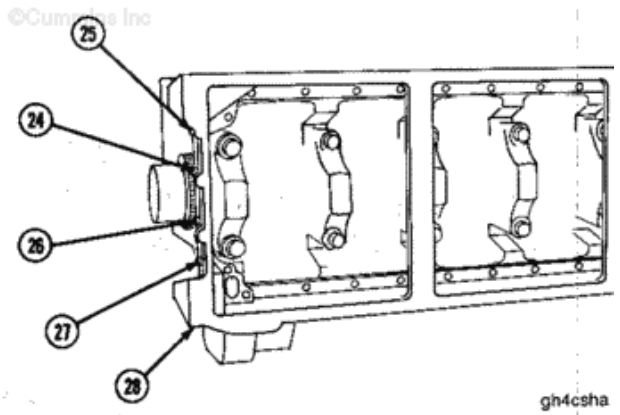


Install the remaining 3/8 inch

washers and capscrews into the bottom of the gear housing.

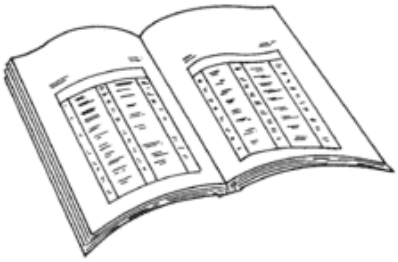
Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

- Install the oil pan or oil pan adapter cover. Refer to Procedure 007-025. or 007-026.
- Install the camshaft gear or camshaft. Refer to Procedure 001-012 or 001-008.
- Install the hydraulic pump idler gear, if equipped. Refer to Procedure 001-039.
- Install the water pump idler gear. Refer to Procedure 001-040.
- Install the camshaft idler gear. Refer to Procedure 001-036.
- Bar the engine, by turning the crankshaft, until the index marks on the camshaft gear and the crankshaft gear are in alignment.
- Install the hydraulic pump drive. Refer to Procedure 009-016.
- Install the fuel pump drive. Refer to Procedure 009-011.
- Install the air compressor. Refer to



Procedure 012-014. • Install the fuel pump. Refer to Procedure 005-016. • Install the engine barring device. Refer to Procedure 009-035. • Fill the engine with lubricating oil. Refer to Procedure 007-037. • Install the front gear cover. Refer to Procedure 001-031. • Install the accessory drive pulley. Refer to Procedure 009-004.		

Last Modified: 08-Dec-2004

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001-036 Idler Gear, Camshaft

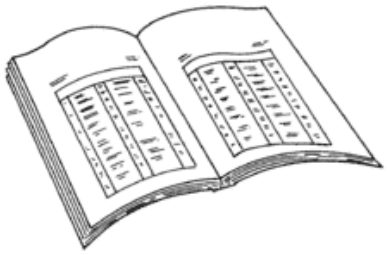
Preparatory Steps

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.

- Remove the front cover. Refer to Procedure 001-031.
- Rotate the engine by turning the crankshaft until the index marks on the crankshaft and camshaft gears are in alignment.

NOTE: The marks on the crankshaft and camshaft gears must point straight at one another. The marks on the idler gear do not have to be aligned as long as the crankshaft and camshaft gears are in alignment.



Remove

Bolt-On Type

The bolt in idler shaft has a flange that requires the shaft, gear, and thrust washers to be removed as an assembly.

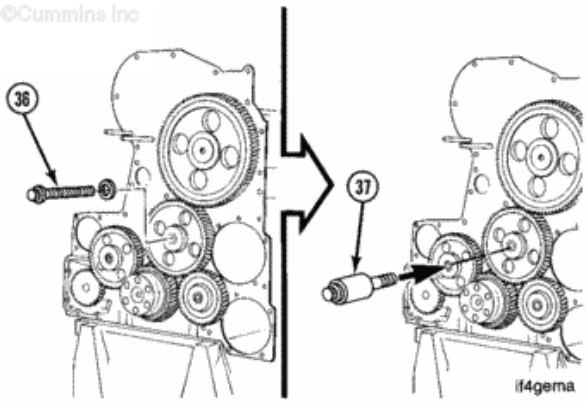
NOTE: The shafts used in newer engines do not have

threads to be used with a puller. Loosen the capscrew (36), but do not completely remove it.

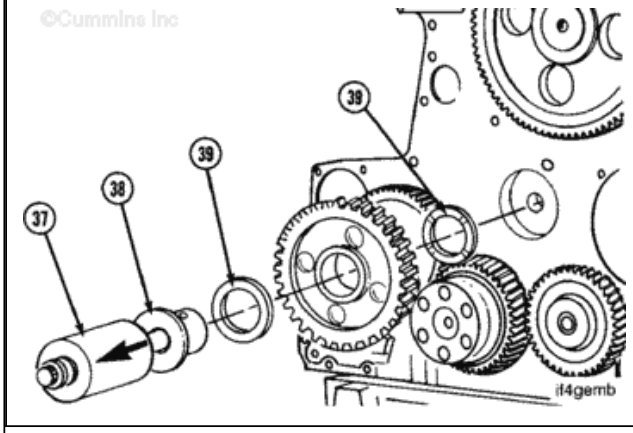
Remove the capscrew (36).

Use an old piston pin and a K19 cylinder head capscrew as a slide hammer (37).

Thread the capscrew into the idler shaft.

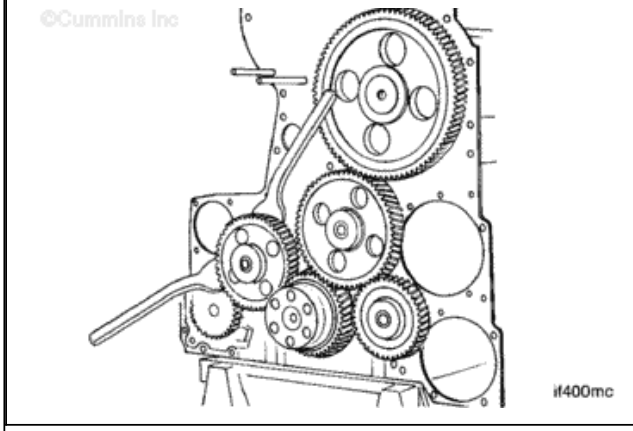


Use the slide hammer (37) to remove the shaft (38), two thrust washers (39), and the gear as an assembly.



For shafts used in newer engines, make sure the capscrew is threaded into the cylinder block.

Pry the gear and shaft assembly out of the cylinder block with two pry bars.

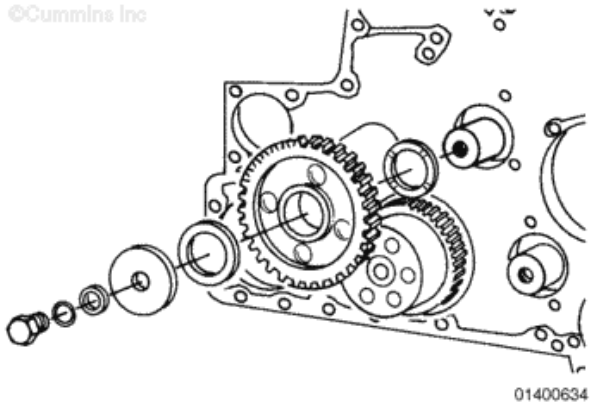


Press-Fit Type

Some engines have a press fit design idler shaft that does **not** have to be removed from the

block to remove the idler gear.

Remove the capscrew, washers, gear, and thrust washer.



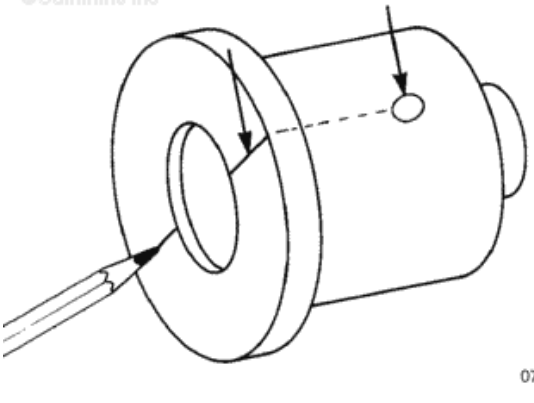
Install

Bolt-On Type

CAUTION

The oil holes in the camshaft idler shaft and hydraulic pump idler shaft must be installed at a specific orientation. If the shaft is not orientated correctly a failure of the gear bushing can result.

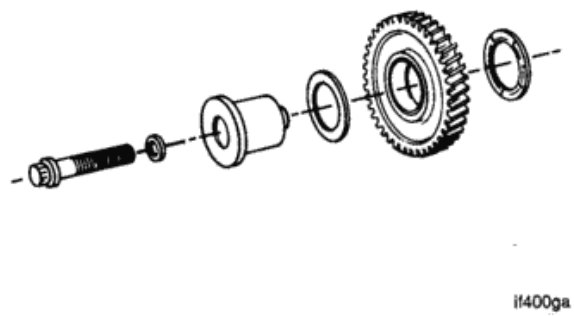
Mark the flange of the shaft to show the oil hole orientation.



CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washers mush be positioned toward the gear.

The timing marks on the camshaft idler gear **must** be visible when the gear is installed.



Lubricate the gear, bushing, shaft, and thrust washer with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrew with clean engine oil.

Assemble the parts as illustrated in the graphic.

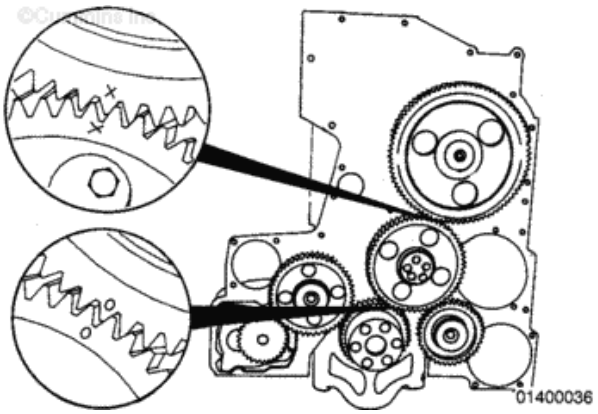
CAUTION

Do not allow the inner thrust washer to fall between the shaft and block or the washer will be damaged and the gear end clearance will be to large.

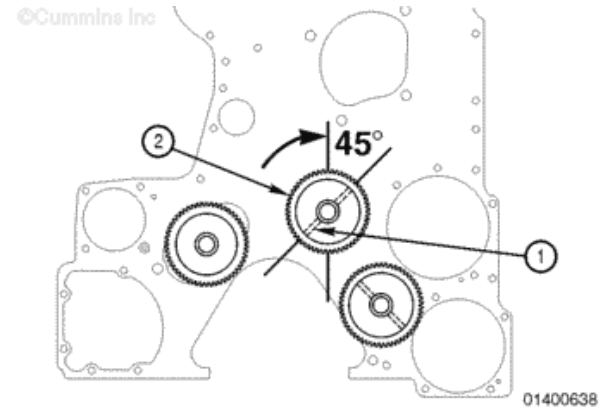
The camshaft idler gear is the **only** gear that has timing marks.

Install the gear and shaft assembly aligning the following:

- The “O” on the idler gear with the “O” on the crankshaft gear.
- The “X” on the idler gear with the “X” on the camshaft gear.



Align the camshaft idler shaft (2) so the oil drilling the shaft (1) is 45 degrees **clockwise** from vertical as shown.

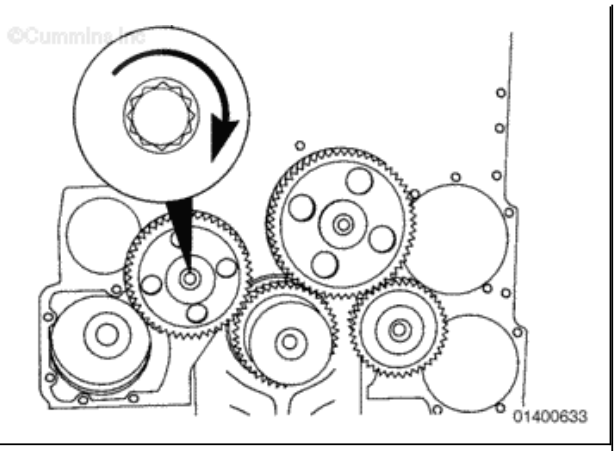


Install the capscrew and use it to pull the shaft into the bore.

Tighten the capscrew.

Torque Value:

Step 1	185 n.m	[135 ft-lb]
Step 2	Loosen completely	
Step 3	60 n.m	[45 ft-lb]
Step 4	Tighten 90 degrees	



Press-Fit Type

CAUTION

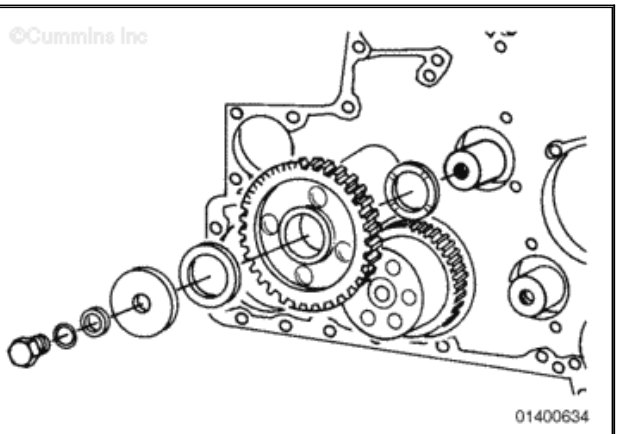
To reduce the possibility of engine damage, the grooves in the thrust washer must be positioned toward the gear.

Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrews with clean engine oil.

Assemble the parts as illustrated in the graphic.

Torque Value: 45 n.m [33 ft-lb]



All Applications

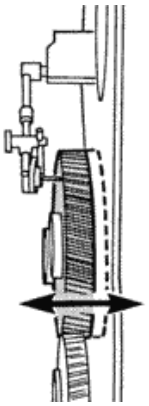
Measure the camshaft idler gear end clearance.

Camshaft Idler Gear End Clearance		
mm		in
0.29	MIN	0.012
0.51	MAX	0.020

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.

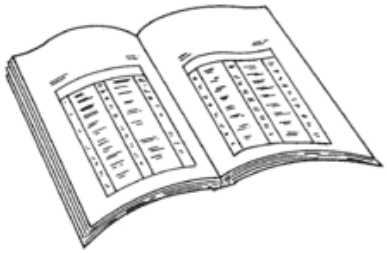


Finishing Steps

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 front gear cover. Refer to Procedure 001-031.



Last Modified: 25-Aug-2004

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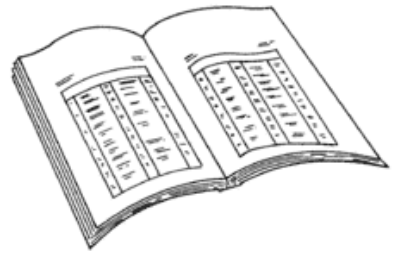
001-039 Idler Gear, Hydraulic Pump

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.

- Remove the front gear cover. Refer to Procedure 001-031.



Remove

Bolt-On Type

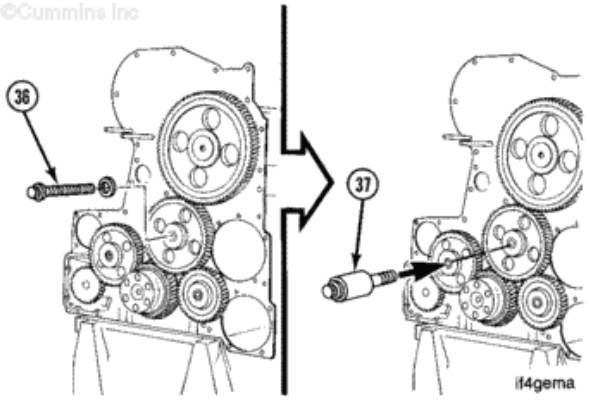
The bolt in idler shaft has a flange that requires the shaft, gear, and thrust washers to be removed as an assembly.

NOTE: The shafts used in newer engines do not have threads to be used with a puller. Loosen the capscrew (36), but do not completely remove it.

Remove the capscrew (36).

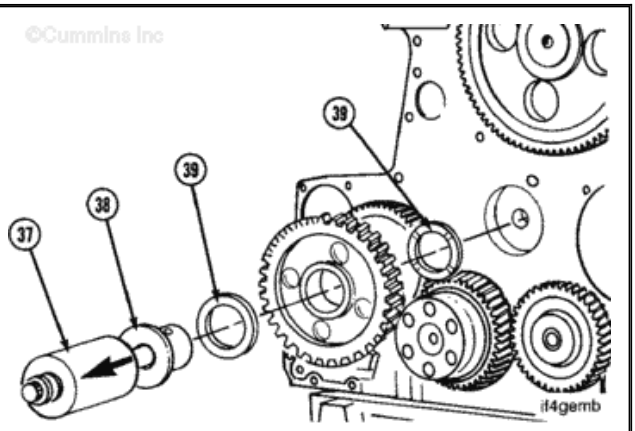
Use an old piston pin and a K19 cylinder head capscrew as a slide hammer (37).

Thread the capscrew into the



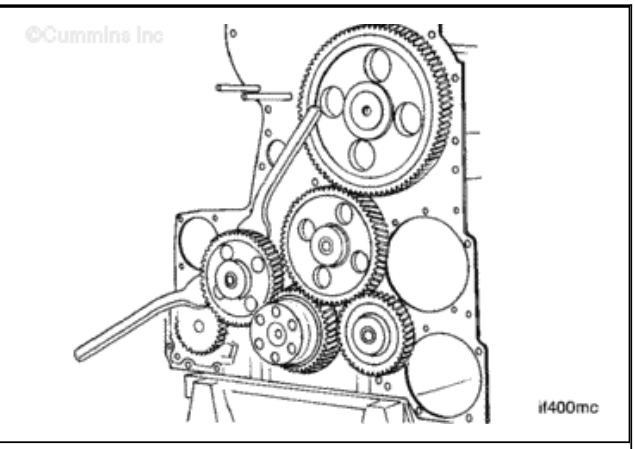
idler shaft.

Use the slide hammer (37) to remove the idler shaft (38), two thrust washers (39) and the gear as an assembly.



For shafts used in newer engines, make sure the capscrew is threaded into the cylinder block.

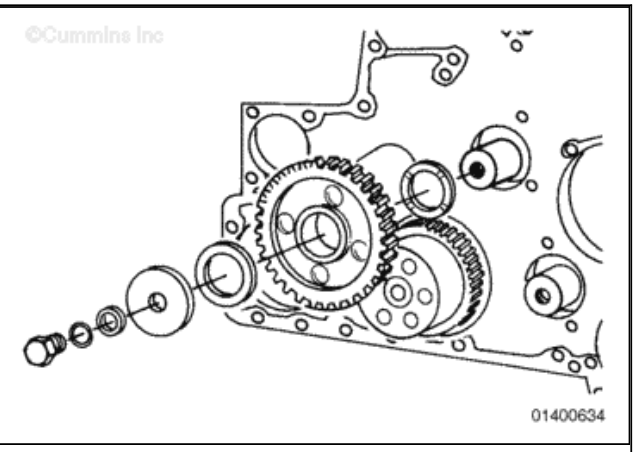
Pry the gear and shaft assembly out of the cylinder block with two pry bars.



Press-Fit Type

Some engines have a press-fit design idler shaft that does **not** have be removed from the cylinder block to remove the idler gear.

Remove the capscrew, washers, gear, and thrust washer.



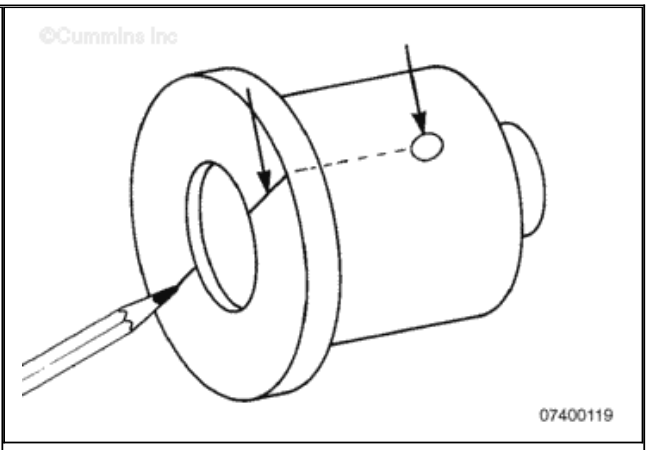
Install

Bolt-On Type

CAUTION

The holes in the hydraulic pump idler shaft and camshaft idler shaft must be installed in a specific orientation. If the shaft is not orientated correctly failure of the gear bushing can result.

Mark the flange of the shaft to show the oil hole orientation.



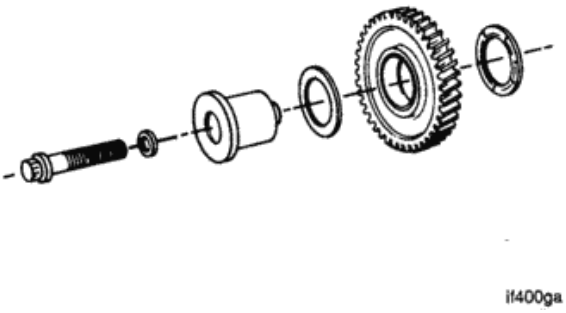
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washer must be turned toward the gear.

Lubricate the gear bushing, shaft and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrews with clean engine oil.

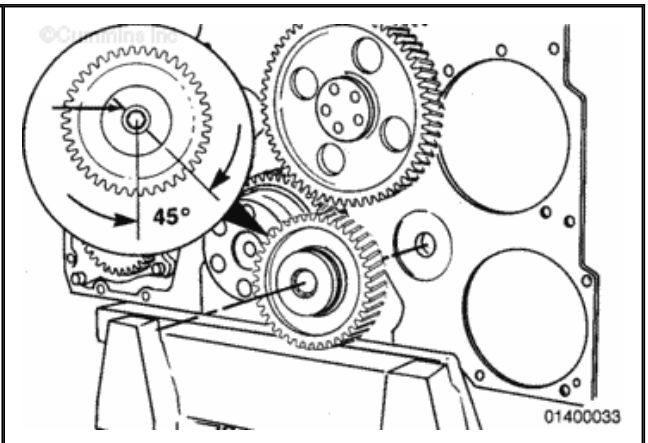
Assemble the parts.



CAUTION

Engines that contain a hydraulic pump must have the oil holes in the hydraulic idler shaft oriented as illustrated in the graphic. Idler gear bushing failure will result if the oil holes are not aligned correctly.

Align the oil holes in the shaft to an



angle 45 degrees to the left of vertical.

Install the gear and shaft assembly, and the capscrew.

Use the capscrew to pull the idler shaft into the cylinder block bore.

Tighten the capscrew.

Torque Value:	Step 1	185 n.m [135 ft-lb]
	Step 2	Loosen completely
	Step 3	60 n.m [45 ft-lb]
	Step 4	Turn capscrew 90 degrees

Press-Fit Type

CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washer must be turned toward the gear.

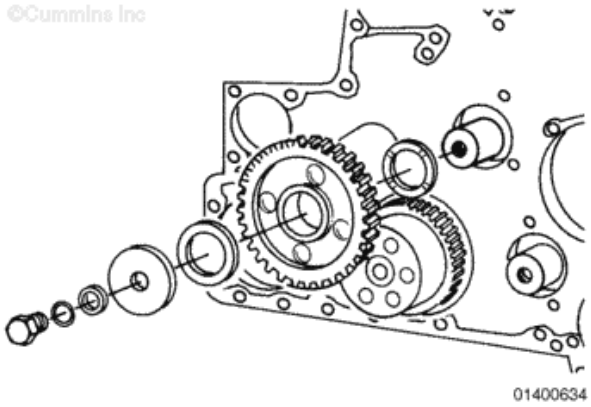
Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 3163086, or equivalent.

Lubricate the capscrews with clean engine oil.

Install the parts as illustrated in the graphic.

Tighten the capscrew.

Torque Value: 45 n.m [33 ft-lb]



All Applications

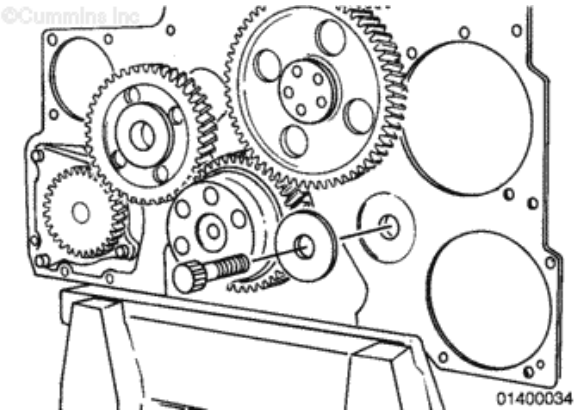
CAUTION

Engines that do not have a hydraulic pump drive must have a plug installed in place of the idler shaft. Low oil pressure will result if the plug is omitted.

Install a 9/16 UNF-inch capscrew, lock washer, and plain washer that is larger than the cylinder block bore.

Tighten the capscrew.

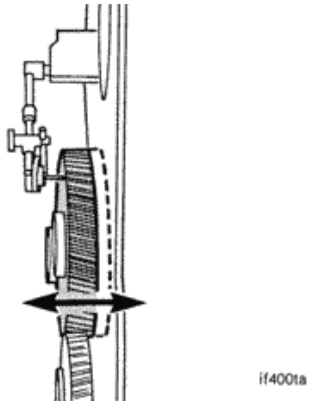
Torque Value: 65 n.m [50 ft-lb]



Measure the hydraulic pump idler gear end clearance with a dial indicator.

Hydraulic Pump Idler Gear End Clearance		
mm		in
0.10	MIN	0.004
0.36	MAX	0.014

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.

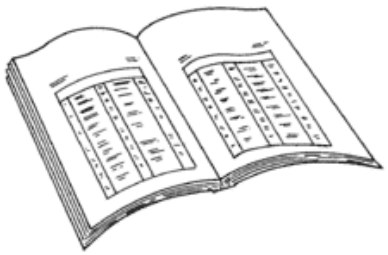


Finishing Steps

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 front cover. Refer to Procedure 001-031.



Last Modified: 04-Nov-2004

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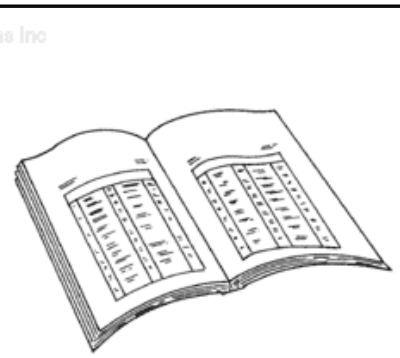
001-040 Idler Gear, Water Pump

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.

- Remove the front gear cover. Refer to Procedure 001-031.



Remove

Bolt-On Type

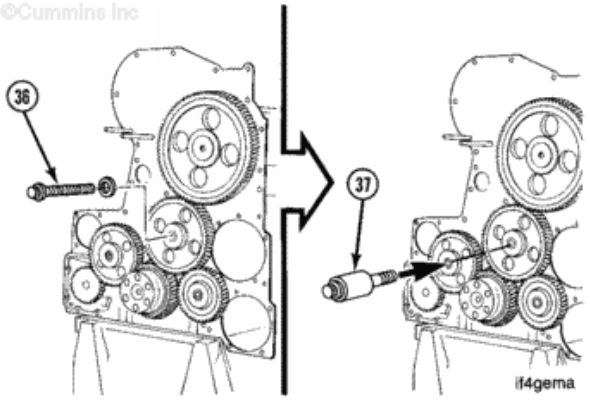
The bolt in idler shaft has a flange that requires the shaft, gear, and thrust washers to be removed as an assembly.

NOTE: The shafts used in newer engines do not have threads to be used with a puller. Loosen the capscrew (36), but do not completely remove it.

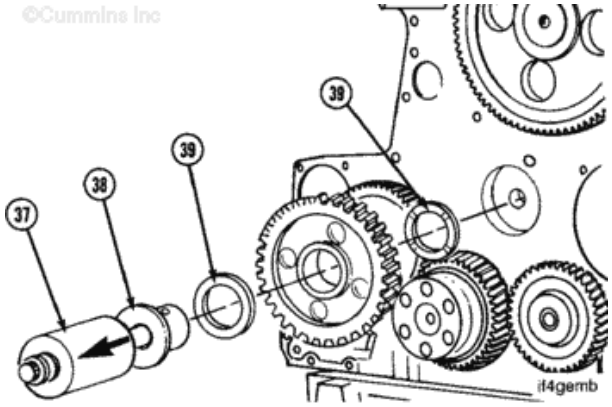
Remove the capscrew (36).

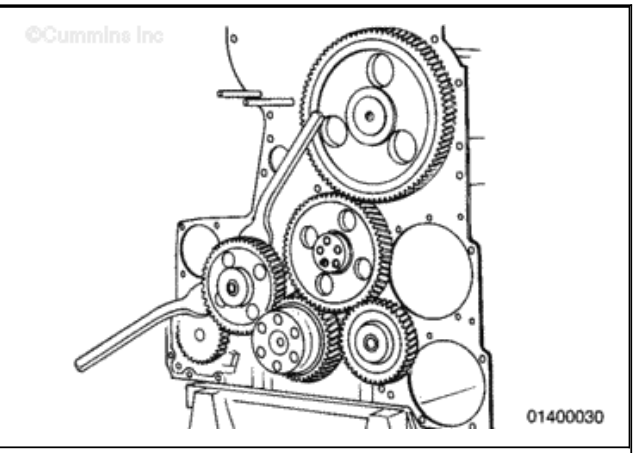
Use an old piston pin and a K19 cylinder head capscrew as a slide hammer (37).

Thread the capscrew into the

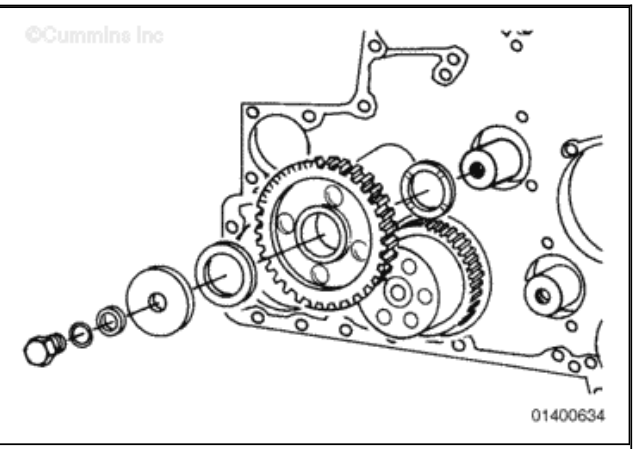


idler shaft.		

Use the slide hammer (37) to remove the shaft (38), two thrust washers (39), and gear as an assembly.		

For shafts used in newer engines, make sure the capscrew is threaded into the cylinder block. Pry the gear and shaft assembly out of the cylinder block with two pry bars.		

Press-Fit Type

Some engines have a press fit design idler shaft that does **not** have to be removed from the block to remove the idler gear. Remove the capscrew, washers, gear, and thrust washer.		

Install

Bolt-On Type

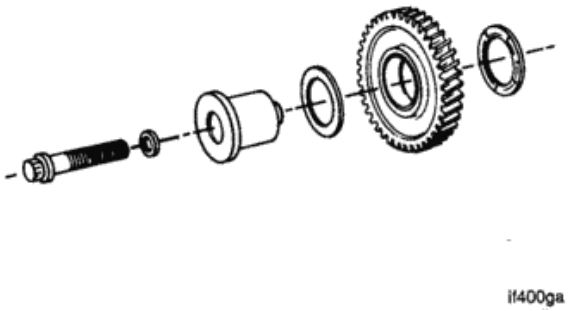
CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washers must be turned toward the gear.

Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant, Part Number 316086, or equivalent.

Lubricate the capscrew with clean engine oil.

Assemble the parts.



CAUTION

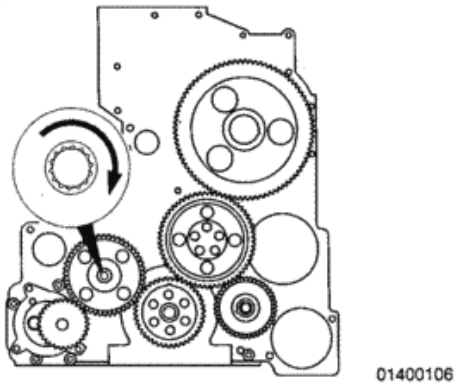
Do not allow the thrust washer to fall between the shaft and block or the will washer will be damaged and the gear end clearance will be to large.

Install the gear and shaft assembly.

Use the capscrew to pull the shaft into the cylinder block.

Tighten the capscrew.

Torque Value:	Step 1	185 n.m [135 ft-lb]
	Step 2	Loosen completely
	Step 3	60 n.m [45 ft-lb]
	Step 4	Tighten 90 degrees



Press-Fit Type

CAUTION

To reduce the possibility of engine damage, the grooves in the thrust washers must, be turned toward the gear.

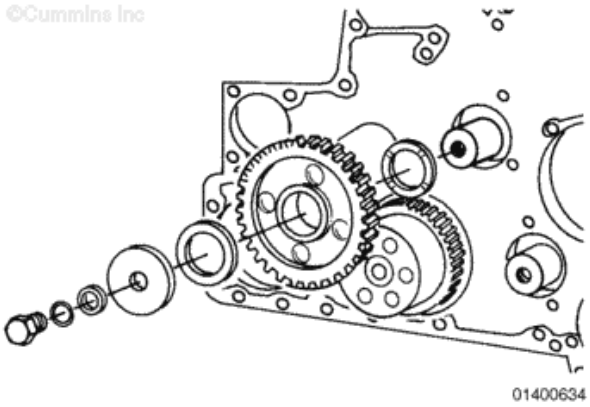
Lubricate the gear bushing, shaft, and thrust washers with Lubriplate® Number 105 multipurpose lubricant or equivalent.

Lubricate the capscrew with clean engine oil.

Install the parts as illustrated in the graphic.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]

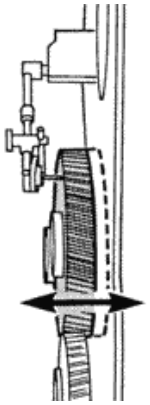


All Applications

Measure the idler gear end clearance with a dial indicator.

Water Pump Idler Gear End Clearance		
mm		in
0.10	MIN	0.004
0.36	MAX	0.014

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.



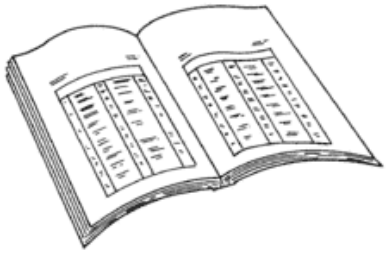
Finishing Steps

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 front cover. Refer to Procedure 001-031.

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ck800wa

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001-043 Piston

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.

CAUTION

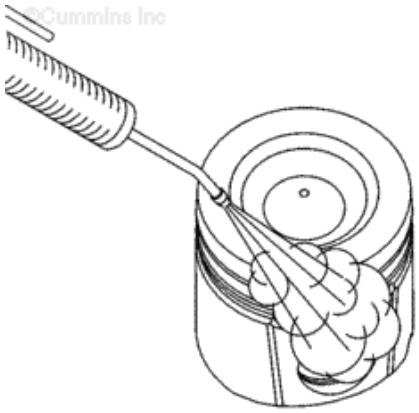
Do not use the bead blast method to clean the ring grooves or the skirt. The piston will be damaged by blast material embedded into the aluminum.

Premium pistons have an anodized surface that is gray in appearance. Do **not** attempt to remove this surface when cleaning.

Make sure the piston rings have been removed.

Clean the outer layer of carbon from the piston with steam.

The bead blast method can be used to clean the top of the piston. If the bead blast method is used, cover the ring grooves and skirt securely.



01400635

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.

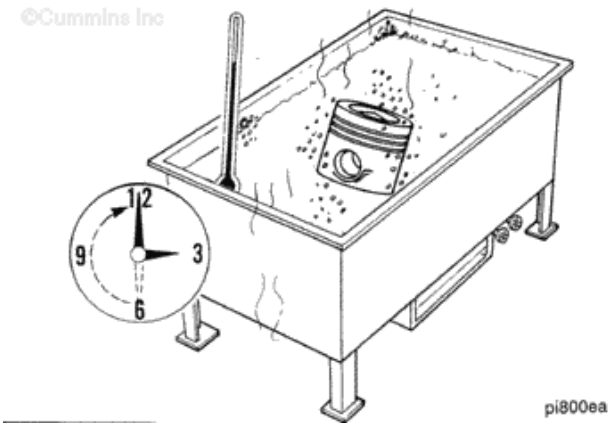
CAUTION

To reduce the possibility of engine damage, do not contaminate the wash tank solution with beat blast material.

Allow the pistons to soak in the solvent for a minimum of 30 minutes.

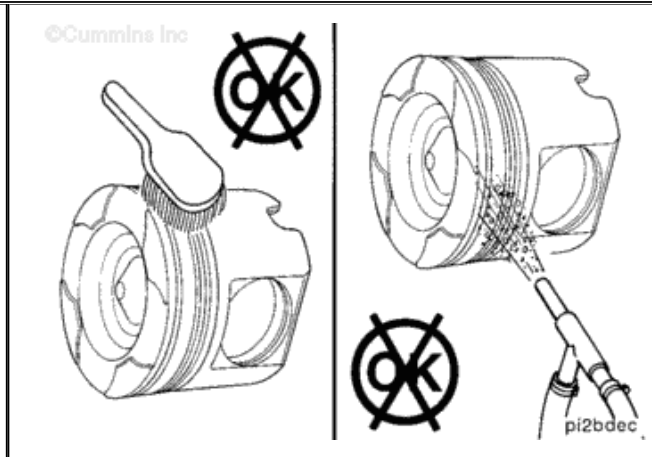
For best results, soak the pistons for several hours, or overnight. Use a solvent that can be heated from 90°C to 95° C [180°F to 200°F]. Use a cleaning tank that will constantly mix and filter the solvent.

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 cresols, phenols, or cresylic components.



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.

CAUTION

Do not use a metal bristle brush. Damage to the piston ring grooves will result.

Clean the piston ring grooves with a brush or the gap end of a used piston ring.

Repeat the soaking and scrubbing process until the piston is cleaned thoroughly.

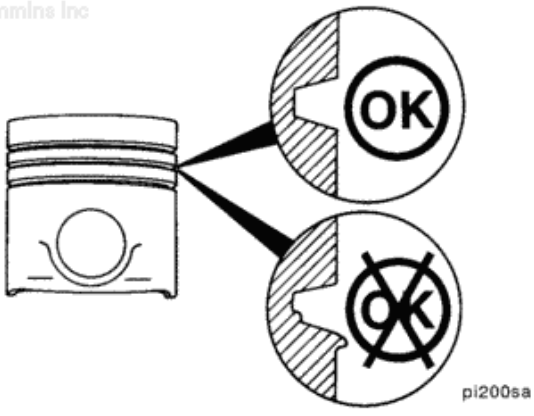
Rinse the solvent from the piston with steam.

Dry the piston with compressed air.

Inspect the ring grooves.

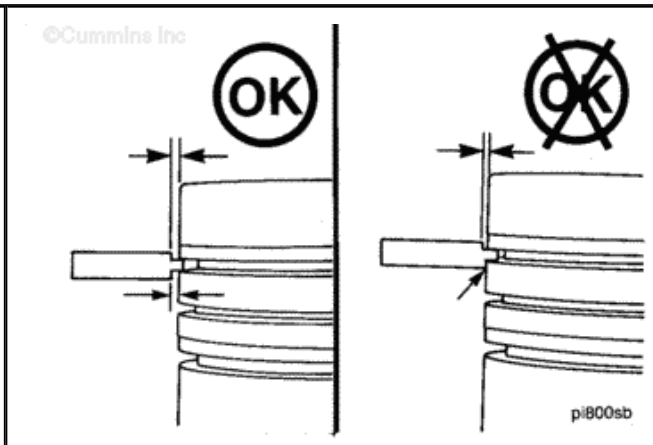
If there is a visible ridge in the back of the ring groove, the piston **must** be replaced.

If a lip has formed on the outside diameter of the groove, the piston **must** be replaced.



Measure both of the piston compression ring grooves with the piston ring gauge, Part Number ST-560

If the measurements are **not** within specifications, the piston **must** be replaced.

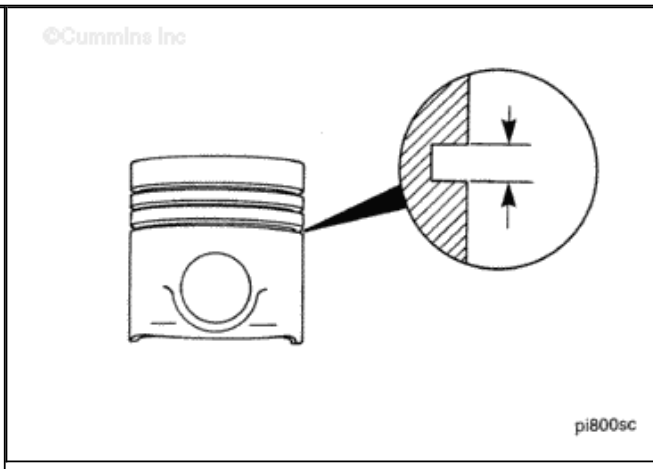


Measure the oil ring groove.

Piston Oil Ring Groove Width

mm		in
4.788	MIN	0.186
4.813	MAX	0.190

If the piston is **not** within specifications, it **must** be replaced.



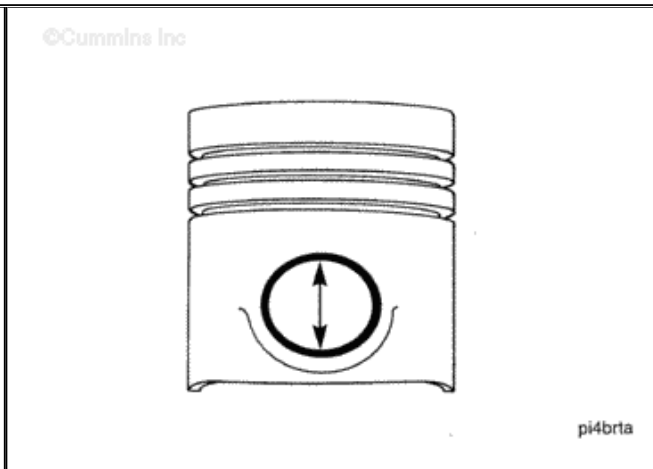
Measure the piston pin bore when the room temperature is approximately 21°C [70° F].

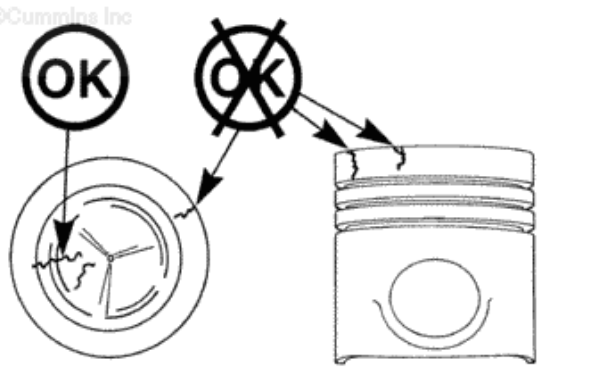
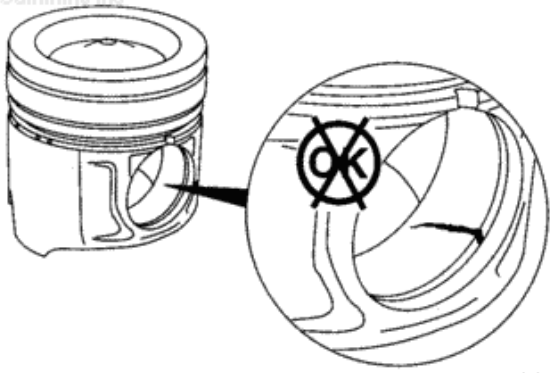
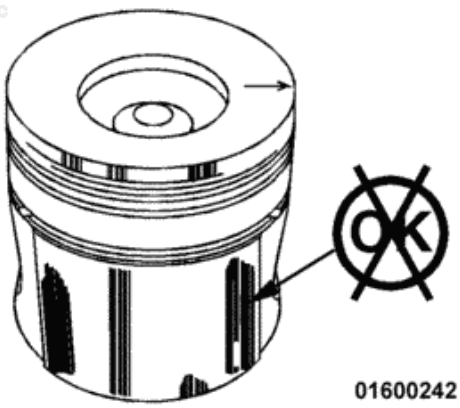
Measure and record the inside diameter of the piston pin bore and the points illustrated in the graphic.

Piston Pin Bore Inside Diameter

mm		in
60.922	MIN	2.3985
60.932	MAX	2.3989

If the piston pin bore is **not** within specifications, the piston **must** be replaced.



The crack detection kit contains cleaner, penetrant, and developer necessary to check for cracks using the dye penetrant method. Check for cracks on the top of the piston and in the piston pin bore with crack detection kit, Part Number 3375432 or equivalent. The piston **must** be replaced if there is a crack on the top of the piston that extends more than half the distance across the shaded area, or a crack on the top of the piston that extends over the rim and toward the ring grooves.		 pi4bdsa
The piston **must** be replaced if there is a crack in the piston pin bore.		 pi8brsa
Inspect the piston for scratches or indications of scuffing. Reference the Parts Reuse Guidelines, Bulletin 3810303.		 01600242

Last Modified: 04-Apr-2011

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001-046 Piston Cooling Nozzle

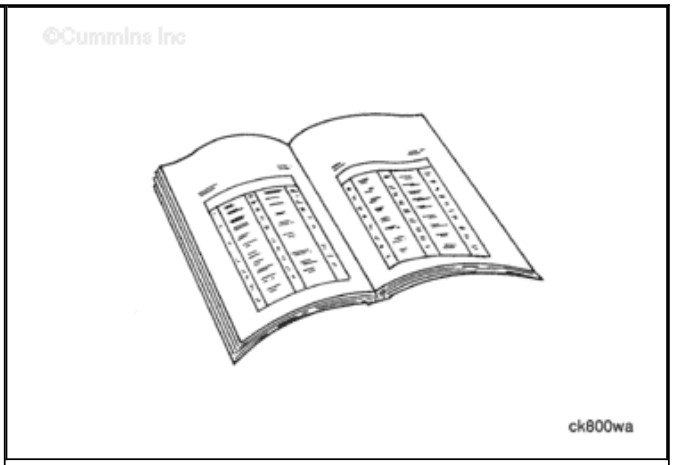
Preparatory Steps

One Piece Design, All Applications

- Remove the fuel pump, if necessary. Refer to Procedure 005-016 in Section 5.
- Remove the air compressor, if necessary. Refer to Procedure 012-014 in Section 12.







Two Piece Design, All Applications

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

Some state and federal agencies have determined that used engine oil can be



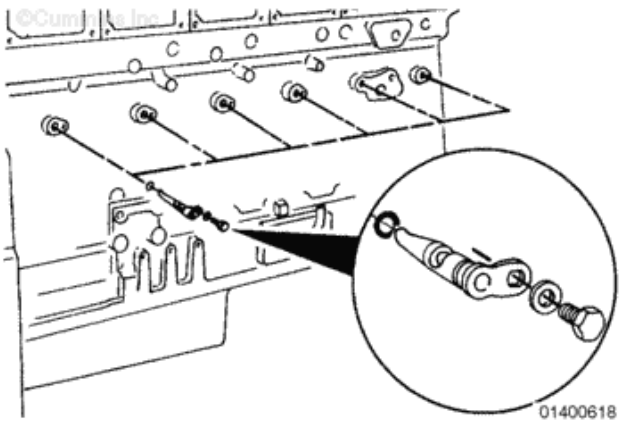




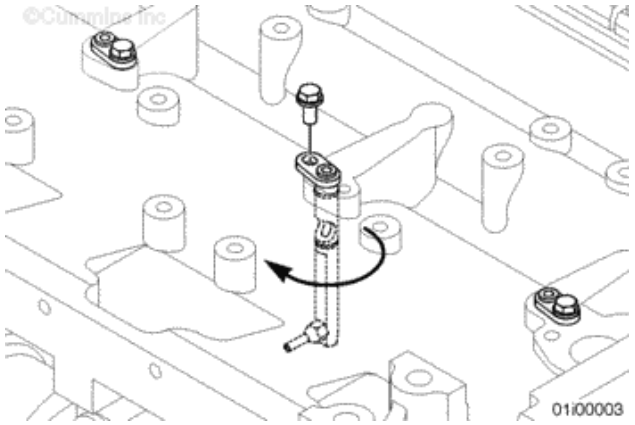
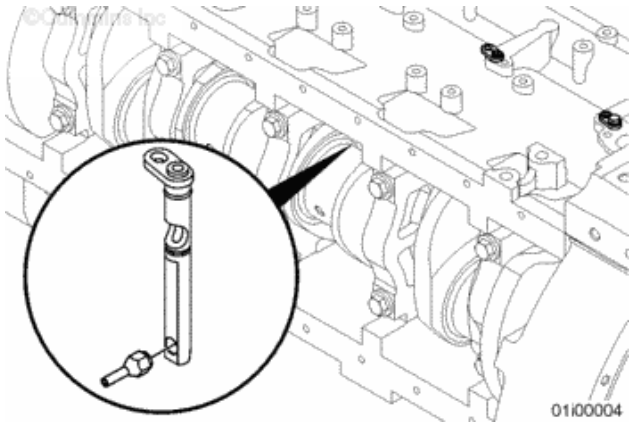
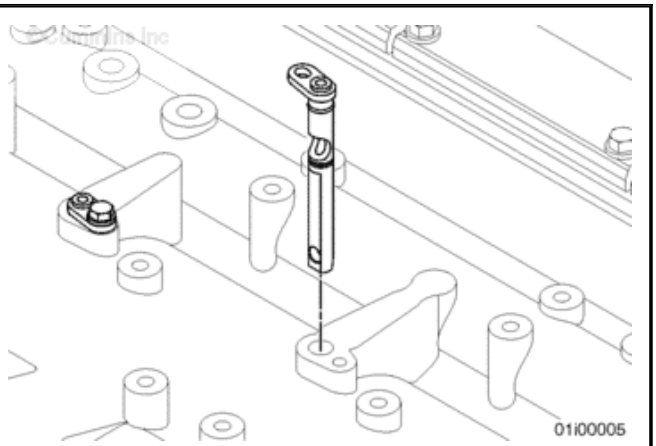
carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations. • Disconnect the batteries. Refer to the OEM service manual. • Drain the lubricating oil. Refer to Procedure 007-037 in Section 7. • Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7. • Remove the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10. • Remove the lubricating oil filters. Refer to Procedure 007-013 in Section 7. • Disconnect the crankcase breather hose. Refer to Procedure 003-001 in Section 3.		

Remove

One Piece Design, All Applications

Remove the piston cooling nozzle capscrew. Remove the piston cooling nozzle.		

Two Piece Design, All Applications

Remove the piston cooling nozzle capscrew. Rotate the nozzle body so the tip points toward the oil pan.		
Remove the piston cooling nozzle tip.		
Remove the piston cooling nozzle body.		

Clean and Inspect for Reuse

One Piece Design, All Applications

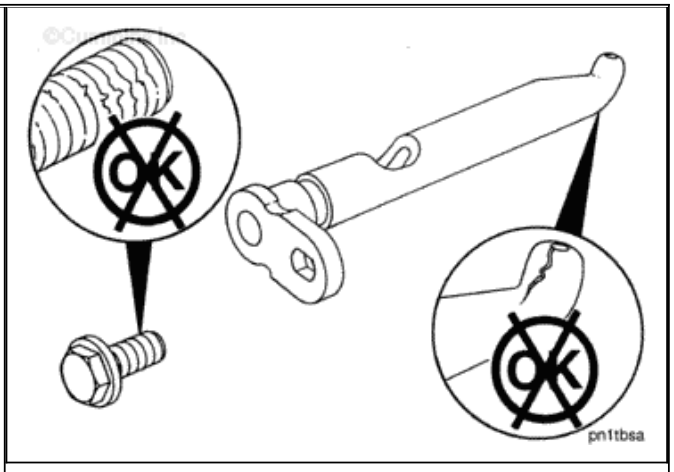
Clean the piston cooling nozzles.

Check for damage at the o-ring groove and spray tip.

If the nozzle is damaged, it **must** be replaced.







Two Piece Design, All 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.

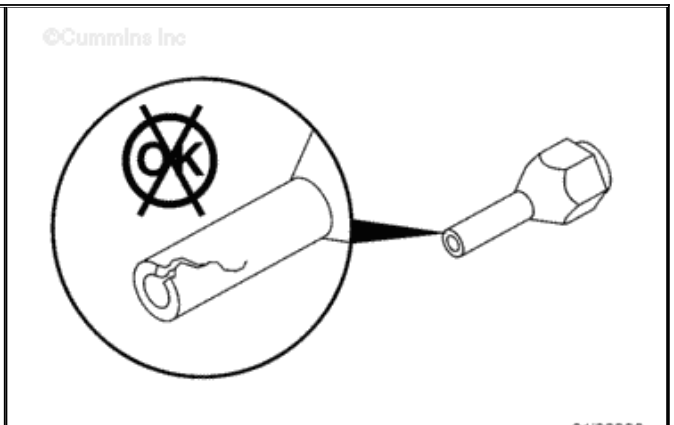
CAUTION

Any damage to the piston cooling nozzle can result in major engine damage.

Clean the piston cooling nozzle



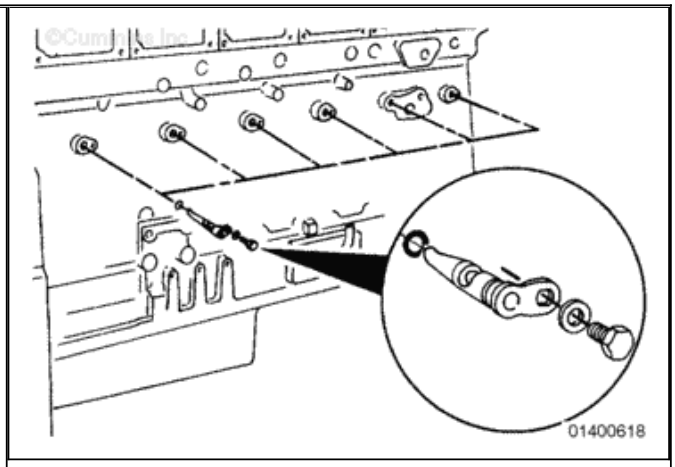




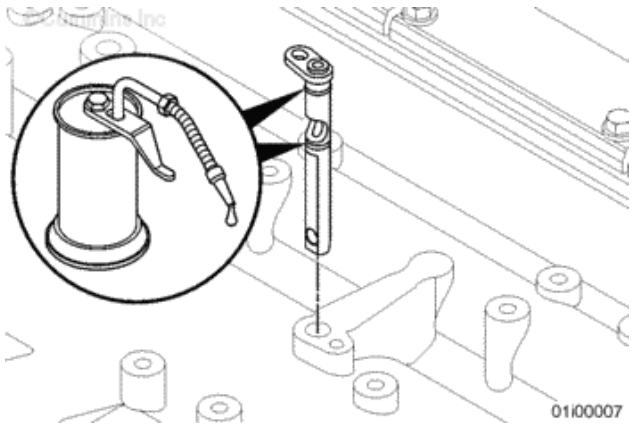
tips with solvent and dry with compresed air. Check the nozzle tips for damage. If the nozzle is damaged, it **must** be replaced.		

Install

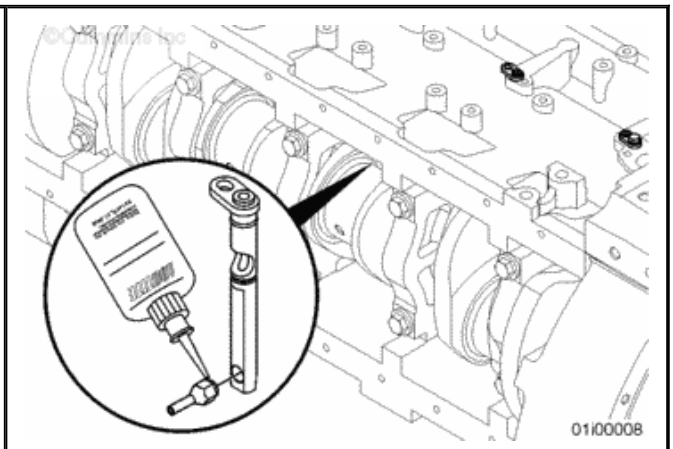
One Piece Design, All Applications

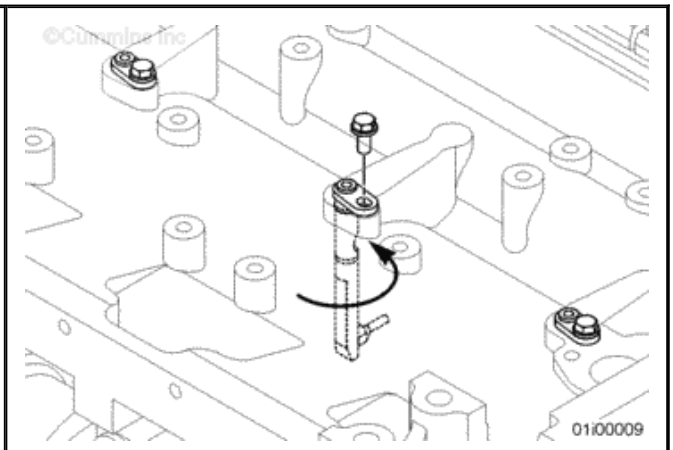
Lubricate the o-ring with vegetable oil and install it onto the piston cooling nozzle. Install the piston cooling nozzle, washer, and capscrew. Tighten the capscrew. **Torque** **Value:** 13 n.m [115 in-lb]		

Two Piece Design, All Applications

CAUTION Use care when handling the piston cooling nozzle. Any damage to the piston cooling nozzle can result in major engine damage. Lubricate the o-rings with vegetable oil. Install the o-rings onto the piston cooling nozzle body. Install the the nozzle body into		

the cylinder block with the tip opening pointing toward the oil pan. The nozzle body should rest on the inboard (bottom) o-ring.		

Apply Loctite™ 242, Part Number 3824041, onto the threads of the nozzle tip. Do **not** allow any Loctite™ to get inside the nozzle tip. Install the nozzle tip onto the nozzle body. Tighten the nozzle tip. **Torque** **Value:** 9 n.m [80 in-lb]	 	

Install the piston cooling nozzle the rest of the way into the cylinder block and rotate into position. Install and tighten the mounting capscrew. **Torque** **Value:** 14 n.m [124 in-lb]	 	

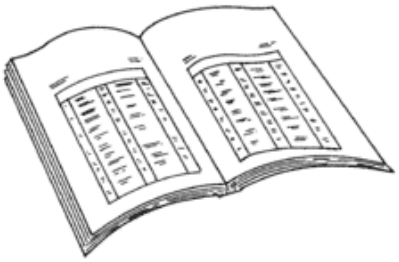
Finishing Steps

One Piece Design, All Applications

• Install the air compressor, if removed. Refer to Procedure 012-014 in		

Section 12.
- Install the fuel pump, if removed. Refer to Procedure 005-016 in Section 5.





ck800wa

Two Piece Design, All Applications

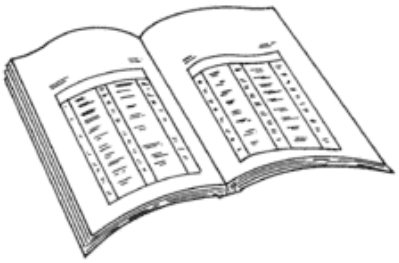
WARNING

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.









ck800wa

- Connect the crankcase breather hose. Refer to Procedure 003-001 in Section 3.
- Install the lubricating oil filters. Refer to Procedure 007-013 in Section 7.
- Install the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.
- 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.
- Connect the batteries. Refer to the OEM service manual.
- Operate the engine and

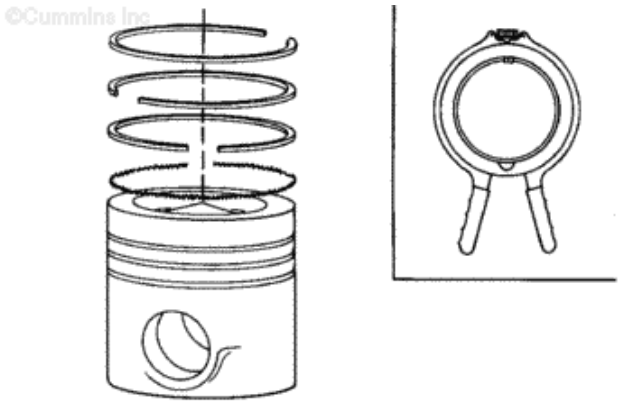
check for leaks.		

Last Modified: 30-Apr-2012

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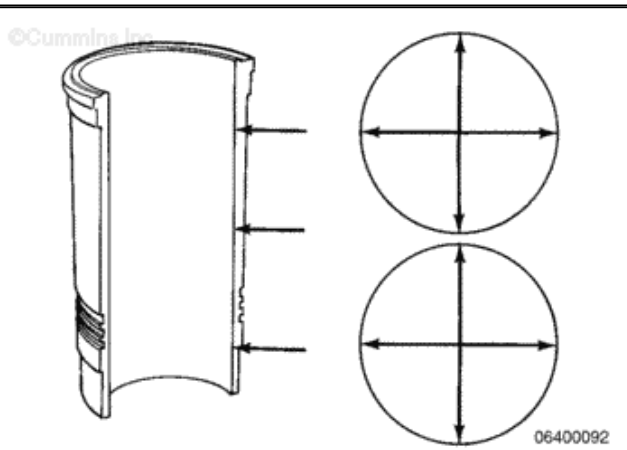
001-047 Piston Rings

Remove

Use a piston ring expander, Part Number ST-1269, or equivalent. Remove the piston rings.		

Measure

with Mechanically Actuated Injector

Make certain that the liners are within specification prior to measuring piston ring gaps. • For the K19 engine, use the following procedure in K19 Service Manual, Bulletin 4021499. Refer to Procedure 001-028 in Section 1. • For the QSK19 engine, use the following procedure in QSK19, QSK19 CM850 MCRS, and QSK19 CM2150 MCRS Service Manual,		

Bulletin 4021592. Refer to Procedure 001-028 in Section 1.

NOTE: Once a set of piston rings has been measured against a cylinder liner, they must only be used on a piston which is to be inserted into that liner. If the piston rings are subsequently required to be used in another cylinder location, the ring gap measuring process described here must be carried out again in the new cylinder liner.

To check the ring gap, place an ink mark on the side of the serviceable piston (with no piston rings fitted) which is 100 mm [3.94 in] from the crown.

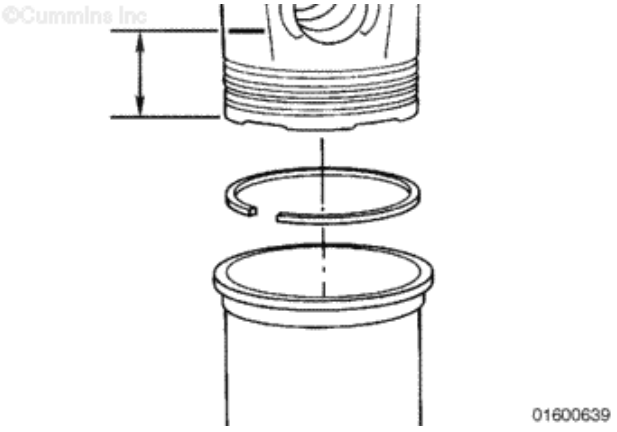
Install a piston ring in the top of a cylinder liner that meets specifications and will be used with the piston rings having their gaps measured.

Use the top part of the piston to position the ring in the liner. Drop the piston down until the 100 mm [3.94 in] marking on the piston reaches the top of the liner.

Carefully remove the piston and carry out the ring gap measurement.

NOTE: Engines built after December 2008 have a revised top piston ring. For these engines, the top piston ring gap must be measured using the specification for an electronically actuated injector.

NOTE: Any engine built prior to December 2008 may have the same top piston ring used in electronically



actuated injector pistons, or they may have the top piston ring used in the mechanically actuated injectors piston. Check the part number on the top piston ring to make sure the correct tolerances are used for the piston ring gap.

CAUTION

If the ring gap is not within the minimum specification, do not attempt to adjust the end gap by filing or grinding. The chrome plating on the ring will be damaged and the ring will fail. Check to make sure the cylinder bore inside diameter is correct. If the end gap remains less than the minimum specification, replace the piston ring.

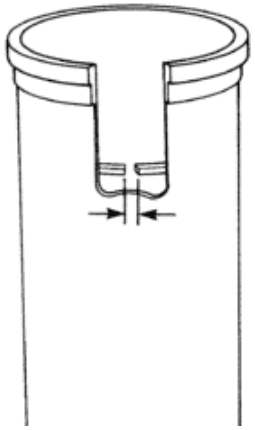
Use a feeler gauge to check the piston ring gap.

The ring **must** be replaced if it does **not** meet the following specifications.

Piston Ring Gap - Mechanically Actuated Injector

	mm	in
Top	0.63 MIN	0.025
	1.02 MAX	0.040
Intermediate	0.63 MIN	0.025
	1.02 MAX	0.040
Oil	0.38 MIN	0.015
	0.59 MAX	0.022

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pi1ritb

with Electronically Actuated Injector

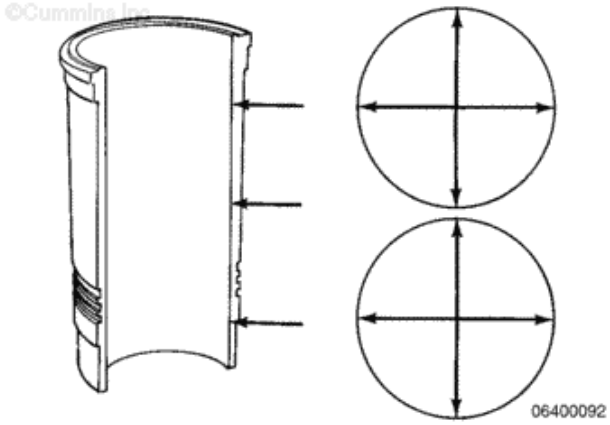
Make certain that the liners are within specification prior to measuring piston ring gaps.

- For the K19 engine, use

the following procedure in K19 Service Manual, Bulletin 4021499. Refer to Procedure 001-028 in Section 1.

- For the QSK19 engine, use the following procedure in QSK19, QSK19 CM850 MCRS, and QSK19 CM2150 MCRS Service Manual, Bulletin 4021592. Refer to Procedure 001-028 in Section 1.

NOTE: Once a set of piston rings has been measured against a cylinder liner, they must only be used on a piston which is to be inserted into that liner. If the piston rings are subsequently required to be used in another cylinder location, the ring gap measuring process described here must be carried out again in the new cylinder liner.

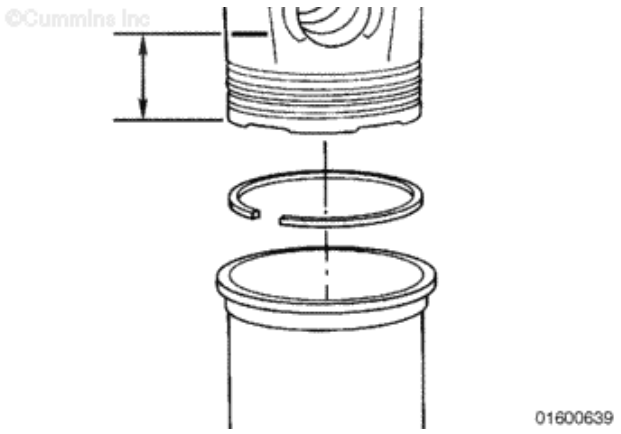


To check the ring gap, place an ink mark on the side of the serviceable piston (with no piston rings fitted) which is 100 mm [3.94 in] from the crown.

Install a piston ring in the top of a cylinder liner that meets specifications and will be used with the piston rings having their gaps measured.

Use the top part of the piston to position the ring in the liner. Drop the piston down until the 100 mm [3.94 in] marking on the piston reaches the top of the liner.

Carefully remove the piston and carry out the ring gap measurement.



CAUTION

If the ring gap is not within the minimum specification, do not attempt to adjust the end gap by filing or grinding. The chrome plating on the ring will be damaged and the ring will fail. Check to make sure the cylinder bore inside diameter is correct. If the end gap remains less than the minimum specification, replace the piston ring.

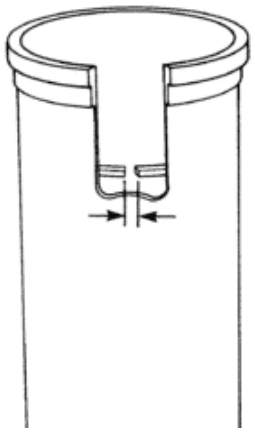
Use a feeler gauge to check the piston ring gap.

The ring **must** be replaced if it does **not** meet the following specifications.

Piston Ring Gap - Electronically Actuated Injector

	mm	in
Top	0.45 MIN	0.018
	0.65 MAX	0.026
Intermediate	0.63 MIN	0.025
	1.02 MAX	0.040
Oil	0.38 MIN	0.015
	0.59 MAX	0.022

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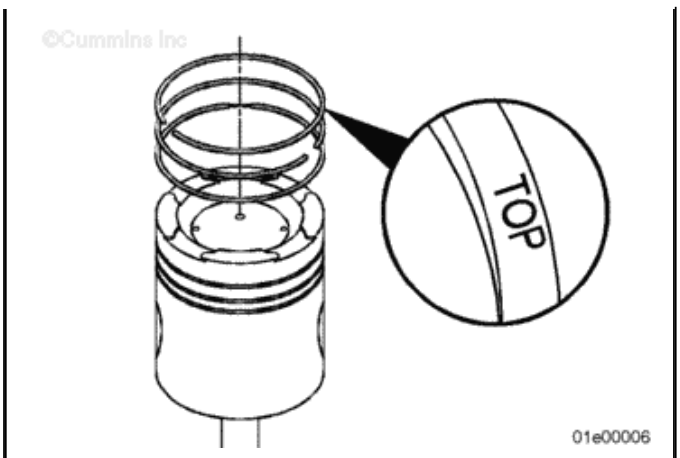
pi1ritb

Install

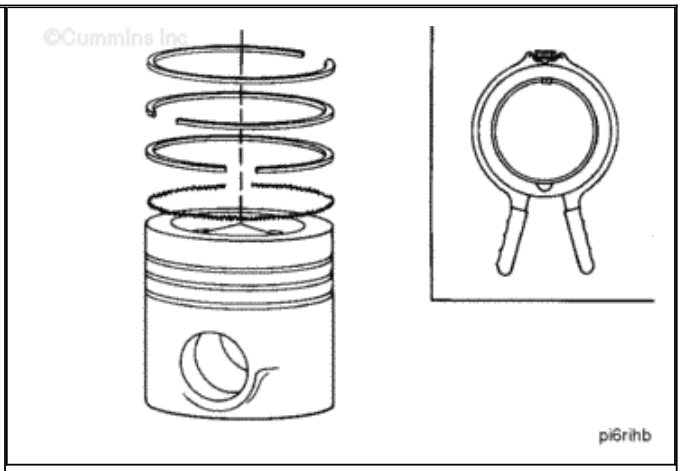
NOTE: Do not install the piston rings until the piston is installed onto the rod. For the K19 engine, use the following procedure in K19 Service Manual, Bulletin 4021499 to assemble the piston to connecting rod. Refer to Procedure 001-054 in

Section 1. For the QSK19 engine, use the following procedure in QSK19, QSK19 CM850 MCRS, and QSK19 CM2150 MCRS Service Manual, Bulletin 4021592 to assemble the piston to connecting rod. Refer to Procedure 001-054 in Section 1.

The top side of the piston rings are marked with the part number. The shipping package is marked with the location. The part number on the ring **must** be positioned toward the top of the piston.



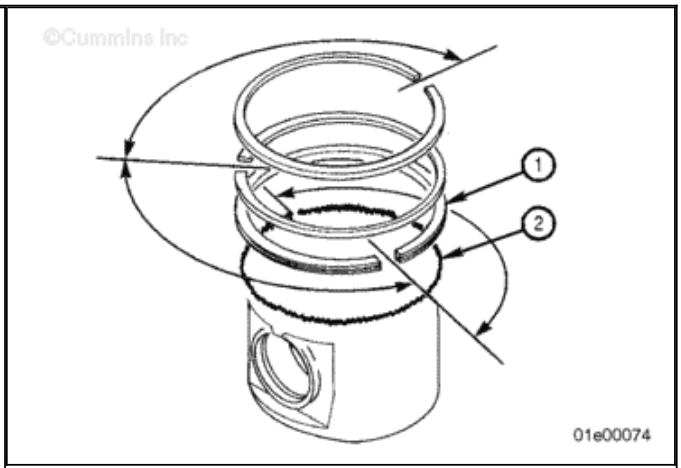
Use a ring expander, Part Number ST-1269 or equivalent, to install the piston rings.



Do **not** align the gap of a ring with the piston pin bore. Rotate the rings until the gaps are positioned as shown.

The gap in the oil ring expander (2) **must** be turned 180 degrees opposite the gap on the oil ring (1).

Position the remaining ring gaps approximately 120 degrees apart from the oil ring gap, as shown in the illustration.



Last Modified: 17-May-2010

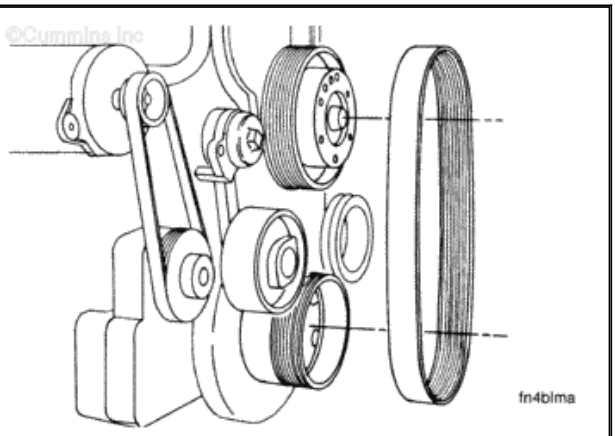
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001-052 Vibration Damper, Viscous

Preparatory Steps

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





Remove

WARNING

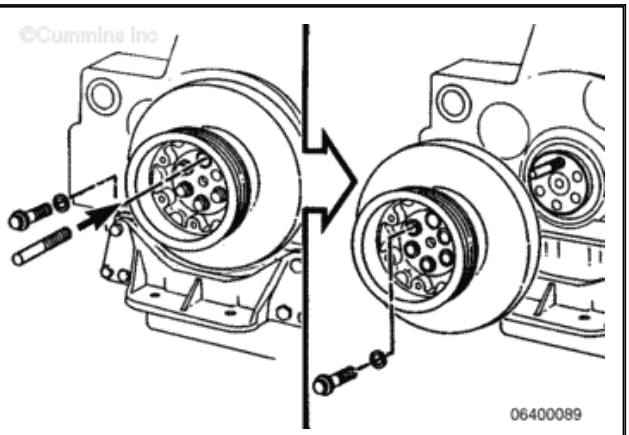
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

CAUTION

Do not pry or hammer on the vibration damper. Damage to the vibration damper can result.

Remove one capscrew and install a [3/4-16x5 in] guide stud.



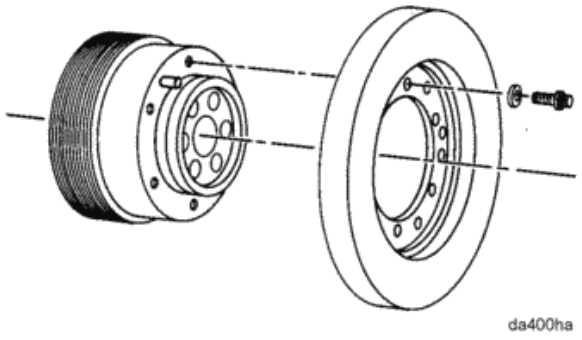


Remove the remaining capscrews from the vibration damper.

Remove the guide stud.

NOTE: Engines that do not have a belt driven fan hub have an adapter instead of a pulley.

Remove the pulley from the vibration damper.



Clean and Inspect for Reuse

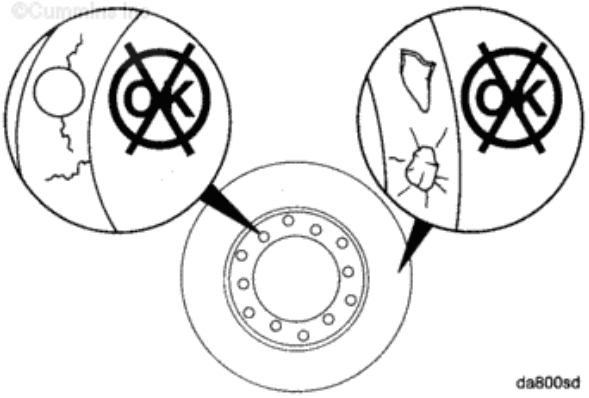
WARNING

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

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Vibration dampers have 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.

Clean the exterior of the damper with solvent.

Dry with compressed air.

Inspect the vibration damper for cracks on the mounting flange and dents or bulges on the housing.

If the vibration damper is damaged, it **must** be replaced.

WARNING

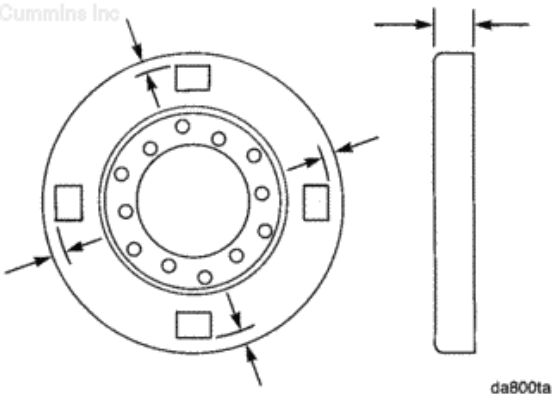
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Use a paint solvent and fine crocus cloth to remove the paint from the front and back of the housing at the four areas illustrated.

Make sure thickness measurements are made on a flat surface of the vibration damper.

Measure the thickness of the vibration damper, in the four locations illustrated, at **not** less than 3 mm [1/8 in] from the outside diameter of the fabrication damper.

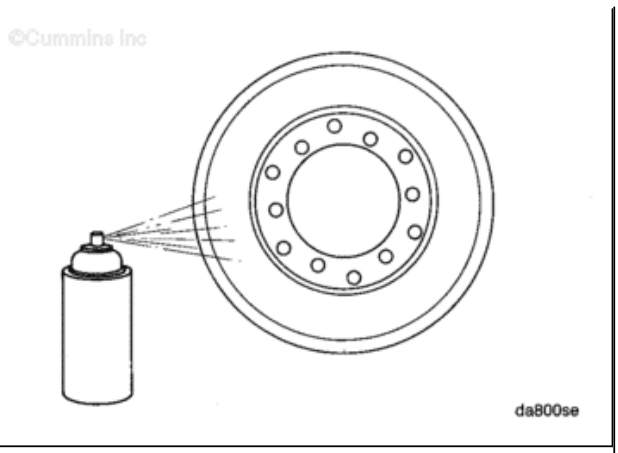
If the measurements vary more than 0.25 mm [0.010 in], or if the thickness exceeds 42.24 mm [1.663 in], the vibration damper **must** be replaced.



Perform the following steps to check the vibration damper for

fluid leaks.

Use crack detection kit, Part Number 3375434, or equivalent to perform the dye penetrant method to check for leaks.

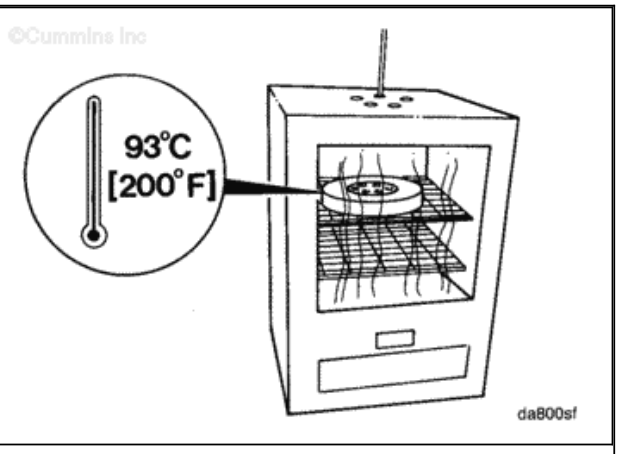


WARNING

Wear protective clothing to prevent personal injury from burns.

Put the vibration damper in the oven, with a temperature adjusted to 93°C [200°F], with the rolled lip down.

Heat the damper for two hours.

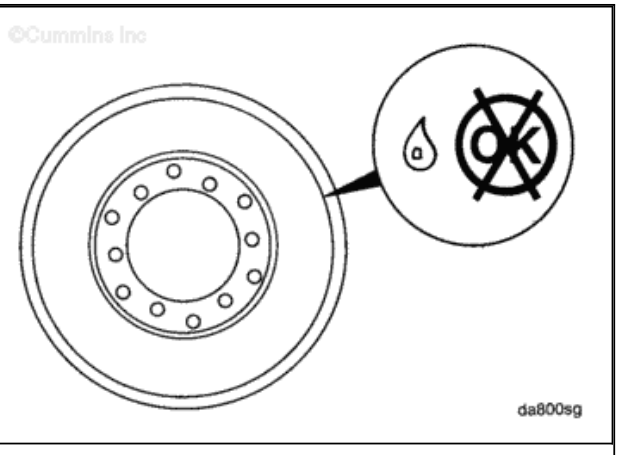


WARNING

Wear protective clothing to prevent personal injury from burns.

Remove the damper and check for leakage around the lip.

If there is any leakage, the vibration damper **must** be replaced.



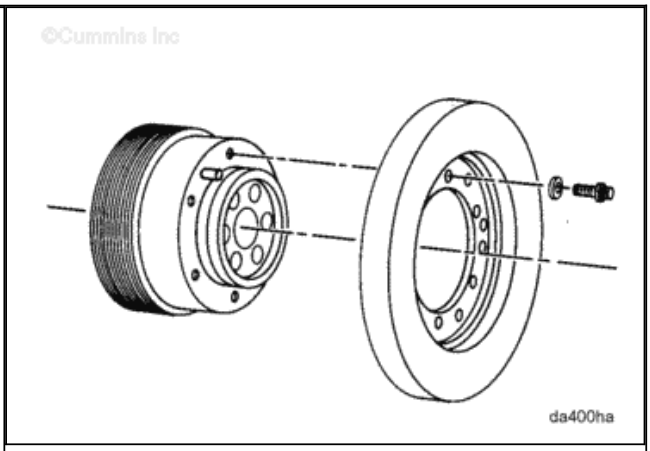
Install

Install the vibration damper on the crankshaft pulley or adapter (if equipped).

Install the six washers and capscrews.

Tighten the capscrews.

Torque Value: 140 n.m [105 ft-lb]



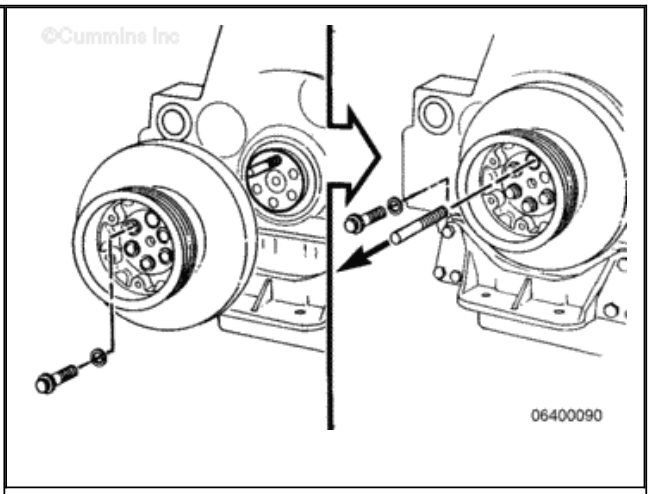
Install the guide stud in the crankshaft.

Install the vibration damper assembly. The pilot **must** be aligned with the crankshaft correctly.

Install the washers and capscrews.

Tighten the capscrews.

Torque Value:	Step 1	230 n.m [170 ft-lb]
	Step 2	445 n.m [330 ft-lb]

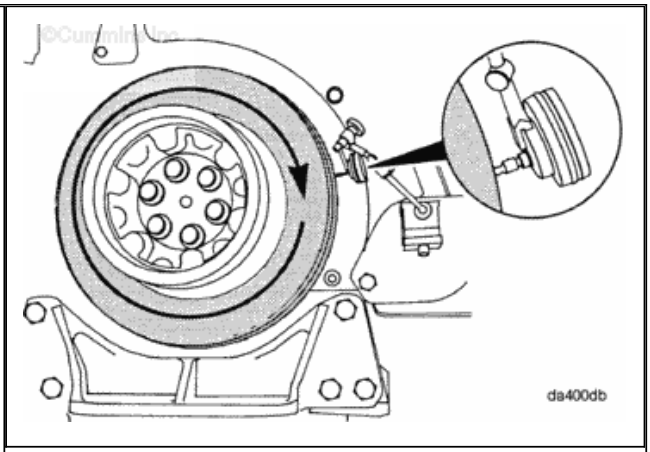


Eccentricity Check

Use a dial indicator and adjust it as shown to measure radial alignment of the vibration damper. Turn the crankshaft 360 degrees and record the total indicator readout.

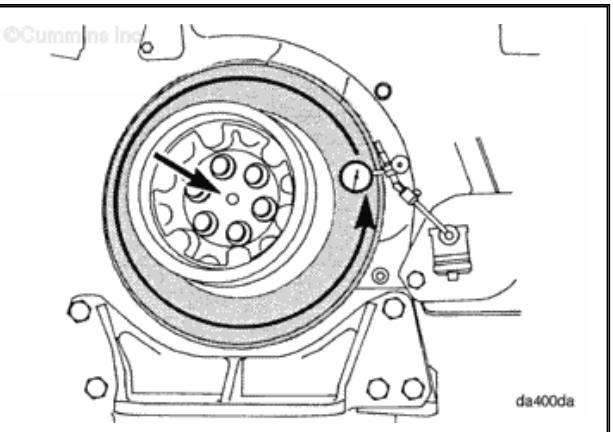
Maximum Eccentricity		
	mm	in
Viscous Damper	1.02 MAX	0.040

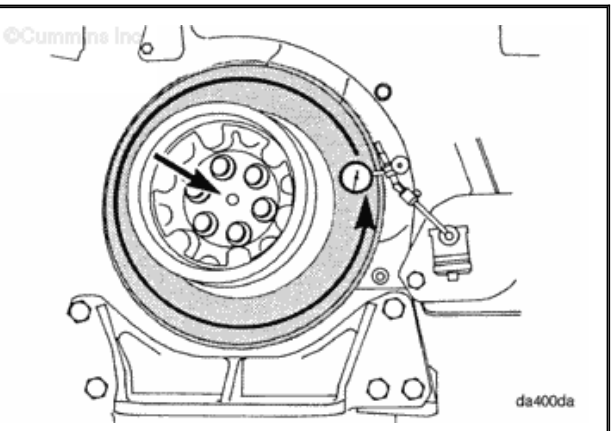
If the measurement is **not** within specifications, make sure the



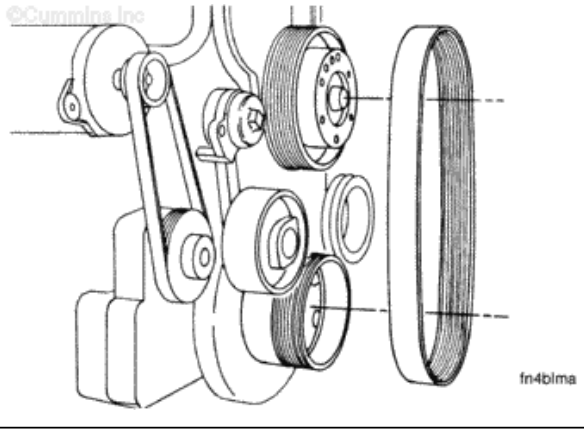
damper pilot is aligned properly.		

Wobble Check

The crankshaft end clearance **must** be pushed or pulled in the same direction each time a measurement is taken.		

When the dial indicator is positioned more than 13 mm [1/2 in] from the outside diameter, the specification is different. To determine the specification: • Measure the distance from the center of the crankshaft to the point the indicator tip touches the damper • Multiply the distance by 0.18 mm [0.007] when the damper is rubber; 0.15 mm [0.006 in] when the damper is viscous, to obtain the maximum total indicator runout. If the measurement is **not** within specifications, check for foreign material between the crankshaft and the adapter (or pulley), and between the adapter (or pulley) and the vibration damper.		

Finishing Steps

• Install the fan belt and related components. Refer to Procedure 008-002.		

Last Modified: 23-Jul-2004

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001-054 Piston and Connecting Rod Assembly

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

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

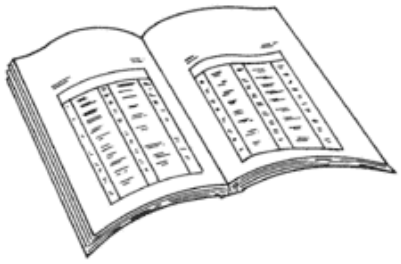
WARNING

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

Some state and federal agencies have determined that used engine oil can be





ck800wa

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.

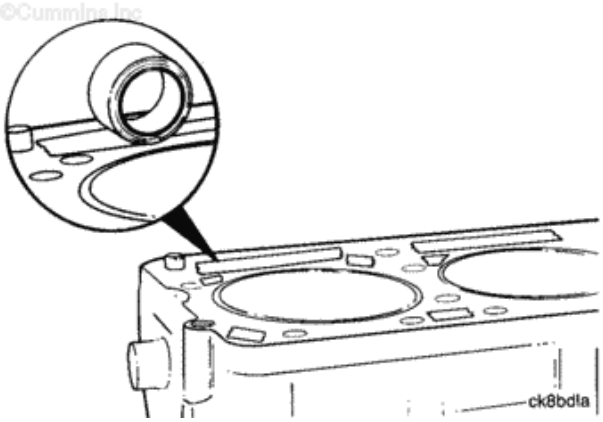
WARNING

To reduce the possibility of personal injury, avoid contact of hot oil with your skin.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Drain the cooling system. Refer to Procedure 008-018 in Section 18.
- Remove the cylinder head. Refer to Procedure 002-004 in Section 2.
- Remove the piston cooling nozzles. Refer to Procedure 001-046 in Section 1.
- Drain the lubricating oil system. Refer to Procedure 007-037 in Section 7.
- Remove the oil pan. Refer to Procedure 007-025 in Section 7.
- Remove the lubricating oil pan adapter cover plate. Refer to Procedure 007-026 in Section 7.
- Remove the oil suction tube. Refer to Procedure 007-027 in Section 7.

Remove

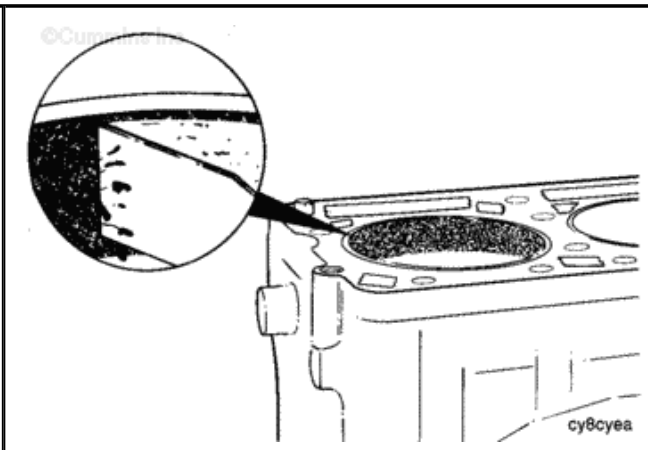
Protect the push rod galleys, coolant passages, and oil passages from contamination.		



CAUTION

Do not use abrasive paper to remove the carbon deposits. Small particles from abrasive paper will cause severe engine damage.

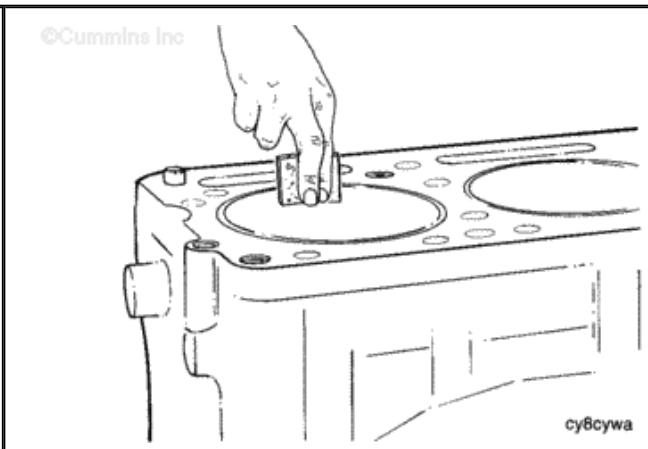
Use a scraper or a similar blunt-edged tool to loosen the carbon deposits in the cylinder liner.



CAUTION

Use extreme care to make sure that no abrasive cleaners or materials are used in the piston ring travel area.

Remove the remaining carbon with a nylon abrasive pad, Scotch-Brite™ 7448, or equivalent, and solvent. The carbon **must** be removed, but the surface does **not** have to appear like new metal.



WARNING

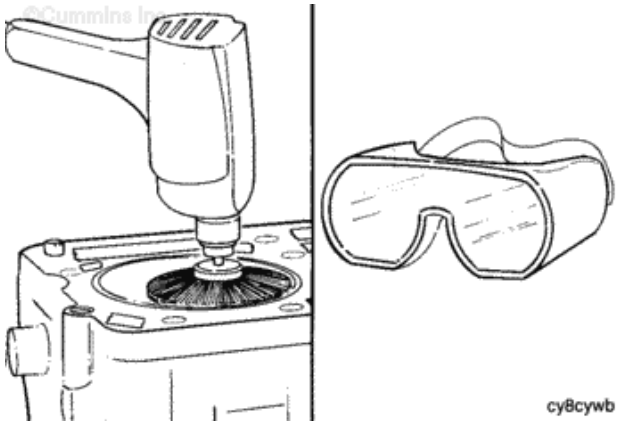
Wear appropriate eye and face protection when using a wire wheel to prevent serious personal injury.

An alternative method to remove the carbon ridge is to use a high quality-steel wire wheel installed in a drill.

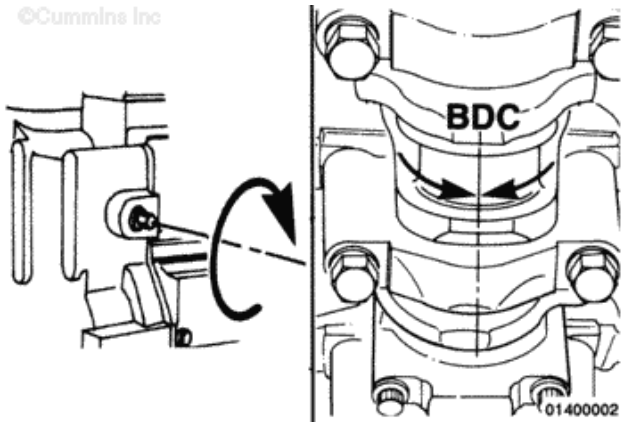
Do **not** use a steel wire wheel of inferior quality. The inferior wire wheel will lose steel bristles during operation and cause additional contamination.

NOTE: 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.



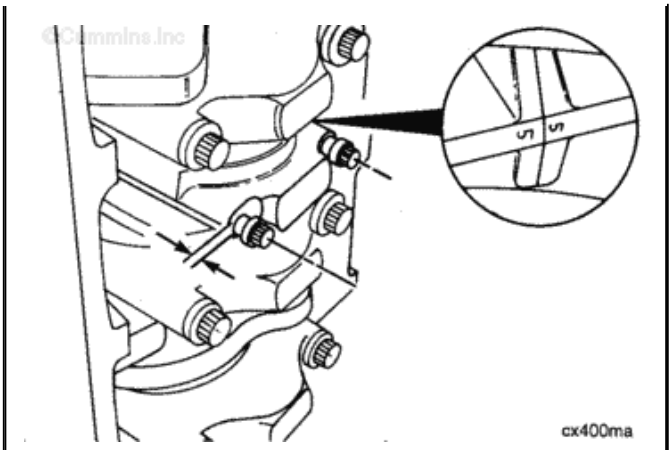
Use the barring mechanism to rotate the engine. Rotate the crankshaft to position the connecting rod at bottom dead center (BDC).



Connecting rods **must** have the cylinder number marked on both the connecting rod and the connecting rod cap on the side positioned toward the camshaft. Check the connecting rods for correct markings. Use a steel stamp and mark any rod that is **not** correctly

marked.

Loosen the capscrews until there is 6 mm [¼ inch] of clearance between the connecting rod cap and the capscrew head.

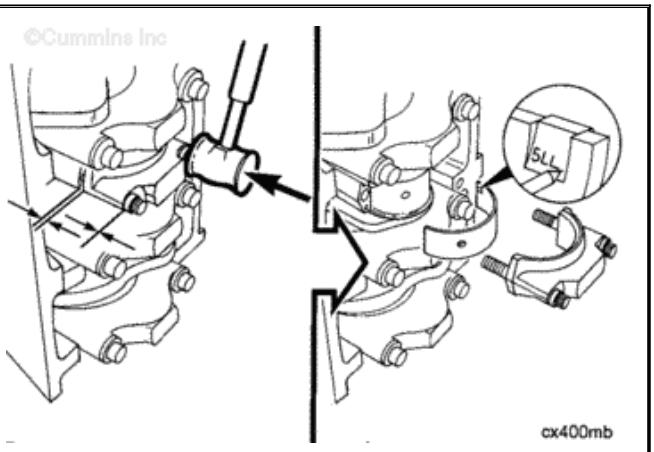


Use a mallet. Tap the connecting rod capscrews until the connecting rod cap and connecting rod separate. Remove the capscrews and the connecting rod cap.

Remove the lower rod bearing.

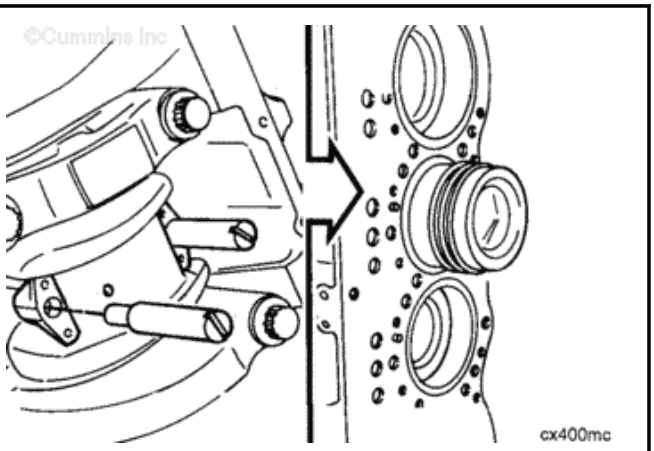
Use an awl to mark the bearing position in the tang area.

Mark the bearing for future identification or for possible failure analysis.



Install two connecting rod guide pins, Part Number 3375098, or equivalent, into the connecting rod.

Push the piston and connecting rod up until the piston rings are above the cylinder liner.



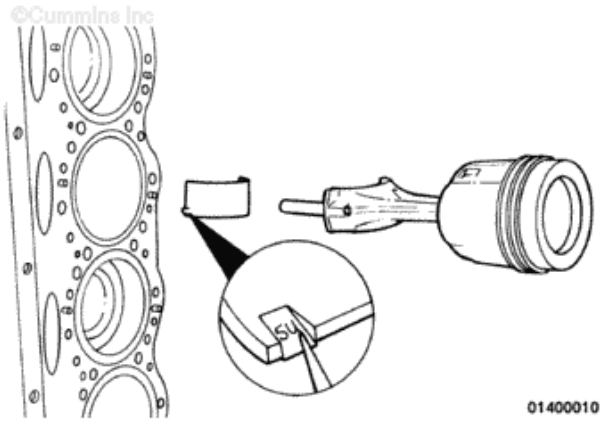
CAUTION

Place the piston and rod assembly in a rack to prevent damage to the piston and rod assembly.

Remove the piston and rod assembly.

Remove the upper connecting rod bearing.

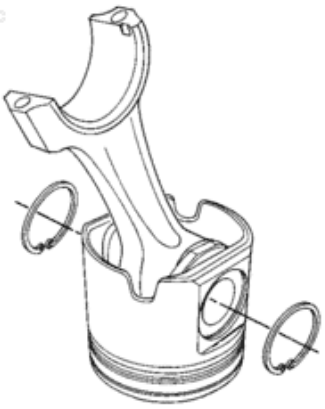
Use an awl to mark the bearing position in the tang area.



Disassemble

Remove the piston rings. Refer to Procedure 001-047 in Section 1.

Remove the snap rings from both sides of the piston with internal snap ring pliers.



CAUTION

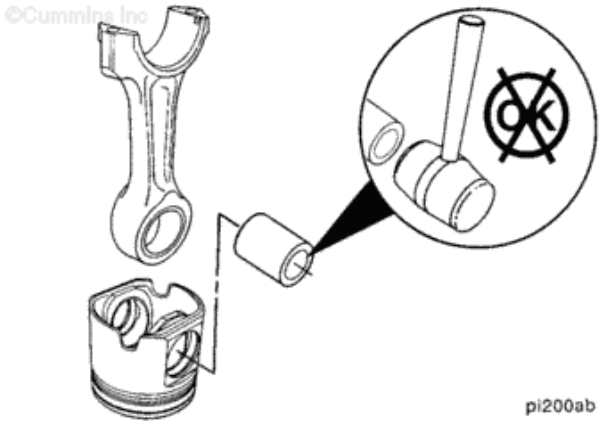
Do not use a hammer to remove the piston pin. The piston can distort, causing it to seize in the cylinder liner.

CAUTION

Do not drop the piston while removing the piston pin. Personal injury and damage to the piston can result.

Remove the piston pin and separate the connecting rod and piston.

Clean and inspect the piston. Refer to Procedure 001-043 in Section 1.

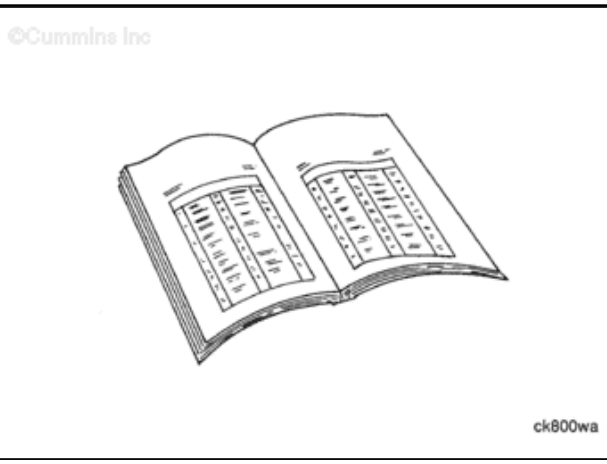


Clean and Inspect for Reuse

Clean and inspect the connecting rods for reuse. Refer to Procedure 001-014 in Section 1.

Clean and inspect the pistons for reuse. Refer to Procedure 001-043 in Section 1.

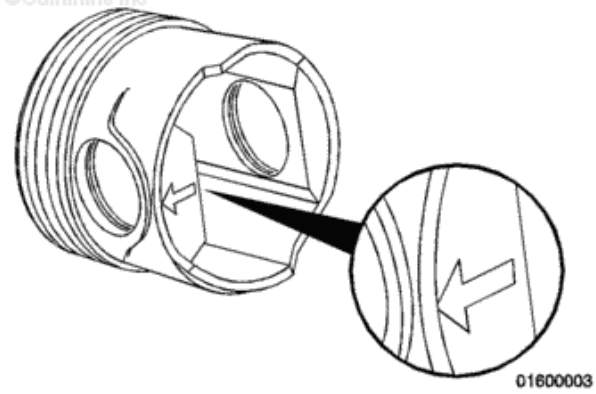




Assemble

There are two different types of pistons for this engine. Offset pin pistons can be identified by the cast arrow on the bottom of

the pin bore.



CAUTION

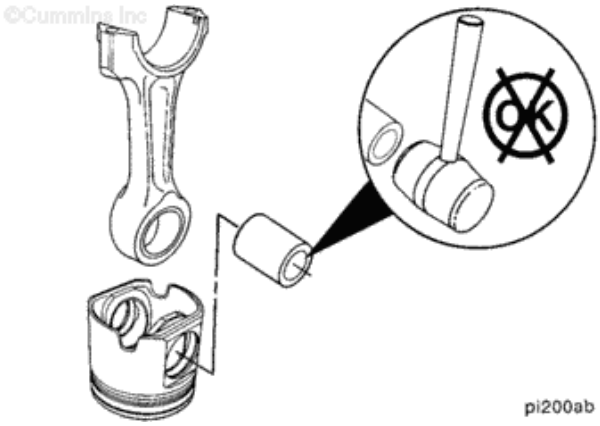
Do not use a hammer to install the piston pin. The piston can distort, causing it to seize in the cylinder liner.

Install a new snap ring into one of the piston pin bores.

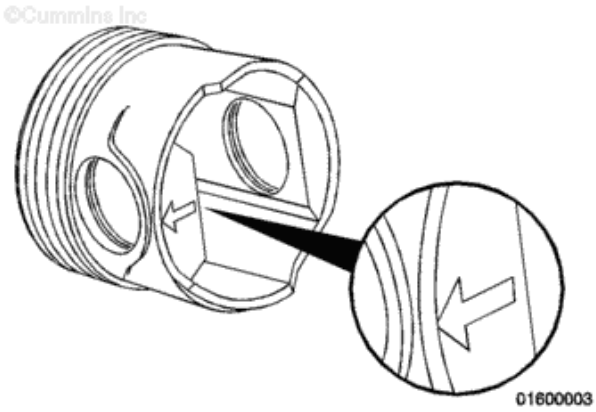
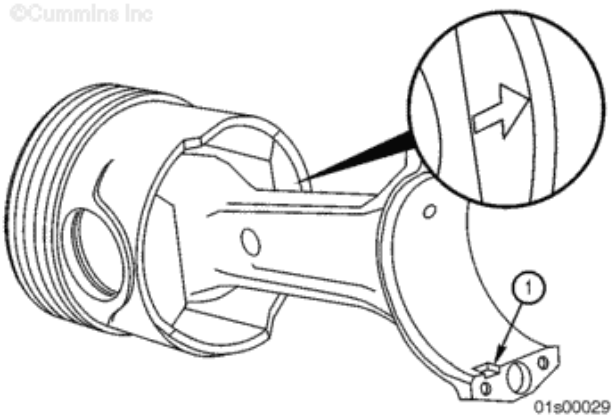
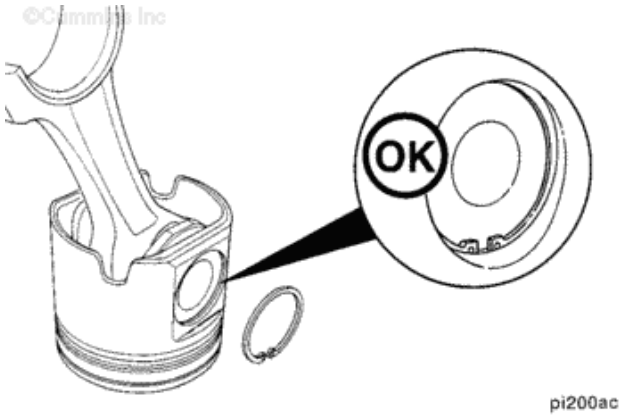
The snap ring **must** be seated completely in the piston groove to prevent engine damage during engine operation.

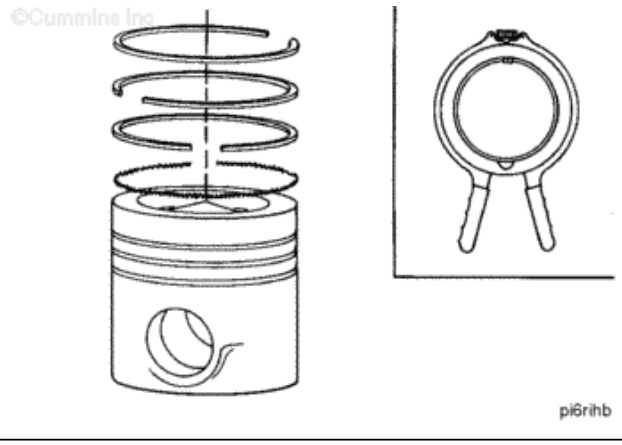
Lubricate the piston pin and connecting rod bushing with clean engine oil.

Align the pin bore of the rod with the pin bore of the piston skirt and crown, and install the piston pin.



Offset pin pistons have a cast arrow on the bottom of the pin bore.

		
Assemble the offset pin with the arrow pointing toward the front of the engine. **NOTE: When properly assembled, the arrow is on the opposite side of the lock tang (1) on the connecting rod.**		
Install a new snap ring in the piston pin bore. The snap ring **must** be seated completely in the piston groove to prevent engine damage during operation.		
Install the piston rings. Refer to Procedure 001-047 in Section 1.		



Install

CAUTION

To reduce the possibility of engine damage, do not lubricate the back side of the bearing shells.

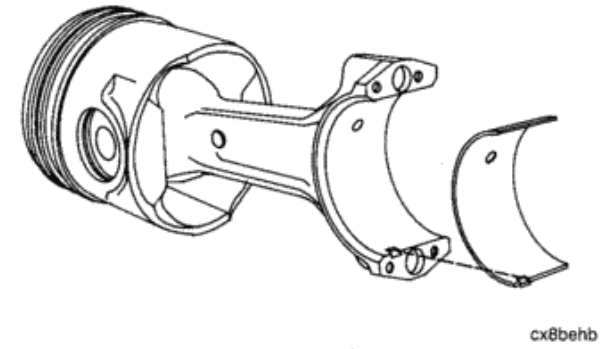
Clean the connecting rod and the bearing shells with a lint free cloth.

NOTE: All of the connecting rod bearings are identical.

NOTE: Do not reuse connecting rod bearings if either the connecting rod or crankshaft has been changed.

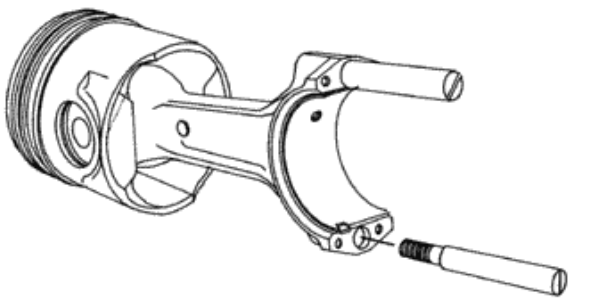
Install the connecting rod bearing. Be sure the tang is positioned as shown. The end of the bearing **must** be even with the cap mounting surface.

Lubricate the connecting rod bearing surface with clean engine oil.



The connecting rod bearings **must** be installed in their original locations if new connecting rod bearings are **not** used.

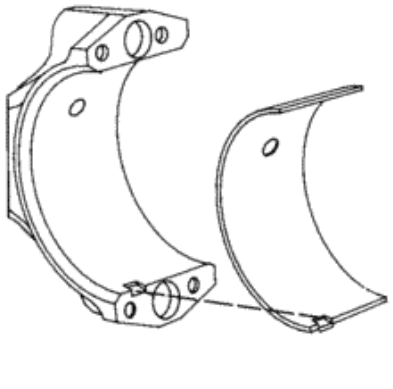
Install two connecting rod guide pins, Part Number 3375098, in the connecting rod. The guide pins will aid the assembly process and protect the crankshaft.



CAUTION

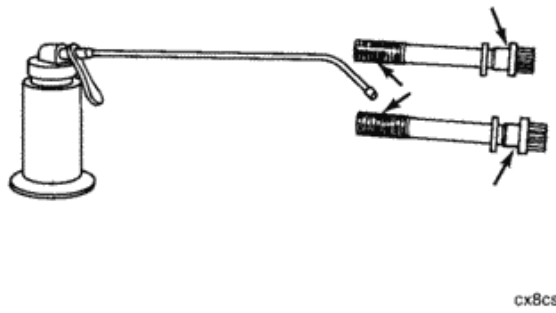
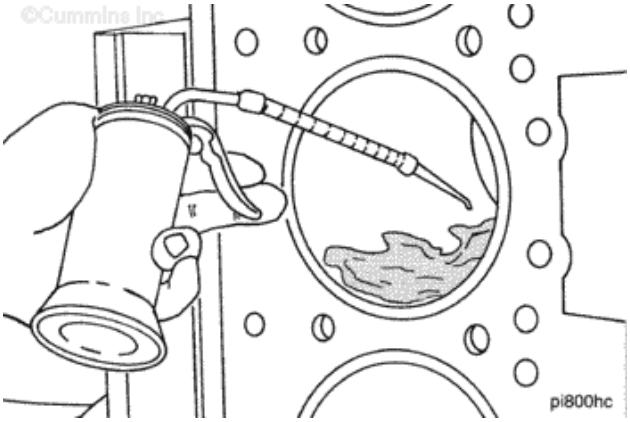
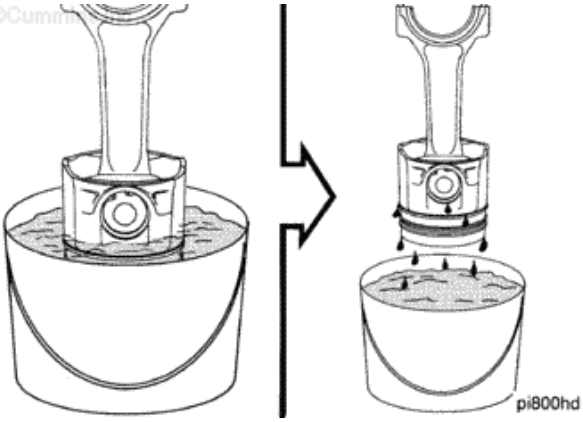
The connecting rods and connecting rod caps are not interchangeable. The connecting rods and the connecting rod caps are machined as an assembly. Damage to the engine will result if they are mixed.

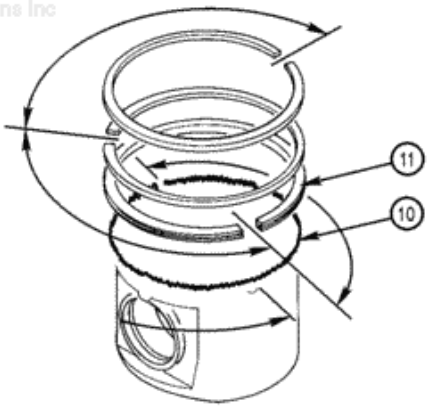
Install the lower bearing shell in the connecting rod cap. Be sure the tang of the bearing shell is in the slot of the connecting rod cap and the end of the bearing is even with the connecting rod cap surface.



Use clean lubricating oil to lubricate the connecting rod capscrews and washers as shown.

Install the washers and capscrews in the connecting rod caps.

		 cx8csha
Lubricate the cylinder liner with clean engine oil. The entire bore **must** be lubricated.		 pi800hc
Immerse the piston in engine oil until the rings are covered. Allow the excess oil to drip off the assembly.		 pi800hd
Make sure the piston ring gap position is still correct.		

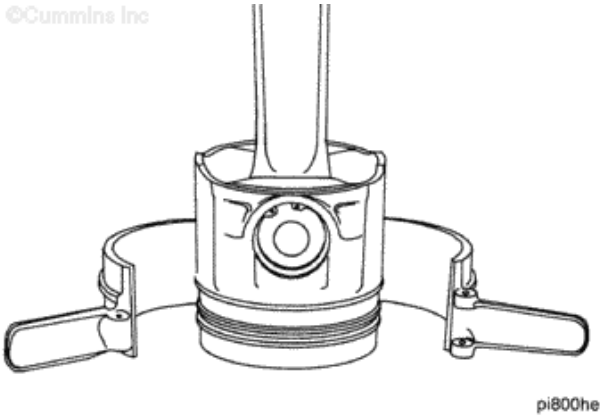


CAUTION

To reduce the possibility of engine damage, make sure the piston rings fit correctly in the piston.

Use a piston ring compressor, Part Number 3375342, or equivalent. Install the ring compressor on the piston.

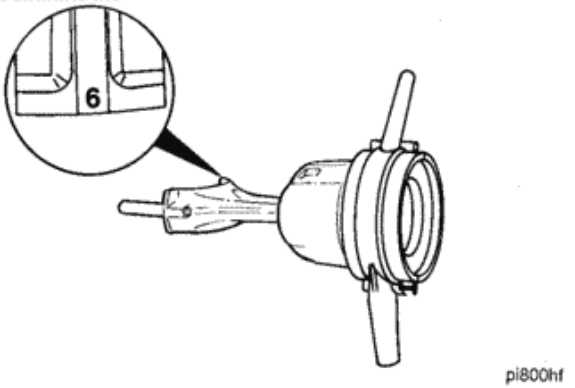
NOTE: The ring compressor has a tapered bore. The small end of the taper must be positioned toward the piston skirt.



CAUTION

To reduce the possibility of engine damage, the cylinder number on the connecting rod and connecting rod cap must be the same and the side of the connecting rod with the cylinder number (bearing tang side) must be toward the camshaft.

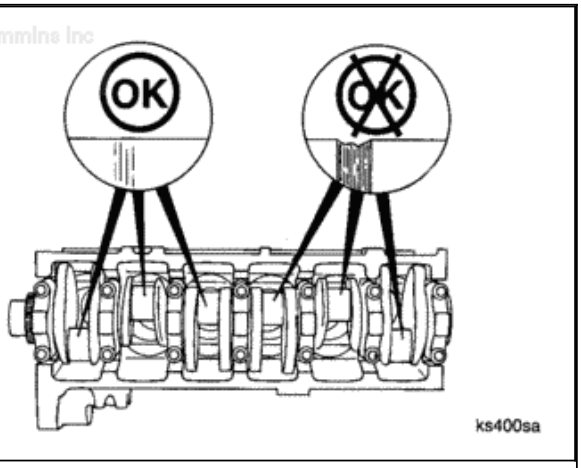
Rotate the crankshaft until the journal for the rod being installed is at bottom dead



center (BDC).

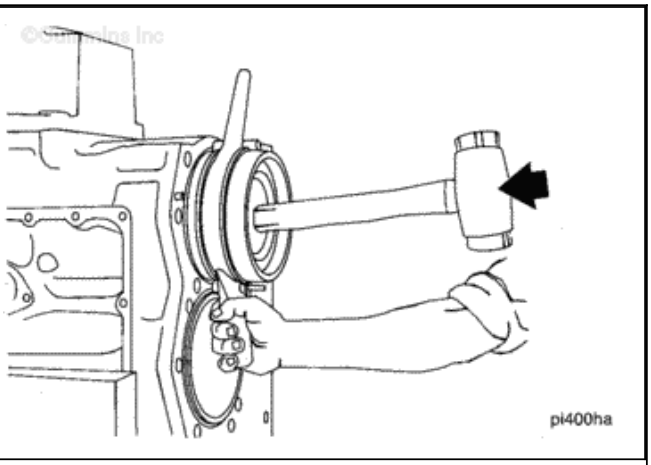
NOTE: If the engine has a crankshaft with bolt-on counterweights, the journal must be at top dead center (TDC).

Check the crankshaft rod journals for damage.



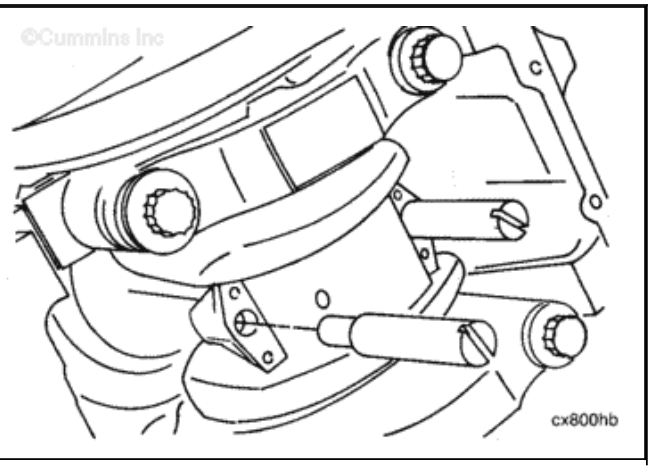
Install the connecting rod and piston until the ring compressor touches the block. Align the rod with the crankshaft journal.

Hold the ring compressor firmly against the block. Use a wooden hammer handle to push the piston into the liner.



Push the piston into the bore until the rod bearing contacts the crankshaft journal.

Remove the guide pins.



CAUTION

To reduce the possibility of engine damage, the cylinder number on the connecting rod and connecting rod cap must be the same and the side of the connecting rod with the cylinder number (bearing tang side) must be toward the camshaft.

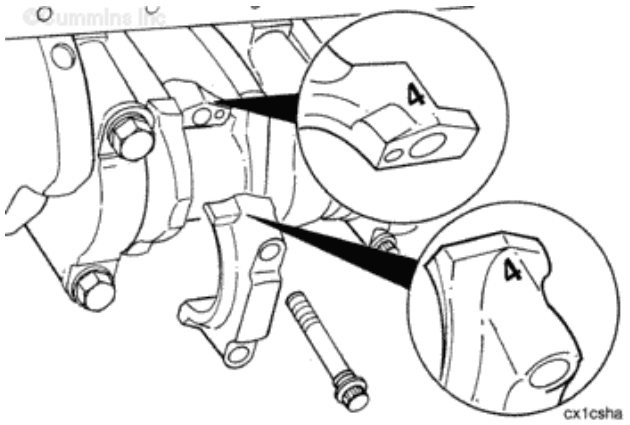
Install the connecting rod cap.

Tighten the capscrews alternately and evenly to pull the cap over the dowel pins. Use the following steps to tighten the capscrews.

Torque Value:

1. 102 n.m [75 ft-lb]
2. 197 n.m [145 ft-lb]
3. 292 n.m [215 ft-lb]
4. 366 n.m [270 ft-lb]
5. Loosen both capscrews to remove all tension.
6. 102 n.m [75 ft-lb]
7. 149 n.m [110 ft-lb]

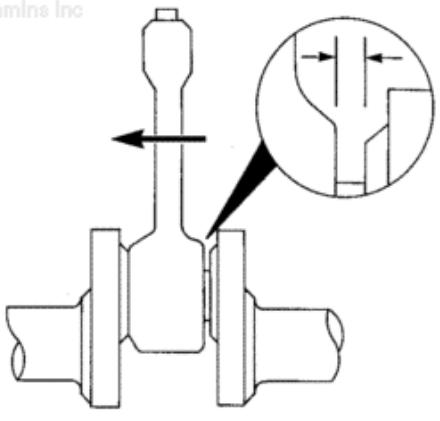
Plus 90° to achieve correct bolt stretch.



Check the side clearance between the rod and the crankshaft. The rod **must** move freely from side-to-side.

Measurements over 0.51 mm [0.020 in] **must** be measured with a dial indicator.

If the side clearance is greater than 0.51 mm [0.020 in], do **not** reuse the parts, unless the same connecting



rod is used on the same crankshaft journal in the same engine. If the parts are reused on the same crankshaft connecting rod journal in the same engine, the maximum allowable side clearance, measured with a dial indicator, is 5.08 mm [0.200 in].

Connecting Rod and Crankshaft Side Clearance, New or Remanufactured Parts

mm		in
0.20	MIN	0.008
0.35	MAX	0.014

Connecting Rod and Crankshaft Clearance, Used Parts

mm		in
0.51	MAX	0.020

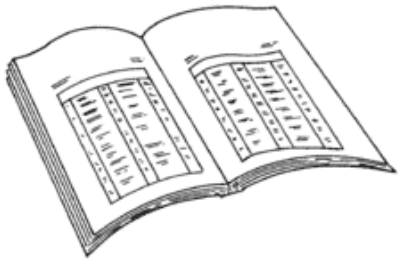
Connecting Rod and Crankshaft Clearance, Same Connecting Rod and Crankshaft Reused on Same Journal of Crankshaft

mm		in
5.08	MAX	0.200

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 (-)



ck800wa

battery cable last.

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

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 oil suction tube. Refer to Procedure 007-027 in Section 7.
- Install the oil pan adapter cover plate. Refer to Procedure 007-026 in Section 7.
- Install the oil pan. Refer to Procedure 007-025 in Section 7.
- Install the cylinder head. Refer to Procedure 002-004 in Section 2.
- Install the piston cooling nozzles. Refer to Procedure 001-046 in Section 1.
- Fill the engine with clean oil. Refer to Procedure 007-037 in Section 7.
- Fill the cooling system. Refer to Procedure 008-018 in Section 18.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine to 70°

C [160°F] coolant temperature and check for leaks.		

Last Modified: 10-Dec-2010

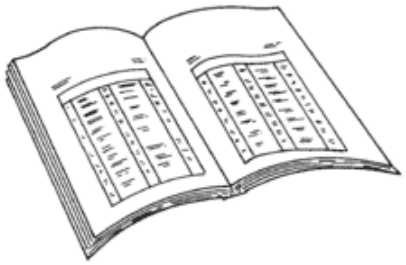
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001-055 Gear Train Backlash, Front

Preparatory Steps

- Remove the front cover. Refer to Procedure 001-031.





ck800wa

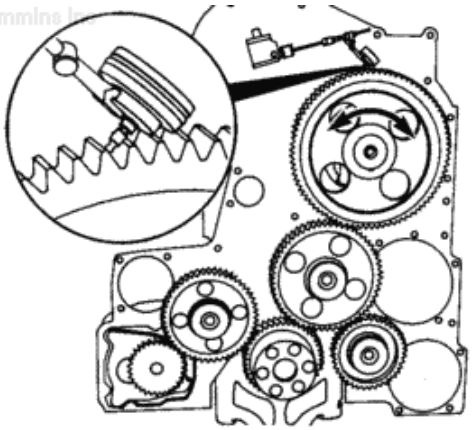
Measure

CAUTION

The adjacent (engaging) gear must not turn as the gear being measured is turned. If the gear is allowed to turn the measurement will not be accurate.

Position a dial indicator so the tip is contacting the surface of the gear tooth as shown.

Do **not** allow the mating gear



cg4geta

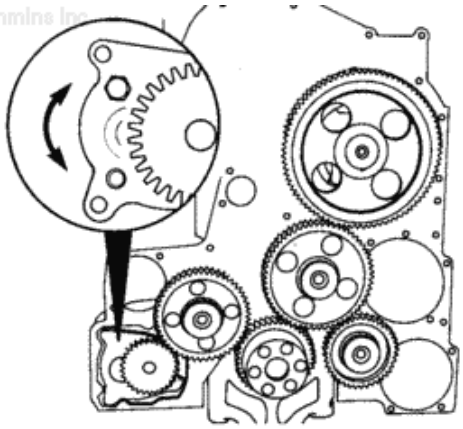
to turn.

Rotate the gear being measured **clockwise**. Position the indicator to "0".

Rotate the gear **counterclockwise** and read the indicator.

Gear Train Backlash		
mm		in
0.07	MIN	0.003
0.30	MAX	0.012

The backlash on the oil pump can be adjusted by rotating the pump body.

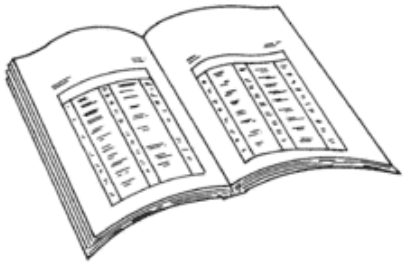


Finishing Steps

- Install the front gear cover. Refer to Procedure 001-031.







Last Modified: 29-Nov-2004

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001-056 Camshaft Thrust Bearing

Inspect for Reuse

Inspect the camshaft thrust bearing for damage.

If there are grooves large enough to catch the fingernail, the bearing **must** be replaced.

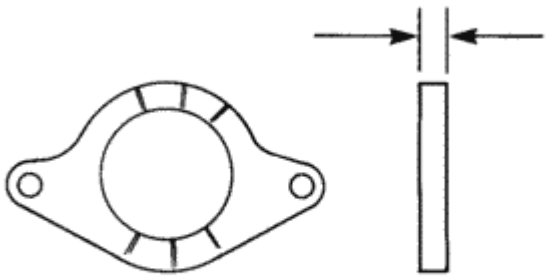
Measure the camshaft thrust bearing thickness.

Camshaft Thrust Bearing Thickness			
mm		in	
9.12	MIN	0.359	
9.44	MAX	0.372	

If the camshaft bearing is **not** within specifications, it **must** be replaced.







Last Modified: 24-Sep-2004

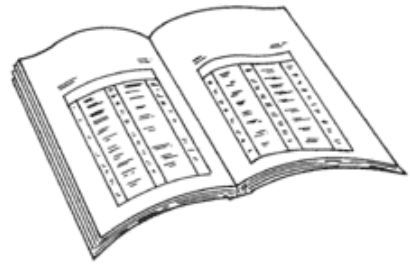
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001-064 Cylinder Liner Protrusion

Preparatory Steps

- Remove the cylinder head. Refer to Procedure 002-004.





Measure

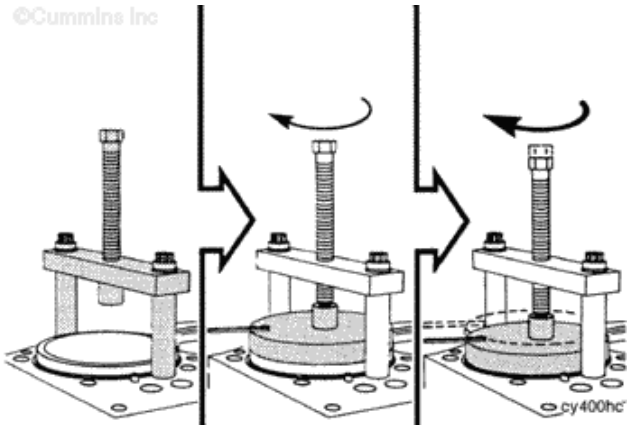
CAUTION

Do not use an impact wrench to tighten the liner pusher plate screw. Excessive torque will cause damage to the liner installation tool.

Use liner installation tool, Part Number 3375422, or equivalent.

Install the bridge assembly and two cylinder head





capscrews.

Tighten the capscrews.

Torque
Value: 45 n.m [35 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.

Torque
Value: 65 n.m [50 ft-lb]

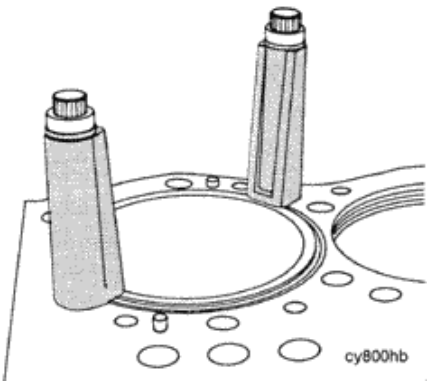
Remove the tool.

When the cylinder liner clamps are installed, the clamps **must** touch the highest part of the liner.

Install two cylinder liner clamps, Part Number 3822503, and two cylinder head capscrews.

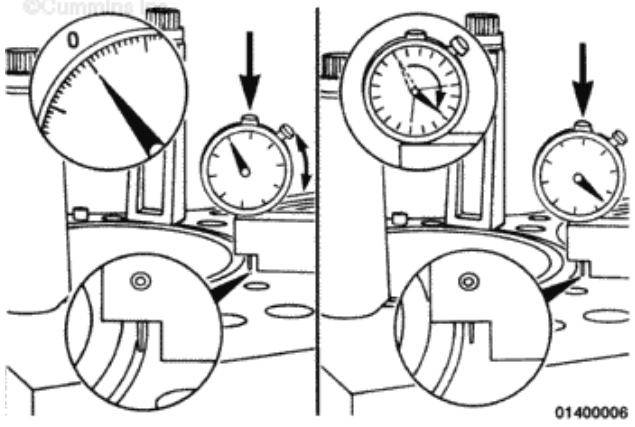
Tighten the capscrews.

Torque
Value: 65 n.m [50 ft-lb]



Use a depth gauge block, Part Number 3164438, or equivalent. 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 "0" is aligned with the head of the dial. Repeat this step several times to be sure the gauge is set to



"0".

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
0.13	MIN	0.005
0.18	MAX	0.007

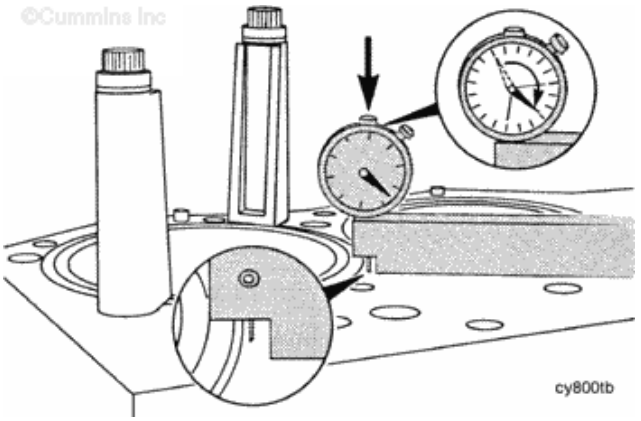
Read the liner protrusion in four places equally spaced on the liner outside diameter. The measurements on each liner **must not** vary more than 0.03 mm [0.001 inch].

If the cylinder liner protrusion is **not** within specifications the cylinder liner **must** be removed and the protrusion adjusted.

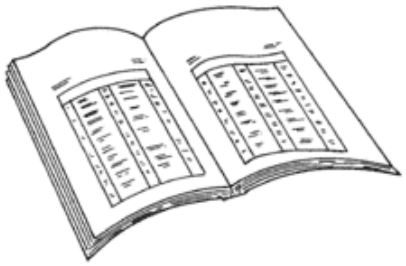
Seal rings of different thickness are available.

Nominal Thickness	
mm	[in]
0.457	0.018
0.508	0.020
0.559	0.022
0.787	0.031

Refer to Procedure 001-028 to remove the cylinder liner and Procedure 001-026 if the cylinder block counter bore needs to be machined.



Finishing Steps

• Install the cylinder head. Refer to Procedure 002-004.		©Cummins Inc  ck800wa

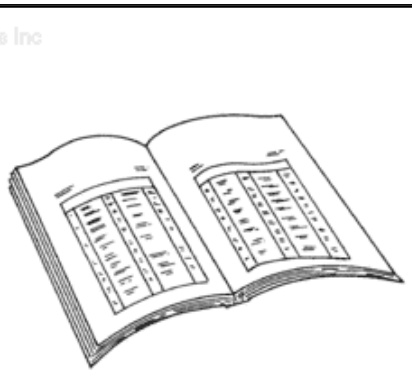
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001-067 Crankshaft Wear Sleeve, Rear

Preparatory Steps

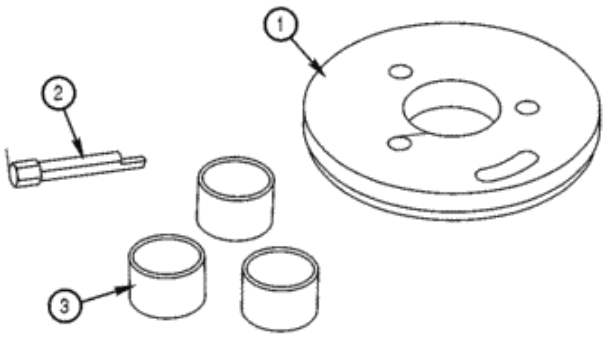
- Remove the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.
- Remove the flywheel. Refer to Procedure 016-005.
- Remove the rear crankshaft seal. Refer to Procedure 001-024.



Remove

The parts contained in the Wear Sleeve Installer/Remover kit, Part Number 3824971 are:

(1) Mandrel, Part Number 3824972
(2) Expander (wedge), Part Number 3824763
(3) Spacer



CAUTION

It is not necessary to completely cut the wear sleeve. If the sleeve is completely cut, the crankshaft can be damaged.

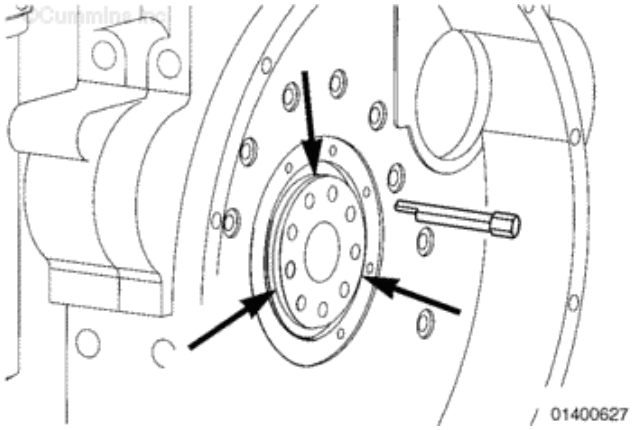
Insert the expander (wedge) between the wear sleeve and flywheel housing.

Turn the expander (wedge) so the wedge nose deforms the wear sleeve.

Repeat this process at three or four points around the wear sleeve.

The wear sleeve press fit will be reduced and it can be removed from the crankshaft.

Remove the wear sleeve from the crankshaft.



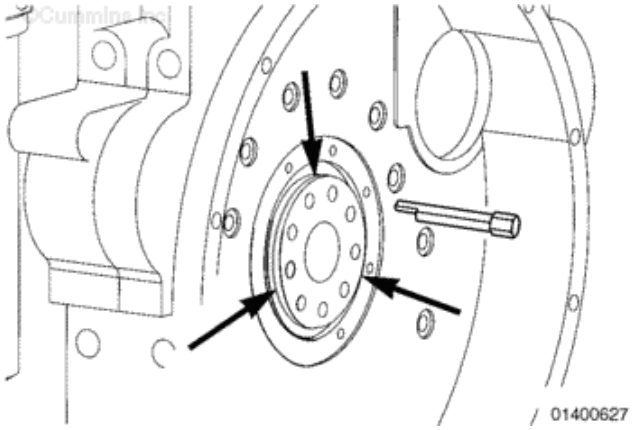
Install

CAUTION

Do not remove the seal from the wear sleeve. If the seal is removed from the wear sleeve it can be damaged during the installation process.

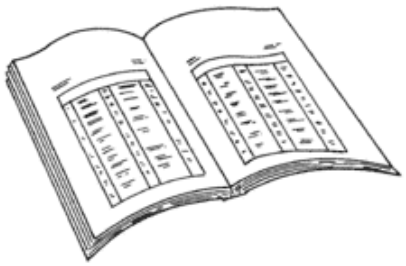
CAUTION

The wear sleeve and the seal must be installed simultaneously using a



special tool. Attempting to install the assembly without the tool will result in failure of the seal and an oil leak. Install the seal and wear sleeve assembly into the mandrel. Position the installation tool onto the crankshaft. Install the capscrews. Tighten the capscrews alternately approximately ½-turn at a time until the tool touches the gear cover. Remove the installation tool.		

Finishing Steps

• Install the flywheel. Refer to Procedure 016-005. • Install the clutch, transmission, and all related components. Refer to the equipment manufacturer's instructions.		©Cummins Inc  ck800wa

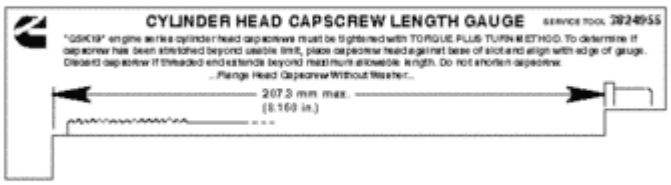
Last Modified: 24-Sep-2004

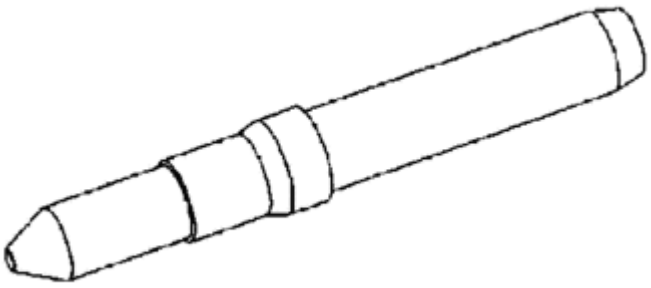
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View Related Topic

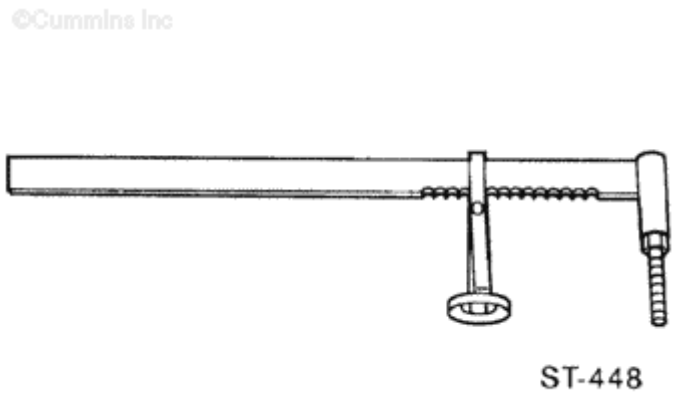
022-001 Service Tools

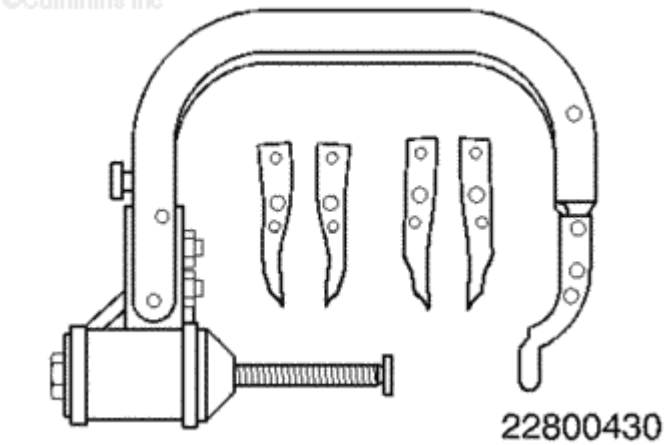
Cylinder Head

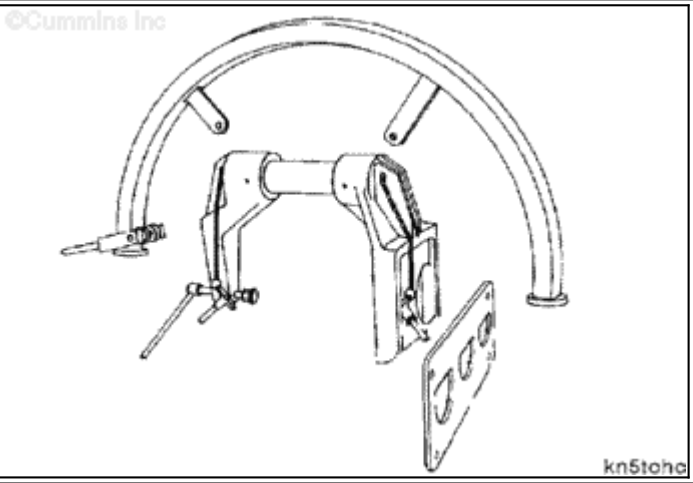
Tool Number		
3824955	**Cylinder Head Capscrew Length Gauge** Used to check the length of the cylinder head capscrews.	 01400399

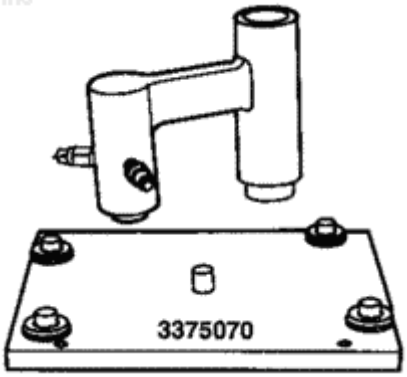
Tool Number		
4919196	**Injector Protrusion Gauge** Used to measure the injector protrusion for proper selection of a wear sleeve.	 22600459

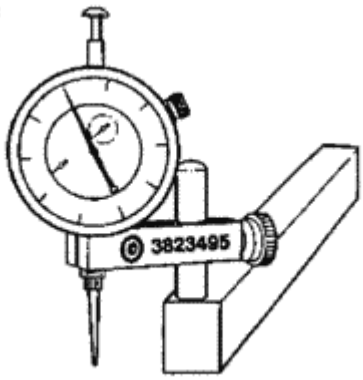
	Valve Spring	

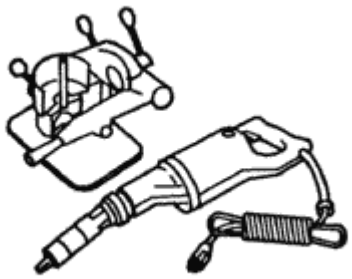
Tool Number	Compressor Compress the valve spring to allow the valve to be removed or installed.	
ST-448		

Tool Number	Valve Spring Compressor Compress the valve spring to allow the valve to be removed or installed. This tool is air operated.	
3375960		

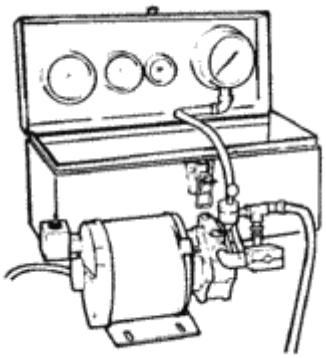
Tool Number	Hydrostatic Tester Check for coolant leaks in the cylinder head. Requires shop air, a lifting hoist, a water tank, and the appropriate Test Adapter Plate and o-ring.	
ST-1012		

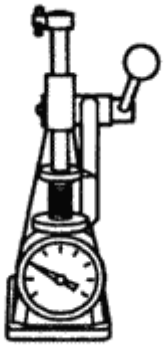
Tool Number 3375070	**Water Test Plates** Check for coolant leaks in the cylinder head. Use with Part Number ST-1012 Hydrostatic Tester. Use with Part Number 3375071 Water Test Plate O-rings.	

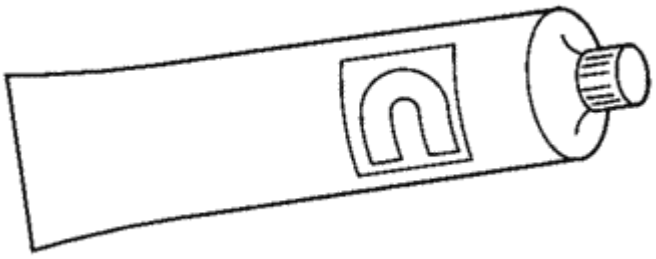
Tool Number 3823495	**Depth Gauge Assembly** Measure cylinder liner counterbore ledge angle and injector protrusion.	 3823495

Tool Number ST-685	**Valve Seat Grinding Machine** Used to grind the valve seats.	 kn8togi

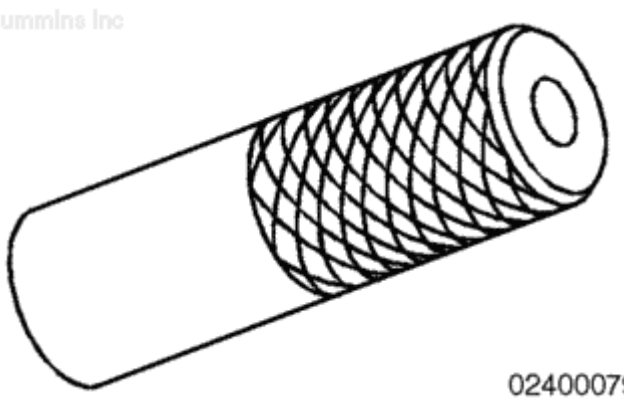
Tool Number	**Valve Vacuum Tester**	

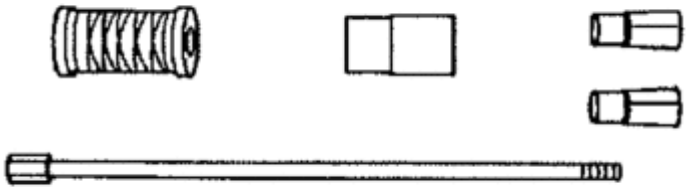
ST-1257	Used to test the valve to valve seat connection.	©Cummins Inc  kn8togr

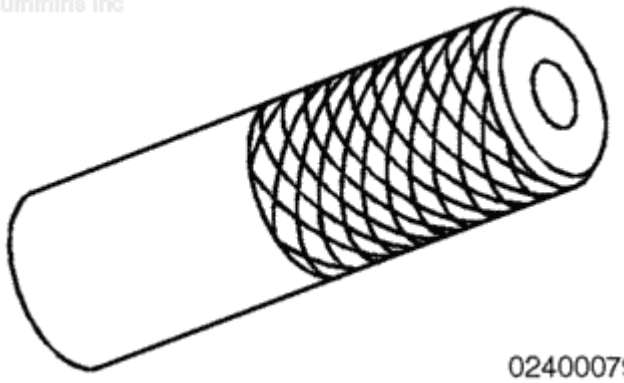
Tool Number 3375182	**Valve Spring Tester** Used to test the valve springs.	©Cummins Inc  kn8togs

Tool Number 3375805	**Valve Lapping Compound** An abrasive compound used to lap the valves.	©Cummins Inc  3377132

Tool Number	**Valve Head Thickness Gauge**	

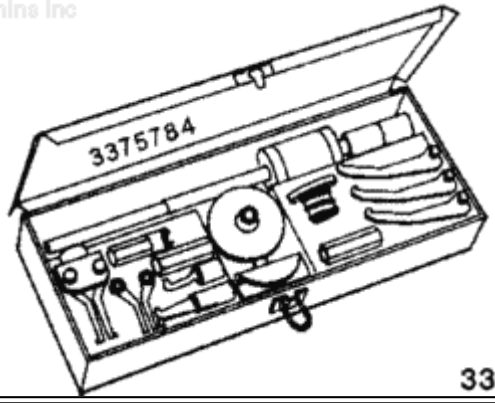
3824861	Used to check the intake and exhaust valve head thickness after reconditioning.	 02400079

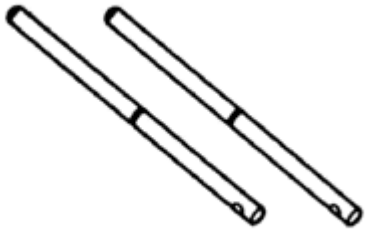
Tool Number ST-1134	**Dowel Pin Extractor** Puller contains various size collets to remove cross head guides or dowels through out the engine.	 ck8toge

Tool Number ST-1264	**Crosshead Guide Tool** Used when installing new crosshead guides in the cylinder head to make sure proper assembled height is attained.	 02400079

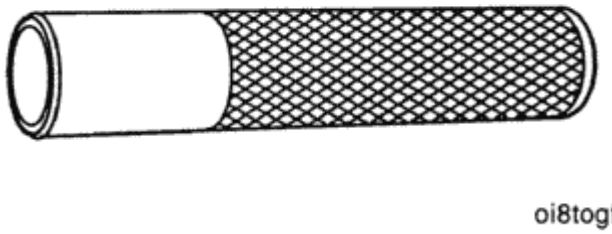
Tool Number	**Cup Plug Loctite® Sealant — Bottle** Used to seal around	

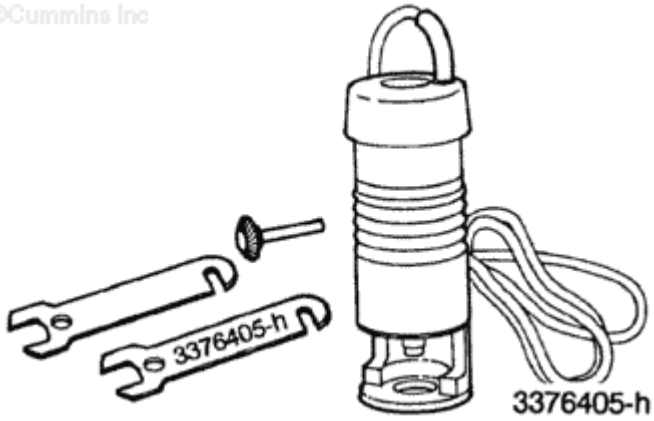
3375068	cup plugs to prevent leaks.	©Cummins Inc  bp8togk

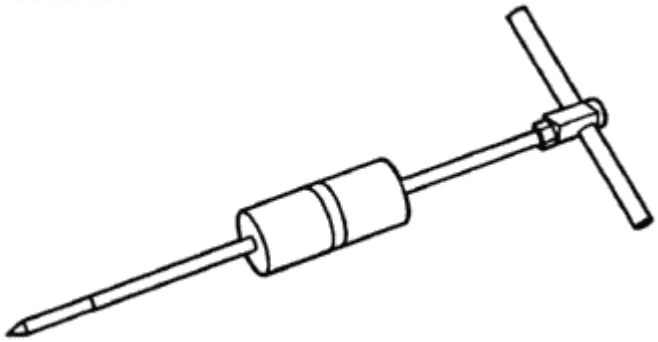
Tool Number 3375784	**Light Duty Puller Kit** Use to remove small seals, sleeves, bearings, grease retainers, bronze or oilite bushings, bearing races and bushings.	©Cummins Inc  3375784

Tool Number 3375946	**Valve Guide Arbor Set** Used with valve facing machine, Part Number ST-685-A.	©Cummins Inc  kn8togj

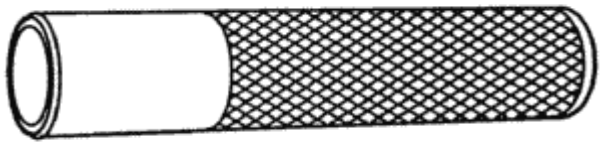
Tool Number	**Valve Guide Driver (Flat Top Guides)** Install the valve guides to the correct	

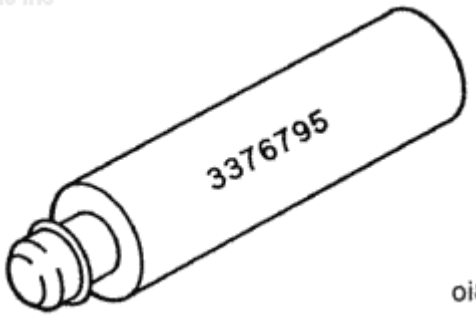
3376149	assembled height in the cylinder head.	 oi8togf

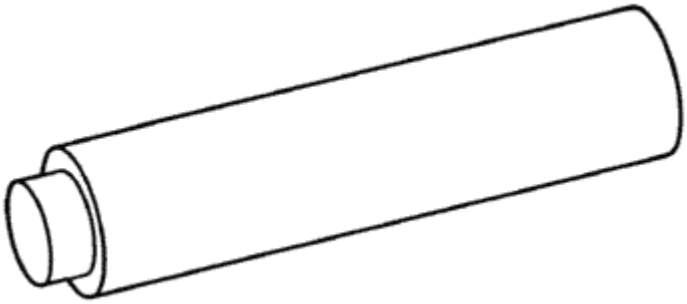
Tool Number 3376405	**Valve Seat Grooving Kit** Used in conjunction with ST-1323. The purpose of this tool is to cut a groove in the inside diameter of the valve seats, to provide a suitable groove for the valve seat pullers lip.	 3376405-h

Tool Number 3376617	**Slide Hammer Assembly** Used with the valve seat extractor to remove the valve seat inserts from the cylinder head.	 bp8togd

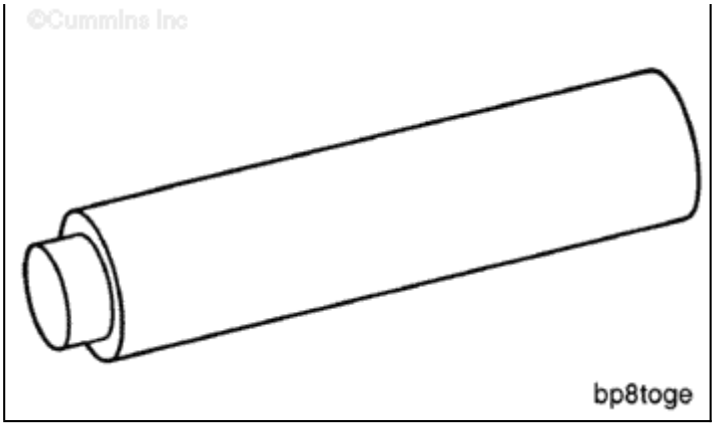
Tool Number	**Valve Guide Driver (Taper Top Guides)** Install the valve guides to the correct	

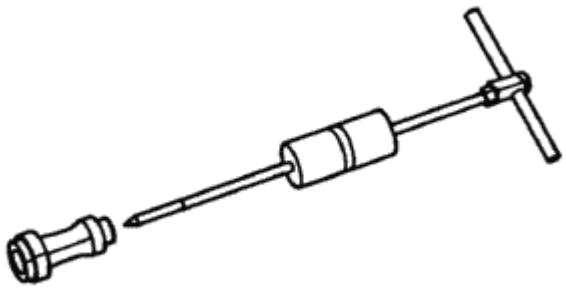
3376779	assembled height in the cylinder head.	 oi8togf

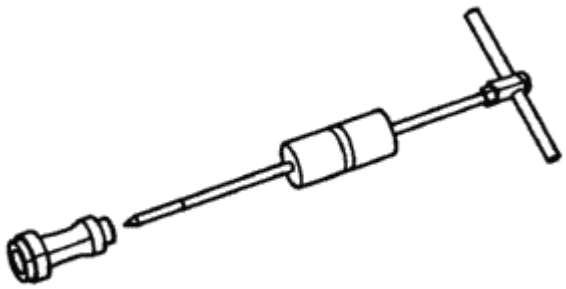
Tool Number 3376795	**Cup Plug Driver Handle** Used with the valve seat extractor to remove the valve seat inserts from the cylinder head. Used with an appropriate expansion plug installer for expansion plug installation.	 oi8togh

Tool Number 3376813	**Cup Plug Driver** Used to install cup plugs.	 bp8toge

Tool Number	**Cup Plug Driver**	

3376814	Used to install cup plugs.	 bp8toge

Tool Number ST-1323-1	**Valve Seat Extractor (Exhaust)** Remove the valve seat inserts from the cylinder head.	 kn8togx

Tool Number 3376799	**Valve Seat Extractor (Intake)** Remove the valve seat inserts from the cylinder head.	 kn8togx

Last Modified: 09-Oct-2008

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002-001 Crosshead

Clean and Inspect for Reuse

With Stem

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.

Remove the nut and adjusting screw.

Clean the parts with solvent and dry with compressed air.

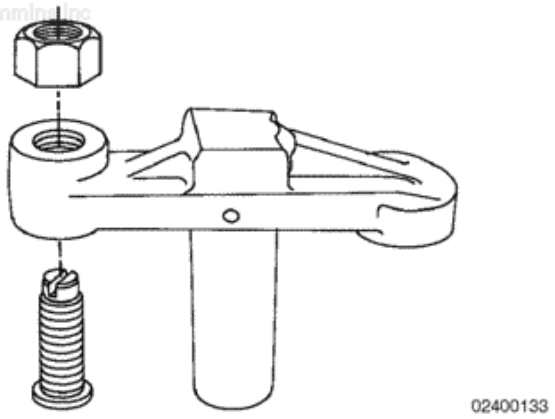
Check the threads of the adjusting screw and crosshead for damage.

If adjusting screw or crosshead threads are damaged, the threads **must** be repaired or crosshead and adjusting screw replaced.

Check the contact pad for cracks.

If the contact pad is cracked





the crosshead **must** be replaced.

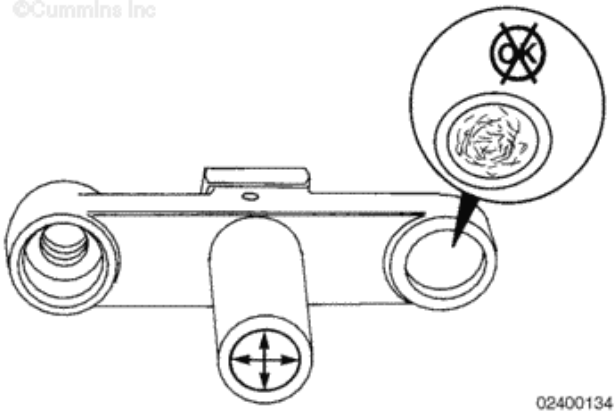
Check the valve stem contact area for wear or damage.

If the valve stem contact area is damaged or worn excessively, the crosshead **must** be replaced.

Measure the crosshead guide bore inside diameter.

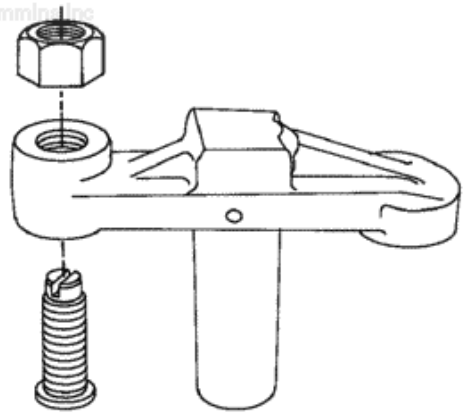
Crosshead Guide Bore Inside Diameter		
mm		in
11.02	MIN	0.434
11.17	MAX	0.440

If the crosshead bore diameter is **not** within specifications, the crosshead **must** be replaced.



Install the adjusting screw and the nut.

Do **not** tighten the nut until the crosshead has been installed and adjusted.



Without Stem

WARNING

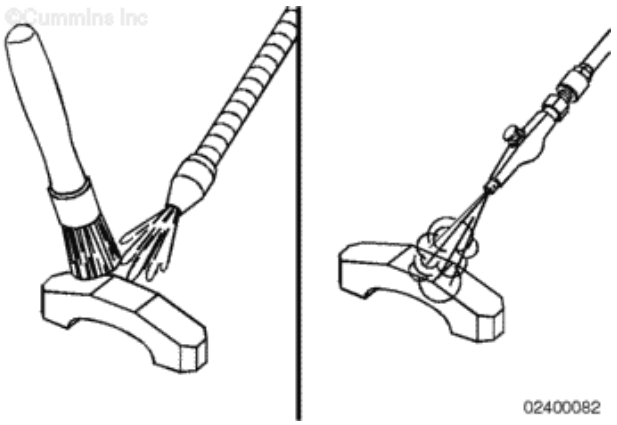
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's

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 crosshead with solvent and dry with compressed air.

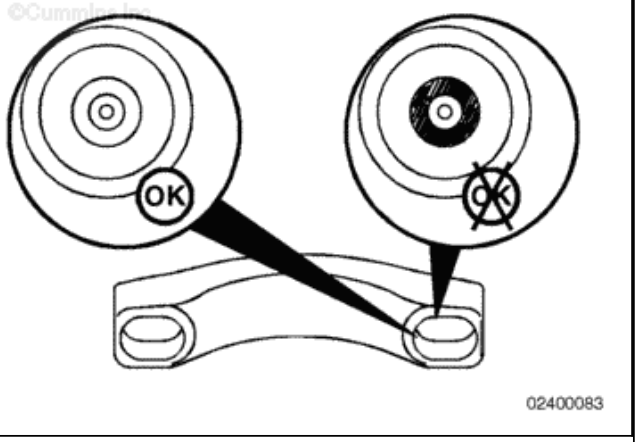


Check the contact pad area for cracks.

If the contact pad area is cracked, the crosshead **must** be replaced.

Check the valve stem contact area for wear or damage.

If the valve stem contact area is excessively worn or damaged, the crosshead **must** be replaced.



Last Modified: 19-Oct-2004

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002-004 Cylinder Head

General Information

ReCon® has implemented a new stamping code for all K and QSK cylinder heads.

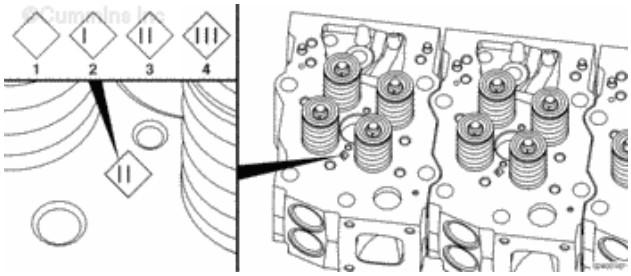
The stamp is a diamond shape located between the short port exhaust valve and long port intake valve on the rocker lever side of the cylinder head. The marking, or lack of a marking inside the diamond shape indicates the size of the injector seal.

- An empty diamond shape indicates that the ReCon® cylinder head is equipped with a standard size injector seal.
- One mark inside the diamond shape indicates the cylinder head is equipped with a 0.010 oversize injector seal.
- Two marks inside the diamond shape indicate that the cylinder head is equipped with a 0.020 oversize injector seal.
- Three marks inside the diamond shape indicate that the cylinder head is equipped with a 0.030 oversize injector seal.

K and QSK cylinder heads use a different injector seal. Reference the tables below.

K Cylinder Head Seal Part Numbers	
Injector Seal Part Number	**Injector Seal Size**
207244	Standard
3001658	0.010 oversize
3001659	0.020 oversize
3001660	0.030 oversize

QSK Cylinder Head Seal Part Numbers	
Injector Seal Part Number	**Injector Seal Size**
3867687	Standard
3347933	0.010 oversize
3347934	0.020 oversize
3347935	0.030 oversize



Injector Seal Markings Location

Injector Seal Markings

1. Standard
2. 0.010 oversize
3. 0.020 oversize
4. 0.030 oversize.

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 connect the negative (-) battery cable last.

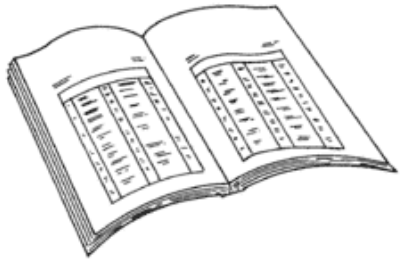
WARNING

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 or 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 to the air



ck800wa

starter to prevent accidental starting. Refer to the OEM service manual. • Drain the cooling system. Refer to Procedure 008-018 in Section 8. • Remove the turbocharger. Refer to Procedure 010-037 in Section 10. • Remove the exhaust manifold. Refer to Procedure 011-007 in Section 11. • Remove the fuel supply lines. Refer to Procedure 006-024 in Section 6. • Remove the aftercooler assembly. Refer to Procedure 010-002 in Section 10. • Remove the fuel supply manifold. Refer to Procedure 006-022 in Section 6. • Remove the STC oil manifold, if equipped. Refer to Procedure 006-038 in Section 6. • Remove the rocker lever covers. Refer to Procedure 003-011 in Section 3. • Remove the rocker levers. Refer to Procedure 003-009 in Section 3. • Remove the push rods or tubes. Refer to Procedure 004-014 in Section 4. • Remove the gear cover clamping plate. Refer to Procedure 001-031 in Section 1. • Remove the rocker lever housing. Refer to Procedure 003-013 in Section 3. • Remove the injector. Refer to Procedure 006-026 in Section 6.		

Remove

WARNING

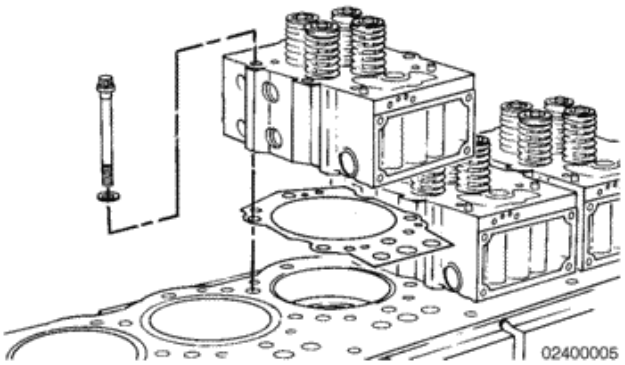
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Remove the six cylinder head capscrews.

Remove the cylinder head and the gasket.

Record the cylinder head gasket part number to determine if the gasket has standard or oversized thickness.

Discard the gasket.



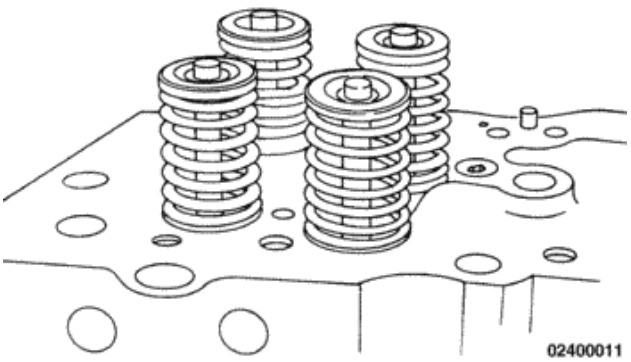
Clean

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.

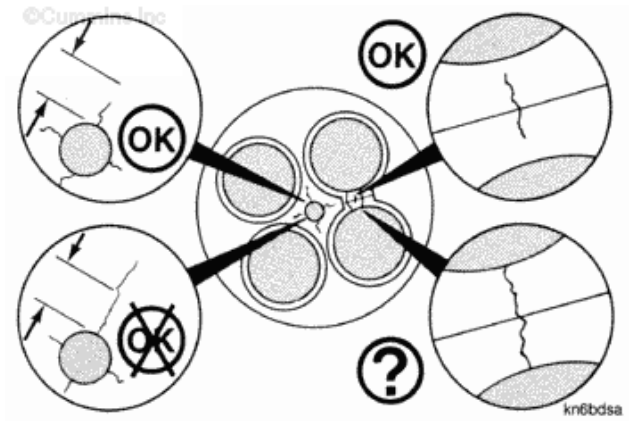
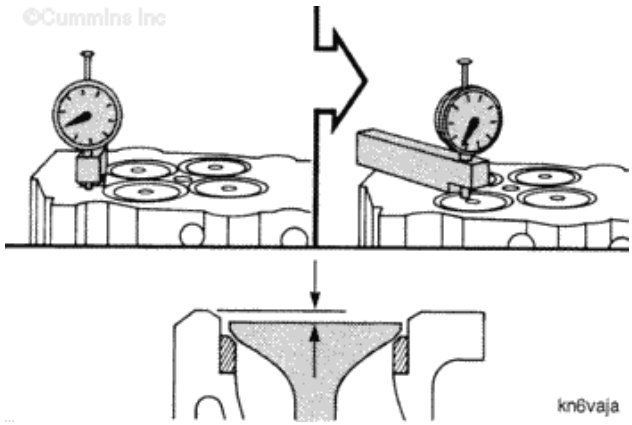
Clean the cylinder heads with solvent, Part Number 3824421, or equivalent.

Check for broken springs or



other damage.		

Inspect for Reuse

Check for cracks on the combustion surface. Cylinder Head Allowable Crack Length mm MAX in 6 MAX 0.25 If a crack around the injector bore exceeds the maximum length, the cylinder head **must** be replaced. Both ends of a crack between the valve **must** be visible. If one end of a crack extends into the valve seat bore (behind the valve seat), the condition of the cylinder head is questionable. To be sure the cylinder head is reusable, remove the valve and valve seat.		
Measure the valve head depth in the cylinder head with a depth gauge, Part Number 3164438, or equivalent. Allowable Valve Depth in Combustion Face mm MAX in 0.00 MIN 0.000 0.51 MAX 0.020 If the valve head depth is **not** within specifications, the cylinder head **must** be reconditioned.		
Check the flatness of the		

cylinder head with a straight edge and feeler gauge.

The cylinder head **must** be resurfaced if a feeler gauge larger than 0.08 mm [0.003 in] will fit between the straight edge and the cylinder head.

The cylinder head can be resurfaced as long as the thickness measurement is within specifications.

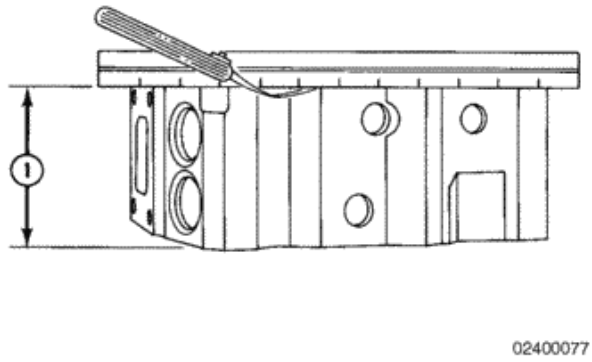
Used Cylinder Head Minimum Thickness (1)

mm		in
119.76	MIN	4.715

New Cylinder Head Thickness (1)

mm		in
120.52	MIN	4.745
120.78	MAX	4.755

If the cylinder head is resurfaced, make sure the injector protrusion and valve depth are adjusted properly.



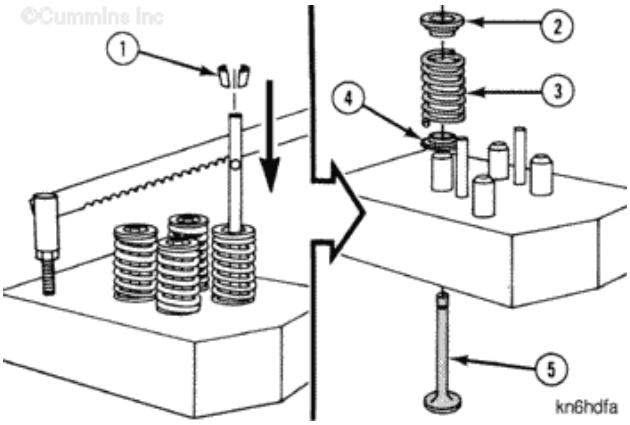
Disassemble

WARNING

The valve springs are under compression. Use caution when using the valve spring compressor. Personal injury can result if the tool slips out of the hands.

Use one of the valve spring compressors listed below to remove the valve springs:

- Valve spring compressor, Part Number 3163606



- Valve spring compressor stand, Part Number ST-1022
- Valve spring compressor plate, Part Number 3163177, can be used with valve spring compressor, Part Number 3163066, and valve spring compressor stand, Part Number ST-1022, to remove four springs at once
- Air operated valve spring compressor, Part Number 3375960.

The intake and exhaust valves are different.

Mark the valves for location prior to removal, to aid in assembly.

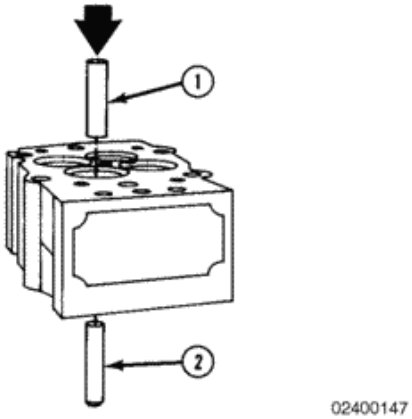
Remove the listed parts:

1. Valve collet
2. Valve spring retainer
3. Valve spring
4. Valve spring rotator/or guide
5. Valve.

If a valve guide is replaced, the valve seat insert for the valve guide **must** be measured for runout. It is likely the seat **must** also be machined or replaced.

NOTE: Only replace the valve guide if it is not within specifications.

Remove the worn valve guide (2) with a mandrel (1) and an arbor press.

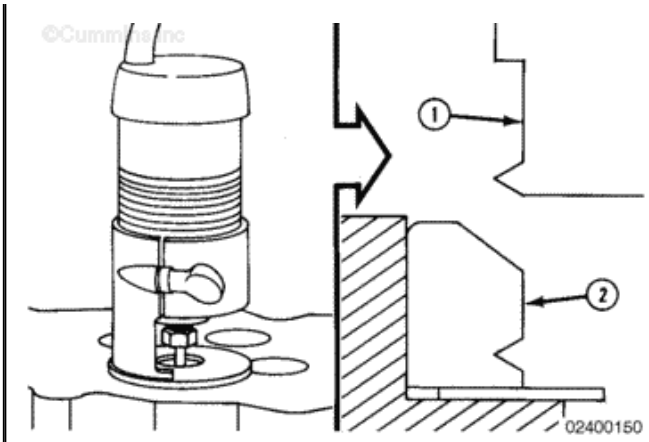


NOTE: Only replace the valve seat if it is not within specifications.

If necessary, a groove (2) can be machined in the valve seat

insert to allow the valve seat extractor (1) to be used.

Machine a groove into the valve seat insert, as close to the bottom of the bore as possible, with valve seat grooving kit, Part Number 3376405, or equivalent.

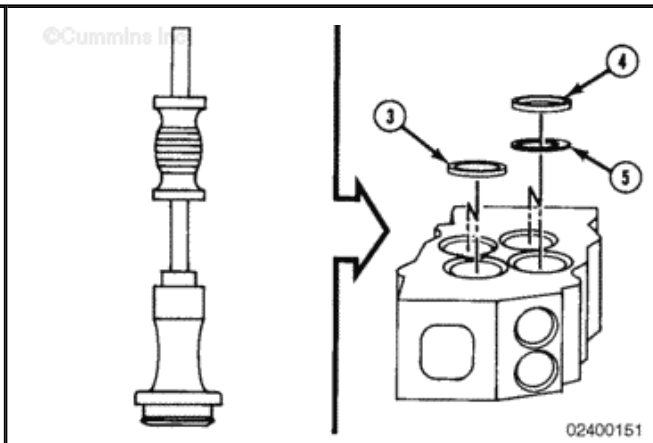


Remove the valve seat with the appropriate valve seat extractor listed below and slide hammer, Part Number 3376799.

- Exhaust seat extractor, Part Number ST-1323-1
- Intake seat extractor, Part Number 3376799.

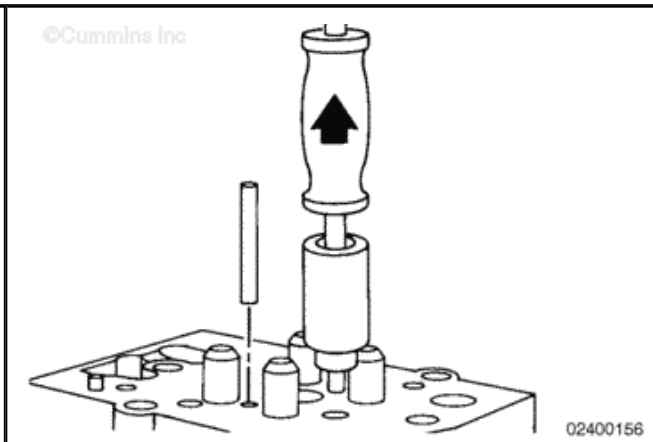
NOTE: In some older cylinder head assemblies, the intake ports contain anti-swirl plates.

Remove and discard the anti-swirl plate, if used.



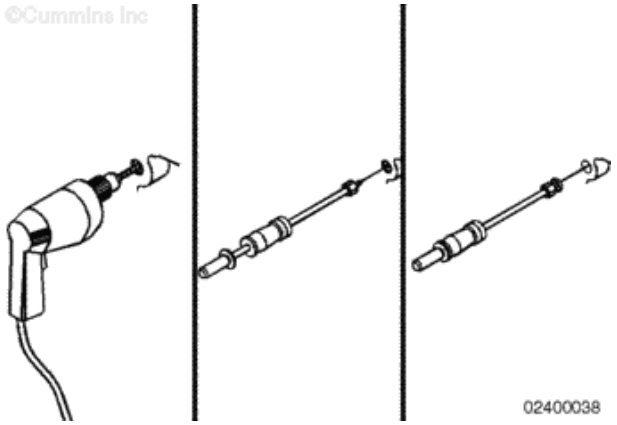
NOTE: Only remove the crosshead guide if it is bent or is not within specifications.

Crosshead guides that are straight and are installed to the correct height do **not** have to be removed to install stemless crossheads.



To remove the cup plugs, a

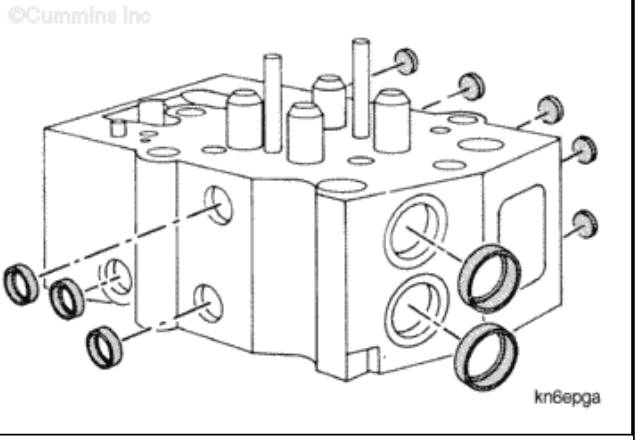
drill, sheet metal screw, and a slide hammer from the light duty puller kit, Part Number 3375784, is used.



Cup plugs **must** be removed from the cylinder head casting for cleaning purposes.

Remove and discard the ten cup plugs.

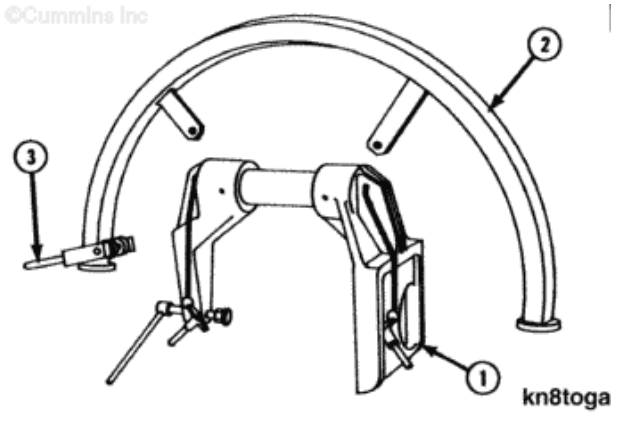


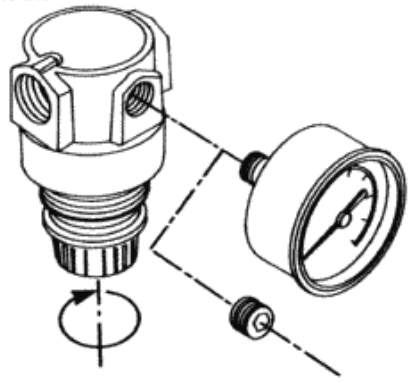
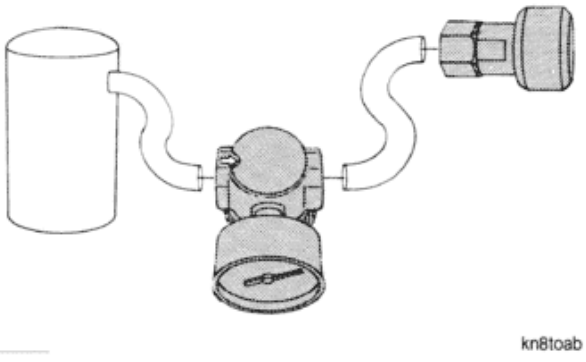
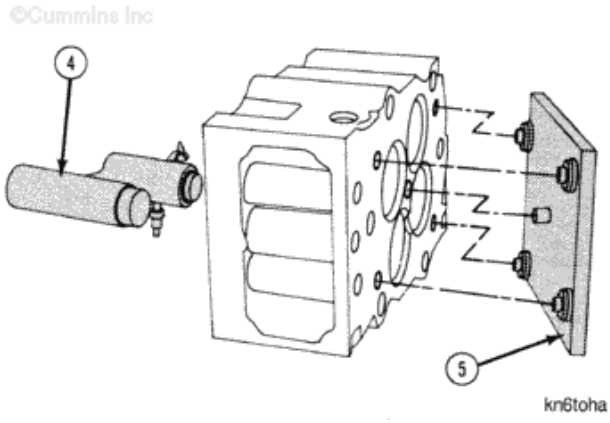


Pressure Test

One method to pressure test the cylinder head is to use the hydrostatic tester, Part Number ST-1012, with the water test adapter plate, Part Number 3375070.

The steps below outline this method.



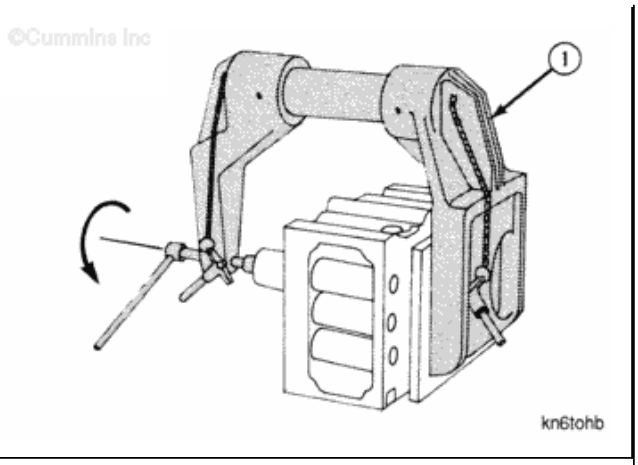
Remove one of the two plugs from the pressure regulator. Install a pressure gauge into the regulator. Turn the adjusting knob on the regulator **counterclockwise** as far as it will turn.		
Install the pressure regulator between the air supply and the quick disconnect fitting. The arrow on the top of the pressure regulator **must** point in the direction of the air flow (toward the disconnect fitting).		
With the head positioned as illustrated in the graphic, assemble the adapter plates. The guide pins on the lower plate, Part Number 3375070, (5) **must** fit into the water passages. The o-ring on the upper plate (4) creates a seal on the upper water passage. The other end of the plate fits into the injector bore.		
Place the clamping assembly (1) over the head		

and adapters.

The guide pins on the clamp **must** fit into the holes in the adapter plate.

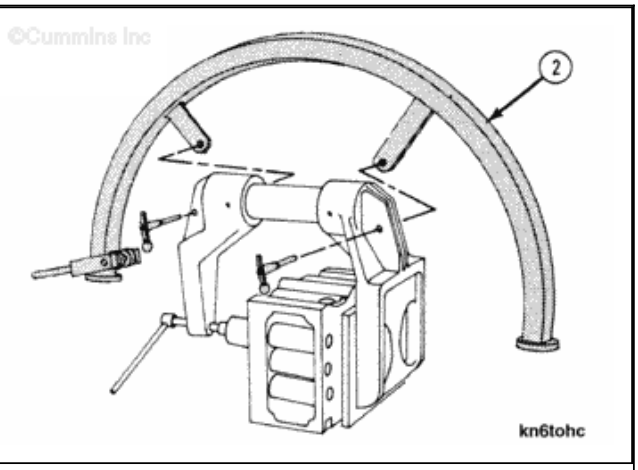
Tighten the clamp on the cylinder head.

Connect the wire hose to the upper adapter fitting.



Attach the lifting arm (2) to the clamp assembly with the lock pins.

One mounting location on each piece is colored red.



WARNING

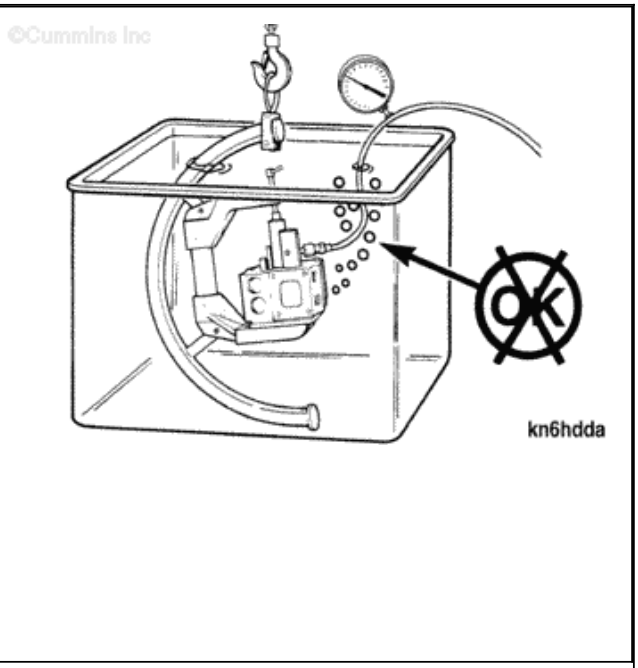
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Adjust the air pressure to 552 kPa [80 psi].

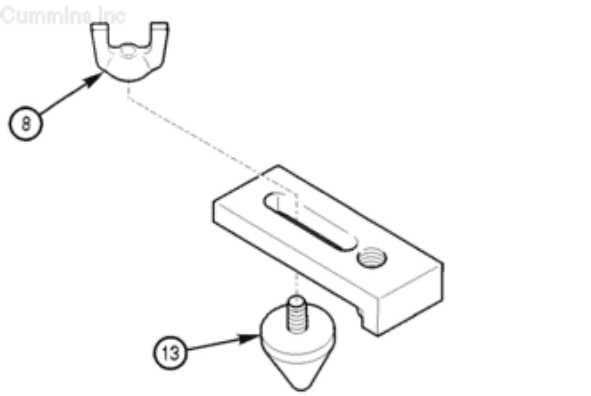
Lower the cylinder head into a tank of water.

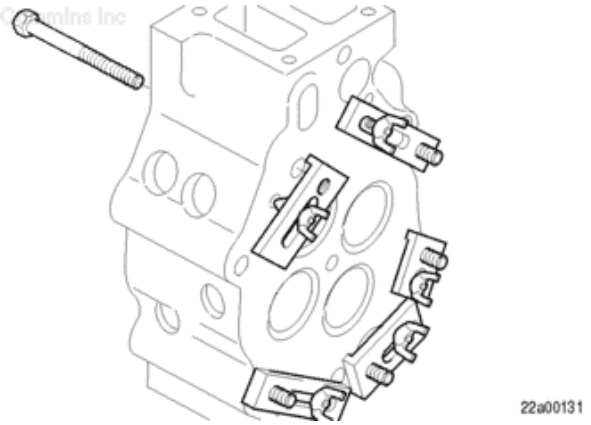
Bubbles will indicate a leak.

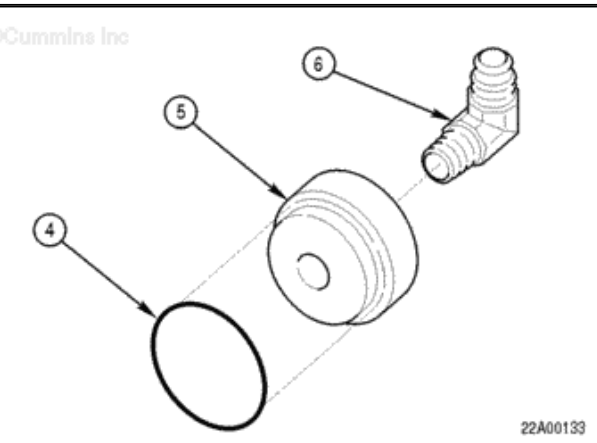
If the cylinder head leaks, it



must be repaired or replaced.		

An alternate method to using the hydrostatic tester, Part Number ST-1012, pressure testing the cylinder head is to use the cylinder head leak test kit, Part Number 3164341, with the pressure regulator valve kit, Part Number 3164231. Assemble the wing nut (8) to the clamp and plug (13).		

NOTE: The K19 engine uses only the four longer assemblies shown. Install the clamp and plug assembly into the cylinder head to block 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]		

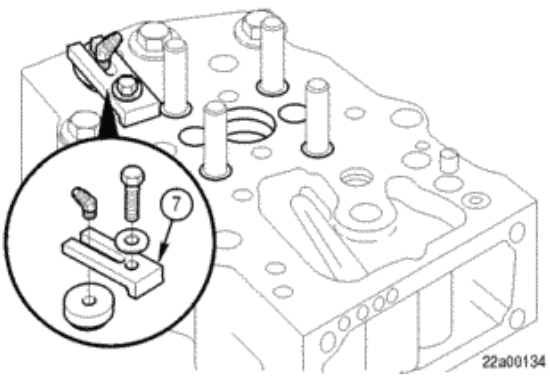
Install the o-ring (4) into the o-ring groove of the test adapter (5). Thread the adapter elbow (6) into the adapter (5).		

Place the test adapter assembly into the cylinder head.

Install the clamp (7) over the test adapter assembly and secure it with the appropriate capscrew and washer.

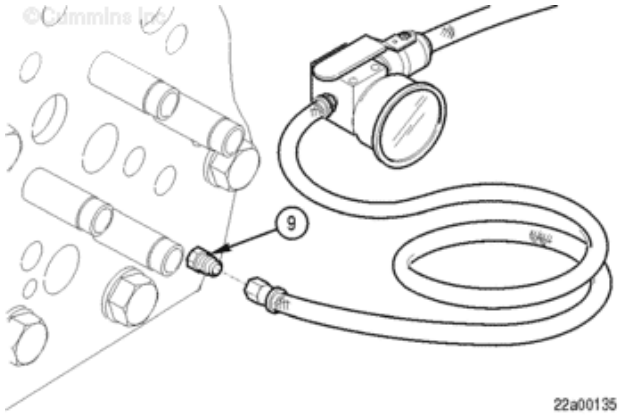
Tighten the capscrew.

Torque
Value: 54 n.m [40 ft-lb]



Connect the pressure regulator valve kit to the pipe nipple.

Connect the pressure regulator valve kit to compressed air and adjust the air pressure to 345 kPa [50 psi].



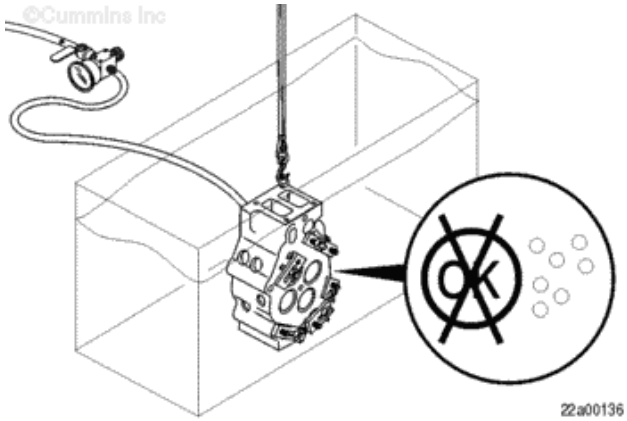
WARNING

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.

Attach an eye bolt 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.

Clean and Inspect for Reuse

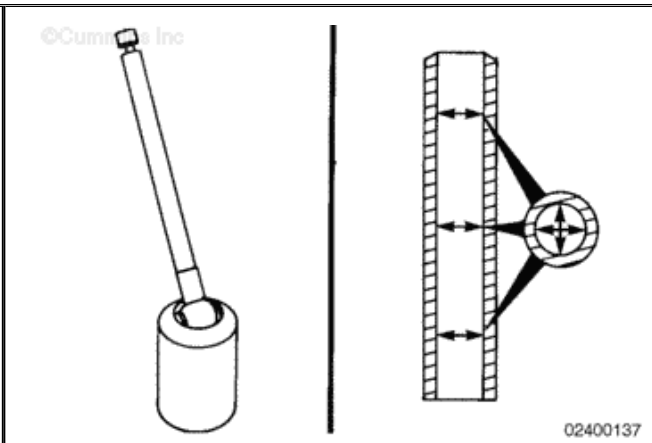
Check the valve guide for chips and cracks.

Measure the inside diameter of the valve guide with a ball gauge or a dial bore indicator.

Valve Guide Inside Diameter (Installed)

mm		in
12.600	MIN	0.496
12.667	MAX	0.499

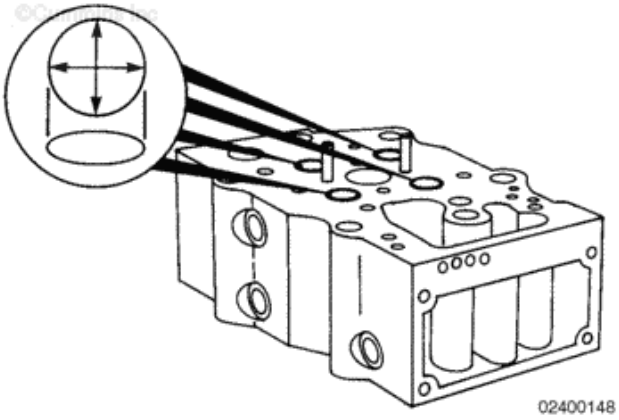
The valve guide can be reusable if the inside diameter of the first 13 mm [0.50 in] from the top or bottom of the valve guide is over specification. However, if an area 13 mm [0.50 in] or greater from the top or bottom is out of tolerance, the valve guide **must** be replaced.



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.

Clean the part with solvent,



Part Number 3824421, or equivalent.

Measure the valve guide bore inside diameter.

Valve Guide Bore Inside Diameter

mm		in
21.425	MIN	0.844
21.450	MAX	0.845

If the valve guide bore is **not** within specifications, ream the bore for an oversize valve guide.

The oversize valve guides are oversized on the outside diameter **only**. The bore in the valve guide is **not** oversized.

Valve guides are available in two oversize guides: 0.25 mm [0.010 in] and 0.38 mm [0.015 in].

Ream the valve guide bore to maintain a press fit within 0.028 to 0.067 mm [0.001 to 0.003 in] between the valve guide and the valve guide bore.

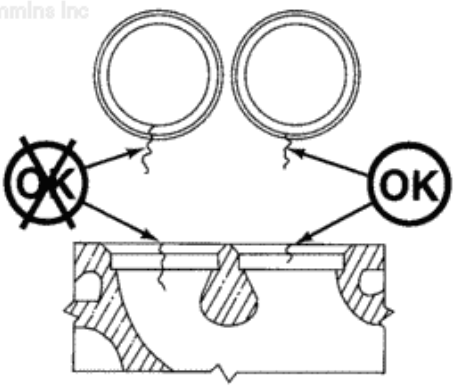
Clean the valve seat insert bore.

Check the length of any cracks extending into the valve 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 cylinder head to use an oversize valve seat insert.

Use valve insert counterbore cutter kit, Part Number ST-257, or equivalent, with the appropriate counterbore cutter listed below:



02400161

- ST-1310-1 (0.010 oversize)
- ST-1310-2 (0.020 oversize)
- ST-1310-3 (0.030 oversize)
- ST-1310-4 (0.040 oversize).

Measure the inside diameter and the depth of the valve seat insert bore.

Valve Seat Insert Bore Inside Diameter (6)

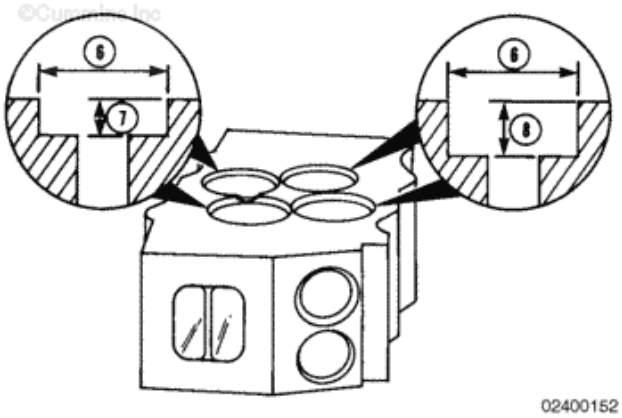
	mm		in
Intake with Anti-Swirl Plates	60.37	MIN	2.377
	60.40	MAX	2.378
Exhaust and Intake without Anti-Swirl Plates	60.37	MIN	2.377
	60.40	MAX	2.378

Valve Seat Insert Bore Depth (7) and (8)

	mm		in
Intake with Anti-Swirl Plates	13.00	MIN	0.512
	13.13	MAX	0.517
Exhaust and Intake without Anti-Swirl Plates	12.50	MIN	0.492
	12.62	MAX	0.497

If the valve guide seat insert inside diameter is **not** within specifications, use an oversize valve seat.

Oversize valve seat inserts



are available in the sizes listed in the table below. Machine the valve seat insert bore in the cylinder head to maintain a press fit within 0.064 to 0.114 mm [0.002 to 0.005 in] between the valve seat insert and the valve seat insert bore.

Outside Diameter Oversize	Depth (Thickness) of Oversize
0.25 mm [0.010 in]	Standard
0.51 mm [0.020 in]	0.13 mm [0.005 in]
0.76 mm [0.030 in]	0.25 mm [0.010 in]
1.02 mm [0.040 in]	0.38 mm [0.015 in]

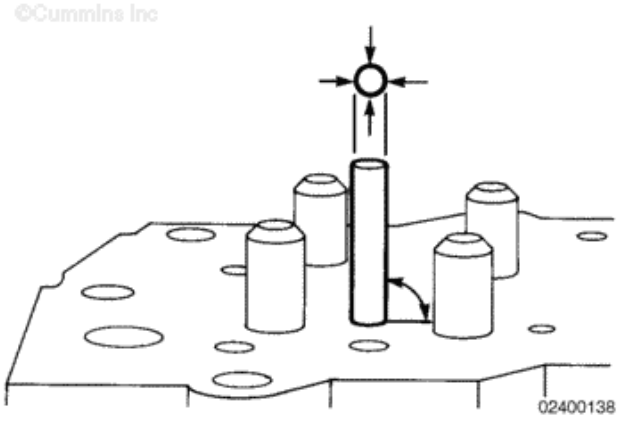
NOTE: K19 engines with an engine serial number greater than 37158462, built 13 July 1995, do not have crosshead guides. These engines use stemless crossheads.

The crosshead guide **must** be straight. Measure the crosshead guide outside diameter.

Crosshead Guide Outside Diameter

mm		in
10.973	MIN	0.432
11.011	MAX	0.434

If the crosshead guide is **not** within specifications it **must** be replaced, or the stemless crosshead guides **must** be used on the engine assembly. It is authorized, but **not** recommended, to have a stemmed and stemless crosshead on the same cylinder. Installation of stemless crossheads is recommended.



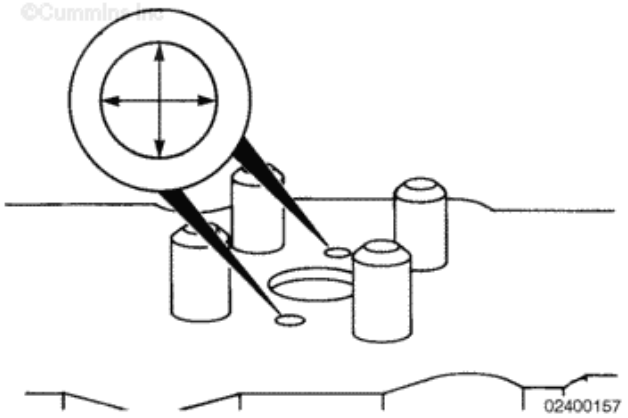
NOTE: Cummins Inc. recommends installing stemless crossheads instead of machining the cylinder head for oversize crosshead guides.

Measure the crosshead guide bore inside diameter.

Crosshead Guide Bore Inside Diameter

mm		in
10.957	MIN	0.431
10.986	MAX	0.433

Ream the bore to accept an oversize crosshead guide if it is **not** within specifications. Size the bore to maintain a 0.013 to 0.053 mm [0.002 to 0.005 in] press fit.



The intake and exhaust valve face and seating surfaces **must** be cleaned and free of carbon deposits before the inspection is performed.

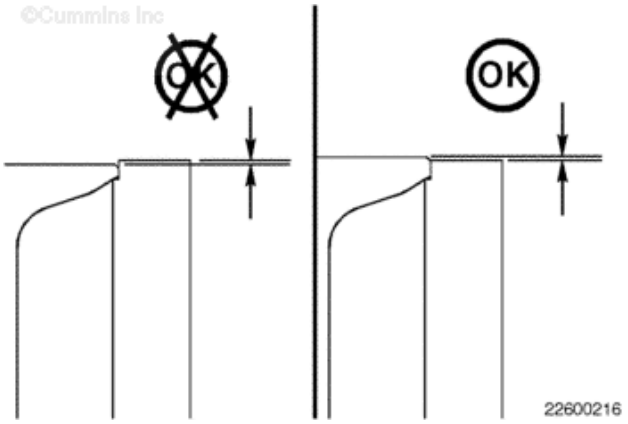
Use Scotch-Brite™ 7448 abrasive hand pad, Part Number 3823258, or equivalent, to clean the valve.

The valve head thickness gauge, Part Number 3164983, is used to check intake and exhaust valve head thickness. The lower gauging surface marked “INTAKE” is for the intake valve. The upper gauging surface marked “EXHAUST” is for the exhaust valve.

Place the valve into the valve head thickness gauge.

Measure the valve height.

If the valve is flush or above the gauging surface, the valve can be reused.



If the valve is below the gauging surface, the valve can **not** be reused.

CAUTION

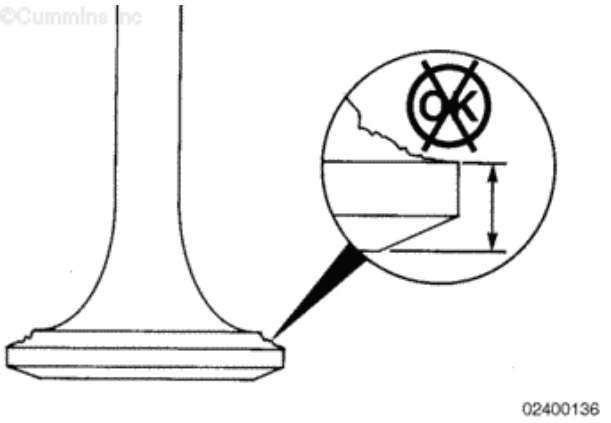
This type of a check is not as accurate as the checking tool. It can result in valves that are too thin to be reused. Valves that are too thin can fail, causing severe progressive damage to the power cylinder.

If a valve checking tool is **not** available, place the valve on a flat surface and check the height of the outside diameter.

Minimum Valve Head Thickness (at the Outside Diameter)

	mm		in
Exhaust	3.00	MIN	0.120
Intake	2.16	MIN	0.085

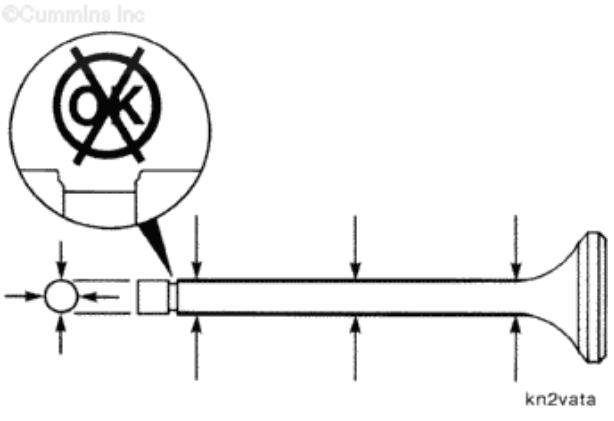
If the valve is **not** within specifications, it **must** be replaced.



It is **not** necessary to remove any black or brown stain on the valve closest to the port unless the buildup affects the movement in the guide. Use nothing more coarse than crocus cloth (1000 grit) to remove the stain.

The valve stems are plated with chrome. If there are scuffs or marks that can be felt with the fingernail, the valve **must** be replaced.

Check the collet groove area for wear. If the groove area is worn, the valve **must** be replaced.



Measure the valve stem outside diameter.

Valve Stem Outside Diameter

mm		in
12.535	MIN	0.494
12.576	MAX	0.495

Valve springs of three different lengths are used on the engine. The springs used with a valve rotator are called “short springs”. Springs that are used when a rotator is **not** used are called “long springs”.

There are two different lengths of "short springs". These are identified as red stripe (old) and white stripe (new) short springs.

Cummins Inc. recommends using new white stripe valve springs when the cylinder head is reconditioned.

A bent or broken spring **must not** be used again.

A spring with a notch worn in the first coil **must not** be used again. The ends of the springs will wear into the first coil, creating a worn notch in the material.

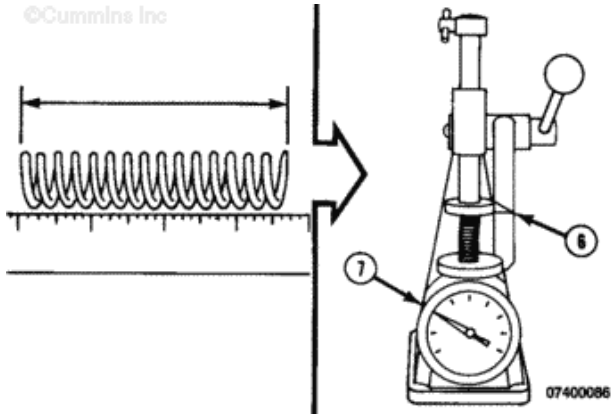
If a worn notch can be seen or felt, the valve spring **must not** be used again.

Often a spring that has these notches will make a clicking sound. Hand compress the spring until the end of the first coil is completely collapsed to check for a click sound. A large notch will cause a clicking sound.

Check both ends of the spring for the clicking sound.

Check the spring free length.





Approximate Free Length		
Long Spring (without rotator)	Red Stripe Spring (with rotator)	White Stripe Spring (with rotator)
85 mm [3.35 in]	65 mm [2.57 in]	69 mm [2.72 in]

Check the spring force at the indicated test height.

Test Height		
Long Spring (without rotator)	Red Stripe Spring (with rotator)	White Stripe Spring (with rotator)
50 mm [2.0 in]	39 mm [1.53 in]	38 mm [1.51 in]

Valve Spring Force

	n		lbf
Long Spring (without rotator)	1053	MIN	237
	1237	MAX	278
Red Stripe Spring (with rotator)	1183	MIN	266
	1308	MAX	294
White Stripe Spring (with rotator)	1241	MIN	279
	1383	MAX	311

If the valve spring is **not** within specification, the valve spring **must** be replaced.

Magnetic Crack Inspect

CAUTION

To reduce the possibility of engine damage, always demagnetize and clean the parts thoroughly after a magnetic particle inspection.

Use the magnetic particle residual method to check the valves for cracks.

Check the exhaust valves with the coil shot method.

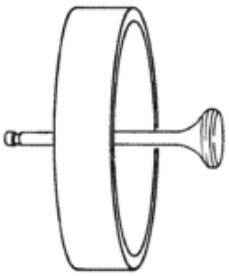
Use a 305 mm [12 in] minimum diameter coil.

Coil Shot Amperage (Ampere Turns)	
Minimum	**Maximum**
400 VDC or rectified VAC	800 VDC or rectified VAC

An ampere turn is an electrical current of one ampere flowing through the coil multiplied by the number of turns in the coil.

Test the valve.

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.



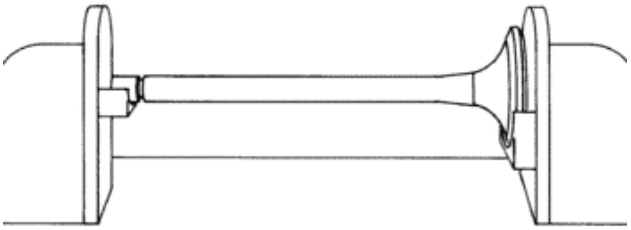
kn2vakb

Use the head shot method to test the intake valve.

Head Shot Amperage (Ampere)	
Minimum	**Maximum**
500 VDC or rectified	700 VDC or rectified VAC

VAC		

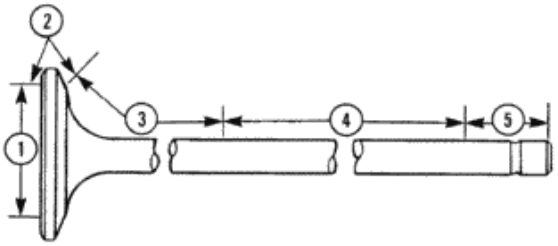
©Cummins Inc



kn2vakd

The acceptable criteria for intake and exhaust data is listed below: 1. Indications less than 38.1 mm [1.50 in] in length are acceptable 2. No indications 3. **Only** longitudinal indications are acceptable 4. **Only** longitudinal indications are acceptable 5. No indications. More than five indications, spaced closer than 3.175 mm [0.125 in] are **not** acceptable.		

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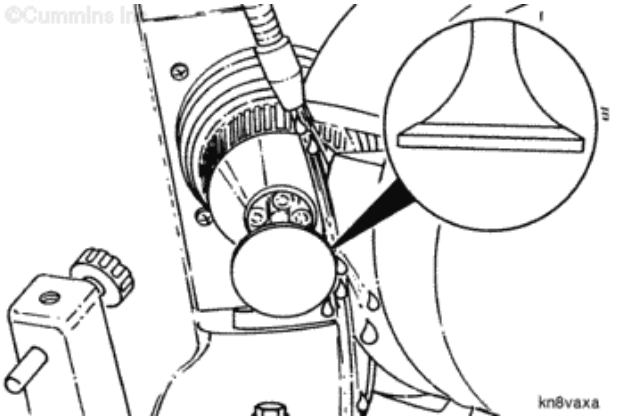
kn2vake

Grind

Valve

Intake and exhaust valves **must** be ground to the same angle. Use valve facing machine, Part Number 3376256, to grind the valve to a 30 degree angle, as illustrated in the graphic.		

Do **not** to remove too much material too quickly. **Only** remove the minimum amount of material, making sure the seating area of the valve is free from grooves.



Machine

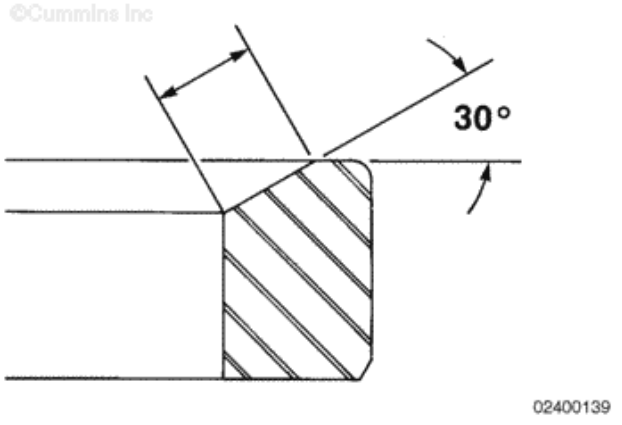
Valve Seat

Cummins Inc. recommends using machines that will cut the valve seat insert. Grinding the valve seat with stones that are too coarse can cause an unacceptable surface finish that can lead to early valve and/or seat wear. If the valve protrusion is too great and a machine to cut the valve seat is **not** available, Cummins Inc. recommends to remove the seat then machine the bore in the cylinder head to a greater depth, if possible.

Use a valve guide arbor set, Part Number 3375946, or equivalent, with valve seat grinding machining ST-685-A (110 VAC) or ST-685-C (220 VAC).

Machine the valve seat insert to the angle illustrated in the graphic.

Measure the valve seat insert width.

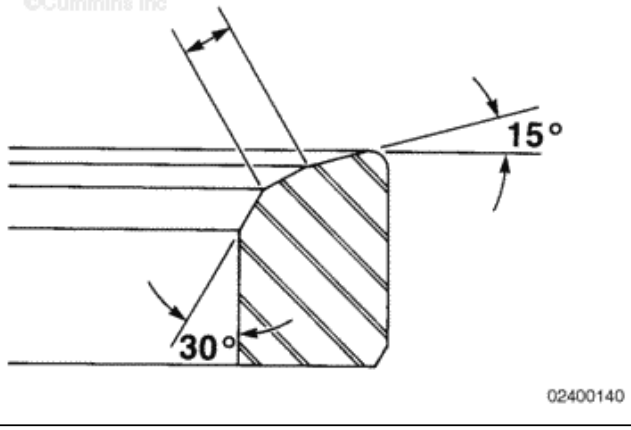


Valve Seat Insert Width

	mm	in
Intake	3.05 MIN	0.120
	3.55 MAX	0.140
Exhaust	1.52 MIN	0.060
	2.54 MAX	0.100

If the width of the valve seat is **not** within specifications, remove the surface material on the inside diameter and outside diameter to decrease the width of the valve seat.

If the valve seat specifications are **not** obtained by machining, the valve seat **must** be replaced.

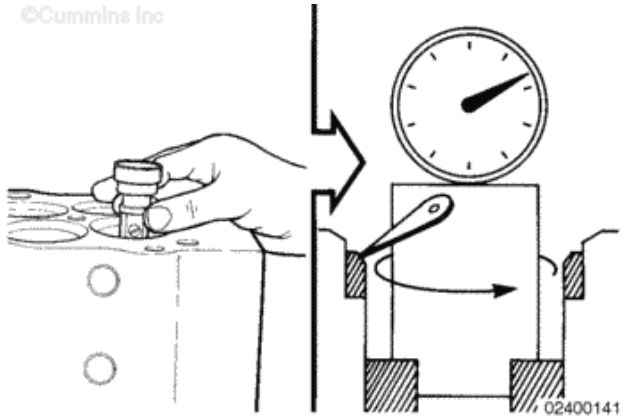


It is important that the eccentrimeter is **not** positioned too far down the arbor. The meter needle **must not** complete more than between one and one and a half revolutions before touching the valve seat insert. If the meter will **not** touch the insert at a minimum revolution, change the arbor to a smaller diameter. The meter will have to be adjusted for each seat and arbor combination.

Use an eccentrimeter, Part Number ST-685-4, or equivalent, and the arbor included in the valve seat grinding machine kit, Part Number ST-685-A or ST-685-C.

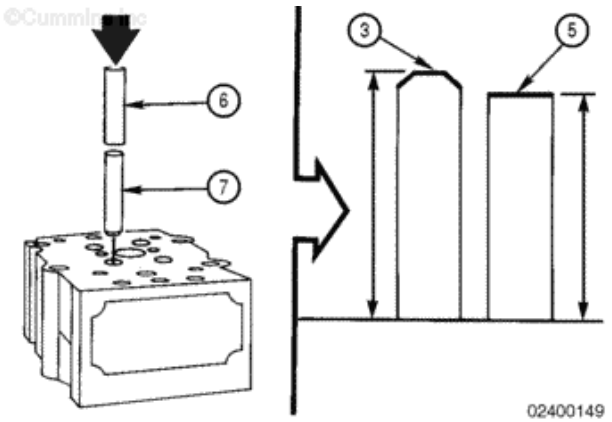
Measure the valve seat to the valve guide concentricity.

The seat and guide **must** be concentric within 0.05 mm [0.002 in].



If the concentricity is **not** within specification, machine the valve seat.		

Assemble

Identify the valve guide style and location. Locomotive and some hydraulic excavator engines **must** use the flat-top style (5). This valve guide is grooved to allow the use of a valve stem seal. When the flat-top style with a seal is used, it is to be installed in all four locations in the cylinder head. All other engines use the taper-top valve guide (3). Use the appropriate valve guide driver (6) and an arbor press to install the valve guide (7) to the specified height. • Taper-Top valve guide (3), use valve guide driver, Part Number 3376779. • Flat-Top valve guide (5), use valve guide driver, Part Number 3376149. Valve Guide Height (Installed) mm in Taper-Top (3) 33.655 MIN 1.325 34.163 MAX 1.345 Flat-Top (5) 29.210 MIN 1.150 29.718 MAX 1.170		

CAUTION

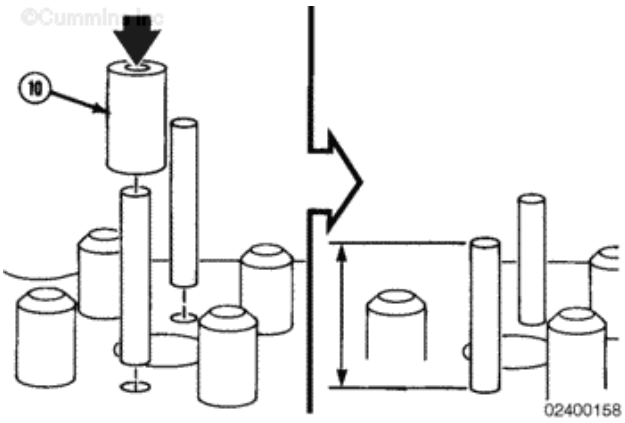
To reduce the possibility of crosshead guide damage, do not use a hammer to install the crosshead guide.

Install the crosshead guide to the specified height into the cylinder head with a crosshead spacer (10), Part Number ST-1264, or equivalent, and a press.

Crosshead Guide Height (Installed)

mm		in
59.69	MIN	2.350
60.20	MAX	2.370

The new crosshead guide **must** be straight.

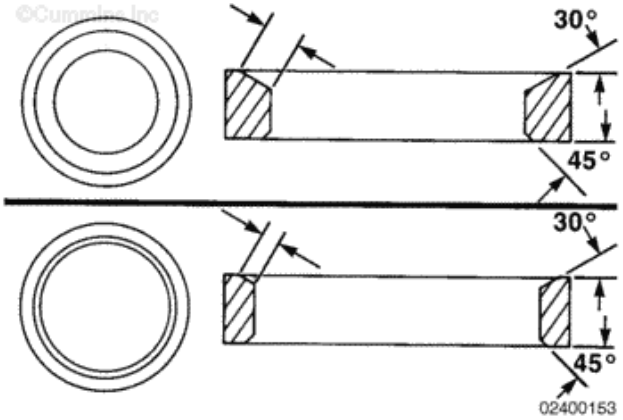


Identify the correct valve seat insert.

- The top of the graphic is the intake port valve seat insert.
- The bottom of the graphic is the exhaust port valve seat insert.

Both the intake and exhaust port valve seat inserts **must** be installed with the 30 degree angle positioned as illustrated in the graphic.

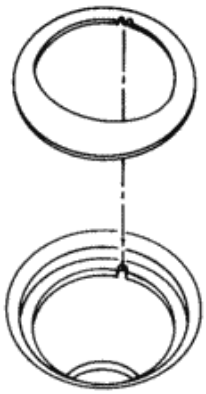
Exhaust valve seat inserts are color coded blue to identify the 30 degree angle side of the seat insert.



NOTE: Some engines do not require an anti-swirl plate. Engines that do not require an anti-swirl plate must have an insert spacer plate.

Install a new anti-swirl plate

in each intake port.

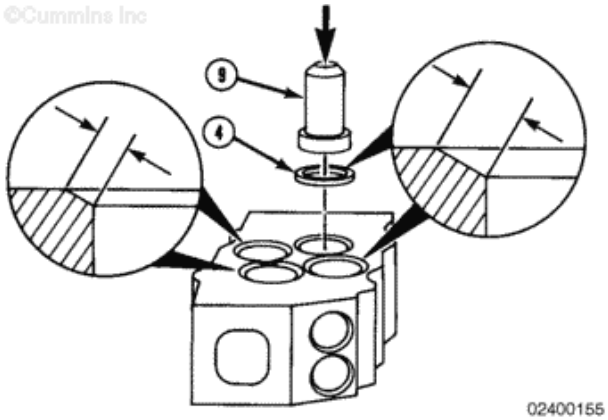


02400154

CAUTION

Do not use a hammer or mallet to install the valve seat inserts. The inserts can be cracked leading to a seat failure.

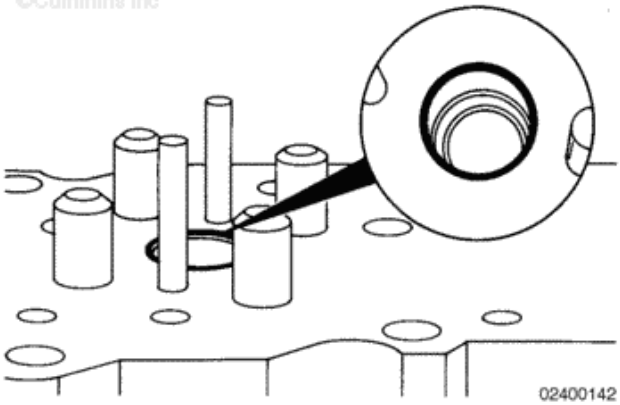
Install the valve seat insert (4) with a mandrel (9) and an arbor press.



02400155

Check the injector bore for cracks or other damage.

If cracks or other damage is found, the cylinder head **must** be repaired or replaced.

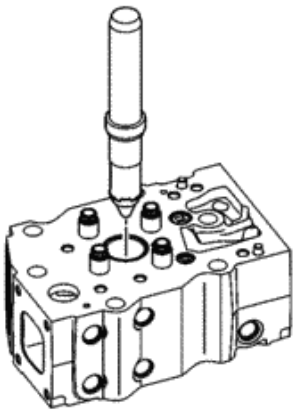


02400142

CAUTION

Support the cylinder head to prevent damage to the injector tip that protrudes from the combustion face.

Install the injector protrusion gauge, Part Number 4919196, into the cylinder head. Refer to Procedure 006-026 in Section 6.



Turn the cylinder head over.

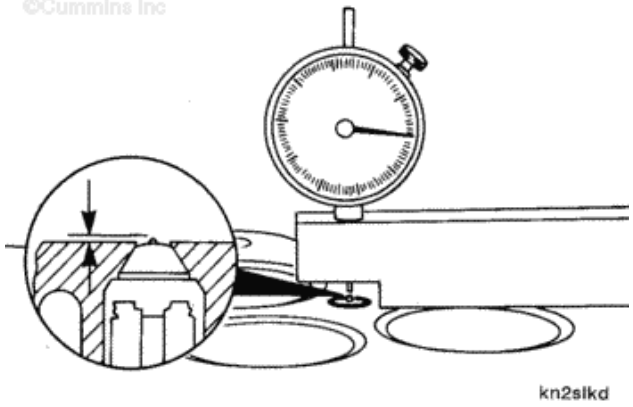
Measure the injector protrusion with a depth gauge, Part Number 3164438.

Injector Protrusion		
mm		in
2.29	MIN	0.090
2.79	MAX	0.110

If the protrusion is **not** within specifications, use an oversize sealing ring.

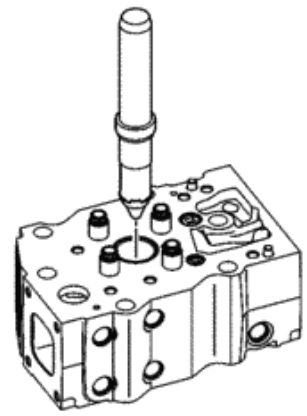
The sealing ring sizes and the amount of injector protrusion associated with the use of each ring is listed in the table below.

Injector Sealing Rings	
Wall Thickness	**Injector Protrusion Change**
0.343 to 0.419 mm [0.014 to 0.017 in]*	0.00 mm [0.000 in]
0.470 to 0.546 mm [0.019 to 0.022 in]	0.25 mm [0.010 in]
0.597 to 0.673 mm	0.51 mm

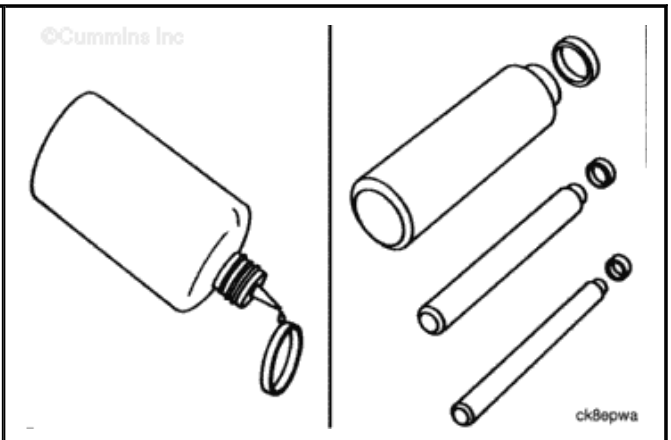


[0.024 to 0.027 in]	[0.020 in]
0.724 to 0.800 mm [0.029 to 0.032 in]	0.76 mm [0.030 in]
* The injector sealing ring with a wall thickness of 0.343 to 0.419 mm [0.014 to 0.017 in] is the standard sealing ring.	

Remove the injector protrusion gauge, Part Number 4919196, or equivalent, from the cylinder head.



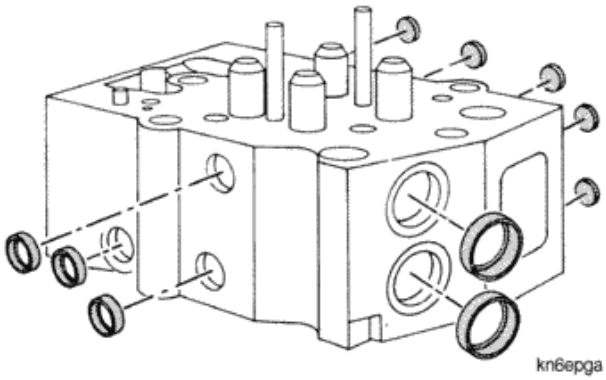
Apply Loctite™ sealant, Part Number 3375068, to the cup plugs.



Cup plug driver handle, Part Number 3164085, is used with expansion plug drivers, Part Numbers 3376813 and 3376814.

Use the appropriate

expansion plug driver and handle combination to drive in the cup plug until the shoulder of the driver contacts the cylinder head.

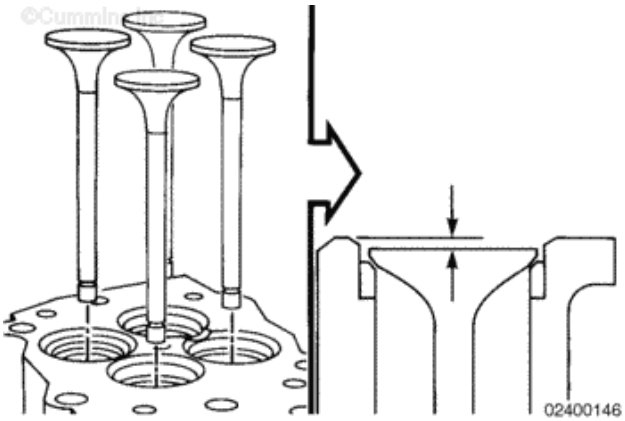


Install the valve into the valve guide.

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 0.51 mm [0.020 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.

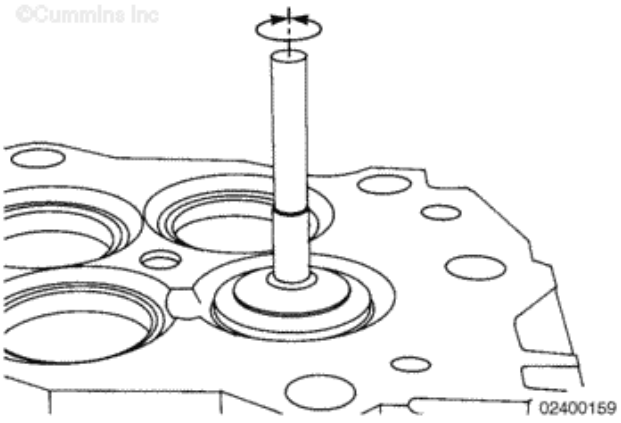


Apply a thin even coating of fine lapping compound, Part Number 3375805, or equivalent, onto the valve face.

Provide pressure in the center of the valve with a power or hand suction lapping tool.

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.

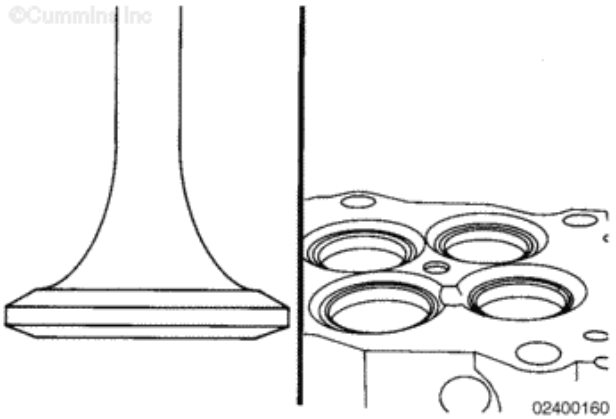


CAUTION

Lapping compound is an abrasive material. Failure will result if the cylinder head, the valves, and the valve seats are not cleaned thoroughly.

Remove the valve.

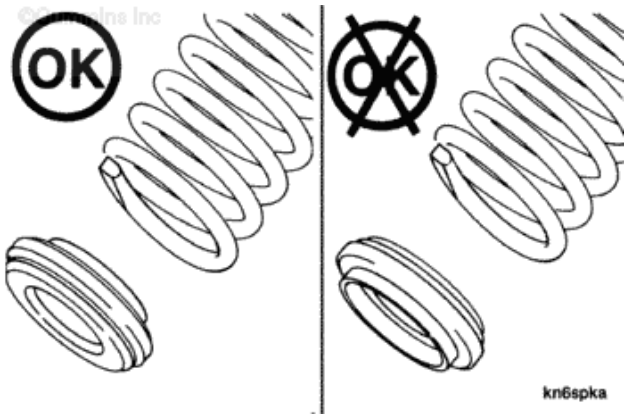
Clean the lapping compound from the valve, valve seat insert, and cylinder head.



When turning the rotator by hand, it can turn roughly, be difficult to turn, or **not** turn at all. This is normal until the rotator is installed; after installation it will rotate freely.

The rotator **must** be soaked in clean engine oil for at least 15 minutes prior to installation.

The rotator **must** be installed over the valve guide with the spring pilot flange facing upwards, as illustrated in the graphic.

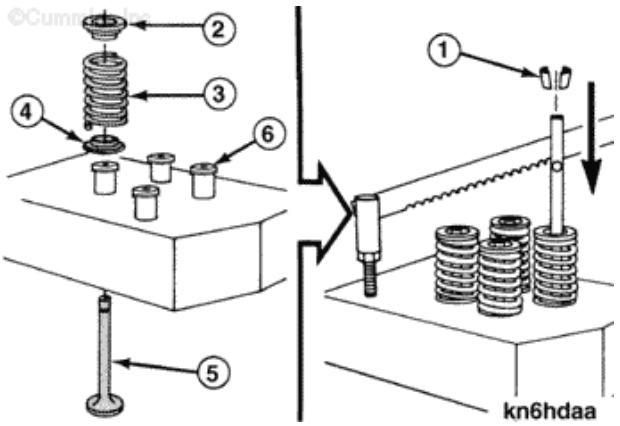


WARNING

The valve springs are under compression. Be cautious when using the valve spring compressor. Personal injury can result if the tool slips out of the hands.

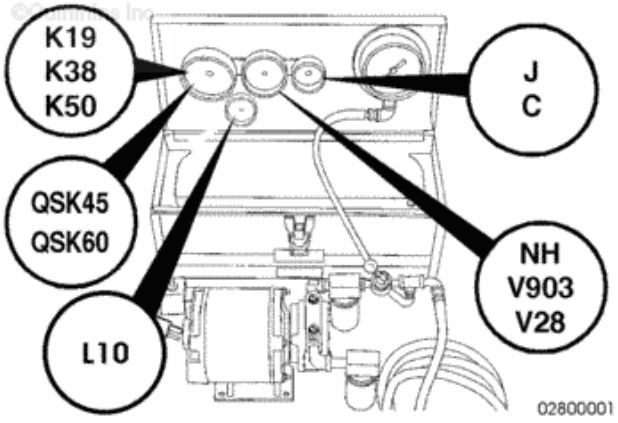
Use one of the valve spring compressors listed below, to install the valve springs:

- Valve spring compressor, Part Number 3163606
- Valve spring compressor stand, Part Number ST-



1022 • Valve spring compressor plate, Part Number 3163177, can be used with valve spring compressor, Part Number 3163066, and valve spring compressor stand, Part Number ST-1022, to remove four springs at a time • Air operated valve spring compressor, Part Number 3375960. Thoroughly lubricate the valve guide inside diameter with 140 weight gear oil. Install the parts: 1. Valve 2. Valve rotator/or guide 3. Valve spring 4. Valve spring retainer 5. Valve collet.		

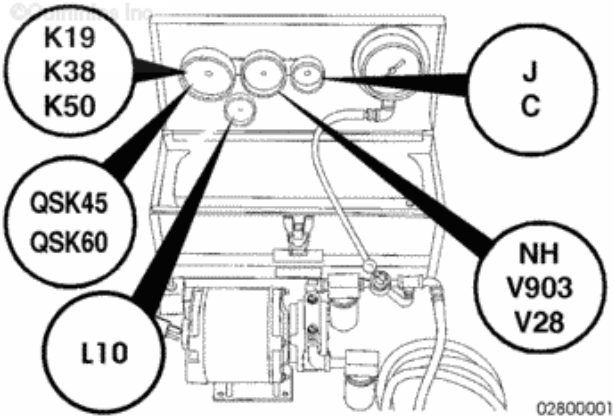
Vacuum Test

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		

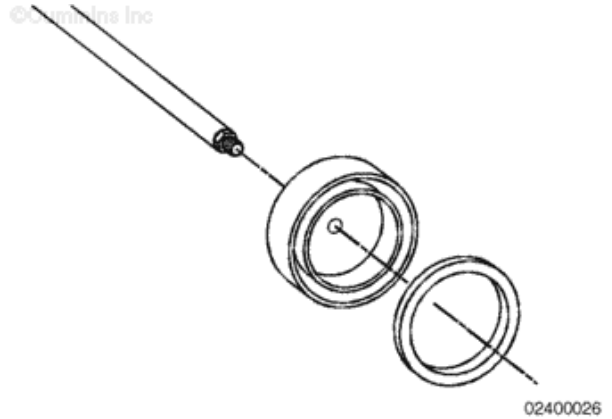
pump
- Wait approximately 10 seconds
- The gauge **must not** drop more than 7 kPa [2 in Hg].

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.

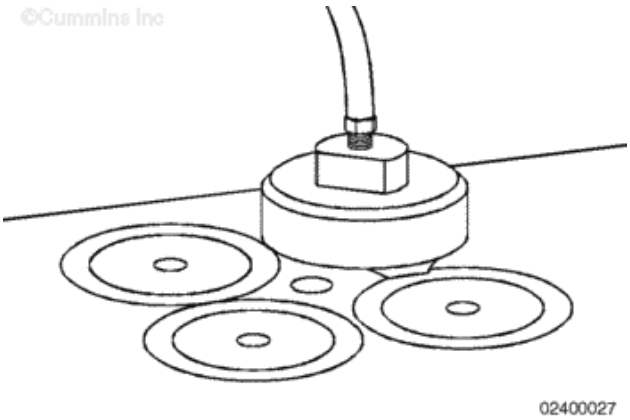


Install the seal and the cup to the vacuum line (hose).



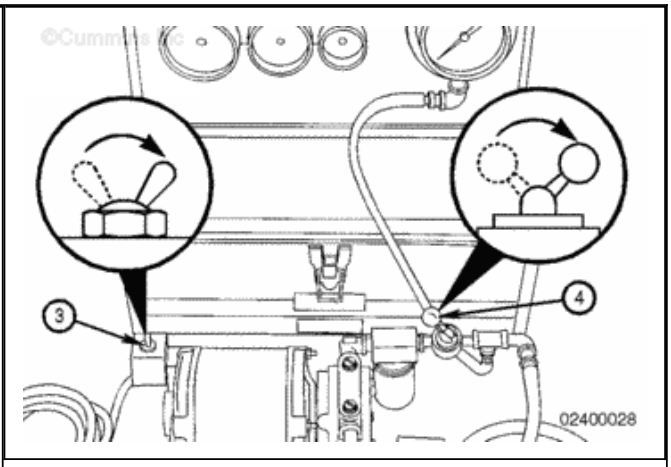
Cover the valve with the cup and the seal. The seal **must** have a tight contact on the cylinder head around the valve.

To check the exhaust valves, the seal **must** completely fill the milled area between the exhaust valves.



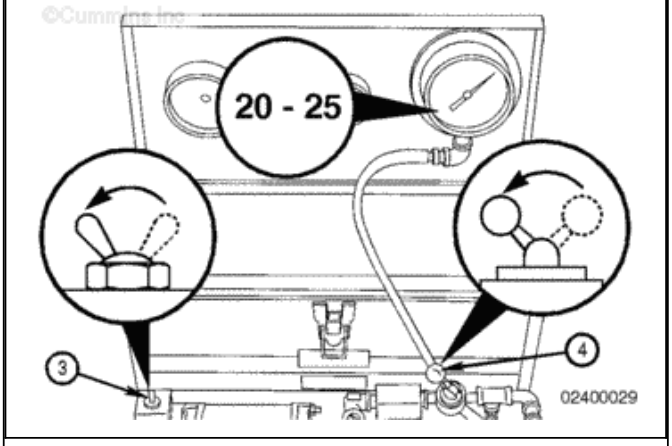
Move the toggle switch (3) to the ON position.

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.

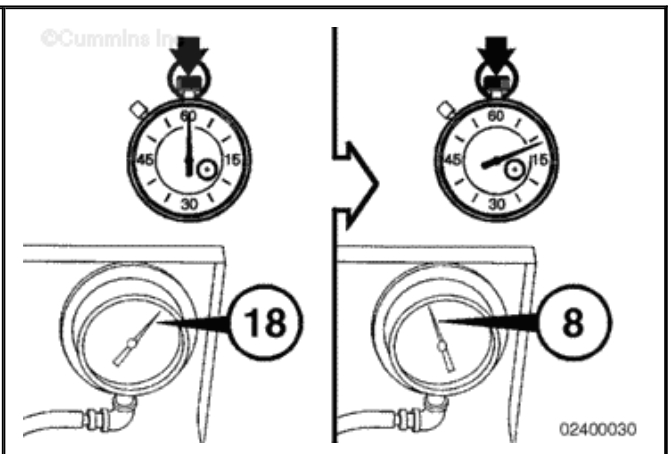


CAUTION

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].

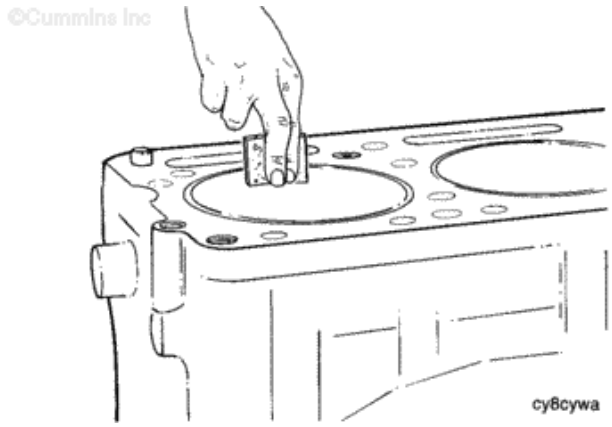
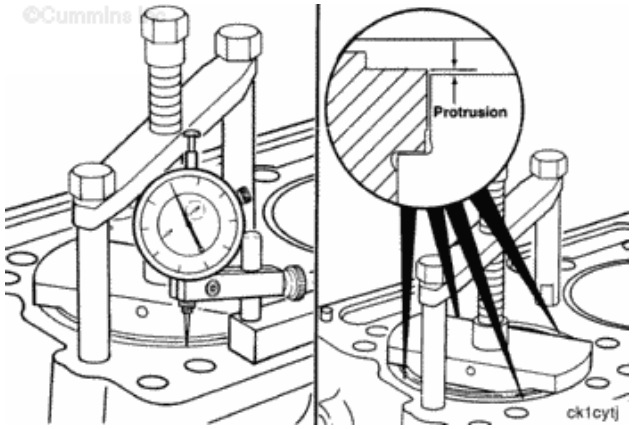
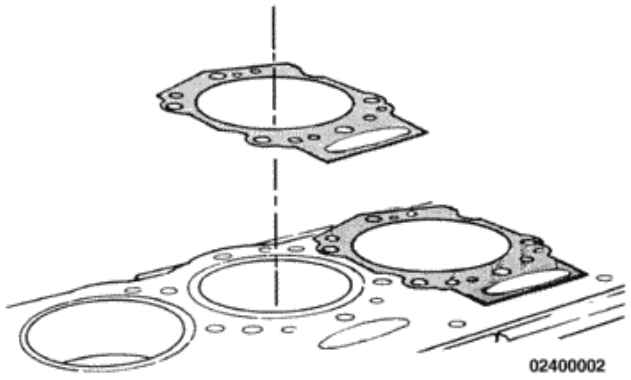
Stop timing when the needle on the gauge points to 27 kPa [8 in Hg].



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

Clean the top of the cylinder block and the cylinder liners.		

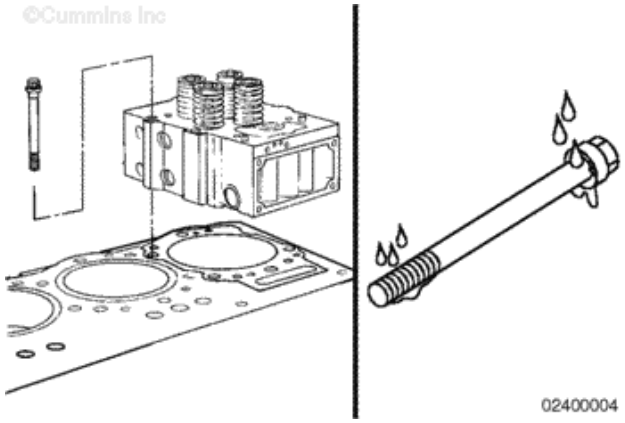
		
Measure the cylinder liner protrusion. Refer to Procedure 001-064 in Section 1.		
The word TOP, stamped on the top of the cylinder head gasket, **must** be visible after the gasket is installed. Install the cylinder head gasket.		
Install the cylinder head. It **must** slide easily over the groove pins.		

Lubricate the cylinder head capscrew flange with SAE EP 140 weight oil.

Lubricate the cylinder head capscrew threads with clean engine oil.

Allow the excess oil to drip off the capscrews before installing them into the block.

Install the capscrews.

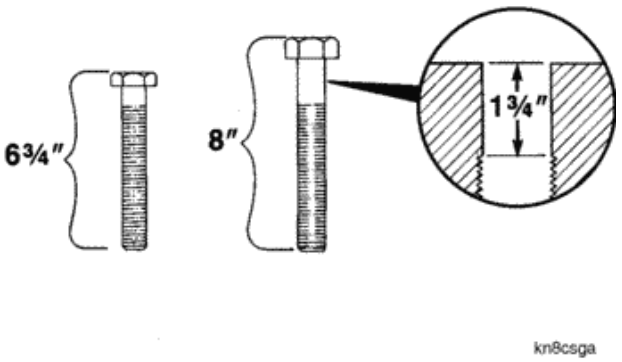


CAUTION

The torque specification for the cadmium plated 170 mm [6¾ in] capscrews is lower than the torque specification for the lubrite coated (black) capscrews of the same length. Over-tightening of the cadmium plated capscrews causes overload of the cylinder blocks, which can result in counterbore cracking or damaged threads. Do not mix cadmium plated capscrews with lubrite coated (black) capscrews on the same engine.

The original K19 cylinder head capscrews are 170 mm [6¾ in]. The capscrews can either be cadmium plated, producing a shiny chrome like finish, lubrite coated which appears black, or have a zinc phosphate coating, which is gray in color but can appear shiny after cleaning with a wire wheel. Make sure the correct torque is used when installing the capscrews.

All K19 engines with a serial number greater than 31103629 and all service blocks shipped since mid-1977 have used 203 mm [8 in] capscrews for the



cylinder heads. The 203 mm [8 in] capscrews can be black or gray in color. Those that are gray in color have a zinc phosphate coating. The gray capscrews can appear shiny after cleaning with a wire wheel. There is **only** one torque specification for all capscrews that are 203 mm [8 in] in length.

Tighten the capscrews in the sequence illustrated in the graphic.

Torque Value:
Shiny Chrome 170 mm [6¾ in]

1. 65 n.m [48 ft-lb]
2. 160 n.m [118 ft-lb]
3. 250 n.m [184 ft-lb]
4. 345 n.m [254 ft-lb]

Torque Value:
Black 170 mm [6¾ in]

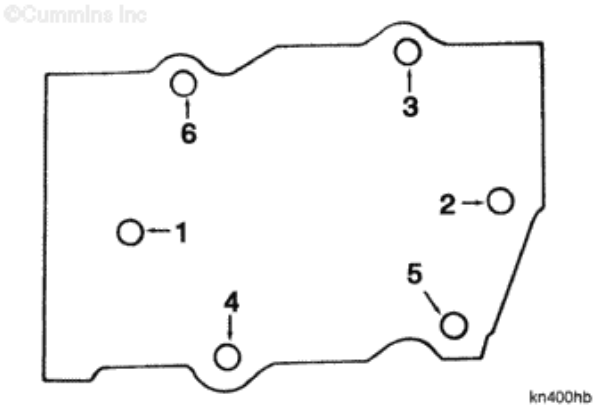
1. 65 n.m [48 ft-lb]
2. 200 n.m [148 ft-lb]
3. 340 n.m [251 ft-lb]
4. 490 n.m [361 ft-lb]

Torque Value:
Zinc Phosphate Gray 203 mm [8 in]

1. 65 n.m [48 ft-lb]
2. 200 n.m [148 ft-lb]
3. 340 n.m [251 ft-lb]
4. 490 n.m [361 ft-lb]

Torque Value:
Zinc Phosphate Gray 203 mm [8 in] (Alternate Method)

1. 65 n.m [48 ft-lb]
2. 200 n.m [148 ft-lb]
3. 300 n.m [221 ft-lb]
4. Advance 90 degrees

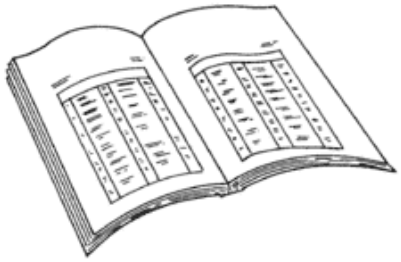


Finishing Steps

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 connect the negative (-) battery cable last.

- Install the injector. Refer to Procedure 006-026 in Section 6.
- Install the rocker lever housing. Refer to Procedure 003-013 in Section 3.
- Install the gear cover clamping plate. Refer to Procedure 001-031 in Section 1.
- Install the push rods or tubes. Refer to Procedure 004-014 in Section 4.
- Install the rocker levers. Refer to Procedure 003-009 in Section 3.
- Install the rocker lever covers. Refer to Procedure 003-011 in Section 3.
- Install the STC oil manifold, if equipped. Refer to Procedure 006-038 in Section 6.
- Install the fuel supply manifold. Refer to Procedure 006-022 in Section 6.
- Install the aftercooler assembly. Refer to Procedure 010-002 in Section 10.
- Install the fuel supply lines. Refer to Procedure 006-024) in Section 6.
- Install the exhaust manifold. Refer to



ck800wa

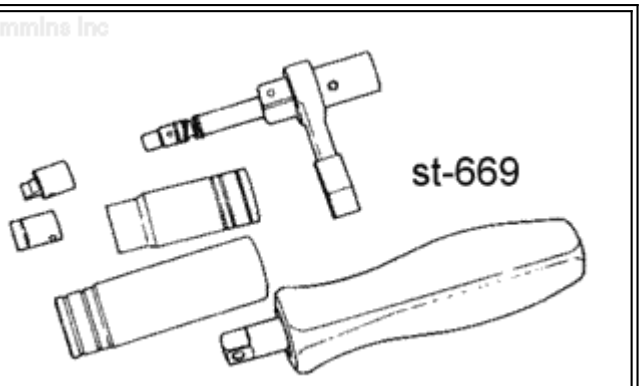
Procedure 011-007 in Section 11. • Install the turbocharger. Refer to Procedure 010-037 in Section 10. • Fill the cooling system. Refer to Procedure 008-018 in Section 8. • Connect the batteries or air supply to the air starter. Refer to the OEM service manual. • Operate the engine to 70° C [160°F] minimum coolant temperature and check for leaks.		

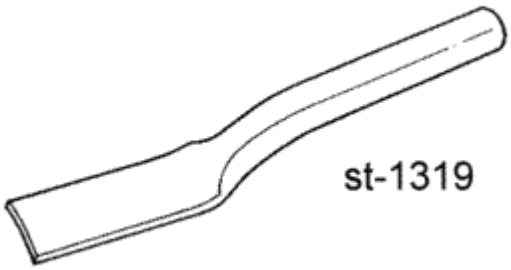
Last Modified: 01-May-2012

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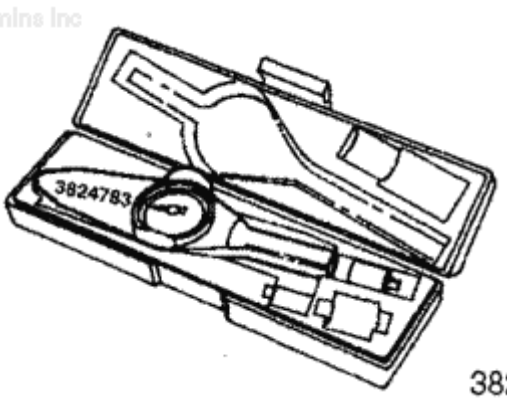
022-001 Service Tools

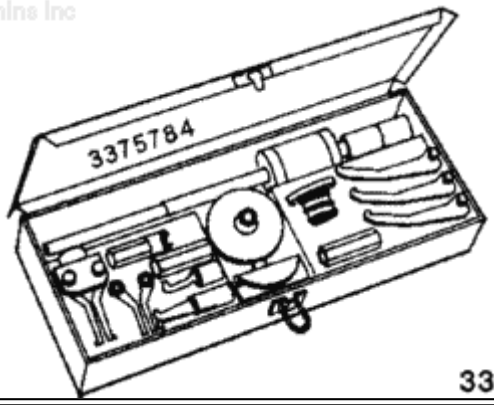
Rocker Levers

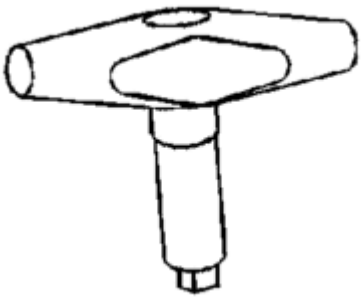
Tool Number		
ST-669	**Torque Wrench Adapter** Secures the rocker lever adjusting screw while tightening the lock nut.	

Tool Number		
ST-1319	**Water Tube Driver** Used to install or remove the water transfer tubes from the rocker housings.	

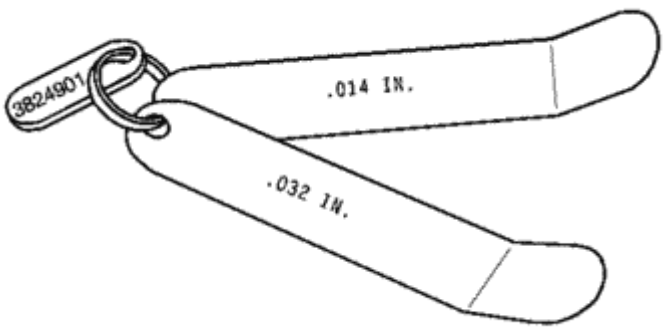
Tool Number		
	Torque Wrench A dial-type torque wrench used to accurately adjust injectors in inch-pounds. Use of a	

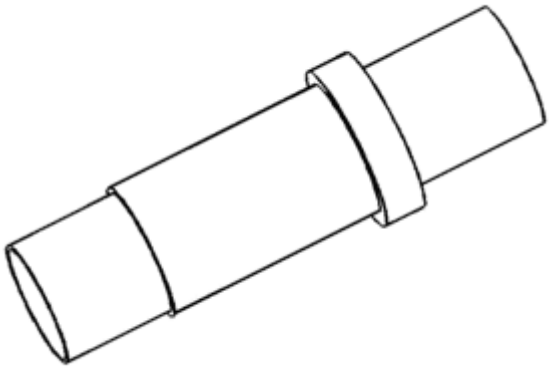
3824783	clicker-type torque wrench is not recommended. 0-35 N•m [0-300 in-lb]	 3824783

Tool Number 3375784	**Light Duty Puller Kit** Used to remove small bushings, oil seals, and bearings.	 3375784

Tool Number 3376592	**Torque Wrench** Inch-pound torque wrench used to tighten the valve lever adjusting screw. Does not require screwdriver attachment.	 3376592

	Valve Setting Gauge Kit Kit contains two 25.4 mm [1 in] wide feeler	

Tool Number 3824901	gauges for centering under the swivel foot of the rocker lever when setting the valves. The kit contains an intake valve gauge at 0.36 mm [0.014 in] and an exhaust valve gauge at 0.081 mm [0.032 in].	©Cummins Inc  3824901

Tool Number 3162458	**Rocker Lever Bushing Mandrel** Used to install and/or remove the rocker lever bushings	©Cummins Inc  03400049

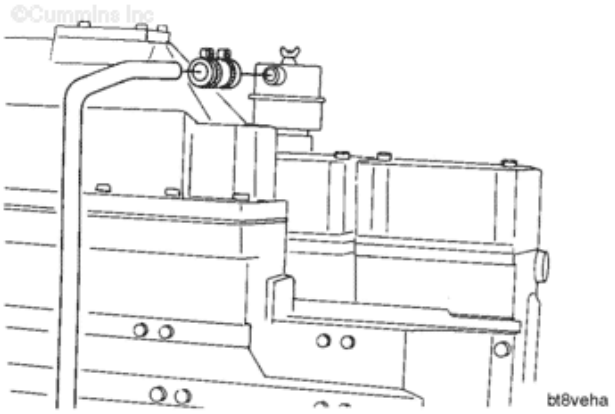
Last Modified: 15-Nov-2004

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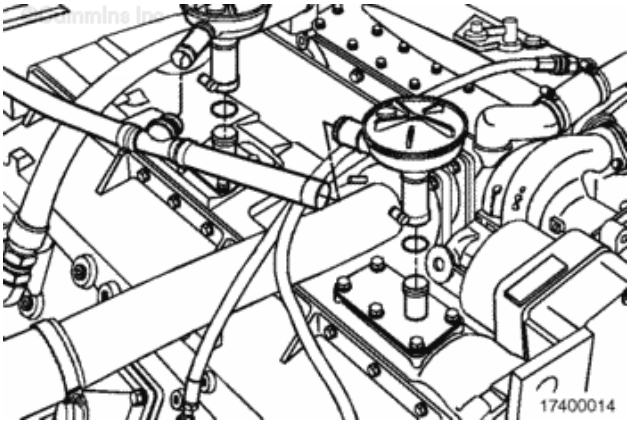
003-001 Crankcase Breather (External)

Remove

All Applications Except Rail

Loosen the hose clamp at the breather vent tube. Remove the support bracket capscrew and the bracket. Remove rocker lever cover. Refer to Procedure 003-011.		

Rail Applications

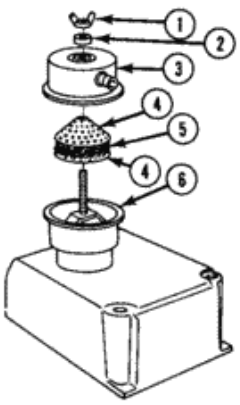
Loosen the hose clamp and remove the crankcase breather hose from the breather canister. Loosen the tube clamp between the breather canister and the hand hole cover. Remove the breather canister from the hand hole cover.		

Disassemble

All Applications Except Rail

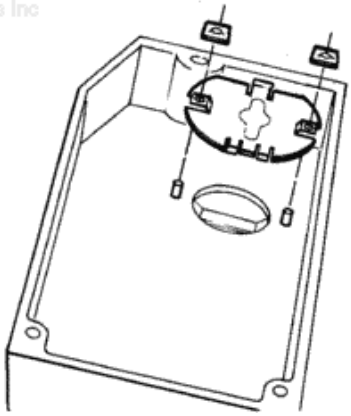
Remove the listed parts from the breather body (6):

1. Wing nut
2. Washer
3. Breather cap
4. Screen mesh
5. Element



Remove the push nuts.

Remove the baffle.

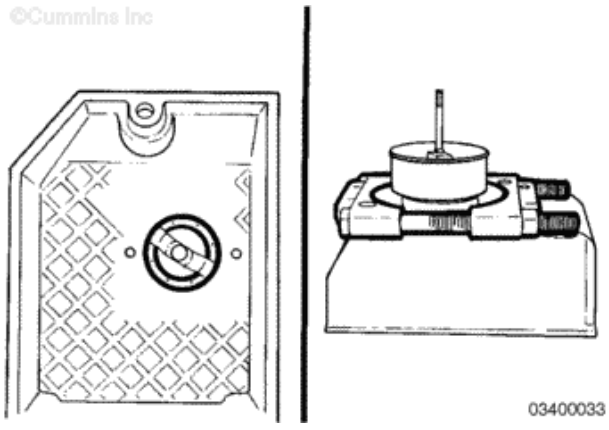


CAUTION

The mandrel must make contact on the breather body to prevent damage.

Use a water pump bearing separator, Part Number 3375326, or equivalent.

Support the cover as close as possible to the breather to prevent cracking of the cover.



Push the breather out.		

Clean and Inspect for Reuse

All Applications Except Rail

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

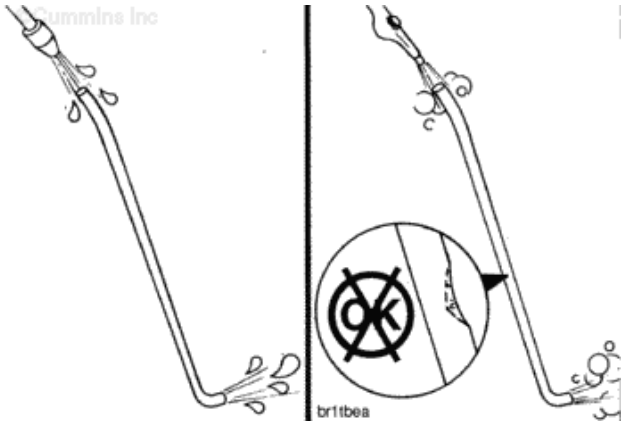
Wear appropriate eye and face protection when using compressed air. Flying dirt and debris can cause personal injury.

Clean the inside of the crankcase tube with solvent and dry with compressed air.

Blow through the vent tube with compressed air.

Replace the vent tube with compressed air.

If the vent tube is clogged or dented it **must** be replaced.

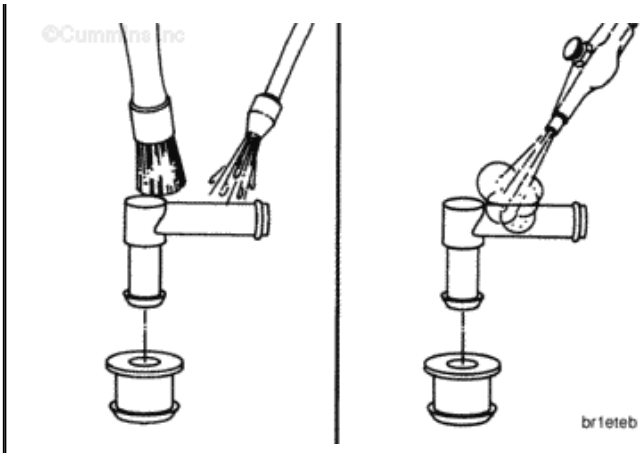


WARNING

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.

Clean the breather tube with solvent.



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.

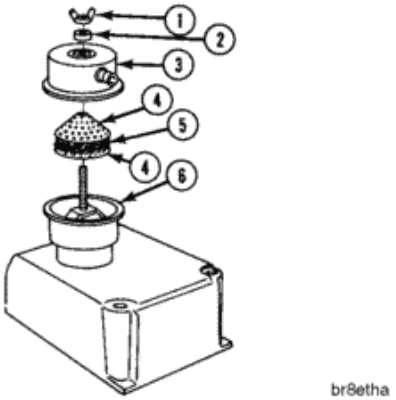
Clean the breather cap element and screens in an approved cleaning solvent.

Dry with compressed air.

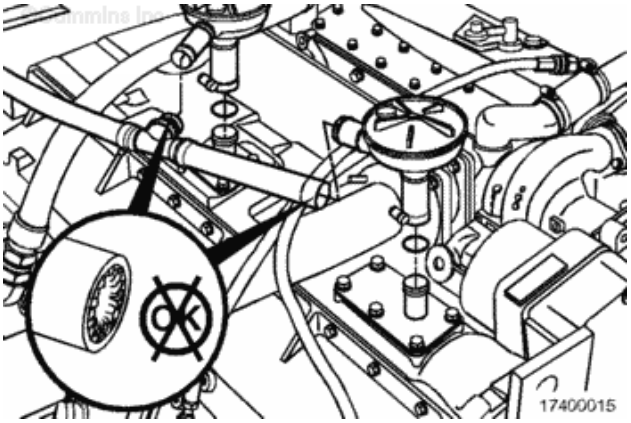
Wipe out the breather housing (6).

Clean the listed parts.

(4) Screen mesh
(5) Element
(3) Breather cap
(2) Washer
(1) Wing nut.

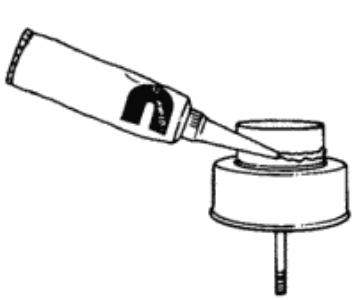


Rail Applications

Check the hose internally for obstructions or sludge build up. If the hose is blocked, clean it to prevent excess crankcase pressure buildup.		

Assemble

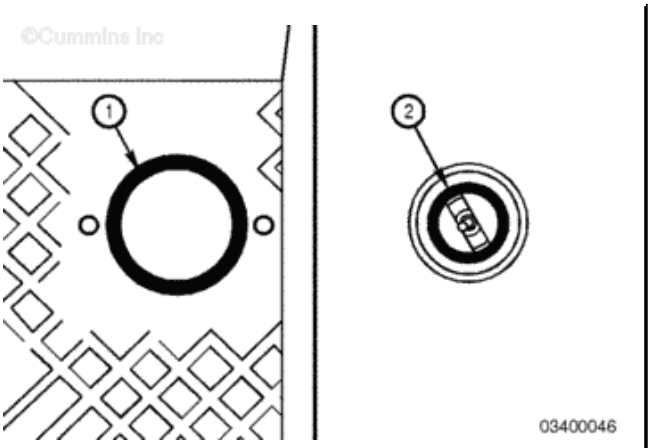
All Applications Except Rail

Apply Loctite 732, or equivalent to the outside diameter of the breather.		

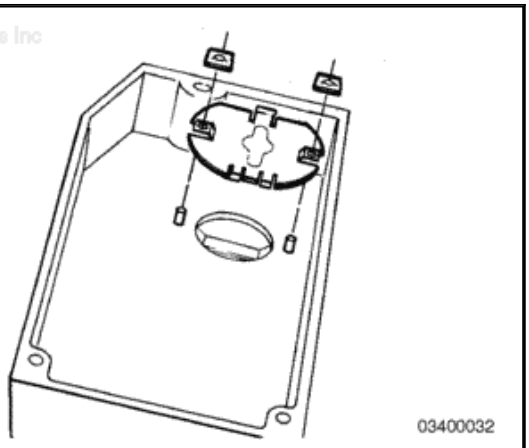
CAUTION Do not use excessive force on the aluminum cover (1). Excessive force to the aluminum cover will cause it to crack.		

Use a mandrel to install the breather.

The mandrel **must** contact the breather body (2) in the area illustrated in the graphic.



Install the baffle and new push nuts.



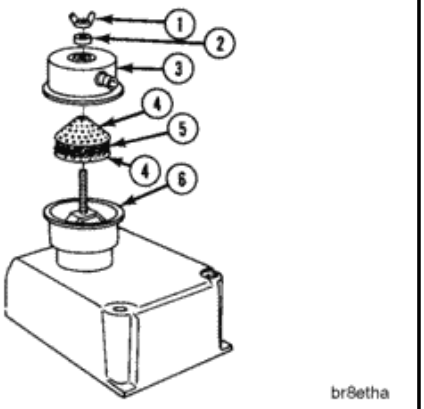
Install the parts in the following order:

(4) Screen mesh
(5) Element
(4) Screen mesh
(3) Breather cap
(2) Washer
(1) Wing nut.

If a breather is **not** used install a service plug and o-ring.

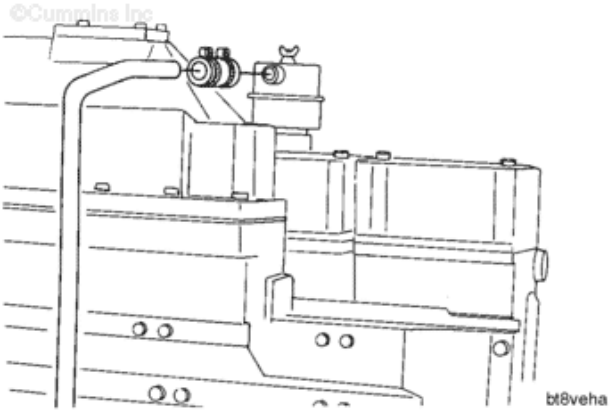
Tighten the service plug.

Torque
Value: 45 n.m [33 ft-lb]

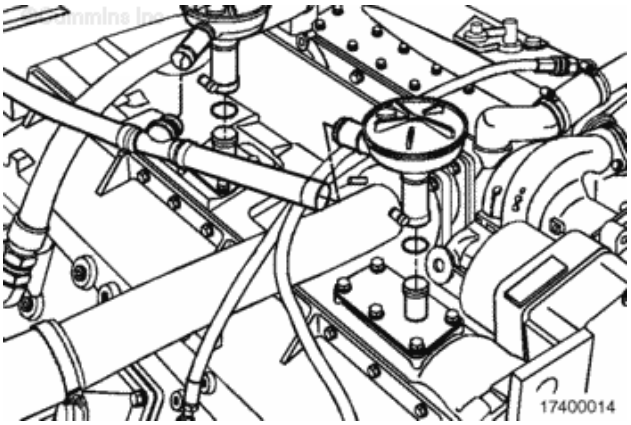


Install

All Applications Except Rail

Install the rocker lever cover. Refer to Procedure 003-011. Install the tube and hose. Install the tube support bracket and capscrew. Tighten the hose clamp at the breather tube.		

Rail Applications

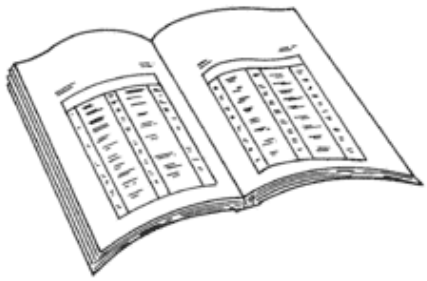
Install the o-ring and breather canister on the hand hole cover. Tighten the tube clamp. Install the crankcase breather hose on the breather canister. Tighten the hose clamp.		

Last Modified: 19-Oct-2004

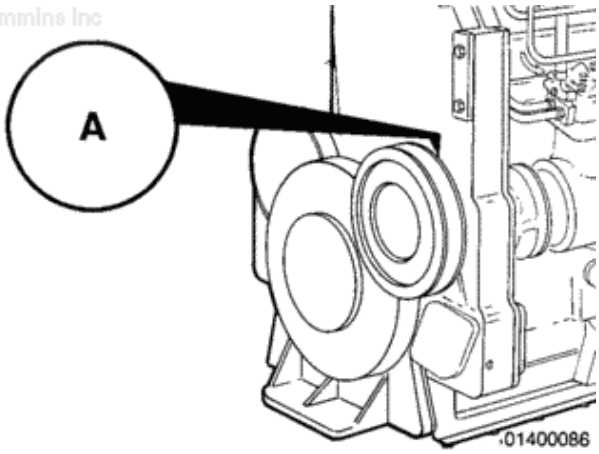
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003-006 Overhead Set (OBC)

Preparatory Steps

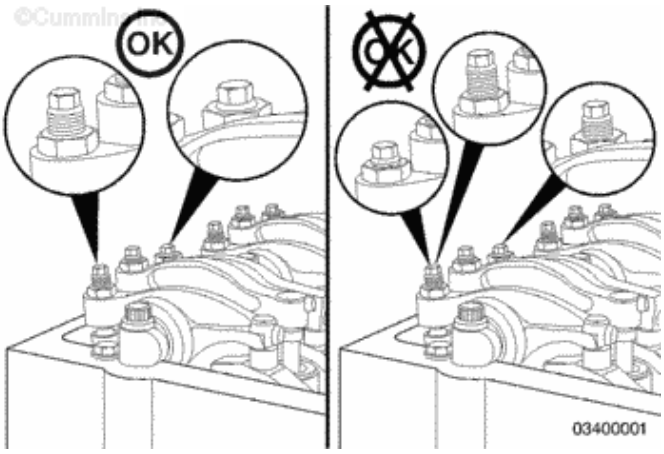
• Remove the rocker lever cover. Refer to Procedure 003-011.		 ck800wa

Adjust

The barring device used on later engines with the one-piece front cover turns approximately two revolutions before the engine begins to turn. The device will **not** turn the engine opposite the direction of normal rotation. The barring device used on older engines with the two-piece front cover will turn the engine opposite		 01400086

the direction of normal rotation. Remove the clip and push the shaft in and turn the barring device **counterclockwise** until the “A” mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.		

Determine the cylinder in position for valve set. The valves will be adjusted on the cylinder that has all of the valves closed. Use the table to determine the cylinders for valve position.		©Cummins Inc **If Valve Set Mark Is:** / **Check Valve Position On:** **A** — **1,6** **B** — **2,5** **C** — **3,4** fi400uz

If the rocker lever assemblies have been removed, use this step to determine the cylinder to be 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 rod **must** remain in alignment. Perform this step on both cylinders to be checked.		©Cummins 

Hold both rocker levers against the crossheads. Turn the adjusting screws until they touch the push rods. Turn the lock nuts until they touch the rocker levers.

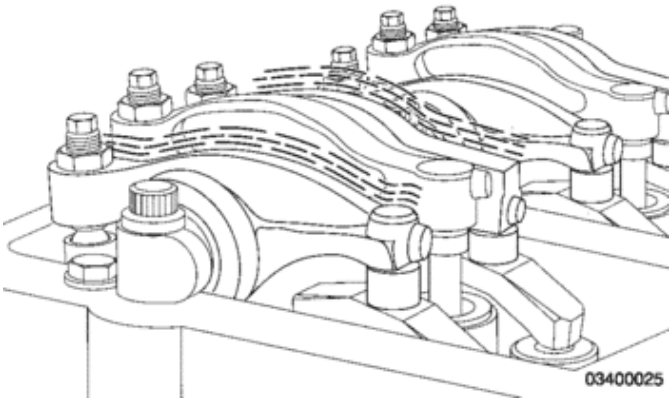
The push rods will be the same height above the top of the rocker lever housing on the cylinder ready for valve adjustment.

CAUTION

There are two different procedures for adjusting the valves and injectors on K19 engines. Engines with fixed time are adjusted on the inner base circle of the camshaft using a dial indicator. Engines with STC (step timing control) or hydraulic variable timing are adjusted on the outer base circle using a torque wrench. Make sure to use the correct procedure for the engine being serviced, or all of the push rods can be bent.

If the rocker levers have **not** been removed, wiggle the valve rocker levers on the two cylinders in question.

Set the valves on the cylinder where both rocker levers feel loose.



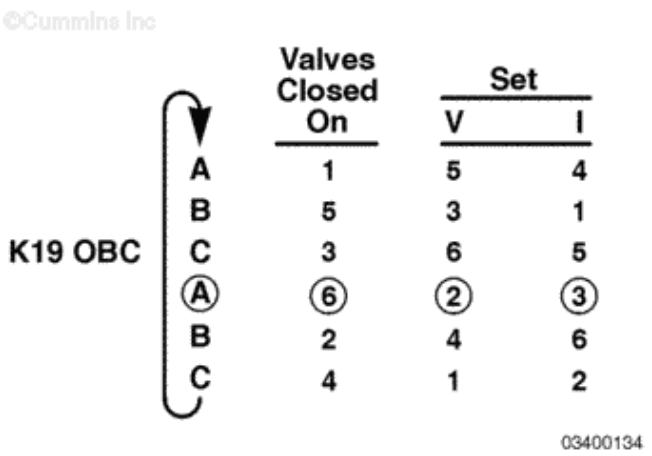
Use the chart to determine the valve and injector that is ready to adjust.

Adjustment can begin on any valve set mark.

In the example, assume the A mark is aligned and the push rod heights indicate the valves on cylinder number 6 are closed, and one valve on cylinder 1 is fully open.

The chart shows the valves on cylinder number 2 and injector on cylinder number 3 are ready to adjust.

After the adjustment, bar the engine to the B set mark. Adjust the valves on cylinder number 4 and injector on cylinder number 6.

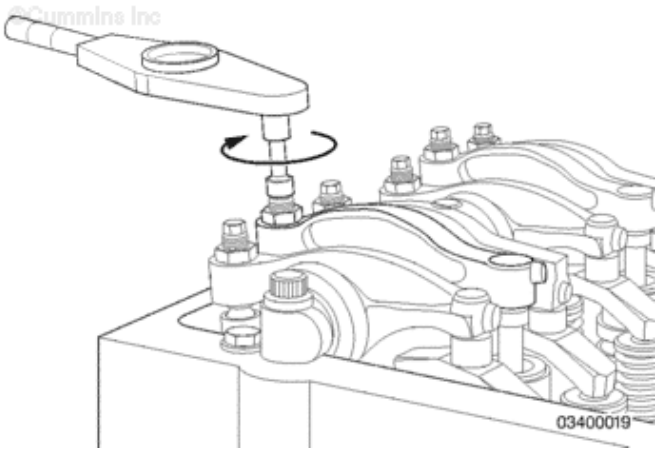


Injectors

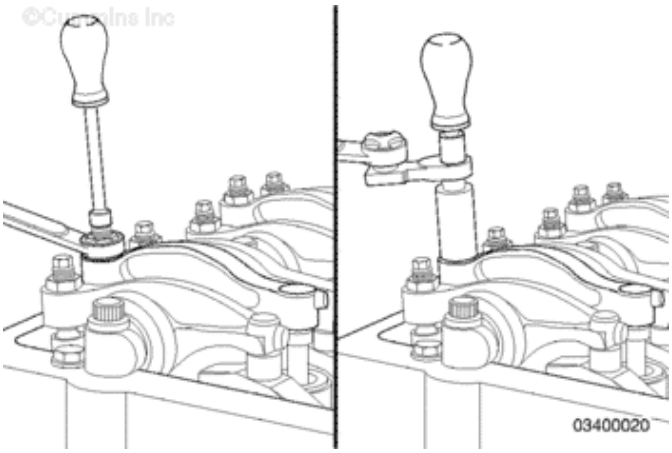
Use a dial-type torque wrench, Part Number 3164795, or equivalent, to tighten the injector rocker lever adjusting screw. If the screw chatters during setting, repair the adjusting screw and rocker lever as required.

Position the torque wrench so the dial can be viewed in a direct line. This will enable the dial to be read accurately.

Make sure the parts are in alignment and squeeze the oil out of the valve and injector train, while tightening the adjusting screw. This is an initial preload to the valve



train and the injector. Tighten the adjusting screw. The torque wrench **must** be calibrated and have a resolution of 0.28 N•m [2.5 in-lb]. and have a range of 17 to 23 N•m [150 to 200 in-lb]. **Torque Value:** 1. 11 n.m [100 in-lb] 2. Loosen adjusting screw 1 revolution 3. 10 n.m [90 in-lb]		

Hold the adjusting screw in position. The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut. **Torque Value:** With Torque Wrench Adapter, Part Number ST-669 1. 45 n.m [33 ft-lb] **Torque Value:** Without Adapter 1. 60 n.m [44 ft-lb]		

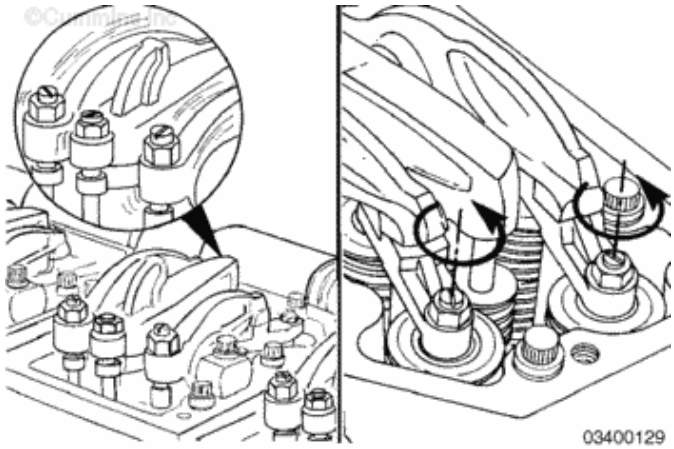
Crossheads

Crosshead adjustment **must always** be		

completed before attempting to adjust the valves.

Adjust the crossheads on the cylinder that has both valves closed.

Loosen the crosshead adjusting screw lock nuts on the intake and exhaust valve crossheads.

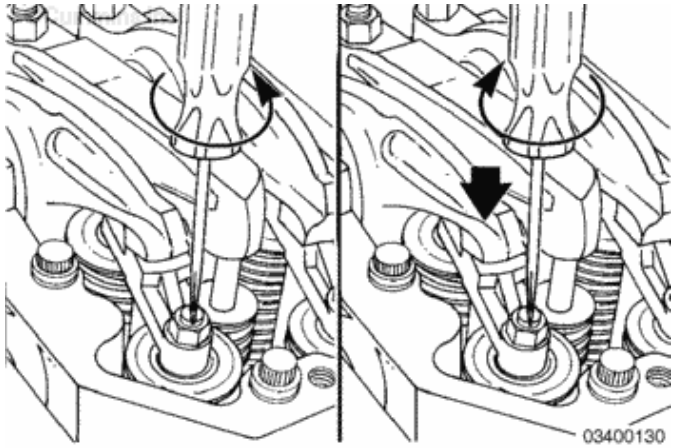


Use this procedure to adjust both the intake and the exhaust crossheads.

Turn the adjusting screw out a minimum of one turn.

Hold the crosshead down against its mating valve stem.

Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.

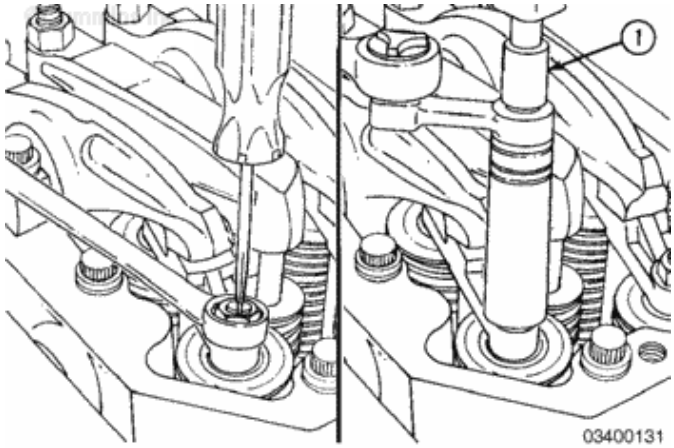


Hold the adjusting screw in position. The adjusting screw **must not** turn when the lock nut is tightened to its torque value.

Tighten the lock nut.

Torque values are given when using and **not** using adapter, Part Number 3133196 (1).

Torque Value:



Without Jacobs® Brake (With Adapter)

1. 35 n.m [25 ft-lb]

Torque Value:
Without Jacobs® Brake (Without Adapter)

1. 40 n.m [30 ft-lb]

Torque Value:
With Jacobs® Brake (With Adapter)

1. 40 n.m [30 ft-lb]

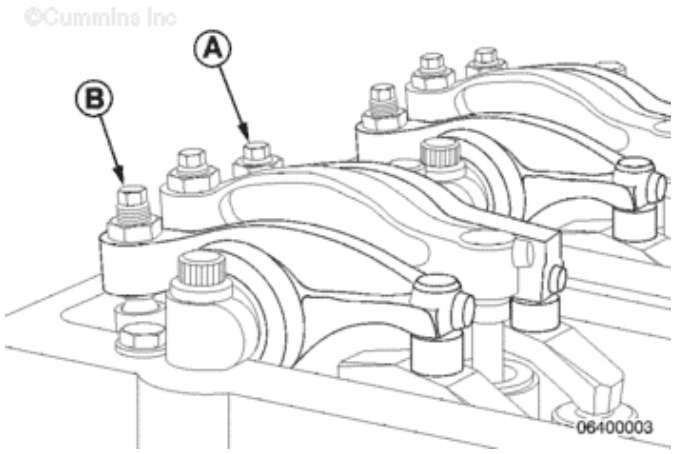
Torque Value:
With Jacobs® Brake (Without Adapter)

1. 45 n.m [33 ft-lb]

Valves

Use the table below to for valve adjustment initial set.

Valve Adjustment (Initial Set)	
Reference Point	**Valve**
A	Exhaust 0.69 mm [0.027 in]
B	Intake 0.36 mm [0.014



	in]

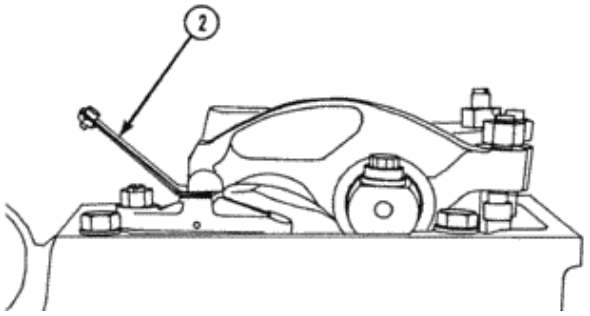
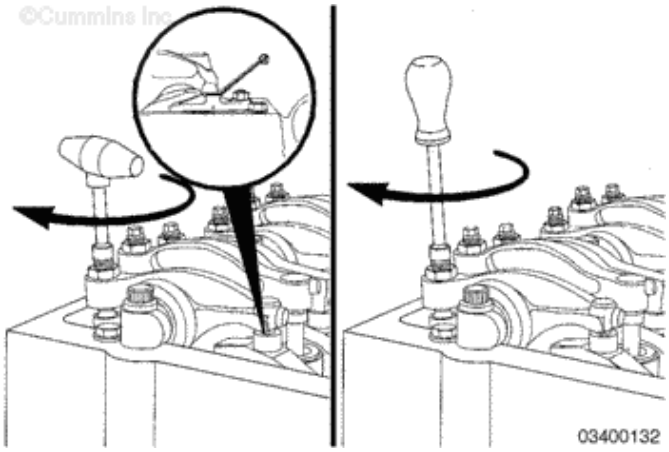
The recheck limits are to be used when checking the overhead set during troubleshooting or periodic maintenance. The initial set specifications **must** be used when the valves are being adjusted.

Valve Recheck Limits	
Reference Point	**Valve**
A	Exhaust minimum of 0.610 mm [0.024 in]
A	Exhaust maximum of 0.762 mm [0.030 in]
B	Intake minimum 0.279 mm [0.011 in]
B	Intake maximum 0.432 mm [0.017 in]

Make sure the crosshead is firmly in place on the valve stem tips.



Select a feeler gauge for the correct valve lash specification. Use service tool, Part

Number 3163171 (intake) or Part Number 3163172 (exhaust). Insert the feeler gauge between the rocker lever socket and crosshead.		
There are two different methods for establishing valve lash clearance. Either method can be used. The torque wrench method has proven to be the most consistent. • Torque wrench method: Tightens the adjusting screw to 0.68 N•m [6 in-lb] against the feeler gauge, using torque wrench, Part Number 3376592. • Feel method: Turns the adjusting screw until the lever touches the feeler gauge using a nut driver. This step outlines the procedure for setting the valve lash using the torque wrench method. Make sure the parts are in alignment and squeeze the oil out of the valve and injector		

train while tightening the adjusting screw. Loosen the adjusting screw one revolution. Insert the appropriate feeler gauge between the rocker lever and the crosshead. 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 lock nut is tightened. Tighten the lock nut. **Torque Value:** With Torque Wrench Adapter, Part Number ST-669 1. 45 n.m [33 ft-lb] **Torque Value:** Without Adapter 1. 60 n.m [44 ft-lb]		

This step outlines the procedure for setting the valve using the feel method. Make sure the parts are in alignment and squeeze the oil out of the valve and injector train while tightening the adjusting screw.	 	

Loosen the adjusting screw one revolution.

Insert the appropriate feeler gauge between the rocker lever and crosshead.

The feeler gauge **must** slide backward and forward with **only** a slight drag.

The adjusting screw **must not** turn when the lock nut is tightened.

Tighten the lock nut.

Torque Value:
With Torque Wrench Adapter, Part Number ST-669

1. 45 n.m [33 ft-lb]

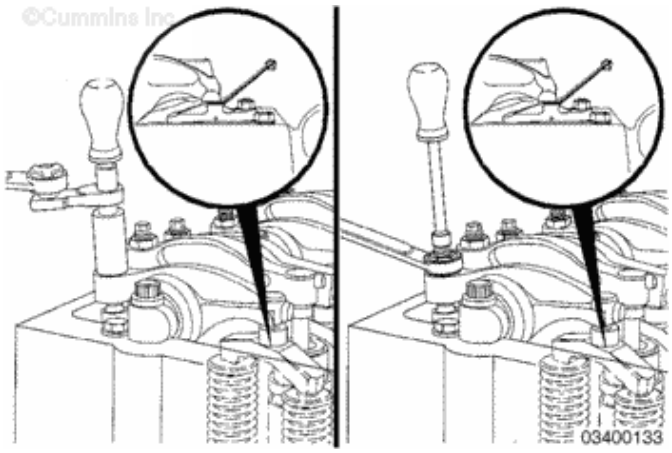
Torque Value:
Without Adapter

1. 60 n.m [44 ft-lb]

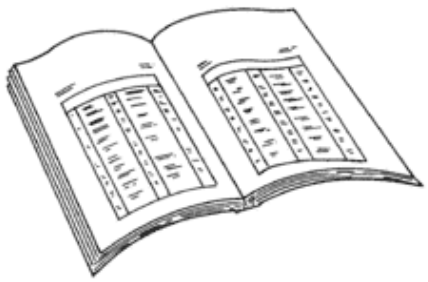
Attempt to insert a feeler gauge 0.03 mm [0.001 in] thicker than used for setting the valve lash.

The valve lash is **not** correct if the feeler gauge will fit.

Repeat the adjustment process until the clearance is correct on both the intake and exhaust valves.



Finishing Steps

• Install the rocker lever cover. Refer to Procedure 003-011.		

Worksheet

1. The engine firing order is 1-5-3-6-2-4.
2. The cylinders are numbered from the front gear cover end of the engine.
3. Two crankshaft revolutions are required to adjust all of the valves and the injectors.
4. One pair of valves and one injector are adjusted at each pulley index mark before rotating the engine to the next index mark.
5. The valves and the injectors on the same cylinder are **not** adjusted at the same mark.
6. Each cylinder has three rocker levers. The rocker lever nearest the front of the engine is the exhaust rocker lever.

The table below is provided for recording values.

Inspection Report for Valve Lash and Injector Torque								
Work Sequence	Valves to be Set	Intake	Exhaust	Reset (Y/N)	Crosshead (OK/Reset)	Cylinder Number	Injector Torque	Reset (Y/N)
	A-5					4		
	B-3					1		

	C-6					5		
	A-2					3		
	B-4					6		
	C-1					2		

Customer:

Location:

Unit Number: Hours: Date:

Job Number:

Engine Model Number: Engine Serial Number:

Type of Inspection (Failure, Routine, Complaint):

Inspection Notes:

NOTE: This page can be copied for convenience.

Last Modified: 16-Dec-2011

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003-007 Overhead Set (Travel Method)

Worksheet

NOTE: The injector travel method is used only on engines with fixed time injectors (no STC or HVT).

The engine firing order is 1-5-3-6-2-4.

The cylinders are numbered from the front gear cover end of the engine.

Two crankshaft revolutions are required to adjust all of the valves and the injectors.

One pair of valves and one injector are adjusted at each pulley index mark before rotating the engine to the next index mark.

The valves and the injectors on the same cylinder are **not** adjusted at the same mark.

Each cylinder has three rocker levers. The lever nearest to the front of the engine is the exhaust lever.

The following table can be used for recording values.

Inspection Report for Valve Lash and Injector Travel								
Work Sequence	VS Mark and Valves to be Set	Intake	Exhaust	Reset (Yes/No)	Crosshead (OK/Reset)	Cylinder Number Injector	Injector Travel	Reset (Yes/No)
	C-1					5		
	A-5					3		
	B-3					6		
	C-6					2		
	A-2					4		
	B-4					1		

Customer:

Location:

Unit Number:

Hours:

Date:

Job Number:

Engine Model Number:

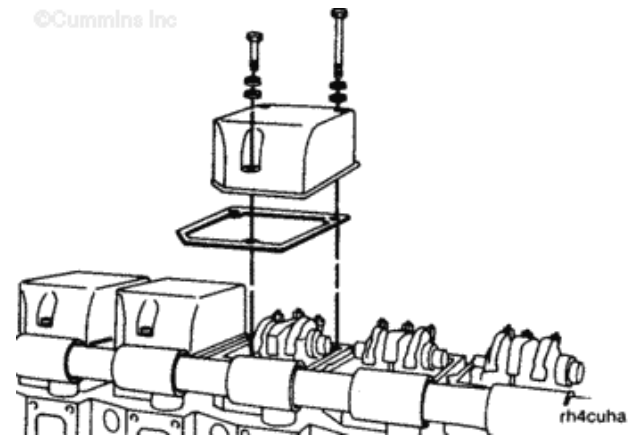
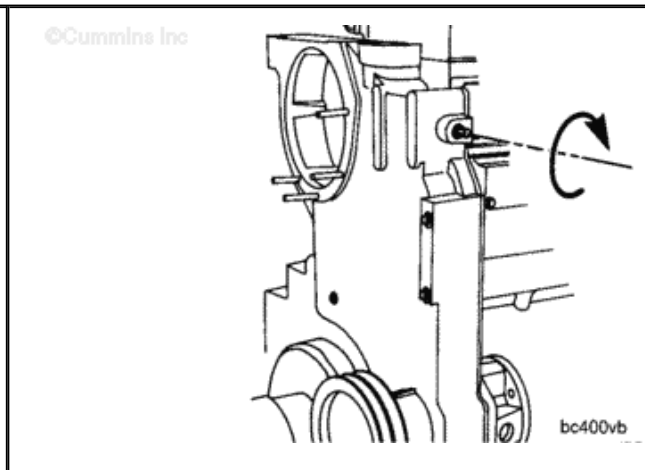
Engine Serial Number:

Type of inspection (failure, routine, complaint):

Inspection notes:

NOTE: This page can be copied for convenience.

Adjust

Remove the rocker lever cover and related components. Refer to Procedure 003-011.		
The valve and injector adjustment marks are found on the outside diameter of the accessory drive pulley or timing disk. Some older engines have different index marks than A, B, and C. On older engines: • 1-6 VS is the same as A		

- 2-5 VS is the same as B
- 3-4 VS is the same as C.

VS represents the valve set. Ignore any 1-6 TC mark during adjustment.

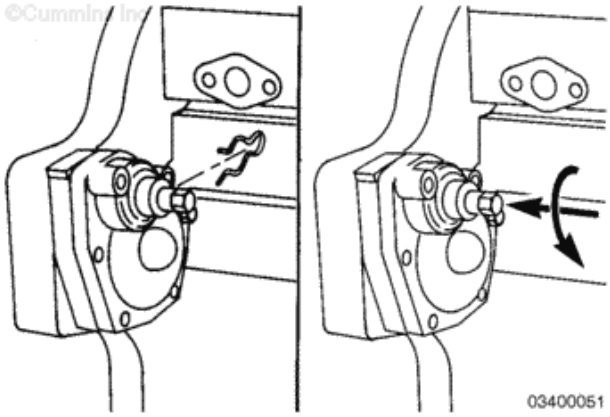
The barring device shaft turns approximately two revolutions before the engine begins to turn. The device will **not** turn the engine opposite the direction of normal rotation.

Push the shaft in and turn the barring device until the A mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.

On engines with a two-piece front cover:

- Remove the clip.
- Push the shaft in to engage the gears.
- Rotate the device shaft **counterclockwise** to turn the engine in the direction of normal rotation.

The alignment mark is also on the boss for the accessory drive seal.



The valves will be adjusted on the cylinder that has all of the valves closed. Use the table to determine the cylinders to check for valve position.

If Valve Set Mark Is:	Check Valve Position On:
A	1,6
B	2,5
C	3,4

fi400uz

If the rocker lever assemblies have been removed, use this step to determine the cylinder to set.

All of the adjusting screws **must** be loose on all cylinders and the push rod **must** remain in alignment.

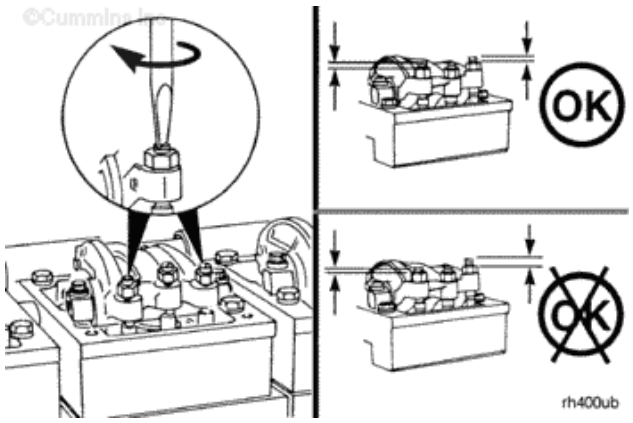
Perform this step on both of the cylinders to be checked.

Hold the rocker levers against the crossheads. Turn the adjusting screws until they touch the push rods.

Turn the locknuts until they touch the rocker levers.

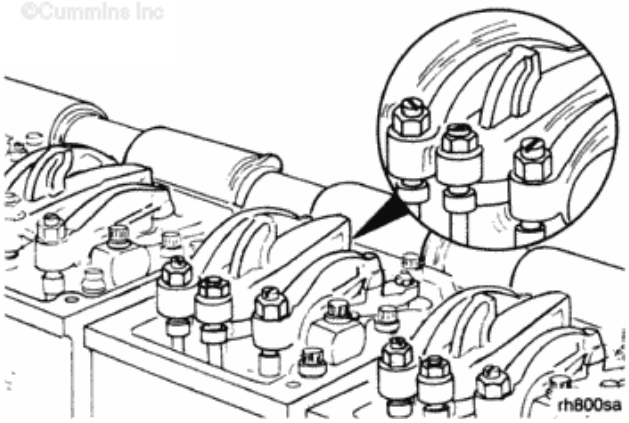
Compare the height of the adjusting screws above the locknut. The cylinder the adjusting screws are the same height are ready for valve adjustment.

The push rods will be the same height above the top of the rocker lever housing onto the cylinder ready for valve adjustment.



If the rocker levers have **not** been removed, wiggle the valve rocker levers on the two cylinders in question.

Set the valves on the cylinder where both levers feel loose.



Use the chart to determine the injector that is ready to adjust.

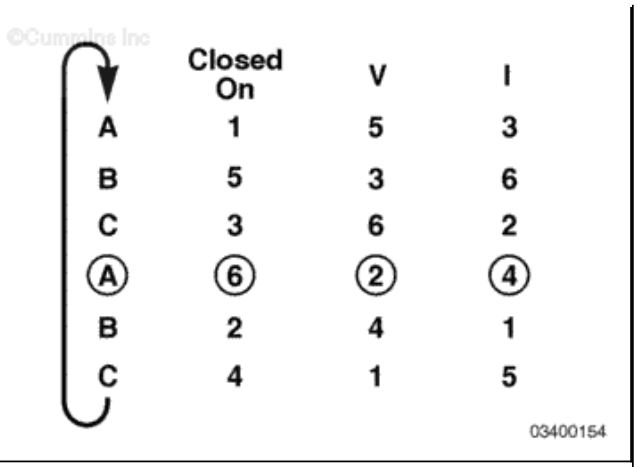
Adjustment can begin on any

valve set mark.

In the example, make sure the A mark is aligned and the adjusting screw height indicates the valves on cylinder number two are closed (ready to set). The chart shows the injector on cylinder number four is ready to adjust.

After the adjustment, bar the engine to the B set mark.

Adjust the valves on cylinder number four and the injector on cylinder number one.

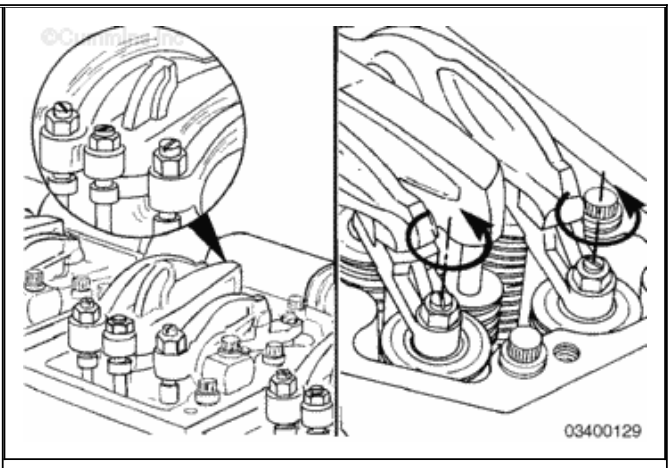


Crossheads

Crosshead adjustment **must always** be made before attempting to adjust the valves.

Adjust the crossheads on the cylinder that has both valves closed.

Loosen the crosshead adjusting screw lock nuts on the intake and exhaust valve crossheads.

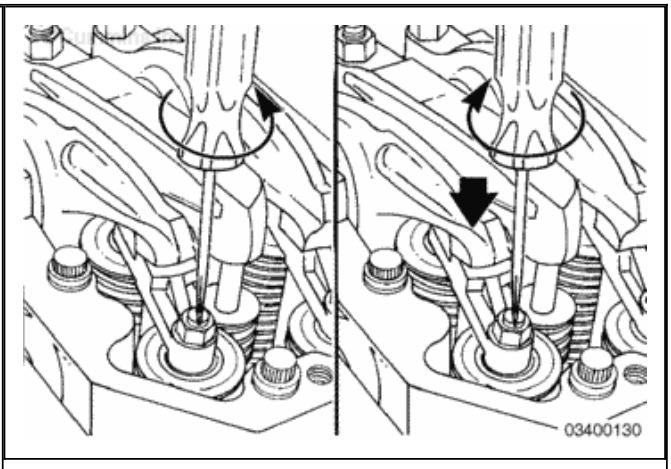


Use the following procedure to adjust both the intake and exhaust crossheads.

Turn the adjusting screw out at least one turn.

Hold the crosshead down against its mating valve stems.

Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.



The adjusting screw **must**

not turn when the lock nut is tightened to its torque value.

Hold the adjusting screw in position.

Tighten the lock nut. The values are presented with and without the use of the torque wrench adapter (1), Part Number ST-669.

Torque Value:
Without Jacobs® Brake (With Adapter)

1. 35 n.m [25 ft-lb]

Torque Value:
Without Jacobs® Brake (Without Adapter

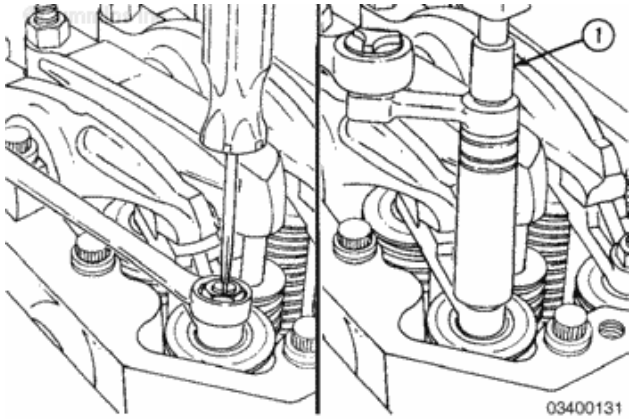
1. 40 n.m [30 ft-lb]

Torque Value:
With Jacobs® Brake (With Adapter)

1. 40 n.m [30 ft-lb]

Torque Value:
With Jacobs® Brake (Without Adapter)

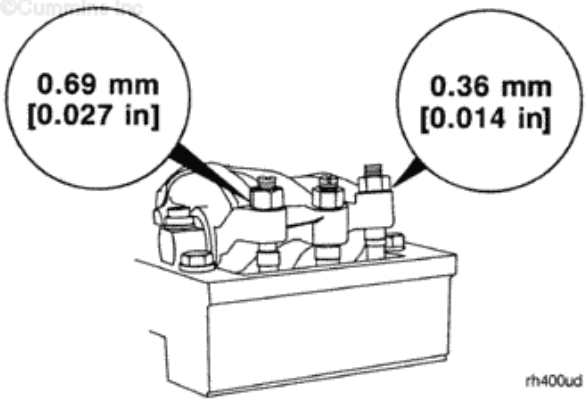
1. 45 n.m [33 ft-lb]



Valves

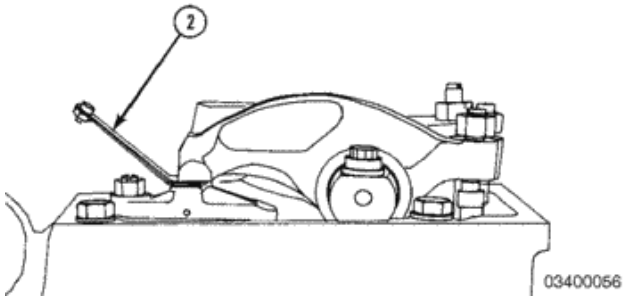
Use the table below to for valve adjustment initial set.

Valve Adjustment (Initial Set)	
Reference Point	**Valve**
A	Exhaust 0.69 mm [0.027 in]
B	Intake 0.36 mm [0.014 in]



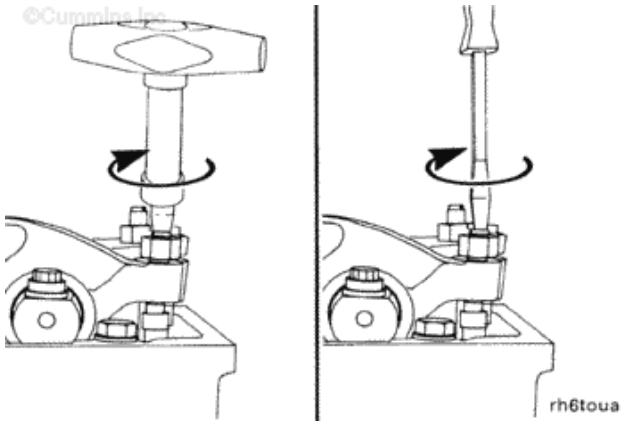
Select a feeler gauge for the correct valve lash specification. Use service tool, Part Number 3163171 (intake) or Part Number 3163172 (exhaust).

Insert the gauge (2) between the rocker lever and the crosshead.



There are two different methods for establishing valve lash clearance. Either method can be used; however, the torque wrench method has proven to be the most consistent.

- The torque wrench method uses an inch pound torque wrench, Part Number 3376592. The adjusting screw is tightened to 0.68 N•m [6 in-lb].
- The feel method uses a screw driver and the adjusting screw is turned **only** until the lever touches the feeler gauge.



The adjusting screw **must not** turn when the lock nut is tightened.

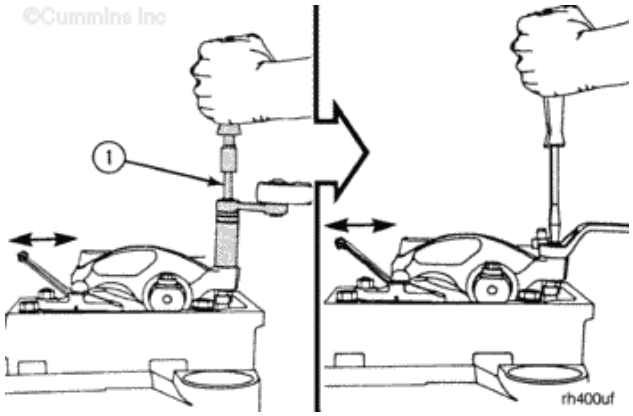
Tighten the locknut.

Torque Value:
With Torque Wrench Adapter, Part Number ST-669

1. 45 n.m [33 ft-lb]

Torque Value:
Without Adapter

1. 60 n.m [44 ft-lb]



The feeler gauge **must** slide backward and forward with **only** a slight drag.

Attempt to insert a feeler gauge that is 0.03 mm [0.001 in] thicker. The valve lash is **not** correct when the thicker gauge will fit.

Adjust the slave cylinder clearance on the Jacobs Brakes. Refer to Procedure 020-999.

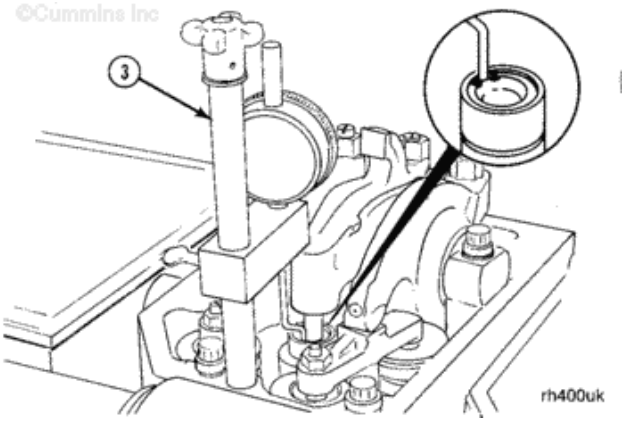
Repeat the adjustment process until the clearance is correct on both the intake and exhaust valves.

Injectors

Assemble the parts of the injector and valve adjustment kit (3), Part Number 3375004, or equivalent. Install the adjustment kit on the cylinder to be adjusted as illustrated in the graphic.

Adjust the indicator so the tip is touching the top of the injector plunger.

Lower the indicator 12.7 mm [0.500 in] to allow for travel. Lock the indicator support to the post.

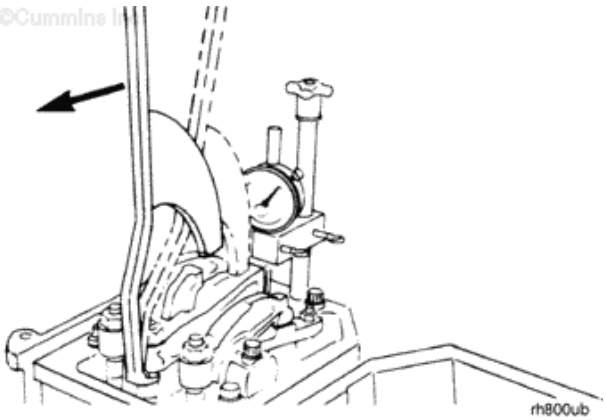


WARNING

The injector plunger is under spring tension. Do not allow the tool to slip. Personal injury can result.

CAUTION

Prevent damage to the indicator by allowing the lever to return slowly.

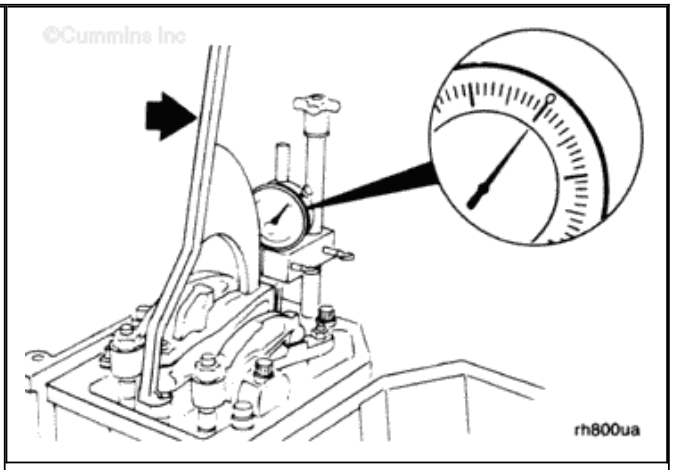


Use a rocker lever actuator, Part Number 3376869, or equivalent, to depress the rocker lever until the injector bottoms two or three times.

This will remove fuel and oil from the cup.

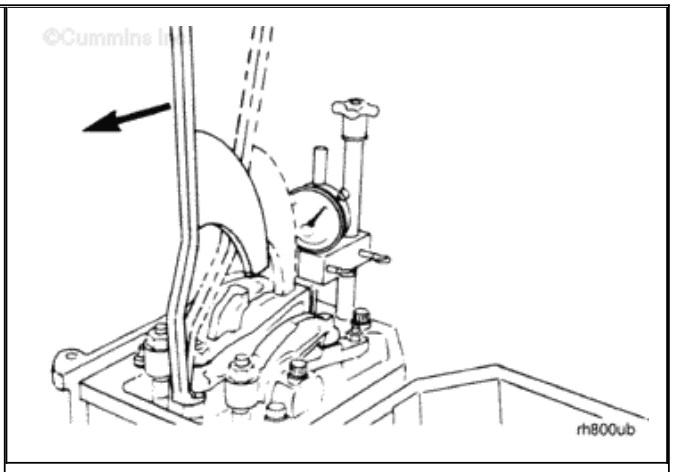
Hold the lever with the injector plunger firmly bottomed in the cup. Set the indicator to zero.

Raise and lower the lever a few time to confirm the zero.



Slowly release the lever and observe the travel of the gauge.

Press down or tap lightly on the adjusting screw to confirm the reading.

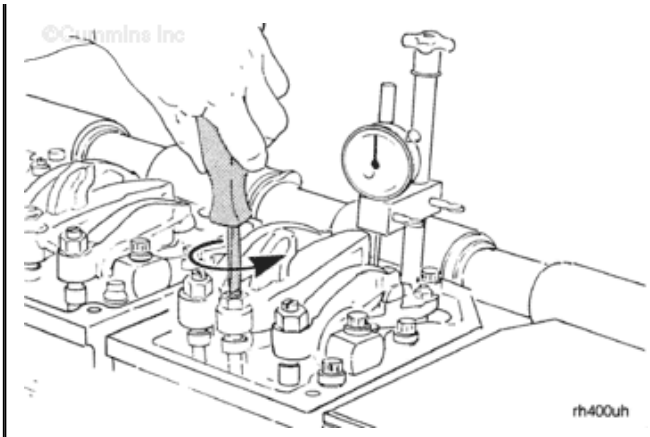


Turn the adjusting screw until the indicator reads the specified travel.

Injector Travel Specifications	
Model	**Specification**
All fixed time	7.72 mm [0.304 in]

Recheck limits are intended to be used on an engine already in service. It is **not** intended as a tolerance to be used when adjusting.

Recheck Limits
7.67 to 7.77 mm [0.302 to 0.306 in]



The adjusting screw **must not** turn when the lock nut is tightened.

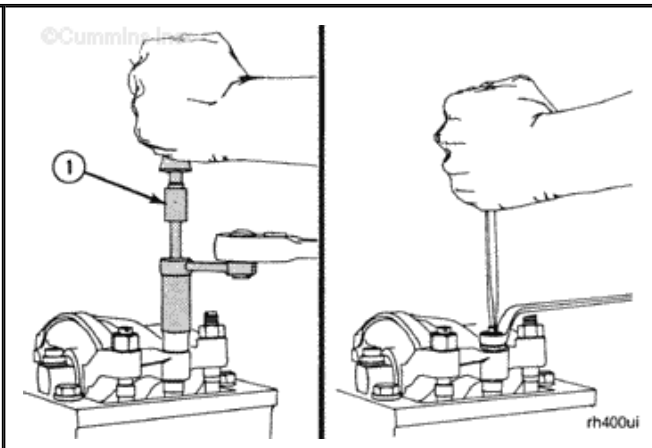
Tighten the lock nut.

Torque Value:
With Torque Wrench Adapter, Part Number ST-669

1. 45 n.m [33 ft-lb]

Torque Value:
Without Adapter

1. 60 n.m [44 ft-lb]



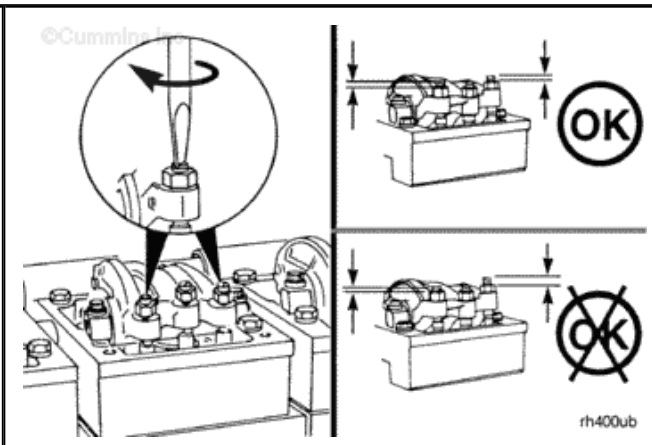
WARNING

The injector plunger is under spring tension. Do not allow the tool to slip. Personal injury can result.

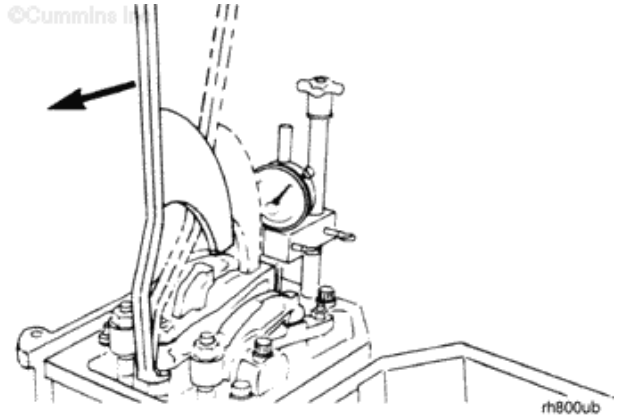
CAUTION

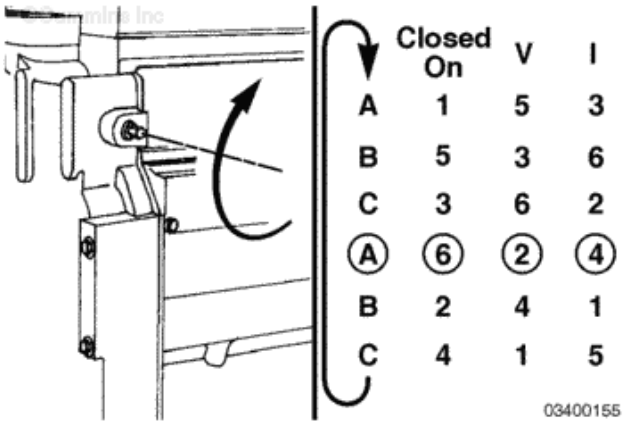
Prevent damage to the indicator by allowing the lever to return slowly.

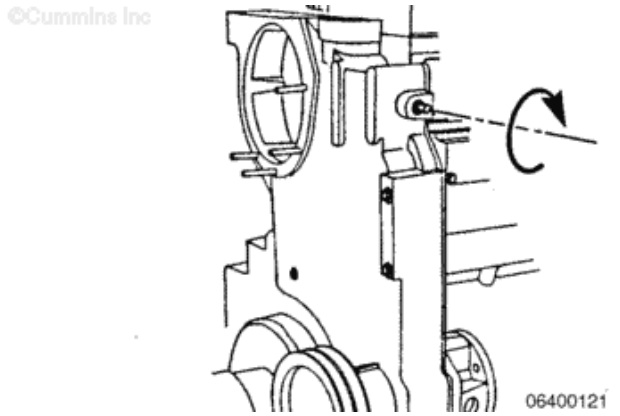
Check the injector adjustment. Use the rocker lever actuator. Bottom the injector plunger.



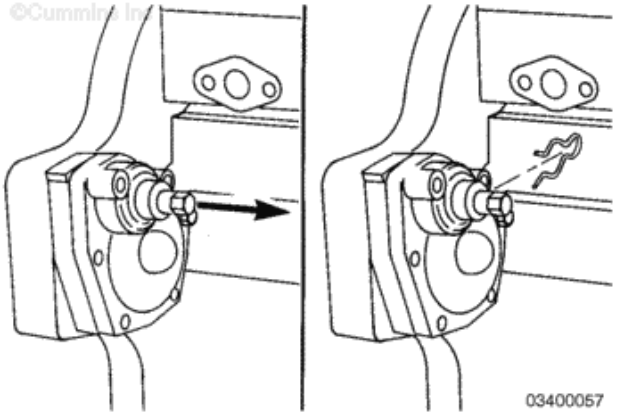
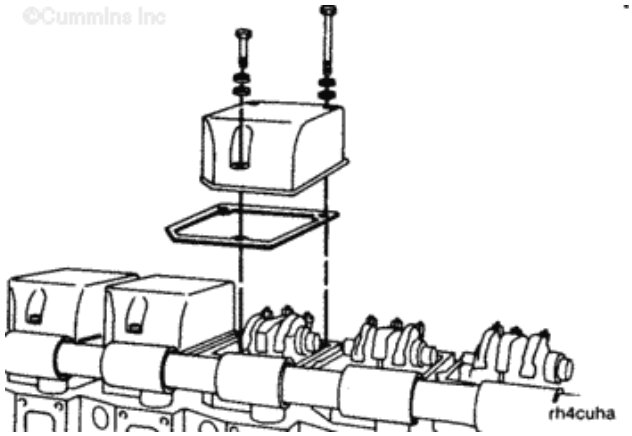
Confirm zero on the indicator.		

Allow the rocker lever to return slowly. Check the injector setting. Repeat the adjustment process if it is **not** within specification.		

Rotate the engine. Align the next mark. Adjust the appropriate valves and injectors. Repeat the process to adjust all of the valves and the injectors correctly.		

Turn the barring device in a **clockwise** direction to disengage the barring mechanism (worm gear). If the worm gear remains engaged during the engine start, the engine rotation will disengage the parts without damage.		

On engines with a two piece		

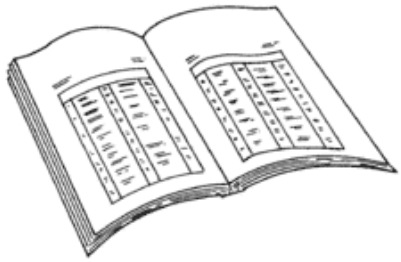
front cover: • Pull the shaft out to disengage the gears. • Install the clip.		
Install the rocker lever cover and all related components. Refer to Procedure 003-011.		

Last Modified: 16-Dec-2011

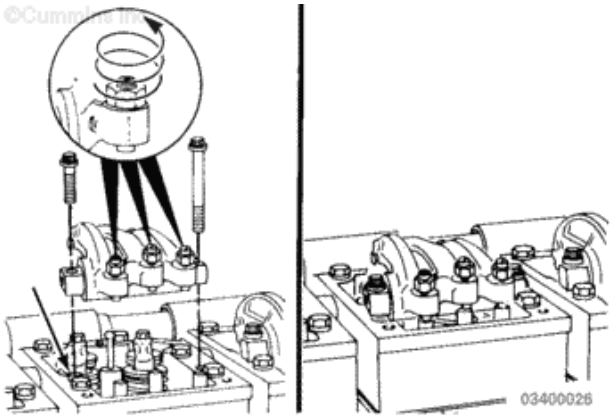
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003-009 Rocker Lever Assembly

Preparatory Steps

• Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.		 ck800wa

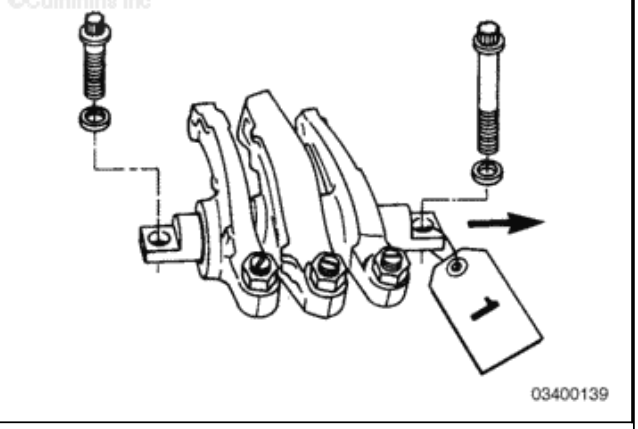
Remove

Do **not** allow the rocker levers to fall off the shaft during removal. Remove the two capscrews. Remove the rocker lever assemblies.		 03400026

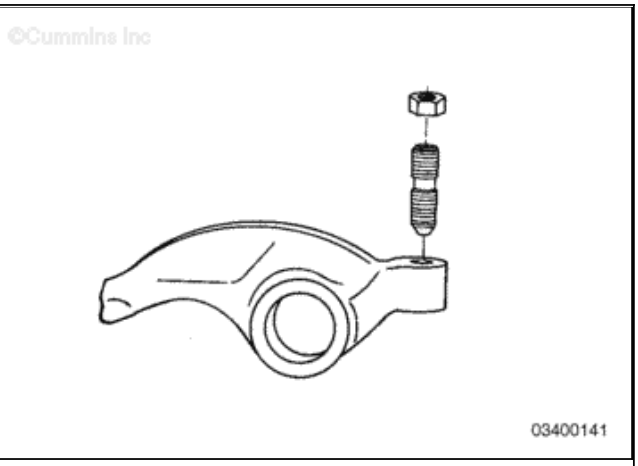
Disassemble

Remove the capscrews and hardened washers.

Pull the shaft out of the rocker levers.



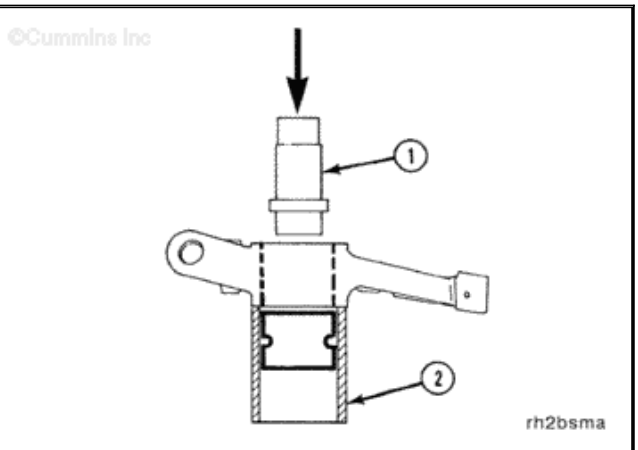
Remove the locknut and adjusting screw in each rocker lever.



NOTE: Do not remove the bushing unless it is damaged or worn.

Support the lever (2).

Press the bushing out of the rocker lever with a mandrel, Part Number ST-1284, or equivalent, and an arbor press.



Clean and Inspect for Reuse

WARNING

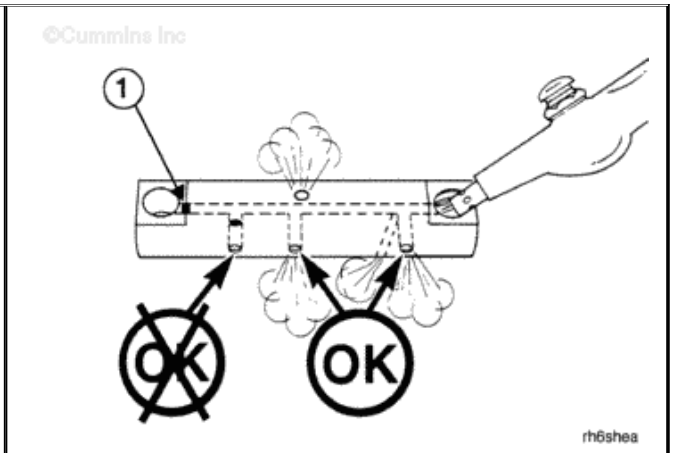
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the shaft with solvent.

Use compressed air to blow through the oil drillings to make sure that all of the nine oil holes are **not** blocked.

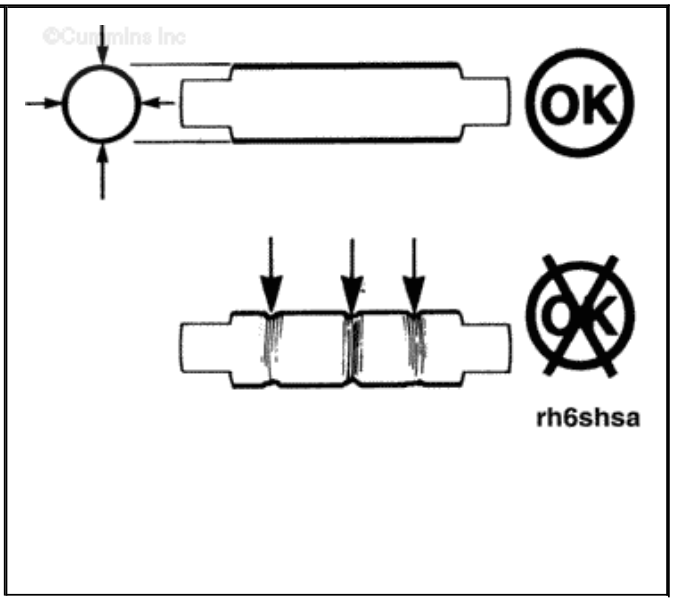


Some removal of the black coating on the loaded side of the shaft is normal. Some scuffing of the shaft is also normal. If the scuffing can **not** be felt with the fingernail, the shaft is acceptable.

Inspect the shaft for damage.

If the shaft is damaged, it **must** be replaced.

Measure the outside diameter of the shaft.



Rocker Lever Arm Shaft Outside Diameter		
mm		in
34.82	MIN	1.371
34.86	MAX	1.372

If the shaft is **not** within specifications, it **must** be replaced.

WARNING

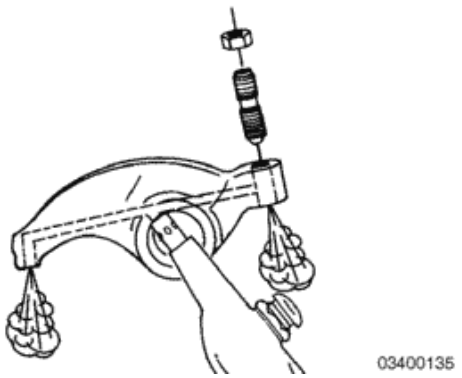
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the rocker lever with solvent.

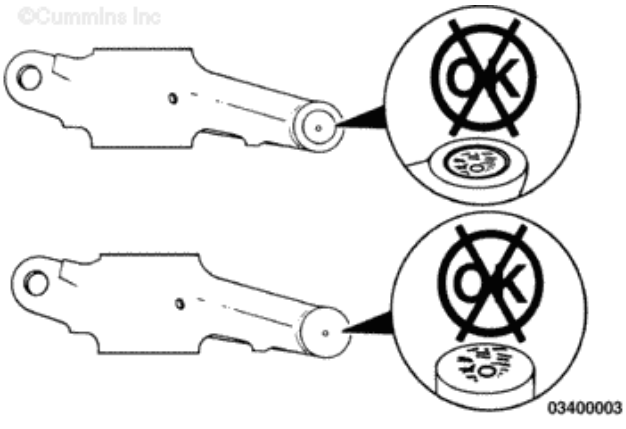
Use compressed air to blow the oil drillings to make sure the drillings are **not** blocked.



Inspect the socket for wear on both the injector and valve sockets.

Inspect the crosshead pad for wear.

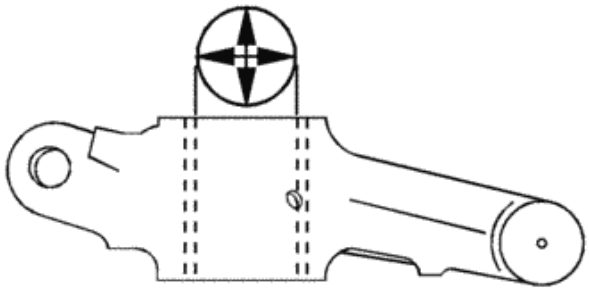
If there is damage that can be felt with the fingernail, the rocker lever **must** be replaced.



Measure the inside diameter of the rocker lever bushing.

Rocker Lever Bushing Inside Diameter		
mm		in
34.89	MIN	1.374
34.99	MAX	1.378

If the rocker lever bushing is **not** within specifications, the bushing **must** be replaced.



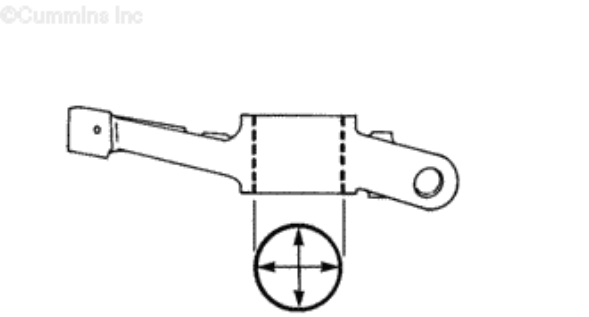
Remove any burrs from the rocker lever bore with abrasive hand pad, Part Number 3823258, or equivalent.

If cracks are suspected, use the magnetic particle method to inspect for cracks.

Measure the rocker lever bushing bore inside diameter.

Rocker Lever Bushing Bore Inside Diameter		
mm		in
36.47	MIN	1.436
36.50	MAX	1.437

If the rocker lever bushing bore is **not** within specifications, the rocker lever **must** be replaced.



Magnetic Crack Inspect

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 the magnetic particle inspection method to check for rocker lever cracks.

Apply coil shot amperage.

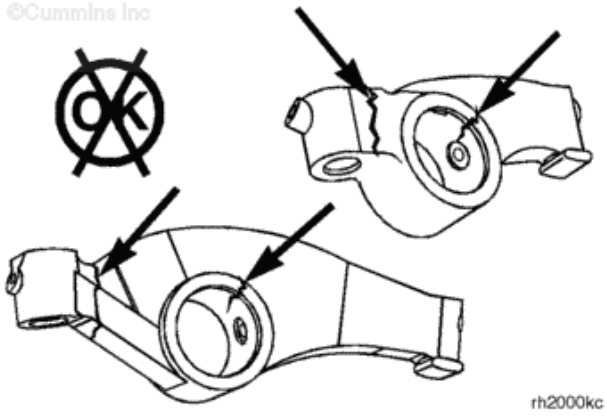
Ampere turn is an electrical current of one ampere flowing through a coil, multiplied by the number of turns in the coil.

Amperage (Ampere Turns)
1200 VDC or rectified VAC
2000 VDC or rectified VAC

The rocker lever **must** be replaced if there is a crack in any location.

Demagnetize the rocker lever.

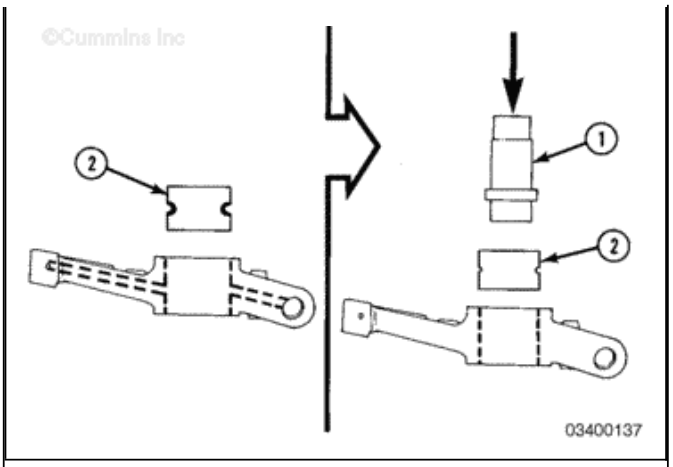
Clean the lever with solvent.



Assemble

Align the oil holes in the bushing (2) with the oil passages in the rocker lever.

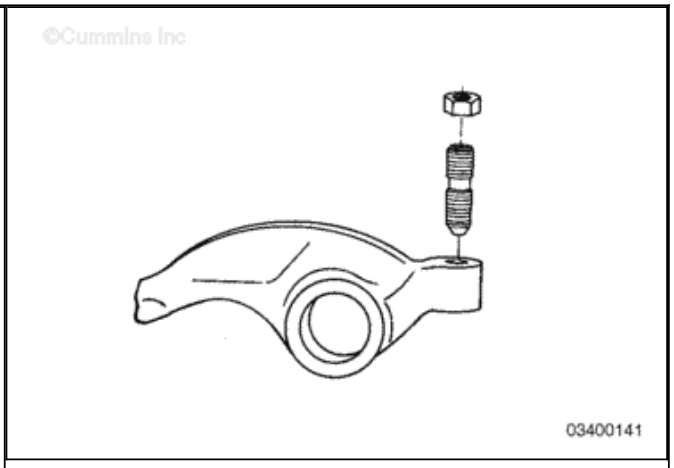
Press in the bushing (2) with an arbor press and a mandrel (1), Part Number ST-1284, or equivalent.



NOTE: A non-slotted adjusting screw must be used on engines that have a Jacobs® engine brake.

Install the adjusting screw and the locknut in each lever.

Do **not** completely tighten the lock nut until the assembly is installed on the engine.



Lubricate the shaft with clean engine oil.

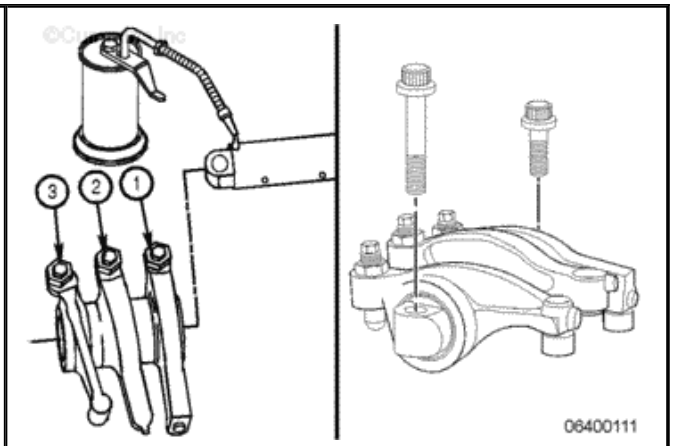
The oil drillings in the shaft **must** be in alignment with the oil drillings in the rocker levers.

Slide the rocker levers onto the shaft in the sequence shown.

(1) Exhaust lever
(2) Injector lever
(3) Intake lever.

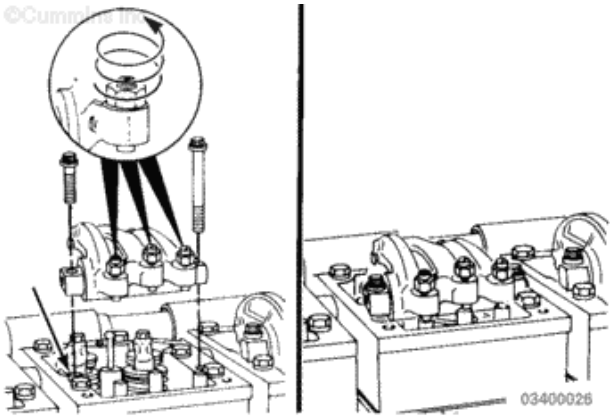
The plug in the shaft **must** be on the same end as the exhaust rocker lever.

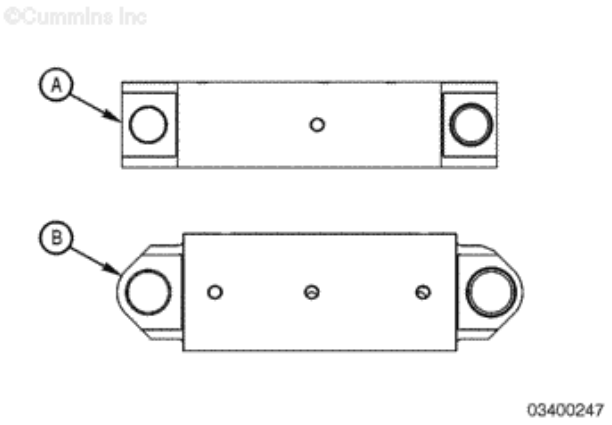
Lubricate the capscrew threads, rocker lever



sockets, and crosshead pads with clean engine oil. Install the washers and capscrews.		

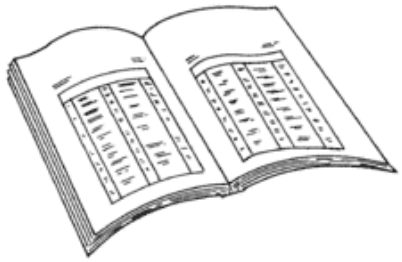
Install

Make sure the two dowels that align the rocker lever shaft are installed. Make sure the rocker lever adjusting screws are loose. Position the rocker lever assembly on the housing. Install the capscrews two or three revolutions. Align the push rod sockets with the adjusting screws.		

There are two different torque values, depending on the type of rocker lever shaft the engine has. For capscrews for rocker lever shaft A: **Torque Value:** 90 n.m [66 ft-lb] For capscrews for rocker lever shaft B: **Torque Value:** 225 n.m [166 ft-lb]		

Finishing Steps

- 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.
- Operate the engine and check for leaks.



ck800wa

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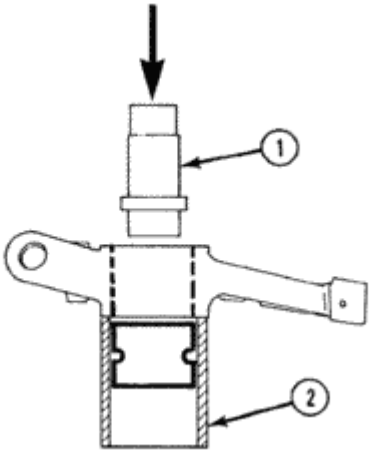
003-010 Rocker Lever Bushings

Remove

NOTE: Do not remove the bushing unless it is damaged or worn.

Support the lever (2).

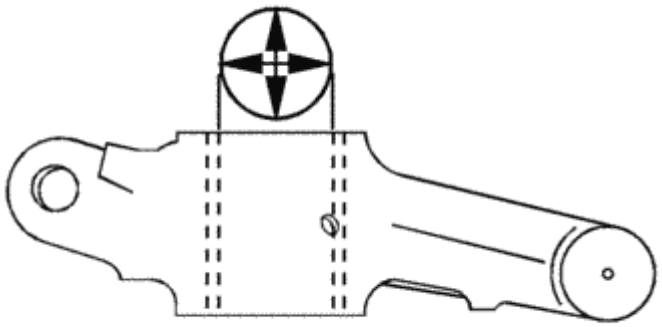
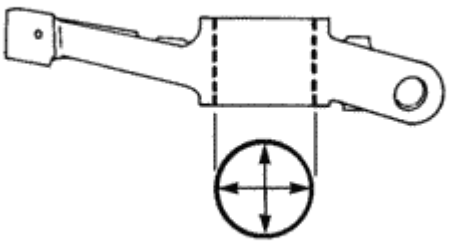
Press the bushing out of the rocker lever with a mandrel, Part Number ST-1284, or equivalent, and an arbor press.



Inspect for Reuse

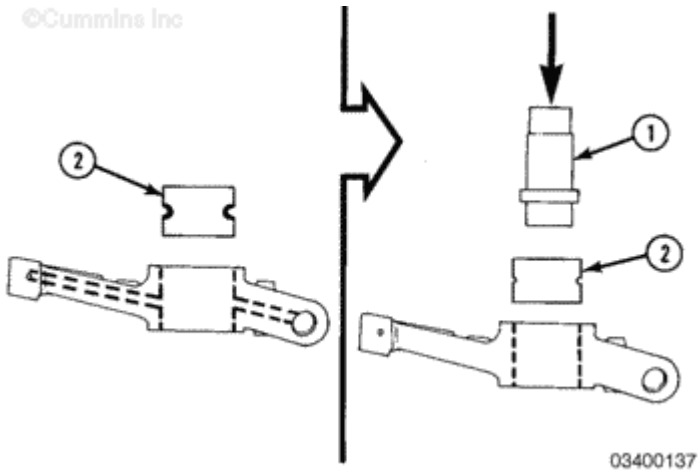
Measure the inside diameter of the rocker lever bushing.

Rocker Lever Bushing Inside Diameter			
mm		in	
34.89	MIN	1.374	

34.99 MAX 1.378 If the rocker lever bushing is **not** within specifications, the bushing **must** be replaced.		©Cummins Inc  03400010
Remove any burrs from the rocker lever bore with abrasive hand pad, Part Number 3823258, or equivalent. If cracks are suspected, use the magnetic particle method to inspect for cracks. Measure the rocker lever bushing bore inside diameter. Rocker Lever Bushing Bore Inside Diameter mm in 36.47 MIN 1.436 36.50 MAX 1.437 If the rocker lever bushing bore is **not** within specifications, the rocker lever **must**	 	©Cummins Inc  03400136

be replaced.		

Install

Align the oil holes in the bushing (2) with the oil passages in the rocker lever. Press in the bushing (2) with an arbor press and a mandrel (1), Part Number ST-1284, or equivalent.		

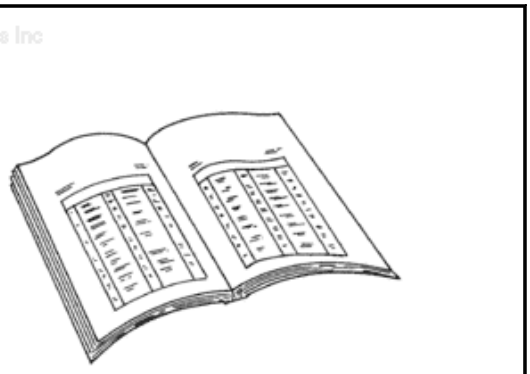
Last Modified: 19-Oct-2004

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003-011 Rocker Lever Cover

Preparatory Steps

- Remove the air crossover. Refer to Procedure 010-019.



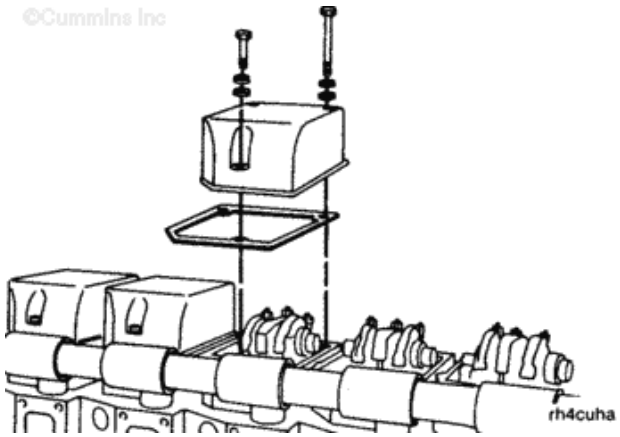
Remove

Crankcase breathers can be mounted in any cylinder location. Record the number of breathers and their location, before removing.

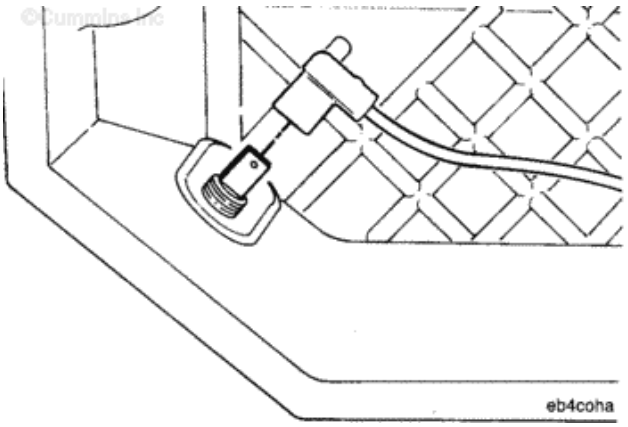
Remove the rocker lever cover capscrews.

Remove the rocker lever cover and gasket.

Discard the gasket.



Disconnect the solenoid wire from inside the cover on engines equipped with an engine brake.



Clean and Inspect for Reuse

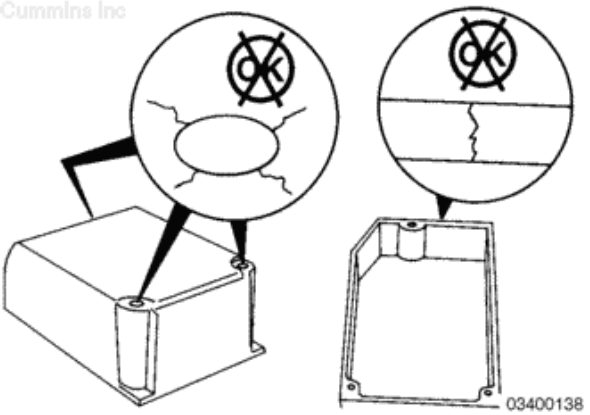
WARNING

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 rocker lever cover with a solvent that will **not** harm aluminum.

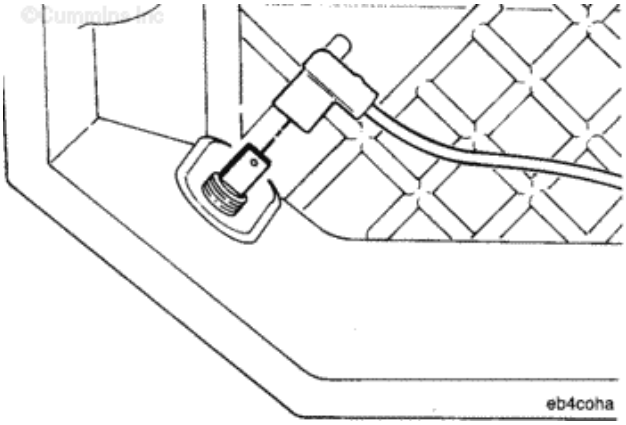
Inspect the rocker lever for cracks.

If the rocker lever cover is cracked, it **must** be repaired or replaced.



Install

If the engine has an engine brake, connect the solenoid wire to the terminal inside the cover.



CAUTION

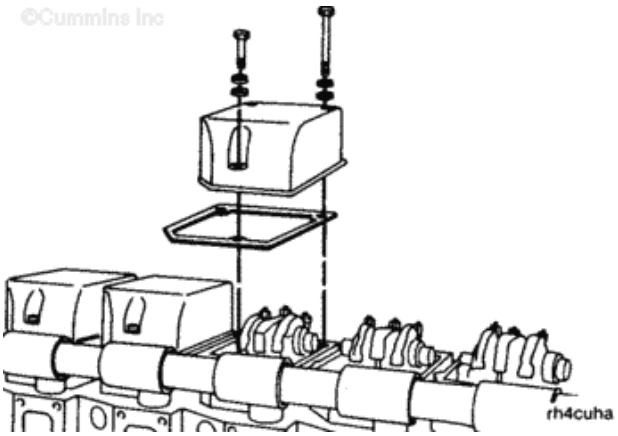
The use of gasket cement on the gasket will prevent the gasket from sealing properly.

Install the gasket and rocker lever cover.

Install the washers and capscrews.

Tighten the short capscrew first, then tighten the remaining capscrews.

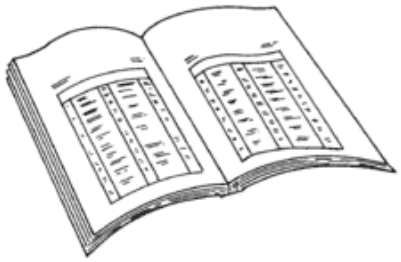
Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

- Install the air crossover. Refer to Procedure 010-019.

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003-013 Rocker Lever Housing

Preparatory Steps

WARNING

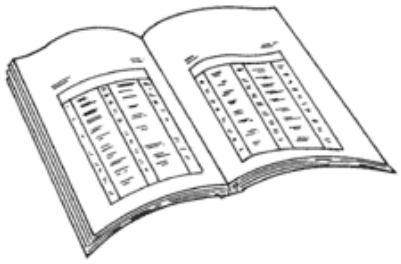
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

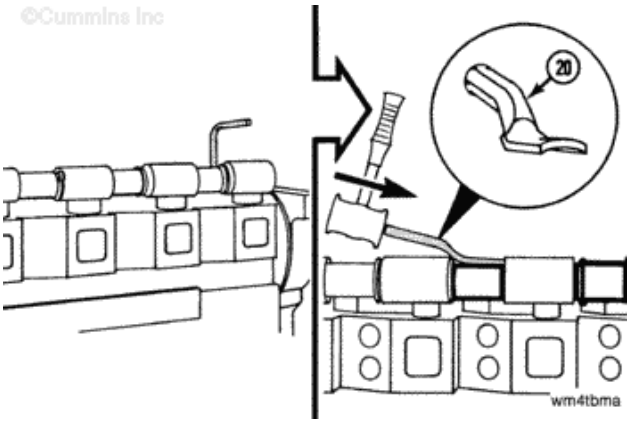
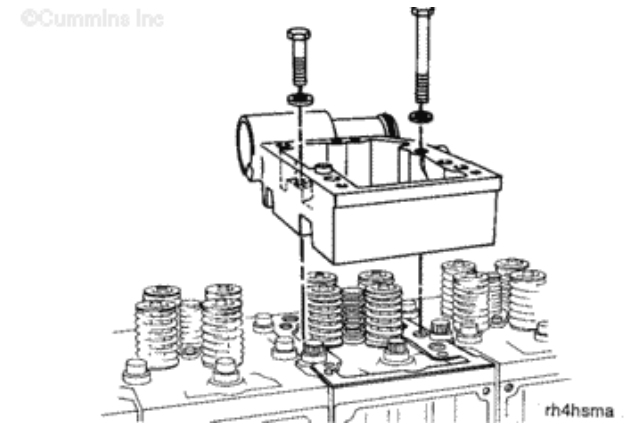
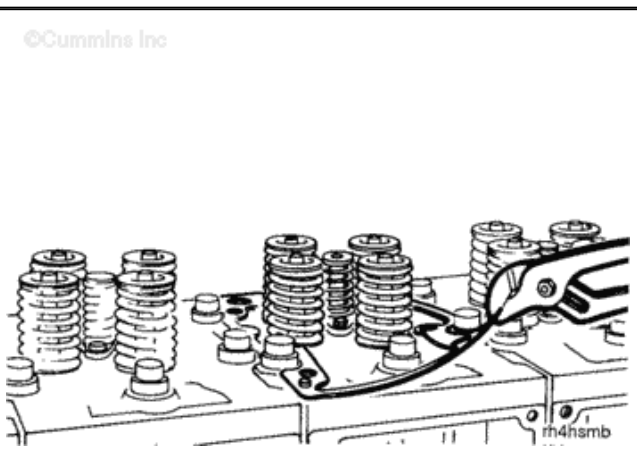
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Remove the thermostat housing. Refer to Procedure 008-015 in Section 8.
- Remove the rocker lever covers. Refer to Procedure 003-011 in Section 3.
- Remove the rocker lever assembly. Refer to Procedure 003-009 in Section 3.
- Remove the crossheads and pushrods. Refer to Procedure 004-014 in Section 4.





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Remove

Using a hammer and water tube driver (20), Part Number ST-1319, drive the water tube toward the front of the engine until the back part of the tube clears the rocker lever housing.		
Some rocker lever housings have brackets, lifting eyes, and supports installed on the side of the housing. Record the location of the components so they can be installed in the correct location. Remove the seven rocker lever housing mounting capscrews. Remove the rocker lever housing.		
Remove and discard the rocker lever housing gasket.		

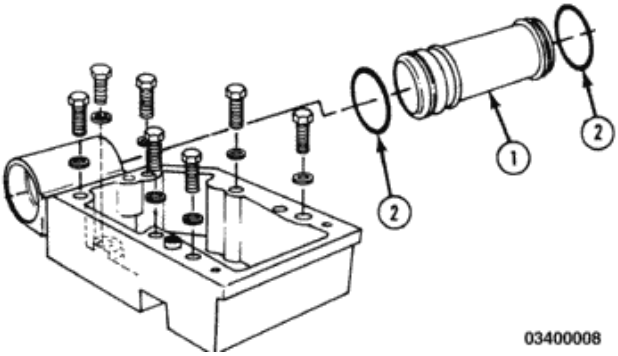
Disassemble

Remove the water transfer tube (1).

Remove the o-rings (2).

Discard the o-rings.

If the ring dowel is damaged, remove the dowel with the blind hole puller in the light duty puller kit, Part Number 3375784, or equivalent.



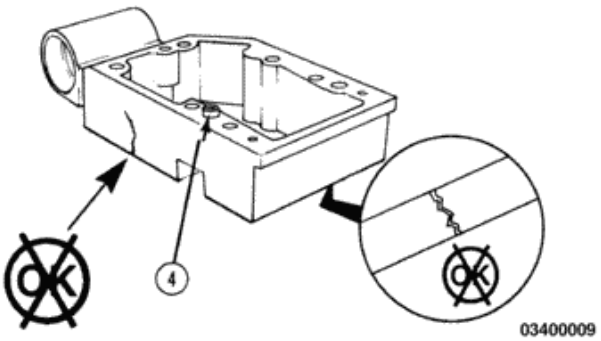
Clean and Inspect for Reuse

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.

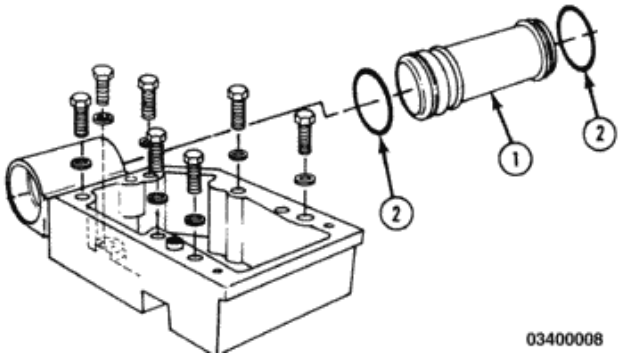
WARNING

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



Use solvent or steam to clean the parts. Inspect the ring dowel (4) for damage. If the ring dowel is damaged it, **must** be replaced. Use the dye crack penetrant method to inspect the rocker lever housing for cracks. If the rocker lever housing is cracked, it **must** be replaced.		

Assemble

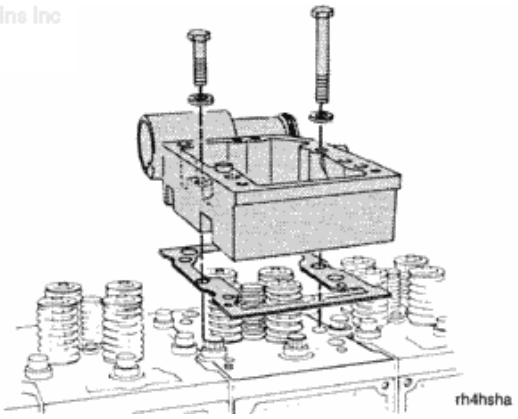
Lubricate the o-rings (2) with vegetable oil. Install the o-rings. Install the water transfer tube (1). Install the ring dowel if it was removed.		

Install

Install the rocker lever housing gasket. Align the rocker lever housing with the dowels and install the housing.		

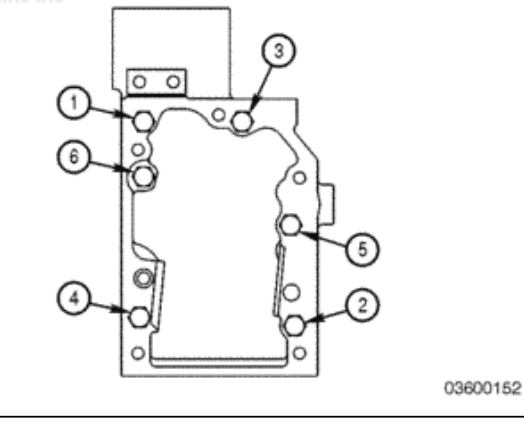
Check the threads of the rocker housing capscrews for damage. Check under the capscrew heads for cracks. Check for any deformation or necking of the capscrew.

Install the six capscrews.

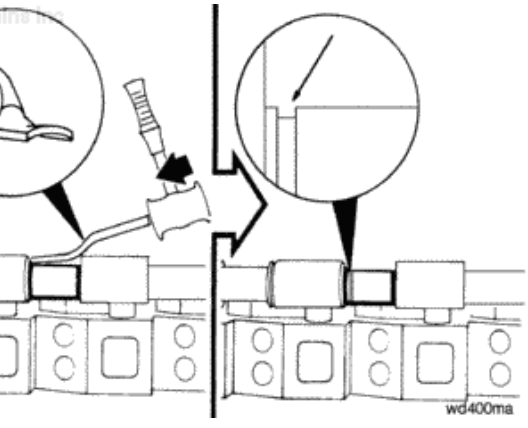


Tighten the capscrews in the sequence illustrated in the graphic.

Torque
Value: 122 n.m [90 ft-lb]



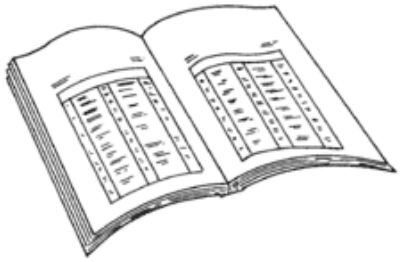
Drive the water tube into the adjacent housing until the tube is approximately centered, with water tube driver, Part Number ST-1319, and a hammer.



Finishing Steps

- Install the push rods and crossheads. Refer to Procedure 004-014 in Section 4.
- Install the rocker lever assembly. Refer to Procedure 003-009 in Section 3.
- Adjust the overhead. Refer to Procedure 003-006 or Refer to Procedure 003-007 in Section 3.
- Install the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Install the thermostat housing. Refer to Procedure 008-015 in Section 8.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine to 70°C [160°F] minimum coolant temperature and check for leaks.





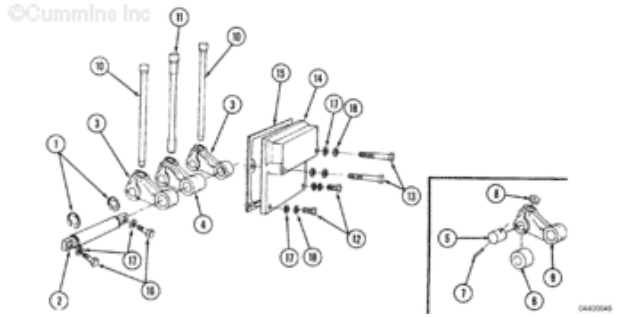
ck800wa

Last Modified: 28-Jun-2013

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004-001 Cam Follower Assembly

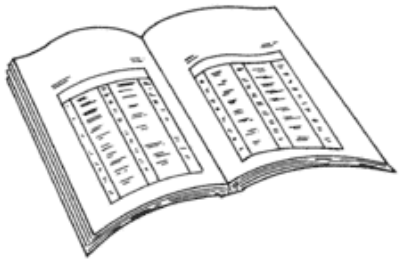
Exploded View



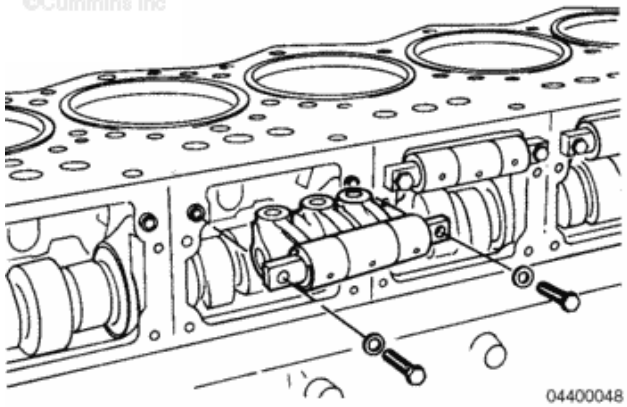
1. Retaining ring
2. Cam follower shaft
3. Valve cam follower
4. Injector cam follower
5. Cam follower pin
6. Cam follower roller
7. Cam follower pin lock wire
8. Cam follower socket
9. Cam follower lever
10. Valve push rod
11. Injector push rod
12. Capscrew
13. Capscrew
14. Cam follower cover
15. Cam follower cover gasket
16. Special hexagon capscrew
17. Plain washer
18. Lock washer.

Preparatory Steps

• Remove the rocker lever cover. Refer to Procedure 003-011. • Remove the Jacobs engine brake. • Remove the rocker	 	

levers and the STC injector link. Refer to Procedure 003-009. • Remove the push rods and the standard injector link. Refer to Procedure 004-014. • Remove the cam follower cover. Refer to Procedure 004-002.		©Cummins Inc  ck800wa

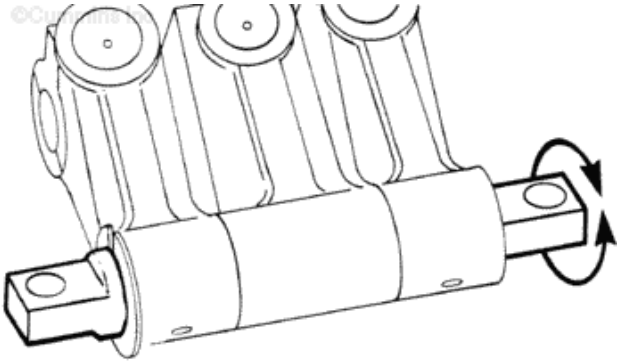
Remove

The cam follower assembly capscrews are a special slotted design. Remove the cam follower assembly mounting capscrews and tag them for future identification. Pull the cam follower assembly straight out until the shaft is off of the ring dowels.		©Cummins Inc  04400048

Inspect for Reuse

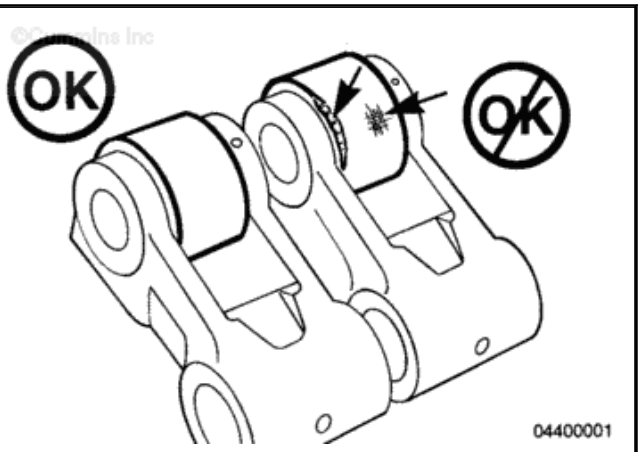
Clean the cam follower assembly. Rotate the shaft. If resistance is apparent,		

disassemble the assembly and check for burrs.



Check the roller for damage.

If the roller is damaged, it **must** be replaced.

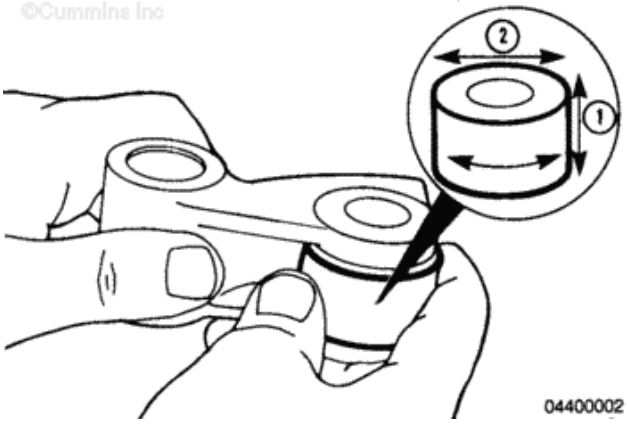


Check the roller rotation, it **must** rotate easily.

Measure the roller clearance.

Roller Clearance			
	mm		in
(1)	0.23	MIN	0.009
	0.61	MAX	0.024
(2)	0.076	MIN	0.003
	0.114	MAX	0.005

If the roller is **not** within specifications, the cam follower lever **must** be reconditioned.



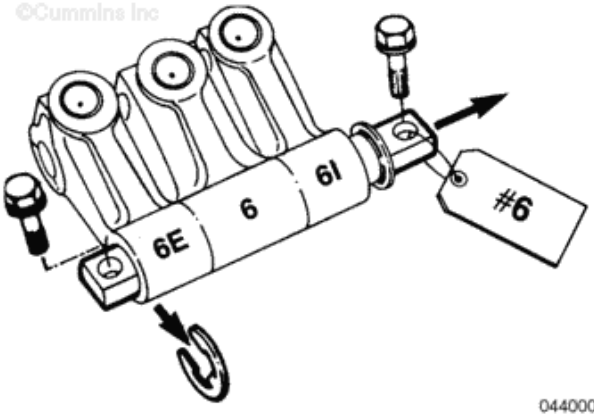
Disassemble

Remove the special capscrews and plain washers.

Remove the retaining ring.

Pull the shaft out.

Mark and tag the parts for future identifications.



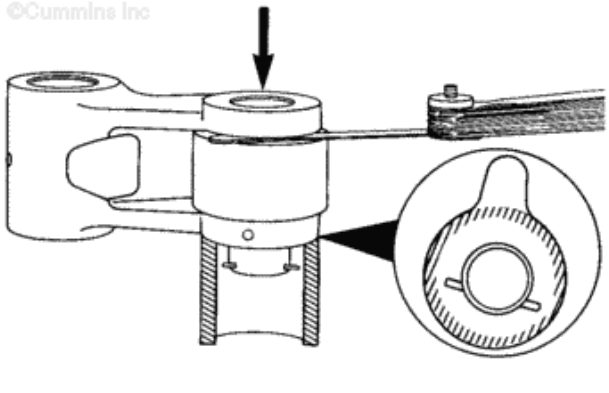
CAUTION

Use a feeler gauge or shim between the roller and the lever to reduce the possibility of damage.

Support the cam follower lever in the area illustrated in the graphic.

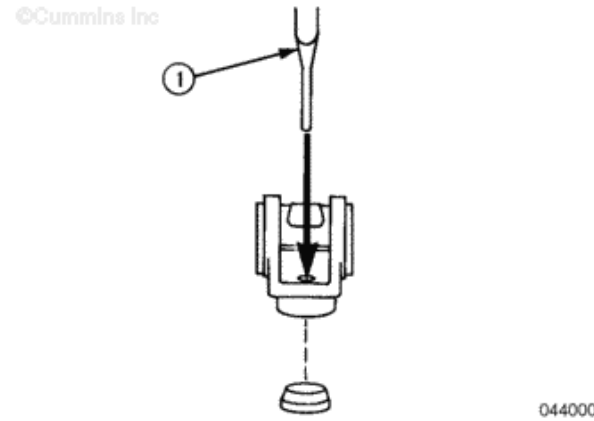
Insert the largest feeler gauge, that will fit, between the roller and lever.

Push the roller pin out with an arbor press.



NOTE: Do not remove the socket unless it is damaged.

Remove the socket with a brass drift (1).



Clean and Inspect for Reuse

WARNING

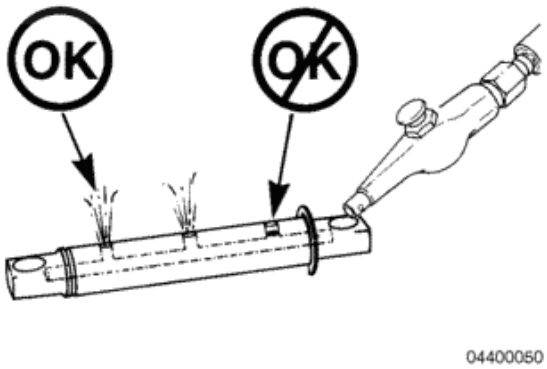
When using solvents, acids, or alkaline materials, for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the shaft with solvent.

Blow compressed air through the drillings to make sure they are **not** blocked.

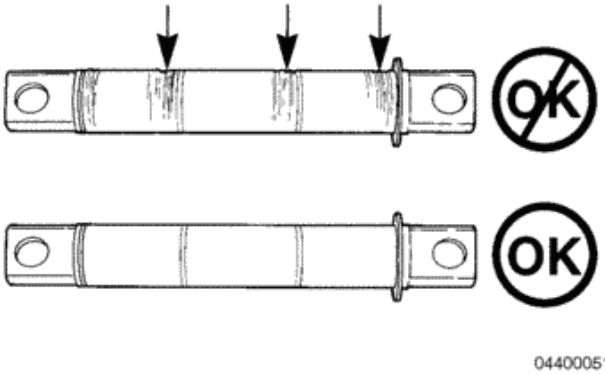


Check the shaft for damage or roughness.

If marks or scratches can be felt with the fingernail, the shaft **must** be replaced.

Measure the outside diameter of the shaft.

Cam Follower Assembly Shaft		
mm		in
22.174	MIN	0.873
22.200	MAX	0.874



If the shaft is damaged or **not** within specifications, 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.

WARNING

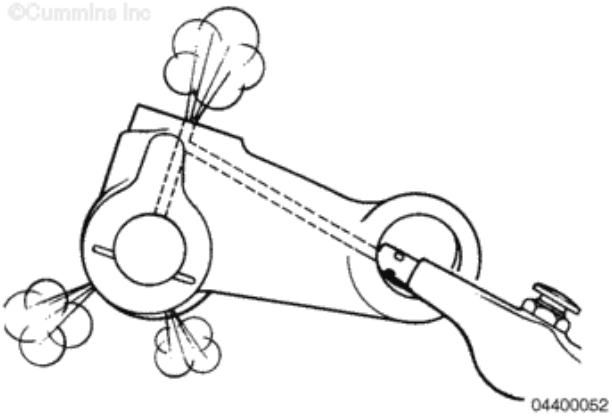
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the lever with solvent.

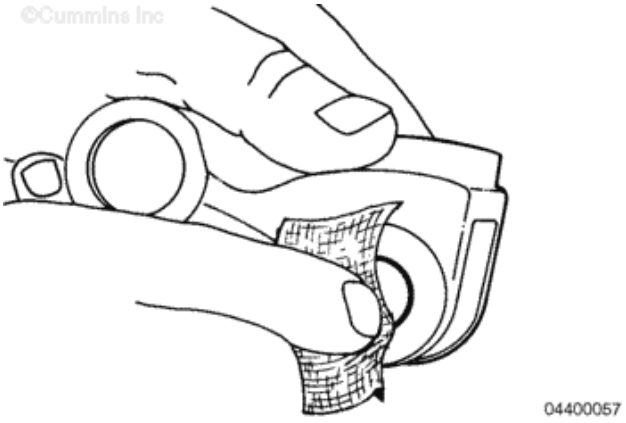
Blow compressed air through the drillings to make sure they are **not** blocked.

Check the socket for damage.

If the socket is damaged, it **must** be replaced.



Remove any burrs from the bore of the lever with abrasive hand pad, Part Number 3823258, or equivalent.



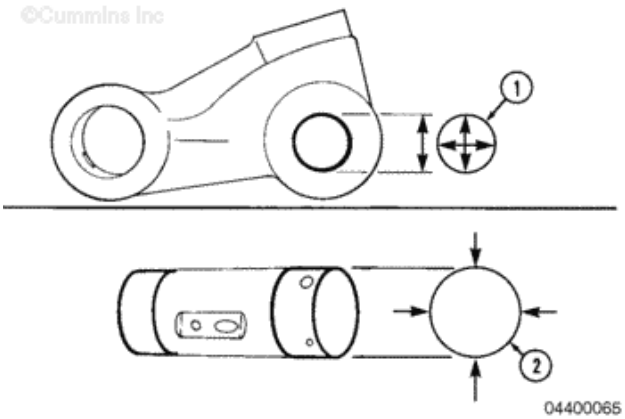
Inspect the pin for damage.

If the pin is damaged it **must** be replaced.

Use the formula below to determine the press fit and if the pin will be used again.

Press fit = dimension (2) - dimension (1).

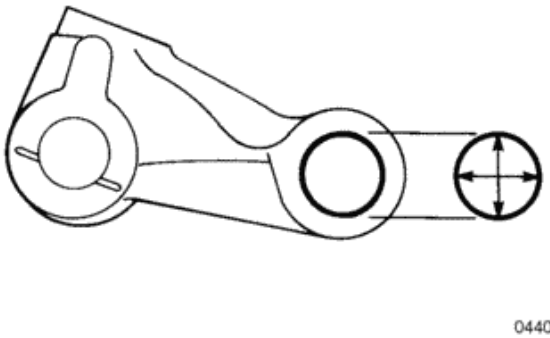
Press Fit Between Pin and Lever		
mm		in
0.005	MIN	0.0002
0.038	MAX	0.0015



Measure the lever bore inside diameter.

Lever Bore Inside Diameter		
mm		in
22.225	MIN	0.875
22.275	MAX	0.877

If the lever bore is **not** within specifications, the lever **must** be replaced.



Magnetic Crack Inspect

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.

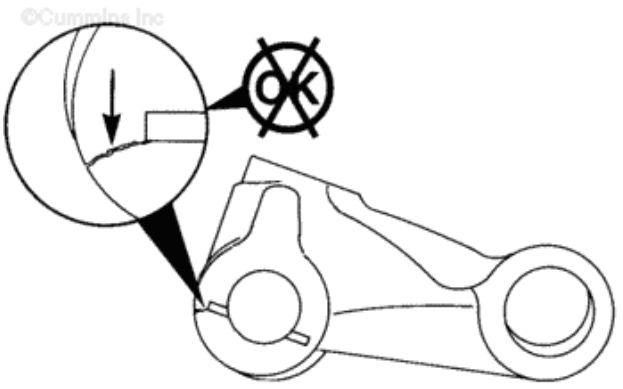
Use the magnetic particle, continuous method to check for cracks in the lever.

Apply a minimum of 300 ampere turns and a maximum of 500 coil turns coil shot amperage to the lever and inspect for cracks.

If the lever is cracked, it **must** be replaced.

Demagnetize the lever.

Clean the lever with solvent.



Assemble

CAUTION

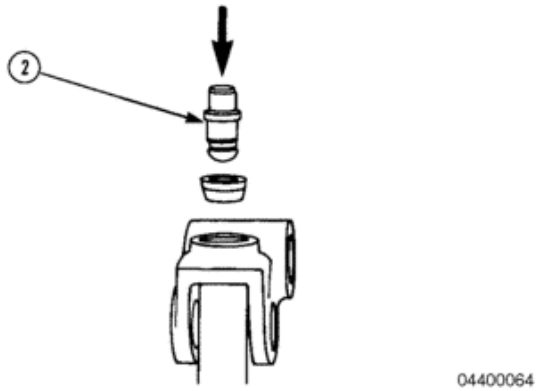
The cam follower must be supported as illustrated in the graphic to reduce the possibility of cracks in the cam follower lever.

The cam follower lever can be supported with an old roller.

Support the cam follower lever in an arbor press.

Install the socket with a brass drift (2) or an old push rod and the arbor press.

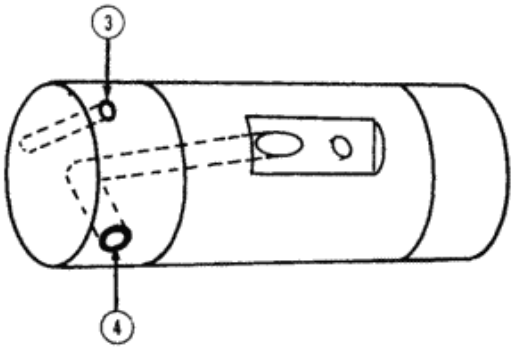
The socket **must** touch the bottom of the bore in the lever.



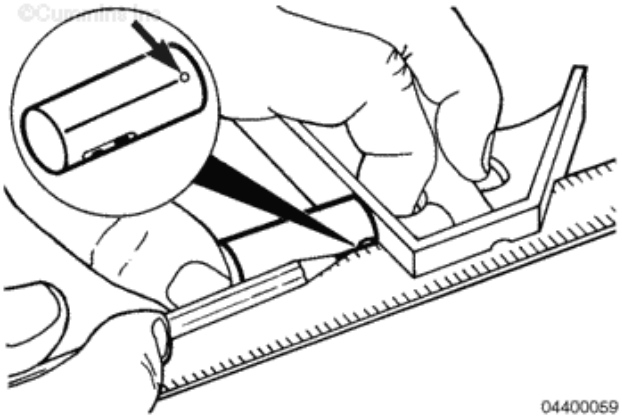
Determine the correct drilling for the lockwire:

(3) Lockwire hole

(4) Oil supply hole.



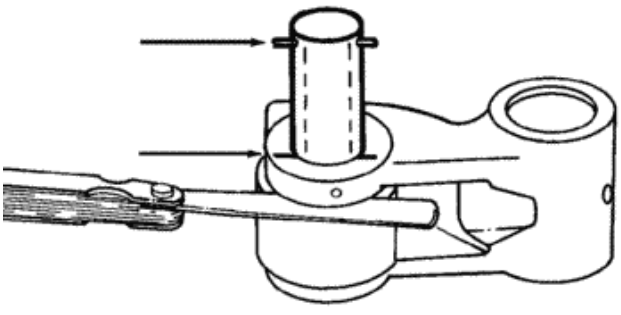
Mark the lock wire holes to aid in alignment during assembly.



Freezing the pin will simplify installation.

Slide the lock wire (5) into the pin.

Align the marked lines on the pin with the with the lockwire slot (6) on the lever.



CAUTION

Make sure the cup plug for the oil drilling in the center of the shaft is to the left end (exhaust valve end). If the shaft is install in wrong way around the cam follower will fail because of a lack of lubrication.

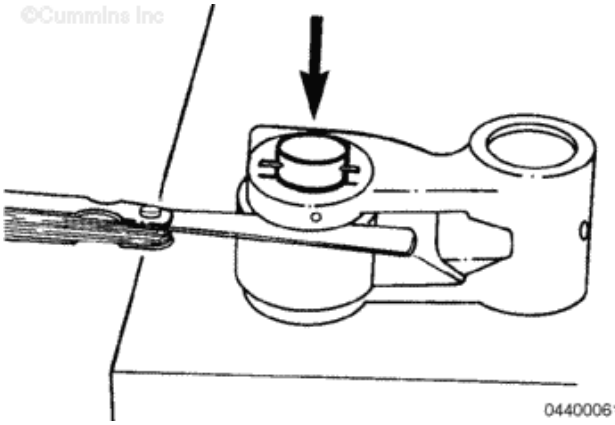
Lubricate the pin with clean engine oil.

Insert the roller into the lever and align it with the pin.

Place a feeler gauge between the lever and roller.

Press the pin into the lever with an arbor press.

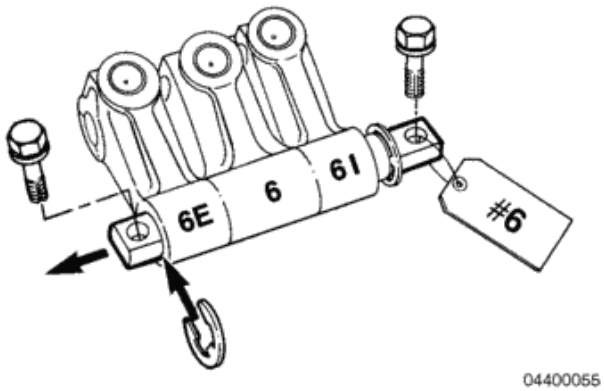
The lock wire **must** align with the slot in the lever.



Lubricate the shaft and lever bores with clean engine oil.

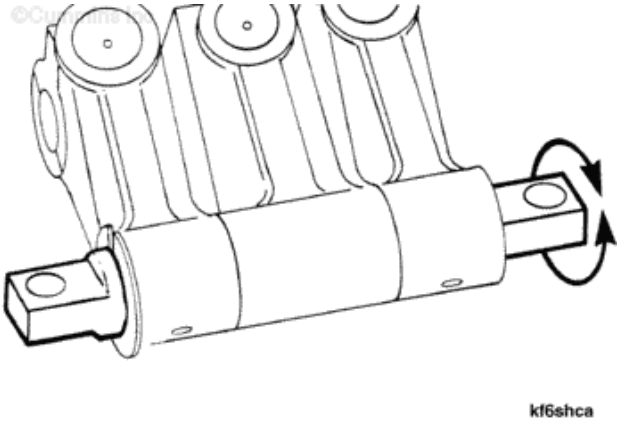
Slide the levers onto the shaft as illustrated in the graphic.

Install the retaining ring and capscrews.



Make sure the shaft rotates easily.

If resistance is apparent, disassemble and check the shaft for burrs.



Install

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.

Service replacement cam followers are coated with a heavy preservative to prevent rust. This preservative **must** be removed completely with solvent before the cam followers are installed on the engine.

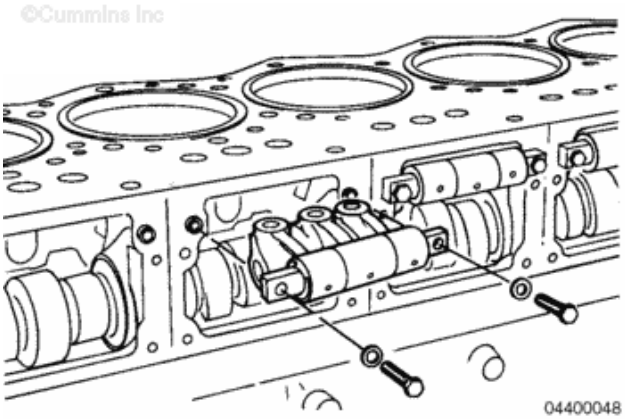
The cam follower mount capscrews are special. They have a slot that allows oil to flow to the cam follower assembly. The oil drilling intersects with the rear capscrew hole. Failure will result if standard capscrews are used.

Lubricate the camshaft and cam followers with clean engine oil.

Install the cam follower assembly.

The shaft **must** fit on both ring dowels.

Install and tighten the capscrews.

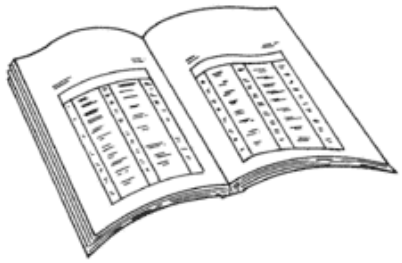


Cam Follower Mounting

Capscrew Torque		
n.m		ft-lb
39	MIN	29
42	MAX	31

Finishing Steps

- Install the cam follower cover. Refer to Procedure 004-002.
- Install the push rods and standard injector link. Refer to Procedure 004-014.
- Install the rocker levers and STC injector link. Refer to Procedure 003-009.
- Install the Jacobs engine brake.
- Install the rocker lever cover. Refer to Procedure 003-011.



Last Modified: 20-Dec-2004

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004-002 Cam Follower Cover

General Information

There are four styles of camshaft follower cover available:

- Plain
- With an oil fill
- With a crankcase breather
- With a tapped hole to mount the HVT oil drain back tube.

All camshaft follower covers are manufactured from aluminum. The mounting location for each style depends on the selected engine option.

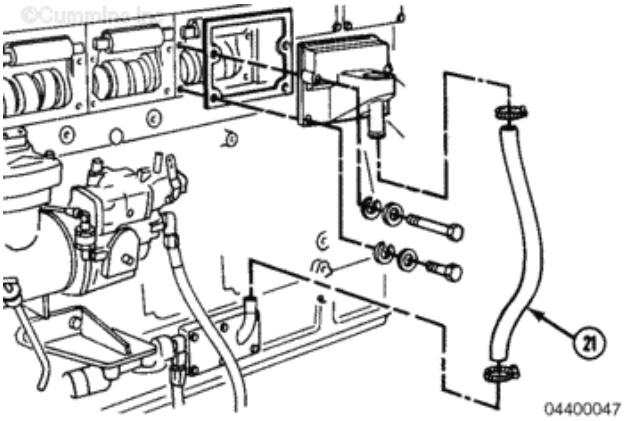
Remove

NOTE: Some camshaft follower covers can not be removed until other parts, such as the wiring harness, fuel tubing, ant the crankcase vent hose (21) are removed.

Remove the camshaftshaft follower cover capscrews.

Remove the camshaft follower cover.

Remove and discard the gasket.



Clean and Inspect for Reuse

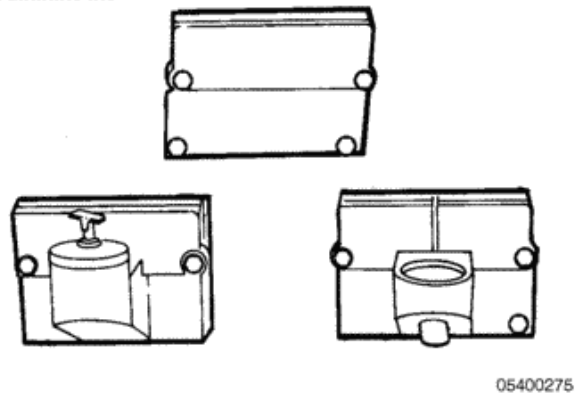
WARNING

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 camshaft follower cover in solvent that will **not** harm aluminum.

Inspect the camshaft follower cover for cracks.

If the camshaft follower cover is cracked it **must** be repaired or replaced.

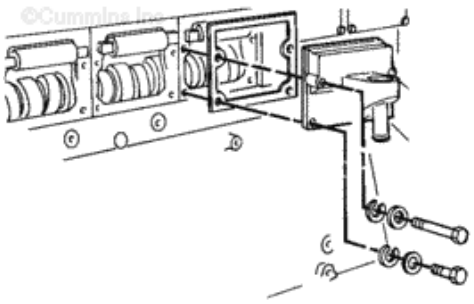


Install

Two types of Gaskets Used on K19 Engines

- Gaskets **with** a raised bead of sealant material **must** be installed so the bead touches the cover.
- Gaskets **without** a bead of sealant are manufactured from a material that enlarges when exposed to engine oil. Do **not** use sealant on this type of gasket. These gaskets **must** be installed dry.

Only one of the camshaft follower covers contain an oil drain back tube. Install the camshaft follower cover with the crankcase ventilation hose in the number four position.



Install the gasket, camshaft follower cover, washers and capscrews. Tighten the capscrews. **Torque** **Value:** 25 n.m [20 ft-lb]		

Last Modified: 19-Dec-2011

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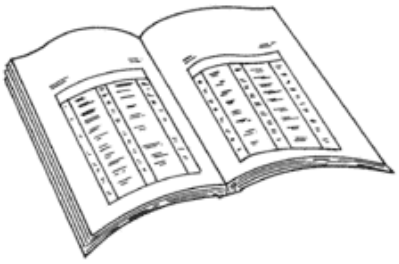
004-014 Push Rods or Tubes

Preparatory Steps

- Remove the rocker lever cover. Refer to Procedure 003-011.
- Remove the rocker lever assembly. Refer to Procedure 003-009.







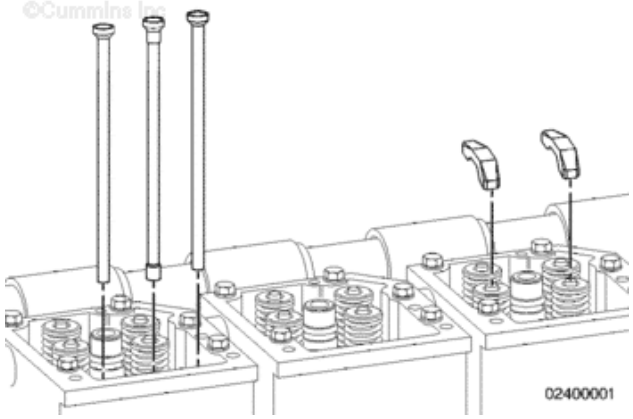
ck800wa

Remove

Mark the push rods, so they can be installed in their original position.

Remove the push rods and crossheads.





02400001

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

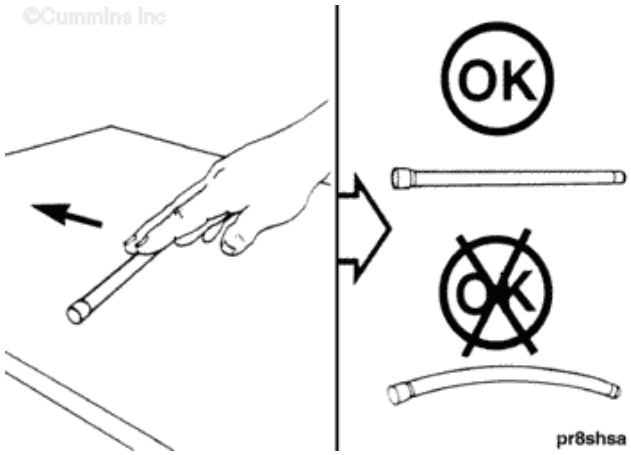
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the push rods with solvent and dry with compressed air.

Inspect the push rod for bends by rolling it across it across a level surface.

Do **not** try to straighten a bent push rod.

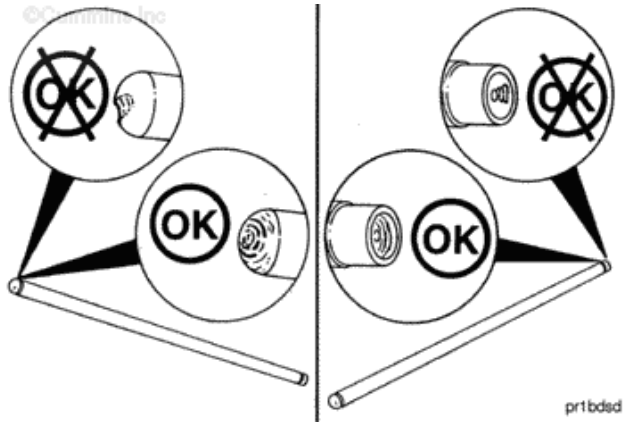
If the push rod is bent, it **must** be replaced.



Inspect both ends of the push rods for wear or damage.

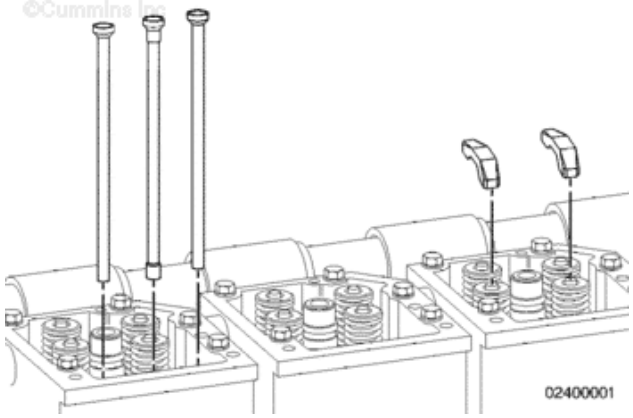
Replace both the rocker lever adjusting screw and push rod if the socket surface in the push rod or on the adjusting screw is damaged.

The cam follower assembly **must** be replaced if the push rod is worn or damaged in the area where it contacts



the socket.		

Install

The injector push rods are thicker in the middle. The valve push rods are the same thickness for both the intake and exhaust. Lubricate the sockets in the cam followers with clean engine oil. Install the push rods. Make sure the push rods are seated correctly in the cam followers. Install the crossheads.		

Finishing Steps

• Install the rocker lever assembly. Refer to Procedure 003-009. • Adjust the overhead. Refer to Procedure 003-006 or 003-007. • Install the rocker lever cover. Refer to Procedure 003-011.		

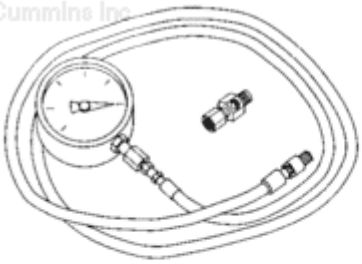
Jahan Compressor

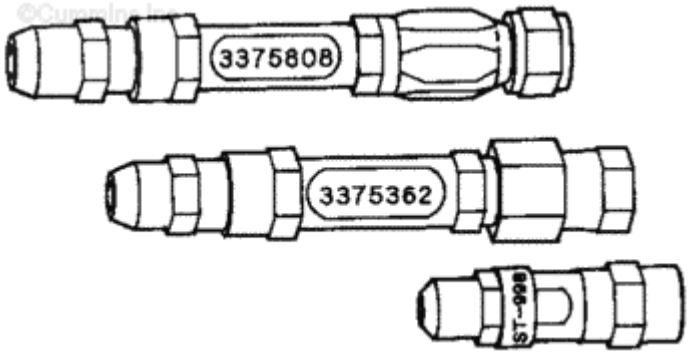
Last Modified: 23-Sep-2004

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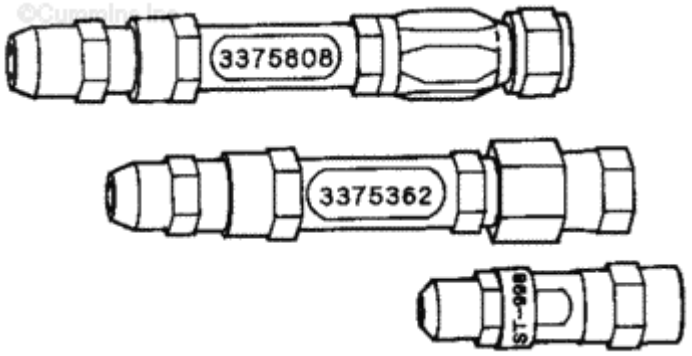
022-001 Service Tools

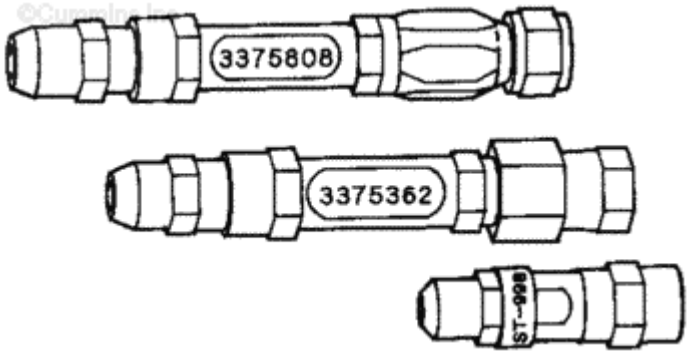
Fuel System

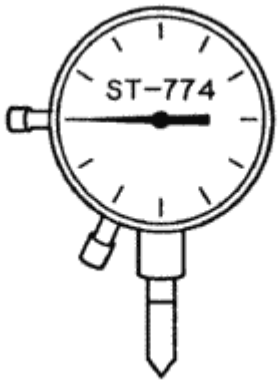
Tool Number		
ST-434	**Vacuum Gauge** Measure fuel pump inlet restriction. Includes hose adapter (number 12 hose), Part Number 3375845 and hose adapter (number 10 hose), Part Number ST-434-2	

Tool Number		
ST-998	**Fuel Sight Glass** Use to check for air in fuel suction line with number 10 hose.	

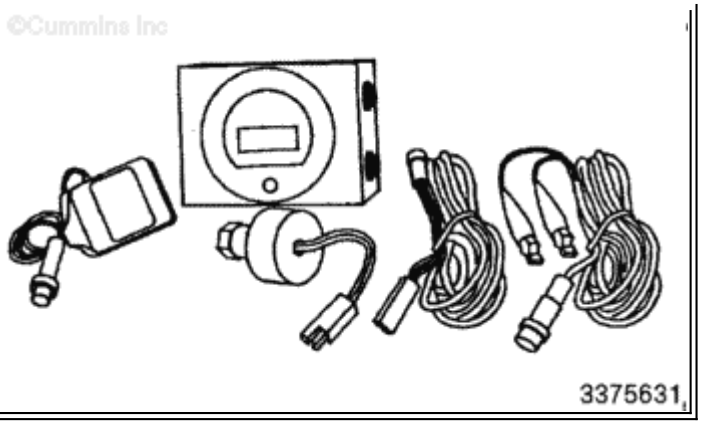
Tool Number		
	Fuel Sight Glass Use to check for air in	

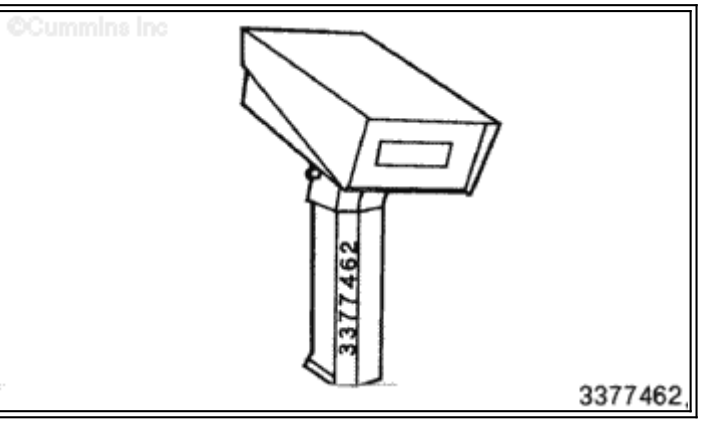
3375362	fuel suction line with number 12 hose.	

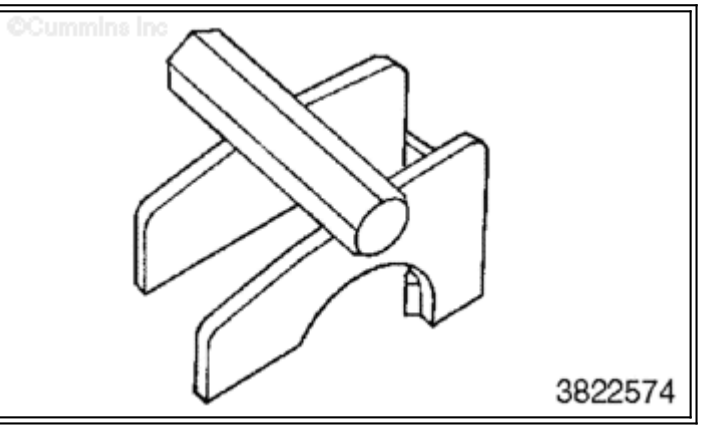
Tool Number 3375808	**Fuel Sight Glass** Use to check for air in fuel suction line with number 16 hose.	

Tool Number ST-774	**Tachometer** Use to measure engine rpm.	 st-774

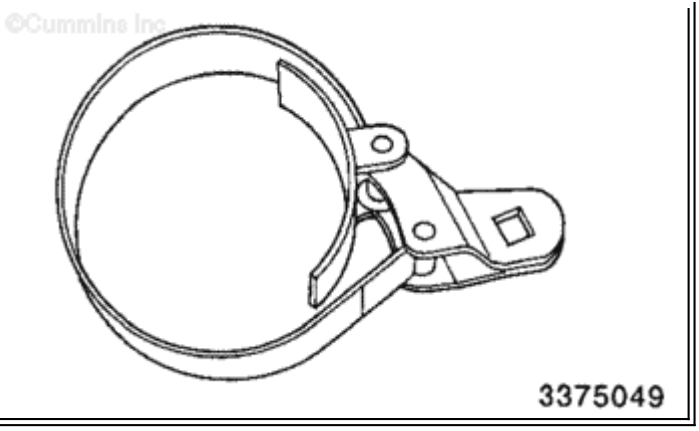
Tool Number	**Digital Tachometer** Use to measure engine rpm.	

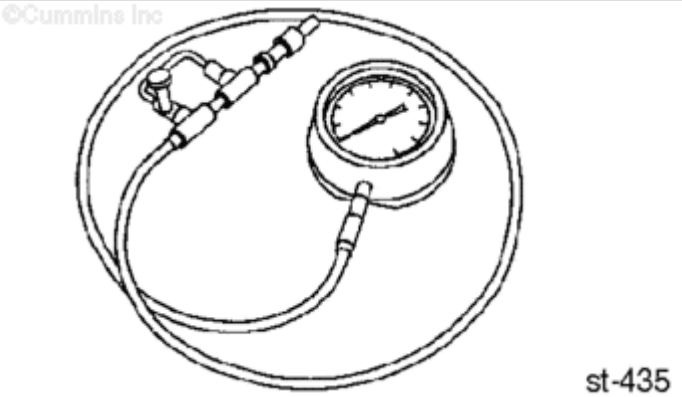
3375631		

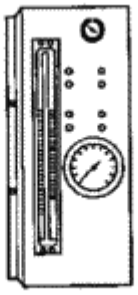
Tool Number 3377462	**Optical Tachometer** Use to measure engine rpm.	

Tool Number 3822575	**Injector and Valve Adjustment Kit** Kit is used to adjust valves and injectors without Jacobs® engine brake installed.	

Tool Number	**Filter Wrench**	

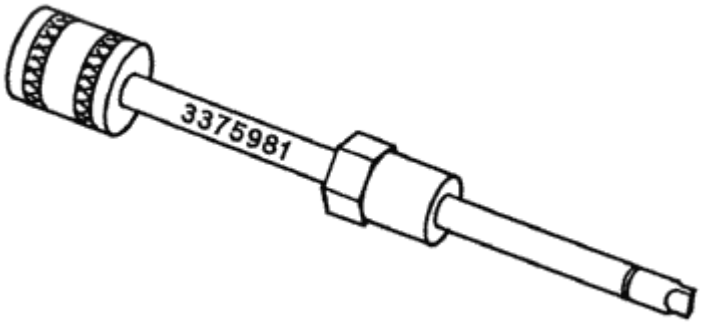
3375049	Use to remove fuel filter.	

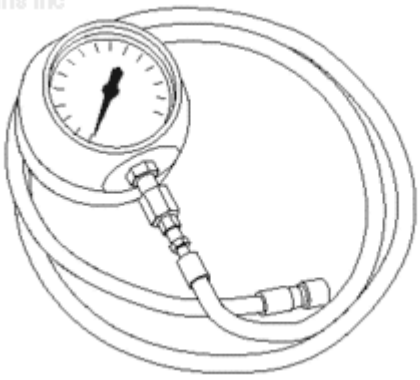
Tool Number ST-435	**Engine Rail Pressure Gauge** Use to measure fuel pump pressure. Includes necessary hoses and hardware to attach to a fuel pump.	

Tool Number 3376375	**Fuel Measuring Device** Use to measure fuel rate on engine.	

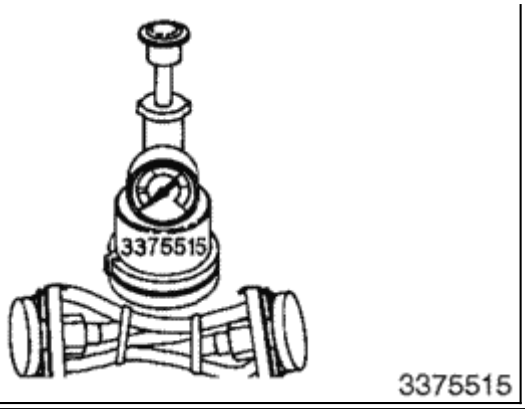
Tool Number	**Remote Starter Switch** Use to turn engine on	

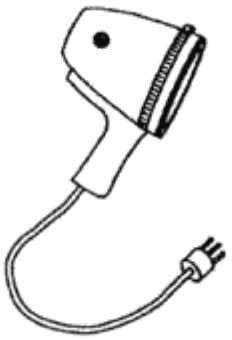
3376506	and off from a remote location.	 3376506

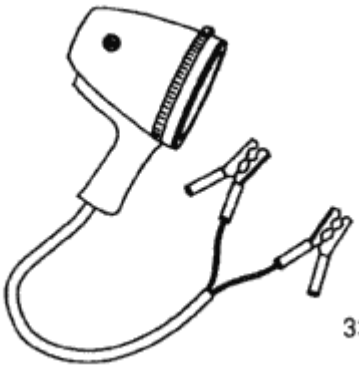
Tool Number 3375981	**Fuel Pump Idle Speed Adjusting Tool** Use to adjust automotive idle setting.	 3375981

Tool Number ST-1273	**Pressure Gauge** Use to measure injector drain line restriction.	 st-1273

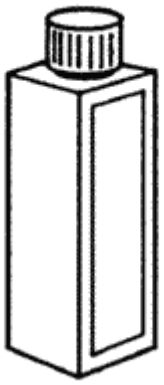
Tool	**Control Pressure**	

Number	Pump	
3375515	Use to check AFC setting.	 3375515

Tool Number	Black Light (AC)	
3377253	Use to locate fuel leaks.	 3377253

Tool Number	Black Light (DC)	
3377394	Use to locate fuel leaks.	 3377394

Tool Number	Fluorescent Tracer	

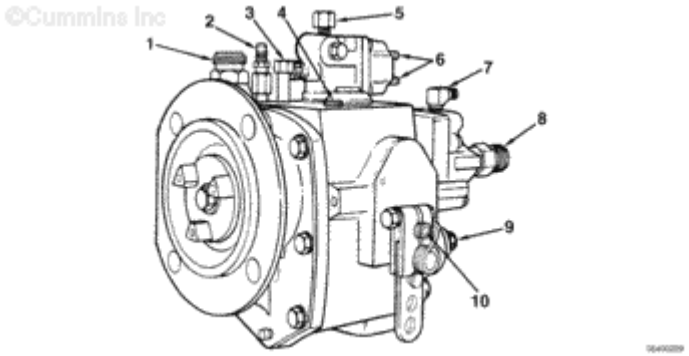
3376891	Place in engine oil or fuel. Use black light to find leaks.	©Cummins Inc  3376891

Last Modified: 15-Nov-2004

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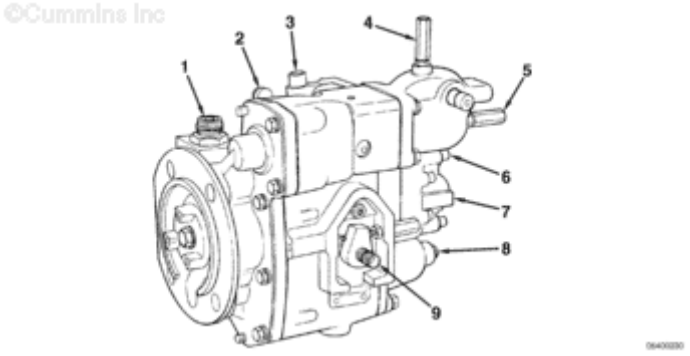
005-001 AFC Assembly

Exploded View



PT (Type G) AFC Connection and Adjustment Locations

1. Tachometer drive
2. AFC air supply
3. AFC fuel return
4. Priming plug
5. Fuel to the injector
6. Shutoff valve electric connection
7. Gear pump fuel return
8. Idle speed screw location
9. Fuel rate (pressure) switch.

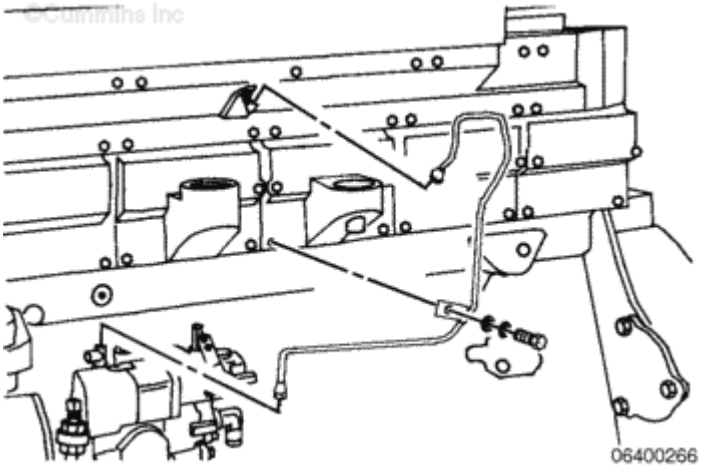
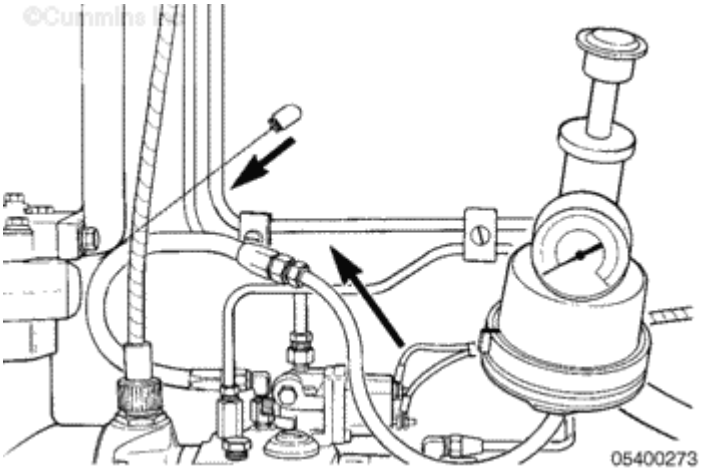


PT (Type G) AFC-VS Connection and Adjustment Locations

1. Tachometer drive
2. AFC air supply

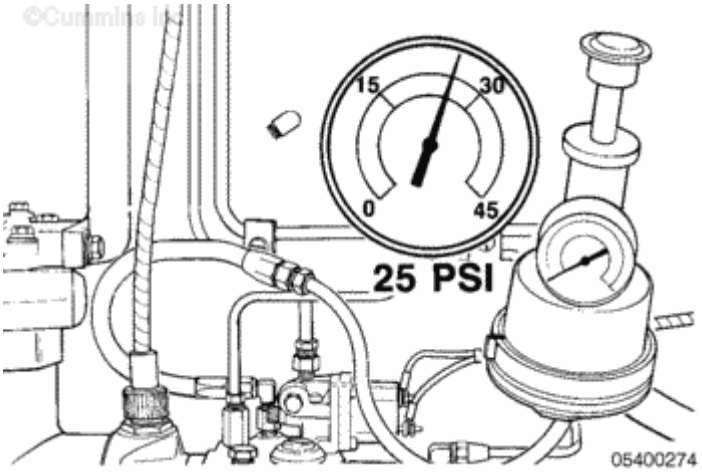
3. Fuel to injectors
4. VS high speed screw
5. VS low (idle) speed screw
6. Gear pump fuel return
7. Fuel inlet connection
8. Idle speed screw location
9. Fuel rate (pressure) screw

Leak Test

Remove the AFC air inlet line. Install a cap on the connection at the intake manifold.		
Install pressure pump, Part Number 3375515, or equivalent. If a pressure pump is **not** available, install a regulated air pressure hose, with a shutoff valve to the line.		

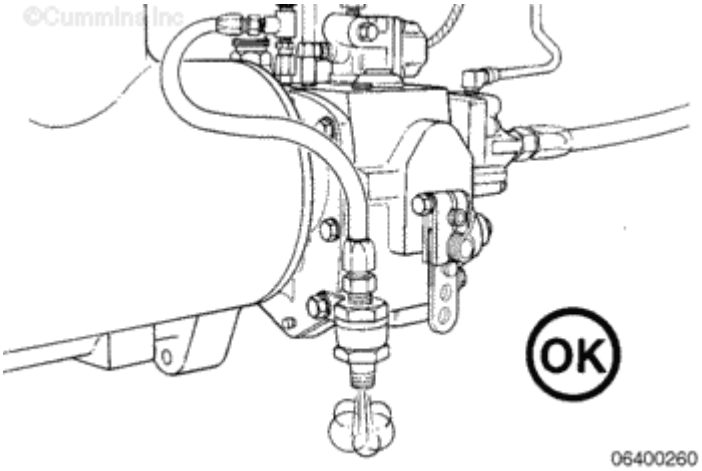
Apply 170 kPa [25 psi] air pressure to the air supply line.

If shop air is in use close the shutoff valve.

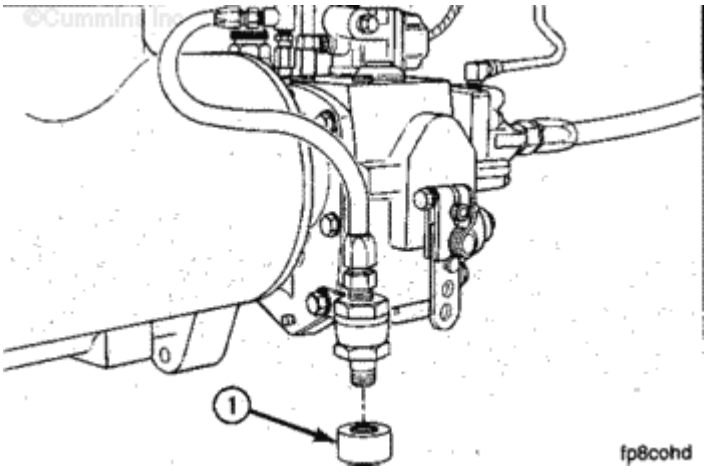


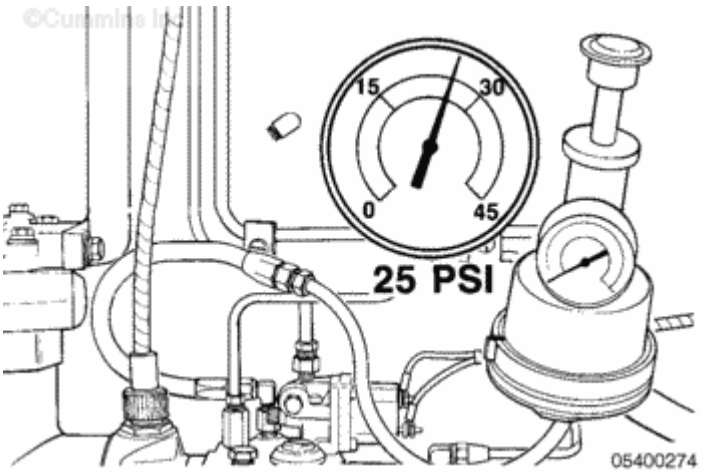
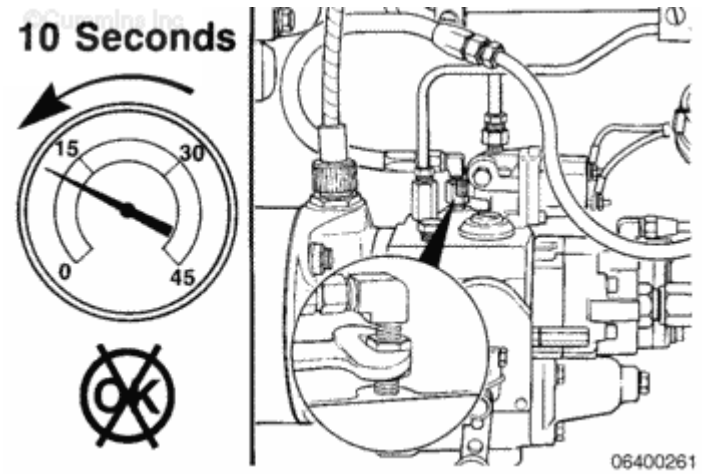
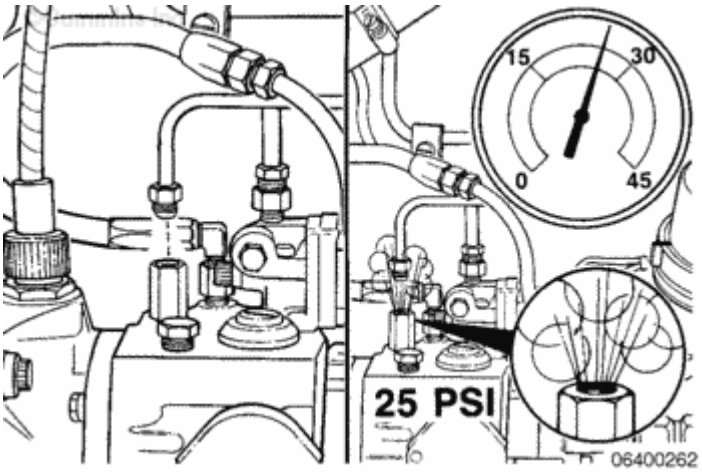
If the engine application contains overhead fuel tanks, check the for air coming out of the AFC leak kit valve.

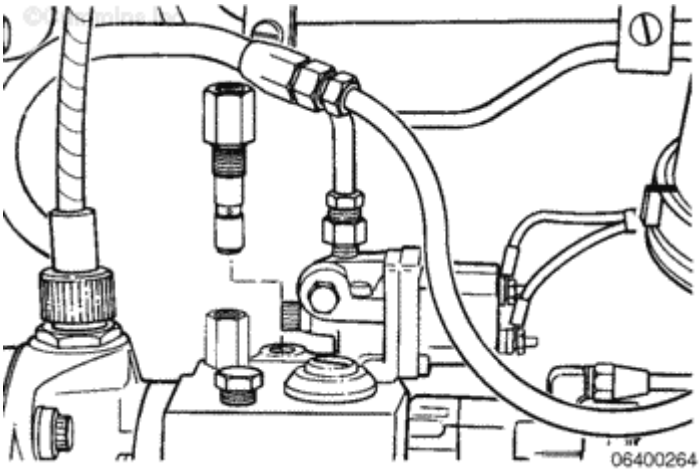
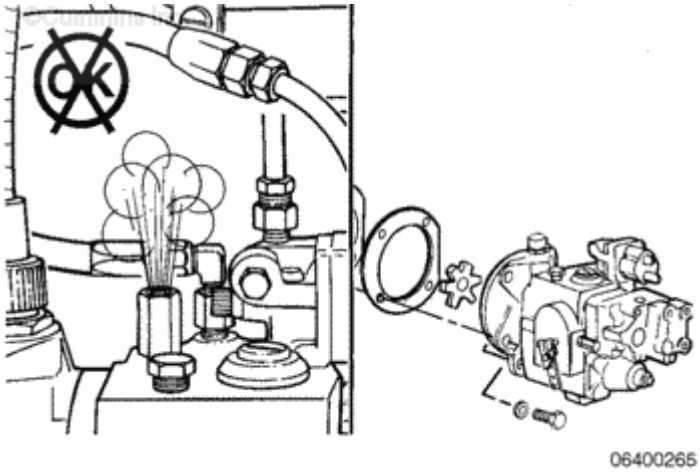
If air is **not** coming out of the AFC valve, replace the valve.

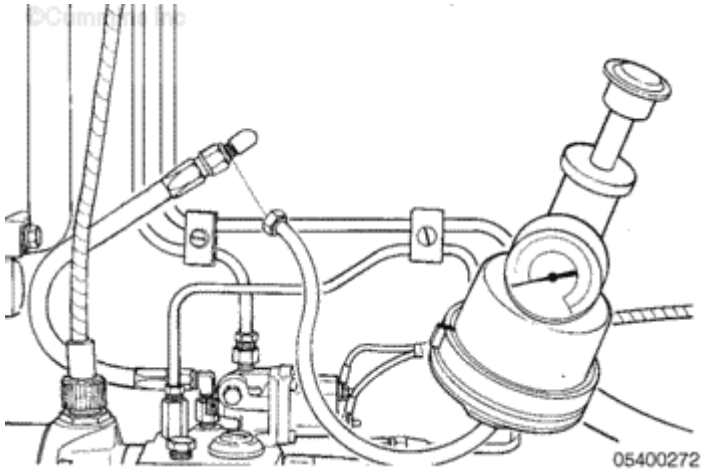


Install a test cap (1) to the AFC leak kit valve to prevent leakage during this test.

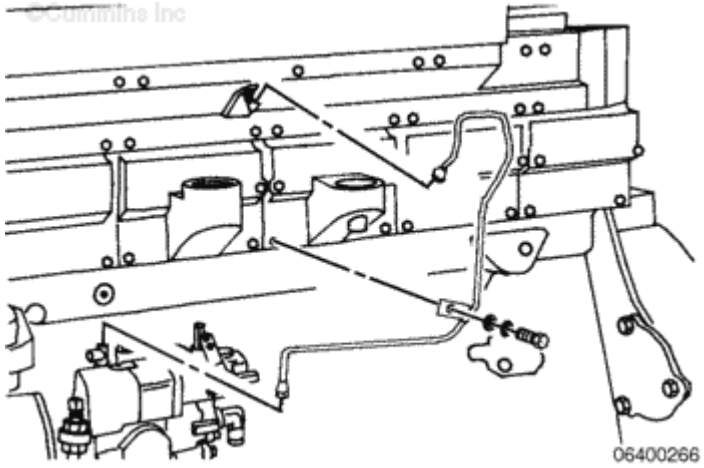


Apply 170 kPa [25 psi] air pressure to the AFC air supply line. If shop air is in use close the shutoff valve.		
If the pressure drops any within 10 seconds, check the line and connections for leaks. Replace the line or tighten the connection if a leak is found.		
If the pressure drops and the line connections do **not** leak, remove the AFC fuel return line from the top of the fuel pump. Apply 170 kPa [25 psi] to the AFC air supply line.		

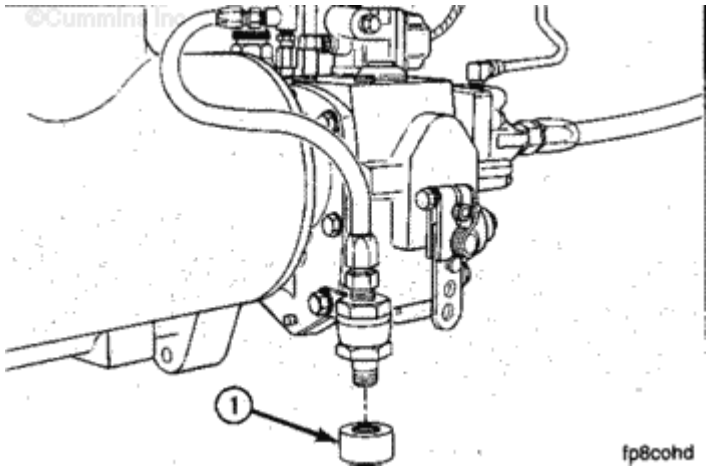
When the AFC bellows moves, a puff of air or a small amount of fuel will escape from the top of the fuel pump.		
Remove and clean, or replace the check valve.		
If the air flow is continuous from the top of the fuel pump, the AFC bellows is defective. Replace the fuel pump. Refer to Procedure 005-016.		
Remove the pressure pump or shop air line.		



Install the AFC air inlet line.



Remove the test cap (1) from the AFC leak kit valve.

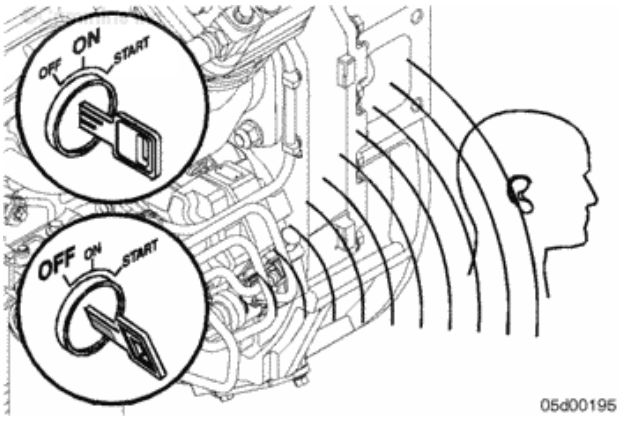
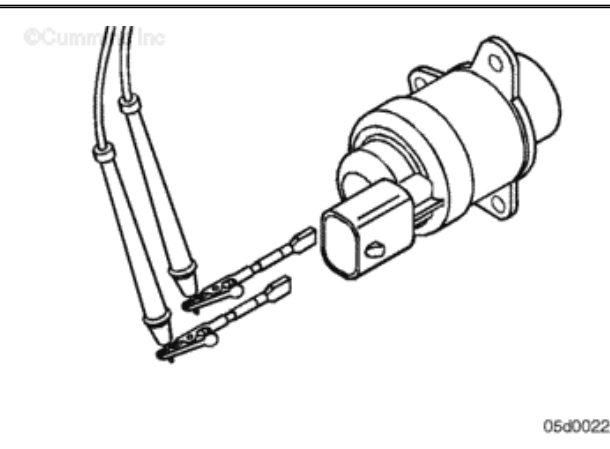


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005-007 EFC Actuator Valve

Initial Check

Check the electronic fuel control actuator for an audible click after a key-on-key-off cycle. If no audible click is heard at key-off, measure the resistance of the electronic fuel control actuator valve. The electronic fuel control (EFC) actuator can also be checked using an INSITE™ electronic service tool. Refer to the OEM service manual for instructions.		
Measure the resistance of the electronic fuel control actuator valve. The maximum resistance is 5 ohms.		

Preparatory Steps

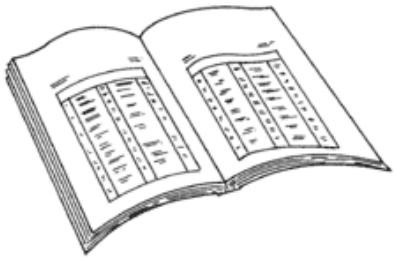
WARNING

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.

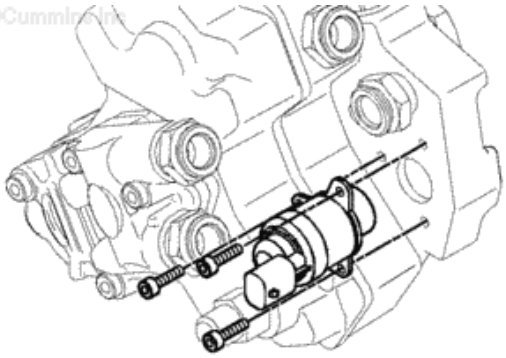
- Steam-clean the fuel pump and the area around the fuel pump.
- Dry with compressed air.



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Remove

Remove the capscrews and electronic fuel control actuator.



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Install

CAUTION

Do not pause more than 2 minutes between Torque Steps 1 and 2. This can cause the capscrews not to maintain their torque value. Leakage or engine damage can result.

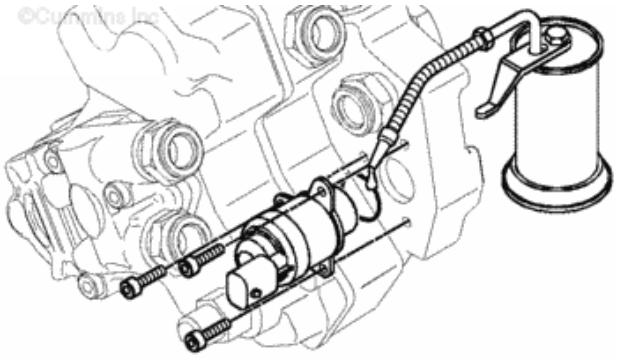
Lubricate the new o-ring with clean oil before installation.

Install a new o-ring on the electric fuel control actuator.

Install the electronic fuel control actuator and capscrews, and tighten.

Torque Value:	Step 1	3 n.m [27 in-lb]
	Step 2	7 n.m [62 in-lb]

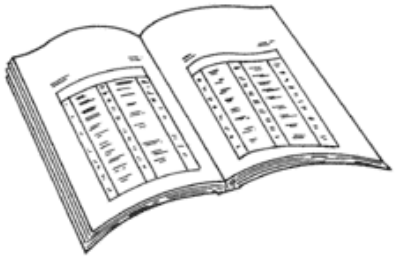
Be sure that the electronic fuel control actuator flange is flush with the mounting surface on the fuel pump.



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Finishing Steps

- Operate the engine and check for leaks or fault codes.



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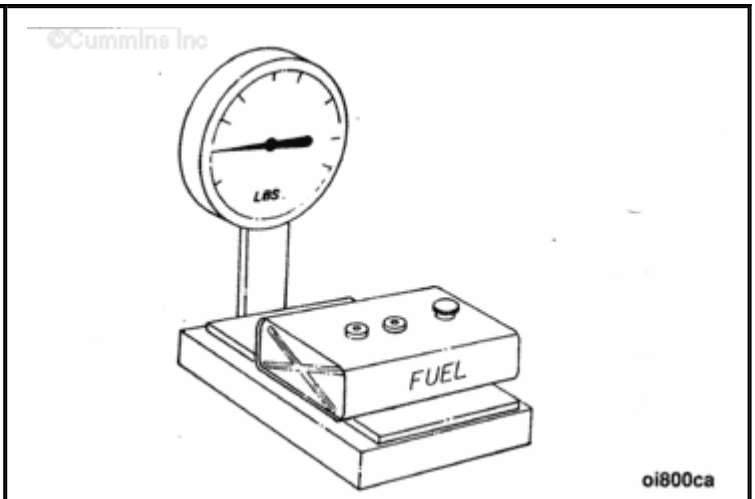
Last Modified: 01-Dec-2004

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005-010 Fuel Consumption

Test

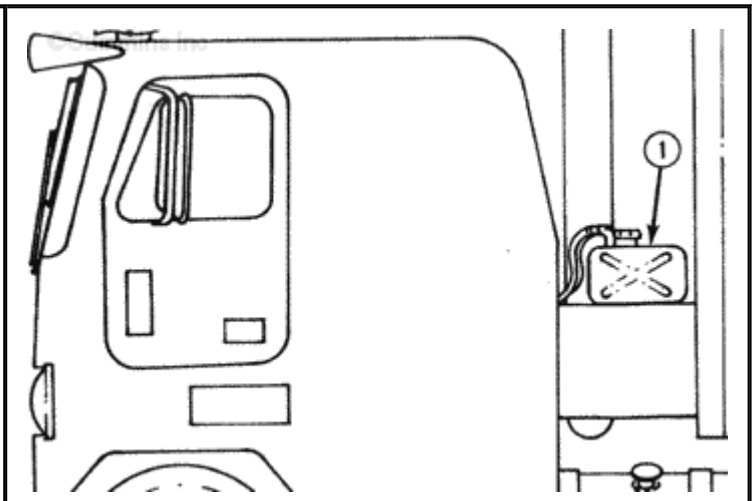
The most accurate method to check the fuel consumption is to weigh the fuel used.

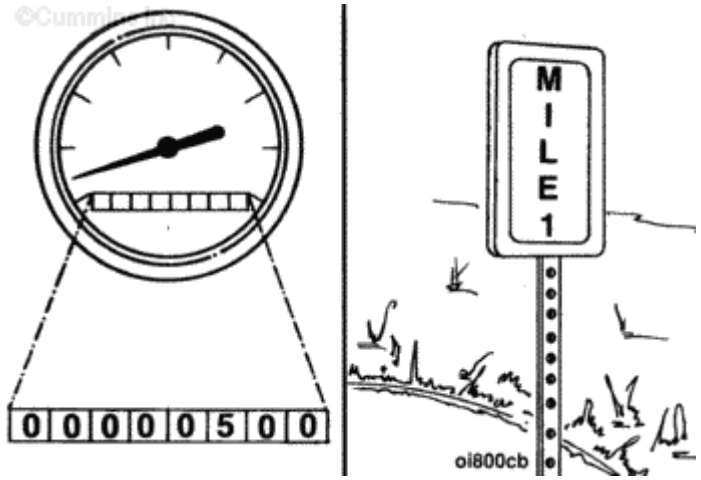
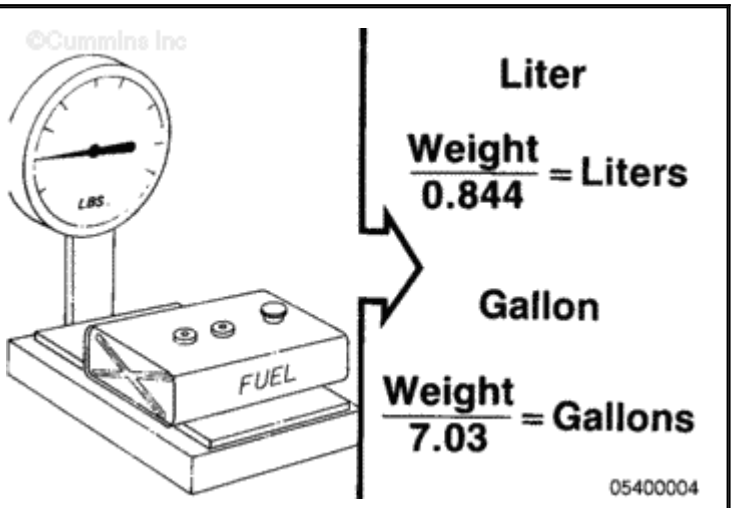


Install a remote fuel tank (1) with enough capacity to run 80 kilometers [50 miles] or one hour.

Use a scale capable of measuring within 0.045 kg [0.1 lb] when weighing the fuel tank.

Fill the fuel tank. Weigh the tank with the fuel. The weight of Number 2 diesel fuel is



0.844 kg per liter [7.03 lbs per gallon].		
For on-highway applications, measure the distance traveled with an accurate odometer. The odometer accuracy can be checked by using measured miles or kilometers. For off-highway applications, measure the time with a stop watch.		
For on-highway applications, after traveling the route, weigh the fuel remaining and compute the fuel used. For off-highway applications, after one hour of operation, weigh the fuel remaining and compute the fuel used.		
For on-highway applications, compute the kilometers per liter [miles per gallon]. For off-highway applications, compute the liters		

per hour [gallons per hour].

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$$\frac{\text{Miles}}{\text{Gallons}} = \text{MPG}$$

$$\frac{\text{Kilometers}}{\text{Liters}} = \text{KPL}$$

In addition to the measurement of the fuel used, the following factors provide points for running the recognized Type II SAE test.

Although the SAE test applies to highway applications, the principles described can be used in off-highway applications also.

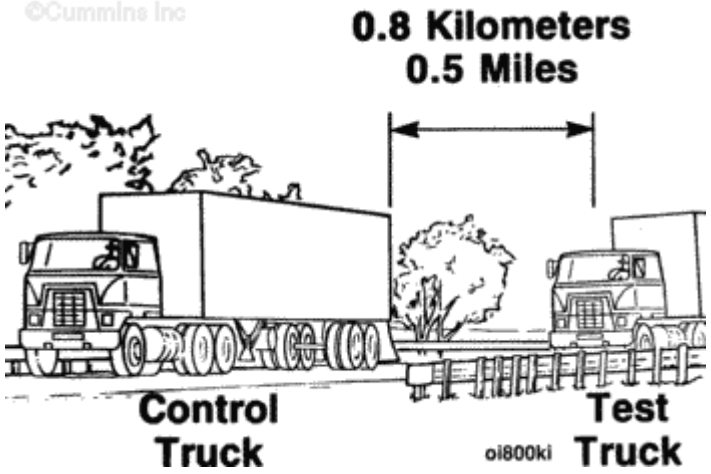
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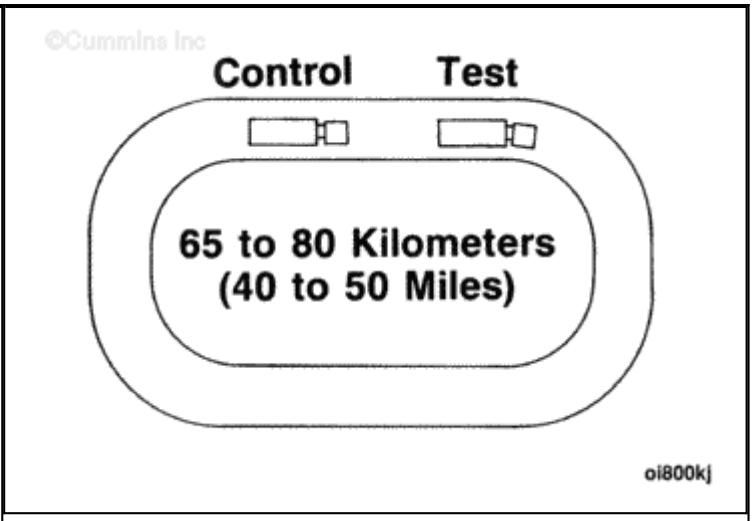
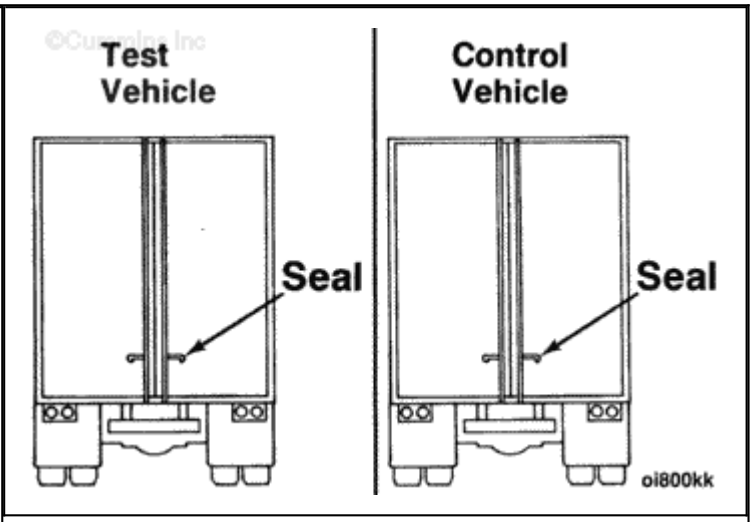
Type II
Fuel Test
SAE
RCCC
ATA

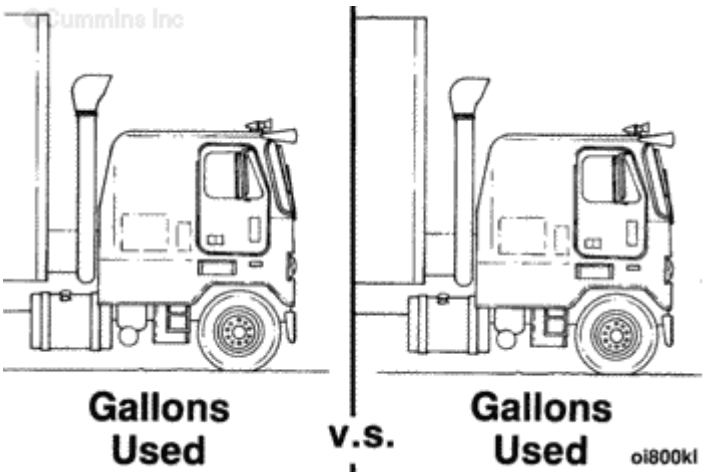
Perform the test with the test vehicle and a control vehicle. The control vehicle compensates for the changes in traffic conditions.

The vehicles **must** stay close together to experience the same varying traffic and weather

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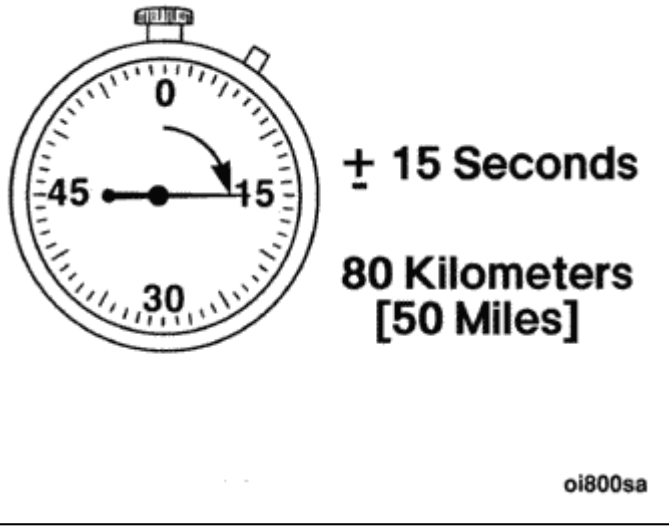


conditions, but **not** so close as to affect each other.		
The test course **must** be 65 to 80 kilometers [40 to 50 miles] long.		
The test route and truck weights **must not** change during the test.		
All of the test results are based on comparing the fuel used by the test truck to the fuel used by the control truck.		



Drive the truck on a "warm up'" test run. Drive enough tests to achieve the following:

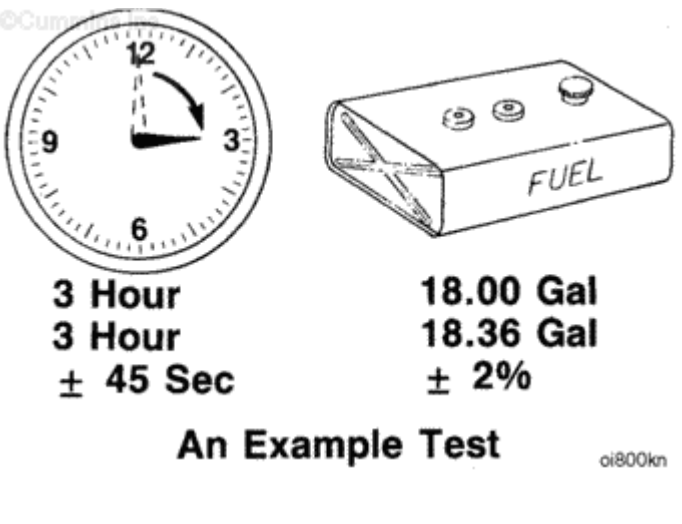
Difference in elapsed time between each test run can **only** be ± 0.5 percent. This is ± 15 seconds on 80 kilometers [50 miles].



The fuel usage of the test truck between test drives **must** fall within a two percent range.

The same range also applies to between drives of the control truck.

The differences in traffic and driving



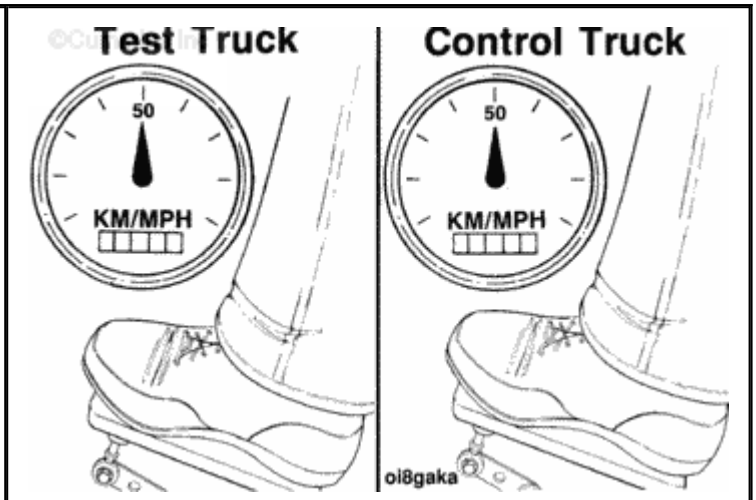
practices can make the test drive fall out of the two percent range.

A minimum of three test drives that meet these conditions make a valid test.

A single test drive is unreliable.

Use the same, experienced drivers for all of the tests.

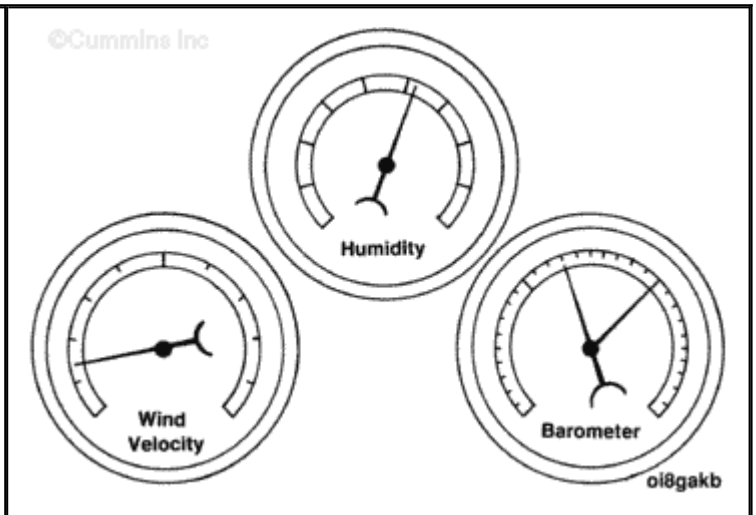
The vehicle speed **must** be representative of a typical operation.



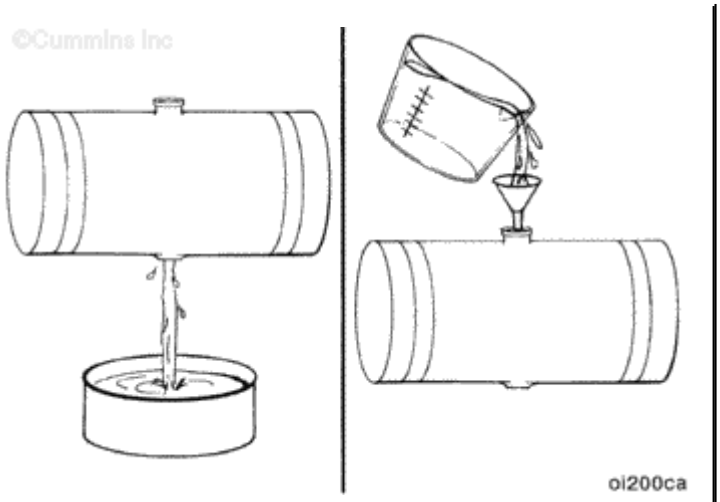
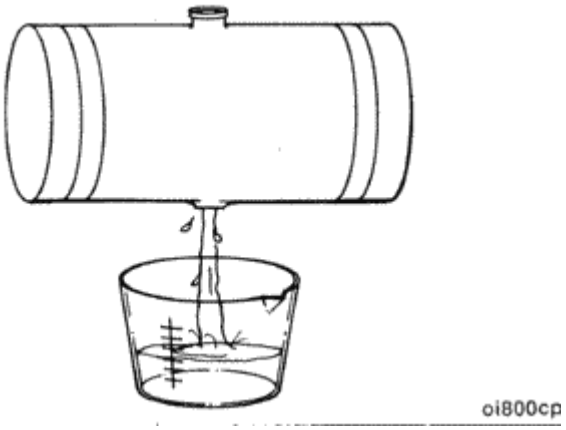
During the test record the following:

- Ambient temperature
- Humidity
- Barometric pressure
- Wind velocity
- Wind direction.

Avoid testing under any extreme conditions.



An alternate method

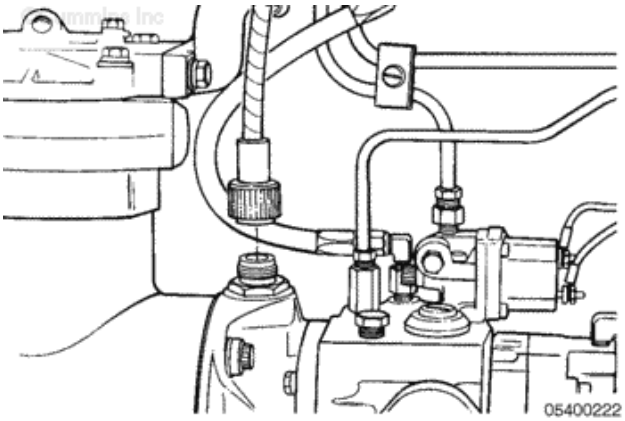
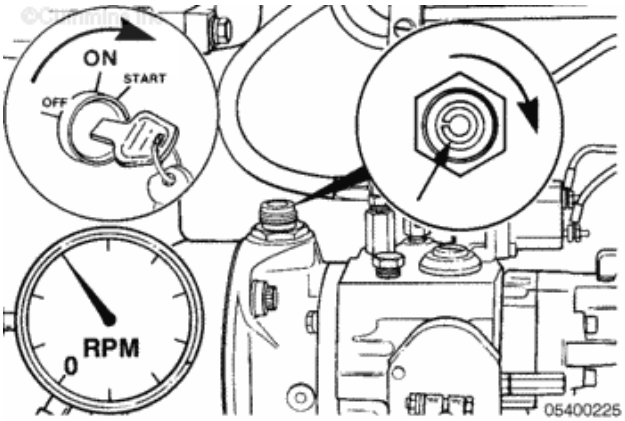
of measuring fuel used is as follows: Drain the fuel tank. Add a measured amount of fuel used to the tank.		©Cummins Inc 
After the test, drain the remaining fuel in the tank into a calibrated container and subtract it from the amount added.		©Cummins Inc 

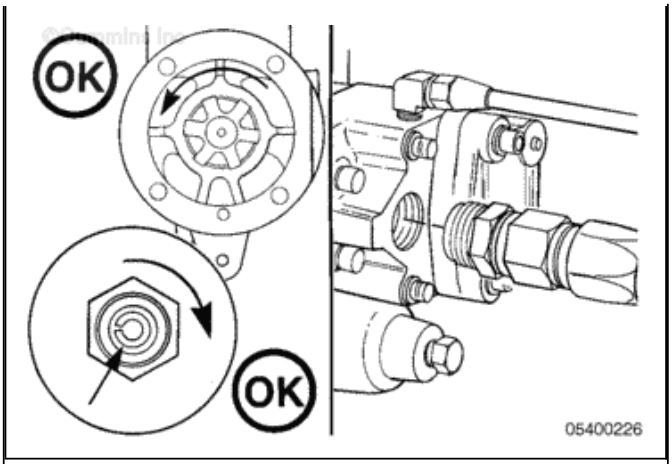
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005-016 Fuel Pump

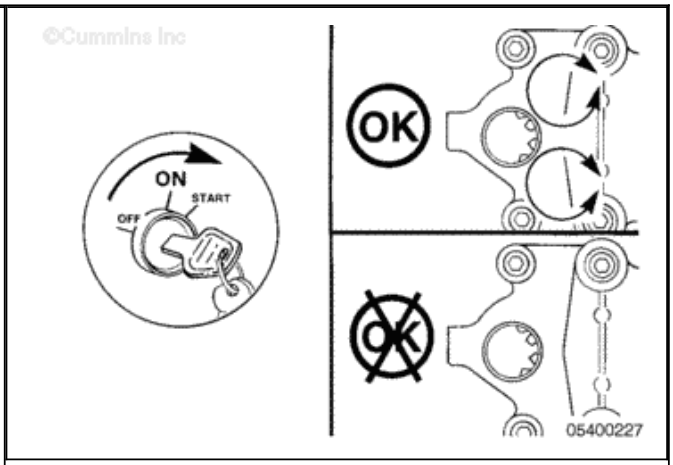
Rotation Check

Remove the tachometer drive cable from the fuel pump.		
Crank the engine and make sure the tachometer drive shaft is turning. If the tachometer drive shaft is **not** turning, Remove the fuel pump and check the air compressor and accessory drive operation.		
If the tachometer drive shaft rotates, the gear pump rotation **must** be checked. Remove the fuel supply hose at the gear pump.		



Look into the gear pump and crank the engine. The gear pump gears **must** turn.

If the gear pump gears do **not** turn, replace the fuel pump.



Preparatory Steps

All Applications Except Rail

WARNING

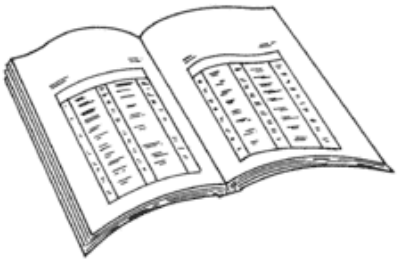
Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation ot reduce the possibility of severe personal injury or death when working

on the fuel system.

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 (-) cable last.

- Clean the fuel pump and surrounding area.
- Disconnect the battery cables.



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Rail Applications

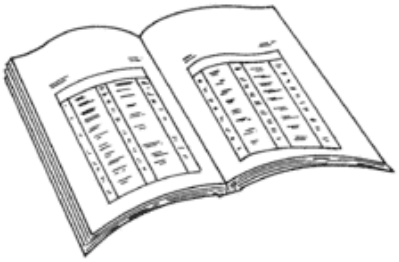
WARNING

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WARNING

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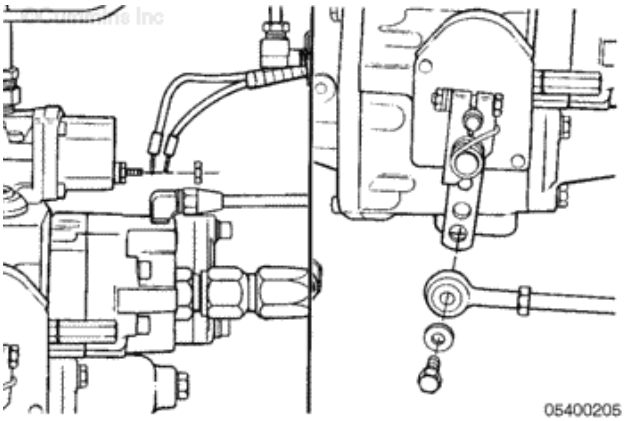
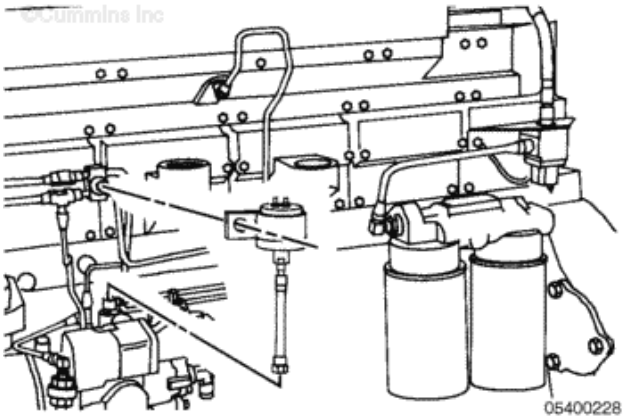
- Clean the fuel pump and surrounding area.



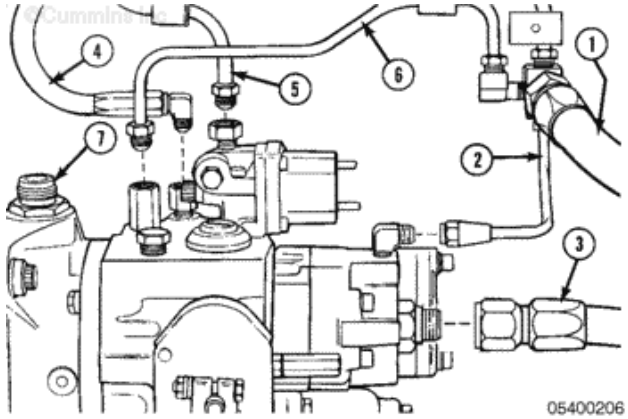
ck800wa

• Disconnect the battery cables. • Remove the lubricating oil scavenge pump.		

Remove

Remove the wire to the fuel shutoff valve. Remove the linkage from the throttle lever.		
NOTE: This step applies only to engines equipped with STC. Remove the STC fuel rail switch.		
Remove the below listed items: • Fuel drain (1) • Gear pump cooling drain (2) • Gear pump suction line (3)		

- AFC fuel drain (4)
- Fuel supply to injectors (5)
- AFC supply hose (6)
- Tachometer cable (7).

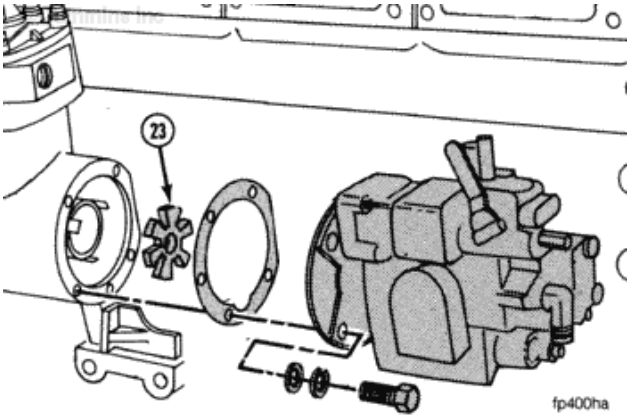


Remove the four fuel pump mounting capscrews.

Remove the fuel pump.

Remove the drive coupling (23).

Remove and discard the gasket.

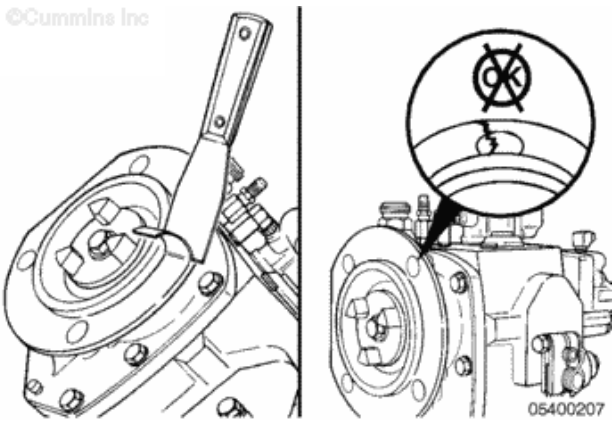


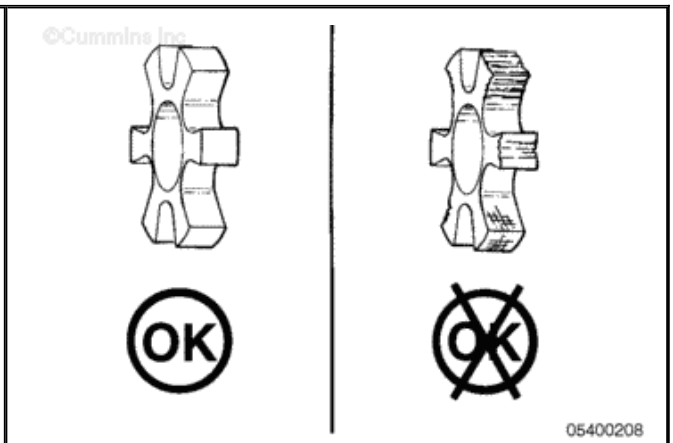
Clean and Inspect for Reuse

Clean the fuel pump and the air compressor or accessory drive mounting surfaces.

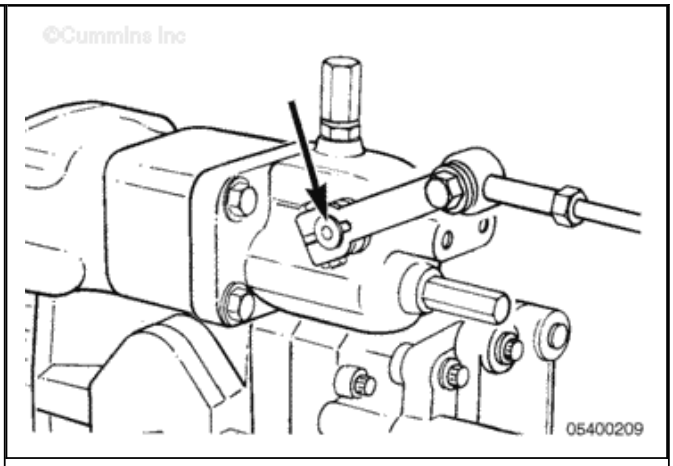
Inspect the mounting surfaces for damage.

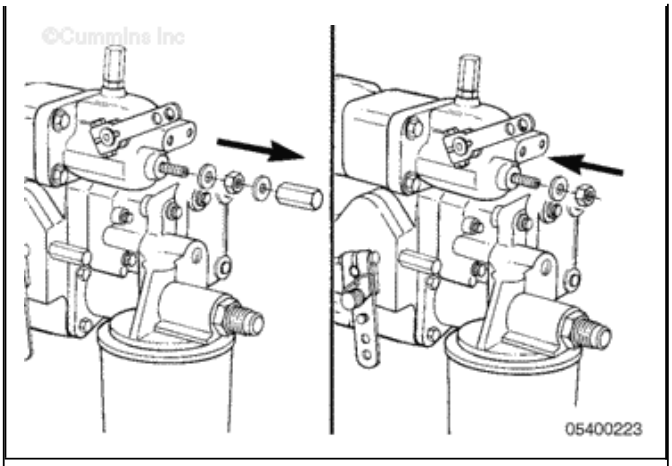
If the mounting surface is damaged, the fuel pump **must** be repaired or replaced.

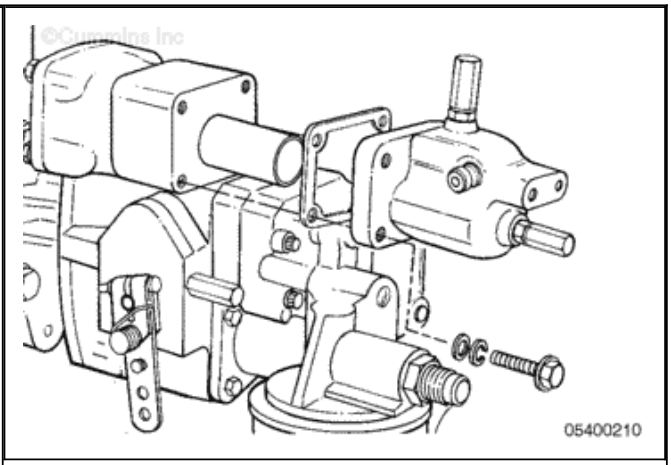
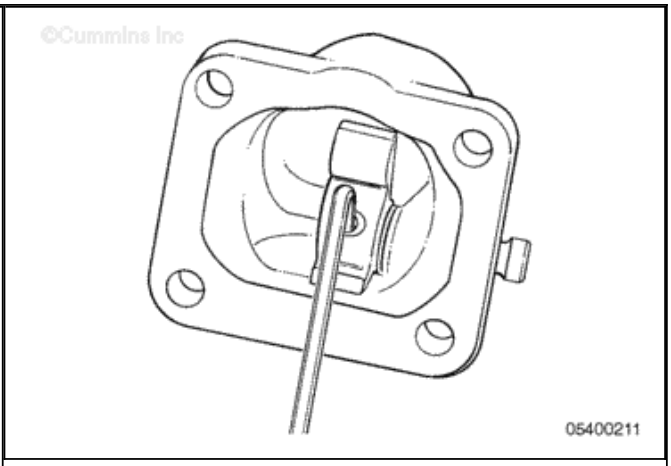


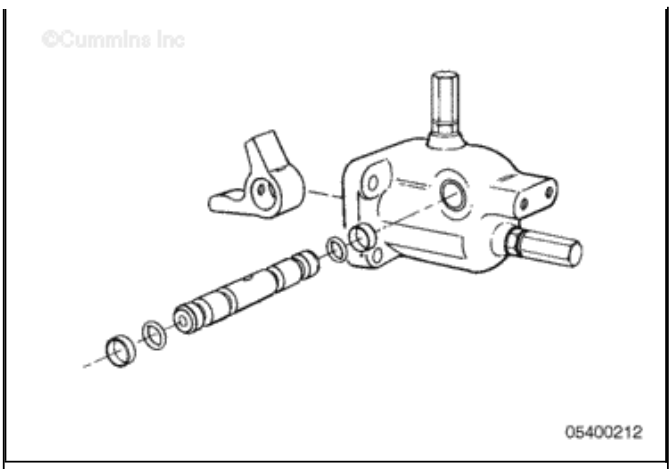
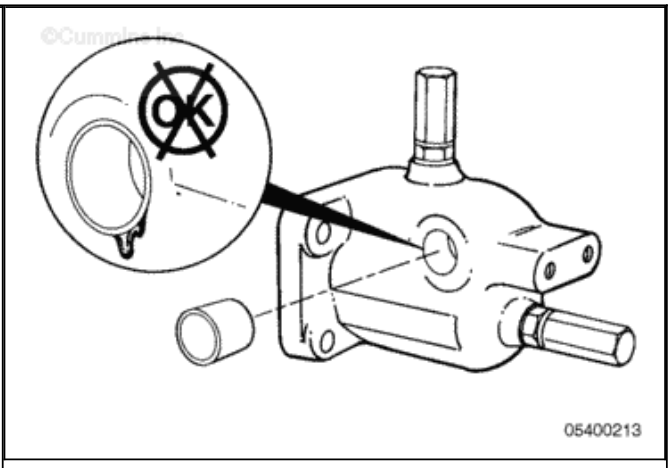
Inspect the spider coupling for damage. If the spider coupling is damaged, it **must** be replaced.		

Disassemble

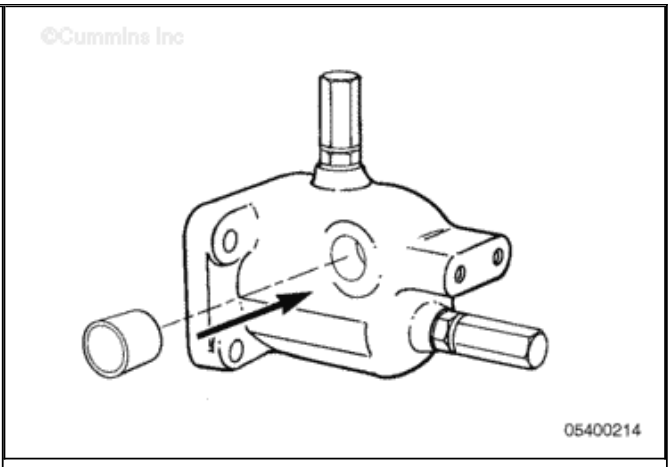
Mark the angle of the variable speed throttle lever on the variable speed throttle shaft. Remove the variable speed throttle lever.		
Remove the adjusting screw lock nuts, jam nuts, and copper washers. Discard the copper washers.		

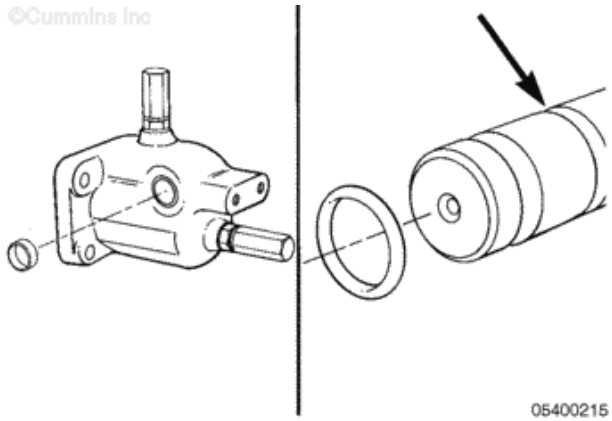
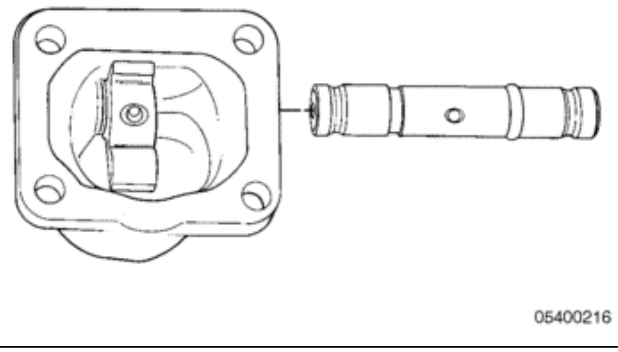
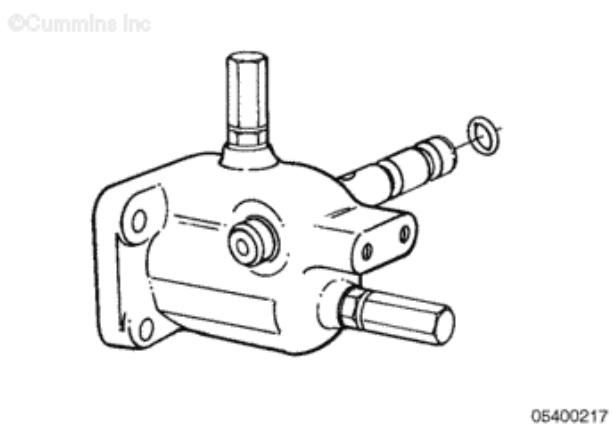


Remove the variable speed spring pack housing cover.		
Loosen the set screw in the variable speed throttle stop.		
Remove the variable speed throttle shaft from the cover. Discard the o-rings.		

Remove and discard the shaft dust seals from the cover.		
If fuel is leaking between the bushing and the cover, the bushings **must** be replaced. Press the bushing from the cover.		

Assemble

Press the new bushings into the cover.		

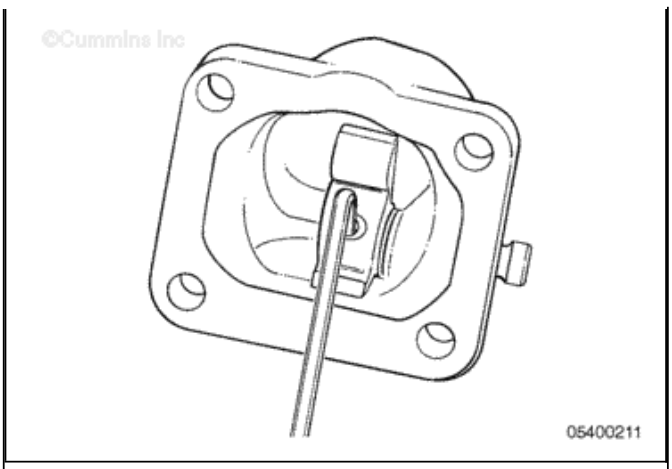
Install new dust seals into the cover. Install a new o-ring onto the shaft near the lever end.		
When installing the throttle stop, the longest lever of the stop goes towards the rear adjusting screw. Install the throttle stop into the cover. Install the shaft into the cover and through the stop.		
Push the shaft out of the other side of the cover. Install the remaining shaft o-ring and push the shaft into the cover.		
Align the set screw hole in the stop with the hole in the		

shaft.

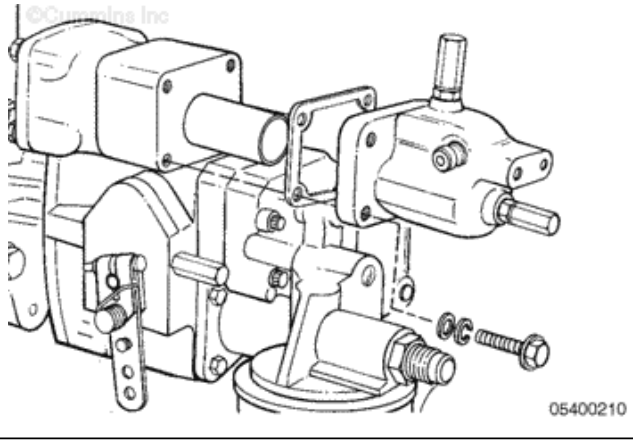
Install the set screw into the stop.

Tighten the setscrew.

Torque
Value: 7 n.m [60 in-lb]



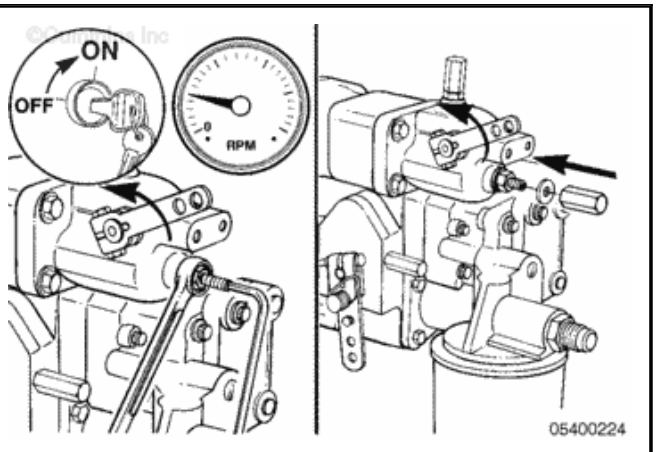
Install a new gasket and the cover onto the fuel pump.



Install new copper washers and the lock nuts.

Install new copper washers between the jam nuts and lock nuts.

Install the jam nuts.

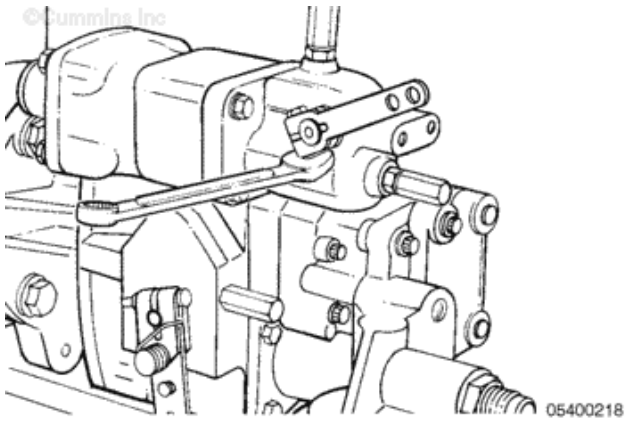


Align the lever with the mark on the idle shaft.

Install the lever onto the idle

shaft.

Tighten the lever retaining nut to secure the lever to the shaft.



Install

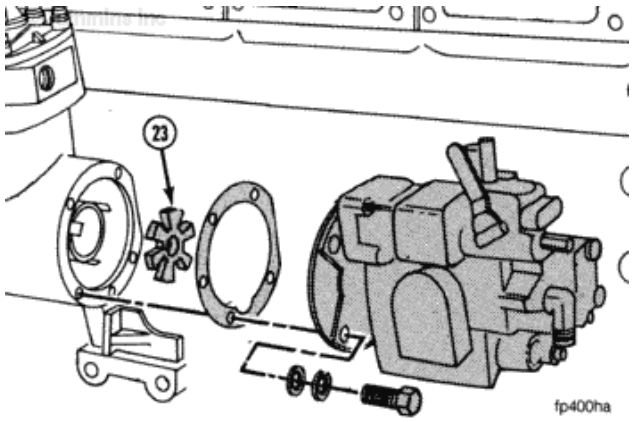
All K19 engines use a white nylon or light green fuel pump drive coupling.

Install the drive coupling (23).

Install the gasket, fuel pump and four capscrews.

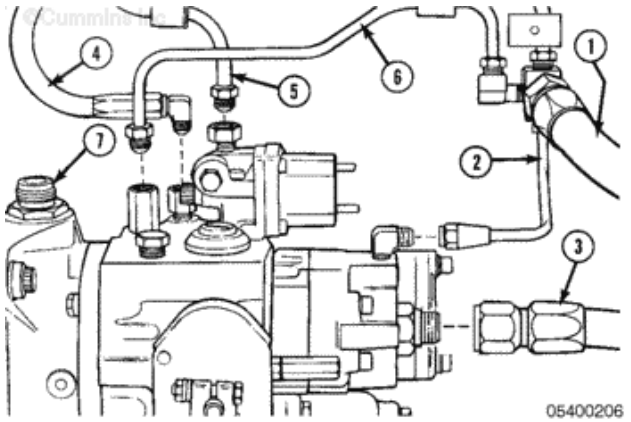
Tighten the capscrews.

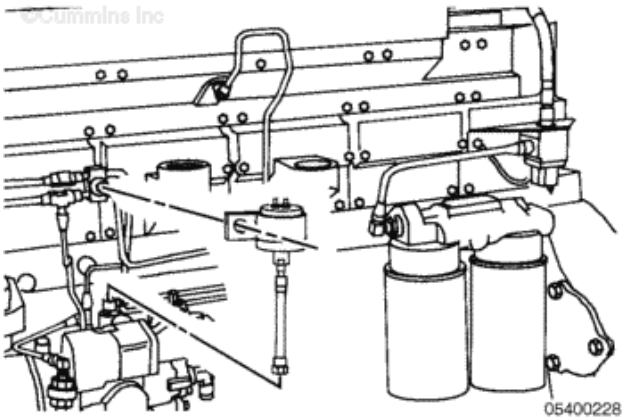
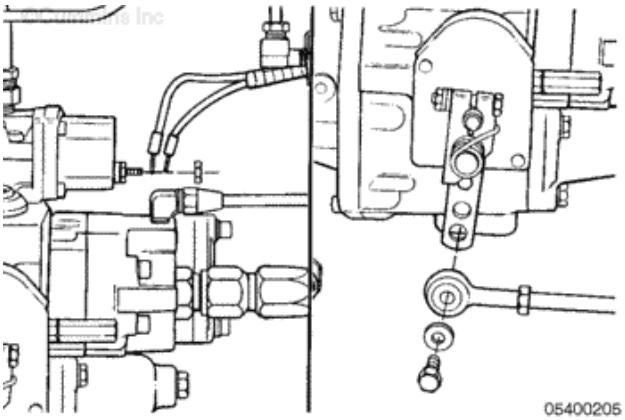
Torque
Value: 45 n.m [33 ft-lb]



Install the following items:

- Fuel drain (1)
- Gear pump cooling drain (2)
- Gear pump suction line (3)
- AFC fuel drain (4)
- Fuel supply to the injectors (5)
- AFC air supply hose (6)
- Tachometer cable (7).



NOTE: This step applies only to engines equipped with STC. Install the STC pressure switch. Connect the hose to the switch and to the fuel pressure tube fitting on the fuel pump.		
Make sure the wire connection nut and ground post are clean. Install the electric wire to the fuel shutoff valve. Tighten the nut. Install the linkage to the throttle lever.		

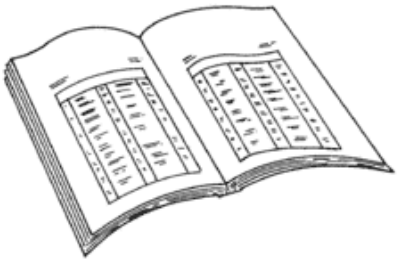
Finishing Steps

All Applications Except Rail

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 (-) cable last.

- Connect the battery cables.



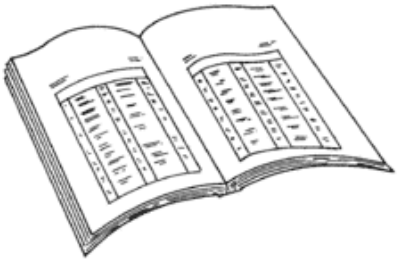
ck800wa

Rail Applications

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 (-) cable last.

- Connect the battery cables.
- Install the lubricating oil scavenge pump.



ck800wa

Prime

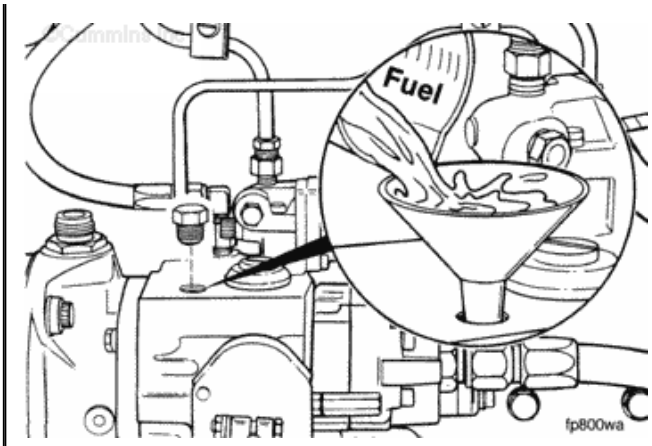
To reduce engine cranking time, the fuel pump can be primed.

NOTE: Only fuel pumps with an automotive governor contain a

priming plug.

Remove the plug from the top of the housing.

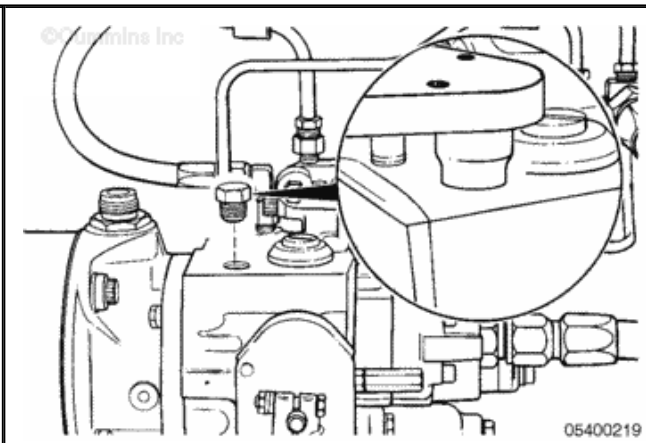
Fill the housing with clean fuel.



Install the plug into the top of the housing.

Tighten the plug.

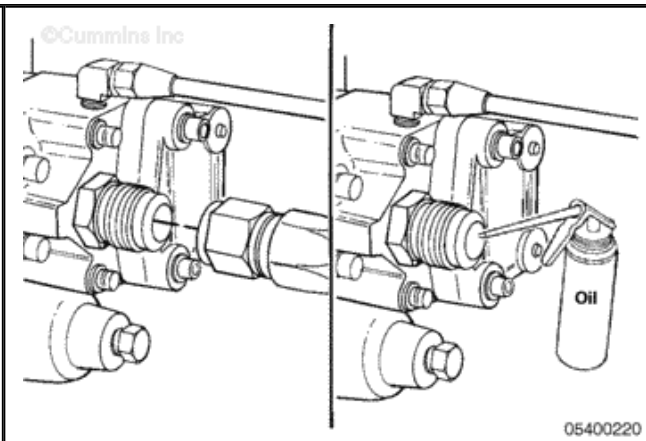
Torque
Value: 30 n.m [20 ft-lb]



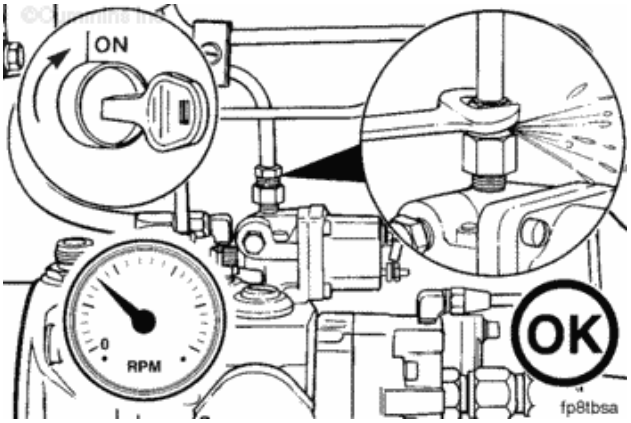
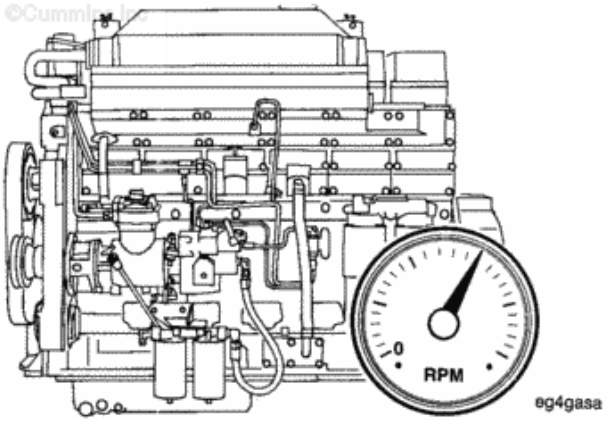
If the priming plug is hard to remove, or the fuel pump is a variable speed type, remove the fuel supply hose to the gear pump.

Fill the gear pump with clean engine lubricating oil. Engine lubricating oil will seal the gears in the fuel pump and cause fuel to be sucked into the pump.

Install the supply hose to the gear pump.



Loosen the fuel outlet connection at the shutoff valve.

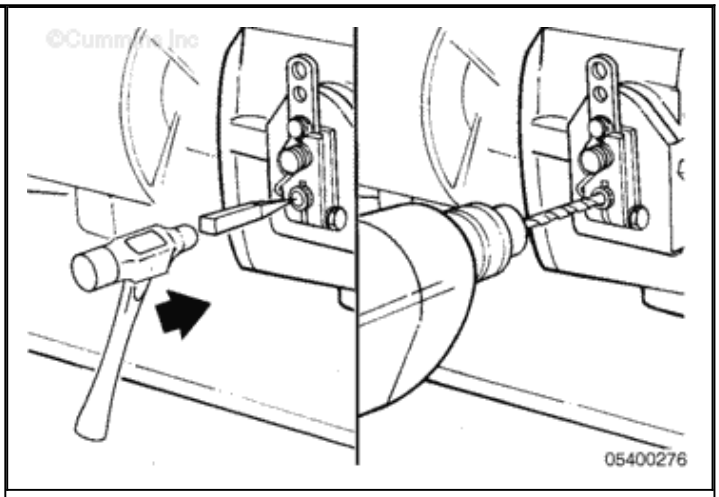
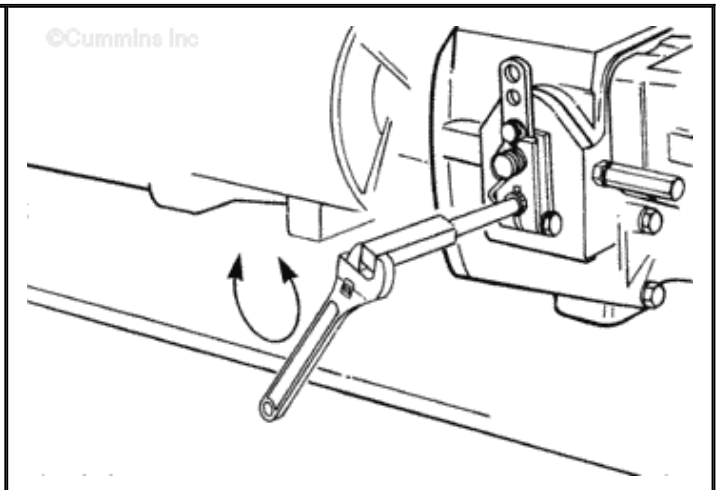
Use the starter to crank the engine until fuel escapes the connection. Tighten the connection. If fuel does **not** escape from the fuel pump, refer to Procedure 006-003.		
Start the engine. Operate at high idle until all air is removed from the fuel lines. Inspect the engine for leaks. Check the governor speed adjustments.		

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005-024 Fuel Pump Fuel Rate with Throttle Shaft Plunger

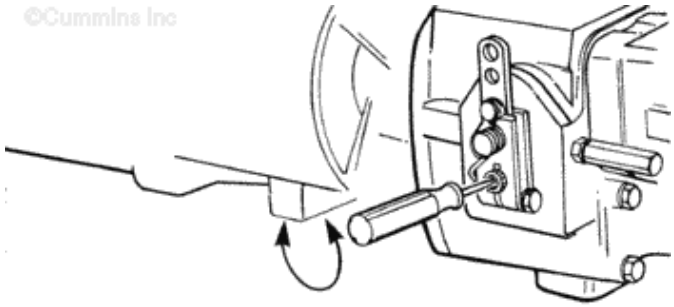
Adjust

To raise or lower the fuel rate, the ball **must** be removed from the end of the throttle shaft. Mark the ball with a center punch. Drill a 4 mm [0.187 in] hole in the ball.		
Use an easy out extractor or a slide hammer to remove the ball.		
Adjust the throttle shaft plunger screw to raise or		

lower the fuel rate.

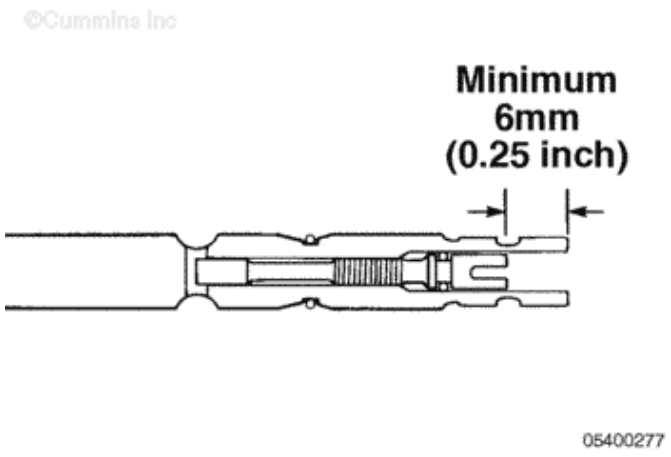
Turn the screw **clockwise** to lower the fuel rate.

Adjust the fuel rate with the screw.



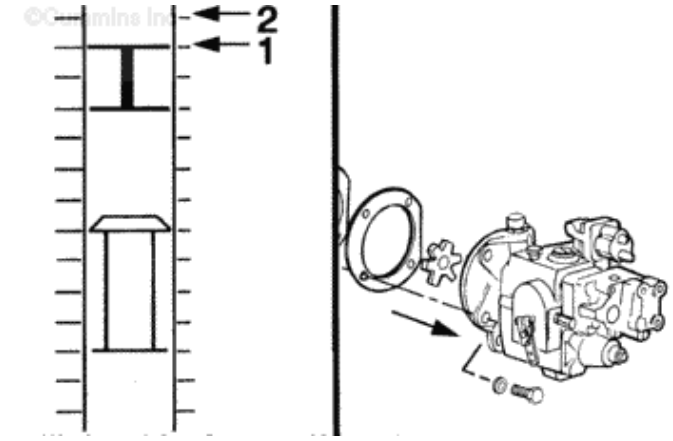
CAUTION

Do not turn the plunger out closer than 6 mm [0.250 in] from the end of the shaft. The fuel pressure can push the plunger out of the shaft. Spilled fuel is a hazard.

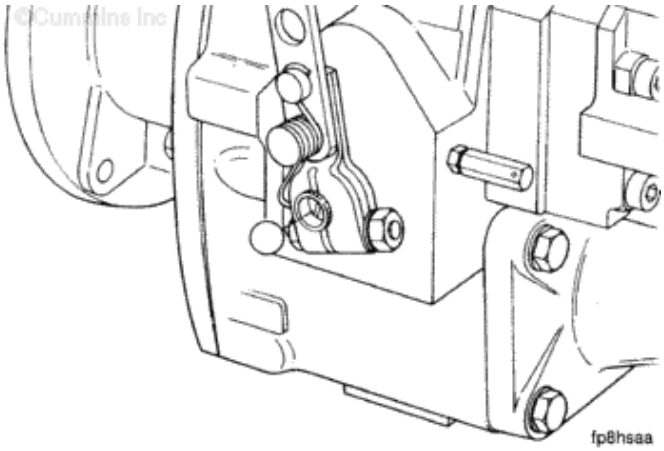


If the maximum flow (1) the pump can be adjusted to is below the correct value, replace the fuel pump, refer to Procedure 005-016





After the fuel rate is

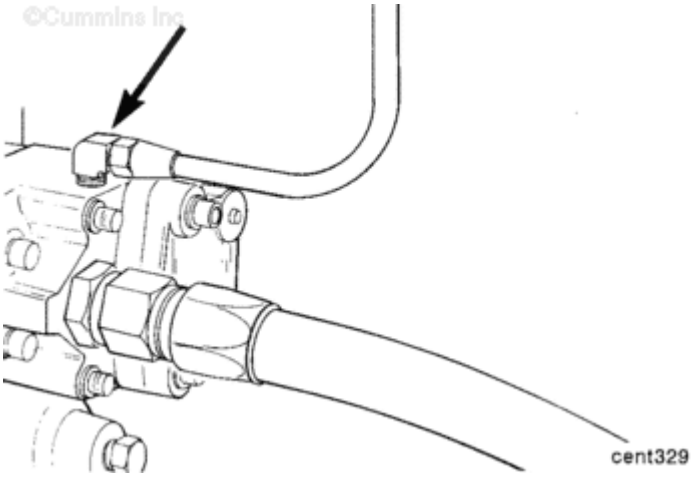
adjusted to the correct value, install a new ball in the end of the throttle shaft. This will help prevent tampering.		

Last Modified: 29-Oct-2004

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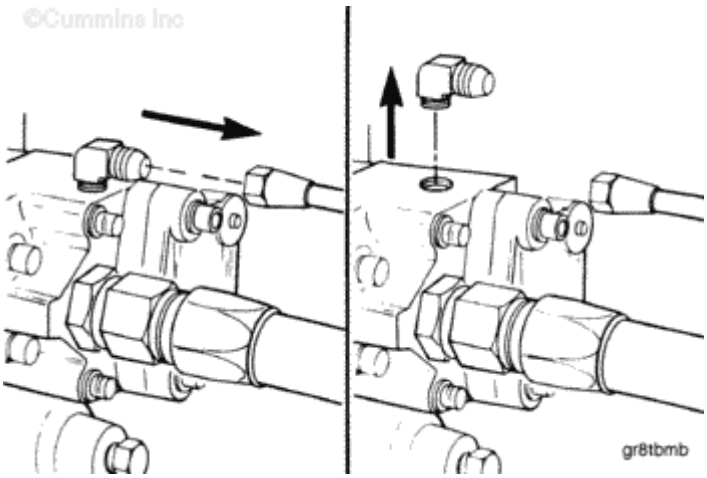
005-026 Fuel Pump Gear Pump Check Valve

Initial Check

If the check valve in the gear pump return elbow stays open or closed, the check elbow **must** be replaced.		

Remove

Remove the drain line. Remove the check valve elbow.		



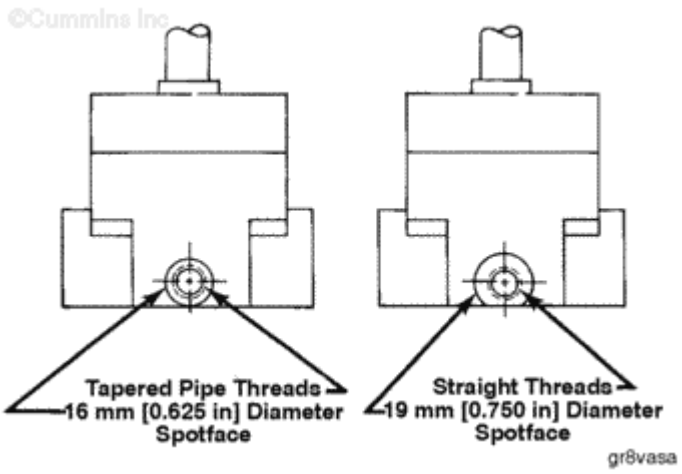
Inspect for Reuse

Check the elbow threads.

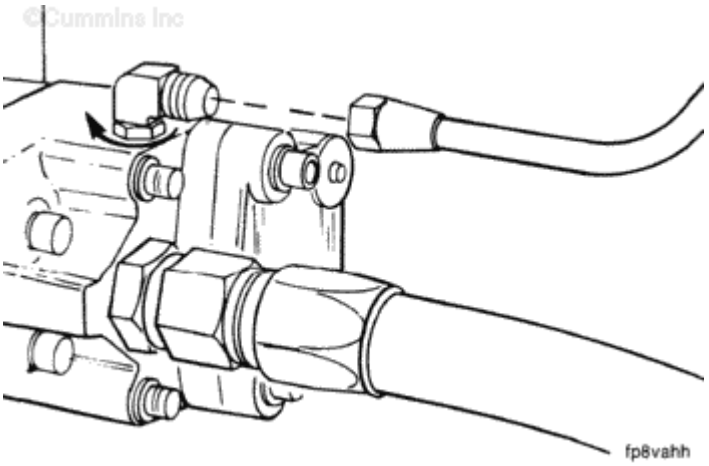
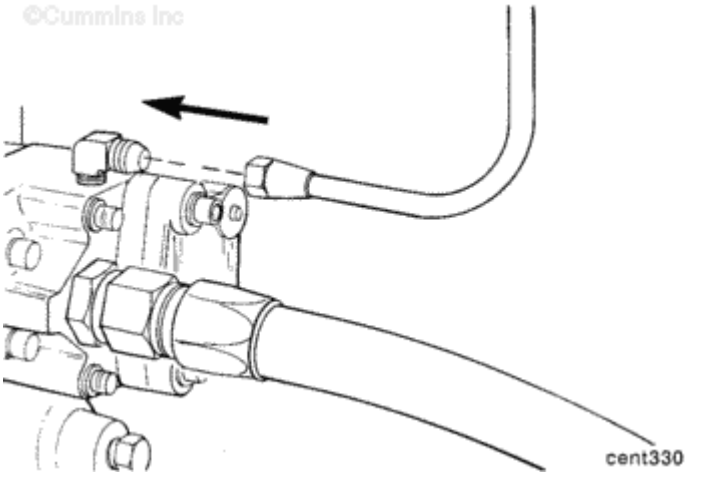
Do **not** install an elbow that has straight machine threads in a hole that has pipe threads.

A gear pump that has straight threads will have a 19 mm [0.750 in] spot face in the valve area.

A gear pump that has pipe threads will have a 16 mm [0.625 in] spot face or no spot face.



Install

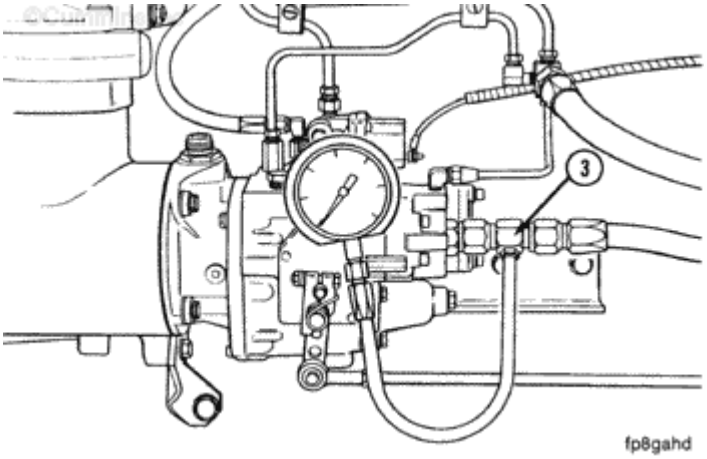
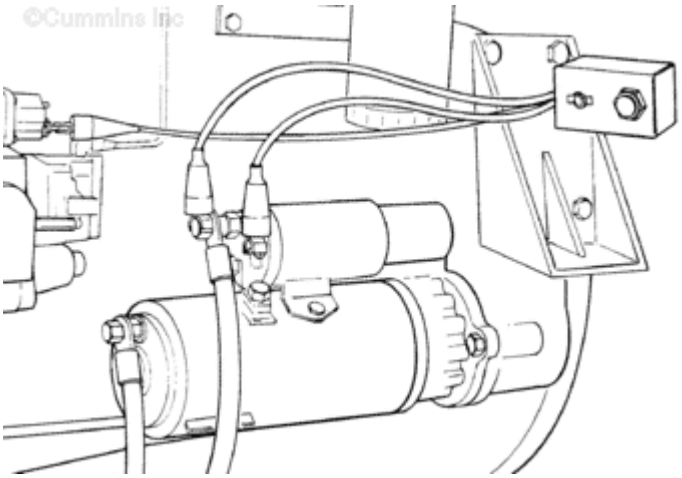
Install the check valve elbow that has machine threads to the maximum thread depth. Turn the elbow until it is pointing toward the drain line. Tighten the jam nut. **Torque Value:** 5 to 6 n.m [45 to 50 in-lb] Install the check valve elbow that has pipe threads until it is tight and pointed towards the drain line.		
Install the drain line.		

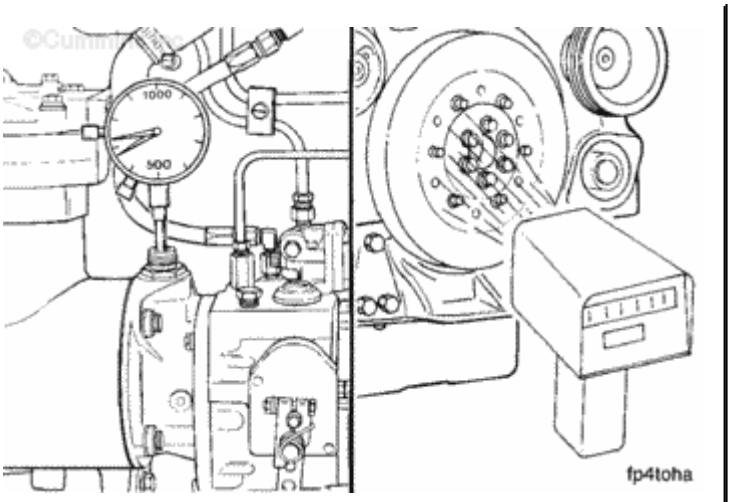
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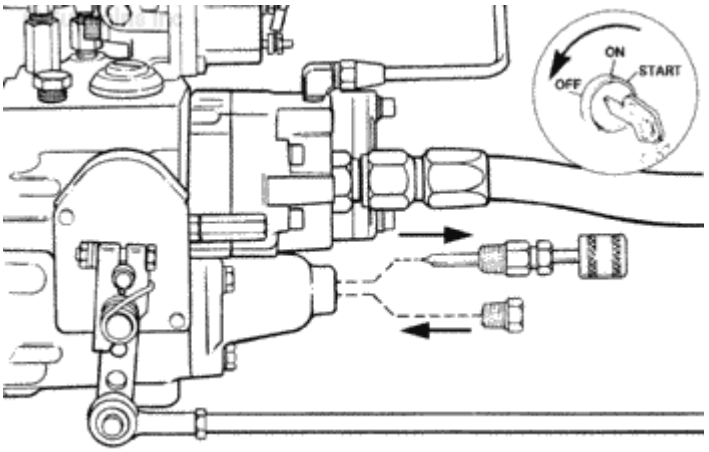
005-029 Fuel Pump Idle Speed

Adjust

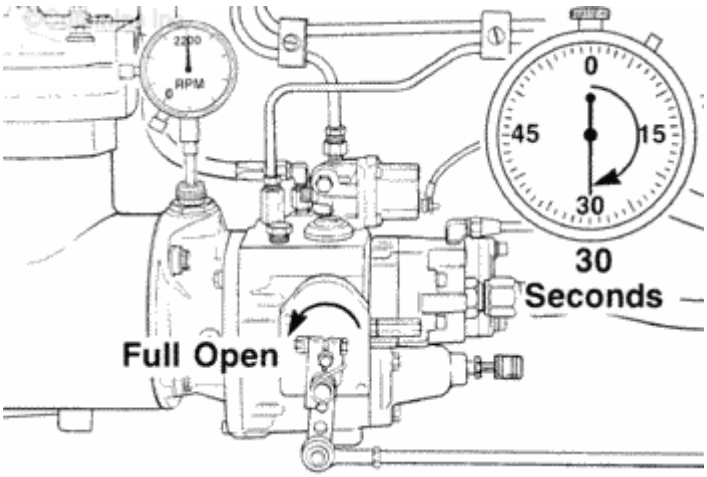
The engine speed can be checked with one of the listed tachometers: • Vehicle tachometer • Hand tachometer, Part Number ST-744 • Digital tachometer, Part Number 3375631 • Optical tachometer, Part Number 3377462.		
Remote starter, Part Number 3376506, can be used to start the engine. The leads are marked for connection points.		

Install the tachometer in the fuel pump drive. If using the optical tachometer, place reflective tape on the vibration damper. Operate the engine at low idle and record the rpm.		

Automotive Applications

The engine low idle speed is adjusted from 650 to 725 rpm. This adjustment is sometimes necessary on a new engine to compensate for the added engine driven accessories that are installed by the truck or vehicle manufacturers. Stop the engine. Remove the plug from the spring pack cover. Install the fuel pump idle adjusting tool, Part Number 3375981, in the plug hole.		

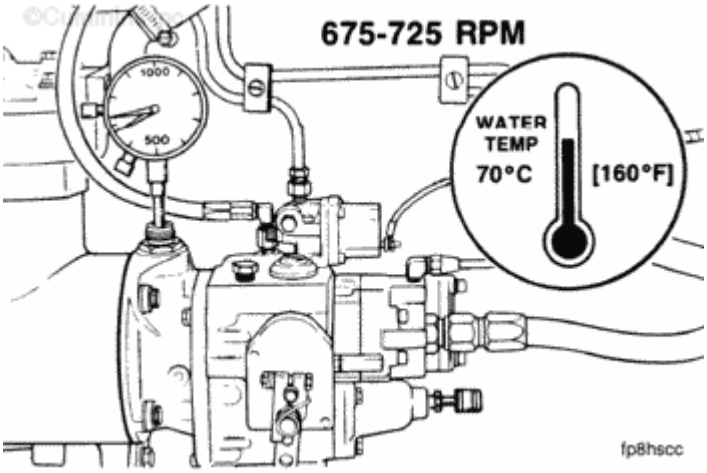
Operate the engine at high idle for 30 seconds to remove the air from the system.



Make sure the engine coolant temperature is at or above 70°C [160°F].

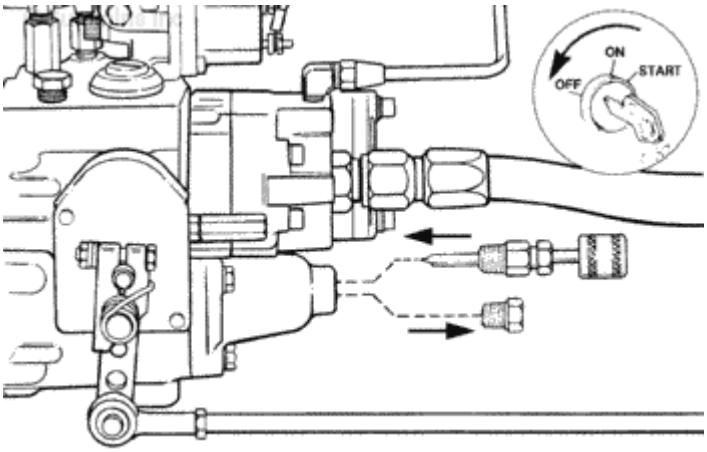
To adjust the idle speed, turn the screw **clockwise** to increase the idle rpm.

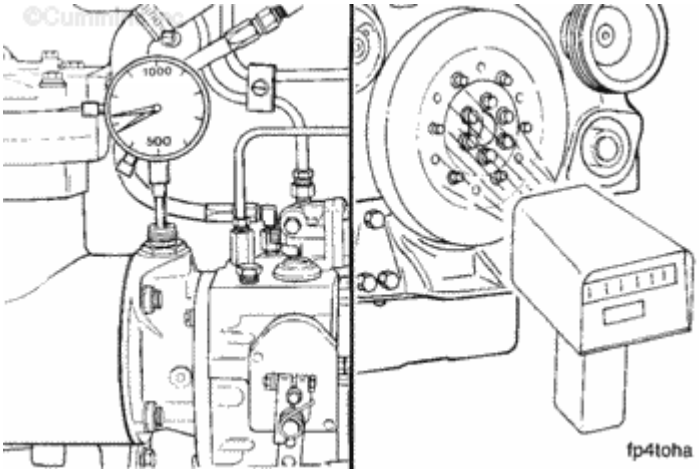
Turn the screw **counterclockwise** to decrease the idle rpm.



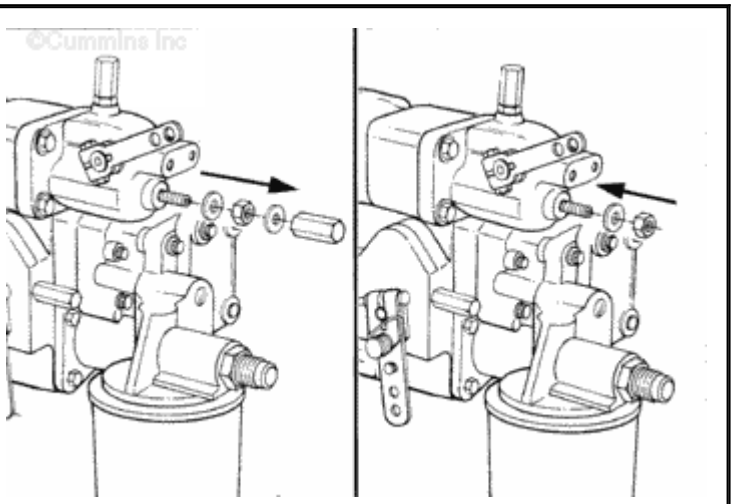
Remove the tool and install the plug.

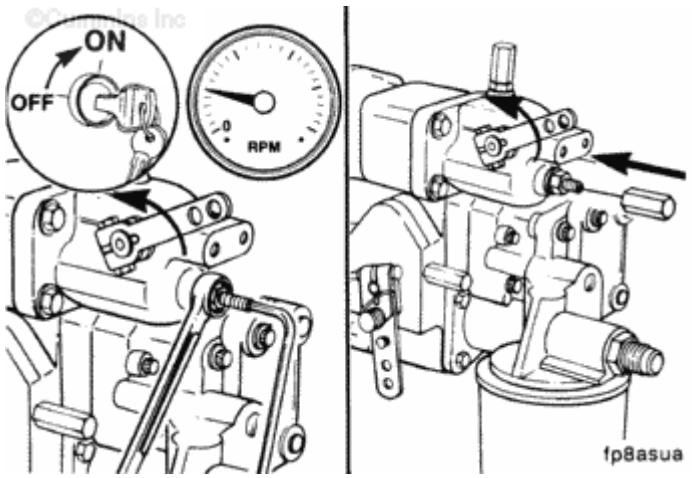
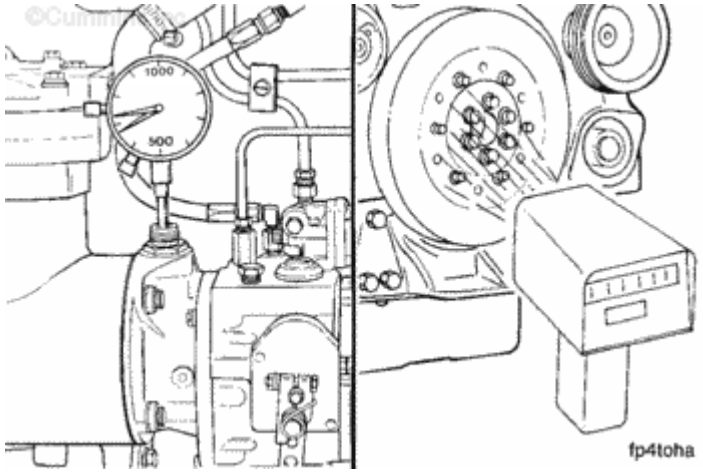
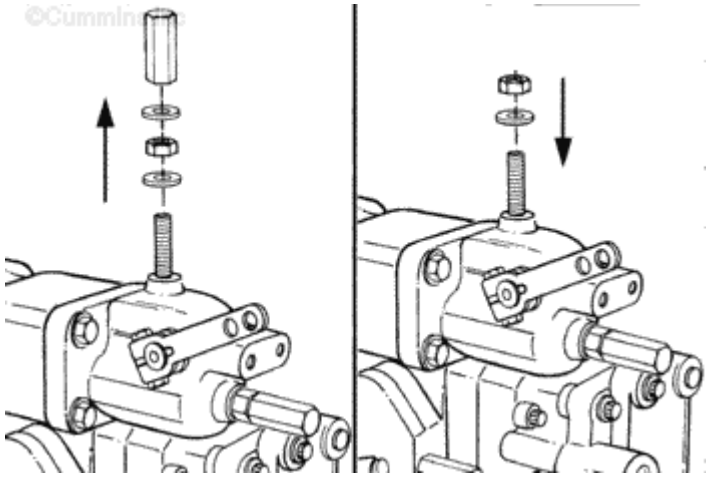


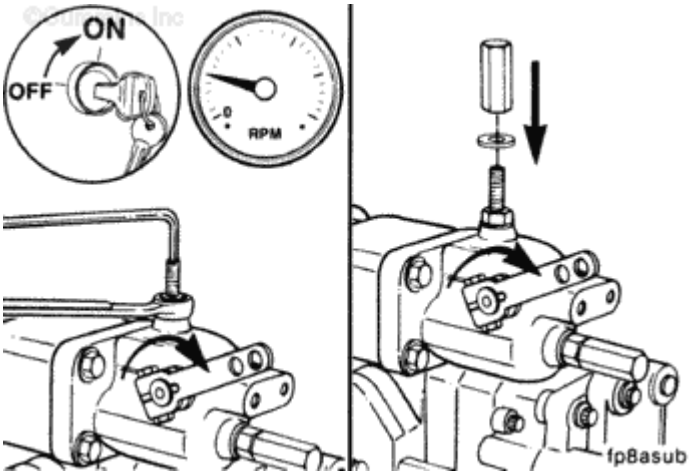
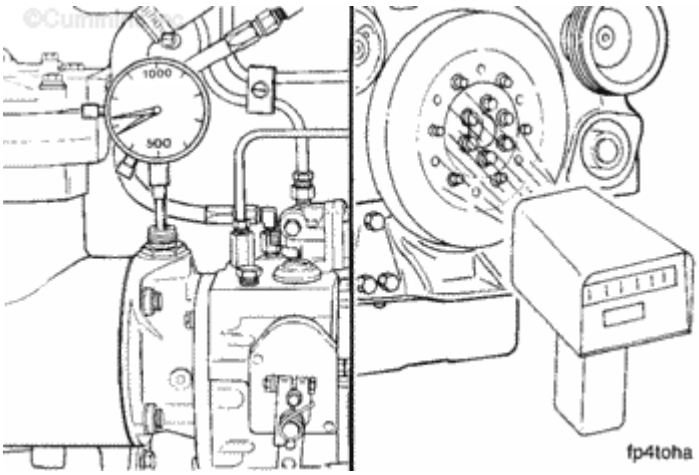


Check the idle speed again.		

Governor

To adjust the VS idle speed, remove the lock nut and jam nut from the screw in the rear of the VS cover. Discard the copper washers. Install a new copper washer and the jam nut.		
Start the engine. Hold the VS lever in the idle position. Adjust the idle screw to the correct rpm and tighten the jam nut.		

Install a new copper washer and lock nut.		
Check the idle speed again.		
To adjust the VS high speed, remove the lock nut and jam nut form the top screw of the VS cover. Discard the copper washers. Install a new copper washer and the jam nut.		

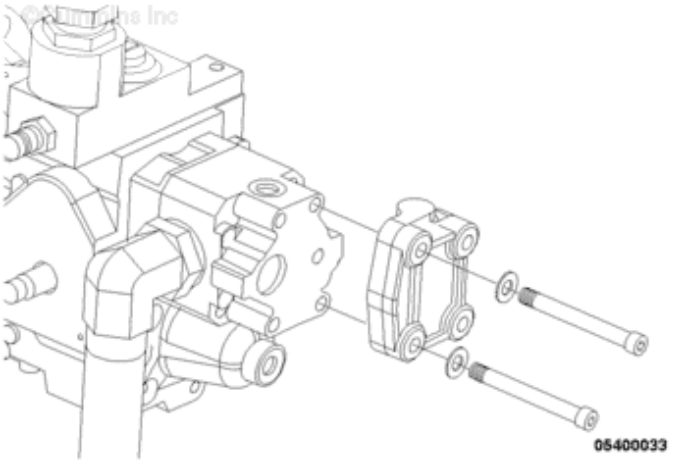
Start the engine. Hold the VS lever **clockwise** (in the high speed position). Adjust the screw to the correct rpm. Tighten the jam nut. Install a new copper washer and lock nut.		
Check the idle speed again.		

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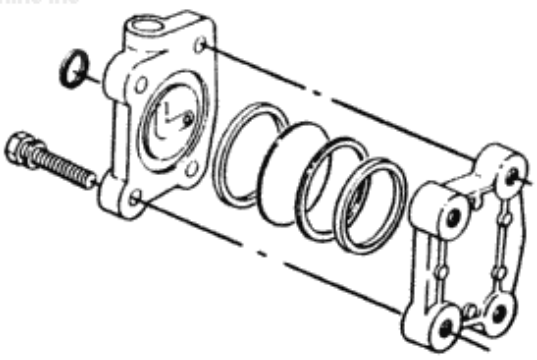
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005-031 Fuel Pump Pulsation Damper

Remove

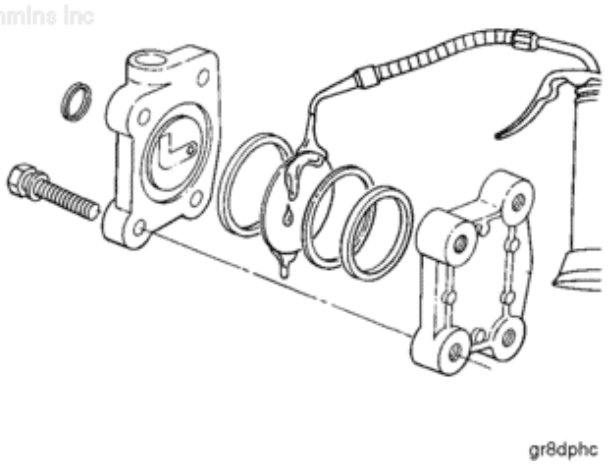
Remove the fuel inlet connection and pulsation damper or the filter head damper assembly. Discard the rubber o-rings.		

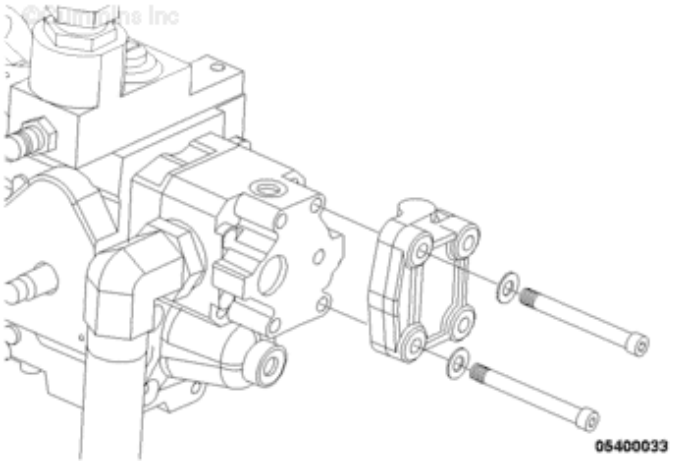
Inspect for Reuse

Remove the housing from the cover. Remove the spring steel diaphragm. Discard the o-rings. Inspect the nylon washer and discard it if is damaged. Check for corrosion, wear, or		

cracks in the cover or the diaphragm. Replace the damaged parts. To check the diaphragm for hidden cracks, drop it on a flat hard surface. It **must** have a clear ring. If it has a flat sound, replace the diaphragm.		

Install

Install new o-rings in the grooves and a new nylon washer. Clean the diaphragm. Coat the diaphragm with clean engine oil. Install the diaphragm in the cover. Assemble the cover to the housing. Tighten the capscrews. **Torque Value:** 18 n.m [13 ft-lb]		
Remove the two damper mounting capscrews. Install the damper assembly with a new o-ring on the gear pump.		

Tighten the capscrews. **Torque Value:** 18 n.m [13 ft-lb] **NOTE: If a fuel filter and damper assembly are mounted on the gear pump, remove the four mounting capscrews.** Install the fuel pump inlet connection. Be careful **not** to let dirt enter the fuel pump. Check for free rotation of the gear pump.		

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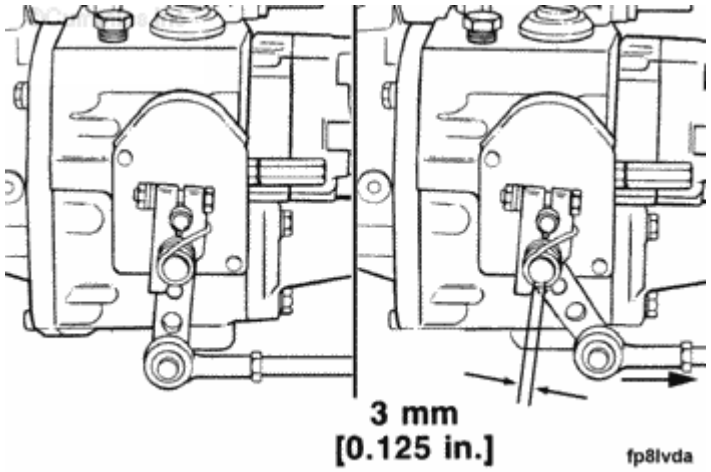
005-035 Fuel Pump Throttle Lever

Adjust

Automotive Applications

For the throttle break over test, make sure the throttle linkage is adjusted so the throttle lever breaks over 3 to 6 mm [0.125 to 0.250 in] when the lever is in the full throttle position.

The throttle lever **must** contact the front throttle stop screw.

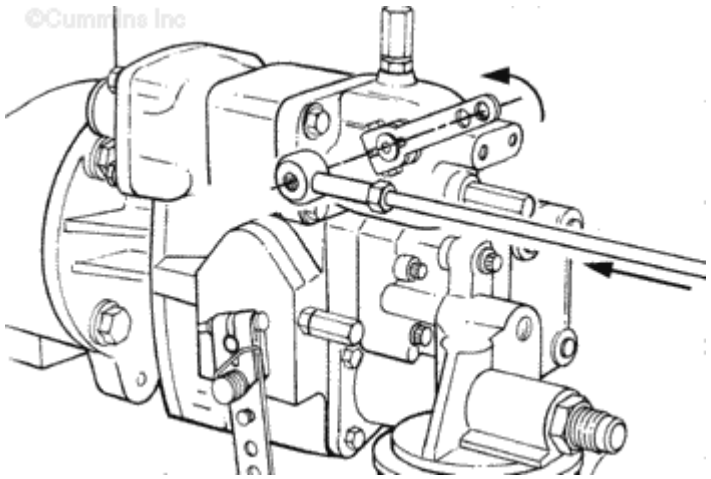


To adjust the variable speed throttle linkage:

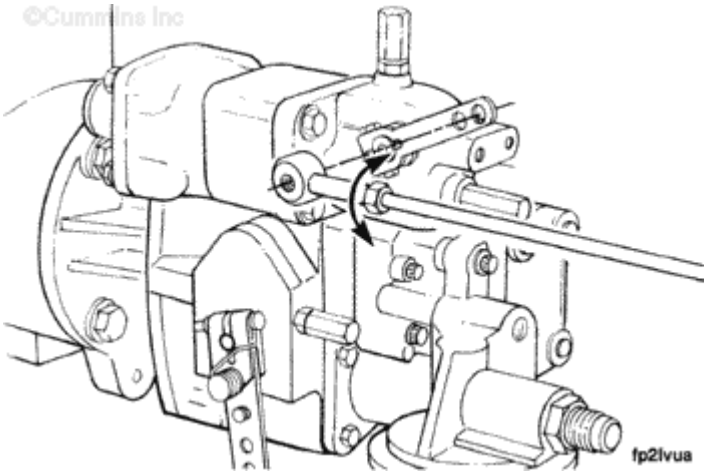
Remove the throttle linkage from the variable speed throttle lever.

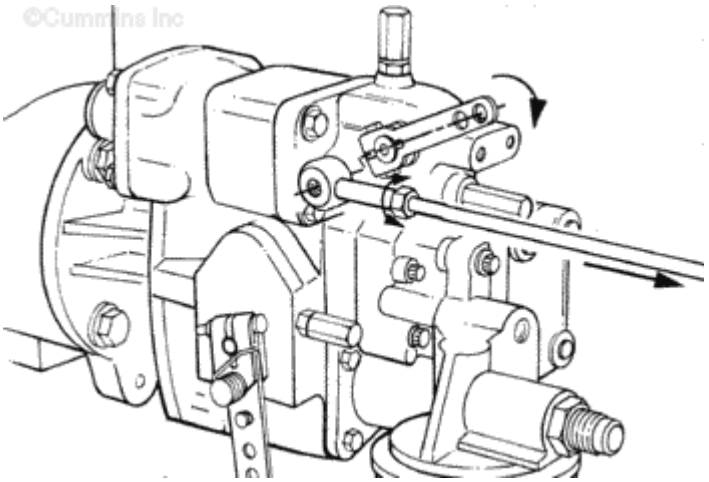
Hold the variable speed throttle lever in the idle position.

Move the linkage

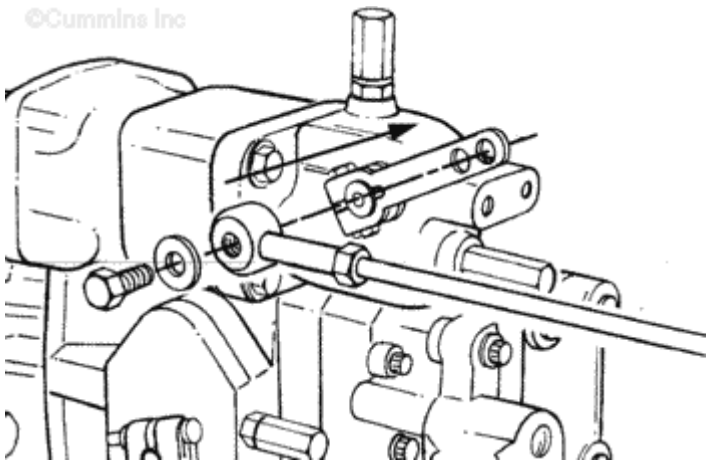


to the idle position.		

If the lever and the linkage are **not** aligned, adjust the linkage.		

Move the variable speed throttle lever and linkage to the maximum speed position. If the lever and the linkage are **not** aligned, adjust the lever. Throttle travel on a variable speed lever is **not** adjustable. The pump can be recalibrated with a stiffer governor spring to reduce the throttle travel.		

Install the linkage on the lever.		

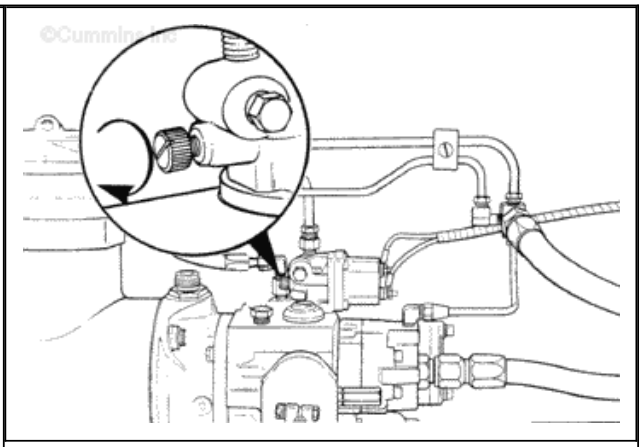
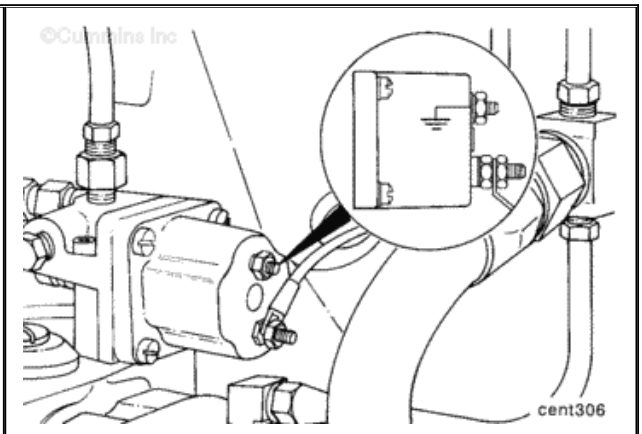


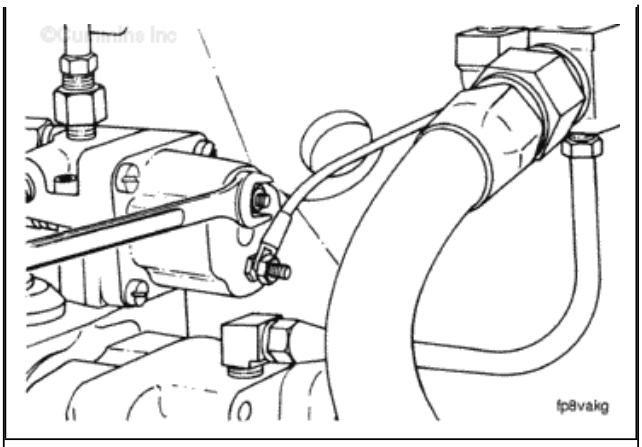
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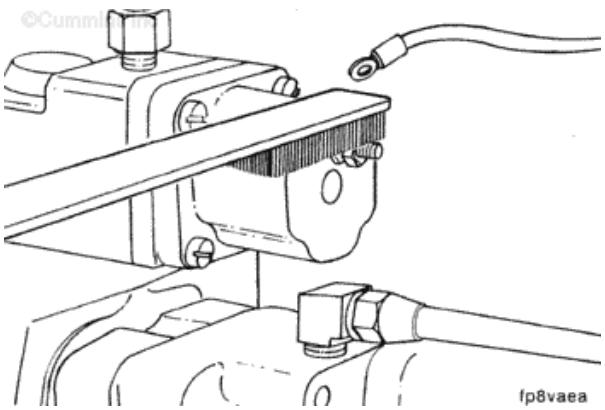
005-043 Fuel Shutoff Valve

Test

Check the override screw to be sure the shutoff valve is open. Turn the screw in a **clockwise** direction to open the valve. Turn the screw in a **counter clockwise** direction to close the valve and shut off the fuel. To start the engine, in case of an electrical failure, turn the valve knob on the shut off valve **clockwise** to open the valve.		
Most of the valves are internally grounded. If the valve has a long post and a short post, the short post is internally grounded.		
Make sure all of the wire connection nuts are tight, whether a wire is attached or **not**.		

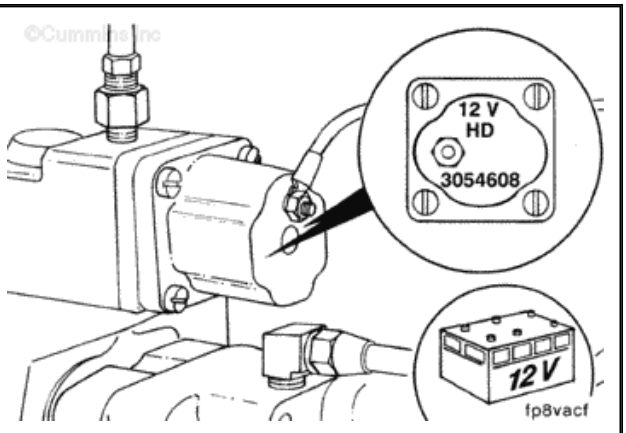


Use a wire brush to clean corroded terminal posts.



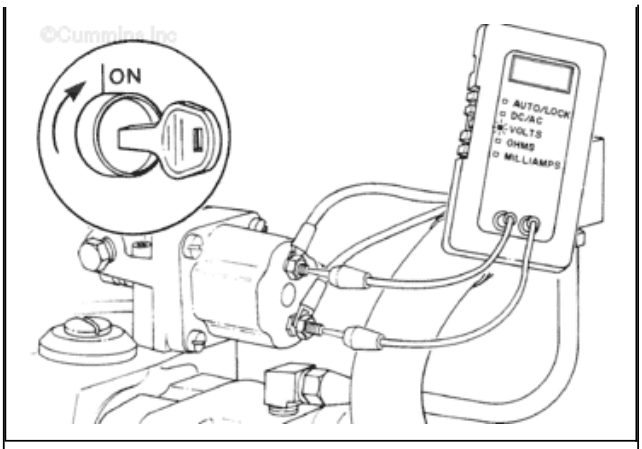
Make sure the shutoff valve coil is the correct voltage.

The coil voltage and part number are cast into the terminal connection end of the coil.



Turn the vehicle ignition ON.

Use a multimeter and check the voltage, as shown. If the voltage is **not** correct check the electrical system.

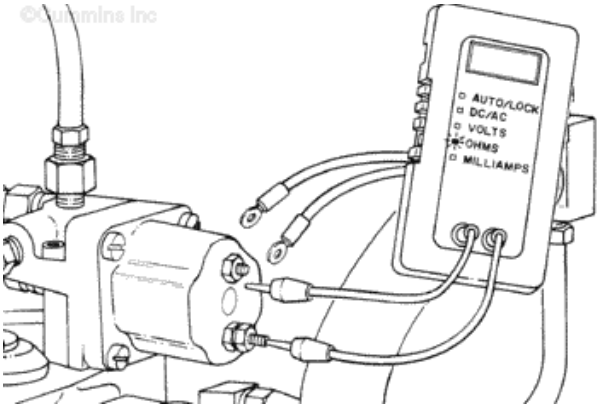


Disconnect the wires from the solenoid.

Measure the coil resistance with a multimeter.

Fuel System Shutoff Valve Specifications		
Voltage	Resistance Minimum (Ohms)	Resistance Maximum (Ohms)
6 VDC	1	5
12 VDC	6	15
24 VDC	24	50
32 VDC	42	80
36 VDC	46	87
48 VDC	92	145
74 VDC	315	375
115 VAC	645	735

If the coil is **not** within specifications, it **must** be replaced.



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005-054 Stall Speed Test

Test

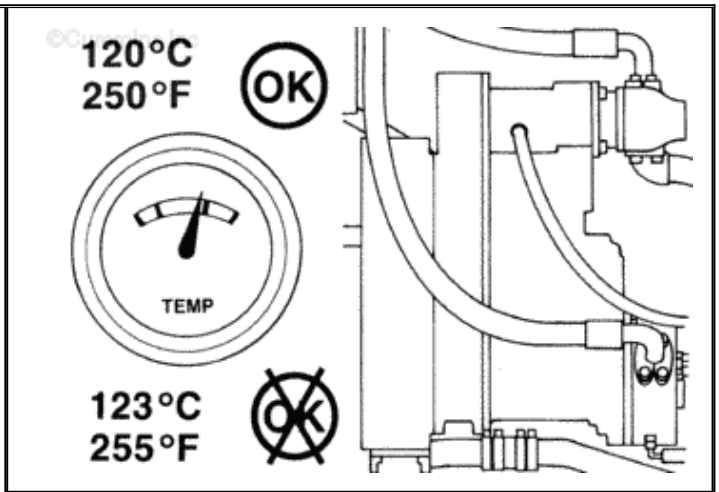
The stall speed is the engine speed (rpm) obtained at full throttle when the converter output shaft is locked.

The vehicle brakes will possibly **not** hold an electronically controlled transmission.

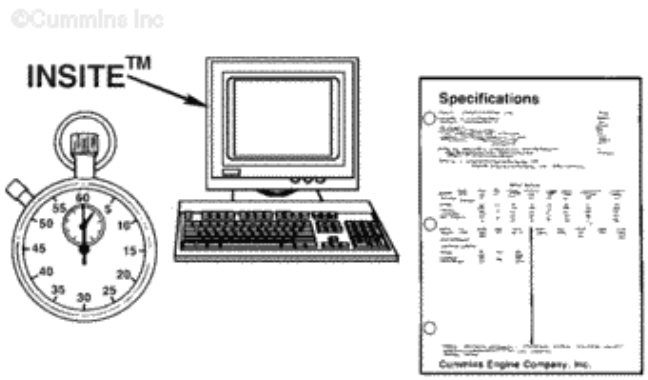
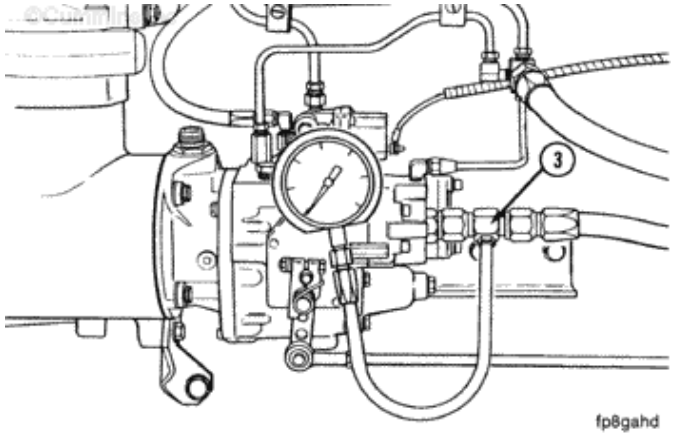
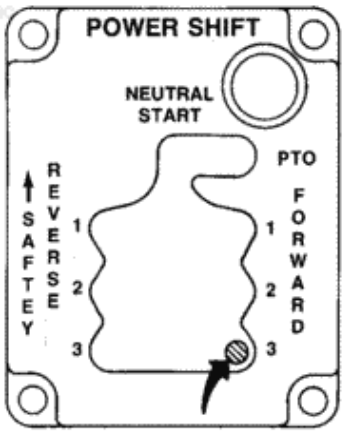


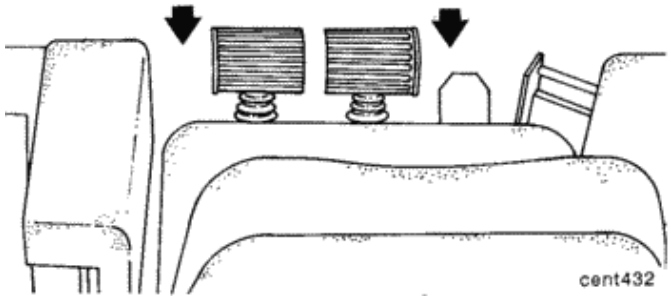
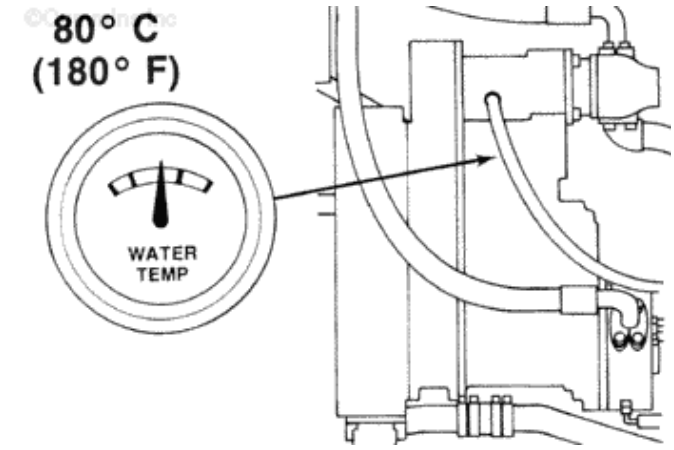
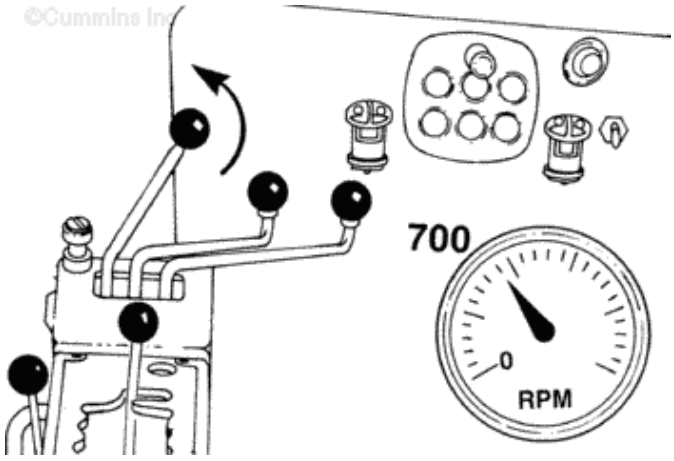
CAUTION

Do not exceed 120°C [250° F] converter oil temperature. 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 equipment listed below is needed to complete this check:

• Stop watch • Digital tachometer, Part Number 3375631, or a hand held optical tachometer, Part Number ST-3377462 • Equipment manufacturer's stall speed and time to stall specifications.		 oi8gaki
Install the tachometer onto the fuel pump.		 fp8gahd
Place the gear selector in the highest gear or full forward. In some types of equipment it is also necessary to engage the hydraulics.		 cent431

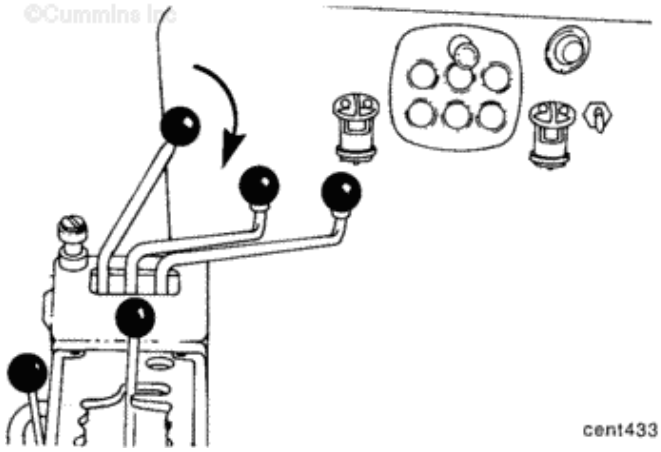
Make sure the vehicle has good brakes and air pressure in the brake system. The brakes **must** prevent the vehicle from moving when the engine is at full throttle. Engage the vehicle brakes or keep the vehicle from moving.		
Operate the engine until the coolant temperature is 70°C [160°F] and the converter temperature is 80°C [180°F] or above. Alternate shift from neutral to the highest speed gear possible. This will warm the entire system uniformly.		
Bring the engine speed back to low idle.		

Do **not** exceed 120°C [250°F] converter oil temperature.

Quickly move the throttle to the full open position.

Do **not** perform this test for more than 15 seconds.

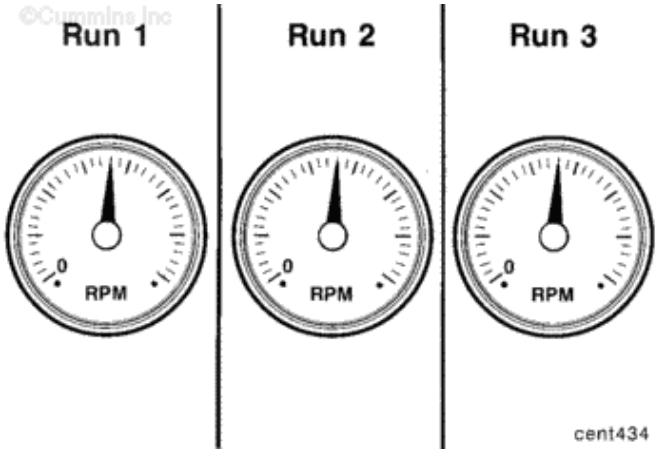
If the engine speed continues to slowly increase, the torque convertor fluid is overheating.



Check the engine speed (rpm) at the point of stall.

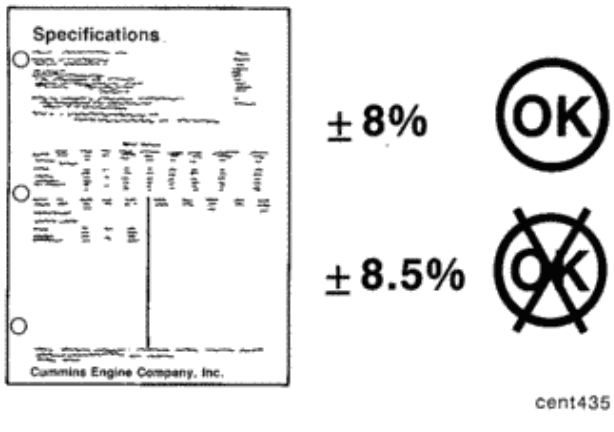
Always hold the speed until it is stable.

Take several readings. Make sure the reading is accurate.



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

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 specifications, the stall speed checklist can be used. The stall speed checklist is located at the end of this procedure.

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





Stall Speed Check List

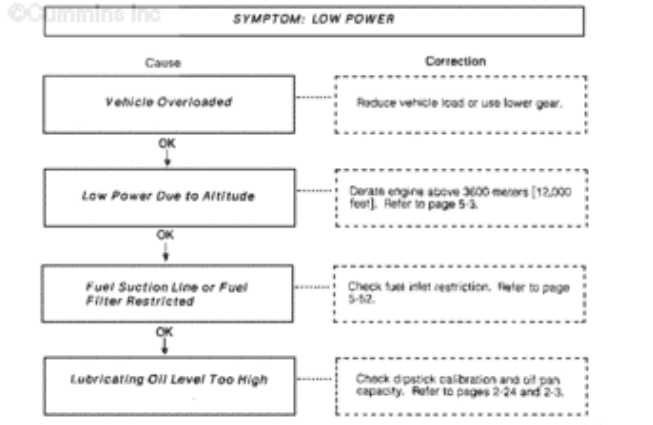
If The Stall Speed Is Too Low, Check The Following:

	Yes	No	
1.	____	____	The tachometer is in error.
2.	____	____	The engine is up to or above 70°C [160°F].
3.	____	____	The converter oil is up to temperature 80°C [180°F] minimum.
4.	____	____	The stall has been held long enough for the engine to accelerate to full power.
5.	____	____	The match curve stall speed was recorded correctly.
6.	____	____	The converter oil is to the converter manufacturer's recommendation. (SAE 30 instead of SAE 10 for instance.)
7.	____	____	The engine driven accessory power requirements exceed 10 percent of the gross engine power. Check for abnormal accessory horsepower losses such as hydraulic pumps, large fans, oversize compressors, etc. Either remove the accessory or accurately determine the power requirement and adjust accordingly.
8.	____	____	The AFC (Air Fuel Control) is properly adjusted.
9.	____	____	The unit is operating at an altitude high enough to affect the engine power.
10.	____	____	The converter charging pressure is correct.
11.	____	____	The tailshaft governor is interfering with and preventing a full throttle opening. (Disconnect the tailshaft governor.) Do not exceed the manufacturers maximum output speed.
12.	____	____	The converter blading is interfering or in a stage of failure. Check the sump or filter for metal particles.
13.	____	____	The converter stators are free-wheeling instead of locking up.
14.	____	____	The engine is set for power other than that specified on the power curve.

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If the cause for the stall speed being too low is low engine power output, refer the engine power output low symptom tree.





SYMPTOM: LOW POWER

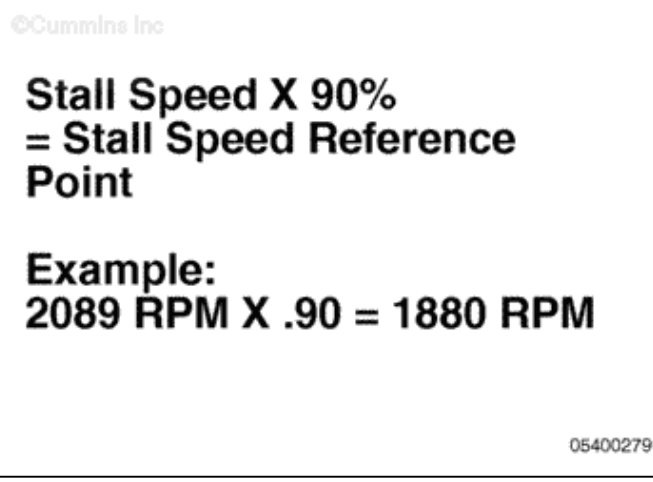
Cause	Correction
Vehicle Overloaded	Reduce vehicle load or use lower gear.
OK	
Low Power Due to Altitude	Derate engine above 3600 meters [12,000 feet]. Refer to page 5-3.
OK	
Fuel Suction Line or Fuel Filter Restricted	Check fuel inlet restriction. Refer to page 5-52.
OK	
Lubricating Oil Level Too High	Check dipstick calibration and oil pan capacity. Refer to pages 2-24 and 2-3.

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To complete a stall or acceleration time check, perform the stall speed check.

Calculate the speed using the formula listed below.

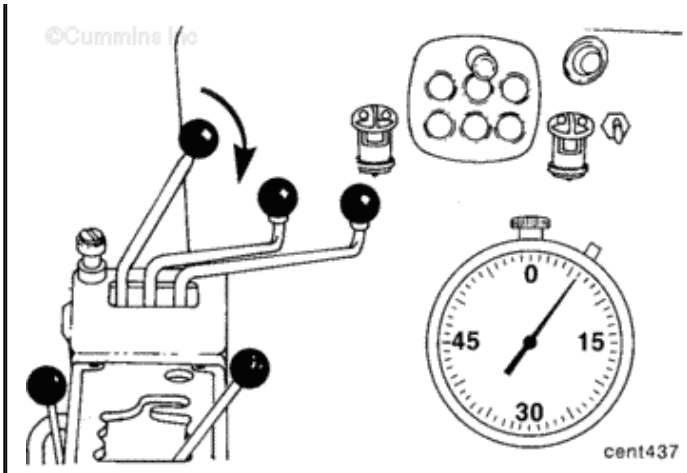
Example: Stall speed =2089, (2089 x .90 = 1880 rpm)

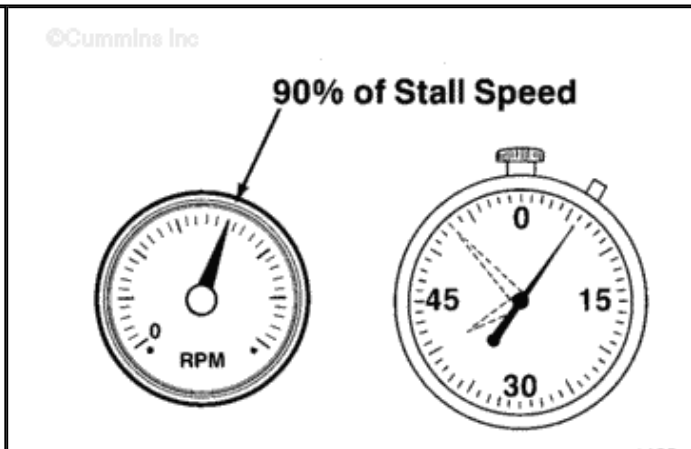


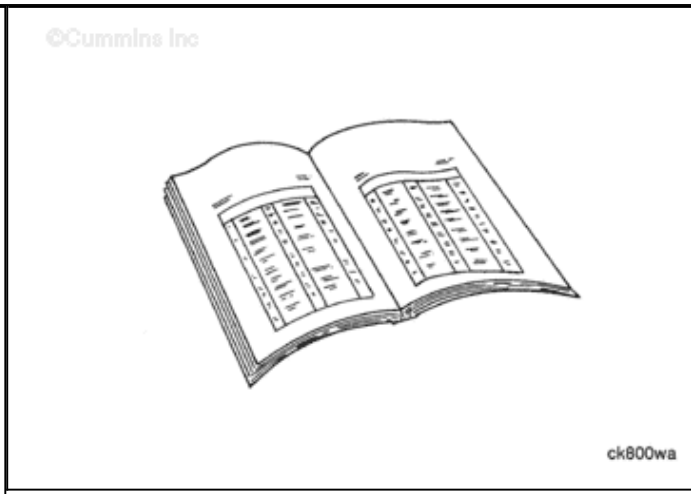
Stall Speed X 90%
= Stall Speed Reference Point

Example:
2089 RPM X .90 = 1880 RPM

05400279

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 of the stall speed (rpm), stop the stop watch. 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 to 12 seconds.		

Check the equipment manufacturer's specifications for the time to stall or the acceleration time. If the time is excessive, check the fuel pump AFC for an air leak. Refer to Procedure 005-001.		

Stall Speed Checklist (Stall Speed to Low)		
Yes	**No**	**Symptom**
		The tachometer is in error.
		The engine is up to or above 70°C [160°F].
		The converter oil is up to 80°C [180° F].
		The stall has been held long enough for the engine to accelerate to full power.
		The match curve stall speed was recorded correctly.
		The converter oil is to the converter manufacturer's recommendation (SAE 30 instead of SAE 10 for example).
		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.
		The AFC (air fuel control) is properly adjusted.
		The unit is operating at an altitude high enough to effect the engine power.
		The converter charging pressure is correct.
		The tailshaft governor is interfering with and preventing a full throttle opening (disconnect tail shaft governor).
		The converter blading is interfering or in a stage of failure. Check the sump or filter for metal particles.
		The converter stators are free-wheeling instead of locking up.
		The engine is set for power other than specified on the power curve.
		The converter is wrong, because of improper rebuild or build of unit.
		The converter is performing to the published absorption curve.
		The engine and converter match is correct. Check the engine and converter models for proper match.
		The engine is matched to too large of a converter. If this condition is believed to exist, report the engine-converter-accessory information to the factory.
		The engine power is down. The engine torque rise can be less than shown on the standard engine curve. See the fuel setting adjustments and the turbocharger air manifold pressure check.

NOTE: It is sometimes easier to change the engine fuel rate than to determine the true cause for low stall speed, but the engine is over fueled which will also negatively affect durability. Do not increase the fuel rate as a cure all.

Stall Speed Checklist (Stall Speed to High)		
Yes	**No**	**Symptom**
		The engine is high in power
		The tachometer is in error.
		The accessory power requirements are less than 10 percent of the gross

		engine power.
		The converter oil is aerating (foaming) - check for low oil level, air leaks in suction line, oil does **not** contain foam inhibitor, suction screen or filter. Can be accompanied by a noticeable loss of machine performance.
		The converter is held at full stall. Check for a slipping disconnect clutch or a rotating output shaft. On the converter-transmission package, this can be impossible to check.
		The converter turbine element is beginning to fail and losing blades or the converter was originally built with the wrong size element.
		The engine and converter match is correct. Because of a revision in the engine rating or converter performance.
		On the transmission-converter units with oil sump in the transmission, if the oil level is too high, it can cause severe aeration because of parts dipping in the oil.
		The converter is performing to the published absorption curve.
		The converter charging pressure is correct.

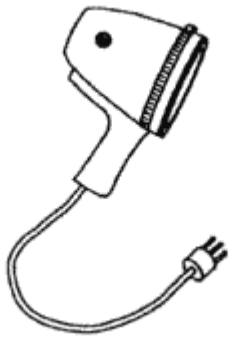
NOTE: The reasons for abnormal stall speeds listed above are some which have been encountered by Cummins representatives and probably do not include all possible causes. The correction of the problem is either covered in the vehicle service manual, or is self explanatory.

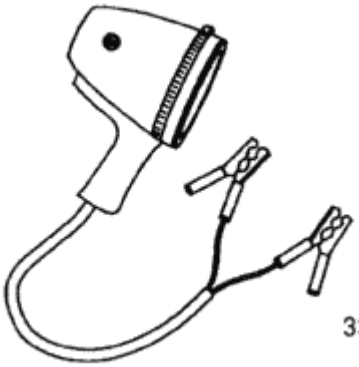
Last Modified: 29-Oct-2004

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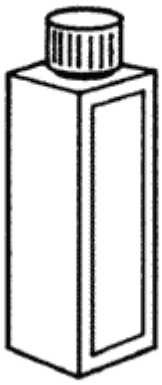
022-001 Service Tools

Injectors and Fuel Lines

Tool Number		
3377253	**Black Light (AC)** Use to locate fuel leaks.	©Cummins Inc  3377253

Tool Number		
3377394	**Black Light (DC)** Use to locate fuel leaks.	©Cummins Inc  3377394

Tool Number		
	Fluorescent Tracer Place in engine oil or	

3376891	fuel. Use black light to find leaks.	©Cummins Inc  3376891

Last Modified: 15-Nov-2004

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006-002 AFC Anti-Drain Back Valve

Initial Check

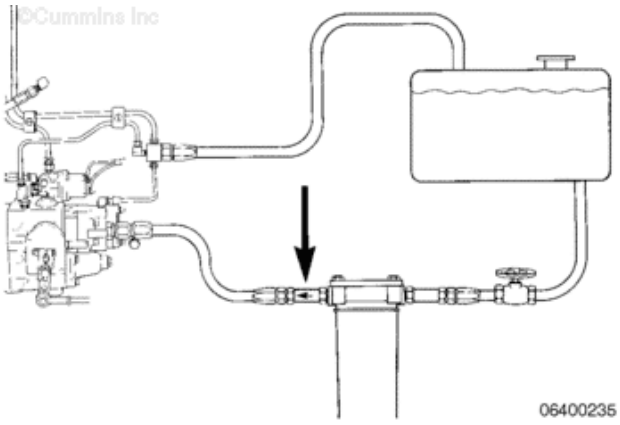
WARNING

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.

If the fuel filter is lower than the fuel tank, install a check valve in the fuel filter outlet fuel line. Refer to the manufacturer's instructions.

The check valve on the outlet side of the fuel filter prevents gear pump fuel drain back.

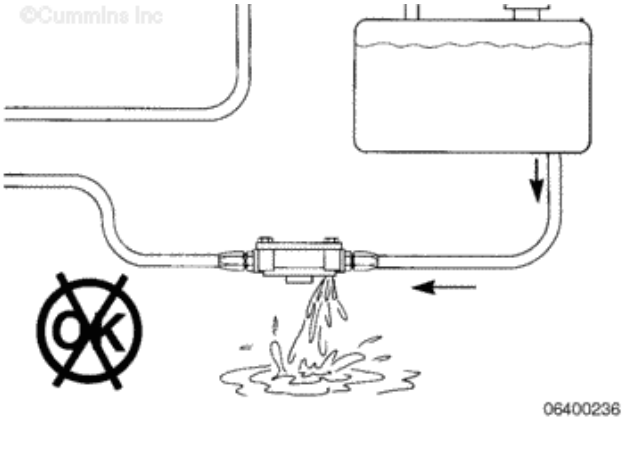
Install a fuel shutoff valve between the fuel filter and the fuel tank.



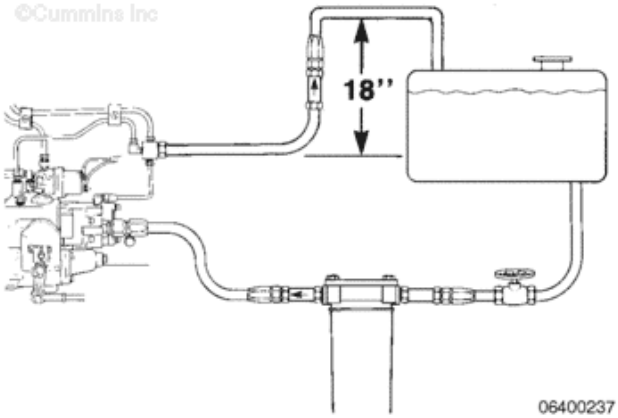
WARNING

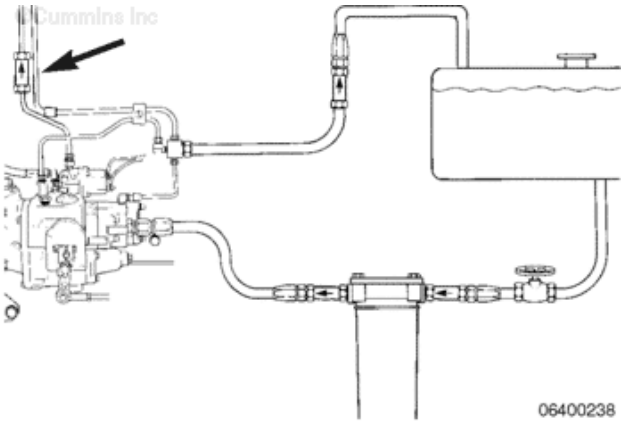
If the fuel line shutoff valve is not installed, the overhead tank can drain when the fuel filter is changed. To reduce the possibility of personal injury, make sure a fuel shutoff valve is installed on a fuel system with a overhead tank.

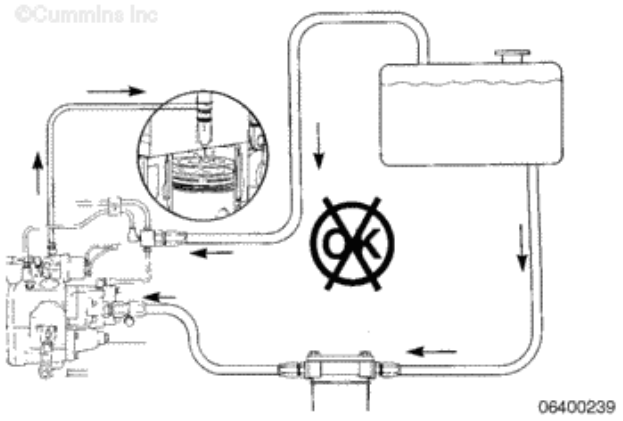
Make sure the fuel system has



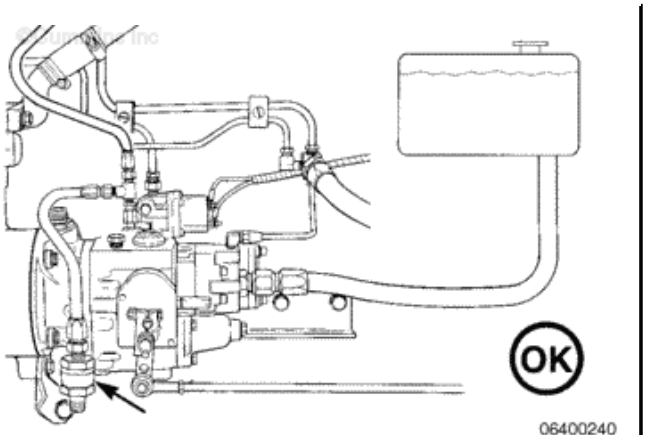
a fuel shut off valve installed or the fuel tank is empty.		

A check valve **must** be installed in the fuel drain line when the maximum fuel level in the fuel tank is even or above the fuel drain line that is in the cylinder head. Install the check valve with the fuel flow arrow pointed toward the fuel tank.		

When the maximum fuel level is above the injector drain, install the check valve in the fuel line between the fuel pump and the cylinder head with arrow pointed toward the cylinder head.		

CAUTION If fuel check line valves are not used, an engine cylinder can be filled with fuel. This can cause a hydraulic lock in the cylinder. Make sure fuel check valves are used.		

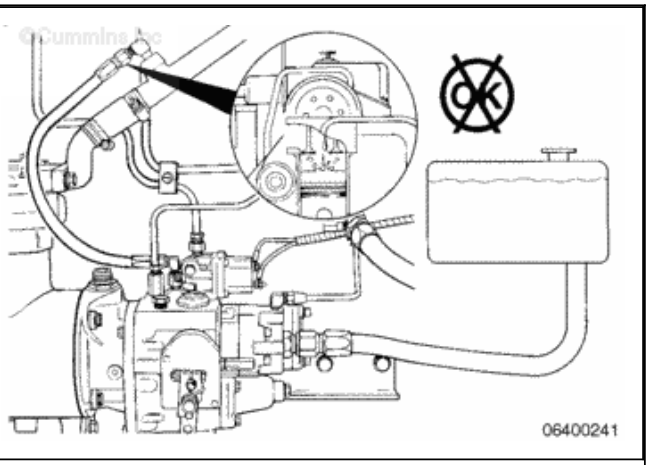
Install the check valve in the AFC air connection when an overhead tank is required.



CAUTION

If the air connection check valve is not in use and the AFC bellows has a hole, the fuel can move up the AFC air hose and into the cylinders. This can cause a hydraulic lock in the cylinder.

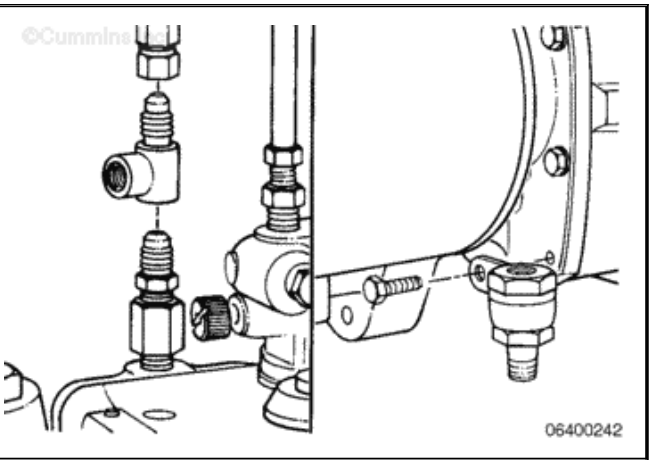
Make sure the air connection check valve is installed.

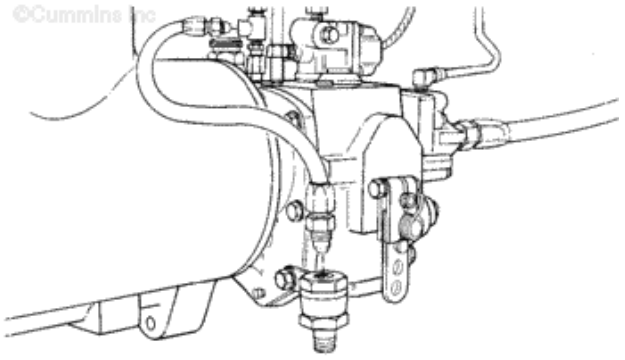
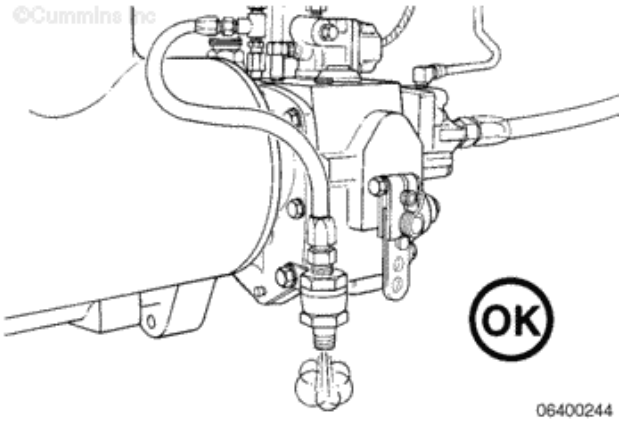
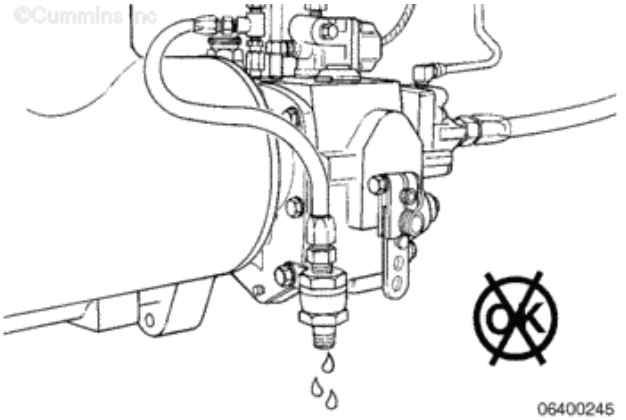


Install

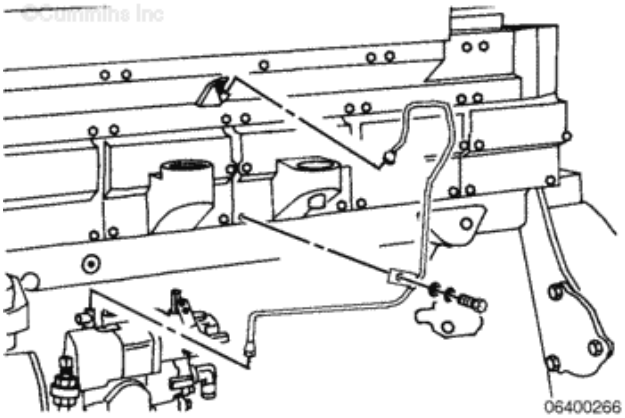
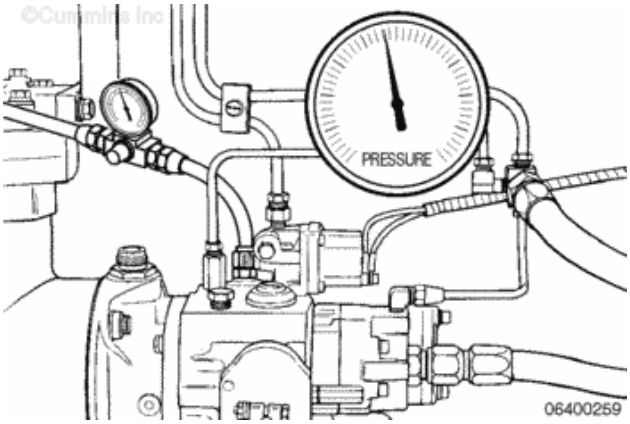
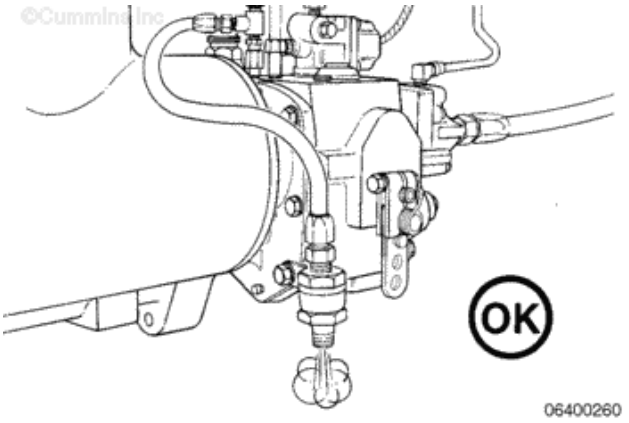
Install a pipe tee in the AFC air connection located in the AFC cover.

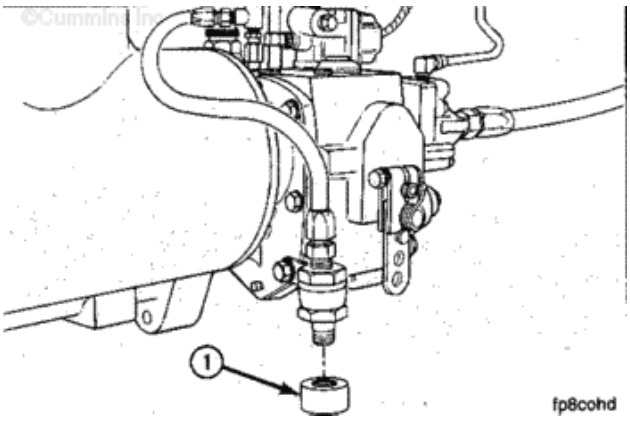
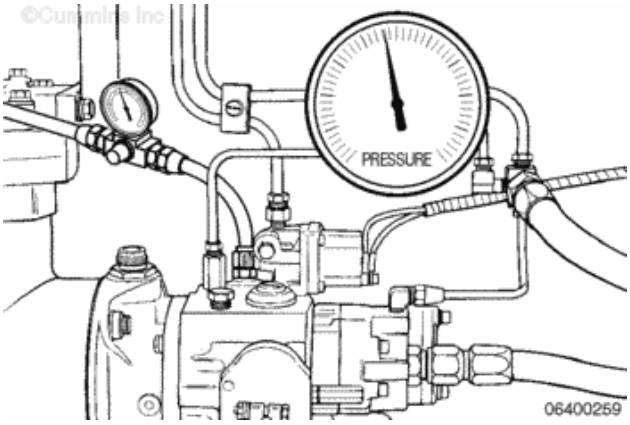
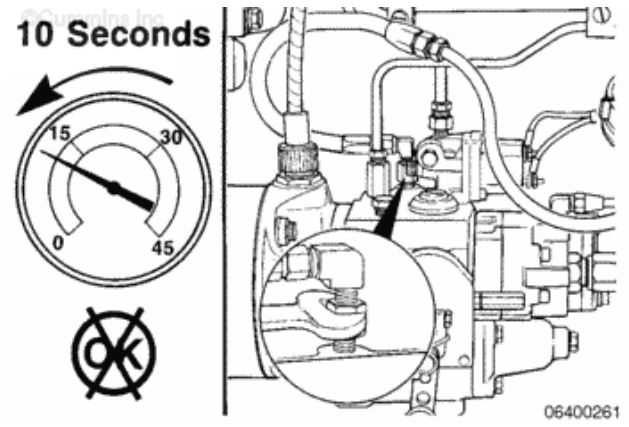
Install a P-clip to hold the check valve on the lower front cover capscrew.



Install a number four hose between the tee and the valve.		 06400243
When the engine is operating, a small amount of air (turbocharger pressure) will escape out of the bottom of the valve.		 06400244
If the AFC bellows fails, fuel will drain out of the valve.		 06400245

Leak Test

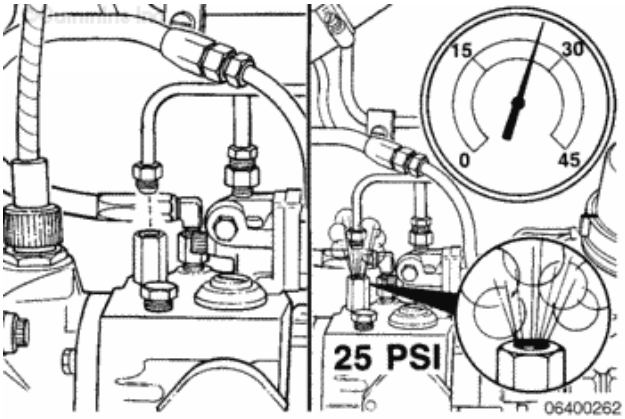
Remove the AFC air inlet line. Install a cap on the connection at the intake manifold.		
Install a regulated air pressure hose, with a shutoff valve onto the fitting on the AFC cover. Apply a maximum of 170 kPa [25 psi] air pressure to the AFC air supply line. Close the shutoff valve.		
If the engine application contains overhead fuel tanks, check for air escaping out of the AFC leak kit valve. If air is **not** escaping out of the valve, replace the leak kit valve.		

Install a test cap (1) to the AFC leak kit valve to prevent leakage during this test.		
Apply a maximum of 170 kPa [25 psi] air pressure to the AFC air supply line.		
If the air pressure drops any within 10 seconds, check the line and connections for leaks. Replace the line or tighten the connection of a leak is found.		
If the air pressure drops and the line connections do **not** leak, remove the AFC fuel return line from the top of the		

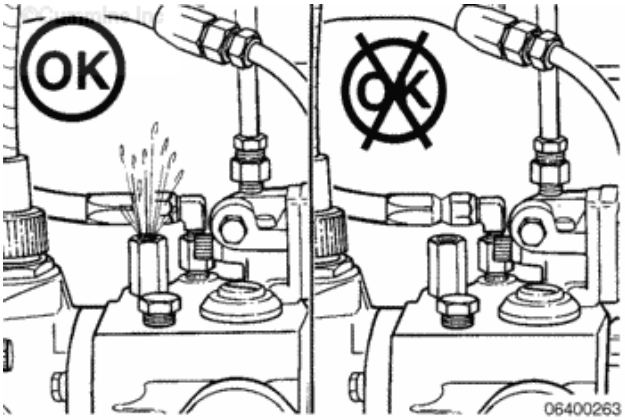
fuel pump.

Apply a maximum of 170 kPa [25 psi] to the AFC air supply line.

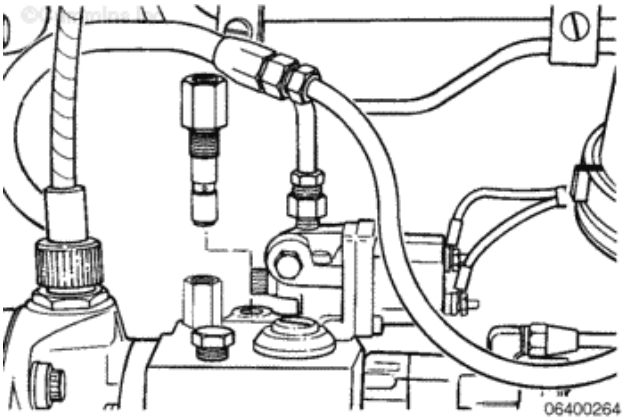
When the AFC bellows moves, a puff of air or a small amount of fuel will escape out of the top of the fuel pump.



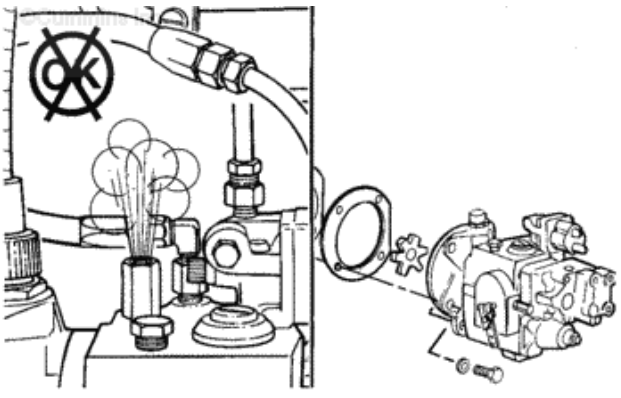
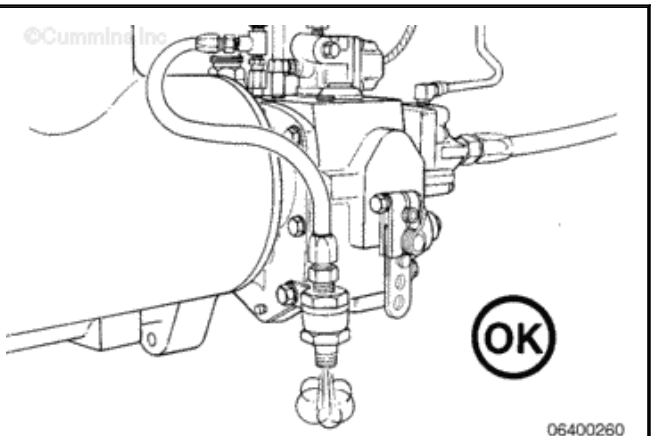
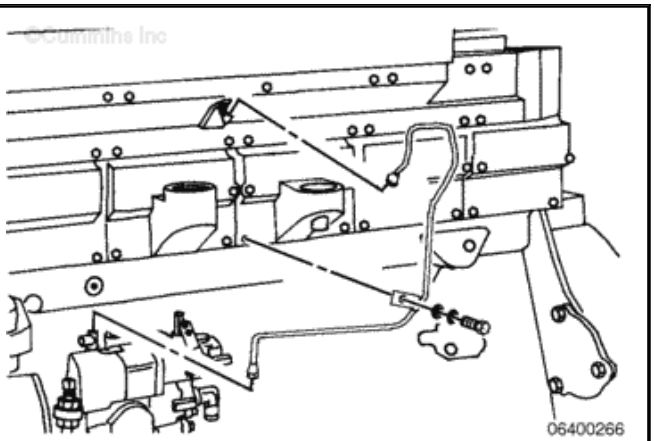
If air does **not** escape out of the top of the fuel pump and the pressure does **not** drop, the check valve connection in the AFC cover plate can have a restriction.

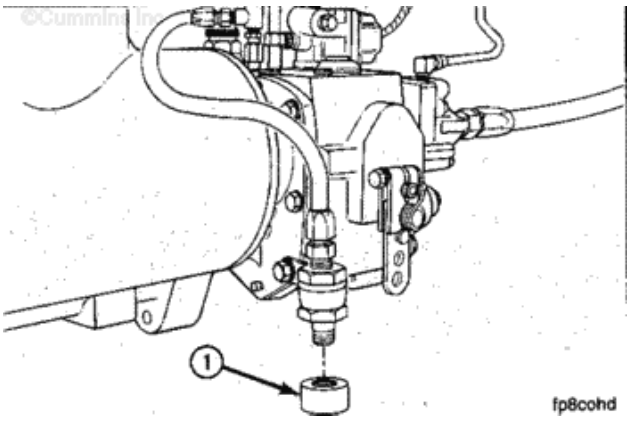


Remove and clean or replace the check valve.



If the air flow is continuous from the top of the fuel pump, the AFC bellows is defective.

Replace the fuel pump. Refer to Procedure 005-016.		
Remove the gate valve and shop air line.		
Install the AFC air inlet line.		
Remove the test cap (1) from the AFC leak kit valve.		

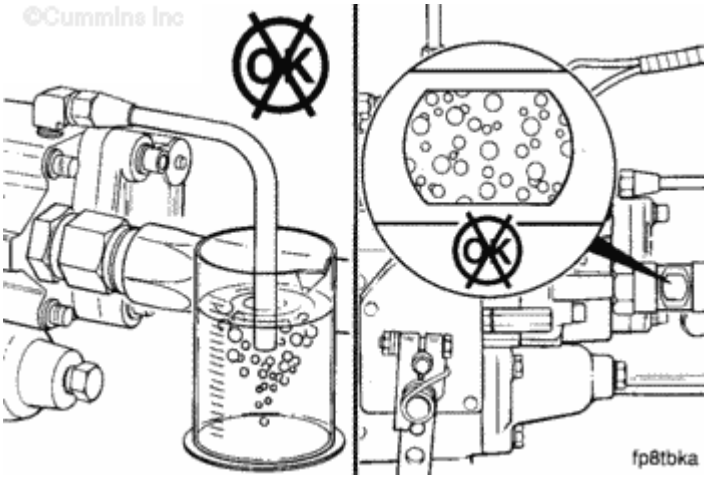
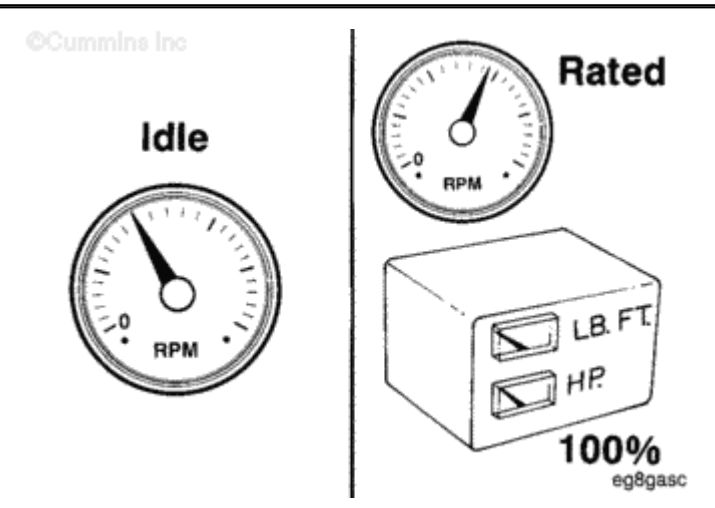


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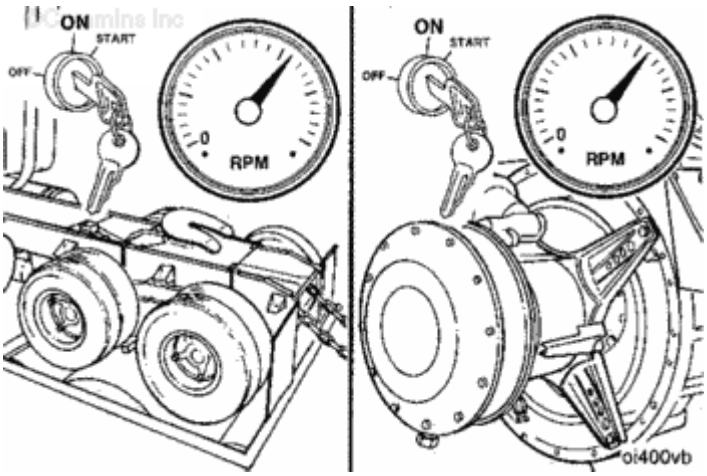
006-003 Air in Fuel

Leak Test

There are two methods to check for air in the fuel suction line. • Gear pump drain method • Sight glass method. Both methods are described in this procedure.		
In most cases, operation at high idle will provide sufficient fuel flow to determine if an air leak exists. However, in some cases it will be necessary to check for air leaks at the full fuel position.		
One method of measuring at the full		

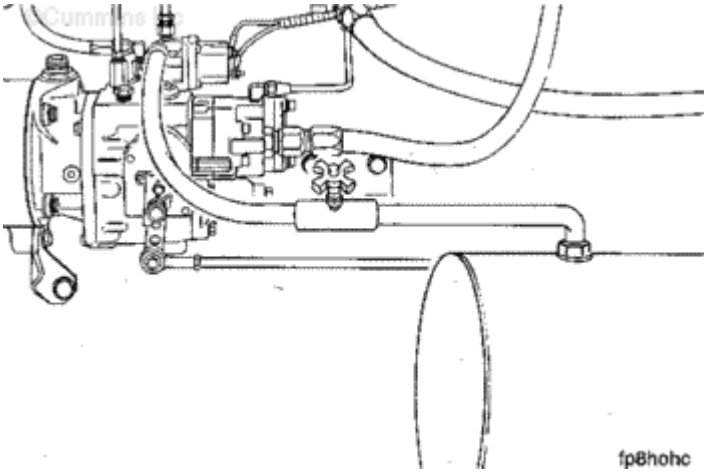
fuel position is to operate the engine at rated rpm and full load (wide open throttle).

This can be accomplished by using a dynamometer, the hydraulics, or a load bank if the equipment allows.

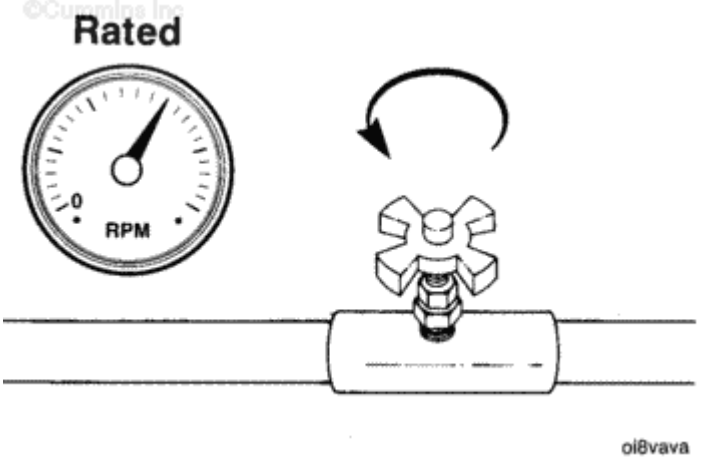


If it is **not** possible to load the engine, install a number six line containing a 7 mm [¼ in] needle valve at the fuel pump shutoff valve.

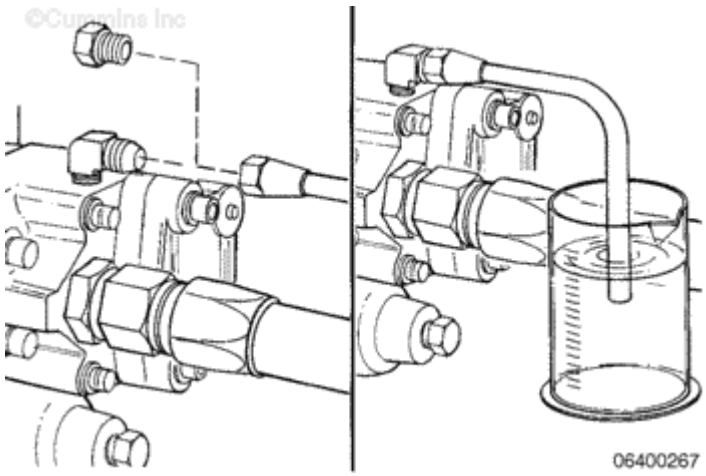
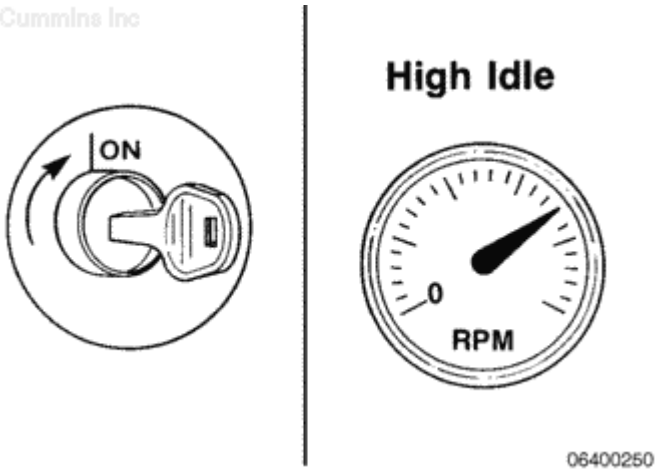
Route the line back to the fuel tank.

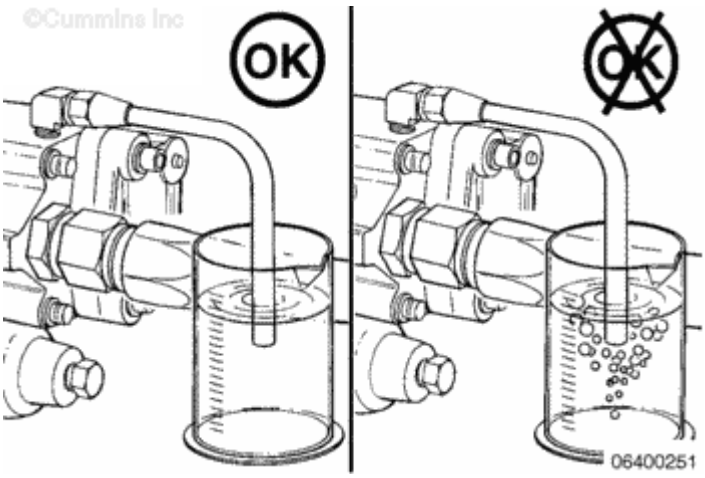


Operate the engine at high idle. Slowly open the valve until the engine rpm drops to rated rpm. This is the full fuel position.



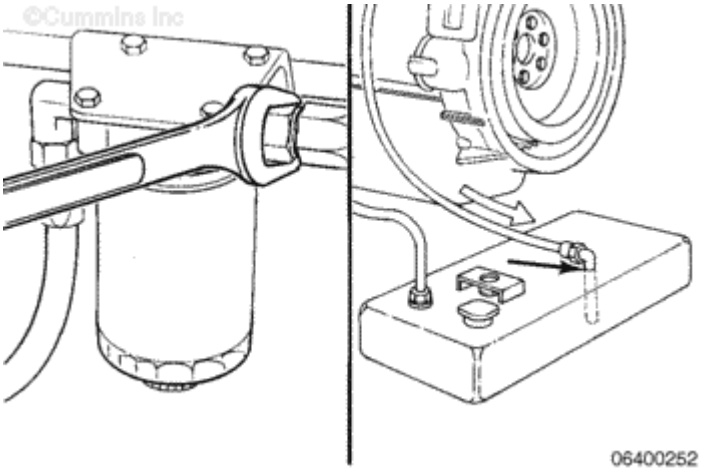
Gear Pump Drain Method

Remove the gear pump cooling drain line from the check valve and plug the line. Install a hose on the check valve and place the other end of the hose in a container with fuel in it.		
Operate the engine at high idle with no load, or in the full fuel flow position.		
Make sure the hose is below the surface of the fuel in the container. If air is in the fuel pump suction line, bubbles will be visible in the fuel.		

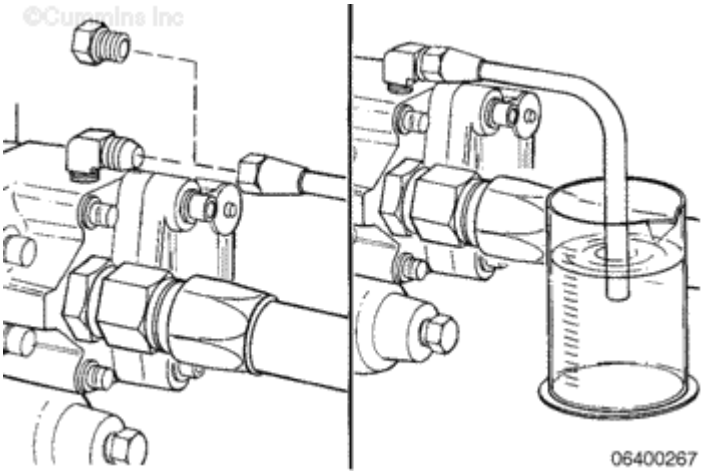


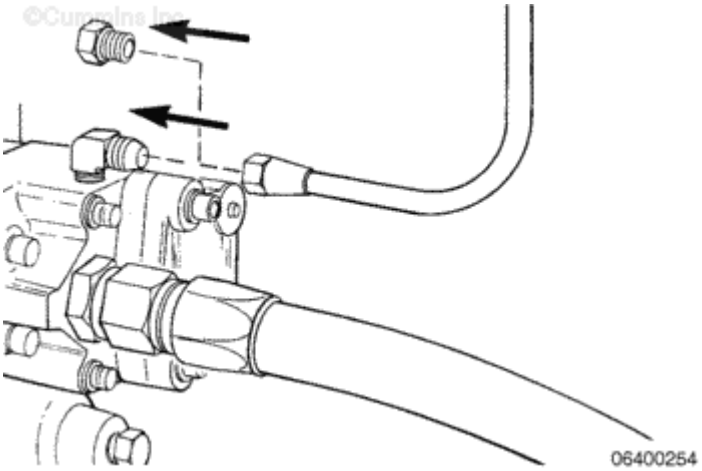
If an air leak is found perform the following:

- Tighten the hose connections and the fuel filter.
- Check the drop tube in the fuel tank for damage.

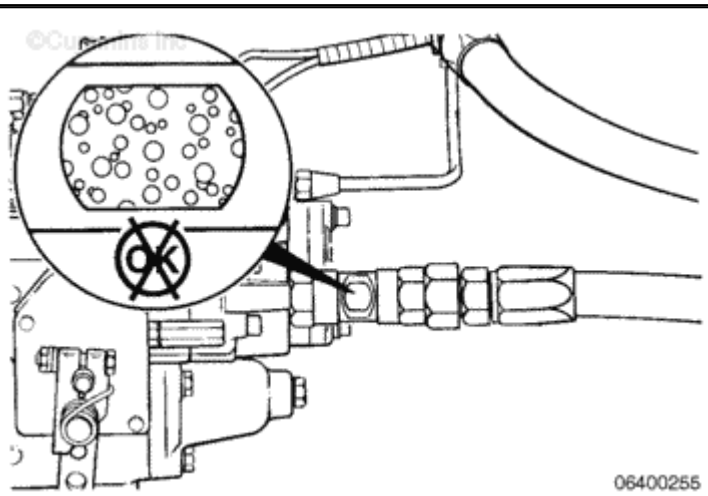


Correct the air leak and test for other leaks.

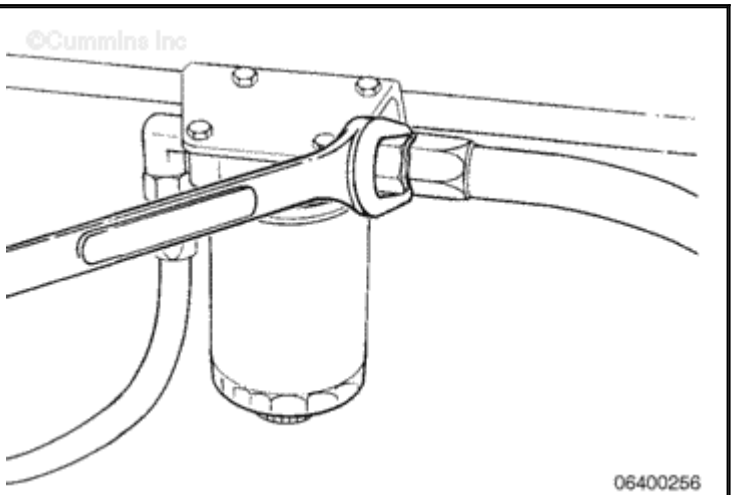


Remove the hose from the check valve and the plug from the cooling drain line. Install the drain line onto the check valve.		

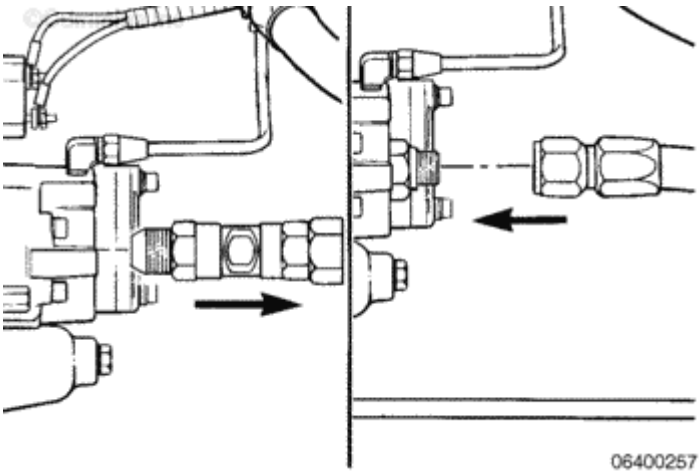
Sight Glass Method

Remove the fuel suction line. Install sight glass, Part Number ST-998, or 3164383, or equivalent. Place a source a light on the opposite side from the side viewed of the sight glass. Operate the engine at high idle with no load, or at the full fuel position. A small air leak will have a milky appearance. A large air leak will look like bubbles in the		

fuel. It is normal to see bubbles smaller than the tip of a pin pass infrequently through the sight glass. A solid stream of small bubbles or large bubbles indicate an air leak. It is also normal for there to be an air bubble at the outlet of the fuel filter head that does **not** disappear.		

If an air leak is found, inspect the fuel lines and fittings for damage. Check fittings for loose connections. Replace damaged fuel lines and tighten loose connections.		

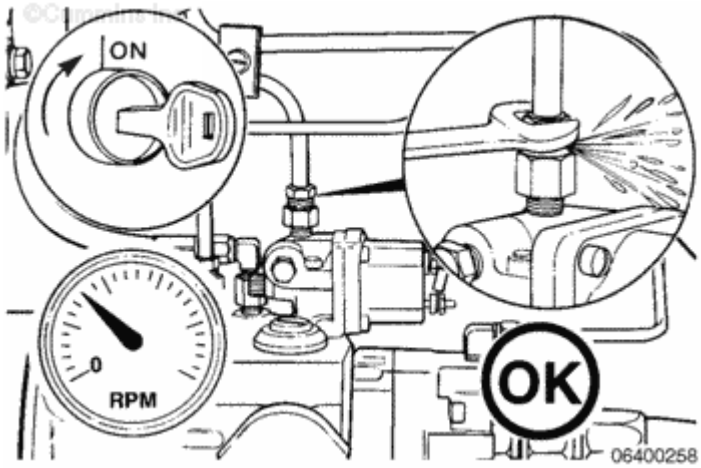
Remove the sight glass and install the suction line. Test the engine for other fuel leaks.	 	



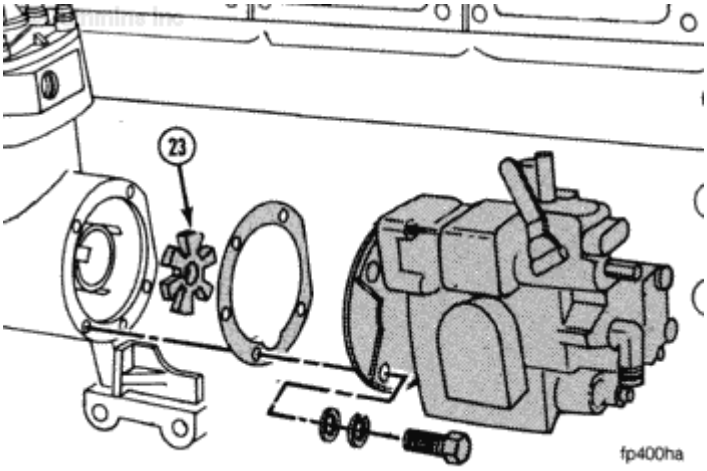
Bleed

Operate the engine at low idle to create pressure in the fuel lines.

Loosen the fuel outlet line at the shutoff valve to remove the air from the fuel pump.



If the air continues, remove and repair the fuel pump. Refer to Procedure 005-016.



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006-011 Fuel Filter, Remote Mounted

Remove

Rail Applications

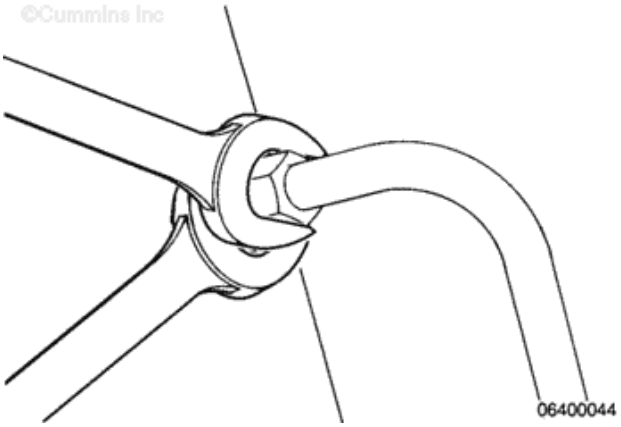
WARNING

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.

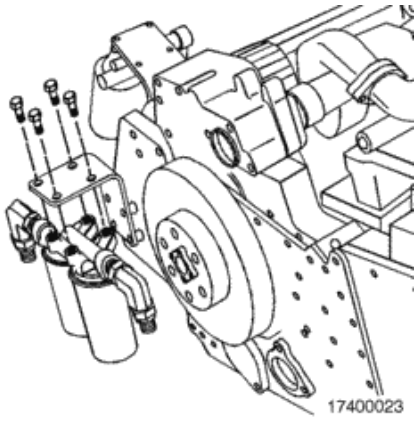
Use two wrenches to remove the fuel hoses.

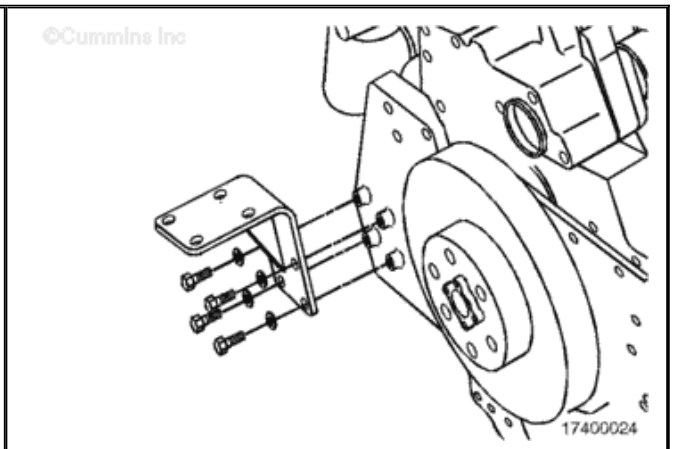
Support the mating fittings with a wrench. Loosen the fuel hose nuts with the other wrench.

Remove the inlet hose, outlet hose, and o-rings from the fuel filter head.



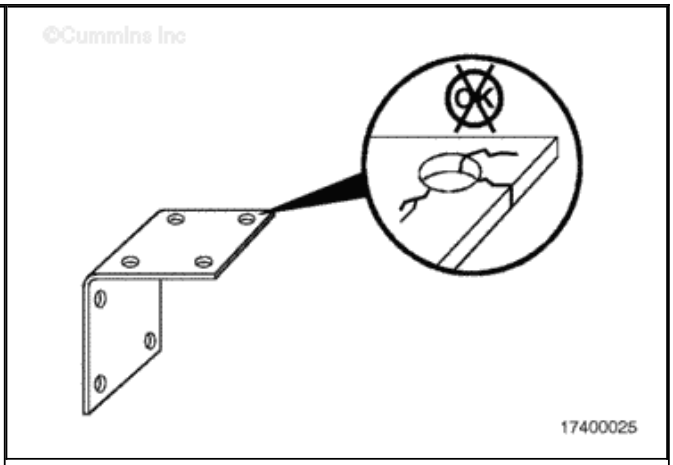
Remove the four capscrews and fuel filter head from the bracket.



Remove the bracket and four capscrews from the lubricating oil pan.		

Inspect for Reuse

Rail Applications

Check for cracks in the fuel filter head bracket. If the bracket is cracked, it **must** be repaired or replaced.		

Install

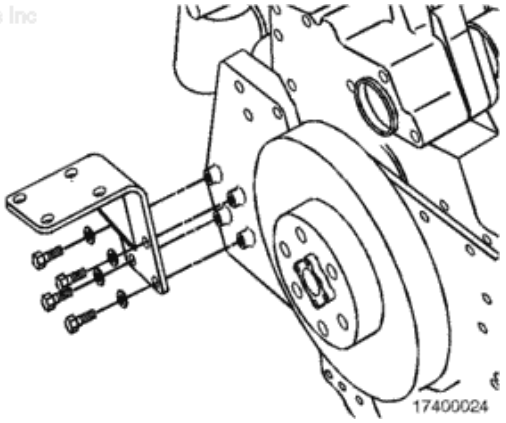
Rail Applications

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.

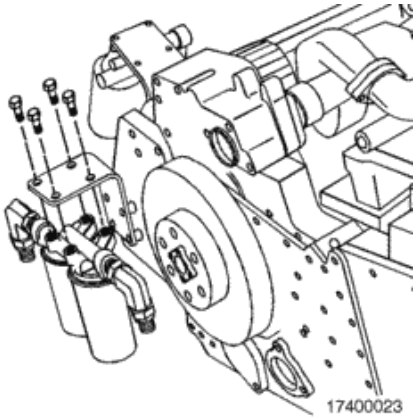
Install the bracket and four capscrews on the lubricating oil pan. Tighten the capscrews.

Torque Value: 75 n.m [55 ft-lb]



Install the fuel filter head and four capscrews on the bracket. Tighten the capscrews.

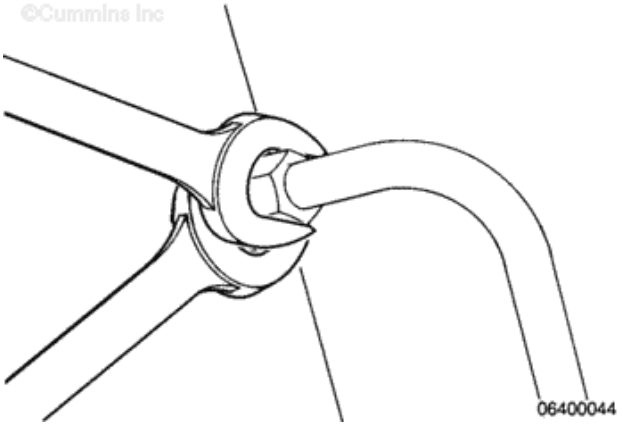
Torque Value: 25 n.m [20 ft-lb]



Install the two hoses and o-rings on the fuel filter head.

Tighten the fittings.

Fitting - Fuel Tank to Fuel Filter	115 n.m	[85 ft-lb]
Fitting - Fuel Filter to Fuel Pump	90 n.m	[65 ft-lb]

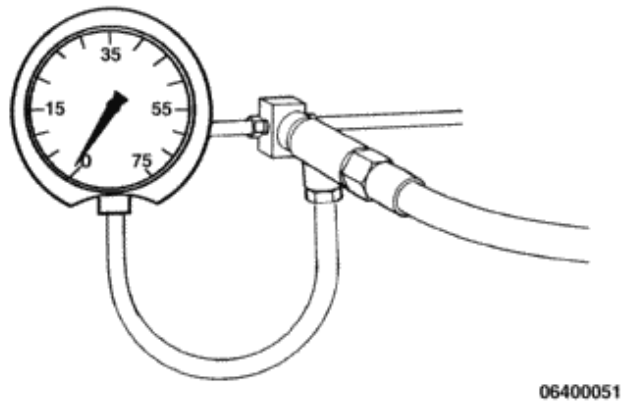
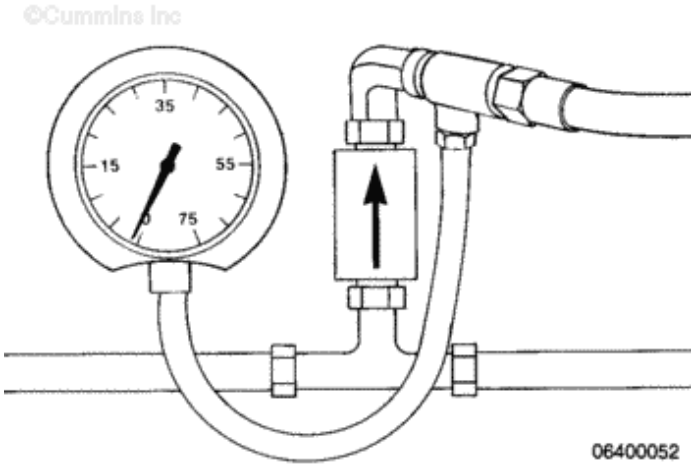


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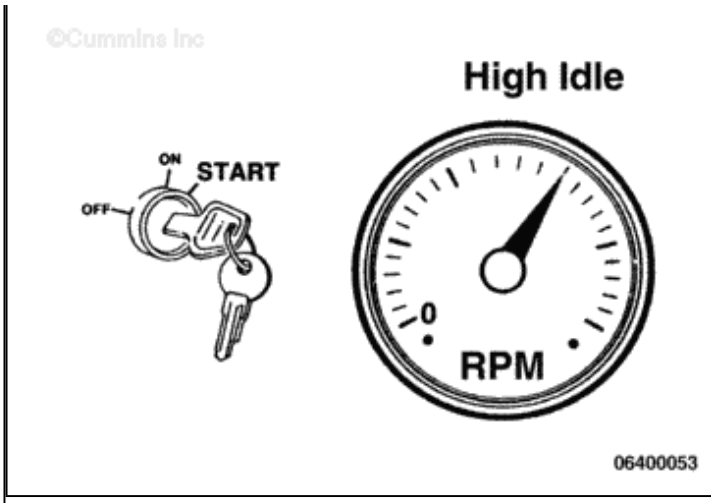
006-012 Fuel Drain Line Restriction

Measure

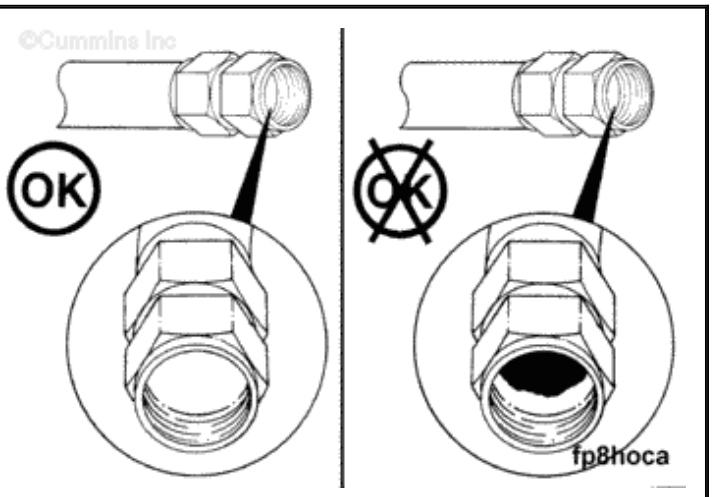
Remove the fuel drain hose. Install the adapter, Part Number ST-434-2, and pressure gauge, Part Number ST-1274-1, between the fuel drain hose and the engine fuel drain fitting.		
If the engine has a drain side check valve, install the adapter between the fuel drain hose and the check valve.		
Start and operate the engine at high idle, no load.		

Maximum Allowable Return Line Restriction

- With check valve: 0 to 21 kPa [0 to 3 psi]
- With check valve removed: 14 to 30 kPa [2 to 5 psi].



If the fuel drain line restriction is above specifications, inspect the fuel drain line. Refer to Procedure 006-013.

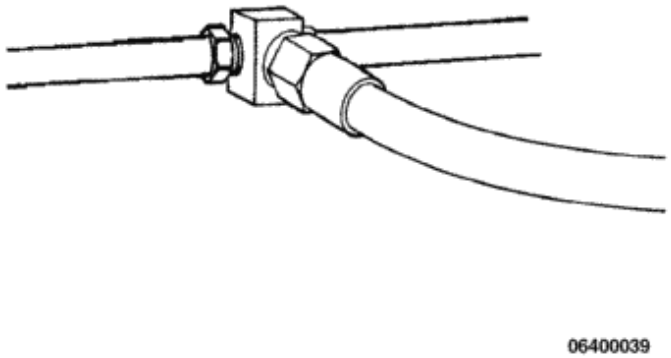


Remove the gauge.

Install the fuel drain line.

Tighten the fuel line.

Torque
Value: 75 n.m [55 ft-lb]

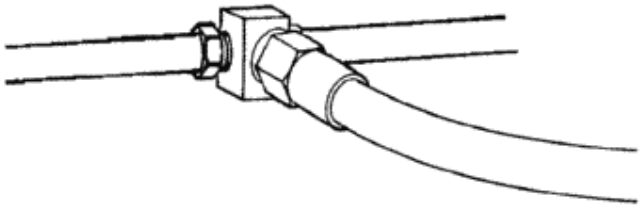
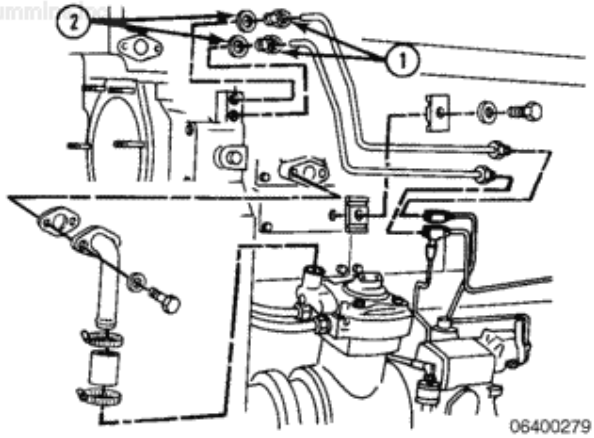


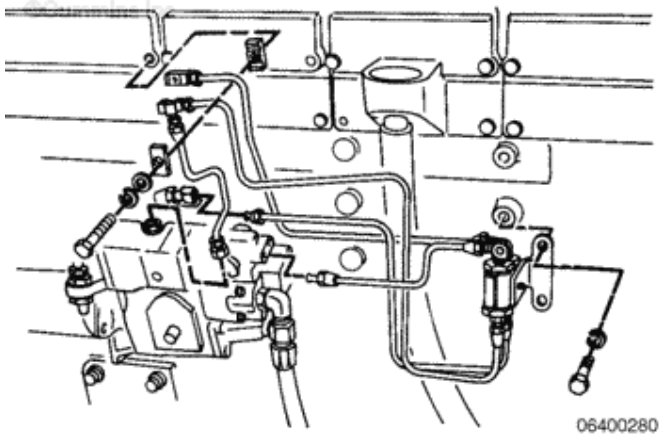
Last Modified: 04-Nov-2004

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006-013 Fuel Drain Lines

Remove

Remove the fuel drain hose from the engine.		 06400039
The fuel drain tube connects closest to the top of the fuel manifold. Disconnect the fuel manifold end of the fuel drain tube.		 06400279
Disconnect the fuel pump end of the fuel drain tube.		



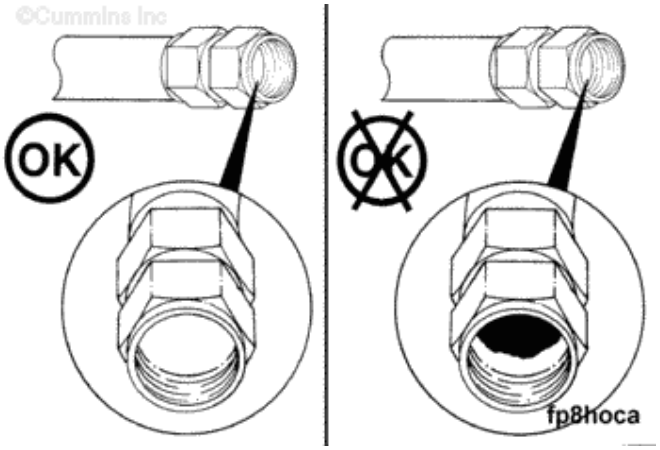
Inspect for Reuse

Inspect the inside of the hose for:

- The inner lining of the hose separated from the center section.
- A separation flap causing a restriction in fuel flow.

Inspect for any pinches in the hose that will obstruct the fuel flow.

Replace the hose if pinched or separated.

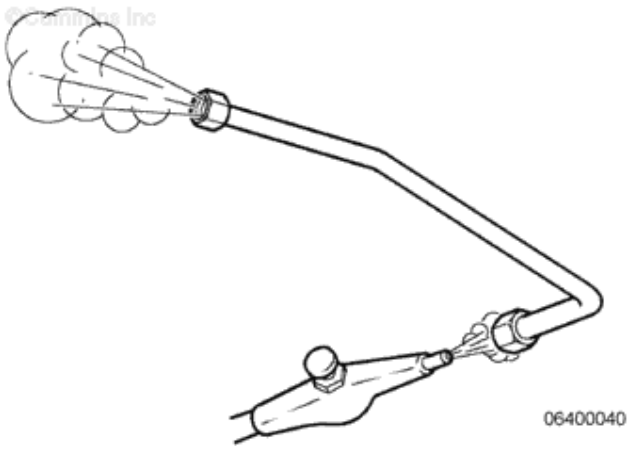


WARNING

Wear appropriate eye and face protection when using compressed air. Flying

debris and dirt can cause personal injury.

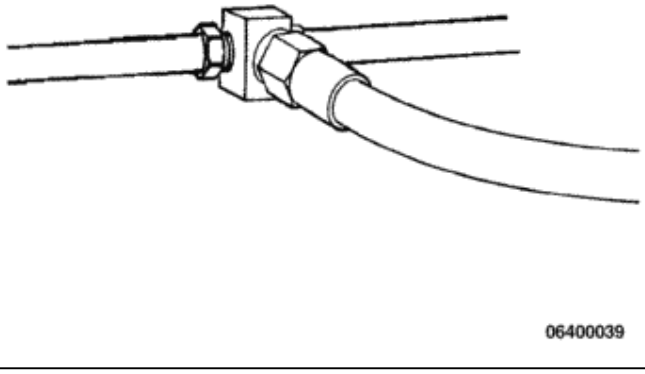
Use compressed air to make sure the fuel tubes are free of blockage or restriction.



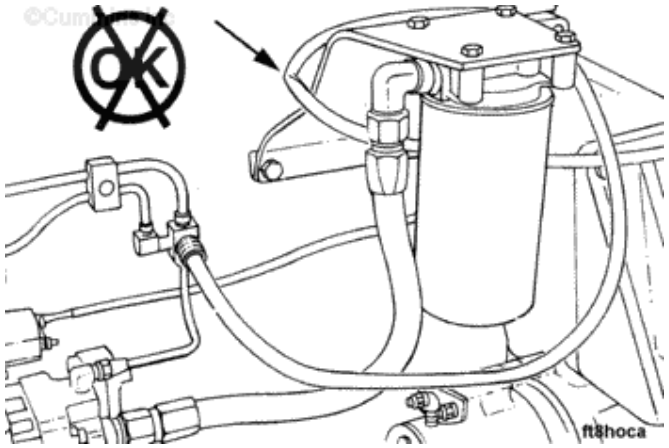
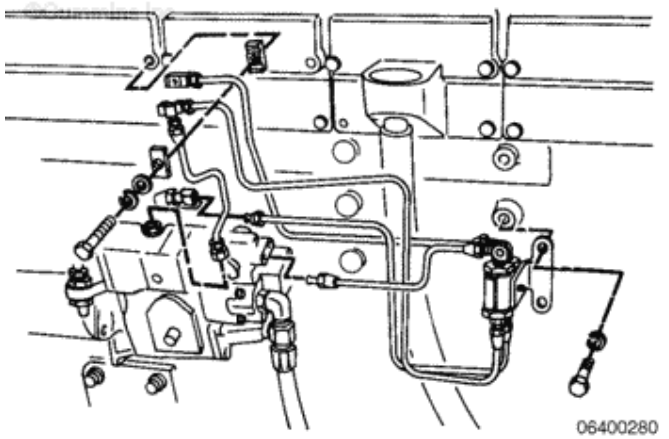
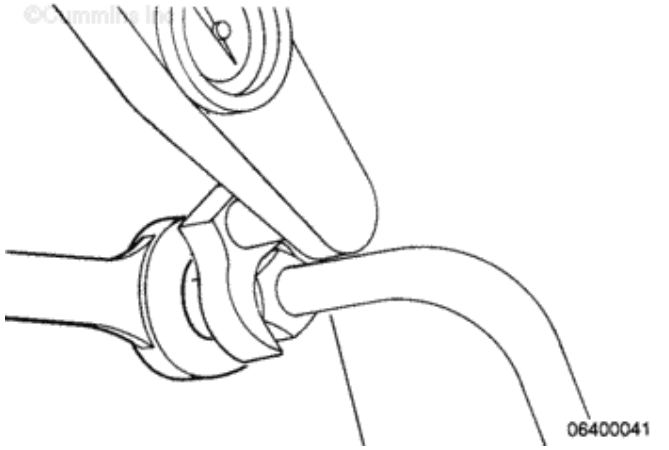
Install

Install and tighten the fuel drain hose.

Torque
Value: 75 n.m [55 ft-lb]



Make sure the hose does **not** have pinches or loops that will obstruct fuel flow.

		
Connect and tighten the fuel pump end of the drain tube.		
Refer to Procedure 006-022 for the correct connection of the fuel tube to the manifold. Connect the fuel manifold end of the fuel drain tube.		

Last Modified: 04-Nov-2004

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006-015 Fuel Filter (Spin-On Type)

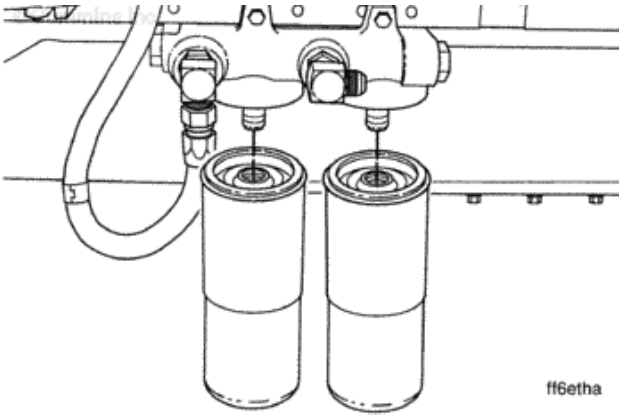
Remove

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.

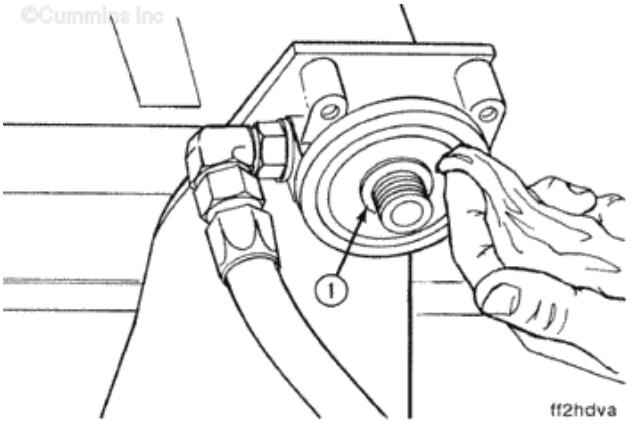
Close the fuel line shutoff valve before changing the fuel filters, or the overhead tank can drain, causing a fuel leak.

Remove the fuel filter with filter wrench, Part Number 3376807.

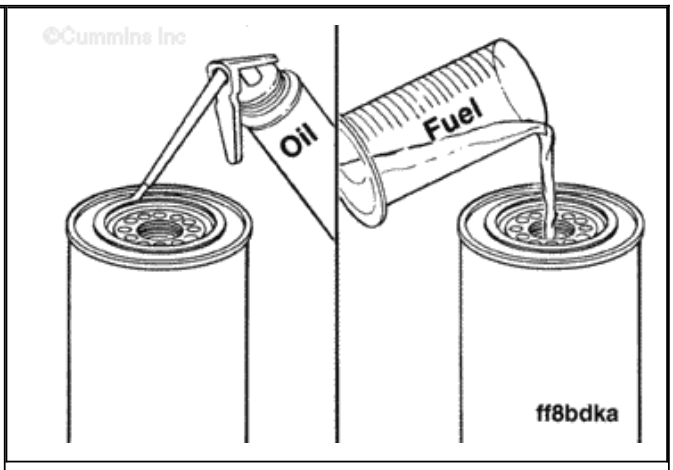
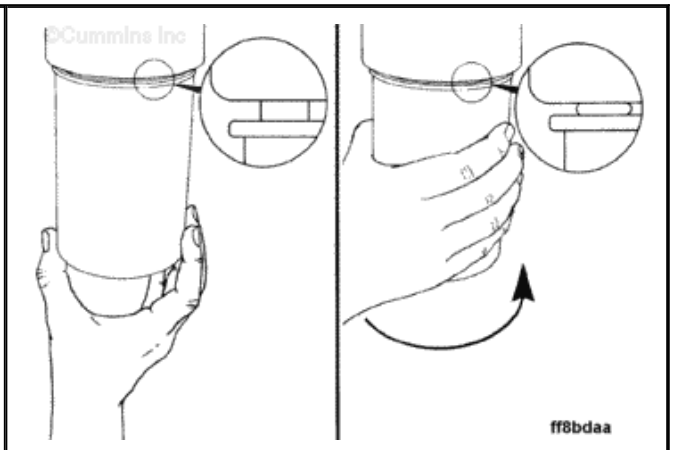


Remove the thread adapter sealing ring (1).

Use a clean, lint-free towel to clean the surface of the filter head gasket.



Install

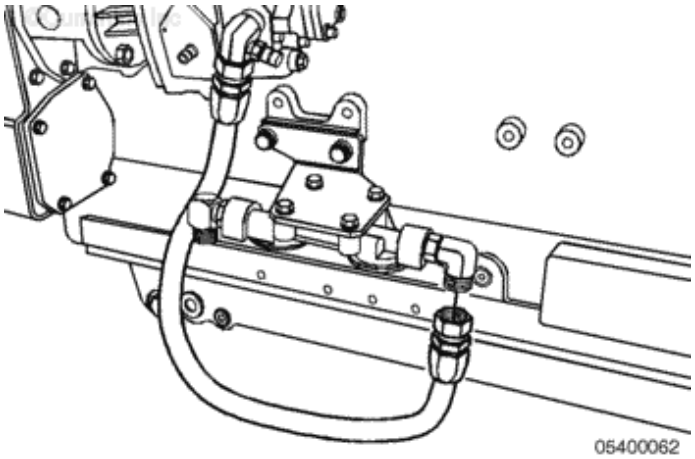
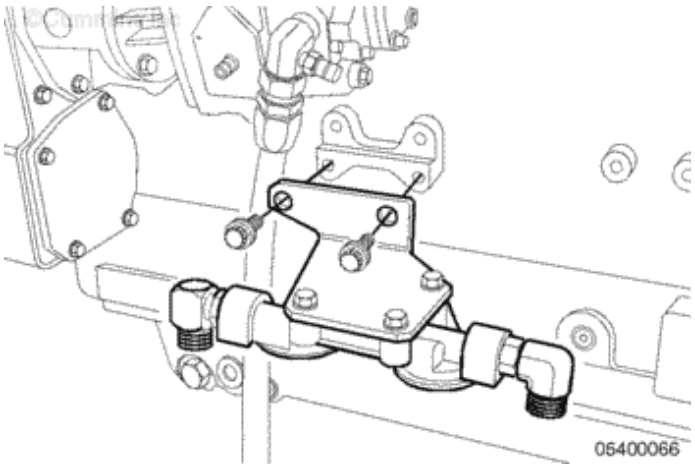
Install a new thread adapter sealing ring supplied with the new filter. A fuel-water separator or fuel filter and water separator combination **must** be installed. Apply a light coating of clean engine oil to the surface of the filter gasket. Fill the filter with clean fuel.		
Install the filter on the filter head. Turn the filter until the gasket touches the surface of the filter head. Tighten the filter an additional 1/2 to 3/4 of a turn after the gasket touches the filter head surface. Open the fuel line shutoff valve and check for leaks.		

Last Modified: 28-Jul-2006

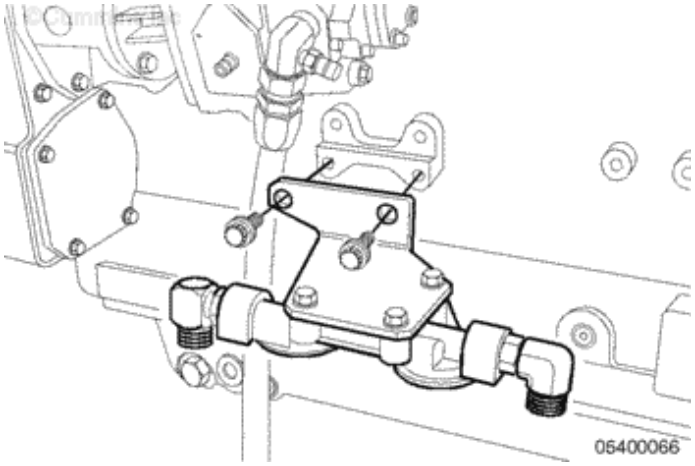
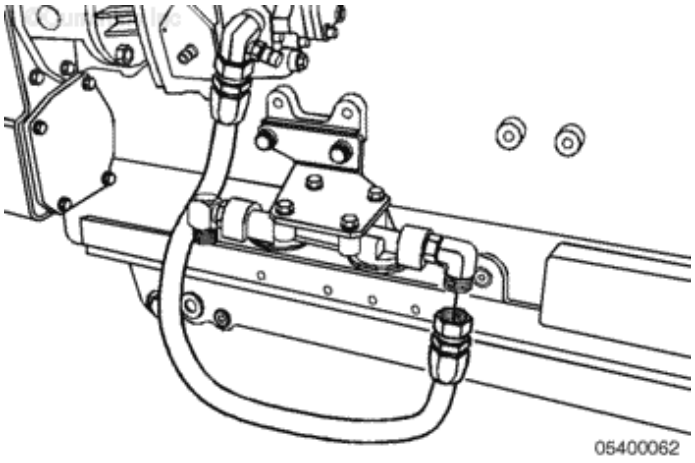
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006-017 Fuel Filter Head

Remove

Disconnect the fuel line from the fuel filter head.		
Remove the two mounting capscrews. Remove the fuel filter head.		

Install

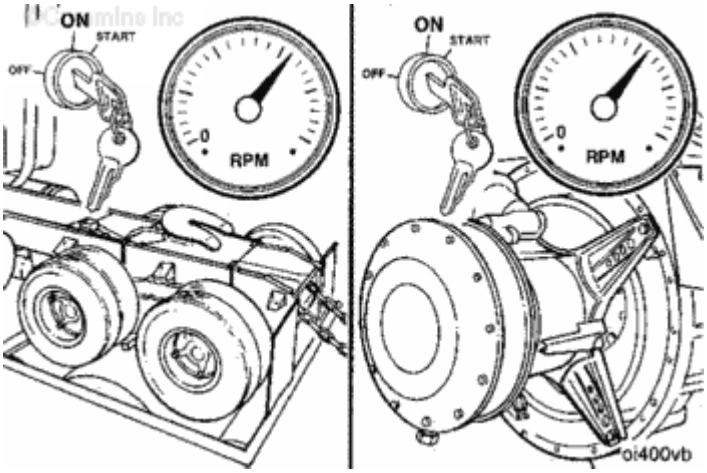
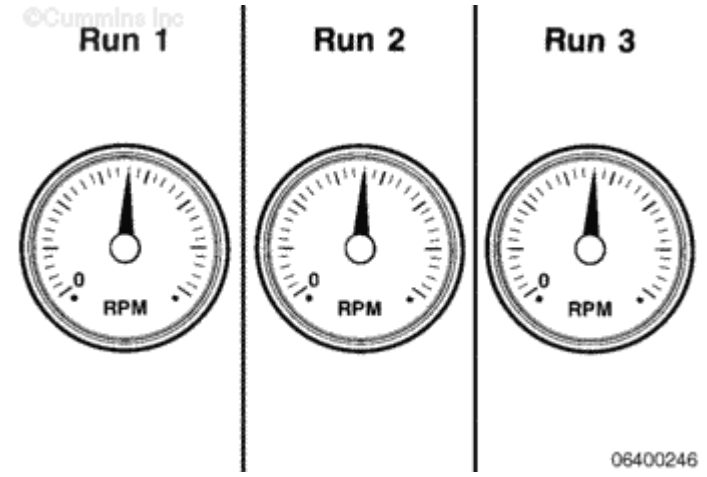
Install the fuel filter head. Install the two mounting capscrews. Tighten the capscrews. **Torque** **Value:** 55 n.m [40 ft-lb]		
Connect the fuel line to the fuel filter head.		

Last Modified: 04-Nov-2004

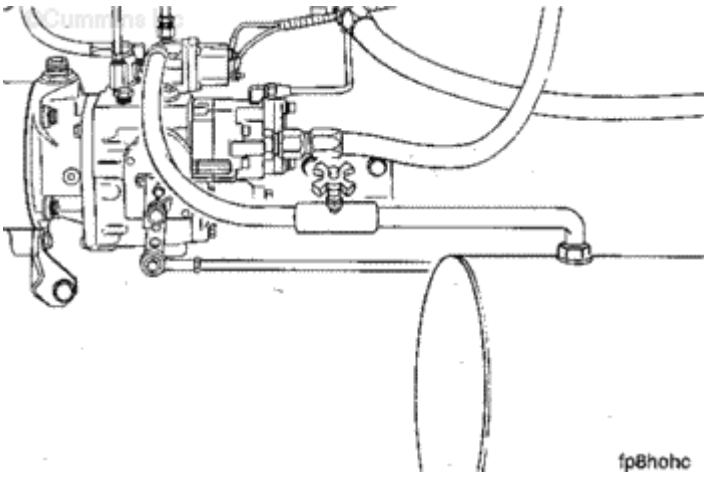
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006-020 Fuel Inlet Restriction

Test

The fuel pump **must** be in the full fuel position to accurately measure fuel line restriction. Operate the engine at rated rpm and full load.		
Perform a stall speed check. Refer to Procedure 005-054.		
Install a line containing a 7		

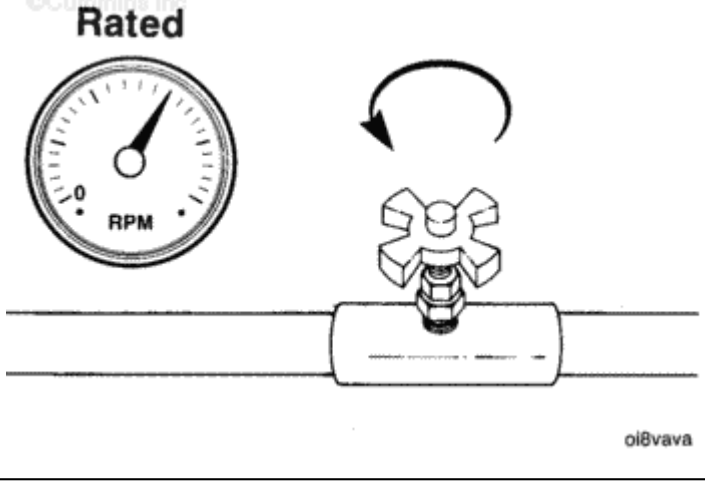
mm [¼ in] needle valve between the fuel pump shutoff valve and the fuel tank.



Operate the engine at high idle.

Slowly open the needle valve until the engine rpm drops to rated rpm.

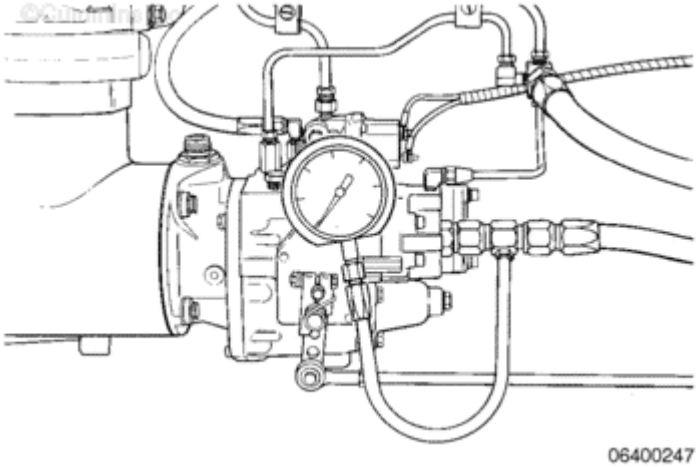
When the engine drops to rated rpm it is at the full fuel position.



Remove the fuel supply hose to the gear pump or the plug from the rear of the fuel pump mounted fuel filter.

Install the adapter as close to the fuel pump as possible.

The minimum vacuum gauge



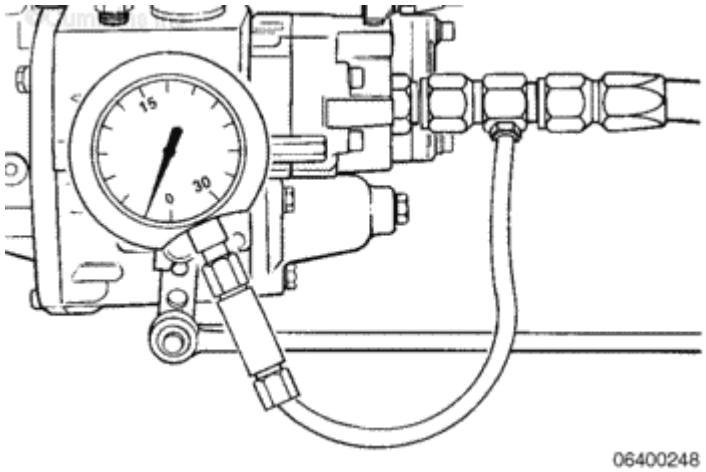
capacity is 760 mm-Hg [30 in-Hg].

Vacuum gauge, Part Number ST-434 contains the gauge, hose and adapter.

Install a vacuum gauge, Part Number ST-434, or equivalent, to the adapter.

The gauge will **not** measure the correct vacuum if it is **not** held at the same level as the gear pump.

Hold the gauge at the same level as the gear pump.

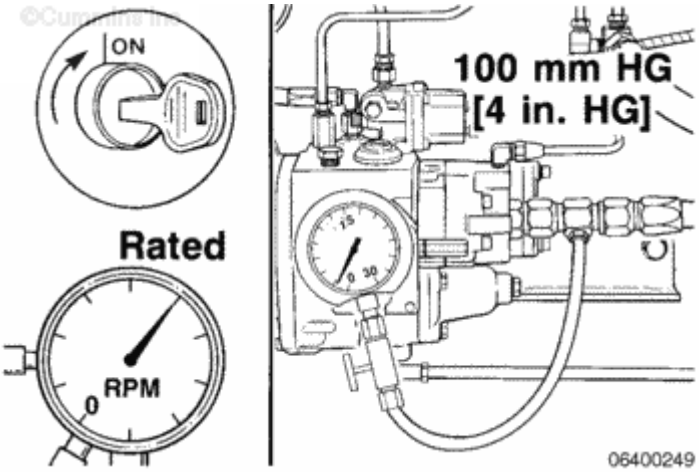


Operate the engine at full fuel position.

Note the reading on the gauge.

The maximum fuel inlet restriction is as follows:

- Clean Fuel Filter is 100 mm-Hg [4.0 in-Hg]



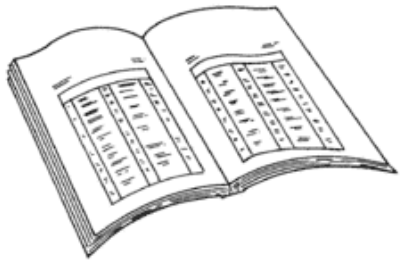
• Dirty Fuel Filter is 200 mm-Hg [8.0 in-Hg]. Correct the restriction or replace the fuel filter. Refer to Procedure 006-011 or 006-012. Remove gauges and adapter. Install fuel supply line.		

Last Modified: 08-Dec-2004

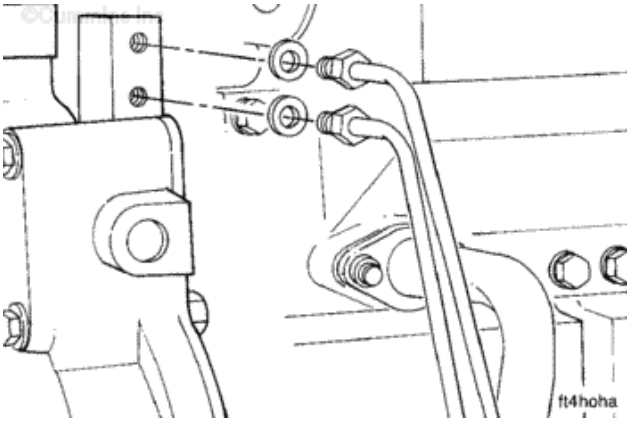
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006-022 Fuel Manifold (Supply)

Preparatory Steps

• Remove the aftercooler or intake manifold. Refer to Procedure 010-002.		 ck800wa

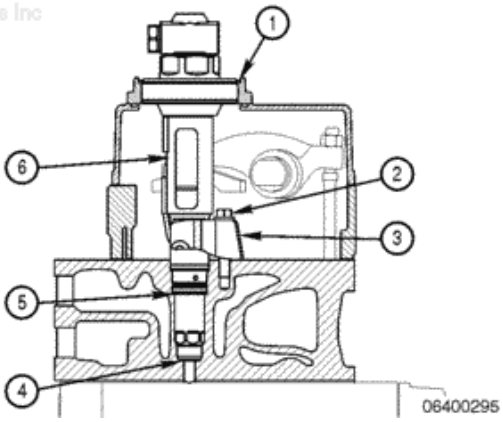
Remove

Disconnect the fuel lines at the fuel block. It will possibly be necessary to remove the tube clamp at the cam follower cover to enable the tubes to be pulled out of the fuel block.		 ft4hoha

Remove the fuel manifold.

Remove the 12 o-rings.

Discard the o-rings.



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.

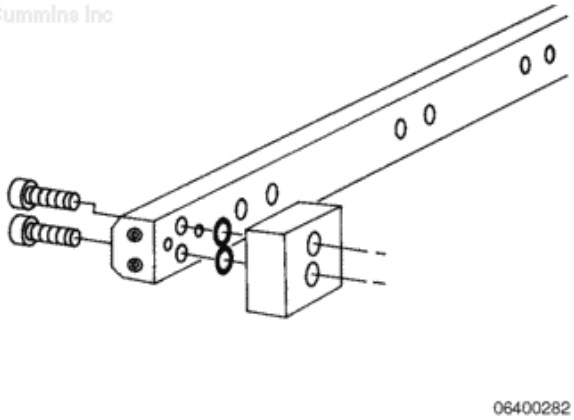
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

NOTE: Newer manifolds will not have removable plugs in the ends of the manifold.

Do **not** remove the pipe plugs unless there is a leak.

Clean and flush the fuel manifold with solvent, Part



Number 3824421, or equivalent.

Dry with compressed air.

Install the pipe plugs if they were removed.

Torque Value: 7 n.m [60 in-lb]

Install

NOTE: The fuel junction block on older engines can be toward the rear of the engine.

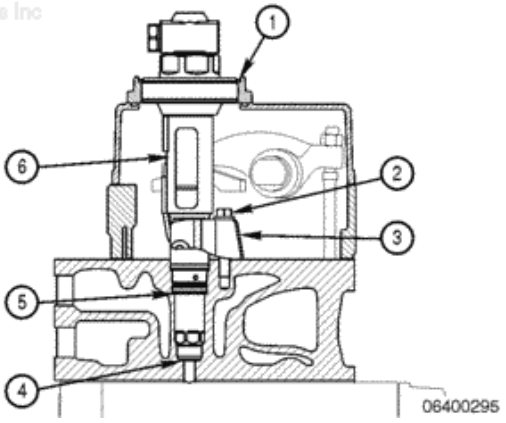
Lubricate the o-rings with vegetable oil.

Install the o-rings onto the fuel manifold.

Install the fuel manifold, washers, and capscrews.

Start from the center of the fuel manifold work towards the outer edges tightening the capscrews.

Torque Value: 10 n.m [89 in-lb]

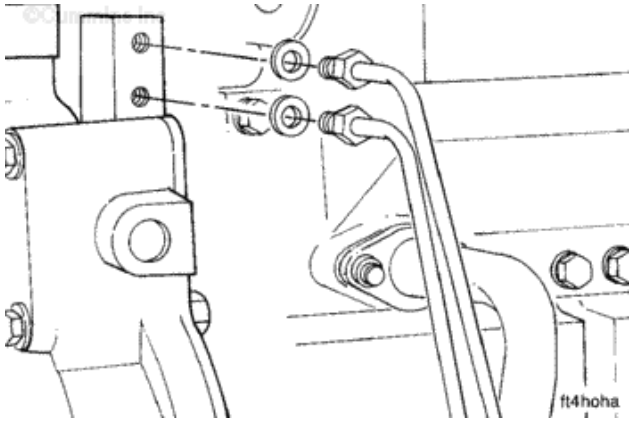


CAUTION

The seals must be installed on the tubes before the tubes are inserted into the junction block.

CAUTION

Do not over tighten the tube

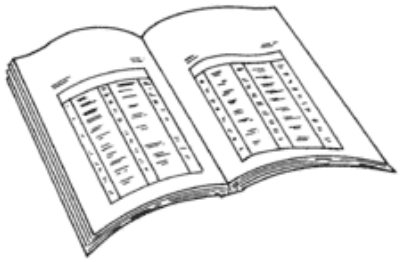


nuts and the junction block. Finger tighten the tube nuts into the junction block. Turn the tube nuts and additional ¾ to 1 turn past finger tight. The fuel pressure tube is the upper tube. The fuel drain tube is the lower tube. Install the tube nut and seals onto the fuel tubes. Connect, but do **not** tighten the fuel tubes to those already installed. Insert the fuel tubes into the junction block. Finger tighten the tube nuts in the junction block. Turn the nuts an additional ¾ to 1 turn beyond finger tight. Tighten the tubing nuts at their connection with the other tubes. Install the capscrew for the clamp and tighten. **Torque** **Value:** 45 n.m [33 ft-lb]		

Finishing Steps

• Install the aftercooler or intake manifold. Refer to Procedure 010-002.	 	

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ck800wa

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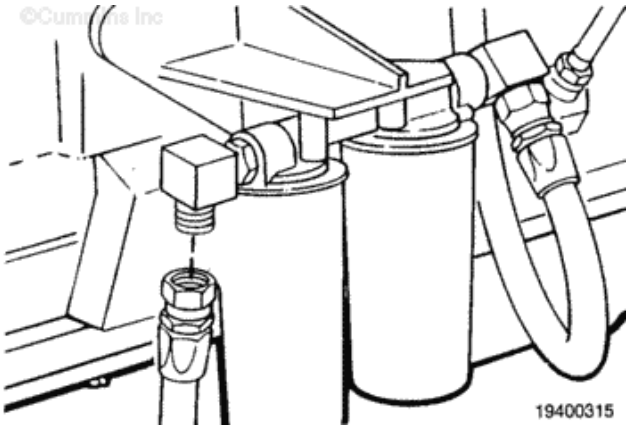
006-024 Fuel Supply Lines

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 a fuel system.

Remove the fuel tank to fuel filter inlet hose.

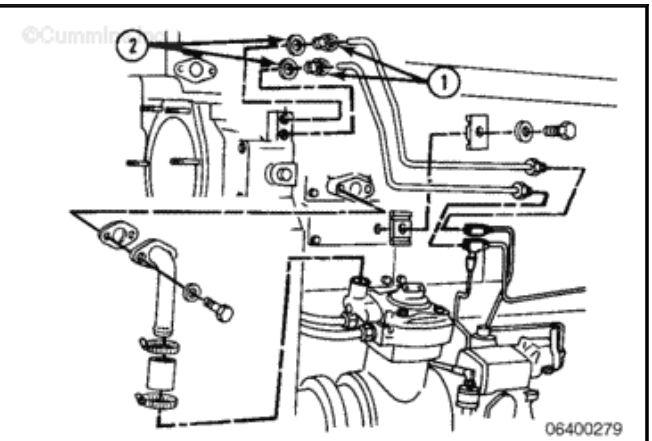


Disconnect the fuel supply tube.

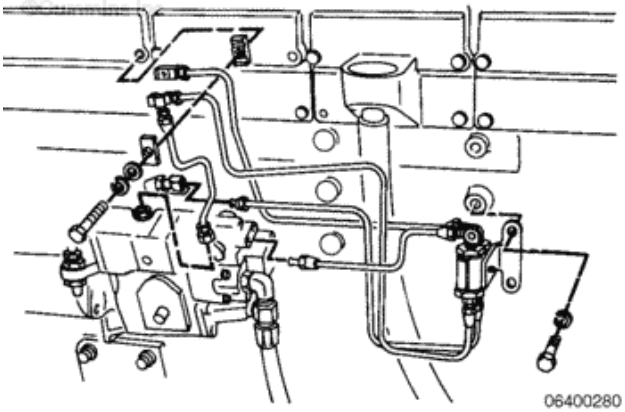
Disconnect the fuel manifold end of the fuel supply tube. The fuel drain tube connects closest to the bottom of the fuel manifold.

On engines with an air compressor, remove the air inlet connection.

Discard the connection hose and gasket.



Disconnect the fuel pump end of the fuel supply tube.



WARNING

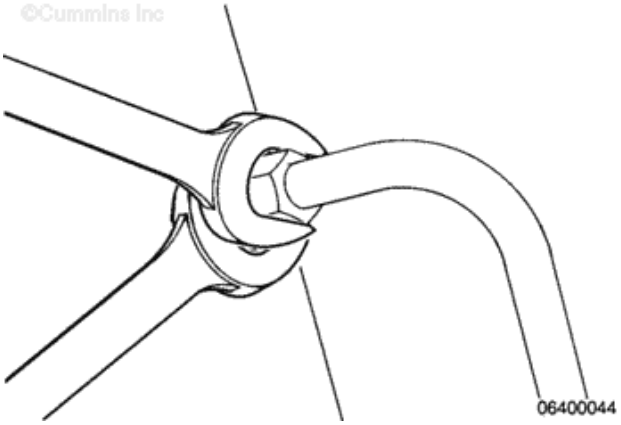
Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on a fuel system.

Use two wrenches on fuel tubes and hoses.

Support the mating fittings with a wrench.

Loosen the fuel tube nuts with the other wrench.

Remove the fuel tubes and hoses.



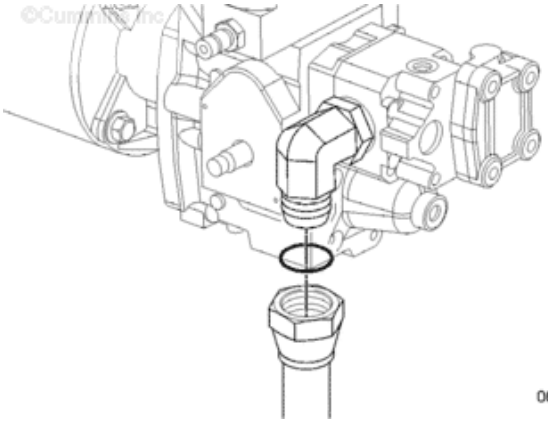
WARNING

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 a fuel system.

Remove the hose between the fuel filter head outlet and the fuel pump inlet fitting.

Remove and discard the o-rings.



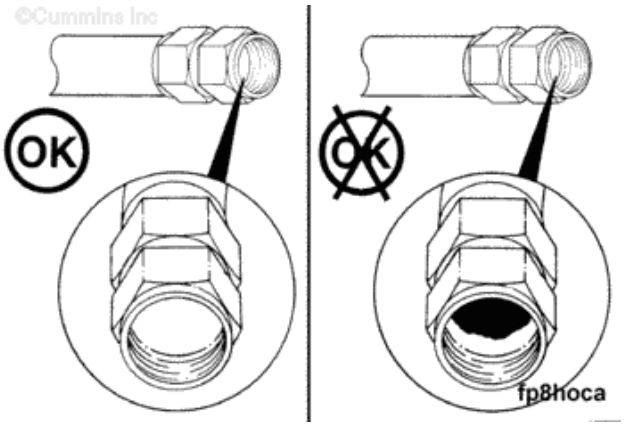
Inspect for Reuse

Inspect the inside of the hose for:

- The inner lining of hose separating from center hose section.
- A separation flap causing a restriction in fuel flow.

Inspect for any pinches in the hose that will cause an obstruction to the fuel flow.

If the hose is separated or pinched, it **must** be replaced.

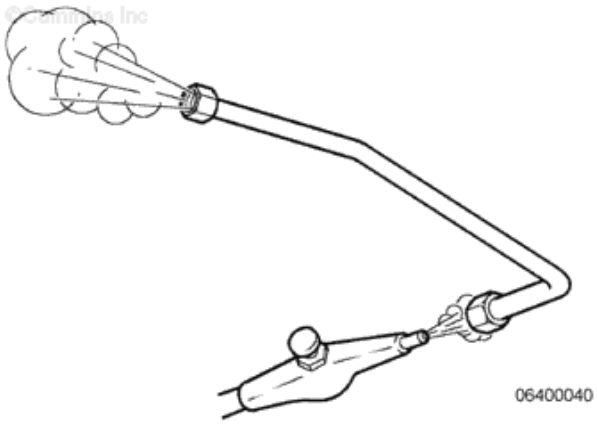


WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

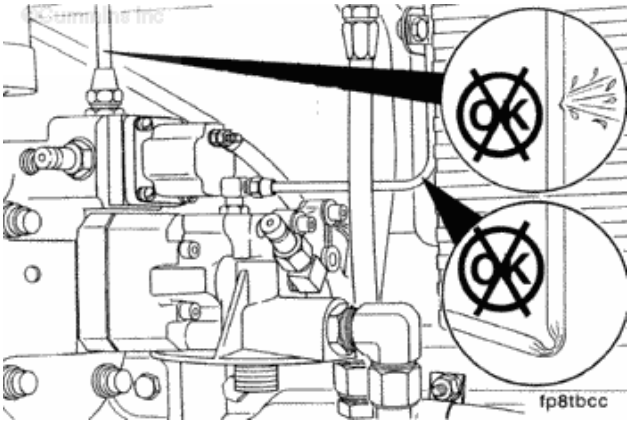
Flush the fuel tubes with compressed air to remove any

loose dirt particles.



Inspect the fuel tubes for cracks that can cause a loss of pressure.

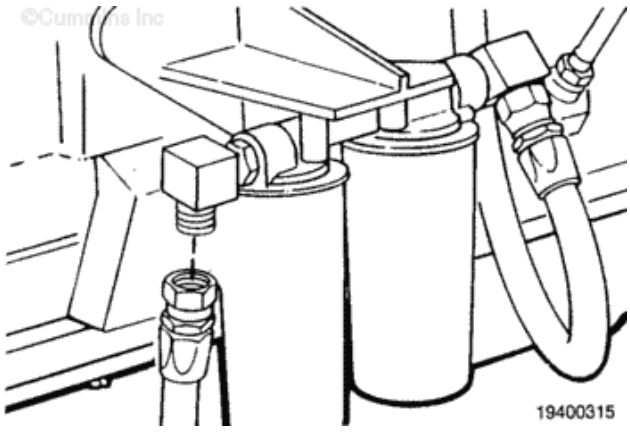
Inspect the fuel tubes for sharp bends that can cause a restriction in pressure.

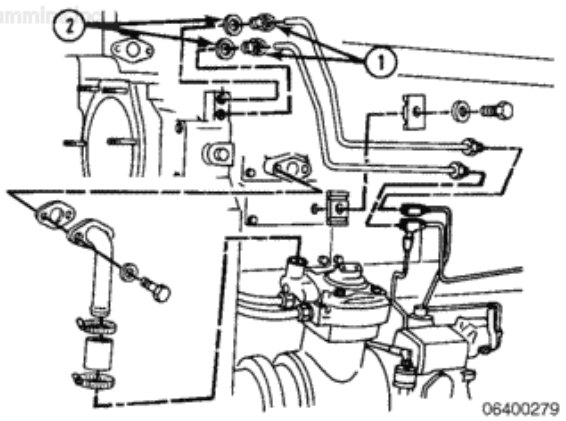
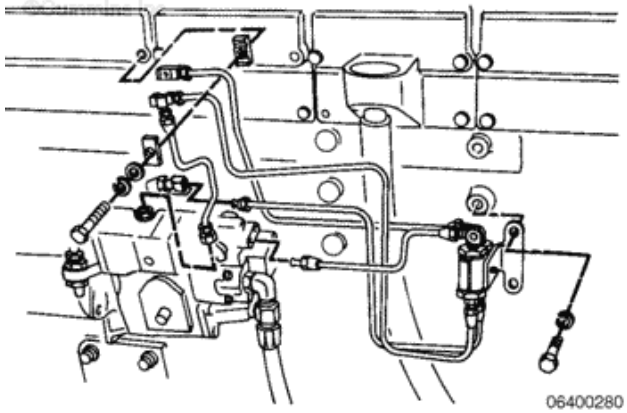
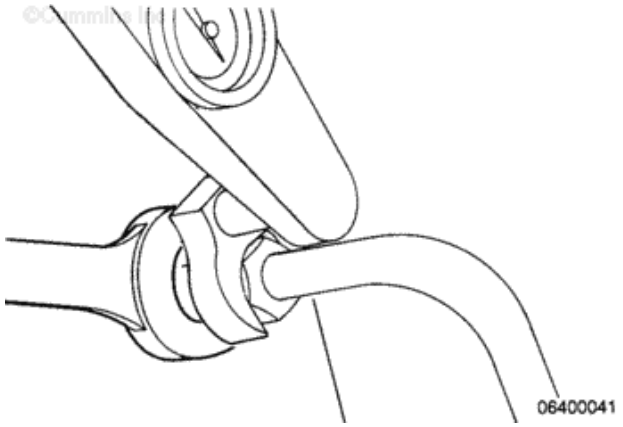


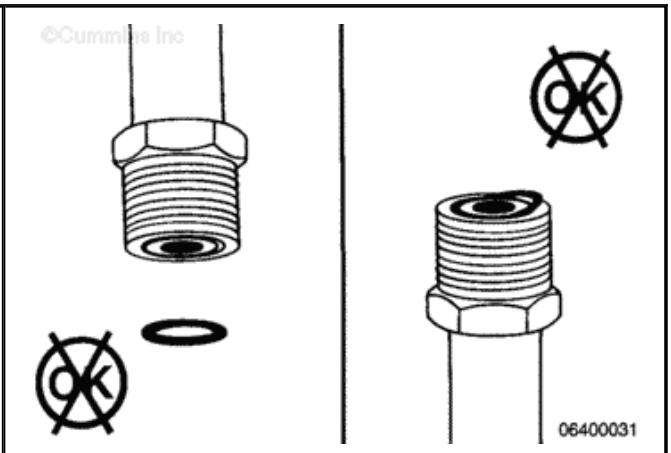
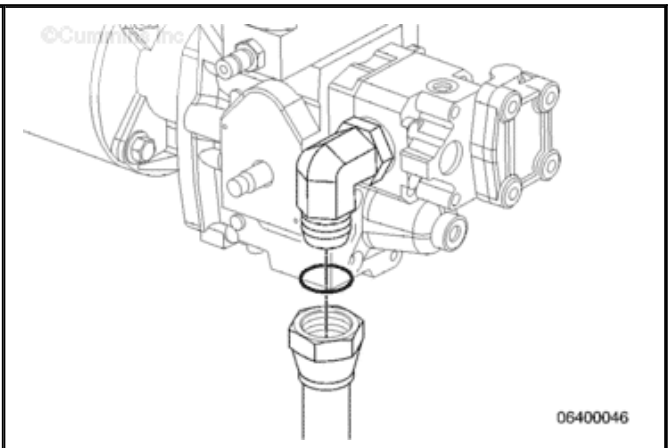
Install

Install the fuel tank to fuel filter fuel inlet hose.

Torque
Value: 115 n.m [85 ft-lb]



Loosely assemble the fuel tubes and clamps. Connect the tube to the fuel manifold. Refer to Procedure 006-022 for the correct connection of the fuel tube to the fuel manifold. On engines equipped with an air compressor, install the air compressor air inlet connection with a new hose and gasket. Flange Capscrew 4 n.m [35 in-lb] Clamp 6 n.m [50 in-lb]		
Connect the tube to the fuel pump.		
Use two wrenches when tightening the fuel fittings. Support the fitting with a wrench and tighten the fuel tube nut with a crowfoot wrench and a torque wrench. **Torque** **Value:** 27 n.m [20 ft-lb]		

Install new o-rings on the fuel inlet fitting and fuel filter head outlet fitting. Make sure the o-rings are installed correctly.		
Install the hose at the fuel pump inlet and fuel filter head outlet fitting. Tighten the hose. **Torque** **Value:** 88 n.m [65 ft-lb]		

Last Modified: 19-Oct-2004

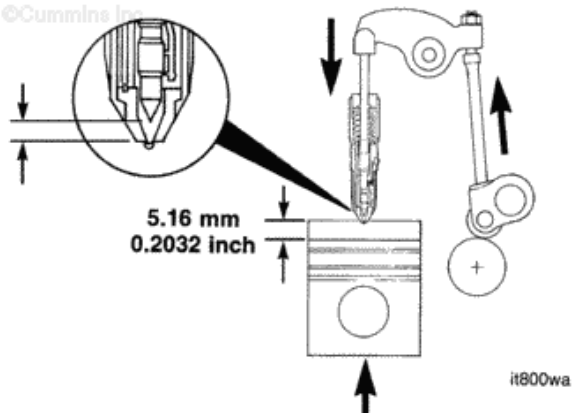
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006-025 Static Injection Timing

General Information

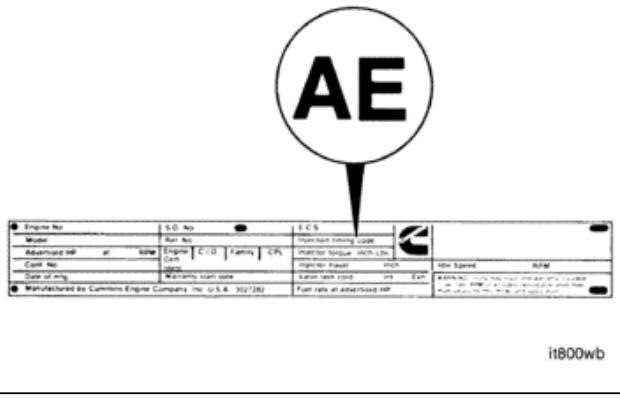
The injection timing is the relative measurement of the distance remaining between the injector plunger and the injector cup when the piston is 5.16 mm [0.2032 in], or 19 degrees before top dead center on the compression stroke.

Injector timing is expressed by the amount of push rod travel remaining.



The injector timing code appears on the engine dataplate. Codes are alphabetic letters that relate to a numerical specification.

Specifications can be found in the Control Part List (CPL) Manual, Bulletin 4021328.

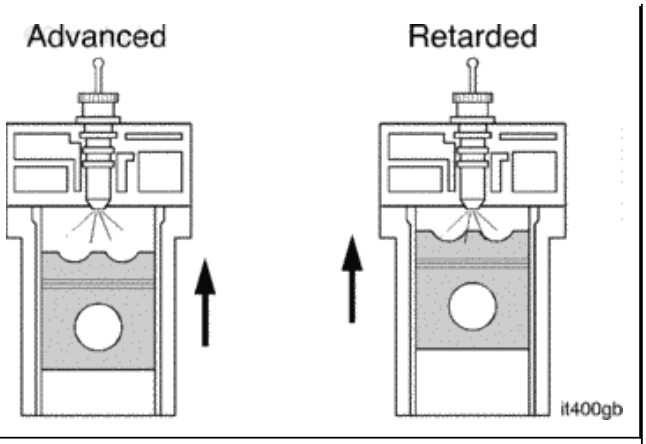


Below is a brief review of injection timing and how it can be adjusted.

Advanced timing means the fuel is injected earlier into the cylinder during the compression stroke.

Retarded timing means the fuel

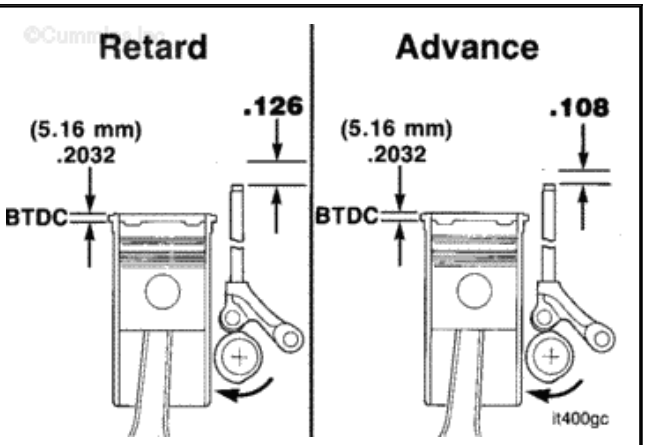
injection occurs closer to top dead center in the cylinder.



The amount of push rod travel determines the time of fuel injection in relation to the piston position.

The higher the numerical value of the push rod travel remaining indicates a greater degree of retarded or slow timing.

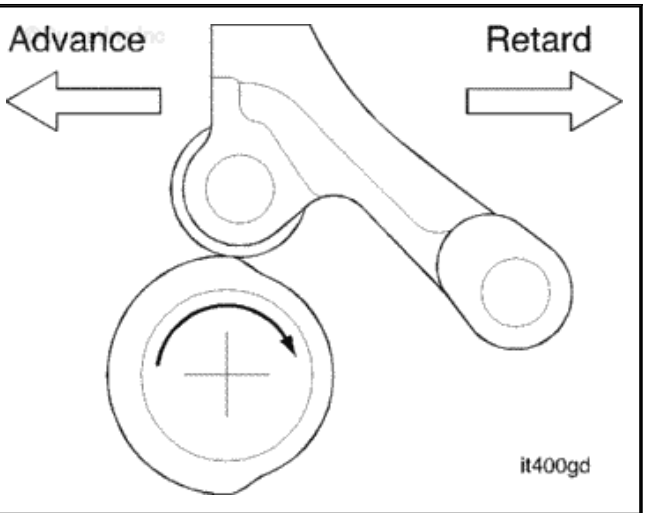
The lower the numerical value of the push rod travel remaining indicates a greater degree of advanced or fast timing.



Injection timing changes are accomplished by advancing or retarding the cam follower action in relation to the piston position.

This is accomplished by changing the orientation of the camshaft lobe to the cam follower using different camshaft gear keys.

Gear train timing (index mark alignment) always remain the same.

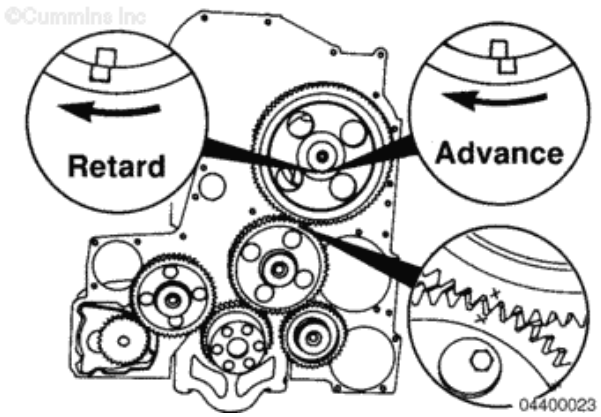


The camshaft key provides a means of indexing the camshaft with the gear.

Offset keys allow the camshaft profile to be rotated slightly while the gear train timing remains the same.

The more the top of the offset is moved in the direction of the camshaft normal rotation, the more the injection timing will be retarded. The push rod travel numerical value will increase.

The direction of normal rotation on a K19 engine crankshaft is **clockwise** as viewed from the front.



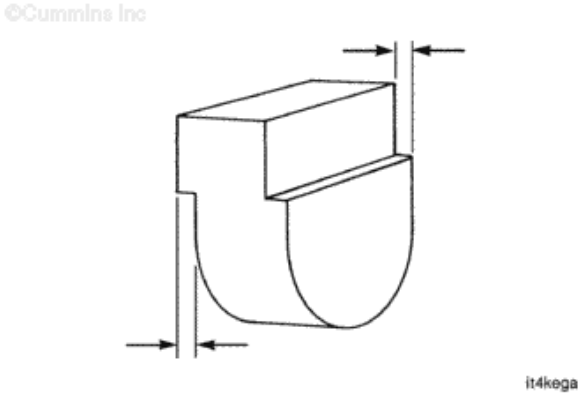
Offset keys can be identified by measuring the offset and referring to the following chart.

Each 0.025 mm [0.001 in] of offset will cause a 0.0127 mm [0.0005 in] change in push rod travel from a straight key.

If checking or setting the injection timing, it is recommended to use a testing gear. A testing gear is a camshaft gear that has been modified to provide a slip-fit on the camshaft.

The camshaft key part number listed in the engine performance parts option is a starting point. Do **not** assume the listed key will provide the specified timing. **Always** measure the injection timing if the gear, camshaft, or key have been changed or if during disassembly the direction of any offset was **not** noted. Part of the reason for the existence of the offset key is to be able to adjust the static timing to all tolerances for the part used in the engine.

If a slip fit gear is used, the injection timing **must** be measured again after installation of the production gear.



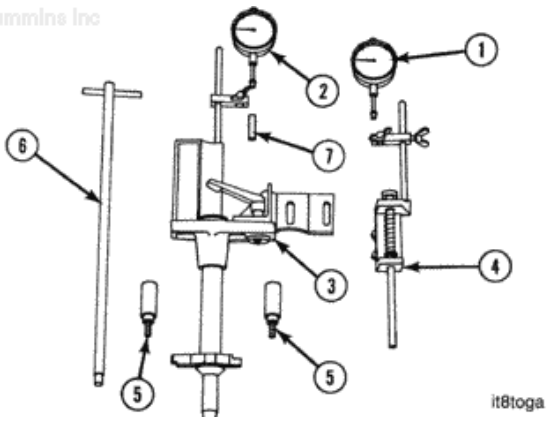
Timing Code	Recommended Code	Direction of Offset
AE	216782	Opposite camshaft rotation

AJ	200706	With camshaft rotation
AM	216782	With camshaft rotation
CI	200711	With camshaft rotation
CL	S-302	None
CU	3000492	With camshaft rotation

Measure

Use the injection timing tool, Part Number 3824942. The indicators (1) and (2) are identical.

- (1) Push rod travel indicator
- (2) Piston travel indicator
- (3) Piston plunger support assembly
- (4) Push rod plunger support
- (5) Hold-down adapter
- (6) Extension assembly (adapter wrench)
- (7) Indicator stem extension.

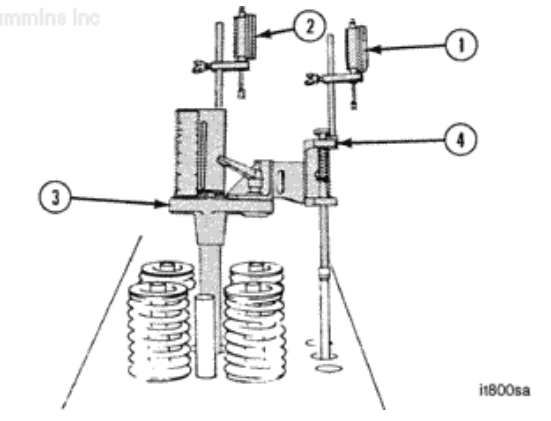


The push rod plunger support assembly alignment is critical.

Install the push rod plunger support (4) in the outside slot in the piston support (3).

Align the push rod plunger support with the mark. Tighten the capscrew.

Install indicators (1) and (2) on the posts. Turn the indicators so they are **not**



over the plungers.

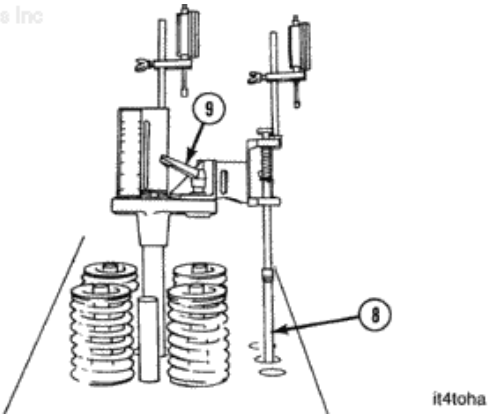
Install the stem extension on the piston travel indicators.

Install the injector push rod (8).

Install the timing tool in the injector bore. Install the hold-down adapter.

Align the push rod plunger and the rod to be sure they are straight.

Tighten the support lock (9).



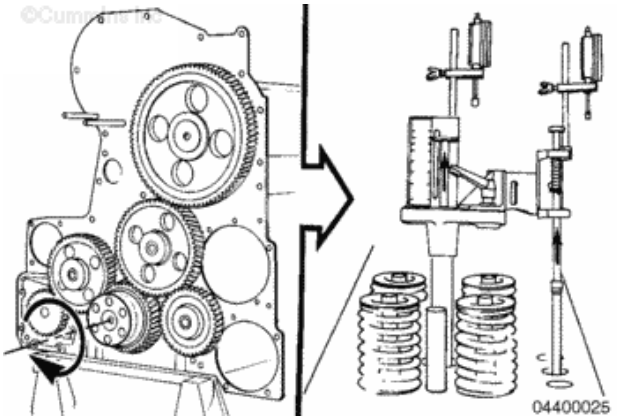
Use **only** the crankshaft to rotate the engine. The use of gears will result in false measurement. Gear lash **must** be closed up in the direction of normal rotation (crankshaft **clockwise**).

Three guide bolts equally spaced in front of the crankshaft will aid in engine rotation.

With the engine in the compression stroke, turn the crankshaft in the direction of normal rotation and observe both timing tool plungers.

Both plungers will begin moving upward when the cylinder is on the compression stroke. The indicators will be rotating in a **clockwise** direction.

If both indicators do **not** rotate in a **clockwise** direction, the engine is on the exhaust stroke. Rotate the crankshaft one revolution to get to the compression stroke.



Slowly rotate the crankshaft in the direction of normal rotation while observing the piston plunger (10). The plunger will

move upward, stop, then begin to move downward. The stop point of the plunger is top dead center.

Rotate the engine opposite the direction of normal rotation until the plunger begins to move downward. The cylinder is now slightly before top dead center.

Turn the indicator so the stem is touching the plunger.

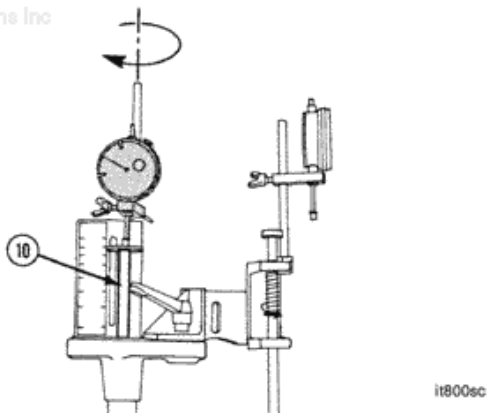
Carefully lower the indicator until it bottoms out. Raise the indicator when the needle has turned a minimum of three revolutions 7.62 mm [0.300 in]. Lock the indicator in position.

Slowly turn the crankshaft in the direction of normal rotation until the indicator needle stops turning **clockwise** (top dead center). Adjust the indicator to zero.

Always zero at top dead center with the crankshaft having just been rotated in the direction of normal rotation.

Slowly and carefully rotate the crankshaft backward and forward until the needle stops at zero before reversing the direction to indicate the piston is after top dead center.

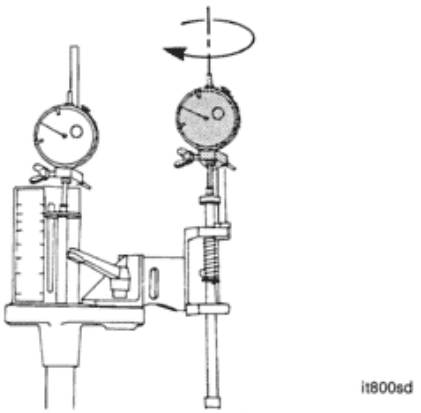
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Turn the push rod indicator so the stem touches the plunger.

Carefully lower the indicator until it bottoms out. Raise the indicator when the needle has turned a minimum of three revolutions 7.62 mm [0.300 in].

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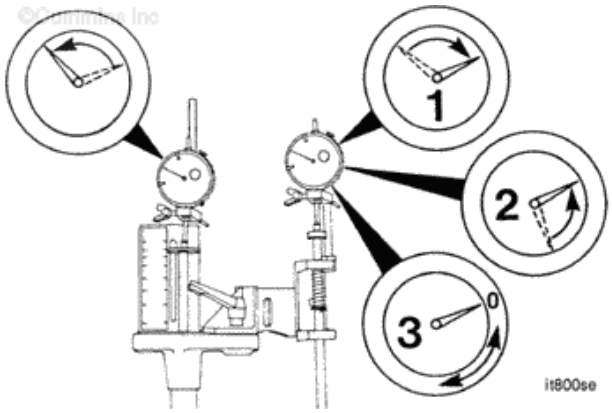
Slowly turn the crankshaft in the direction of normal rotation until

the push rod indicator stops (1), momentarily reverses direction (2), (this is the crush nose on the camshaft), and stops again (3). The cam follower is now on the outer base circle of the camshaft. The piston is now approximately 90 degrees after top dead center.

It is important to record the amount of travel remaining in the push rod travel indicator for later reference.

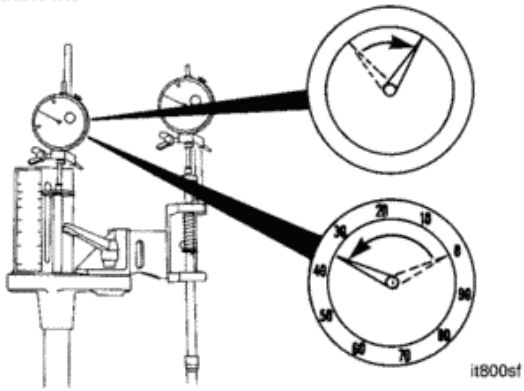
Carefully lower the push rod travel indicator until it bottoms out. Raise the indicator approximately ¼ revolution 6.35 mm [0.025 in]. Lock the indicator in position.

Set the indicator at zero.



Observe the piston travel indicator as the crankshaft is slowly rotated opposite the direction of normal rotation.

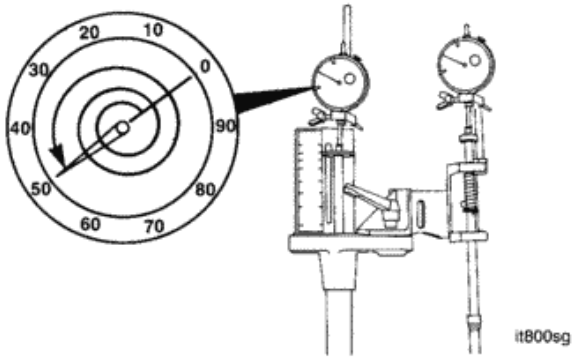
Stop rotating the crankshaft when the piston travel indicator indicates the piston is at top dead center (zero).



The crankshaft **must** be turned slowly to accurately count the indicator revolutions.

Turn the crankshaft opposite the direction of normal rotation until the indicator needle moves 2½ revolutions, 6.35 mm [0.250 in].

The piston is now 6.35 mm [0.250 in] before top dead center.



Only move the piston to 5.16 mm [0.2032 in] before top dead center by turning the crankshaft in the direction of normal rotation. If the crankshaft is turned too far, turn the crankshaft back opposite the direction of normal rotation more than 5.16 mm [0.2032 in] before top dead center. Then very slowly turn the crankshaft in the direction of normal rotation until the indicator indicates the piston is 5.16 mm [0.2032 in] before top dead center.

All K19 injection timing specifications are more than one indicator revolution 2.54 mm [0.100 in].

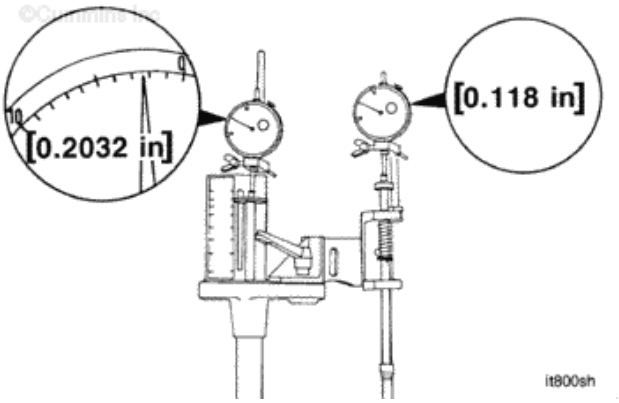
Read the push rod indicator **counterclockwise** from zero. This is the injection timing measurement. An example of 0.118 in is illustrated in the graphic.

If unsure of the number of push rod indicator revolutions, check by carefully lifting the indicator stem until the indicator has bottomed out. Lower the stem the amount of excess travel. Lower the stem to the plunger. Read the indicator.

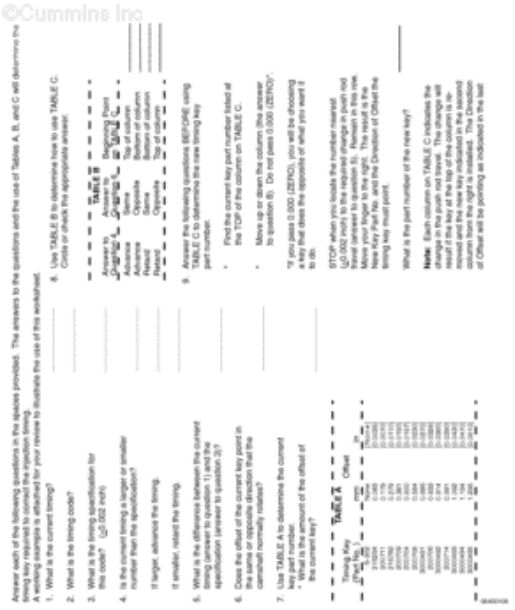
If the injection timing is within specification and a slip fit gear is used, install the standard camshaft gear. Refer to Procedure 001-012 in Section 1. Repeat the injection timing procedure after the gear has cooled.

If the injection timing is still **not** within specification, repeat the measurement procedure to check the tool set up and zero settings.

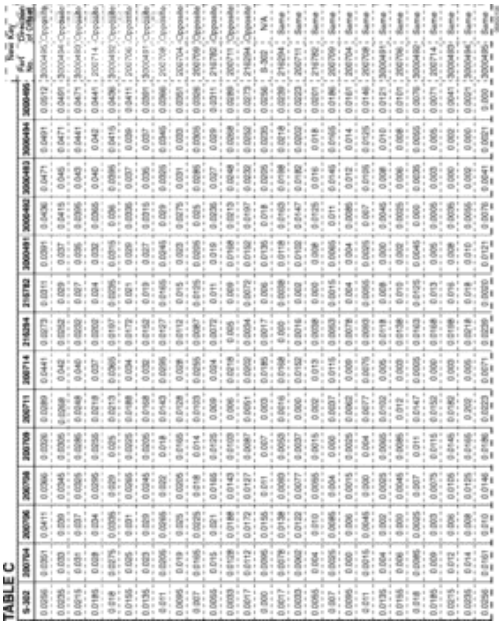
If the timing is still **not** within specification, the camshaft key **must** be changed. Remove the camshaft gear.



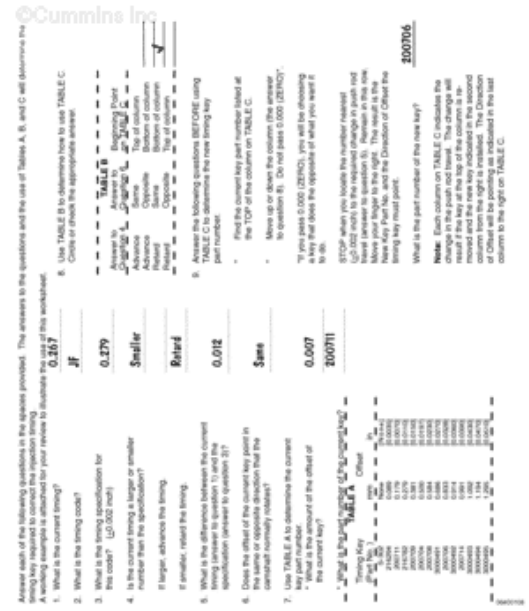
Refer to Procedure 001-012 in Section 1. Record the orientation of the offset of the key. Use the following worksheet to determine the alternate key. The timing measurement **must** be confirmed after changing the key.		



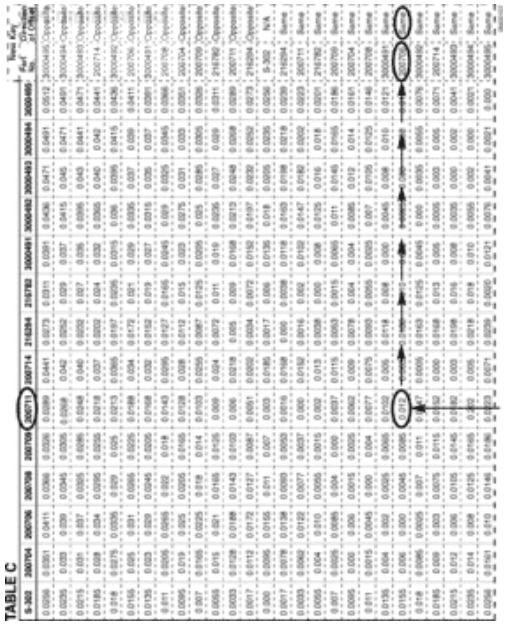
NEEDS TEXT FOR CORRECT STRUCTURE



NEEDS TEXT FOR CORRECT STRUCTURE



NEEDS TEXT FOR CORRECT STRUCTURE



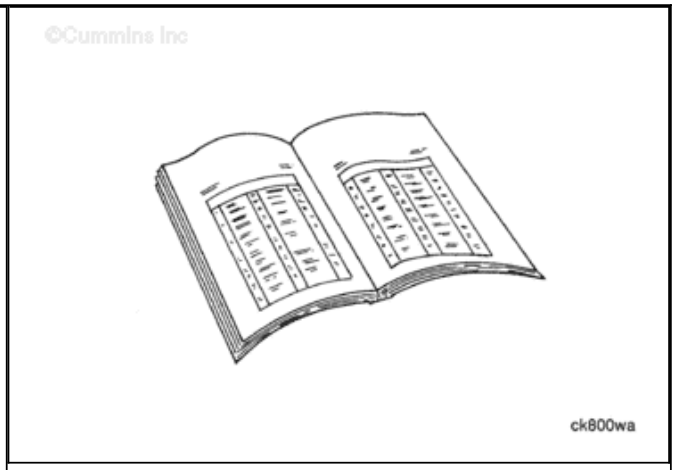
NEEDS TEXT FOR CORRECT STRUCTURE

Last Modified: 27-Jun-2012

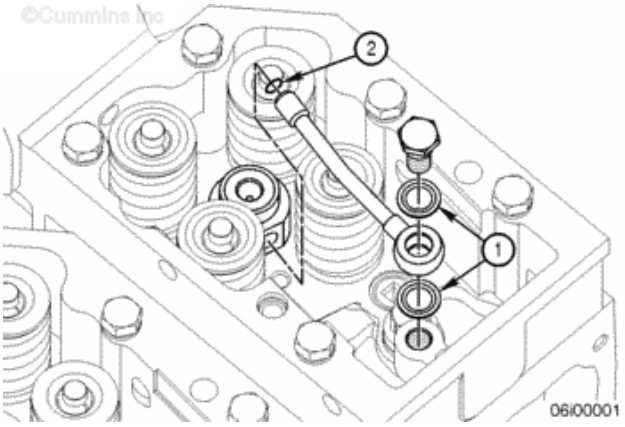
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006-026 Injector

Preparatory Steps

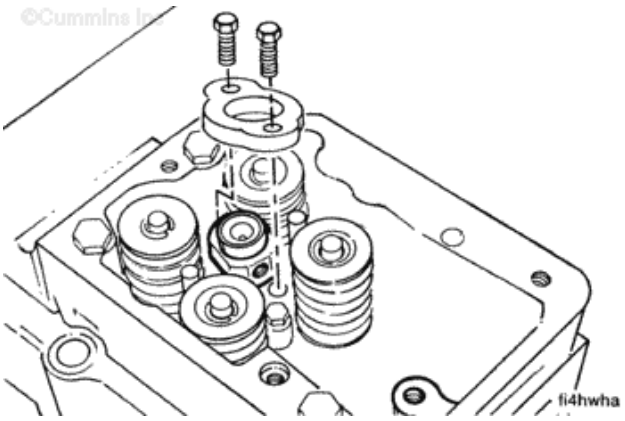
• Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3. • Remove the Jacobs® engine brake. Refer to Procedure 020-999 in Section 20. • Remove the rocker lever assembly. Refer to Procedure 003-009 in Section 3. • Remove the injector supply line. Refer to Procedure 006-051 in Section 6.		

Remove

Remove the step-timing control (STC) oil jumper tube. Remove and discard the sealing washers (1) and o-ring (2).		

Remove the injector hold down clamp capscrews.

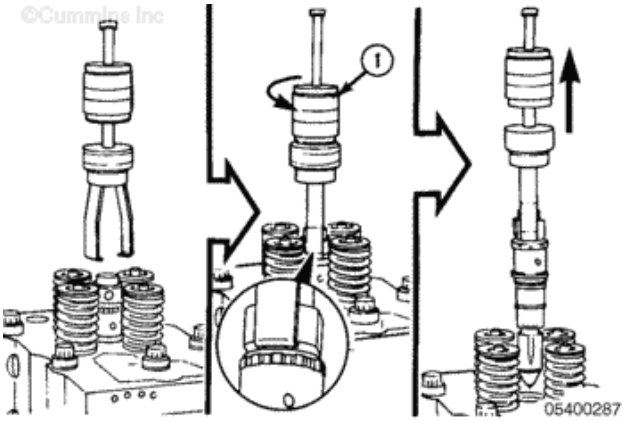
Remove the injector hold down clamp.



CAUTION

Do not allow the STC tappet to fall out of the injector, engine damage can result.

NOTE: The rocker housing has been removed from the illustration for clarity.



For top stop injectors, use injector puller, Part Number 3376497.

Make sure the puller arms are firmly under the top stop screw.

Tighten the clamping ring (1).

Use the slide hammer to remove the injector.

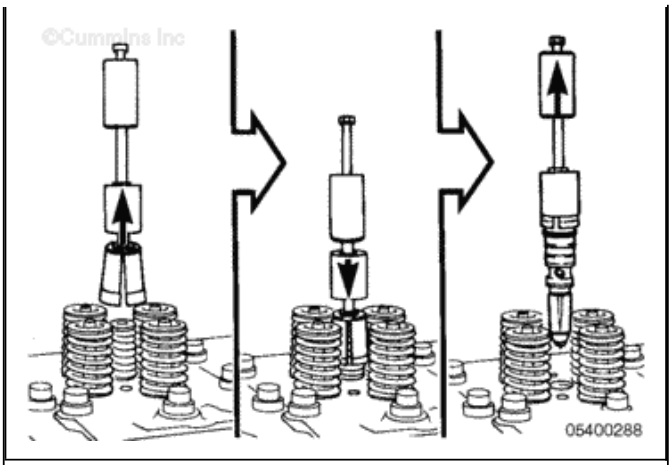
For standard injector injectors use puller, Part Number 3376000 or 3376497.

Place the split collar over the injector.

Slide the locking collar over the split collar.

Use the slide hammer to

remove the injector.



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.

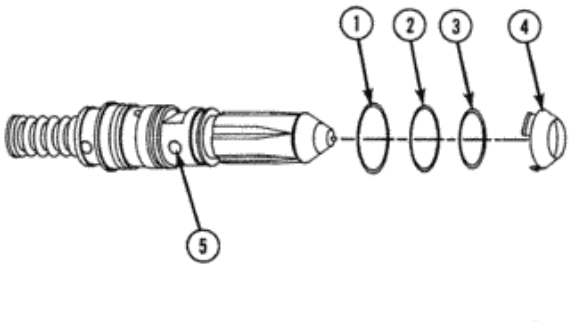
WARNING

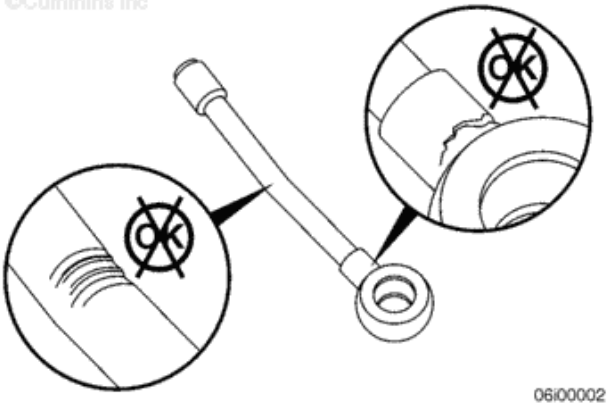
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Injector plungers and barrels have a precise fit and are damaged easily. Only trained technicians are authorized to remove the plungers. Do not allow the





plunger to fall out of the injector. **NOTE: Sealing rings are available in different thicknesses to adjust the injector protrusion.** Remove o-rings (1), (2), and (3). Remove the sealing ring (4) and record its thickness. Clean the exterior of the injector with a lint-free cloth. Check the area the makes contact with the injector. Check the orifice screen (5). It **must** be clean. If there is debris on the screen, remove the retaining clip and the screen for cleaning. Clean the screen in solvent and dry with compressed air. Install the screen and retaining clip.		
Check the STC oil jumper tube for cracks or evidence of fretting. If any damage is found, the tube **must** be replaced.		

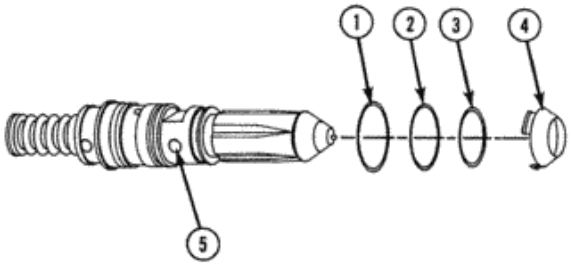
Install

Identify the o-rings so they can be installed in the correct groove.

- O-ring (1) has a red dot or stripe and is dull gray in appearance.
- O-ring (2) has no markings.
- O-ring (3) has a green dot or stripe. The o-ring has a shiny black appearance.

Lubricate the o-rings with vegetable oil and install them in the appropriate location.

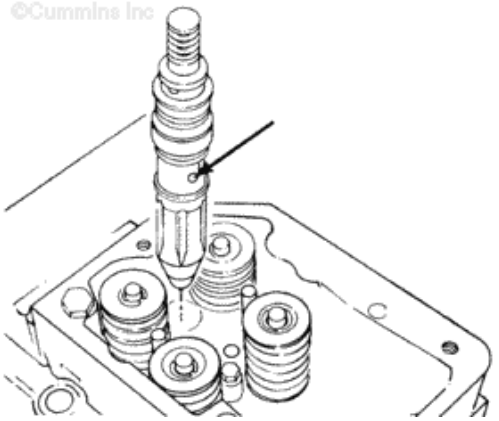
Install the proper size seal ring (4).



fi4orga

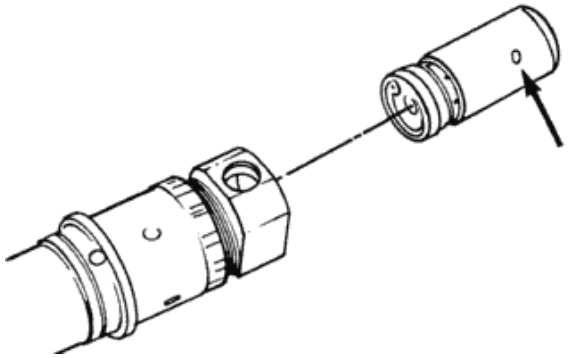
Place the standard injector in the bore.

Turn the injector so the screen points toward the hold-down capscrew hole on the intake side of the cylinder head.


fi800ha

Do **not** allow the STC tappet fall out of the STC (top stop) injector. Damage can result.

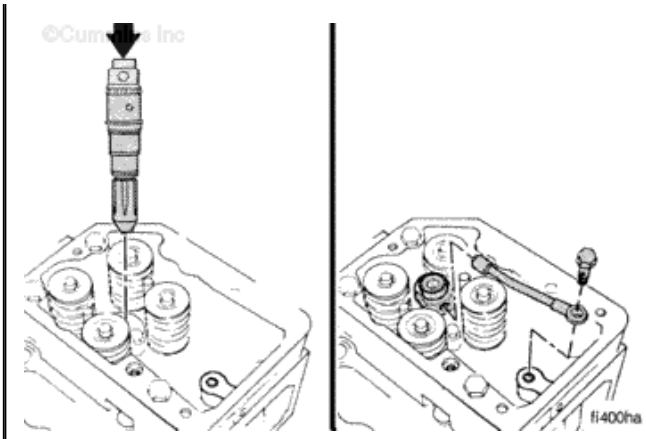
The STC tappet **must** be near the rocker lever assembly.


fi8taha

Do **not** push the injector on the seat until it is correctly aligned.

Place the STC injector in the bore. Turn the injector so the hole in the top stop screw points to the oil supply hole in the rocker lever housing.

Use the oil jumper tube and the connector screw as tools. Turn the injector until the holes are aligned. Remove the connector screw and the tube.

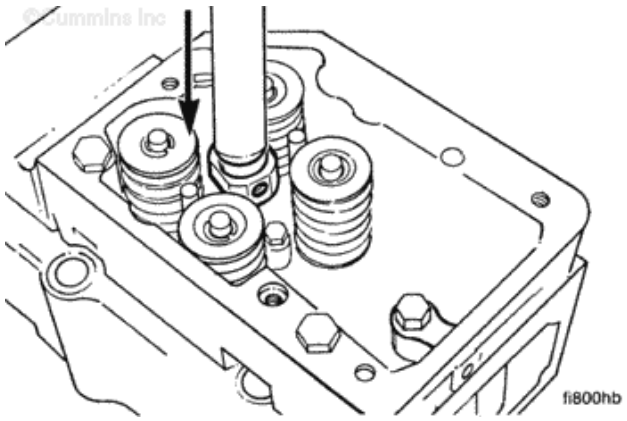


CAUTION

Do not use a wooden tool to push the injector onto the seat. Failure can result because of splinters falling into the tappet.

Apply a quick hard push with a blunt object that touches the top stop screw, to seat the injector.

A single snapping sound will be heard when the injector is seated properly.

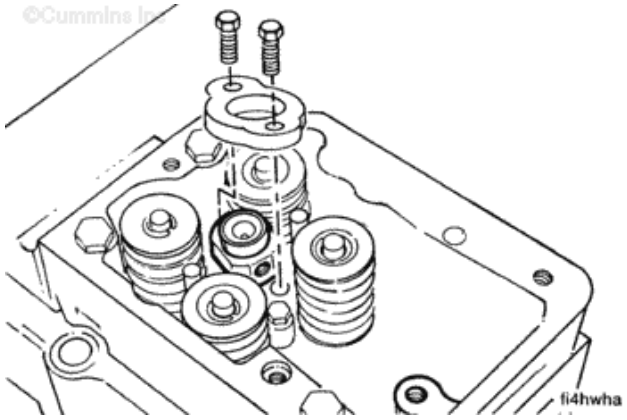


CAUTION

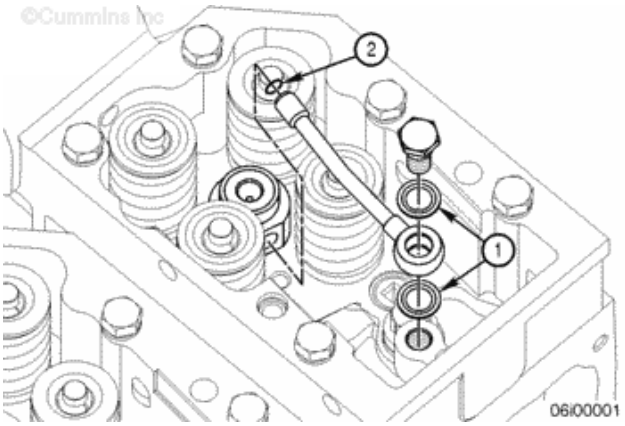
The injector hold-down clamp that is used on engines with STC requires capscrew that are 3 mm [1/8 in] longer than those on other K19 engines.

Install the hold-down clamp and the self-locking capscrews.

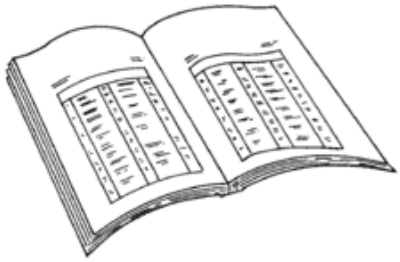
Alternately tighten the capscrews in sequence so the clamp is centered on the injector body.



Torque **Value:** 16 n.m [145 in]		

Install the o-ring (2) onto the jumper tube. Lubricate the o-ring with clean engine oil. Install the jumper tube and new copper sealing washers (1). Install the connector screw. **Torque** **Value:** 25 n.m [221 in-lb]		

Finishing Steps

• Install the injector supply line. Refer to Procedure 006-051 in Section 6. • Install the rocker lever assembly. Refer to Procedure 003-009 in Section 3. • Adjust the over head. Refer to Procedure 003-006 in Section 3. • Install and adjust the Jacobs® engine brake. Refer to Procedure 020-999 in Section 20. • Install the rocker lever cover. Refer to Procedure 003-011 in Section 3.		

Last Modified: 13-Sep-2010

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006-033 STC Fuel Pressure Switch

Clean and Inspect for Reuse

NOTE: Some engines use a hydromechanical STC control valve instead of the electric switch covered in this procedure. Refer to Procedure 205-001, Service Literature for more information on the hydromechanical valve.

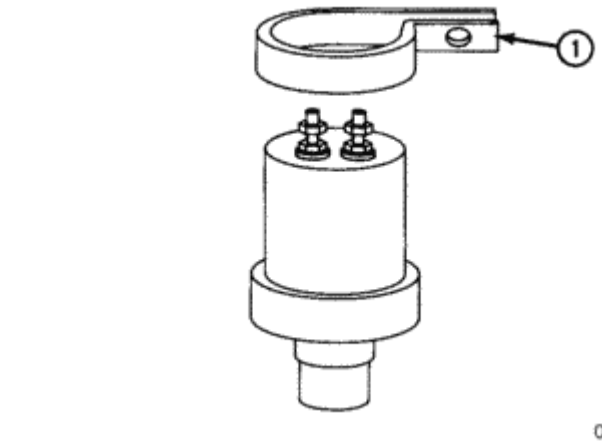
Remove the mounting clamp (1).

Inspect the switch for damage.

Connect multimeter, Part Number 3164488, 3164489, or equivalent to the terminal studs on the switch. The multimeter indicator will show the switch is in the closed position (zero ohm).

Connect a





regulated compressed air line and a gauge to the switch. Increase the air pressure until the multimeter indicates the switch is in the open position (infinite resistance). Read the pressure gauge. The air pressure gauge will indicate 345 to 386 kPa [50 to 56 psi] when the switch opens. Decrease the air pressure until the multimeter indicates the switch has returned to the closed position (zero ohm). The air pressure gauge will indicate 138 to 179 kPa [20 to 26 psi] when the switch closes. If the switch is **not** within specifications, it **must** be replaced.		

Last Modified: 27-Oct-2004

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006-036 STC Oil Control Valve (Electrical)

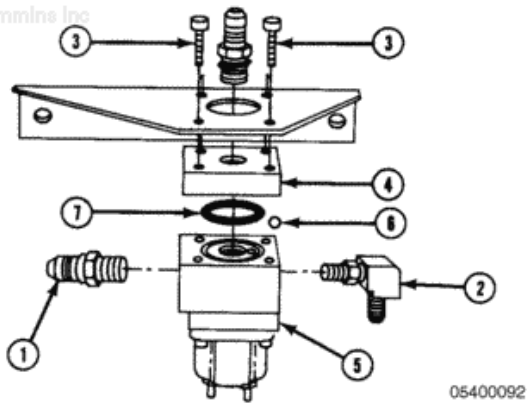
Disassemble

NOTE: Some engines use a hydromechanical STC control valve instead of the electric switch covered in this procedure. Refer to Procedure 205-001, Service Literature for more information on the hydromechanical valve.

Remove the listed parts from the bracket:

(1) Oil inlet fitting
(2) Check valve
(3) Capscrews
(4) Cover
(5) Valve.

Remove the check ball (6) and the o-ring (7) from the valve.

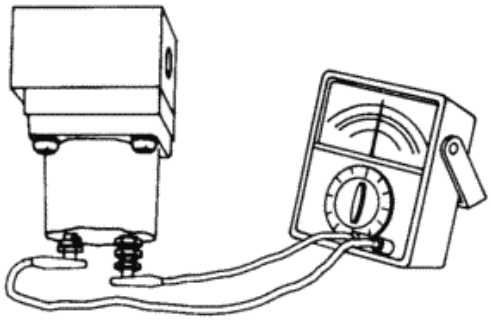


Clean and Inspect for Reuse

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 parts in solvent, Part Number 3824421, or equivalent, that will **not** harm aluminum.



Check the resistance of the solenoid with a multimeter, Part Number 3164488, 3164489, or equivalent.

STC Control Valve Solenoid Resistance		
Voltage	Minimum Coil Resistance	Maximum Coil Resistance
24 VDC	24 Ohms	50 Ohms
12 VDC	6 Ohms	15 Ohms
74 VDC	315 Ohms	375 Ohms
32 VDC	42 Ohms	80 Ohms

If the resistance is **not** within specifications, the solenoid **must** be replaced.

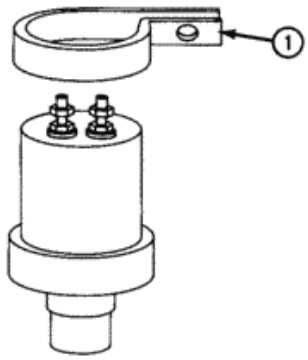
WARNING

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.

Flush the pressure relief valve clean with solvent, Part Number 3824421, or equivalent.

Check the o-ring for damage.

The check valve closes the 0.51 mm [0.020 in] orifice between 14 to 41 kPa [2 to 6 psi].



Assemble

Lubricate the o-ring (7) with clean engine oil.

Install the o-ring (7) and the

check ball (6) on the valve.

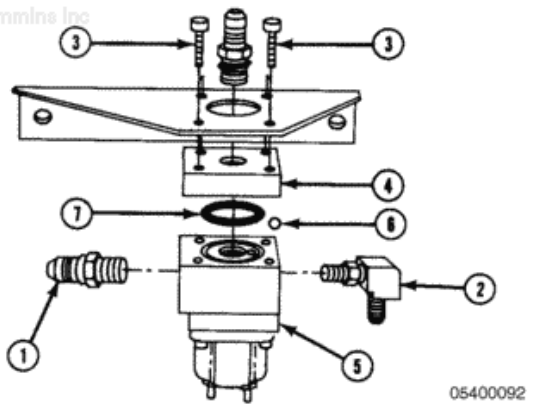
Install the listed parts onto the bracket:

(5) Valve
(4) Cover
(3) Capscrews.

Tighten the capscrews.

Torque Value: 9 n.m [80 in]

Install the check valve (2) and oil inlet fitting (1).



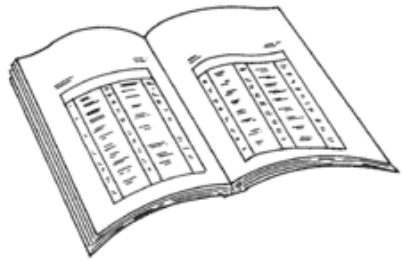
Last Modified: 27-Oct-2004

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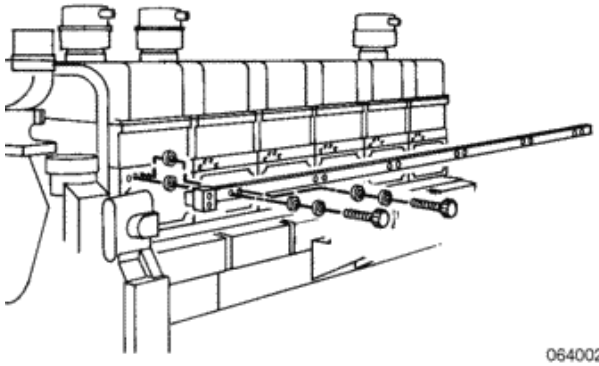
View Related Topic

006-038 STC Oil Manifold

Preparatory Steps

• Remove the aftercooler or intake manifold. Refer to Procedure 010-002 in Section 10.		 ck800wa

Remove

Remove the STC oil manifold capscrews. Remove the STC oil manifold. Remove and discard the o-rings.		 06400285

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.

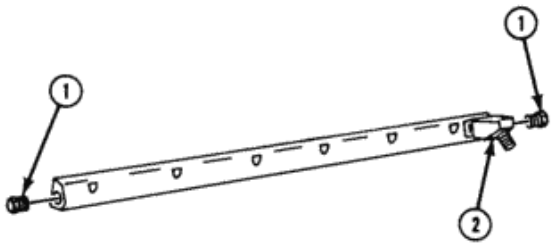
Remove the straight threaded plugs and o-rings (1).

Remove the junction block, capscrews, and o-rings (2).

Use solvent that will **not** damage aluminum, Part Number 3824421 or equivalent, to clean the parts.

Check the STC oil manifold for cracks.

If the manifold is cracked, it **must** be replaced.



06400281

Install

Lubricate all o-rings with vegetable oil.

Install the o-rings, junction block, and capscrews.

Tighten the capscrews.

Torque
Value: 7 n.m [62 in-lb]

Install and tighten the STC oil manifold pipe plugs.

Torque
Value: 20 n.m [177 in-lb]

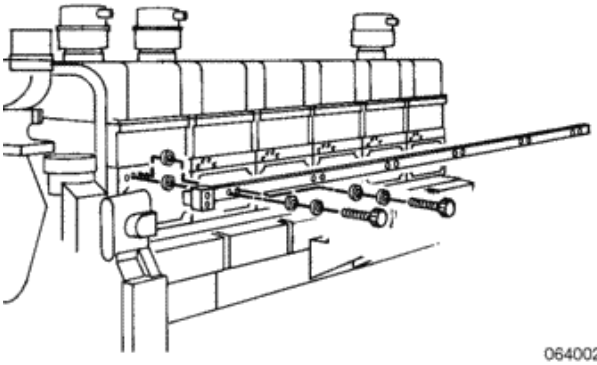
Apply Loctite™ 271, Part Number 3375068, or equivalent, to the capscrews.

Install the STC oil manifold, washers, and capscrews.

Begin tightening the capscrews at the center of the manifold and out to the ends.

Torque
Value: 16 n.m [142 in-lb]

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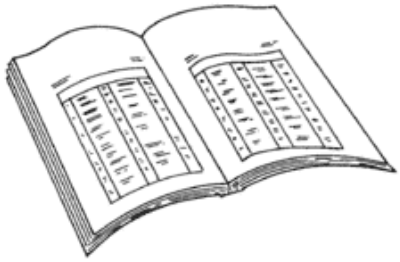


06400285

Finishing Steps

- Install the aftercooler or intake manifold. Refer to Procedure 010-002 in Section 10.

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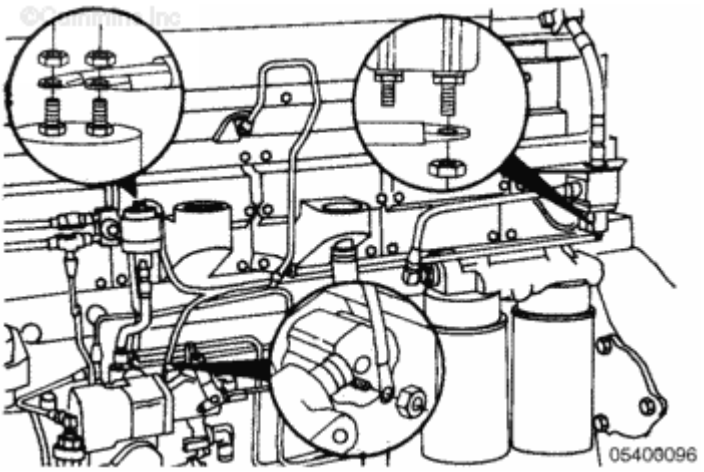
ck800wa

Last Modified: 20-Jan-2009

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006-042 STC Wiring Harness

Remove

Place tags on all of the STC wiring harness wires to identify mounting locations. Remove the wiring harness.		

Inspect for Reuse

Use multimeter, Part Number 3164488, 3164489, or any volt-ohmeter with a rating of 10,000 ohm per volt or greater. Check for broken wires. The wire is broke if the		

multimeter reads a high (infinite) resistance.

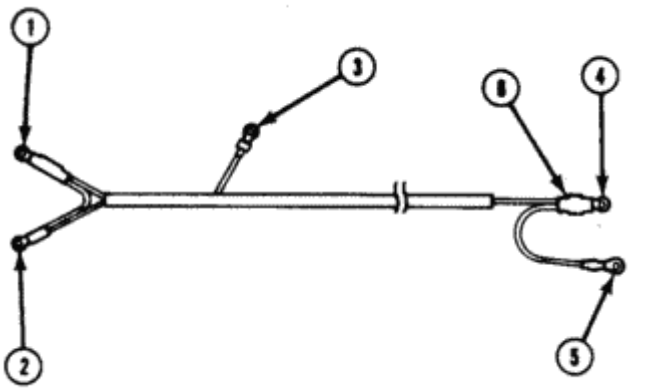
Connect terminals (2) and (4) to the multimeter. Check the resistance. The multimeter **must** indicate zero ohms.

Connect terminal (1) and (3) to the multimeter. Check the resistance. The multimeter **must** indicate zero ohms.

Check the diode (6). Connect terminals (4) and (5) to the multimeter. Record the reading. Reverse the connections. Record the reading.

- If one reading has a high resistance and the second reading has a low resistance, the diode is functioning properly.
- If both of the readings have a high or both readings have a low resistance, the diode **must** be

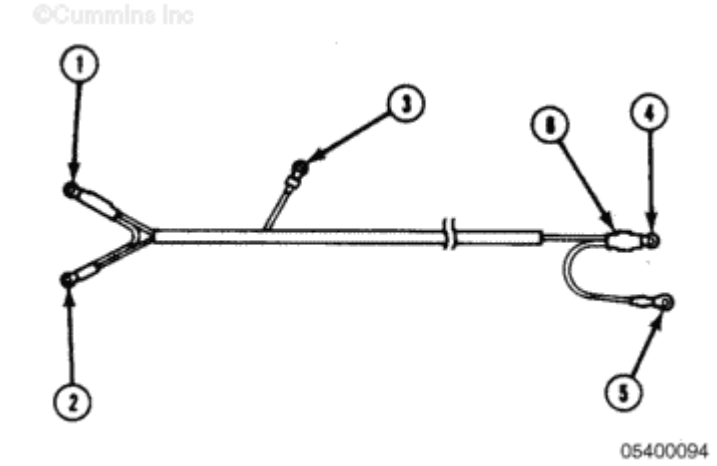
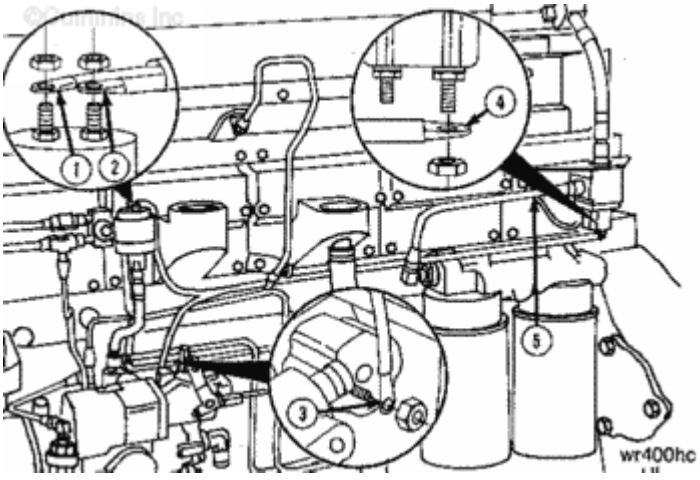
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replaced.		

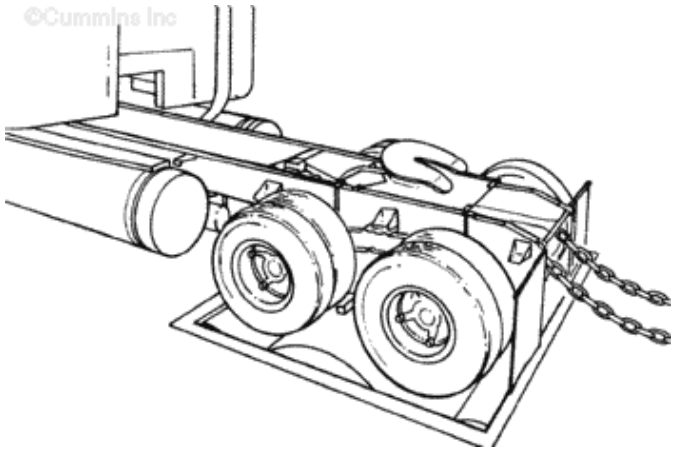
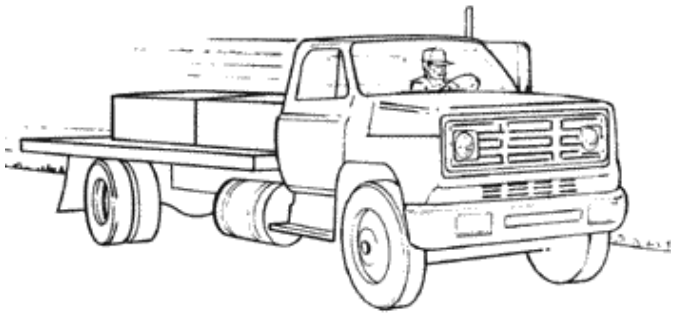
Install

Identify the mounting location for each terminal of the STC wiring harness. (1) Fuel rail pressure switch (2) Fuel rail pressure switch (3) Fuel pump solenoid - positive terminal (4) Oil control switch - positive terminal (5) Ground.		
Install the wiring harness. Tighten the mounting nuts. **Torque** **Value:** 4 n.m [35 in-lb]		

Last Modified: 27-Oct-2004

006-047 AFC No Air Check

General Information

This adjustment can be made on the chassis dynamometer.		
This adjustment can also be made over the road.		
On off road vehicles with an automatic transmission perform the stall speed test. Refer to Procedure 005-054.		

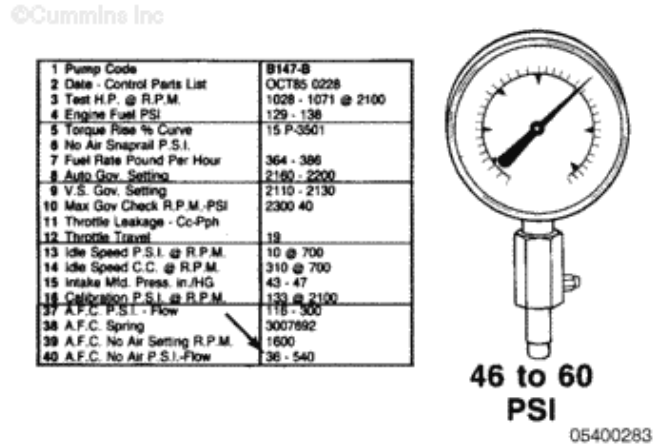


Initial Check

Check the fuel pump code AFC no-air fuel (rail) pressure at 1600 rpm.

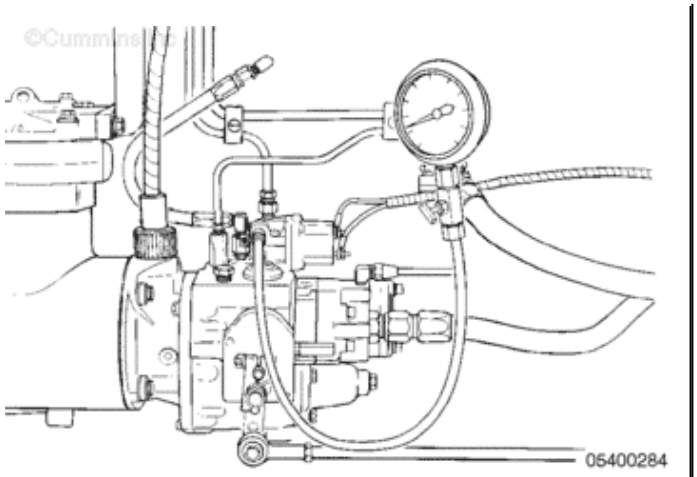
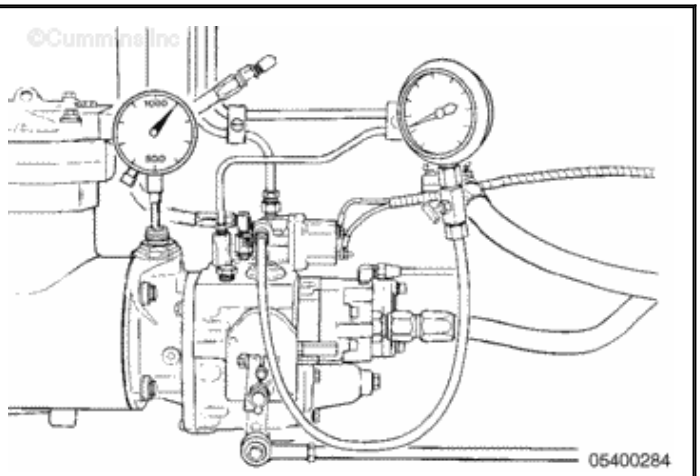
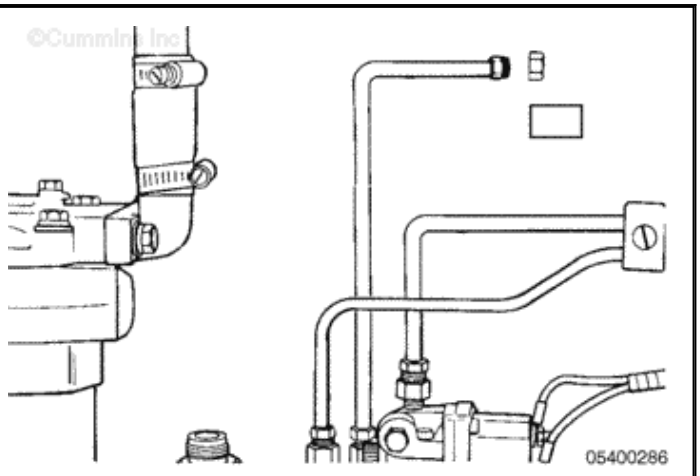
The pressure on the engine **must** be within 48 kPa [7 psi] of the no-air pressure setting on the fuel pump test stand.

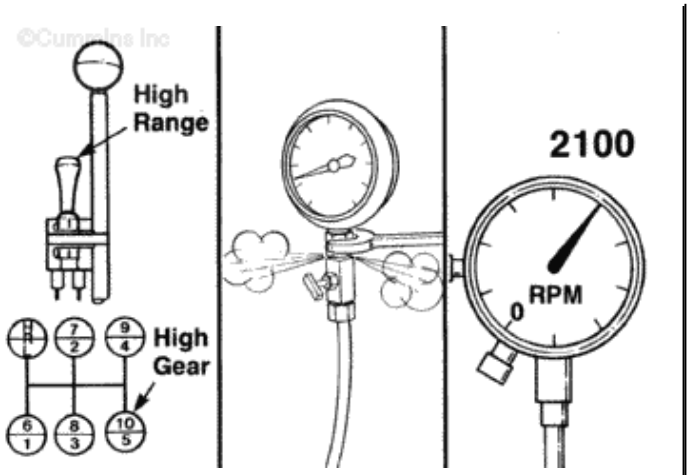
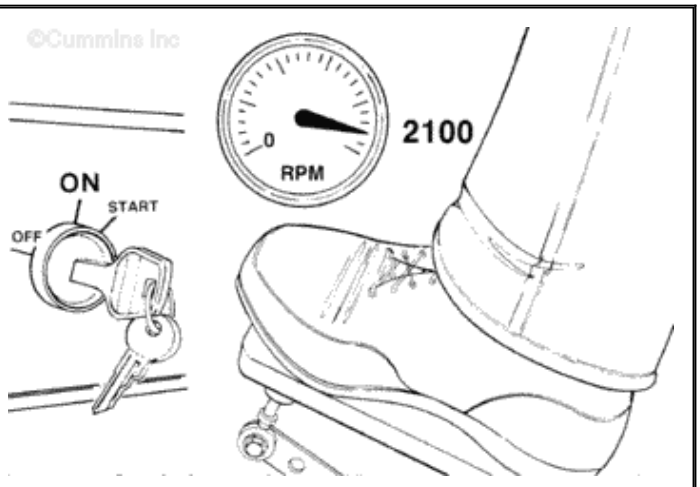
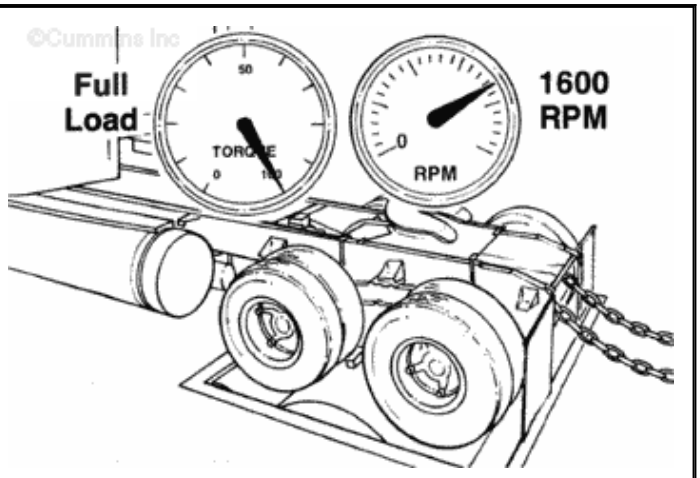
The fuel pump test stand no-air values are listed in the Fuel Pump Calibration Values Manual, Bulletin 3379352.

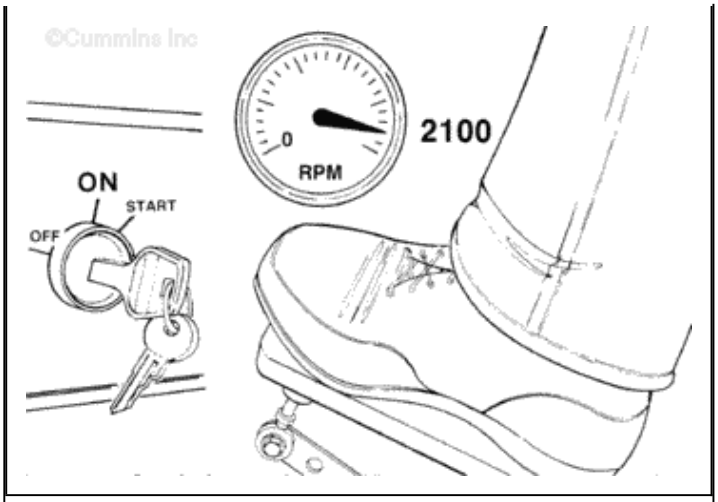
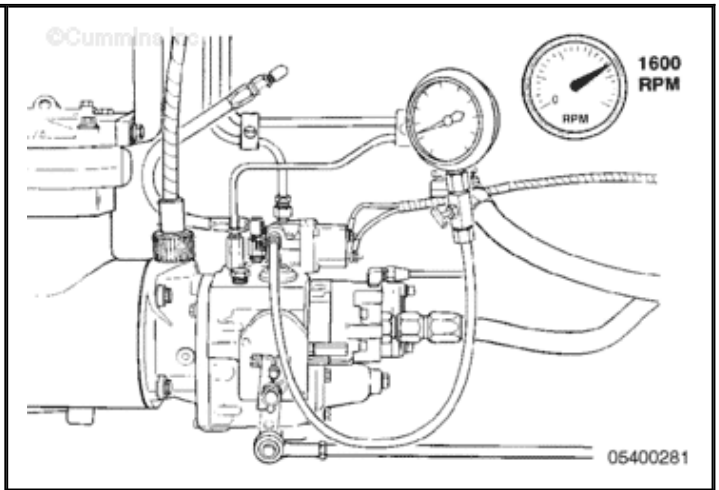


Minimum gauge capacity **must** be 2070 kPa [300 psi].

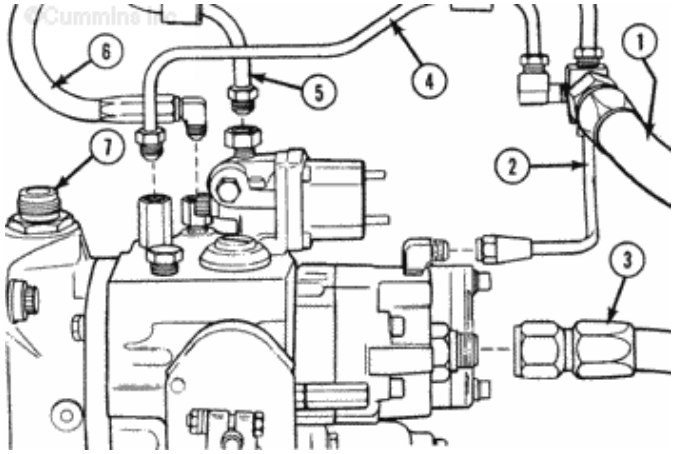
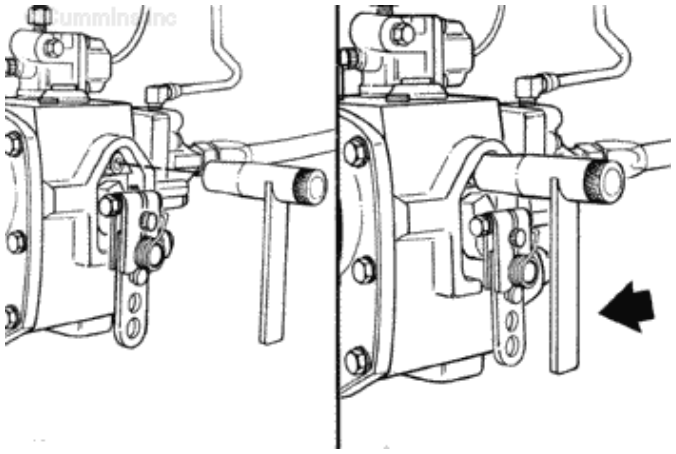
Install rail pressure gauge, Part Number ST-434 onto the shutoff valve.

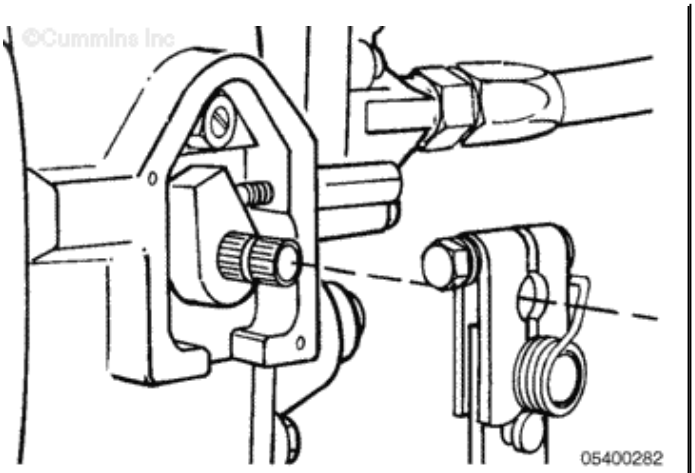
		
Install tachometer, Part Number ST-774, 3375631, or 3377462.		
Remove the AFC air supply line from the air intake manifold or the compressor air tube. Install a plug or a cap on the air manifold hole.		

Operate the engine in the highest possible gear. Remove the air from the pressure gauge supply tube while the engine is warming to operating temperature.		
Progressively increase the load and depress the accelerator or open the fuel pump throttle lever to the full throttle position.		
On a chassis dynamometer, increase the load until the engine is at 1600 rpm.		

On the road, drive the vehicle with the throttle full open. Apply the vehicle brakes to slow the vehicle to the specified 1600 rpm.		
For off-road equipment, check the manufacturer's specifications for the time to accelerate to stall speed from idle. Refer to Procedure 005-054.		
Read the fuel rail pressure gauge. This is the AFC no-air rail pressure.		

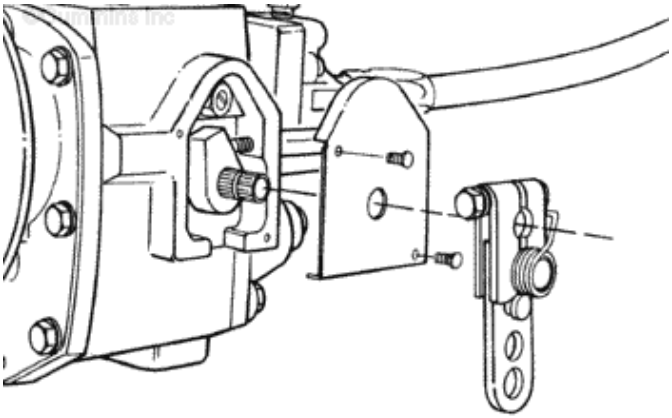
Adjust

If the pressure is **not** within the specifications, remove the throttle lever from the fuel pump. Remove the throttle cover plate. Install the throttle lever.		
Loosen the lock nut on the no-air valve. Install the AFC no-air adjustment tool, Part Number 3375140. Turn the knurled knob **clockwise** to lower the pressure. Tighten the lock nut. **Torque Value:** 5 n.m [45 in-lb]		
Test the engine. Do **not** exceed the maximum specification. Remove the throttle lever.		



Install the throttle shaft cover plate.

Install the throttle lever.



CAUTION

It is illegal to adjust the fuel pump greater than the specifications in the Fuel Pump Calibration Manual.

1 Pump Code	B147-B
2 Date - Control Parts List	OCT85 0228
3 Test H.P. @ R.P.M.	1028 - 1071 @ 2100
4 Engine Fuel PSI	129 - 138
5 Torque Rise % Curve	15 P-3501
6 No Air Snaprail P.S.I.	
7 Fuel Rate Pound Per Hour	364 - 386
8 Auto Gov. Setting	2160 - 2200
9 V.S. Gov. Setting	2110 - 2130
10 Max Gov Check R.P.M.-PSI	2300 40
11 Throttle Leakage - Cc-Pph	
12 Throttle Travel	19
13 Idle Speed P.S.I. @ R.P.M.	10 @ 700
14 Idle Speed C.C. @ R.P.M.	310 @ 700
15 Intake Mfd. Press. in./HG	43 - 47
16 Calibration P.S.I. @ R.P.M.	133 @ 2100
37 A.F.C. P.S.I. - Flow	118 - 300
38 A.F.C. Spring	3007892
39 A.F.C. No Air Setting R.P.M.	1600
40 A.F.C. No Air P.S.I.-Flow	36 - 540

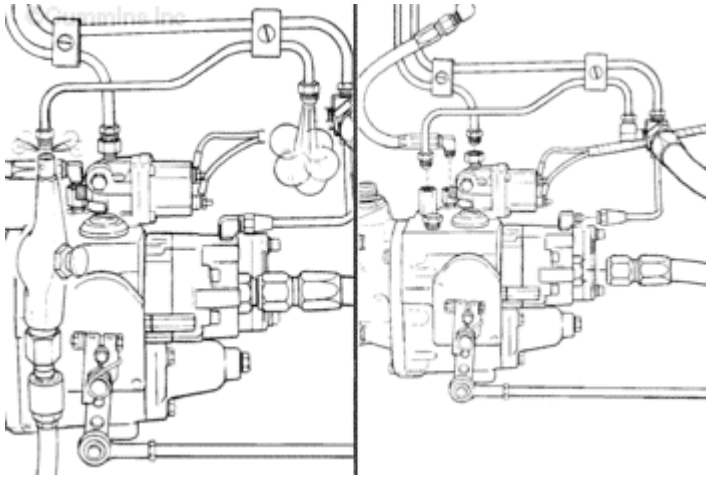
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Last Modified: 08-Dec-2004

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006-051 Injector Supply Lines (High Pressure)

Remove

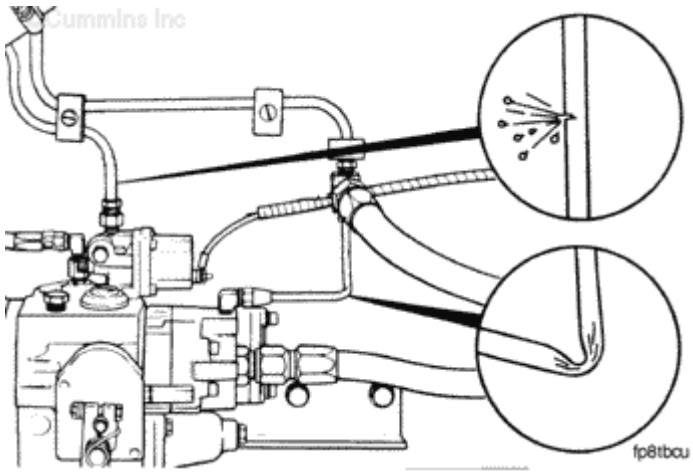
Remove the fuel lines.		

Inspect for Reuse

Check the metal fuel lines for kinks which can cause a pressure restriction. If the fuel line is kinked it **must** be replaced. Check the fuel line for cracks		

which can cause a pressure loss.

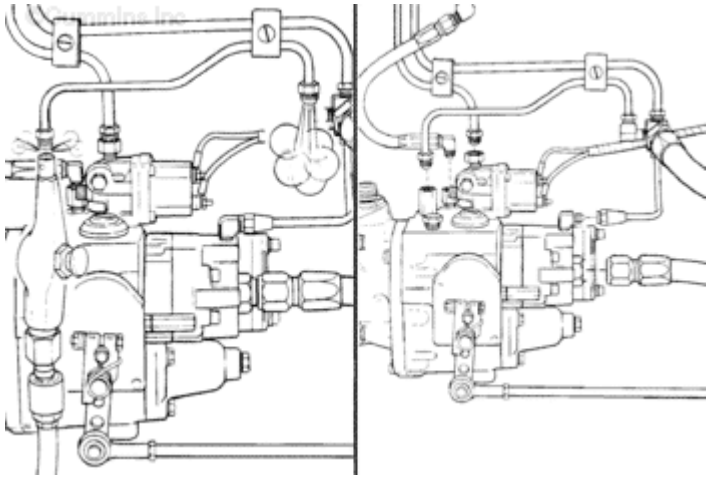
If the fuel line is cracked it **must** be replaced.



Install

Flush the fuel lines with compressed air to remove any loose particles.

Install the fuel lines.

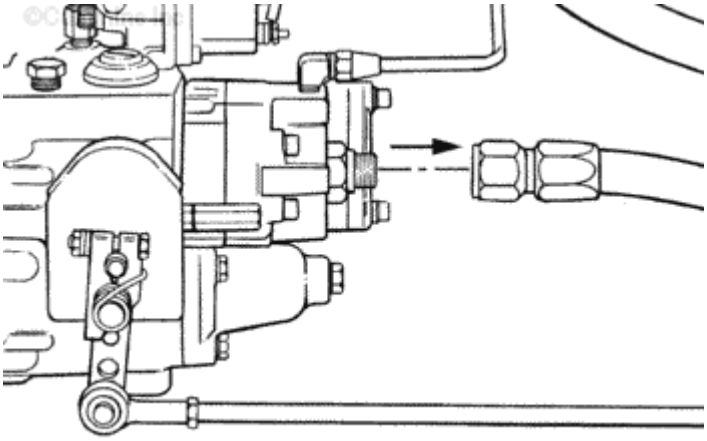


Last Modified: 29-Nov-2004

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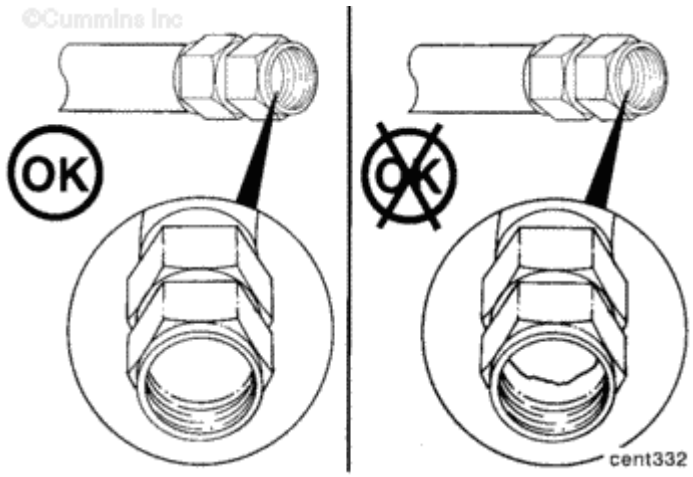
006-059 Fuel Lines, Low Pressure

Remove

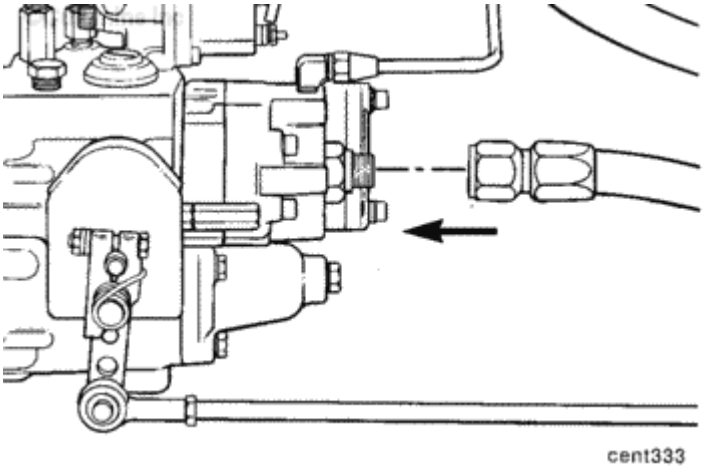
Remove the fuel hose.		

Inspect for Reuse

Inspect the inside of the hose and the hose fitting sealing surface. The inner lining of the hose can separate from the center hose section. A separation or		

flap can cause a restriction in the fuel flow. Replace the fuel hose if damage is found.		

Install

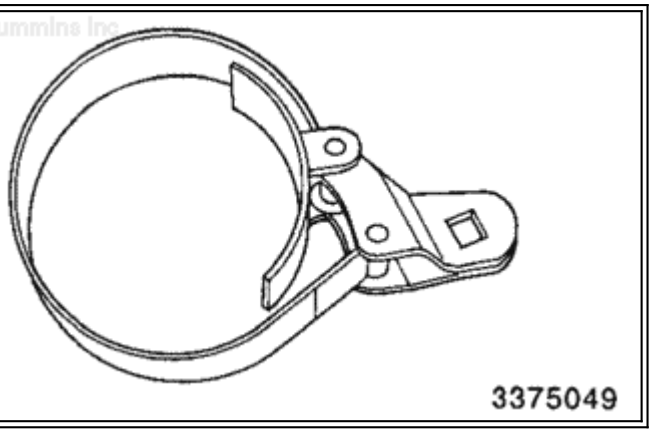
Install the fuel hose.		

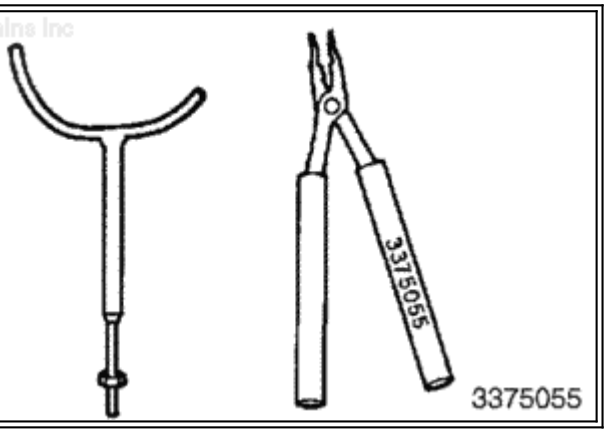
Last Modified: 04-Nov-2004

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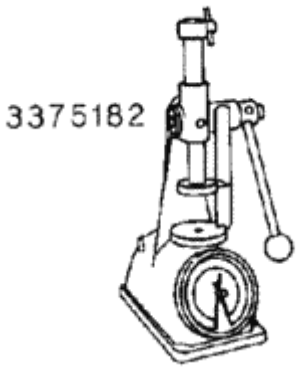
022-001 Service Tools

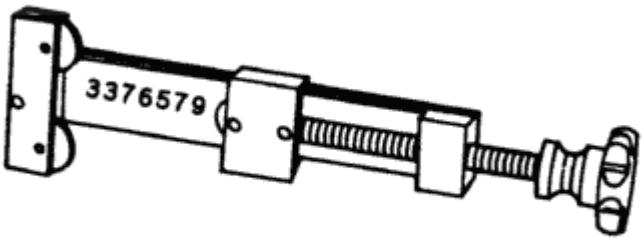
Lubricating Oil System

Tool Number		
3375049	**Oil Filter Wrench** Use to remove spin oil on filter.	

Tool Number		
3375055	**Pressure Regulator Removal Tool** Use to remove retaining ring from lubricating oil pump regulator (on engine).	

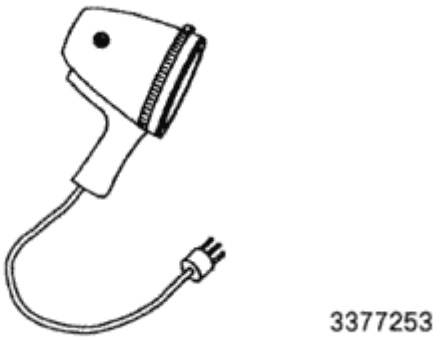
Tool Number		
	Valve Spring Tester Use to check the high	

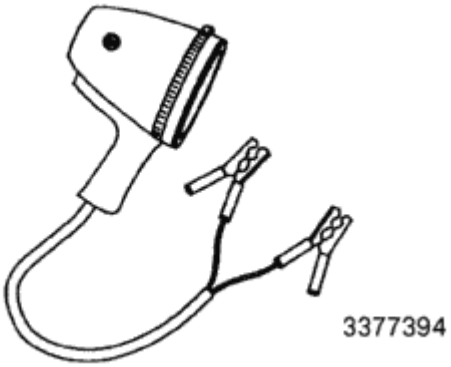
3375182	pressure relief valve spring.	©Cummins Inc 

Tool Number 3376579	**Filter Cutter** Use to open spin-on full-flow filter for inspection.	©Cummins Inc  If8togd

Tool Number 3376891	**Fluorescent Tracer** Add to oil. Use with black light to find oil leaks.	©Cummins Inc  3376891

Tool		

Number		
3377253	**Black Light (AC)** Use to locate fuel leaks.	©Cummins Inc  3377253

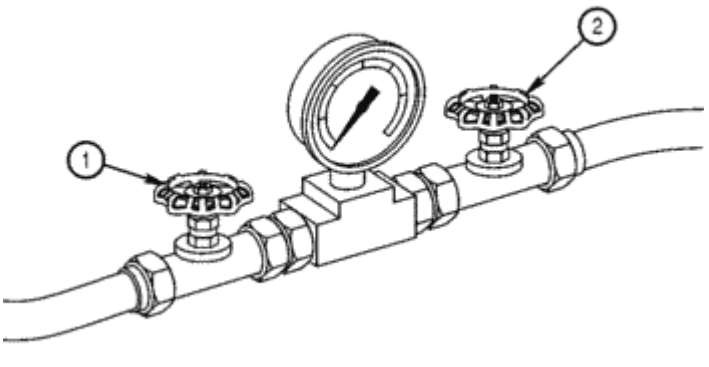
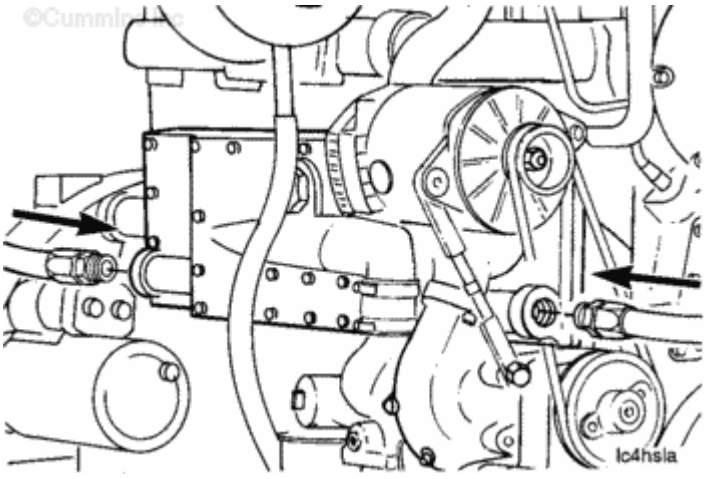
Tool Number		
3377394	**Black Light (DC)** Use to locate fuel leaks.	©Cummins Inc  3377394

Last Modified: 15-Nov-2004

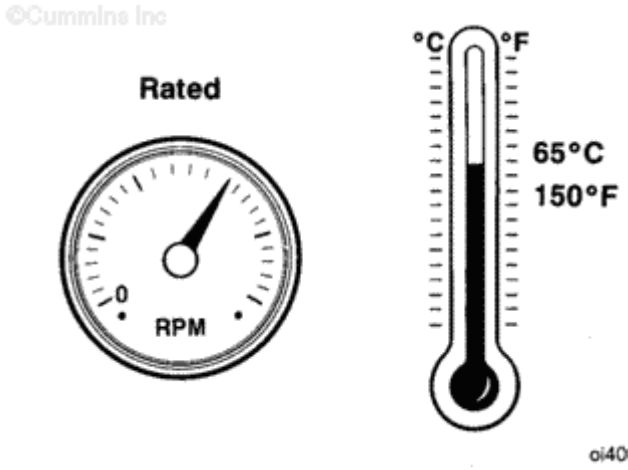
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007-003 Lubricating Oil Cooler

Pressure Differential Test

Use a differential pressure gauge or one pressure gauge with two oil hoses and two valves to eliminate gauge error. The gauge **must** have a minimum capacity of 517 kPa [75 psi].		
Install a hose into each of the 11/16-12 UNF inch plugged holes located at the ends of the oil cooler housing.		
Operate the engine at rated		

rpm until the oil is at a minimum temperature of 65°C [150°F].



Close valve (1) and open valve (2).

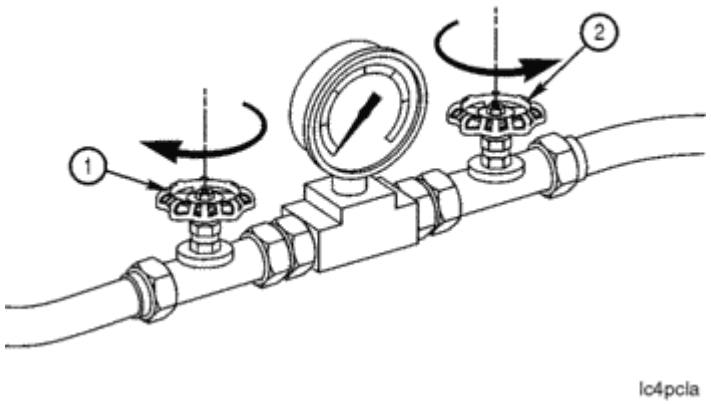
Record the oil pressure after the oil coolers.

Open valve (1) and close valve (2).

Record the pressure of the oil supplied to the oil coolers.

Compare the difference between the two pressures.

If the difference is greater than 138 kPa [20 psi], the oil cooler element **must** be replaced. Refer to Procedure 007-007.



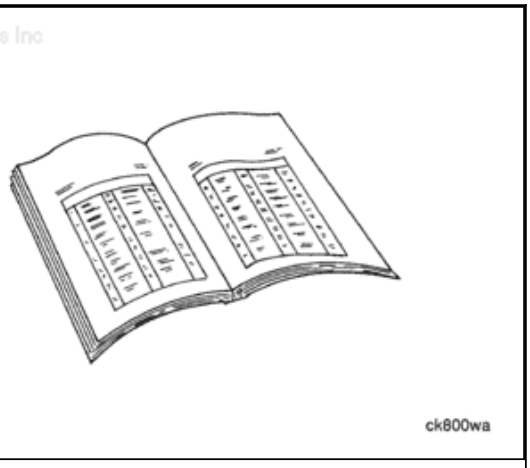
Last Modified: 08-Dec-2004

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007-007 Lubricating Oil Cooler Element

Preparatory Steps

- Remove the oil cooler cover. Refer to Procedure 007-045.

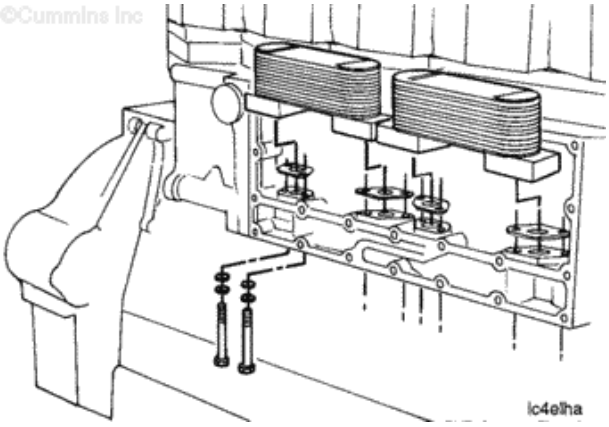


Remove

There is little clearance between the capscrews and the block on some engines. If necessary, use a drift and a mallet to tap the loosened capscrews from the oil cooler housing.

Remove the eight capscrews and the two oil cooler elements.

Remove and discard the gaskets.



Pressure Test

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.

Discard the oil cooler element if debris from a failure is found in the oil filter.

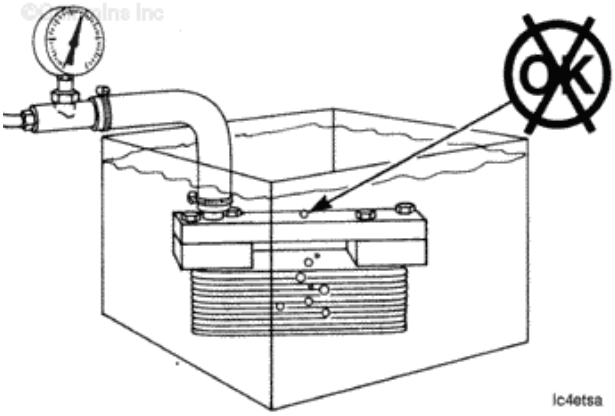
Clean the elements with solvent that will **not** harm copper.

Heating the water in the tank to 50°C [120°F] will improve the test results.

Pressure check the elements to check for leaks.

Measurements		
	kpa	psi
Air Pressure	415	60

If leaks are found, the elements **must** be replaced.



Install

NOTE: Remove the plastic shipping plugs from the new oil cooler elements.

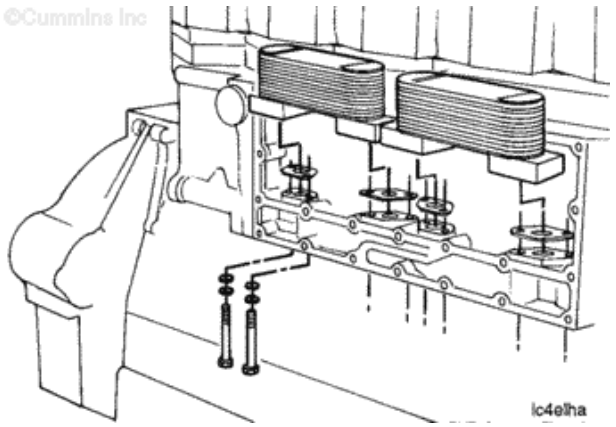
In early 1988 the threads in the oil cooler element mounting feet changed. The

older elements had fine threads (24 threads per inch). The new elements have coarse threads (16 threads per inch). Service oil cooler elements are supplied with capscrews that have coarse threads. Make sure the proper capscrews are used or the oil cooler element will be damaged beyond reuse.

Install the gaskets, oil cooler elements, and capscrews.

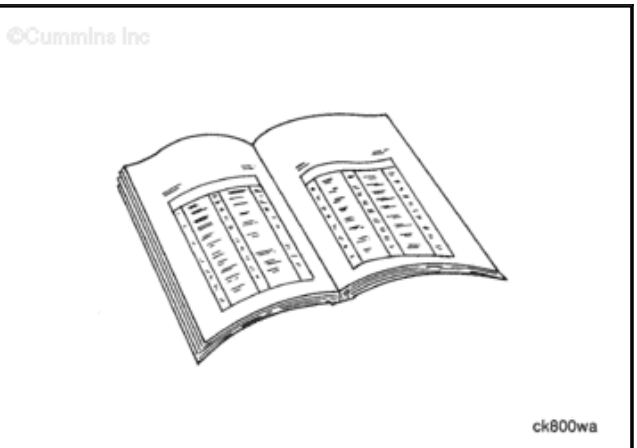
Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

- Installl the oil cooler cover. Refer to Procedure 007-045.



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007-009 Lubricating Oil Dipstick

Calibrate

WARNING

To reduce the possibility of personal injury, avoid contact of hot oil with your skin.

WARNING

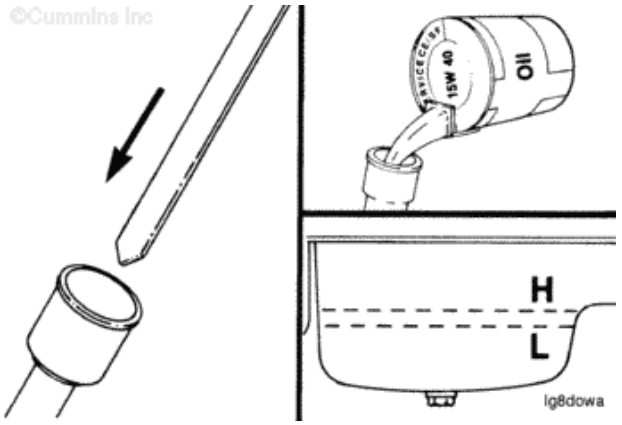
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Make sure the vehicle is sitting on a level surface.

Drain the oil. Use the following procedure in the Operation and Maintenance Manual. Refer to Procedure 007-002 in Section 5. Use the following procedure in the Service Manual. Refer to Procedure 007-037 in Section 5.

Install the dipstick into the dipstick tube housing.

Use the correct volume of clean 15W-40 engine oil. Fill the oil pan to the specified LOW or L oil level.



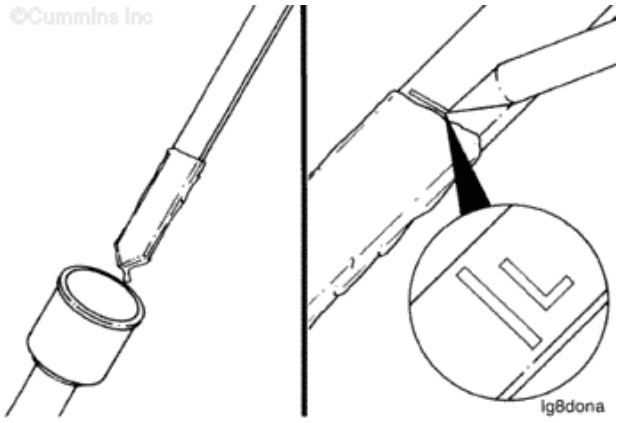
Use the lubricating oil system specifications for the correct engine oil capacity for the application. Refer to Procedure 018-017 in Section V.

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 it at the oil level. Label the mark "L" to indicate the low oil level.

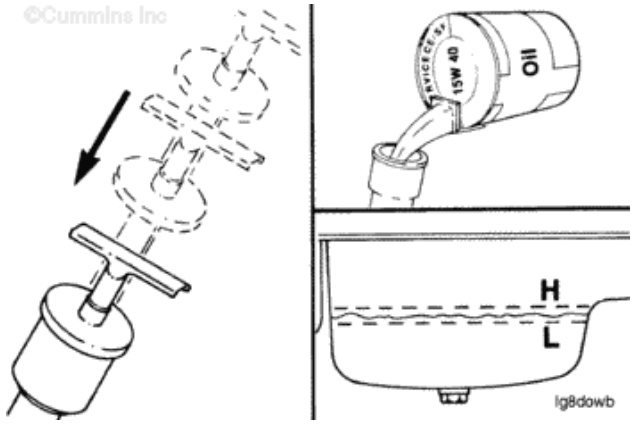
If a new, blank dipstick is being used, cut the dipstick approximately 38 mm [1.5 in] below the LOW or L oil level mark.



Wipe the excess oil from the dipstick and install it into the dipstick housing.

Use the correct amount of oil to fill the oil pan to the specified HIGH or H oil level.

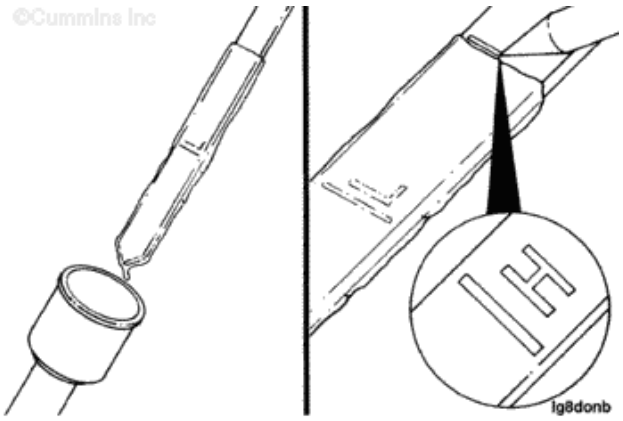
Use the lubricating oil system specifications for the correct engine oil capacity. Refer to Procedure 018-017 in Section V.



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 it at the oil level.

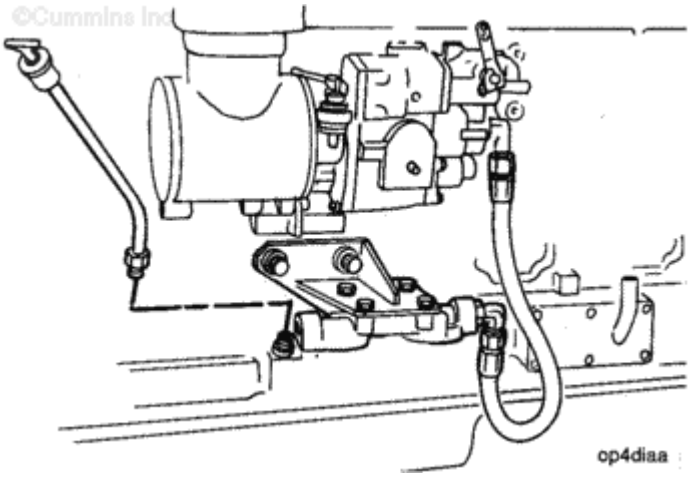
Label the mark "H" to indicate the high oil level.		

Last Modified: 18-Mar-2010

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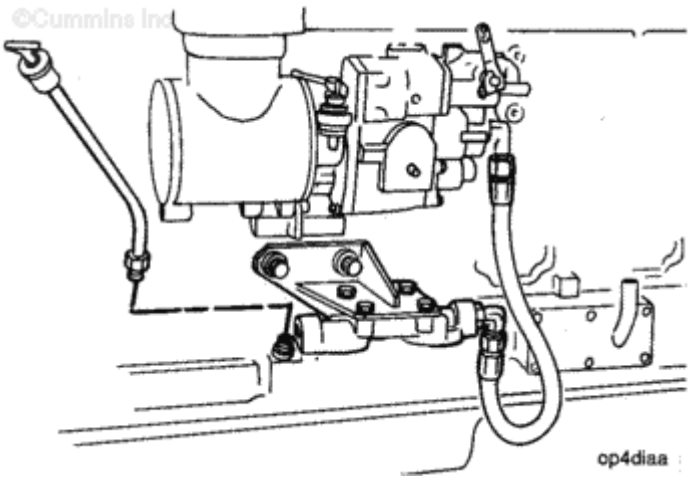
007-011 Lubricating Oil Dipstick Tube

Remove

Remove the dipstick and dipstick tube.		

Install

NOTE: The dipstick tube and fuel filter mounting locations vary depending on the application of the engine. Install the dipstick tube.		

Tighten the nut ¾ turn to 1 turn after contact with the ferrule.		

Last Modified: 29-Nov-2004

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007-013 Lubricating Oil Filter (Spin-On)

General Information

CAUTION

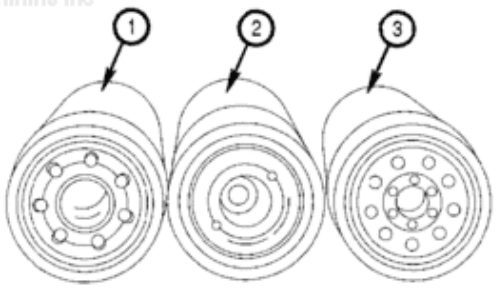
The bypass and combination oil filters both have the same threads. Verify the correct oil filter is used for replacement to reduce the possibility of engine damage.

The external appearance of the full-flow (1) the bypass (2) and the combination (3) oil filters are the same.

The differences are illustrated in the graphic.

The full-flow oil filter contain 1½-16 inch threads.

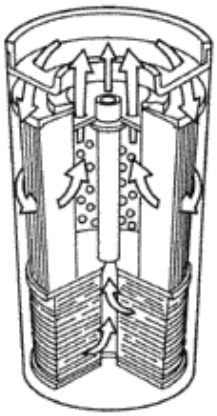
The bypass and combination oil filter contain 2¼-12 inch threads.



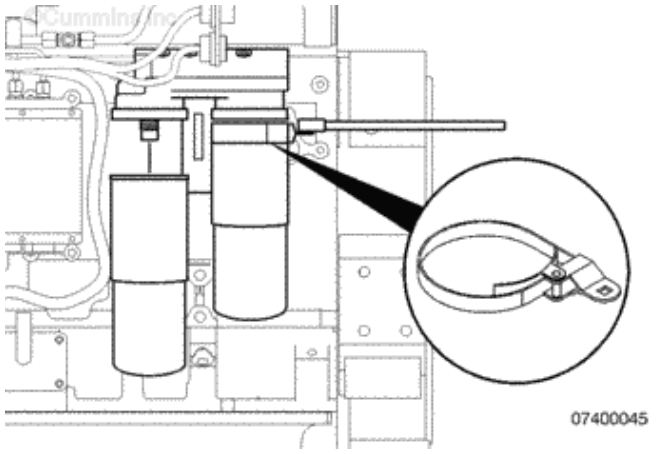
07400059

A combination oil filter is used on some newer engines.

The upper section of the oil filter contains the full-flow element, while the lower section contains the bypass element.

Remove

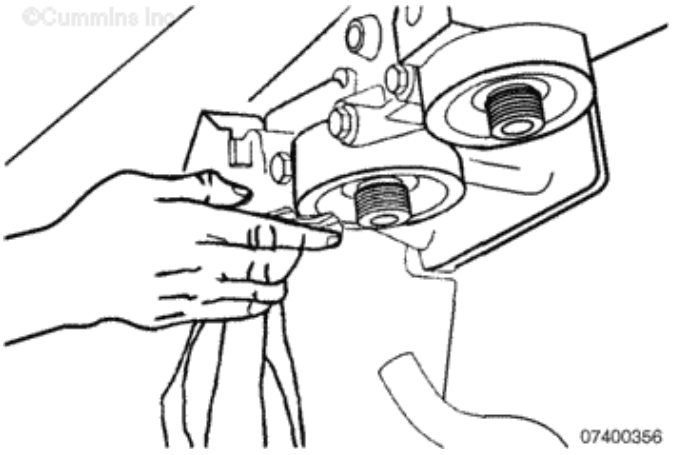
NOTE: The following steps show the combination oil filter. Use the same procedures when changing the remote bypass oil filters. Remove the oil filters with oil filter wrench, Part Number 3400157 or 3400158, or equivalent. Discard the oil filters if they are **not** needed for failure analysis.		

Install

Clean the oil filter		

head surface.

Lubricate the gasket surface of the oil filter with clean engine oil.



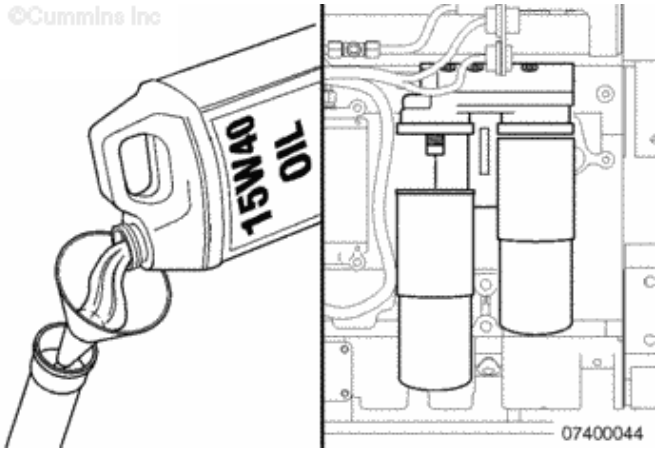
Fill the oil filters with clean 15W-40 oil.

Install the oil filters on the oil filter head.

Mechanical overtightening can distort the threads or damage the oil filter element seal.

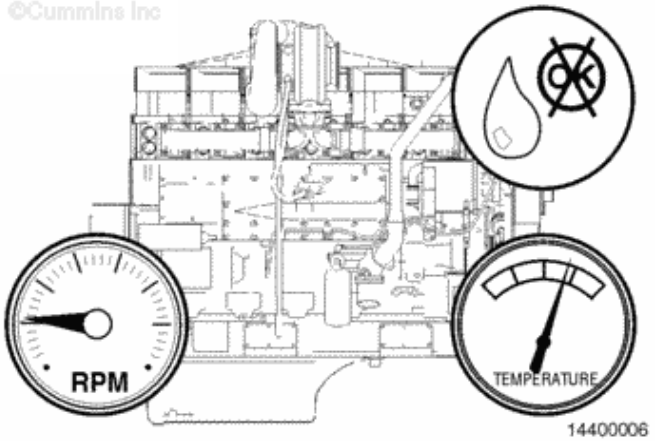
Turn the oil filter until the seal contacts the oil filter head.

Turn an additional ¾ to 1 turn.

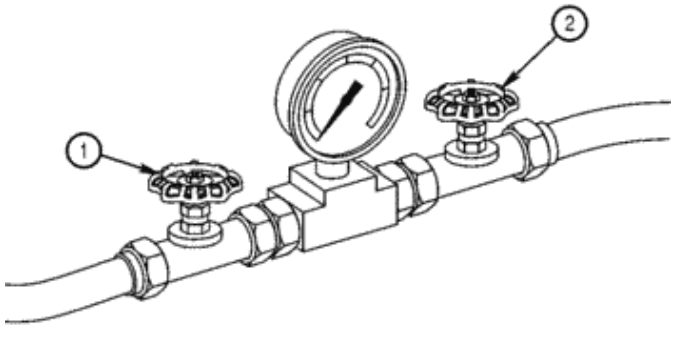
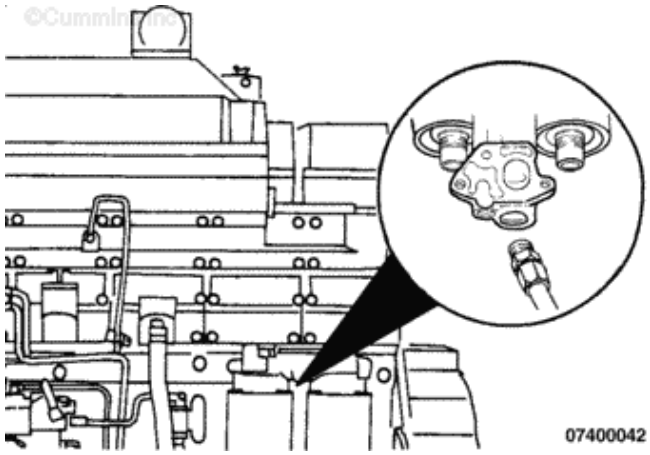


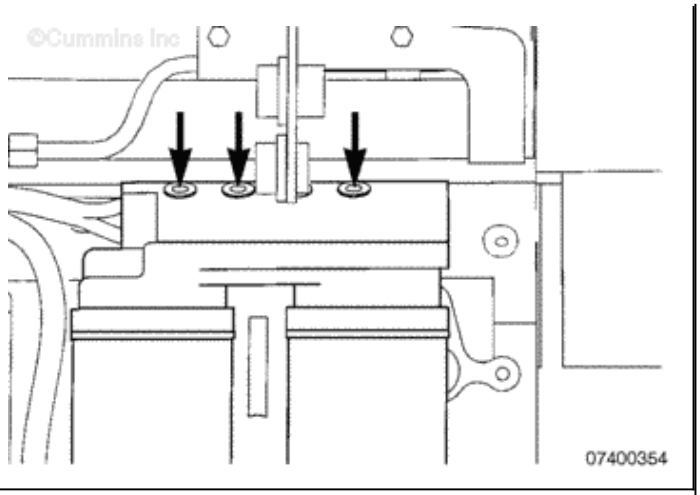
Operate the engine until the oil temperature is at a minimum of 65°C [150°F].

Check for leaks.



Pressure Differential Test

Use a differential pressure gauge, with a minimum pressure capacity of 517 kPa [75 psi] or a gauge with two oil hoses and two valves to eliminate error.		
Connect one hose in the plug hole at the bottom of the oil filter head. This reading will indicate the oil pressure before it goes through the filters.		
Connect one hose in one of the plug holes on the top of the oil filter head. This reading will indicate the oil pressure after the oil goes through the filter.		

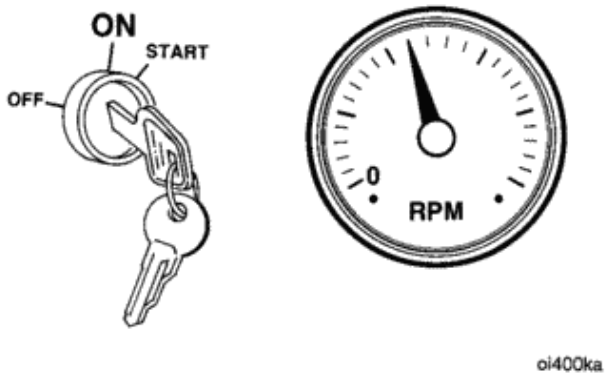


Operate the engine at rated rpm and normal operating temperature.

Open the valve to read the pressure after the oil filter. Record the pressure.

Close the valve.

Open the valve to read the pressure before the oil filter. Record the pressure.

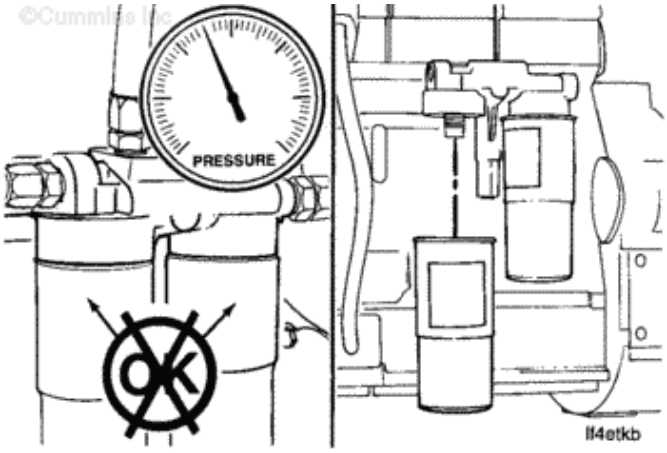


If the difference in pressure is more than 103 kPa [15 psi], replace the oil filters.

If the difference in pressure, using clean oil filters, is more than 69 kPa [10 psi], an oil filter with excessive restriction is used.

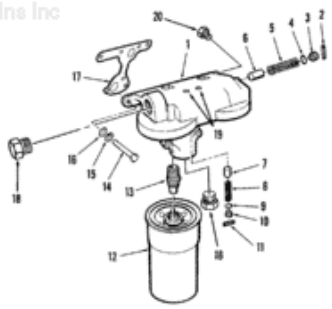
Replace the oil filters.

Remove the test gauge.



007-015 Lubricating Oil Filter Head

Exploded View



1. Lubricating oil filter head
2. Roll pin
3. Stop pressure regulator
4. O-ring
5. Bypass valve spring
6. Bypass valve plunger
7. Piston cooling valve plunger
8. Piston cooling valve spring
9. O-ring
10. Stop pressure regulator
11. Roll pin
12. Lubricating oil filter element
13. Oil filter adapter
14. Capscrew
15. Lock washer
16. Plain washer
17. Lubricating oil filter head gasket
18. Pipe plug, 1-in
19. Pipe plug, 1/8-in
20. Pipe plug, 3/8-in.

General Information

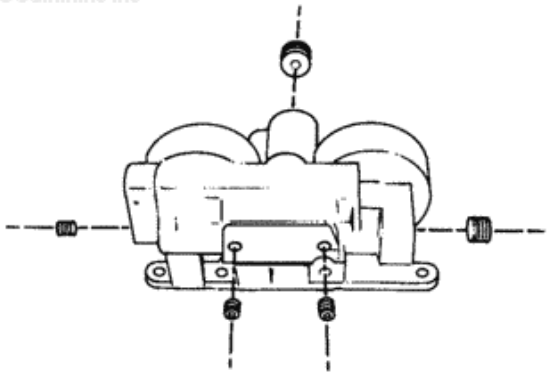
The oil filter head contains two spring loaded plungers. One plunger controls the oil pressure for the piston cooling		

nozzles. The second spring plunger will bypass oil if a filter element becomes plugged or clogged.

When installing a new filter element, **always** check to be sure there is **not** interference between the filter head and the element.

Three different designs of filter adapters have been used in the filter head. The revised design has slots machined on the inside diameter. This allows any ¾-in drive tool to be used to remove the adapter. It is **not** necessary to remove the adapter unless it is damaged.

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Preparatory Steps

WARNING

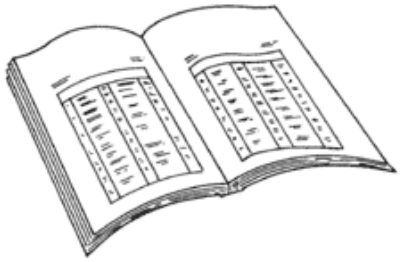
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

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.

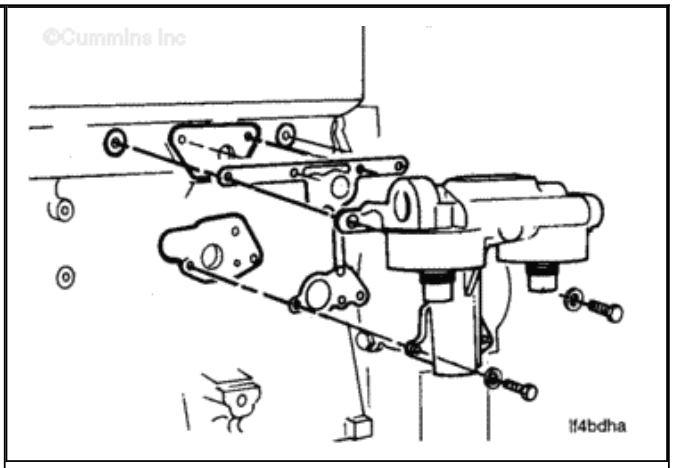
- Remove the oil filters. Refer to Procedure 007-013.

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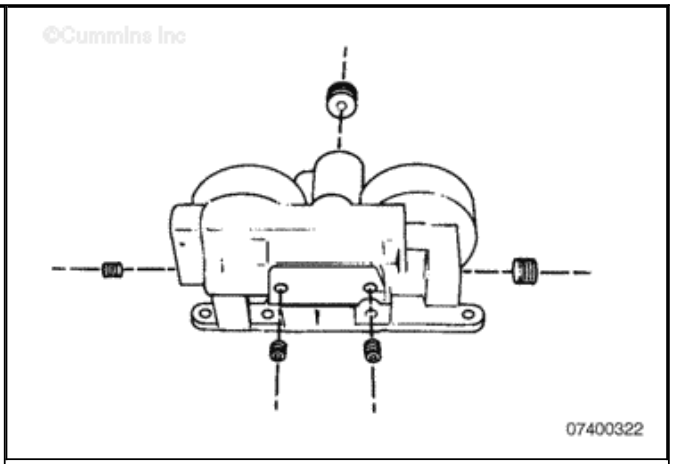


ck800wa

Remove

Remove the six oil filter head mounting capscrews. Remove the oil filter head assembly. Remove and discard the gasket.		

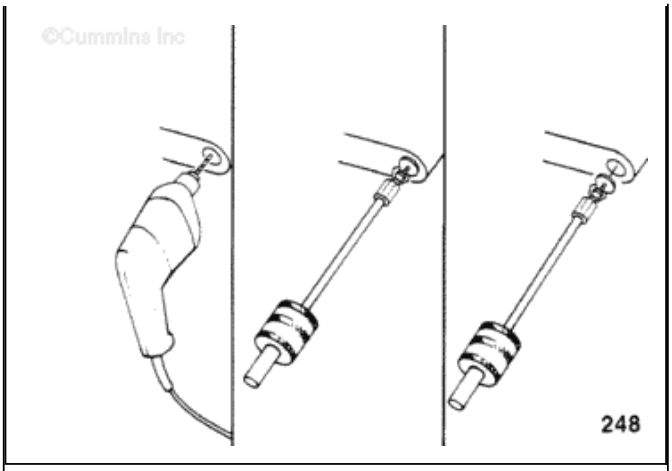
Disassemble

NOTE: Older filter heads have pipe plugs. Newer filter heads have straight-thread o-ring plugs. Remove the plugs.		
Use a drill, a sheet metal screw, and the below listed parts from the light duty puller kit, Part Number 3375784.		

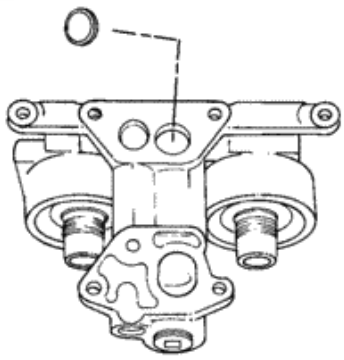
- Slide hammer
- Hook.

Drill a hole in the cup plug and install a sheet metal screw.

Attach the slide hammer to the sheet metal screw.



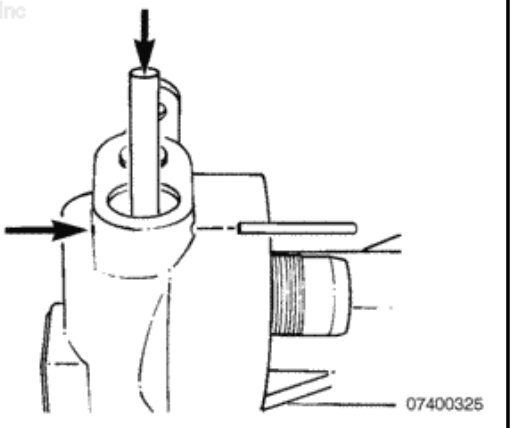
Remove the cup plug.



WARNING

To reduce the possibility of personal injury, hold the regulator stop in position when removing the roll pin. The regulator stop is under pressure and can pop out.

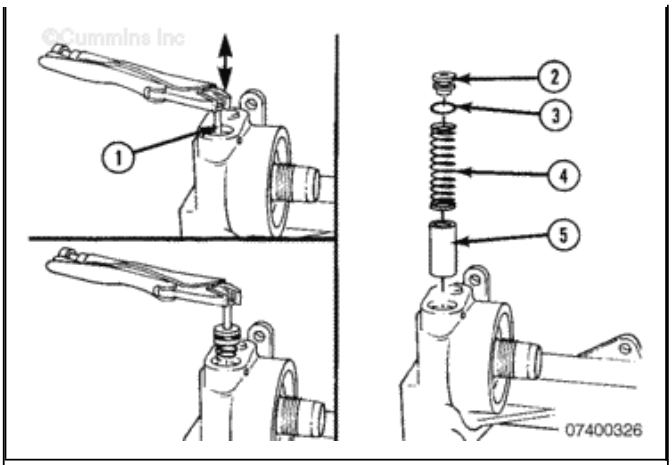
Remove the roll pin.



A ¼-20 UNC-2A capscrew (1) can be used to remove the into the regulator stop (2).

Remove the o-ring (3), bypass valve spring (4), and bypass valve regulator plunger (5).

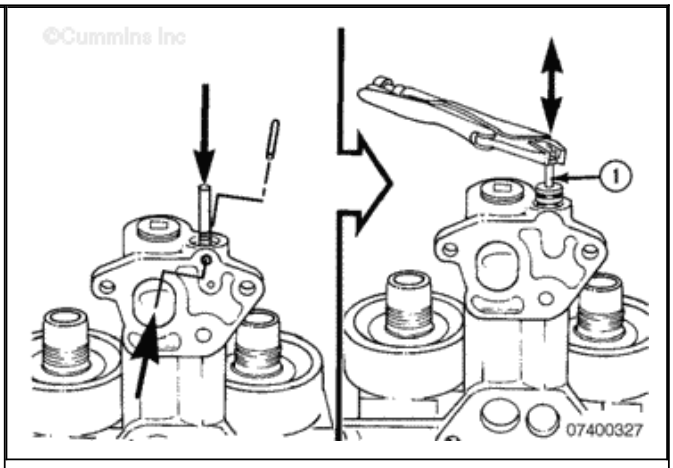
Discard the o-ring.



WARNING

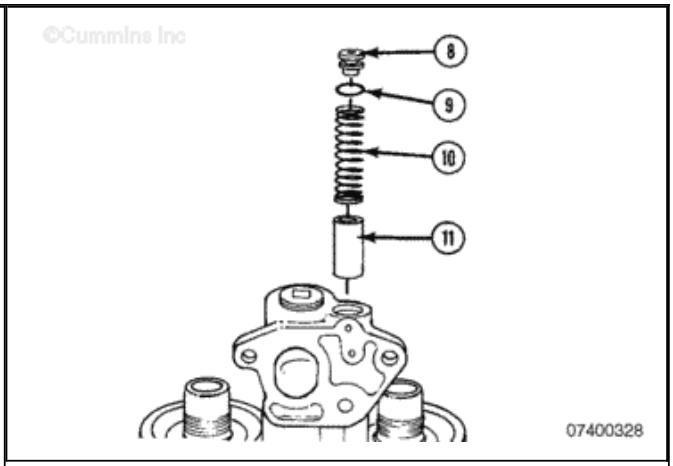
To reduce the possibility of personal injury, hold the regulator stop in position when removing the roll pin. The regulator stop is under pressure and can pop out.

A ¼-20 UNC-2A capscrew can be used to remove the regulator stop.



Remove the pressure regulator stop (8), o-ring (9), piston cooling spring (10), and piston cooling valve plunger (11).

Discard the o-ring.



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

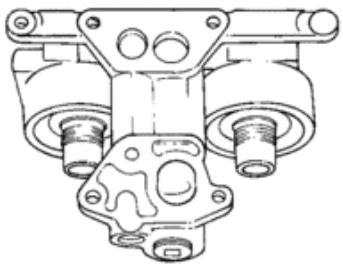
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent to clean the lubricating oil filter head and dry with compressed air.

The solvent **must** be removed from the oil drillings.

Inspect the filter head for cracks and damage.

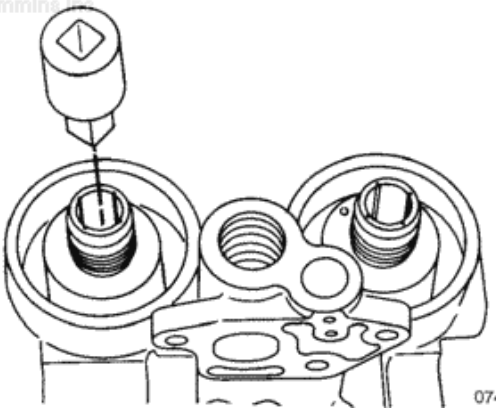
The filter head **must** be replaced if cracked or damaged.



lf4hdea

Inspect the lubricating oil filter head for adapter for damage.

If the adapter is damaged it **must** be replaced. Refer to Procedure 007-018.



07400332

WARNING

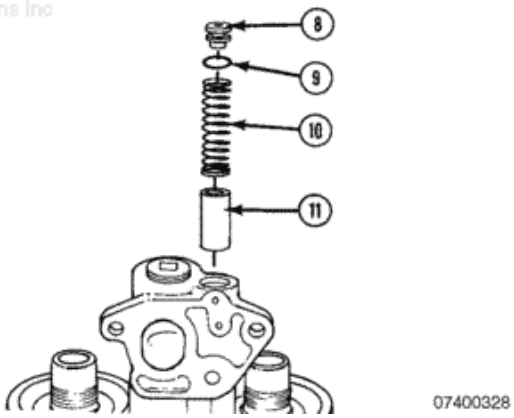
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean lubricating oil filter head parts in solvent and dry with compressed air.

Inspect the parts for damage. If the parts are damaged they **must** be replaced.



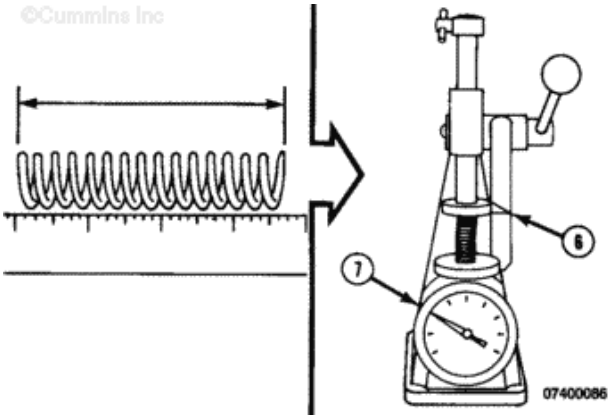
Check the length of the springs.

Spring Free Length	
Piston Cooling	Bypass
63.50 mm [2.50 in]	88.90 mm [3.50 in]

Use valve spring tester, Part Number 3375182, or equivalent to measure the spring force at the (7) at the spring working height (6).

Spring Working Height (6)	
Piston Cooling	Bypass
45.42 mm [1.788 in]	50.80 mm [2.000 in]

Spring Force (7)



	n		lbf
Piston Cooling	49.0	MIN	11.0
	54.0	MAX	12.1
Bypass	109.0	MIN	24.4
	128.0	MAX	28.7

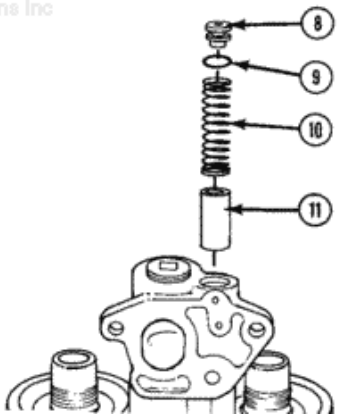
Assemble

Lubricate the parts with clean engine oil.

Install the new o-ring (9) onto the regulator stop (8).

Install the piston cooling valve regulator plunger (11) into the oil filter head.

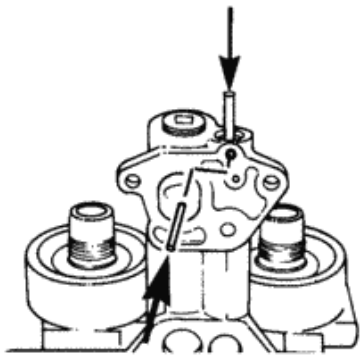
Install the piston cooling pressure spring (10) and the pressure regulator stop (8) with o-ring (9) into the oil filter head.



WARNING

To reduce the possibility of personal injury, hold the regulator stop in position when removing the roll pin. The regulator stop is under pressure and can pop out.

Use a mandrel and an arbor press to hold the regulator stop in position while installing the roll pin.



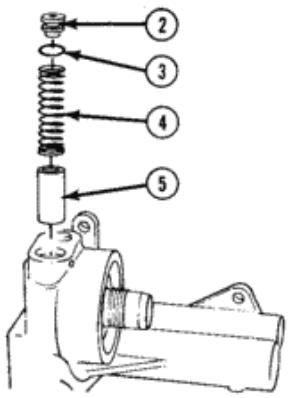
Lubricate the parts with clean engine oil.

Install the new o-ring (3)

onto the regulator stop (2).

Install the bypass valve regulator plunger (5) into the oil filter head.

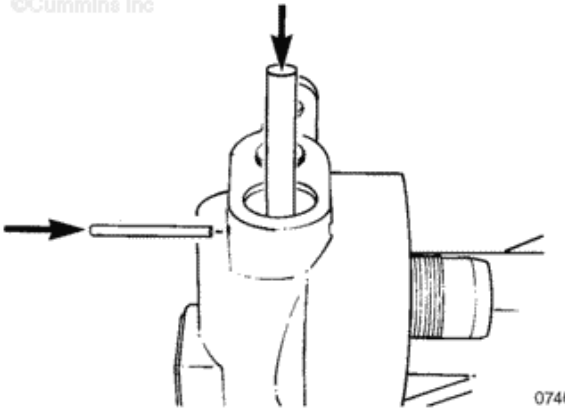
Install the bypass valve spring (4), regulator stop (2) with o-ring (3).



WARNING

To reduce the possibility of personal injury, hold the regulator stop in position when removing the roll pin. The regulator stop is under pressure and can pop out.

Use a mandrel and an arbor press to hold the regulator stop in position while installing the roll pin.



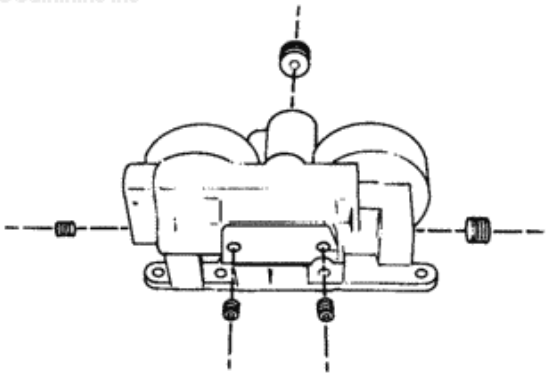
Apply pipe plug sealant, Part Number 3375066, or teflon tape, or equivalent to the pipe plug threads.

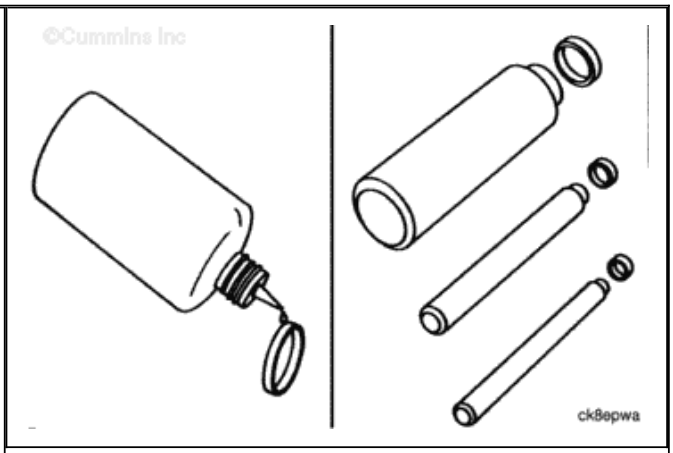
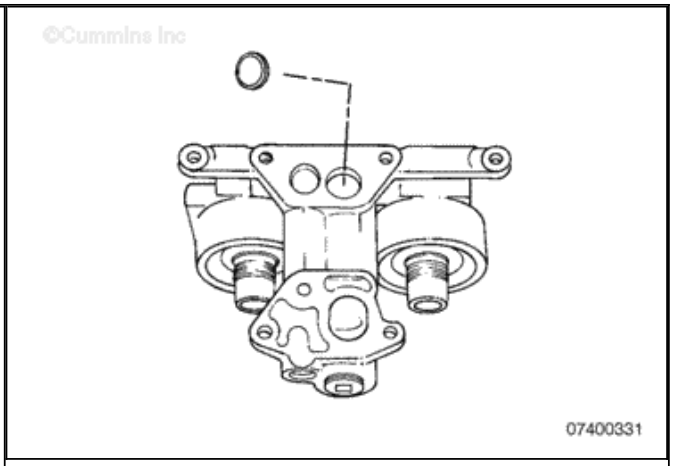
Install the pipe plugs.

Tighten the pipe plugs.

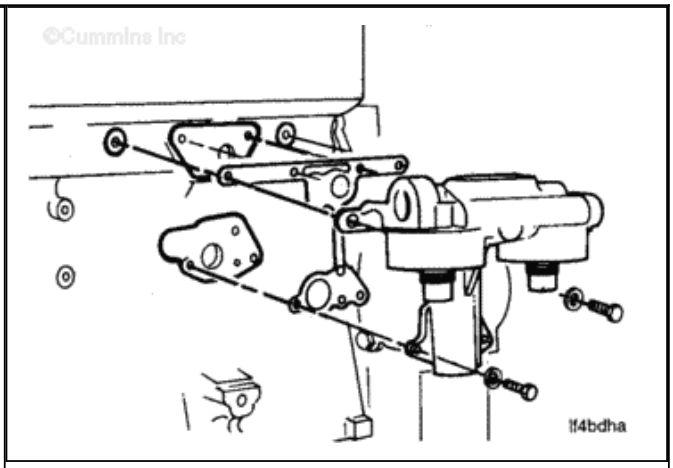
1-inch pipe plug	75 n.m	[55 ft-lb]
3/8-inch pipe plug	27 n.m	[20 ft-lb]
1/8-inch pipe plug	14 n.m	[120 in-lb]

NOTE: The torque values are the same for the plugs with straight threads and an o-ring seal.

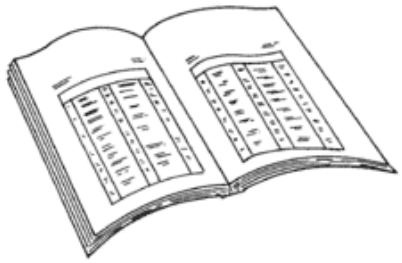


Apply cup plug sealant, Part Number 3375068, or equivalent to the cup plug. Select the correct size driver.		
Install the cup plug.		

Install

Install the gasket, lubricating oil filter head, and capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]	 	

Finishing Steps

• Install the lubricating oil filters. Refer to Procedure 007-013.		 ck800wa

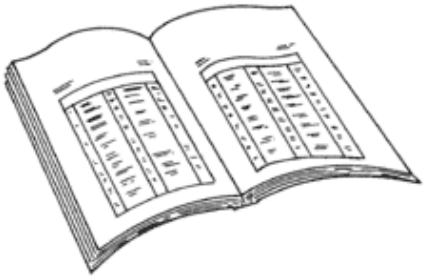
Last Modified: 20-Dec-2004

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007-017 Lubricating Oil Filter Head (Remote-Mounted)

Preparatory Steps

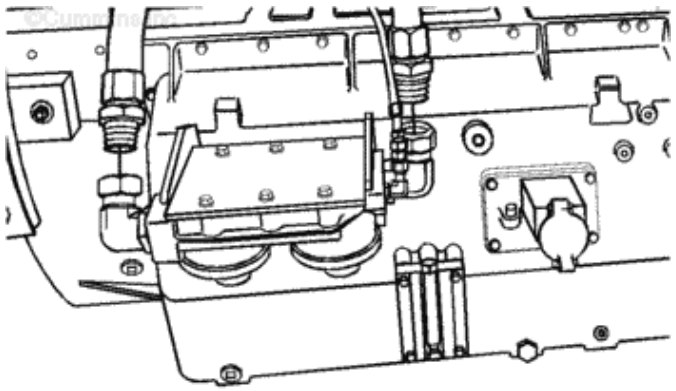
- Remove lubricating oil filters. Refer to Procedure 007-013.



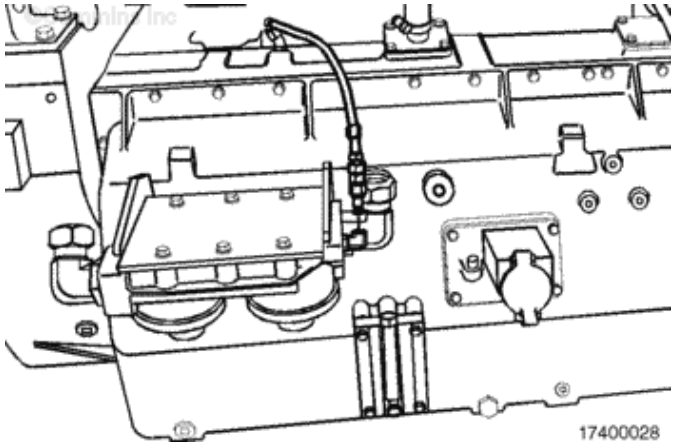
Remove

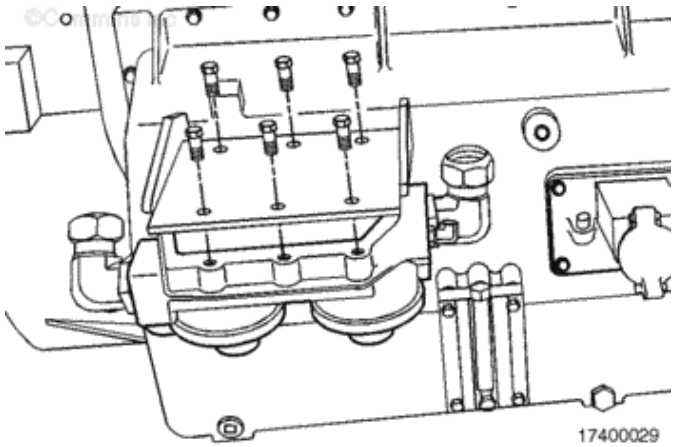
NOTE: A remote oil filter is used as an example in this procedure. The filter can be mounted in a different location depending on the equipment manufacturer.

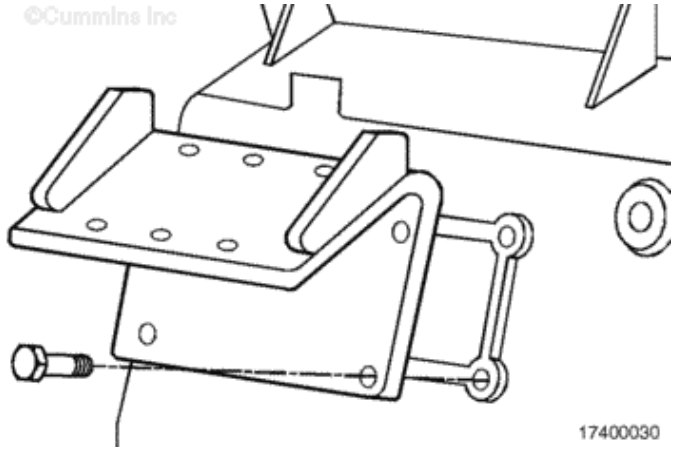
Disconnect the inlet and outlet hoses from the lubricating oil filter



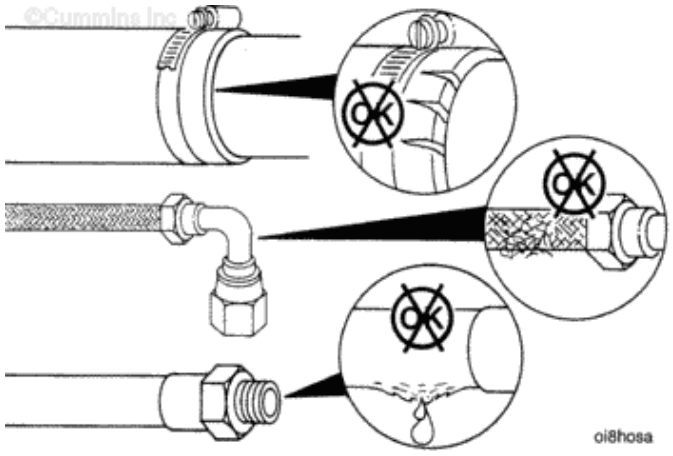
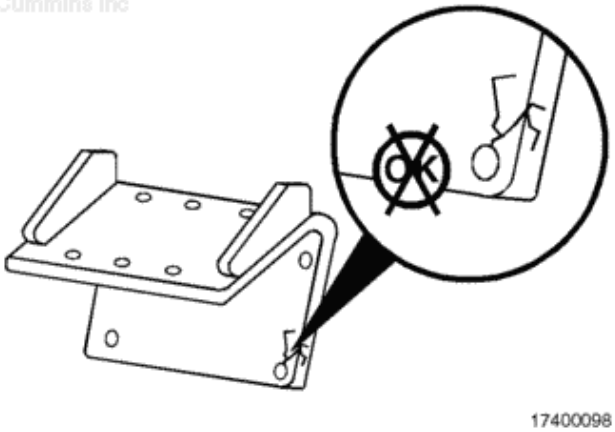
head.		

Disconnect the bypass oil hose from the lubricating oil filter head.		

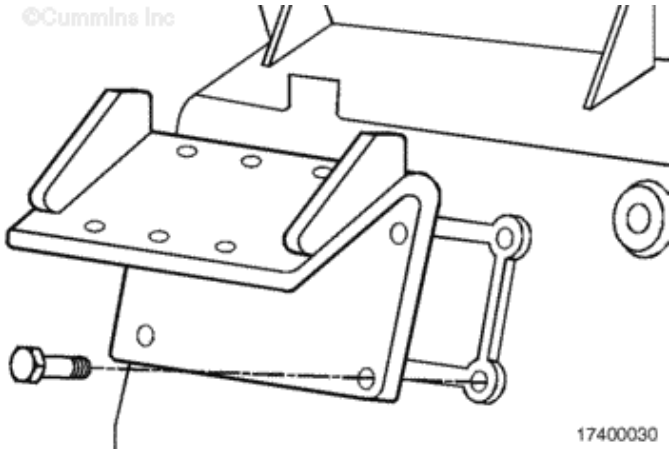
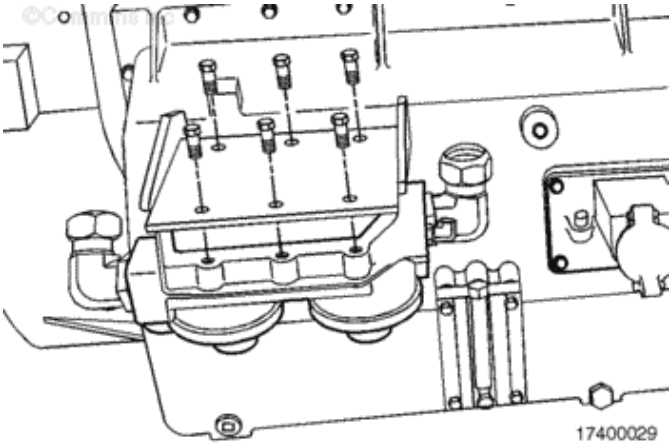
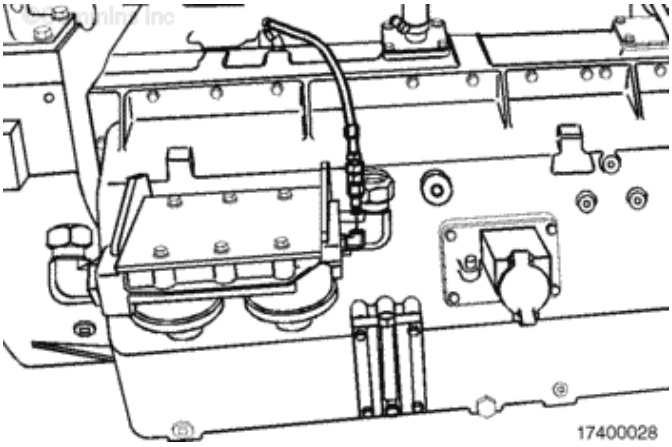
Remove capscrews and the lubricating oil filter head from the bracket.		

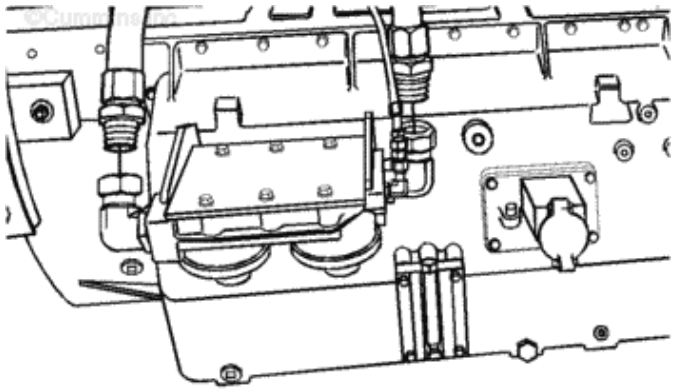
Remove the capscrews and lubricating oil filter head bracket.		

Inspect for Reuse

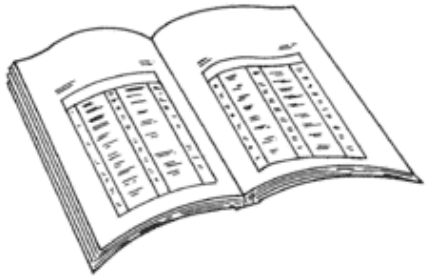
Check lines and hoses for cracks. If the lines or hoses are cracked, they **must** be replaced.		
Inspect the lubricating oil filter head bracket for cracks or damage. If the lubricating oil filter head bracket is cracked or damaged, it **must** be repaired or replaced.		

Install

Install the lubricating oil filter head bracket and capscrews. Tighten the capscrews. Refer the capscrews markings and torque values in Procedure 018-009 for the correct torque.		
Install the lubricating oil filter head and capscrews. Tighten the capscrews. **Torque Value:** 25 n.m [20 ft-lb]		
Connect the bypass oil hose to the lubricating oil filter head. **Torque Value:** 35 n.m [25 ft-lb]		

Connect the inlet and outlet hoses to the lubricating oil filter head. **Torque** **Value:** 270 n.m [200 ft-lb]		 17400027

Finishing Steps

• Install the lubricating oil filters. Refer to Procedure 007-013.		 ck800wa

Last Modified: 19-Oct-2004

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007-018 Lubricating Oil Filter Head Adapter

Preparatory Steps

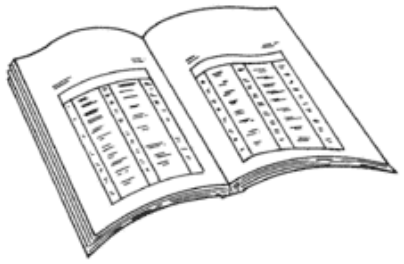
WARNING

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 the oil filters. Refer to Procedure 007-013.



ck800wa

Remove

Threaded

Remove the adapter using a ¾-in drive tool.

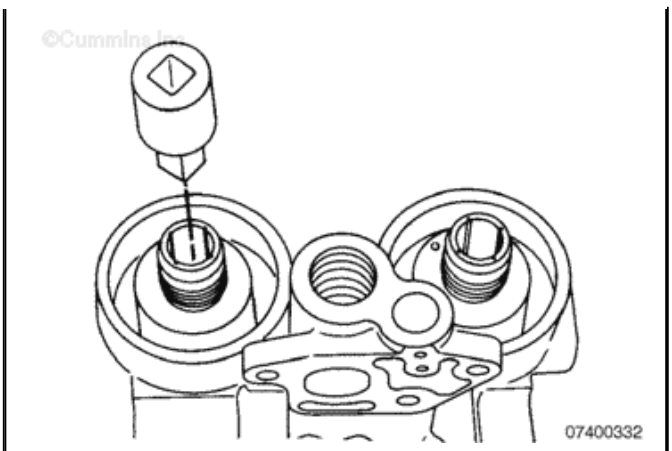
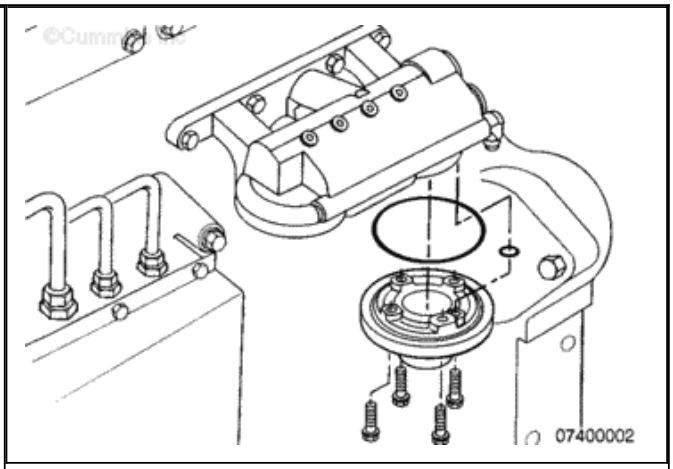


Plate Type

Remove the four capscrews.

Remove the oil filter head adapter.

Remove and discard the o-ring.



Clean and Inspect for Reuse

Threaded

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 adapter with solvent.

Check the adapter for damage.

If the adapter are damaged, it **must** be replaced.

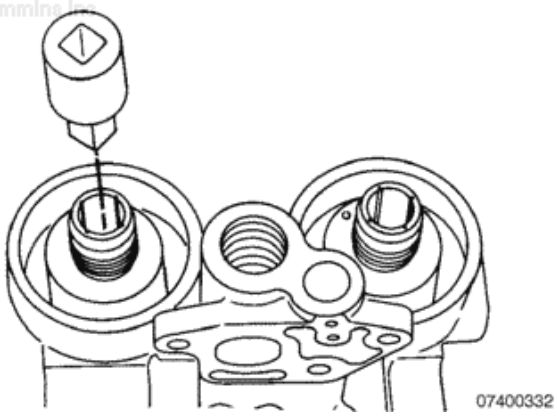


Plate Type

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 adapter with solvent.

Check the adapter for cracks or damage.

If the adapter is damaged, it **must** be replaced.



Install

Threaded

Apply Loctite® 609 or equivalent to the threads of the adapter.

Install the adapter.

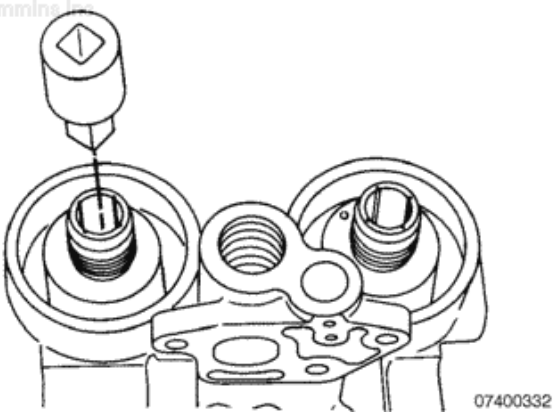
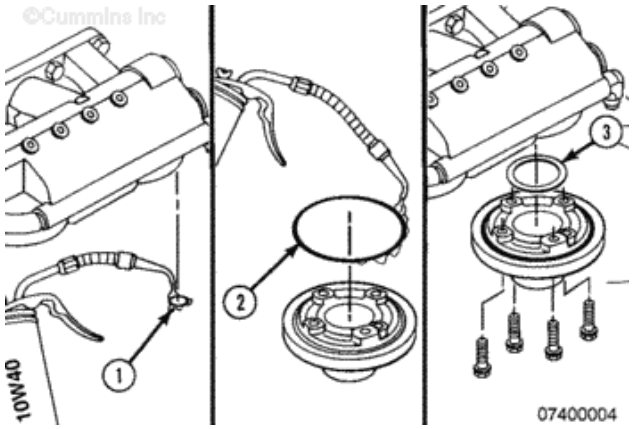
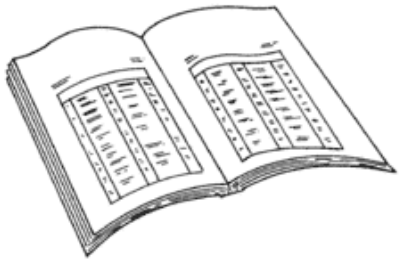
Tighten the adapter. **Torque** **Value:** 135 n.m [100 ft-lb]		

Plate Type

Lubricate the o-ring (1) and install it into the oil filter head prior to installing the adapter. Lubricate o-rings (2 and 3) and install them into the adapter. Use the locating pin to align the oil filter head adapter and with the oil filter head and install the adapter. Install the capscrews. Tighten the capscrews. **Torque** **Value:** 23 n.m [17 ft-lb]		

Finishing Steps

• Install the oil filters. Refer to Procedure 007-013.		



ck800wa

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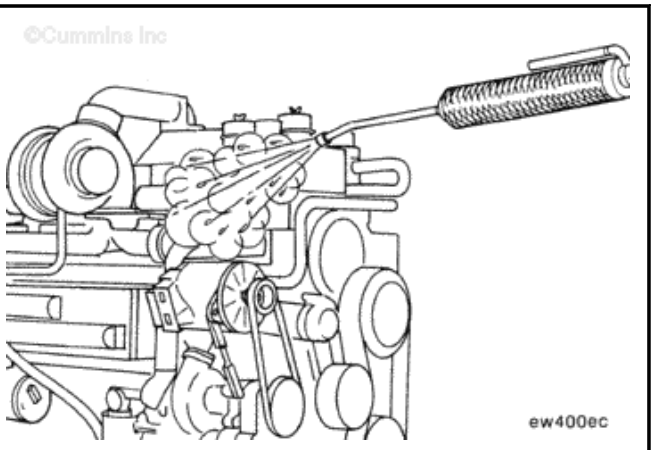
007-024 Lubricating Oil Leaks

Inspect

WARNING

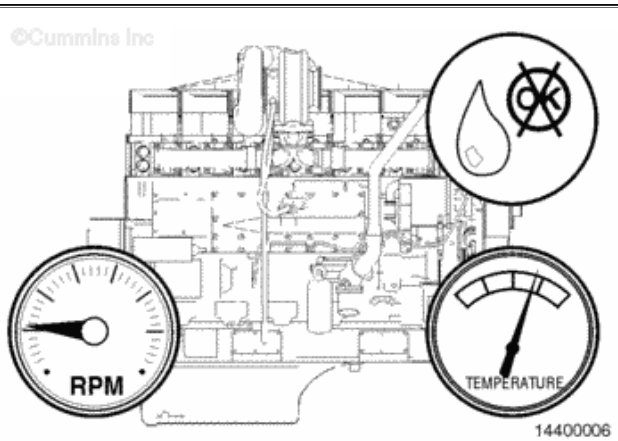
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

Use a steam cleaner or a high pressure washer to clean the engine.

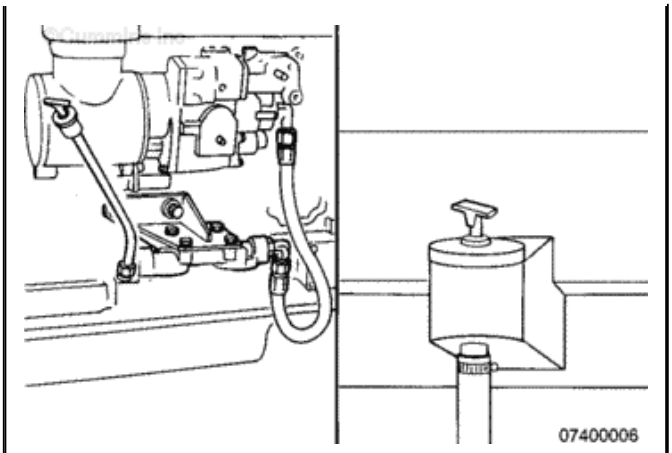


Operate the engine until the coolant temperature reaches 80°C [176°F]. Inspect the exterior of the engine for leaking gaskets, seals, o-rings, pipe plugs, or fittings.

Before replacing any gaskets, check that the capscrews are tightened to the correct torque values. Refer to Procedure 018-009 in Section V.

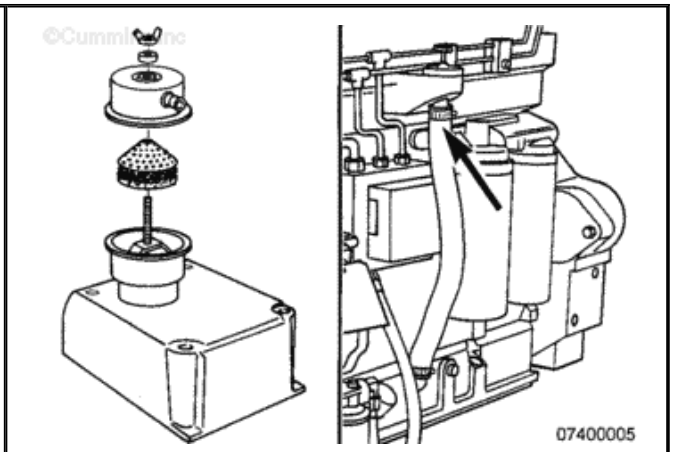


Check for a loose, broken, or missing oil dipstick tube, dipstick, or oil filler cap.



Check the engine crankcase breather elements and breather hose for restriction.

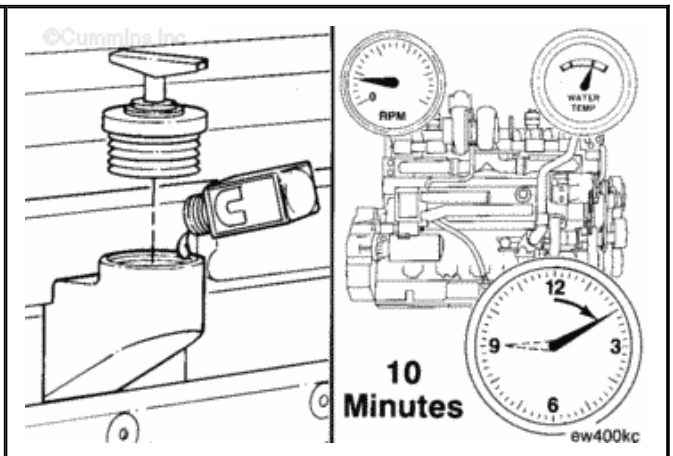
If **not** restricted, check the blowby. Refer to Procedure 014-005 in Section 14. High blowby can cause gasket and seal leakage.

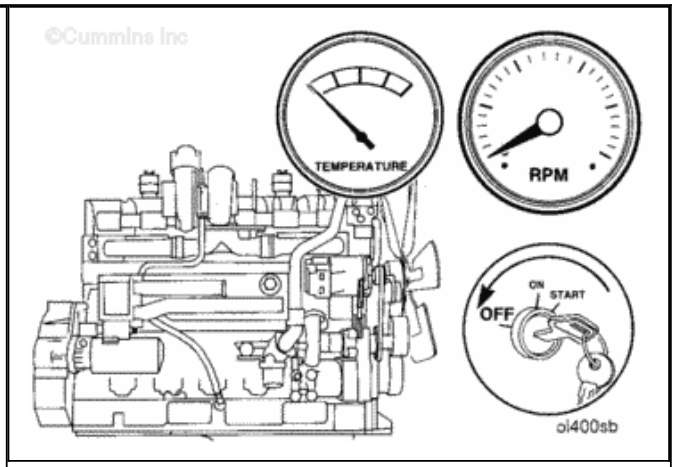
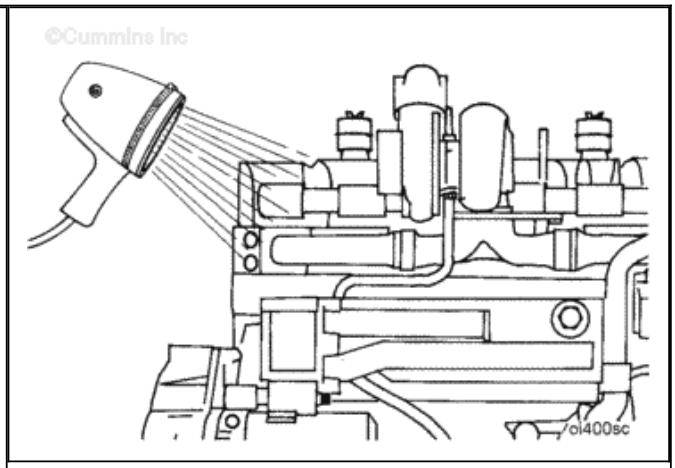
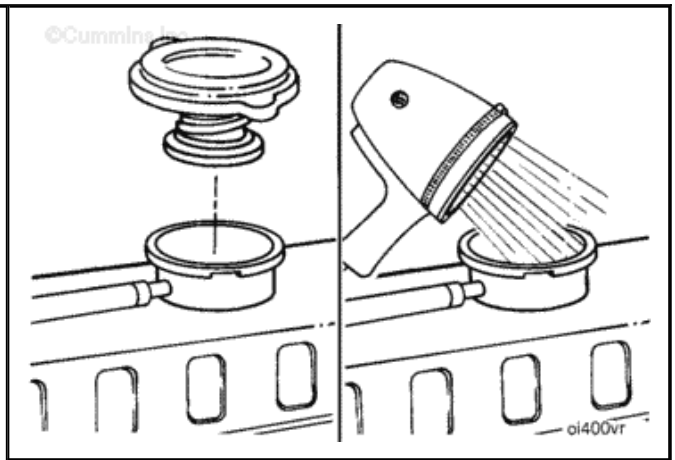


Fluorescent Dye Tracer

Add one unit of Fluorescent Tracer, Part Number 3376891, to each 38 liters [10 gals] of engine lubricating oil. Use the following procedure to determine oil pan capacity. Refer to Procedure 018-017 in Section V.

Operate the engine at low idle for 10 minutes.



Shut the engine OFF.		
Use a high intensity black light, Part Number 3163337 or equivalent, to inspect for oil leakage. Oil will glow a dark blue color.		
If an oil leak into the coolant is suspected, check the coolant. If oil is found in the coolant, refer to the Lubricating Oil in the Coolant Troubleshooting Symptom Tree in Section TS.		

Last Modified: 18-Mar-2010

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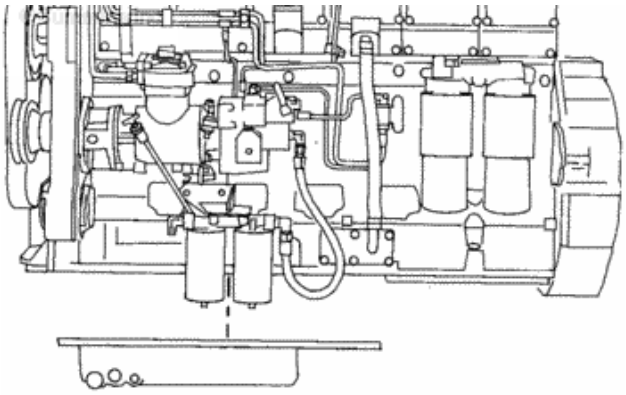
007-025 Lubricating Oil Pan

General Information

Lubricating oil pan sumps are available in various capacities. Check the part number and refer to Procedure 018-017 for the correct high and low capacities. When the rear gear train option is specified, add 7.6 liters [2 gallons] to the sump capacity.

Service dipsticks are available in two pan types. The first is the locking type. The second is the bottle stopper type that does **not** lock. When converting from one style to the other, change both the dipstick and the oil gauge tube.

Service dipsticks are supplied by length. The dipsticks do **not** have the high and low marks indicated. Do **not** calibrate the dipstick until the engine is installed in the application that it is to be used on.



op400hb

Preparatory Steps

All Applications Except Rail

WARNING

To reduce the possibility of personal injury, avoid direct

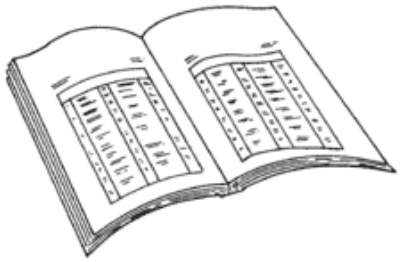
contact of hot oil with your skin.

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. Refer to Procedure 007-037.

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ck800wa

Rail Applications

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

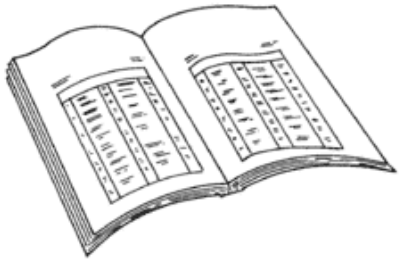
WARNING

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

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature

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ck800wa

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 lubricating oil. Refer to Procedure 007-037.
- Drain the coolant. Refer to Procedure 008-018.
- Remove the lubricating oil filter (remote mounted). Refer to Procedure 007-017.
- Remove the fuel filter (remote mounted). Refer to Procedure 006-011.
- Remove the coolant filter (remote mounted). Refer to Procedure 008-008.

Remove

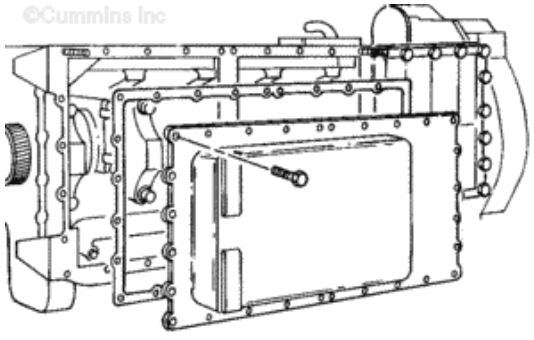
All Applications Except Rail

WARNING

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

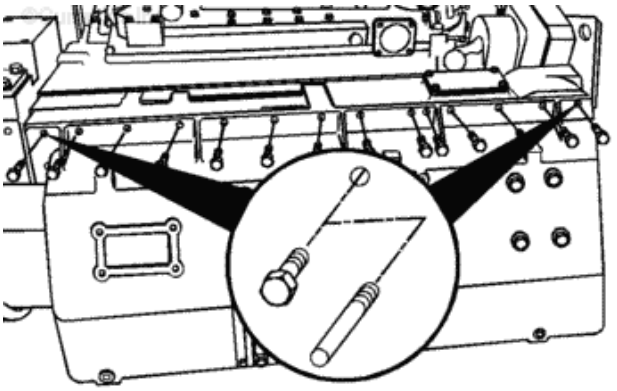
Remove the 28 capscrews.

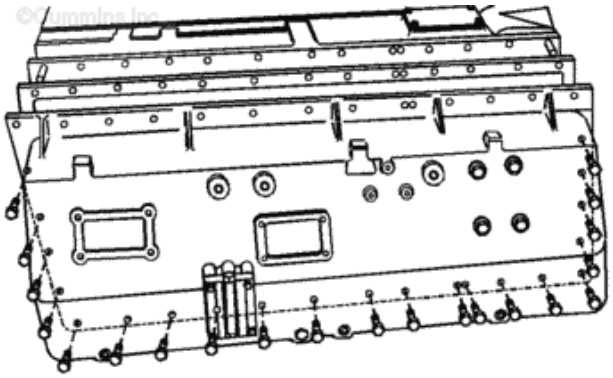
Remove the lubricating oil pan.



Remove and discard the gasket.		

Rail Applications

Remove 15 capscrews on the top of the lubricating oil pan. Install two 3/8- 16 guide studs in the capscrew holes.		 17400050

WARNING The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component. Remove the remaining 23 capscrews. Remove the lubricating oil pan. Remove and discard the gasket.		 17400051

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.

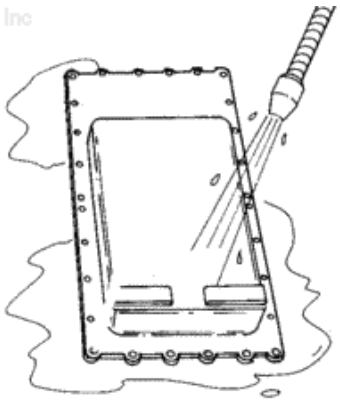
CAUTION

Use solvent that will not harm aluminum.

Clean the lubricating oil pan with solvent.

Inspect for cracks or other damage.

If the lubricating oil pan is cracked or damaged it **must** be repaired or repalced.



07400007

Install

All Applications Except Rail

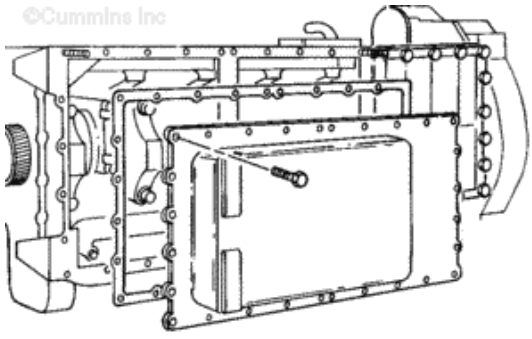
WARNING

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

CAUTION

Gasket cement will prevent the gasket from sealing properly.

Use a contact adhesive such as 3M Spray 77 or 3M 4693 to



07400008

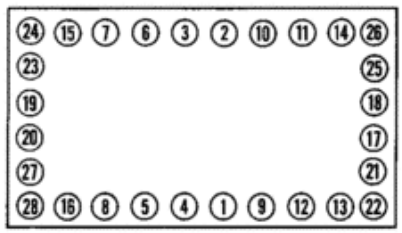
hold the gasket in position.

Install the gaskets and lubricating oil pan.

Install the capscrews.

Tighten the capscrews in sequence.

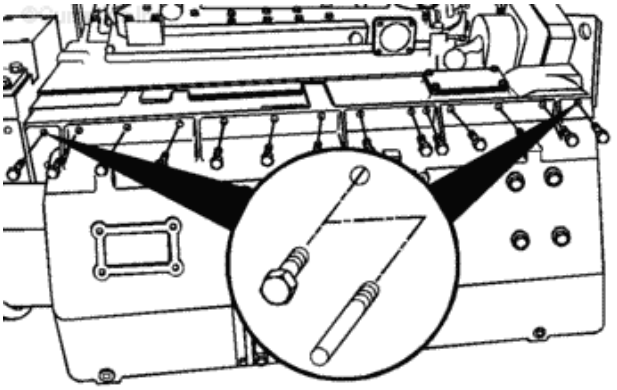
Torque
Value: 45 n.m [33 ft-lb]



07400009

Rail Applications

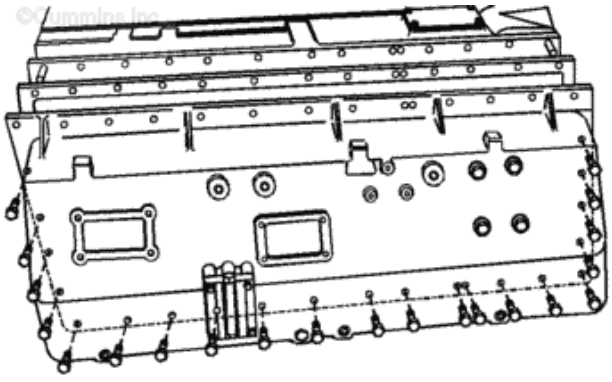
Install two 3/8 - 16 guide studs in the top row of capscrew holes.


17400050

WARNING

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

CAUTION


17400051

Gasket cement will prevent the gasket from sealing properly.

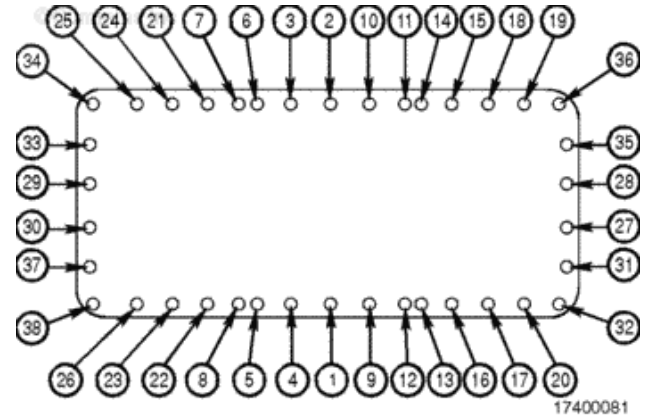
Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the gasket in position.

Install the gasket and lubricating oil pan.

Install the 38 capscrews.

Tighten the capscrews in the sequence shown.

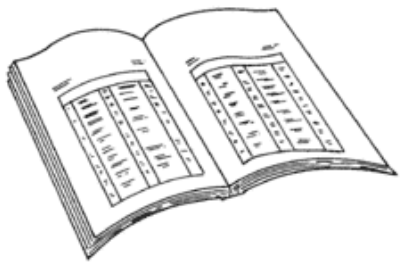
Torque
Value: 45 n.m [33 ft-lb]



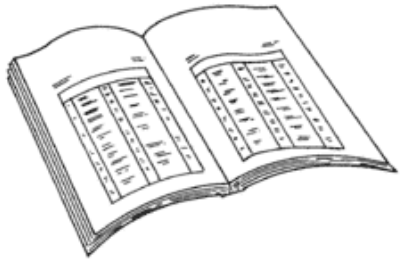
Finishing Steps

All Applications Except Rail

- Fill the engine with lubricating oil. Refer to Procedure 007-037.



Rail Applications

• Install the coolant filter (remote mounted). Refer to Procedure 008-008. • Install the fuel filter (remote mounted). Refer to Procedure006-011. • Install the lubricating oil filter (remote mounted). Refer to Procedure 007-017. • Fill cooling system. Refer to Procedure 008-018. • Fill the engine with lubricating oil. Refer to Procedure 007-037.		 ck800wa

Last Modified: 08-Dec-2004

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007-026 Lubricating Oil Pan Adapter Cover Plate

Preparatory Steps

WARNING

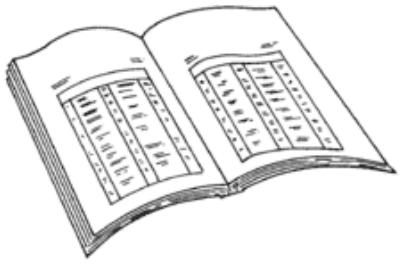
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

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. Refer to Procedure 007-037.





ck800wa

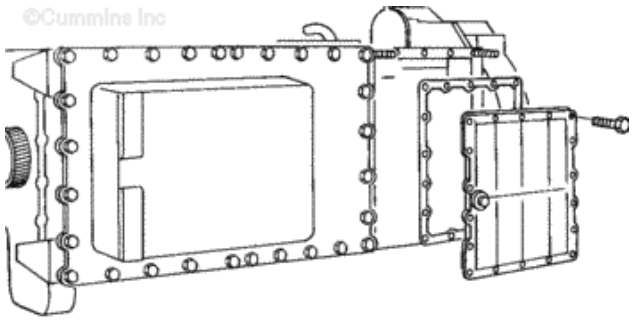
Remove

Remove the 18 capscrews.

Remove the lubricating oil pan adapter cover plate.

Remove and discard the gasket.





Clean and Inspect for Reuse

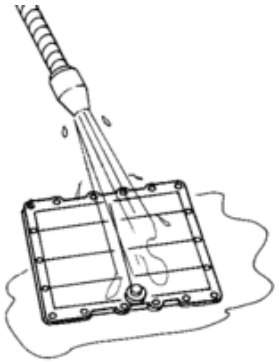
WARNING

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.

NOTE: The oil pan adapter cover can be made of aluminum or stamped steel. Some older stamped steel covers had stiffening plates that were not permanently attached to the cover. Cummins Inc. recommends the covers with the loose stiffening plates be replaced with a cover made of aluminum or a stamped steel cover that has the plates permanently attached.

Use solvent that will **not** harm aluminum to clean the parts.

Inspect for cracks or other



damage.

Repair or replace the lubricating oil pan adapter cover plate if cracked or damaged.

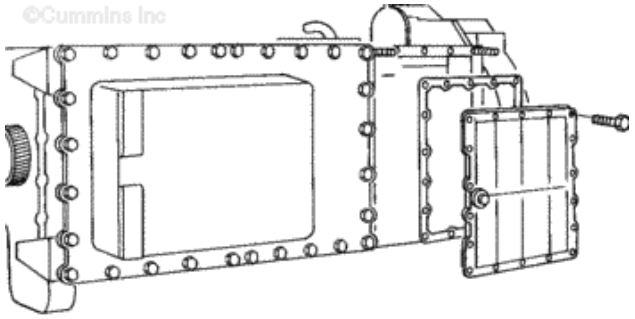
Install

CAUTION

Do not use gasket cement. Gasket cement will prevent the gasket from sealing properly.

Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the gasket in position.

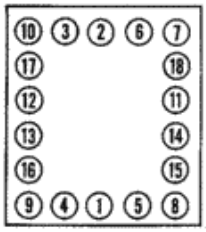
Install the gasket and lubricating oil pan adapter cover plate.



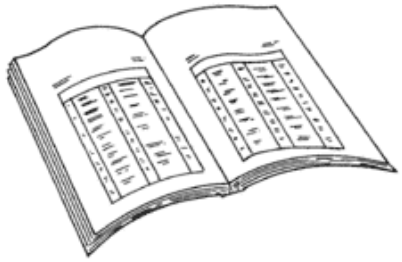
Install the capscrews.

Tighten the capscrews in sequence.

Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

• Install new oil filter elements. Refer to Procedure 007-013. • Fill the engine with lubricating oil. Refer to Procedure 007-037.		©Cummins Inc  ck800wa

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007-027 Lubricating Oil Pan Adapter

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

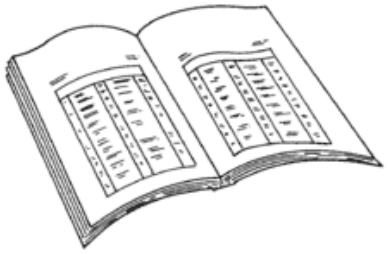
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

WARNING

To reduce the possibility of serious personal injury, securely support the engine, before removing the engine support bracket.

- Drain the oil. Refer to Procedure 007-037.
- Remove the oil pan. Refer to Procedure 007-025.
- Remove the oil pan adapter cover. Refer to Procedure 007-026.
- Remove the turbocharger oil drain hoses. Refer to Procedure 010-045.
- Remove the dipstick tube

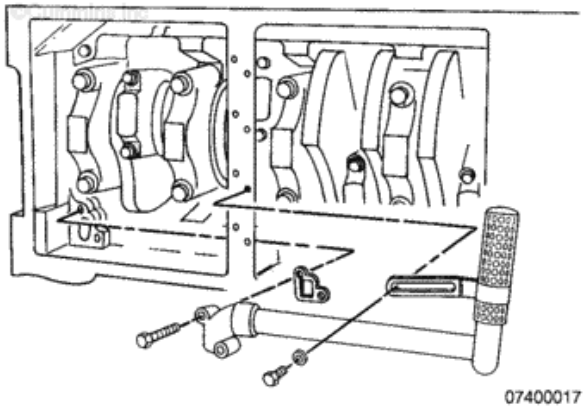
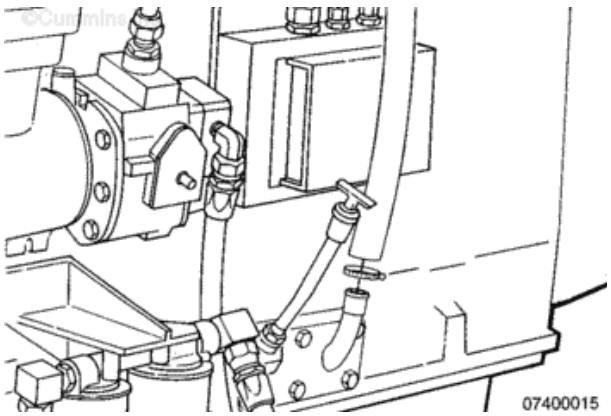


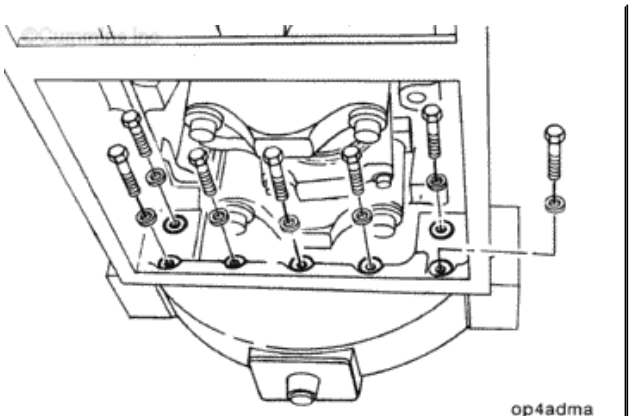


ck800wa

and dipstick. Refer to Procedure 007-011. • Remove the front engine support bracket. Refer to Procedure 016-002. • Remove the oil filters. Refer to Procedure 007-013.		

Remove

Remove the three capscrews from the suction tube. Remove the oil pan suction tube. Remove and discard the gasket.		 07400017
Disconnect the breather vent hose from the handhole cover.		 07400015
Remove the two 7/16-14 inch and five 3/8-16 inch capscrews from the flywheel housing.		



WARNING

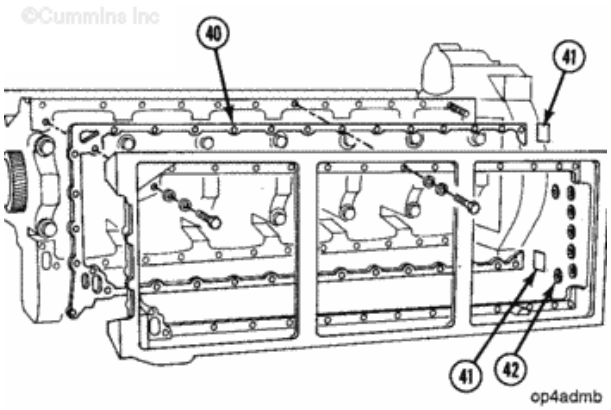
This component weighs 23 kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Remove all of the capscrews and the oil pan adapter.

Remove and discard the gasket (40).

Remove and discard the two rectangular seals (41).

Remove and discard the seven capscrew seals (42) from the adapter.



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.

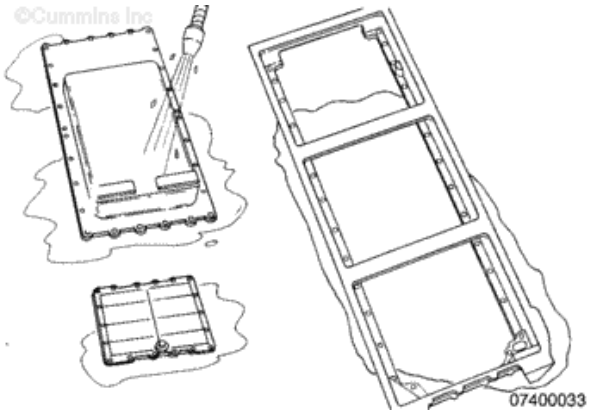
Clean the lubricating oil pan adapter with solvent, Part Number 3824421, or equivalent, that will **not** harm aluminum.

Inspect the oil pan adapter for cracks or other damage.

If cracks are suspected, use the crack detection kit, Part Number 3375432, or an equivalent kit which allows for use of the dye penetration method.

Check threaded holes for damage.

If the lubricating oil pan adapter is damaged, the lubricating oil pan adapter **must** be repaired or 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.

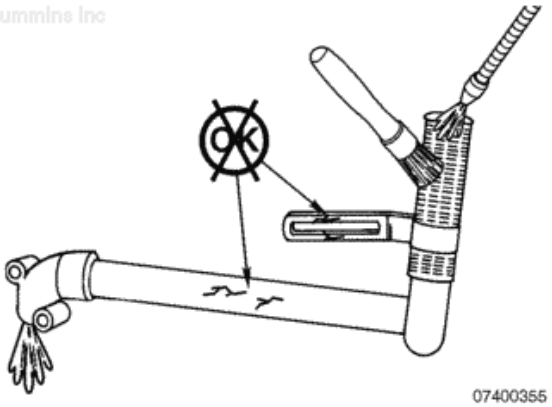
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the oil suction tube with solvent and dry with compressed air.

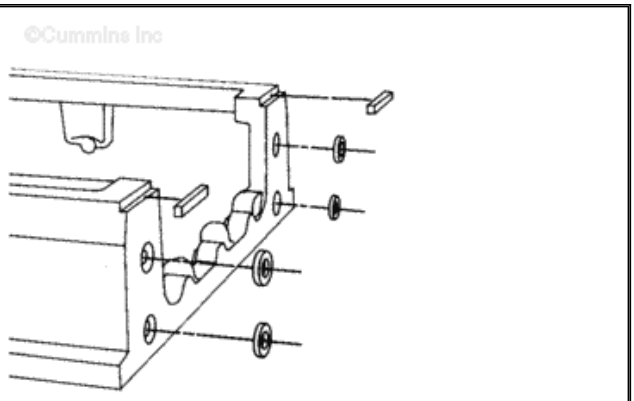
Inspect the oil suction tube for cracks or other damage.

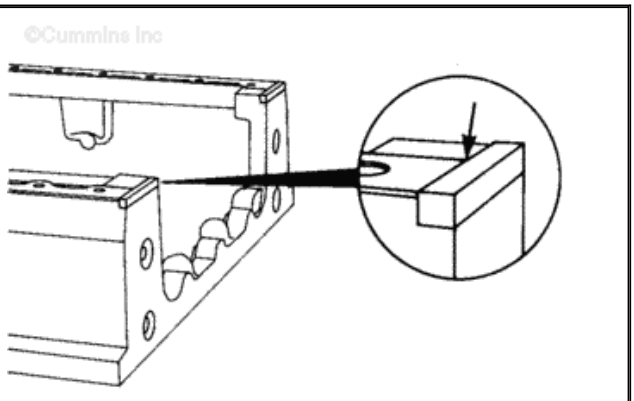
If the oil suction tube is cracked



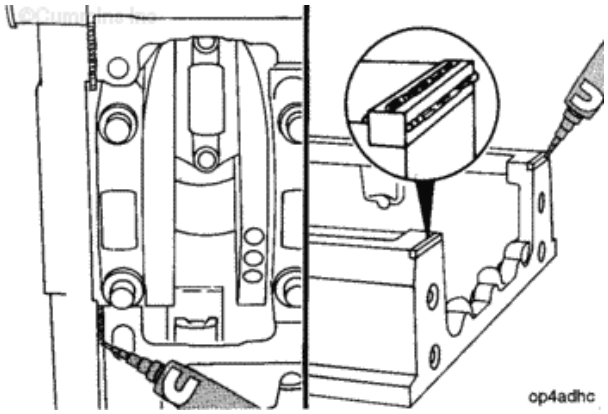
or damaged, the oil suction tube **must** be replaced.		

Install

Apply contact adhesive, such as 3M Spray 77 or 3M 4693, to the capscrew seals to hold them in position. Install the four capscrew seals onto the lubricating oil pan adapter. Use Cummins® sealant, Part Number 3823494, or equivalent on the oil pan adapter to hold the two rectangular seals in place before installing the seals on the oil pan adapter. After the seals are in place, wipe off any excess sealant to keep the sealant out of the lubricating oil system.		

CAUTION Do not use gasket cement. Gasket cement will prevent the gasket from sealing properly. Use a contact adhesive such as 3M Spray 77 or 3M 4693 to hold the pan adapter gasket to the pan adapter. Do **not** use the 3M Spray 77 or 3M 4693 adhesive on the rectangular seals. Install the gasket onto the oil pan adapter. The flywheel end of the gasket **must** touch the rectangular seals as shown.		

Apply sealant, Part Number 3164067, as illustrated in the graphic.		



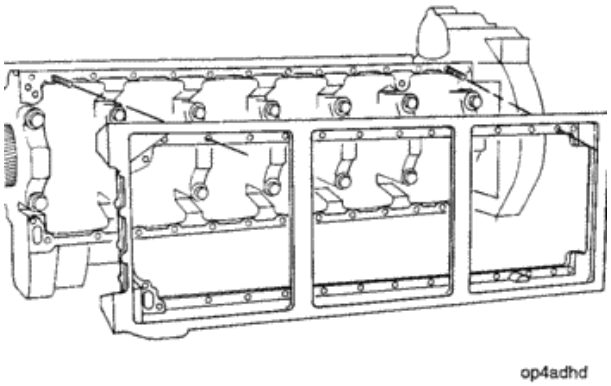
WARNING

This component weighs 23 kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Be sure to check the rectangular seal after the adapter has been set into place, and again when the adapter is tight. Seals **must** be checked prior to the sealant curing.

Position the oil pan adapter against the cylinder block and then move it back until it contacts the flywheel housing.

Install capscrews at the four corners of the oil pan adapter and hand-tighten.



The four capscrews shown in the graphic **must** be tightened alternately and evenly to make sure the adapter is pulled evenly to the block and flywheel housing.

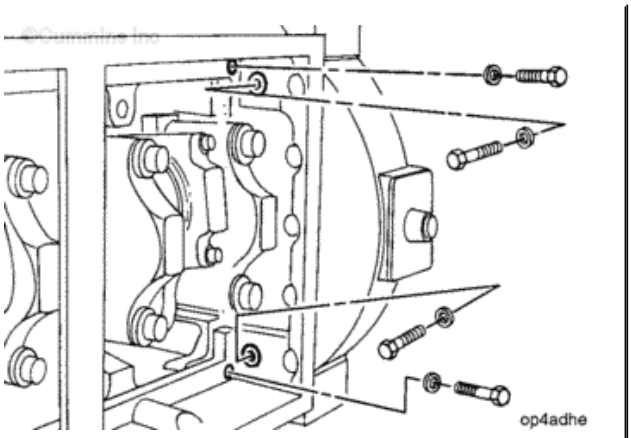
Install the four washers and capscrews.

Push the lubrication oil pan adapter towards the flywheel housing when tightening the

capscrews.

Tighten the capscrews.

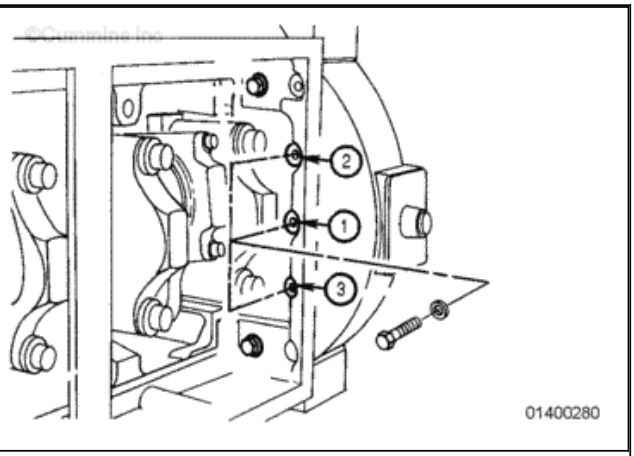
Torque Value:	Step 1	15 n.m [120 in-lb]
	Step 2	25 n.m [20 ft-lb]
	Step 3	40 n.m [30 ft-lb]
	Step 4	45 n.m [33 ft-lb]



Install the three capscrews located in the center of the flywheel housing.

Tighten the capscrews in the sequence illustrated in the graphic.

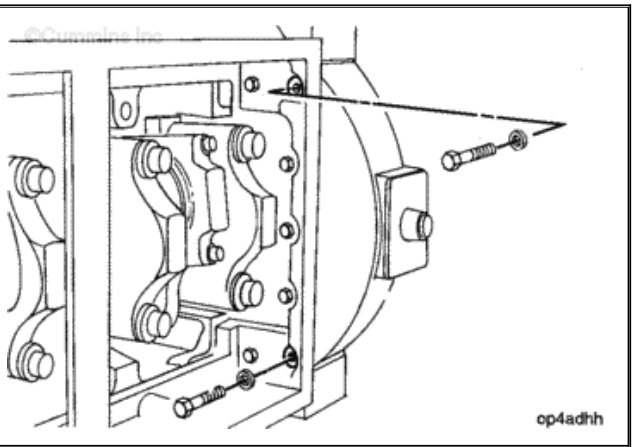
Torque Value:	Step 1	25 n.m [20 ft-lb]
	Step 2	40 n.m [30 ft-lb]
	Step 3	45 n.m [33 ft-lb]



Install the two 7/16-inch washers and capscrews illustrated in the graphic.

Tighten the capscrews.

Torque Value: 65 n.m [50 ft-lb]



Capscrews (24) through (28) thread into the front cover.

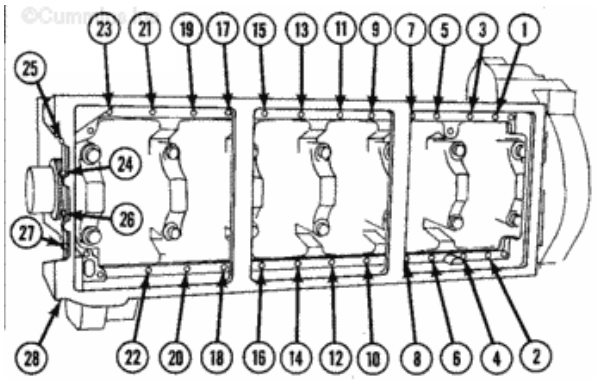
Install capscrews (24) through

(28).

Install the 3/8-inch capscrews (1) through (23).

Tighten the capscrews.

Capscrews (1) through (23)	60 n.m	[45 ft-lb]
Capscrews (24) through (28)	45 n.m	[33 ft-lb]

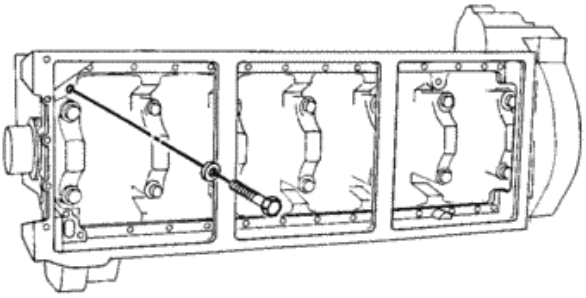


op4adhg

Install the 9/16-inch washer and capscrew.

Tighten the capscrew.

Torque Value: 150 n.m [110 ft-lb]


op4adhi

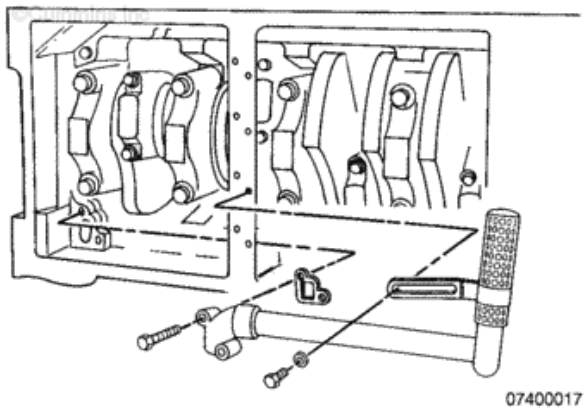
Install the gasket, oil pan suction tube, and capscrews.

Tighten the capscrews.

Torque Value: 60 n.m [45 ft-lb]

Tighten the clamp capscrew.

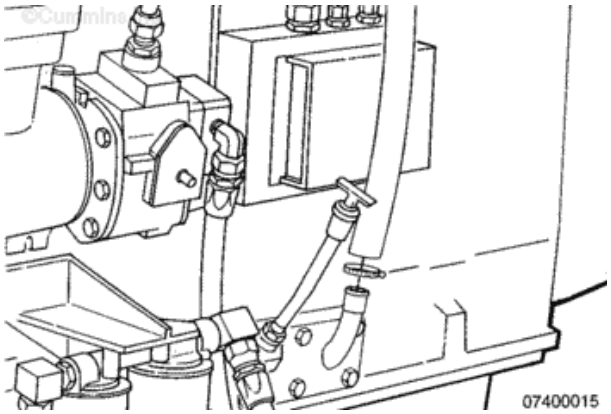
Torque Value: 35 n.m [25 ft-lb]


07400017

Install the breather vent hose onto the handhole cover.

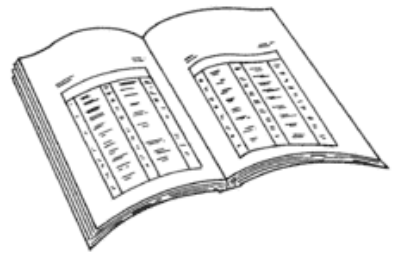
Tighten the hose clamp.

Torque Value: 15 n.m [132 in-lb]



Finishing Steps

- Install the oil filters. Refer to Procedure 007-013.
- Install the front engine support bracket. Refer to Procedure 016-002.
- Install the dipstick tube and dipstick. Refer to Procedure 007-011.
- Install the turbocharger oil drain hoses. Refer to Procedure 010-045.
- Install the oil pan adapter cover. Refer to Procedure 007-026.
- Install the oil pan. Refer to Procedure 007-025.
- Fill the engine with oil. Refer to Procedure 007-037.
- Operate the engine to normal operating temperature and check for leaks.

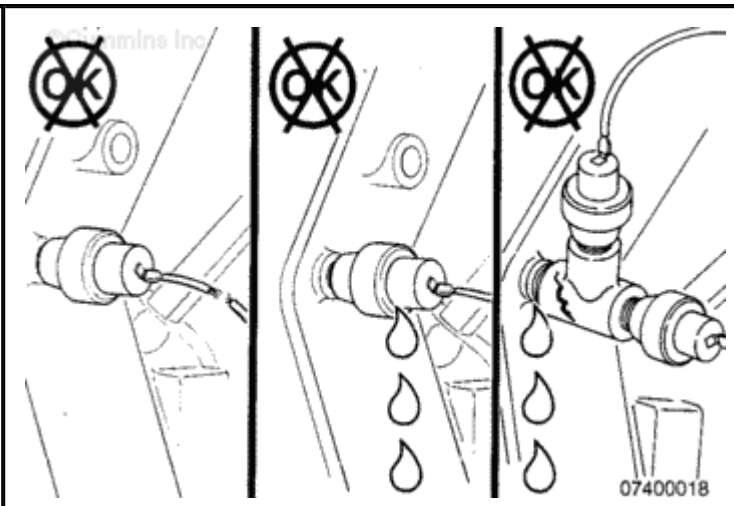
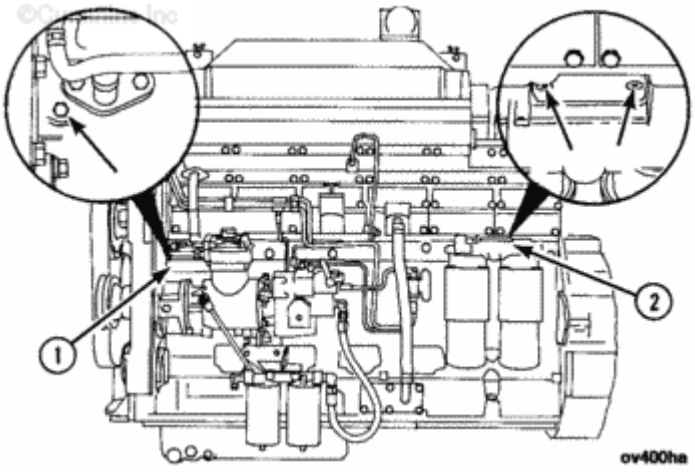


Last Modified: 24-Oct-2006

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007-028 Lubricating Oil Pressure Gauge

Inspect for Reuse

Inspect for the following defects: • Electrical wiring that is broken • Sending unit malfunction • Plumbing that is loose or broken.		
Use a reference gauge of known accuracy to verify the reading of the suspect gauge. Connect the line from the reference gauge at location (1). If this location is **not** accessible, remove one of the three plugs in the lubricating oil filter head (2) and connect the line from the reference gauge.		

Measurements		
	kpa	psi
Minimum Gauge Capacity	830	120

Operate the engine. Compare the pressure reading of the reference gauge and the suspect gauge.

The sending unit **must** be replaced if it is defective.

Last Modified: 23-Jul-2004

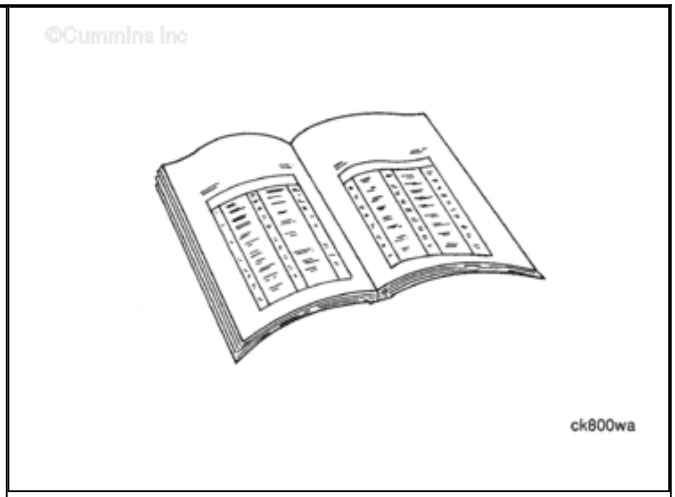
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007-029 Lubricating Oil Pressure Regulator (Main Rifle)

Preparatory Steps

NOTE: The lubricating oil pump does not need to be removed on engines manufactured prior to engine serial number 31117702. These engines use a retaining ring to secure the pressure regulator assembly into the lubricating oil pump and can be accessed without removing the lubricating oil pump.

- Remove the lubricating oil pump. Refer to Procedure 007-031.

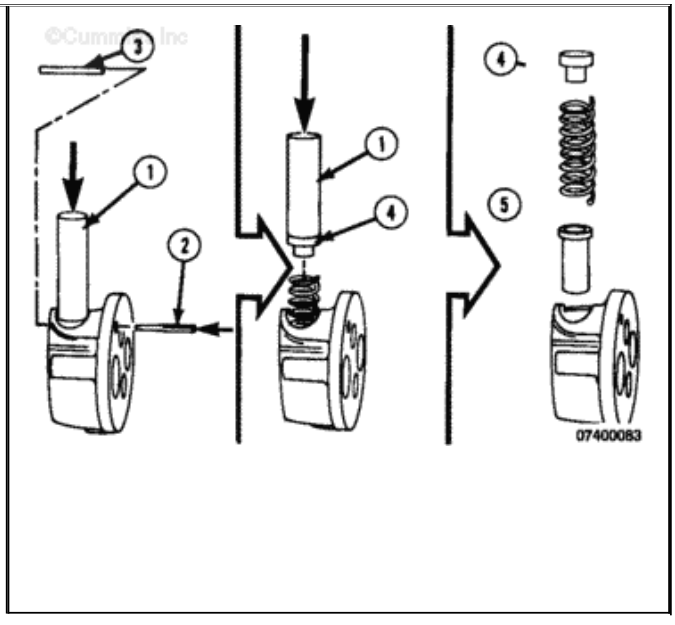


Remove

WARNING

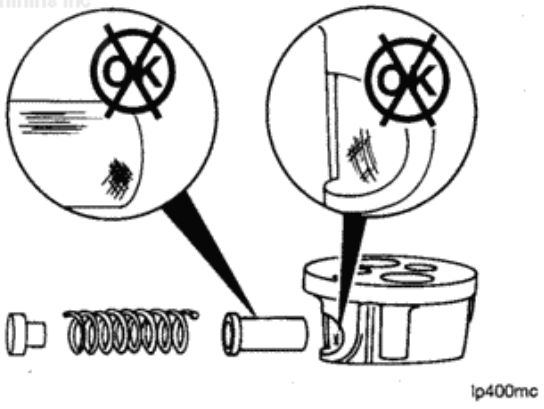
To reduce the possibility of personal injury, hold the regulator stop in position when removing the roll pin. The regulator stop is under pressure and can pop out.

NOTE: For engines that do not need the oil pumped removed, use the pressure regulator removal tool, Part Number 3375055, to remove the pressure regulator.



Use an arbor press and mandrel (1) to hold the retainer (4) in place while the dowel pin is being removed. Some models use a short dowel and roll pin to hold the retainer. Remove the dowel pin (3) with a brass drift. Slowly raise the arbor press to relieve the spring tension. Remove the retainer (4), spring, and regulator plunger (5).		

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 parts with solvent and dry with compressed air. Inspect the plunger for damage. The plunger **must** be replaced		

if damaged.

Inspect the plunger bore in the oil pump for damage.

Place the plunger in the bore and check for free movement.

If the bore in the lubricating oil pump is damaged the lubricating oil pump **must** be reconditioned or replaced. Refer to Procedure 007-031.

Check the free length of the spring.

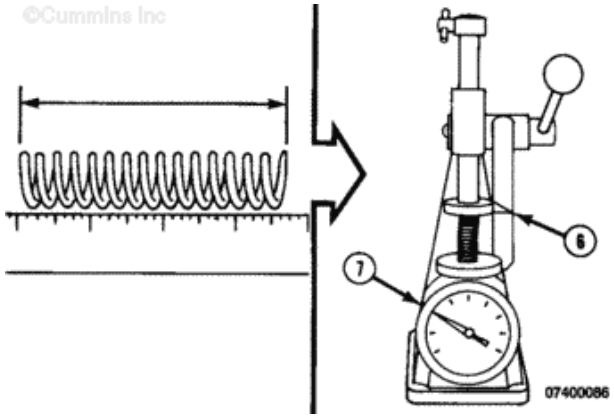
Spring Free Length (Approximately)	
mm	in
95	3.75

Measure the spring force (7) at the working height (6) with valve spring tester, Part Number 3375182.

Spring Working Height	
mm	in
63.88	2.515

Spring Force		
n		lb
300	MIN	68
310	MAX	70

If the spring is **not** within specifications, it **must** be replaced.



Install

Some models use a short dowel and a roll pin. Install the short dowel even with the gasket surface before

installing the remaining parts.

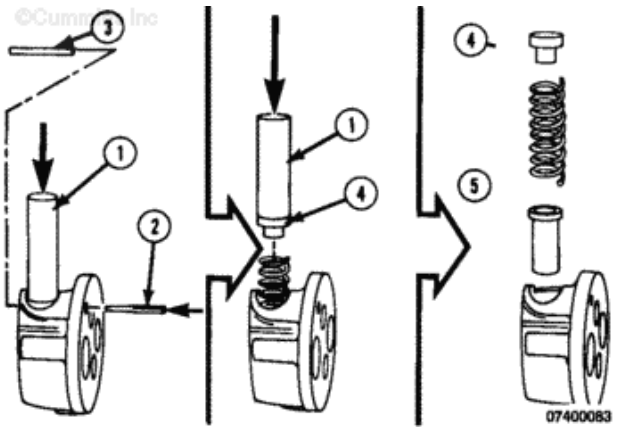
Lubricate the regulator plunger, lubricating oil pump bore with clean engine oil.

NOTE: For engines that did not need the oil pump removed, use the regulator removal tool, Part Number 3375055, to install the regulator.

Install the plunger (5), spring, and retainer (4).

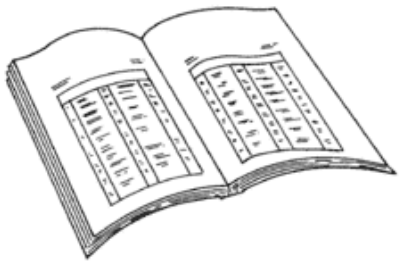
Use a mandrel (1) and a arbor press to compress the spring.

Use a mallet to install the roll pin even with the casting.



Finishing Steps

- If removed, install the lubricating oil pump. Refer to Procedure 007-031.

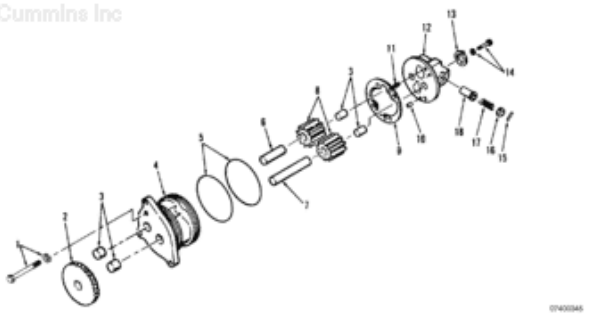


Last Modified: 23-Jul-2004

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007-031 Lubricating Oil Pump

Exploded View



1. Capscrew and lock washer
2. Lubricating pump gear
3. Lubricating pump bushing
4. Lubricating pump body
5. Lubricating pump body o-ring
6. Idler shaft
7. Lubricating pump drive shaft
8. Idler and pump gear
9. Lubricating pump gasket
10. Dowel
11. Dowel
12. Lubricating pump cover and bushing
13. Rectangular sealing ring
14. Capscrew and lock washer
15. Roll pin
16. Retainer
17. Pressure regulator spring
18. Pressure regulator plunger.

Preparatory Steps

WARNING

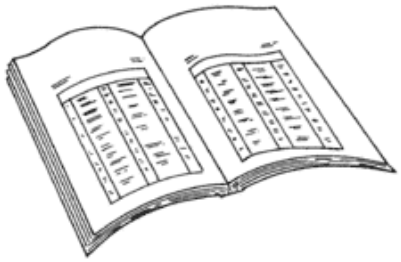
To reduce the possibility of personal injury, avoid direct

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. Refer to Procedure 007-037.
- Remove the lubricating oil pan. Refer to Procedure 007-025.
- Remove the front gear housing. Refer to Procedure 001-033.



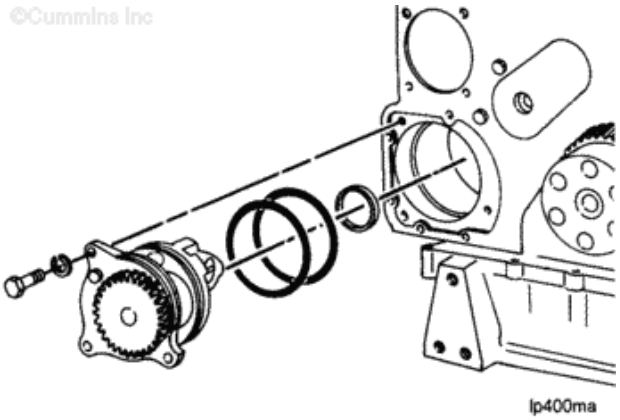
ck800wa

Remove

Remove the three capscrews from the oil pump mounting flange.

Use a pry bar and gently pry the oil pump out of the engine block.

Remove and discard the two o-rings and the seal ring from the lubricating oil pump.



lp400ma

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

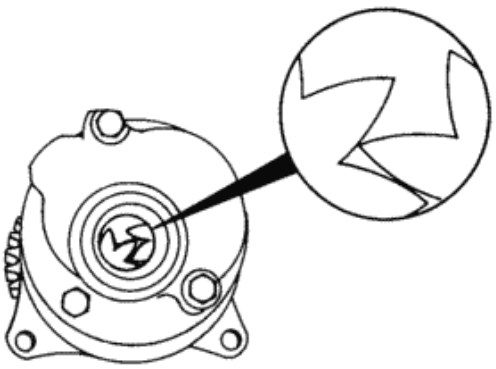
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the oil pump body with solvent and dry with compressed air.

Flush the oil pump with solvent.

Rotate the gears and inspect for damage.

If the gears are damaged the oil pump **must** be reconditioned or replaced.

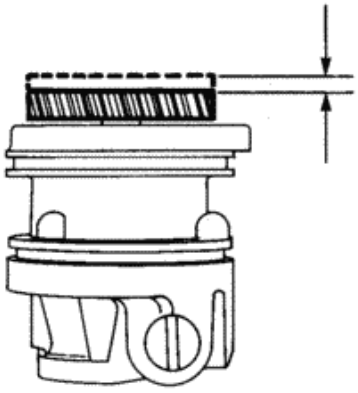


lp4geda

Measure the oil pump end clearance.

Oil Pump End Clearance		
mm		in
0.102	MIN	0.004
0.254	MAX	0.010

If the oil pump is **not** within specifications, the oil pump **must** be reconditioned or replaced.



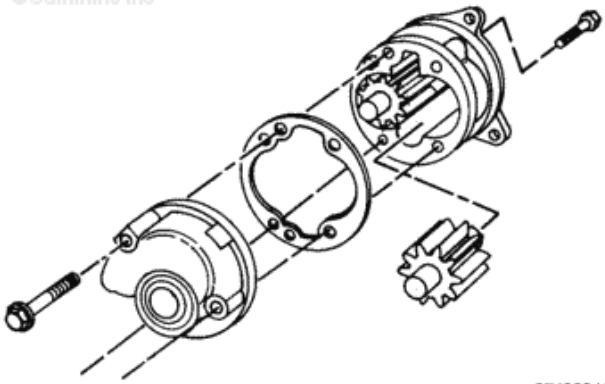
lp400da

Disassemble

Remove the four capscrews.

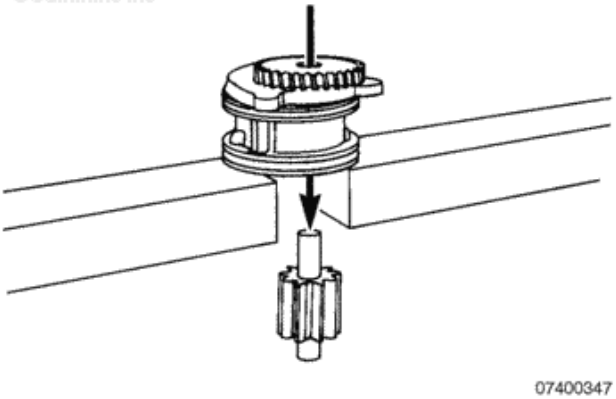
Tap on the dowel with a mallet to separate the cover from the oil pump housing.

Remove the idler gear and shaft from the housing.



Support the housing on an arbor press.

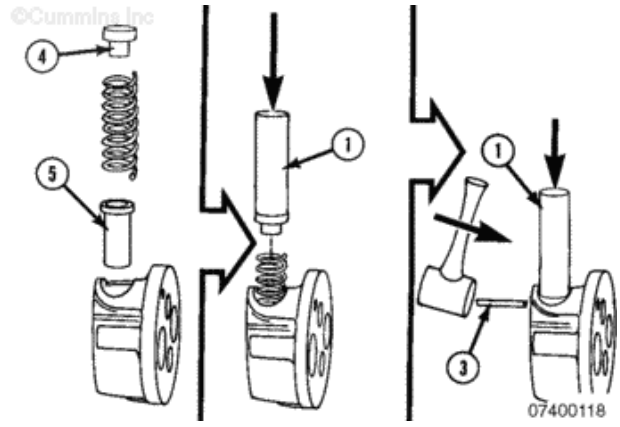
Press the shaft and through the drive gear.



WARNING

To reduce the possibility of personal injury, hold the regulator stop in position when removing the roll pin. The regulator stop is under pressure and can pop out.

Use an arbor press and mandrel (1) to hold the retainer (4) in place while the dowel pin



is being removed.

Some models use a short dowel and roll pin to hold the retainer.

Remove the dowel pin (3) with a brass drift (2).

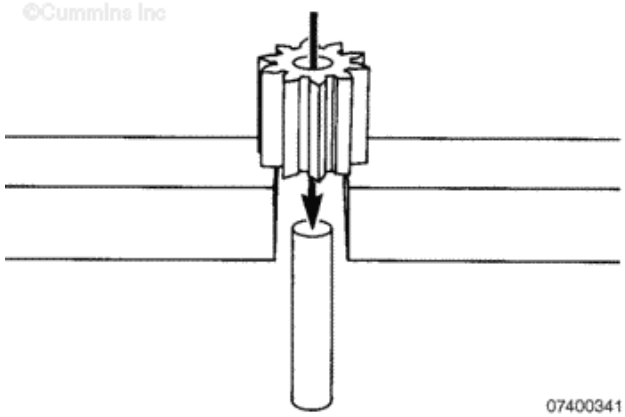
Slowly raise the arbor press to relieve the spring tension.

Remove the retainer (4), spring, and regulator plunger (5).

NOTE: Only disassemble the gear and shaft when the gear or shaft must be replaced.

Support the gear and shaft in an arbor press.

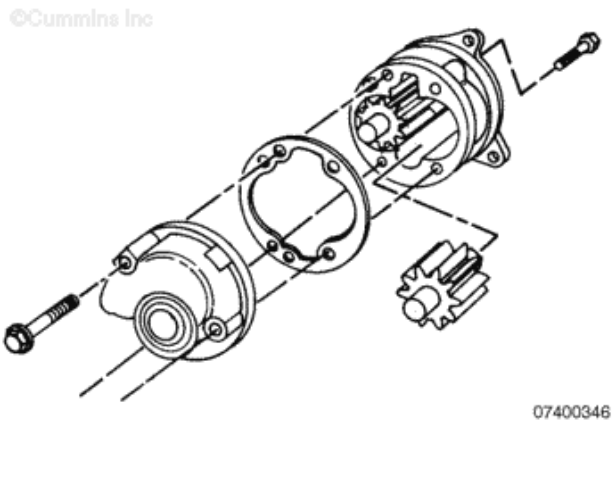
Press the shaft through the gear.



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 toreduce the possibility of personal injury.



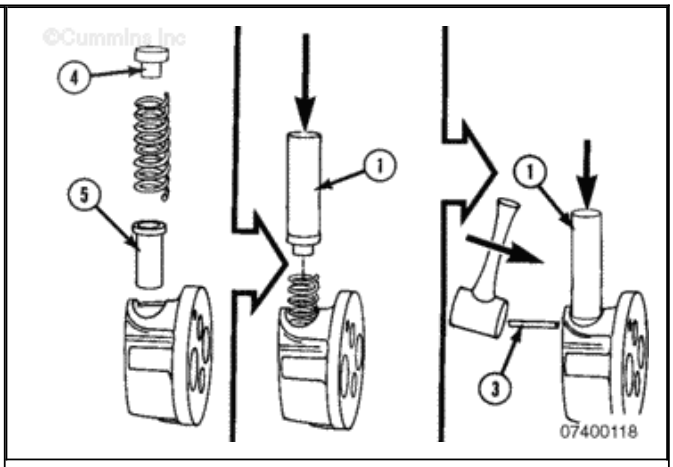
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the oil pump parts with solvent and dry with compressed air.

Inspect the regulator plunger (5), spring, and retainer (4) for damage.

If the regulator plunger, spring or retainer are damaged, the damaged component **must** be replaced.



Check the free length of the spring.

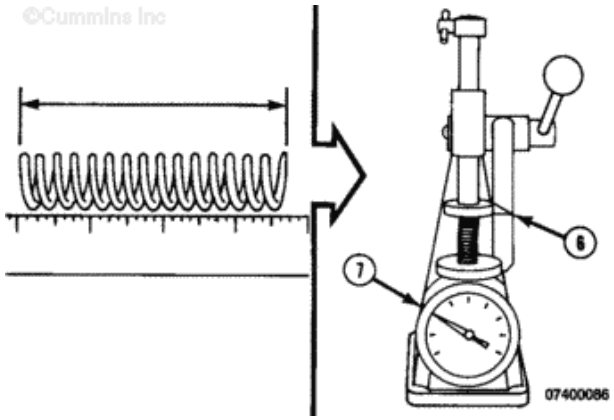
Spring Free Length (Approximately)	
mm	in
95	3.75

Measure the spring force (7) at the working height (6) with valve spring tester, Part Number 3375182.

Spring Working Height	
mm	in
63.88	2.515

Spring Force

n		lb
300	MIN	68
310	MAX	70



If the spring is **not** within specifications, it **must** be replaced.

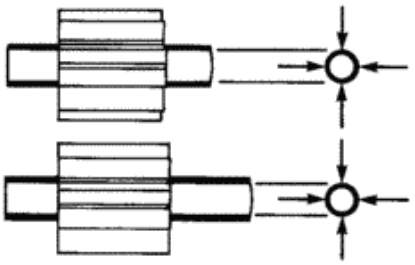
Inspect the gears for damage.

If the gears are damaged they **must** be replaced.

Measure the oil pump shaft outside diameter.

Oil Pump Shaft Outside Diameter		
mm		in
22.212	MIN	0.8745
22.225	MAX	0.8750

If the oil pump shaft is **not** within specifications, the oil pump shaft **must** be replaced.

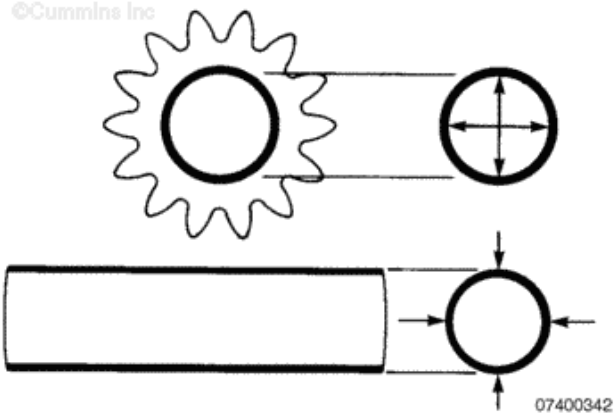


NOTE: Do not disassemble the gear and shaft to make this measurement. Only measure the gear inside diameter if the shaft is replaced.

Measure the oil pump gear inside diameter.

Oil Pump Gear Inside Diameter		
mm		in
22.174	MIN	0.8730
22.187	MAX	0.8735

If the oil pump gear inside diameter is **not** within specifications, the oil pump gear **must** be repalced.



Inspect the oil pump housing and cover for damage.

If the oil pump body or cover are damaged, the damaged component **must** be replaced.

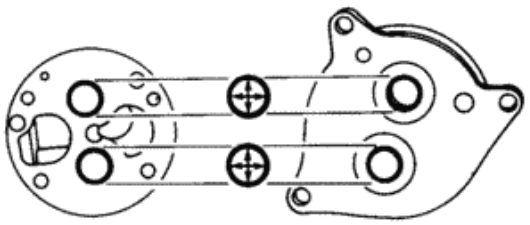
Measure the inside diameter of the oil pump bushings.

Oil Pump Bushing Inside Diameter		
mm		in
22.263	MIN	0.877
22.324	MAX	0.879

If the oil pump bushings are **not** within specifications, the bushings **must** replaced.

Replace the oil pump bushings from the oil pump body and or oil pump cover.

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07400348

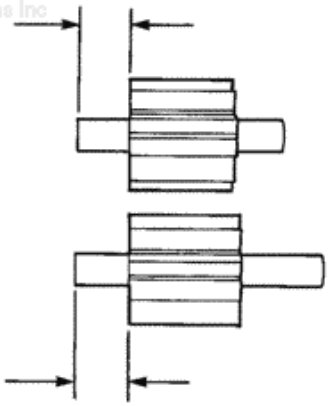
Assemble

Lubricate the shaft and gear with engine oil.

Install the gear onto the shaft with an arbor press.

Gear Location on Shaft			
	mm		in
Idler Gear	3.30	MIN	0.130
Drive Gear	3.81	MAX	0.150

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07400343

Lubricate the parts with engine oil.

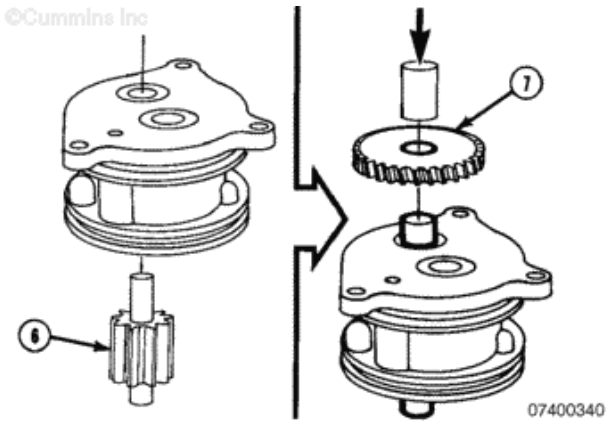
Install the drive gear and shaft assembly (6) into the housing.

Support the shaft in an arbor press.

Place the gear (7) over the shaft with the part number

positioned up.

Use a mandrel and the arbor press to install the gear until it is even with shaft.



Lubricate the bushings with engine oil.

Install the shaft into the housing.

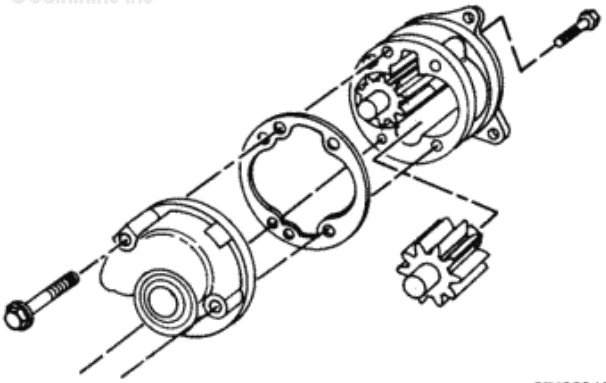
Install the gasket.

Install the cover onto the dowels. Drive the cover onto the dowels with a mallet.

Install the capscrews.

Tighten the capscrews.

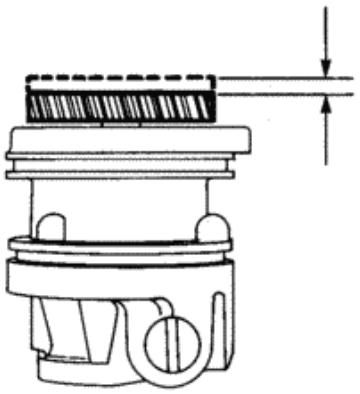
Torque
Value: 45 n.m [33 ft-lb]



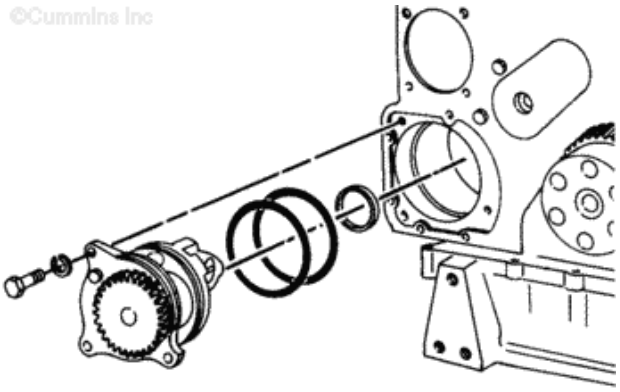
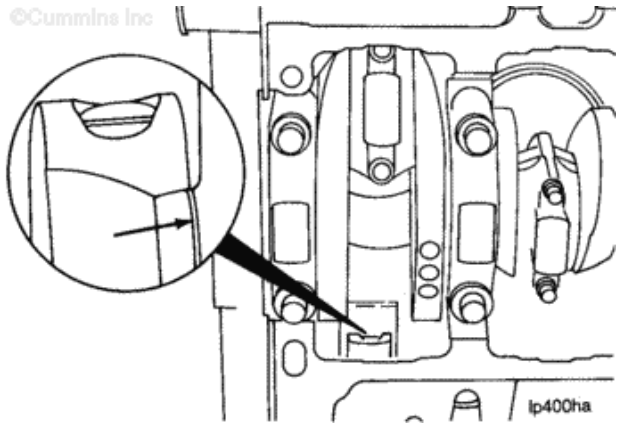
Rotate the assembly and measure the end clearance.

Oil Pump End Clearance		
mm		in
0.102	MIN	0.004
0.254	MAX	0.010

If the oil pump is **not** within specifications, the oil pump **must** be reconditioned or replaced.

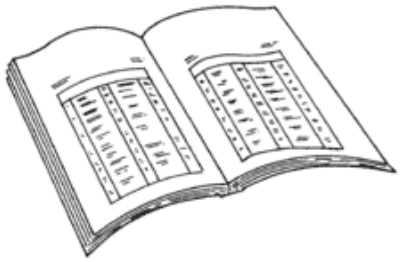


Install

Apply a light coat of grease to the seal ring to hold it in place during assembly. Install the o-rings and the seal ring onto the pump. Lubricate the o-rings and bore in the block with vegetable oil. Install the pump and the capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]		
Look between the number one and number two main bearing caps. The seal **must** be visible in the space between the rear of the pump and the engine block.		

Finishing Steps

• Install the front gear housing. Refer to Procedure 001-033. • Install the lubricating oil pan. Refer to Procedure 007-025. • Fill the engine with lubricating oil. Refer to		

Procedure 007-037.		©Cummins Inc  ck800wa

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007-037 Lubricating Oil System

Drain

WARNING

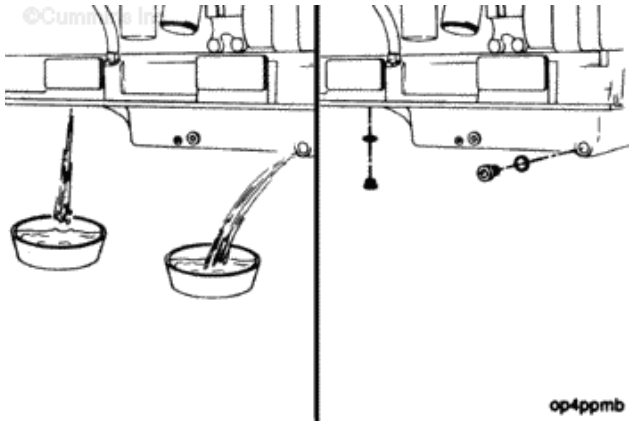
To reduce the possibility of personal damage, avoid direct contact of hot oil with your skin.

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.

NOTE: Drain the engine oil when the temperature is approximately 60°C [140°F].

Remove the oil drain plug and copper washers from the bottom of the oil sump and the oil pan adapter cover plate and drain the oil.



Fill

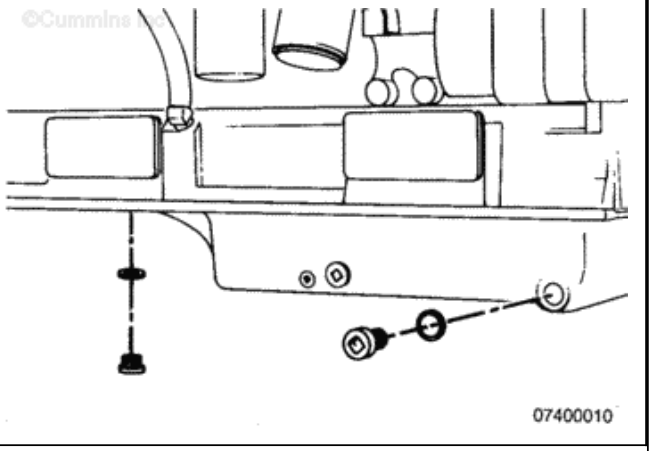
Install the oil drain plugs and		

new copper washers into the oil sump and oil pan adapter cover plate.

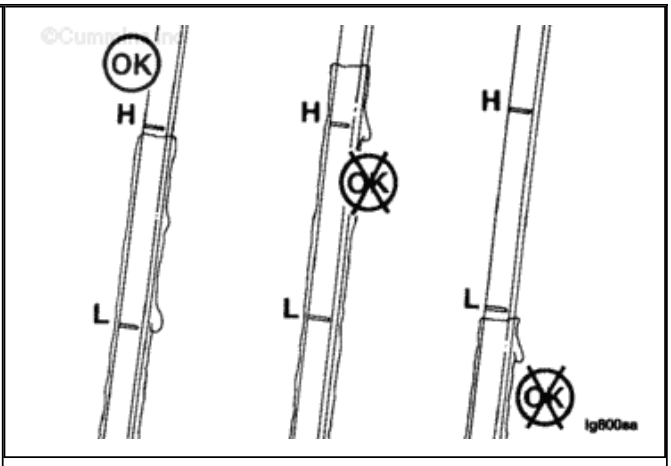
Tighten the oil drain plugs.

Torque
Value: 100 n.m [75 ft-lb]

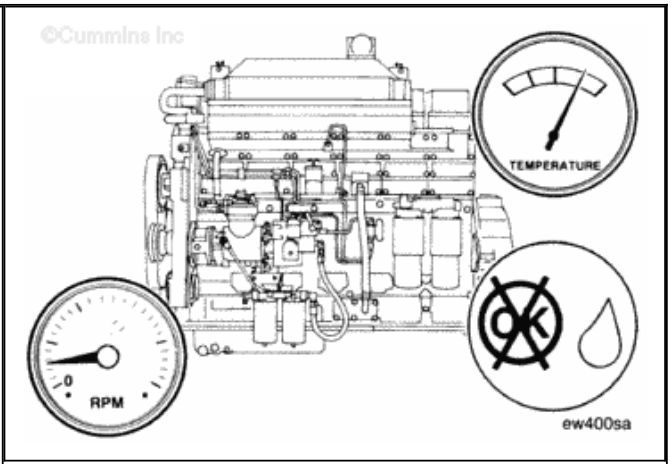
Fill the engine with clean 15W-40 oil. For oil pan capacities, refer to Procedure 018-017.



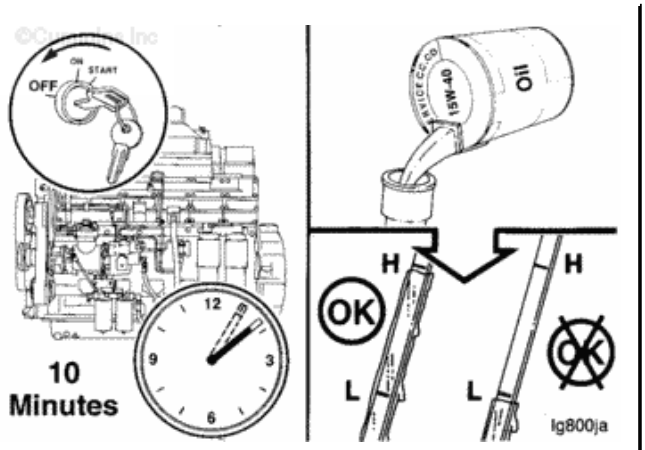
Check the oil level on the dipstick. The level **must** be to the “H” (high) mark on the dipstick.



Operate the engine to normal operating temperature and check for oil leaks.



Shut the engine off and wait five to seven minutes to allow the oil to drain back into the oil pan.

Check the oil level. Add oil as necessary to bring the level up to the “H” (high) mark on the dipstick.		

Last Modified: 23-Jul-2004

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007-038 Lubricating Oil Temperature Gauge

Inspect for Reuse

WARNING

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

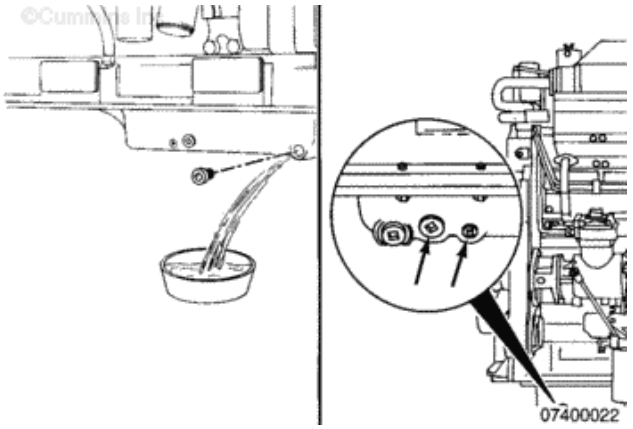
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Drain the oil from the oil pan. Refer to Procedure 007-037.

Remove one of the pipe plugs on either side of the oil pan.

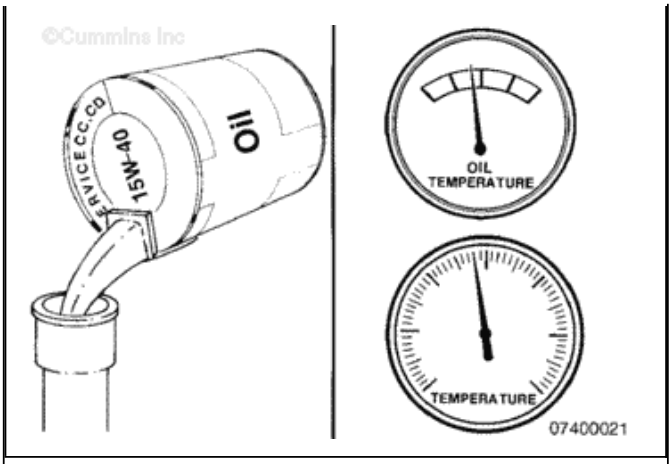
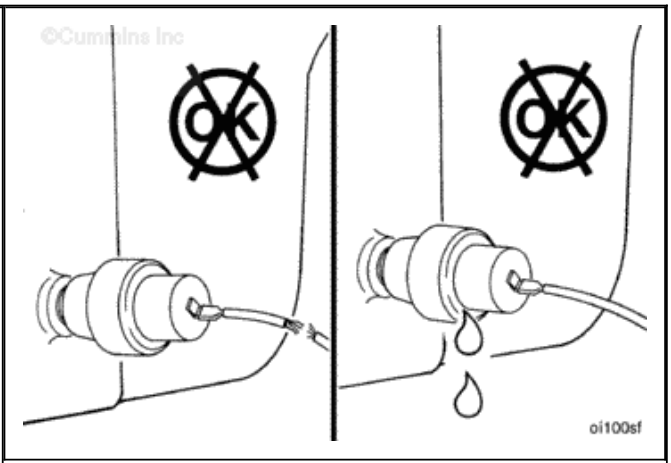
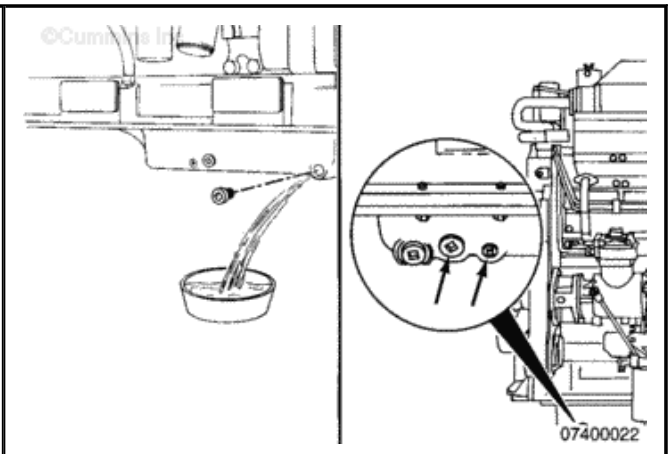
The reference gauge **must** have a minimum capacity of 150°C [300°F].

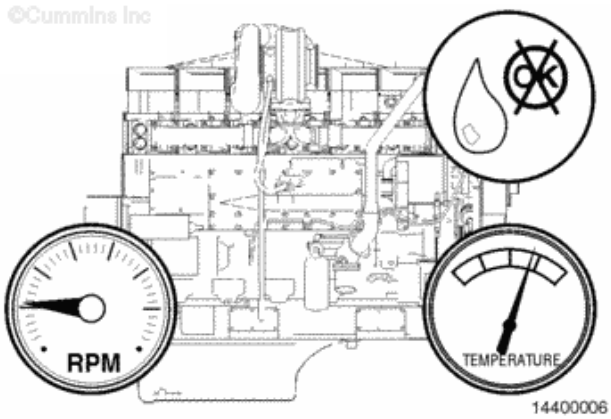
Install a reference gauge of known accuracy to verify the reading of the suspect gauge.



Fill the engine with oil. Refer to Procedure 007-037.

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 for the following defects: • Electrical wiring • Sending Unit. Replace the defective parts. Refer to Procedure 019-067 or 019-068 in the Troubleshooting and Repair Manual CENTRY™ System, Bulletin 3666070.		
Drain the oil from the oil pan. Refer to Procedure 007-037. Remove the gauge. Install and tighten the oil pan plug.		
Fill the engine with oil. Refer to Procedure 007-037. Operate the engine to		

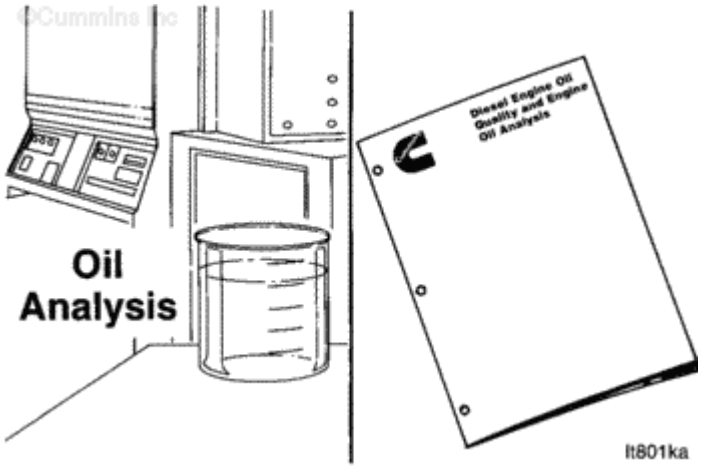
normal operating temperature. Check for leaks.		

Last Modified: 10-Dec-2004

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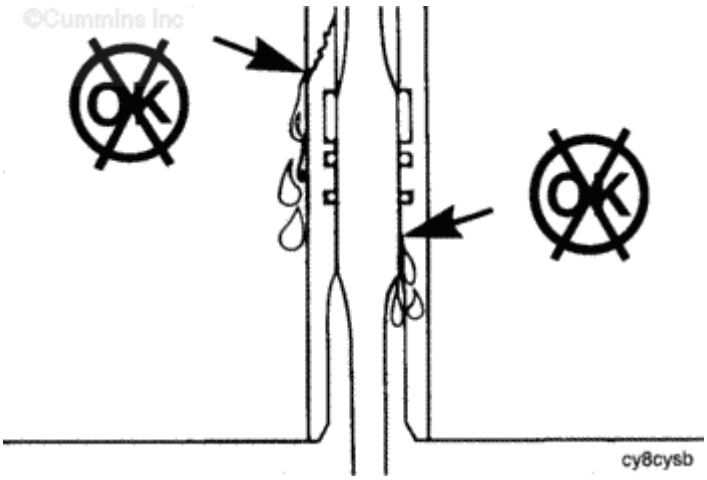
007-044 Lubricating Oil Contamination

General Information

A 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

If the oil is diluted with coolant, pressure test the cooling system. Refer to Procedure 008-018.		

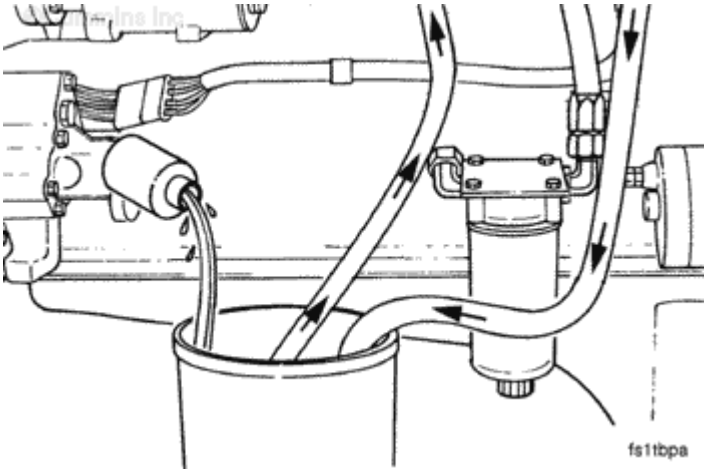


Fluorescent Dye Tracer

NOTE: This test is not effective on a cold engine, less than 21°C [70°F] coolant temperature, or with a loose overhead setting.

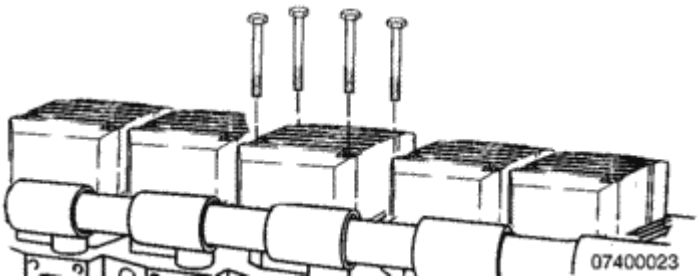
Install an isolated fuel supply tank to the inlet and drain lines.

Add fluorescent tracer, Part Number 3376891, to the fuel supply tank.



Remove the rocker lever

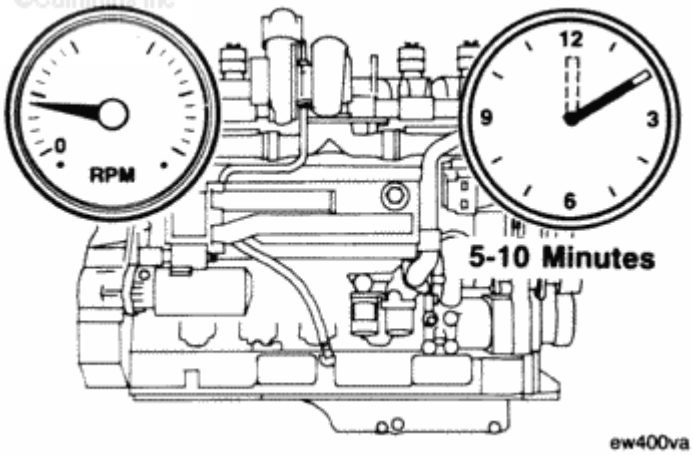
cover mounting capscrews, but do **not** remove the valve covers.



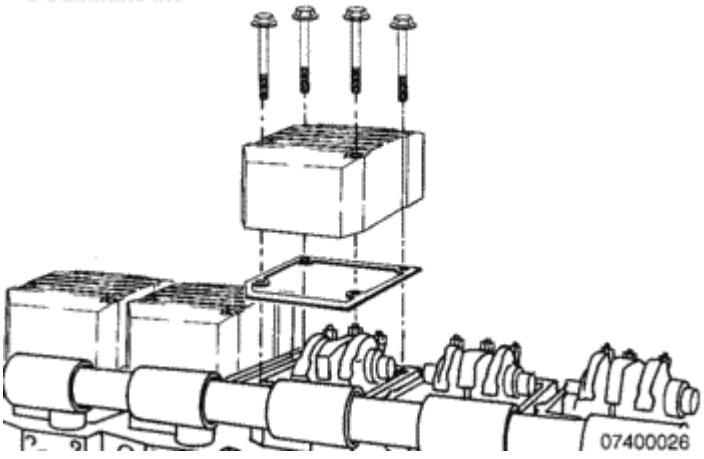
Start the engine and operate it at high idle for 30 seconds.

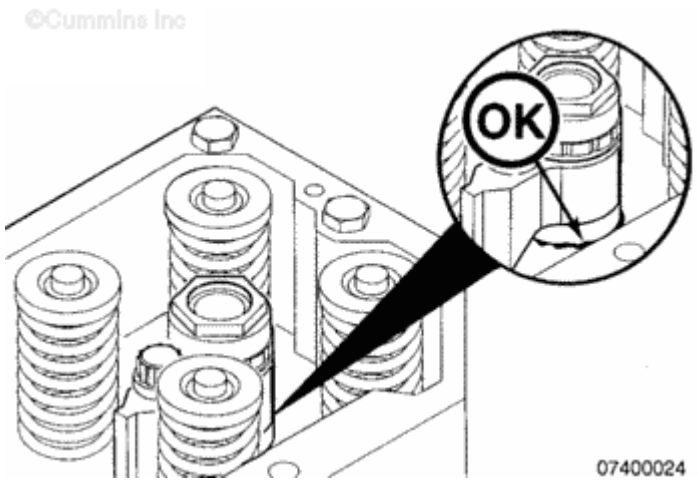
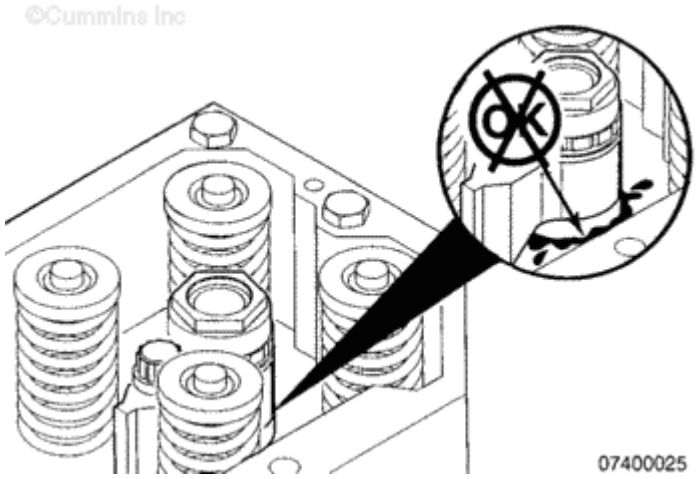
Allow the engine to low idle.

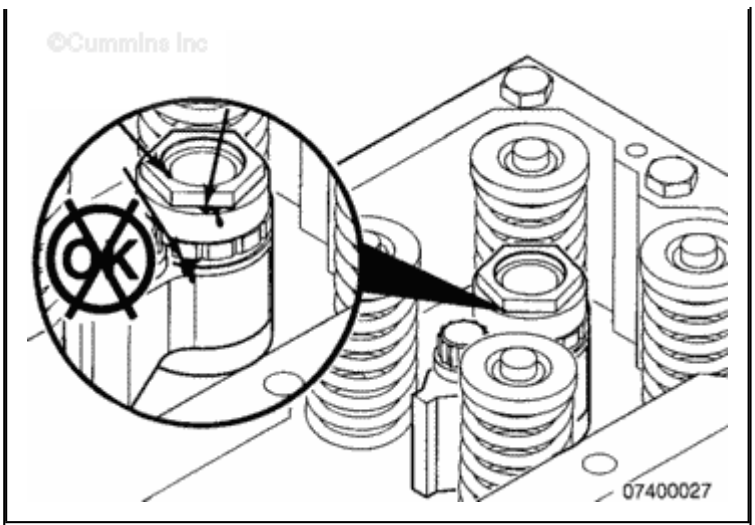
Complete the next step within five minutes.



While the engine is operating at low idle, remove the rocker lever covers.



Injectors normally have a small amount of fuel leakage. Fuel will be a yellow color. For operation of the black light, refer to the black light operating instructions. Use a black light to find fuel leaks from inside or around the injector.		
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.		
If there is excess leakage from the inside the injector, replace the injector. Refer to Procedure 006-026. Install the rocker lever covers. Refer to		

Procedure 003-011.		

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007-045 Lubricating Oil Cooler Cover

Preparatory Steps

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. Hot 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 coolant. Refer to Procedure 008-018.
- Open the drain cock on lubricating oil cooler housing and water pump to make sure coolant is drained.
- Remove the turbocharger oil drain hose. Refer to Procedure 010-045.
- Remove the water bypass tube. Refer to Procedure 008-062.
- Remove the water pump outlet connection assembly. Refer to Procedure 008-062.



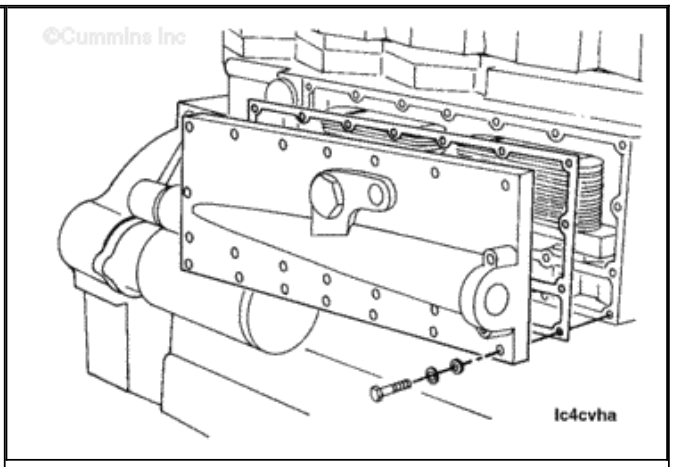


Remove

Remove the lubricating oil cooler cover capscrews.

Remove the lubricating oil cooler cover.

Remove and discard the gasket.



Clean and Inspect for Reuse

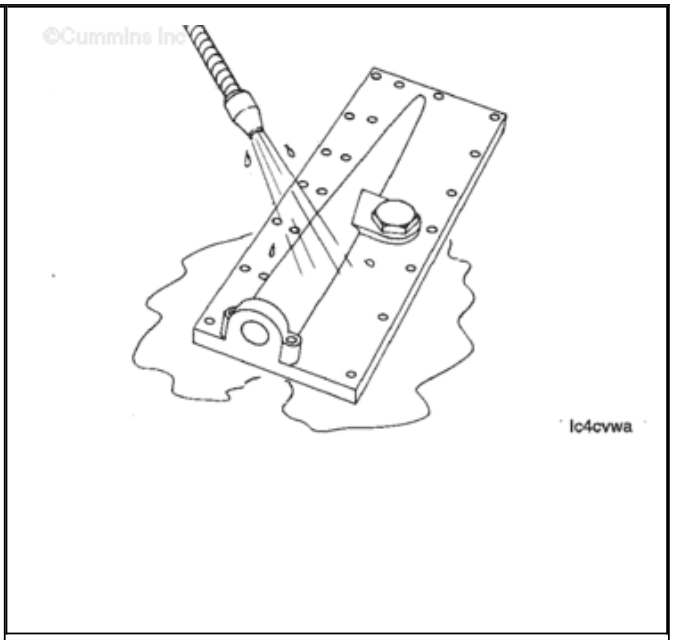
WARNING

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.

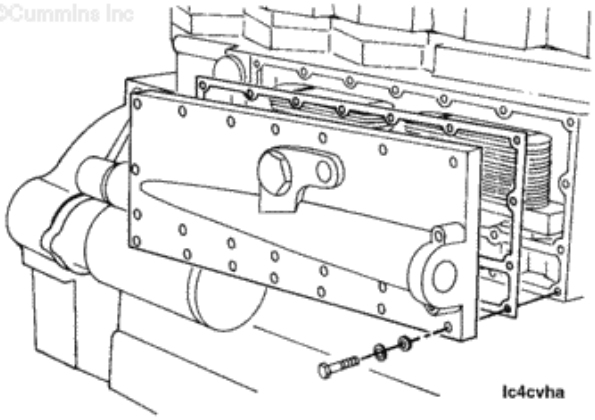
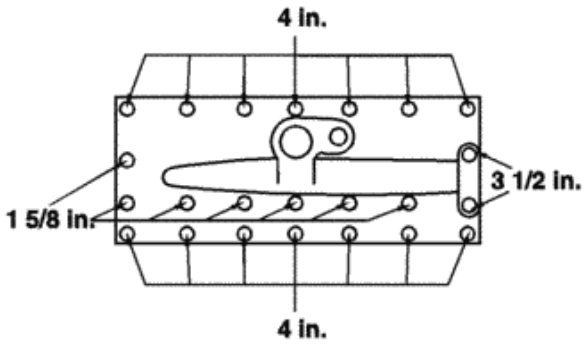
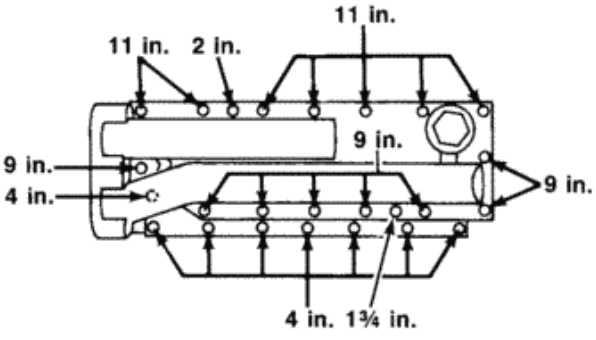
Clean the lubricating oil cooler cover with solvent.

Inspect the cast iron lubricating oil cooler cover for corrosion.

If the lubricating oil cooler cover is corroded beyond reuse, replace the cover.

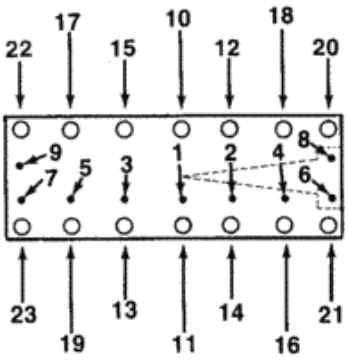


Install

Install the lubricating oil cooler cover and gasket. Install several capscrews to secure the cover in position, but do **not** tighten the capscrews.		
Install the remaining lubricating oil cooler cover capscrews as illustrated in the graphic.		
If the engine has a torque converter cooler, install the lubricating oil cooler cover capscrews as illustrated in the graphic.		

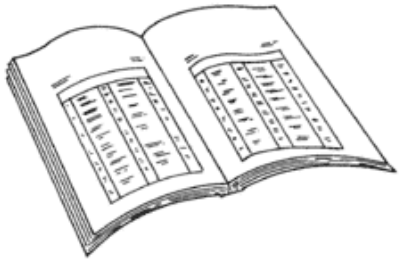
Tighten the capscrews in the sequence illustrated in the graphic.

Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

- Install the water pump outlet connection assembly. Refer to Procedure 008-062.
- Install the water bypass tube. Refer to Procedure 008-062.
- Install the turbocharger oil drain hose. Refer to Procedure 010-045.
- Make sure drain cock on lubricating oil cooler housing and water pump are closed.
- Fill the cooling system. Refer to Procedure 008-018.
- Operate the engine to normal operating temperature and check for leaks.



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007-046 Lubricating Oil Cooler Housing

Preparatory Steps

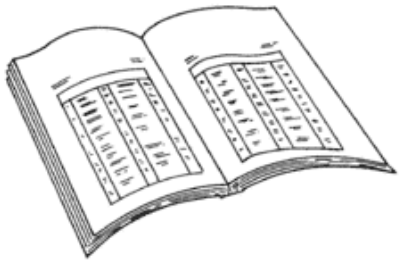
WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature us 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 coolant. Refer to Procedure 008-018.
- Remove the water pump. Refer to Procedure 008-062.
- Remove the oil cooler cover, torque converter cooler, or marine gear oil cooler. Refer to Procedure 007-045, 008-065, or 008-041.
- Remove the starter if it is located on the right side of the engine. Refer to Procedure 013-020.



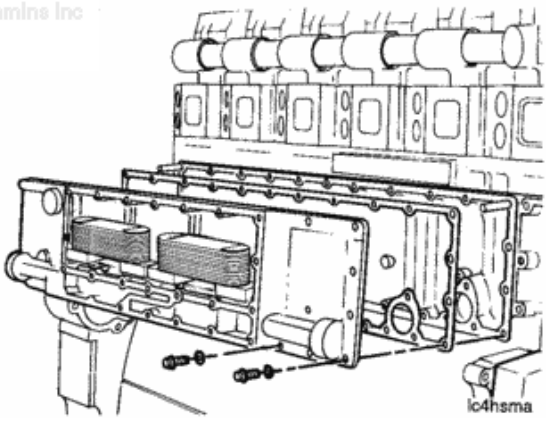
ck800wa

Remove

Remove the lubricating oil cooler housing capscrews.

Remove the lubricating oil cooler cover housing.

Remove and discard the gasket.



Clean and Inspect for Reuse

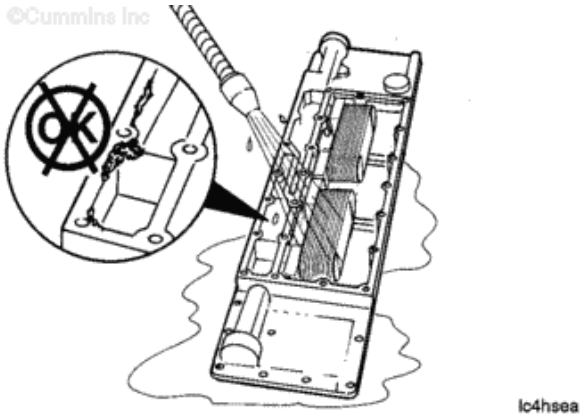
WARNING

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 lubricating oil cooler housing with solvent.

Inspect the cast iron lubricating oil cooler housing for corrosion.

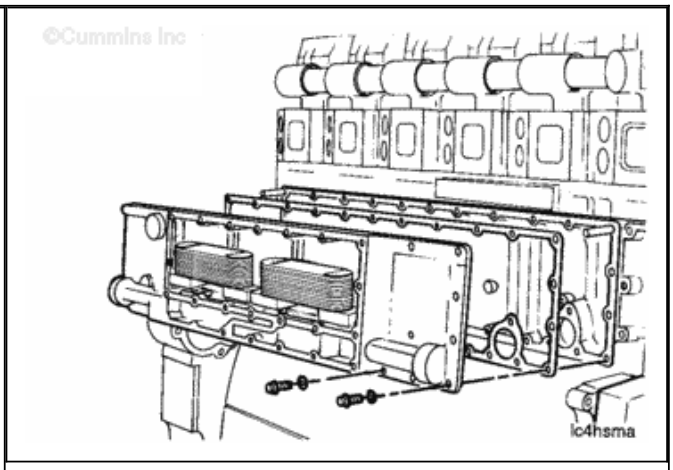
If the lubricating oil cooler housing is corroded beyond reuse, it **must** be replaced.



Install

Install two guide studs.

Place the gasket and lubricating oil cooler housing into position.

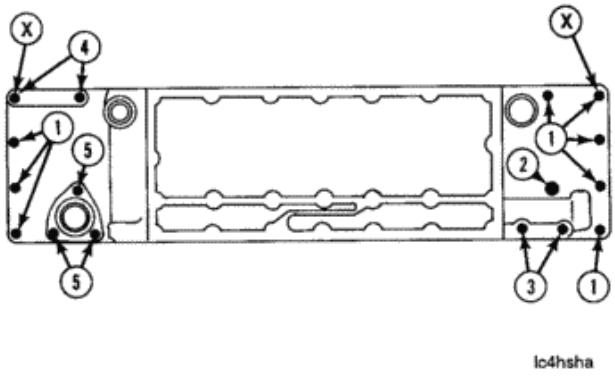


CAUTION

Two capscrew holes, marked with an (x) in the graphic, align with the cylinder head. The cylinder head capscrews will be damaged if the lubricating oil cooler capscrews are too long.

NOTE: Do not tighten the capscrews until the oil cooler cover, torque converter cooler, or marine gear oil cooler is installed.

Install the capscrews as illustrated in the graphic using the table below.



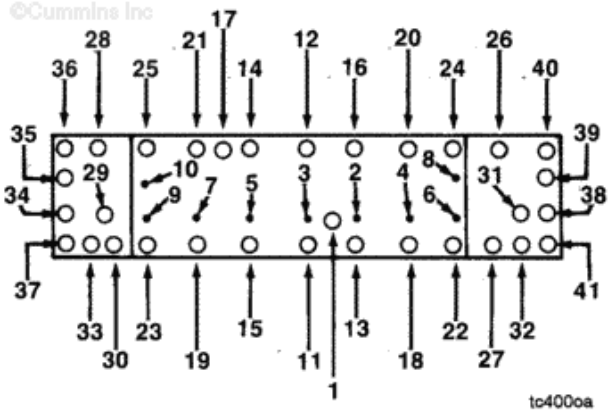
Lubricating Oil Cooler Housing Capscrew Lengths	
Illustration Call Out	**Without Oil Filter**
(1)	31.750 mm [1.250 in]
(2)	44.450 mm [1.750 in]
(3)	41.275 mm

	[1.625 in]
(4)	44.450 mm [1.450 in]
(5)	41.275 mm [1.625 in]

Install the oil cooler cover, torque converter cooler, or marine gear oil cooler. Refer to Procedure 007-045, 008-065, or 008-041.

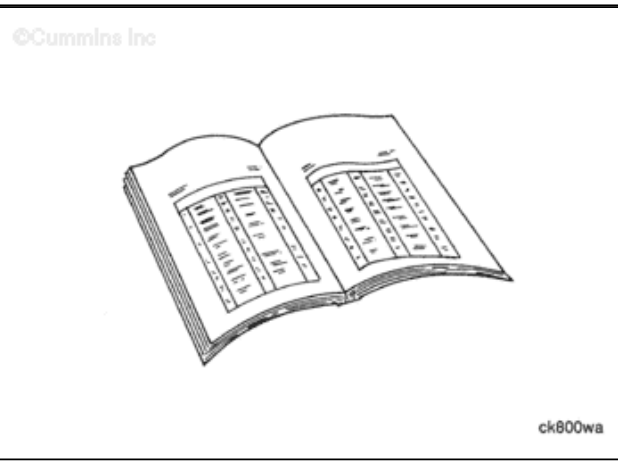
Tighten the capscrews in the sequence illustrated in the graphic.

Torque
Value: 45 n.m [33 ft-lb]



Finishing Steps

- Install the starter if removed. Refer to Procedure 013-020.
- Install the water pump. Refer to Procedure 008-062.
- Fill the coolant system. Refer to Procedure 008-018.



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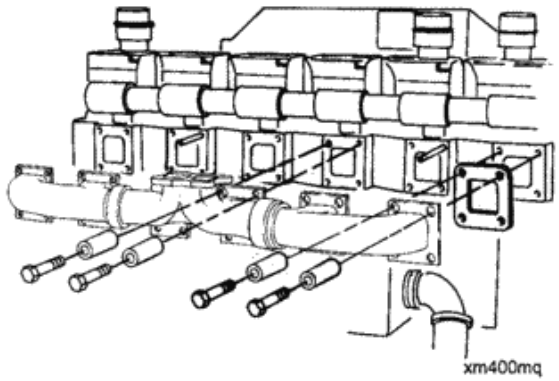
007-050 Cylinder Smokes (Blue Smoke)

Fluorescent Dye Tracer

WARNING

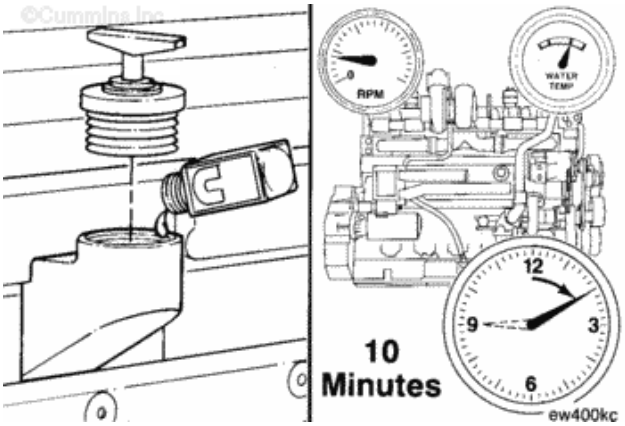
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

To check for single cylinder oil consumption, remove the exhaust manifold. Refer to Procedure 011-007.



Add one unit of fluorescent dye tracer, Part Number 3376891 to each 38 liters [10 gal] of engine oil.

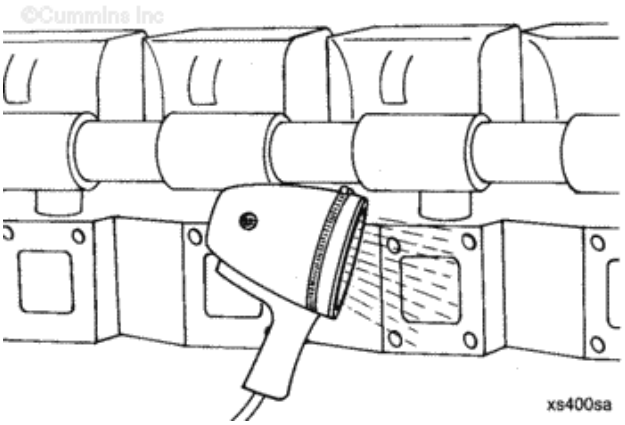
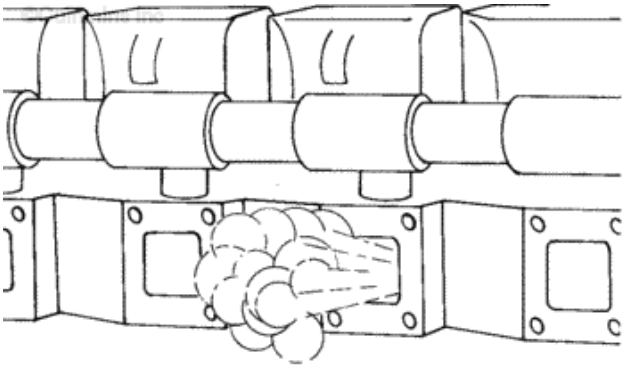
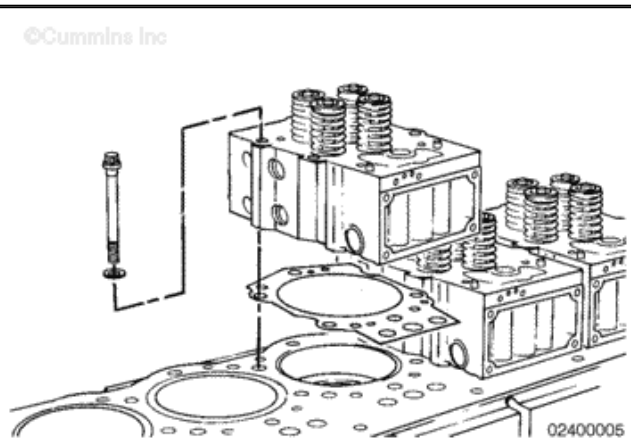
Idle the engine for 5 to 10 minutes or until normal operating temperature is reached to allow the dye to circulate through the lubricating system.

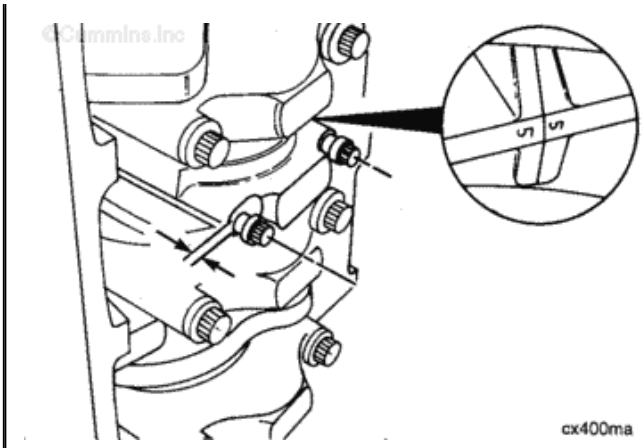


Use a high intensity black light to inspect the exhaust ports.

A yellow glow indicates a fuel leak.

A dark blue glow indicates

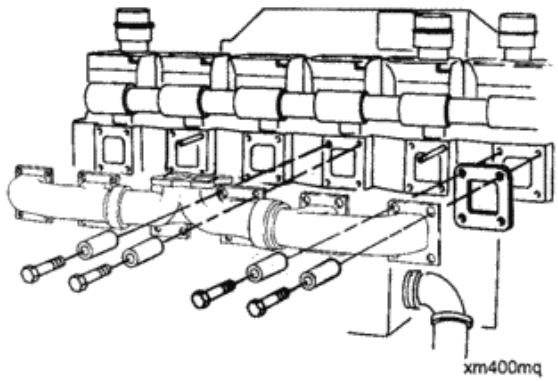
an oil leak.		
Look for excessive blue smoke coming out of the faulty cylinder.		
Check the cylinder heads. Refer to Procedure 002-004.	 	
Check the pistons and rings. Refer to Procedure 001-054.		



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 exhaust manifold. Refer to Procedure 011-007.



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007-061 Oil Transfer Connection

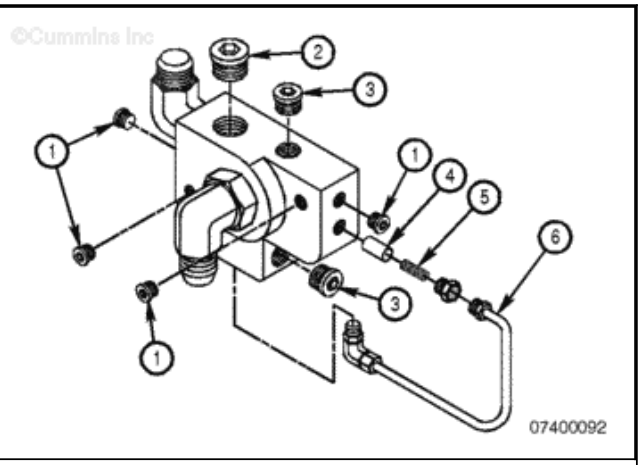
Disassemble

Rail Applications

Remove the straight thread o-ring plugs (1), (2), and (3).

Discard the o-rings.





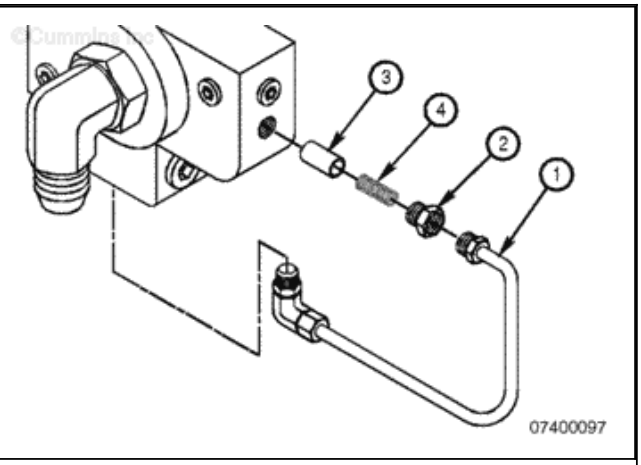
CAUTION

Use caution when removing the threaded plug (2), it is under spring pressure.

Remove the vent tube (1).

Remove the threaded plug (2), piston cooling nozzle plunger (3), and spring (4).





Clean and Inspect for Reuse

Rail 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.

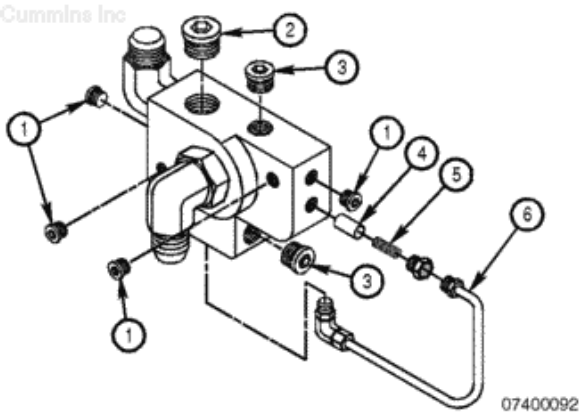
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvent to clean the parts and dry with compressed air.

Inspect the parts for wear or damage.

The parts **must** be replaced if worn or damaged.

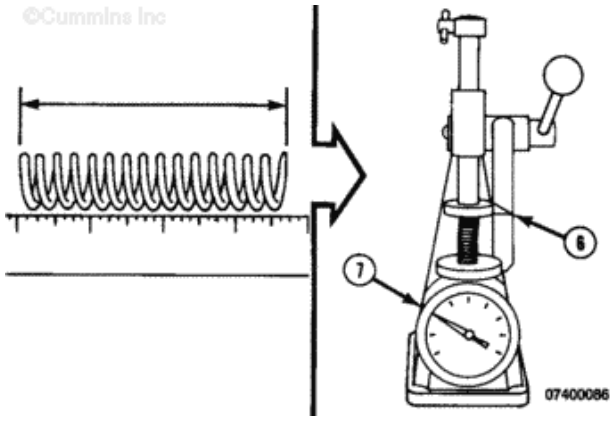


Check the piston cooling nozzle spring.

Piston Cooling Nozzle Spring		
	mm	in
Free Length	88.98 MAX	3.500
Working Height (6)	50.80 MAX	2.000

Use valve spring tester, Part Number 3375182, or equivalent to measure the spring force and the working height.

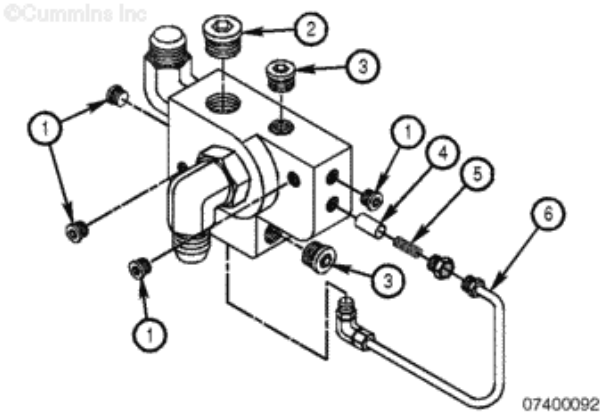
Spring Force (7)		
n		lbf
26	MIN	19.3



29 MAX 21.3 If the spring is **not** within specifications, it **must** be repalced.		

Assemble

Rail Applications

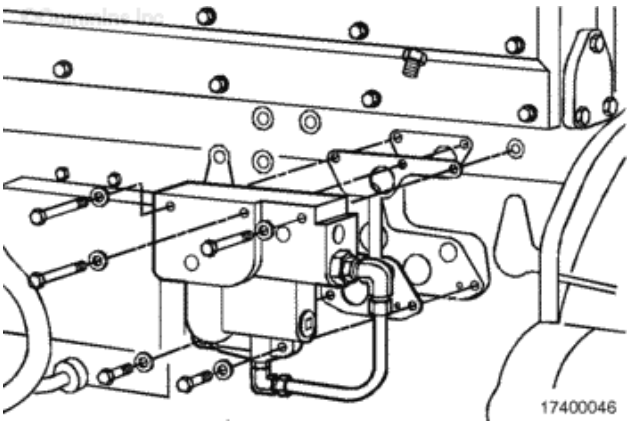
Lubricate the parts with clean engine oil. Install the new o-rings onto the plugs. Install the plunger, spring, threaded plug, and vent tube. Install and tighten the straight thread o-ring plugs. 9/16 Plug 14 n.m [120 in-lb] 13/16 Plug 54 n.m [40 ft-lb] 17/8 Plug 95 n.m [70 ft-lb]		

Install

Rail Applications

The lubricating oil transfer connection gasket is the same as the oil filter head gasket, but the tab on the end **must** be removed prior to installing the new gasket.		

Install the gasket lubricating oil transfer connection, and five washers and capscrews. Tighten the capscrews.		
76.2 mm [3 in] (1 each)	45 n.m	[33 ft-lb]
31.75 mm [1.25 in] (2 each)	45 n.m	[33 ft-lb]
95.25 mm [3.75 in] (2 each)	45 n.m	[33 ft-lb]



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007-083 Lubricating Oil and Filter Analysis

Disassemble

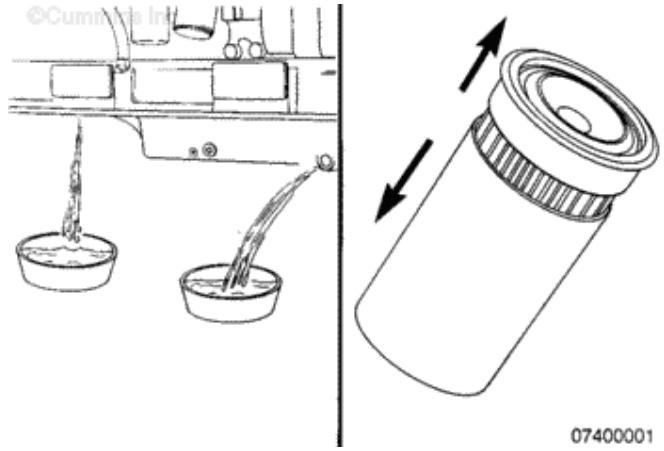
WARNING

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

Carefully cut the combination filter open. The filter element spring is under compression and cause personal injury.

Use tube cutter, Part Number 3376579, to open the full-flow oil filter.



Inspect

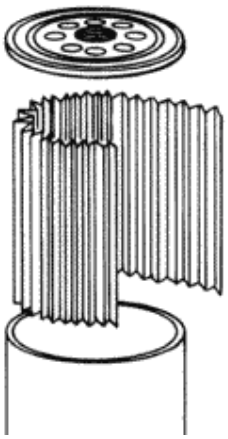
Inspect the oil filter element for evidence of		

moisture or metal particles.

Metal	Probable Source
Copper	Bearings and busings
Chromium	Piston rings
Iron	Cylinder liners
Lead	Bearing overlay material
Aluminum	Piston wear or scuffing

Discard the filters.

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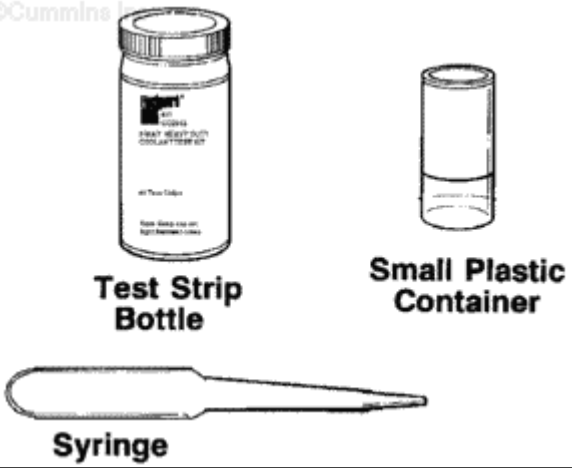
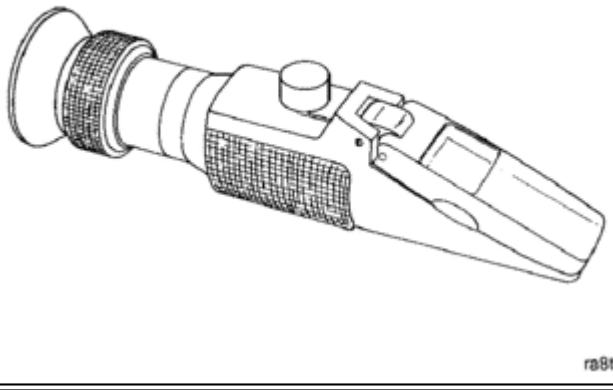
IfBetka

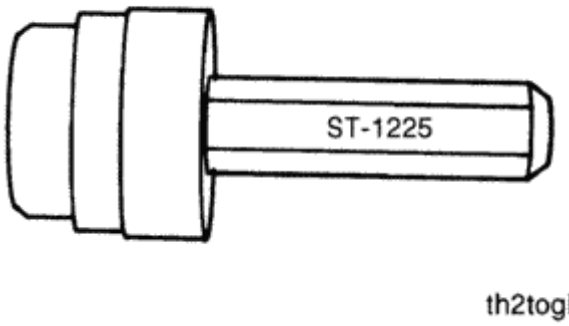
Last Modified: 27-Jul-2004

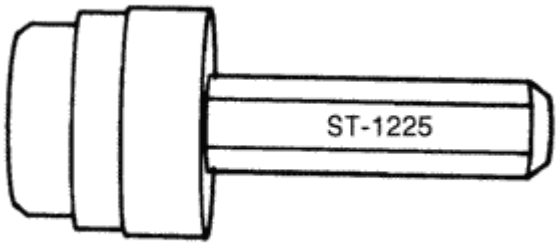
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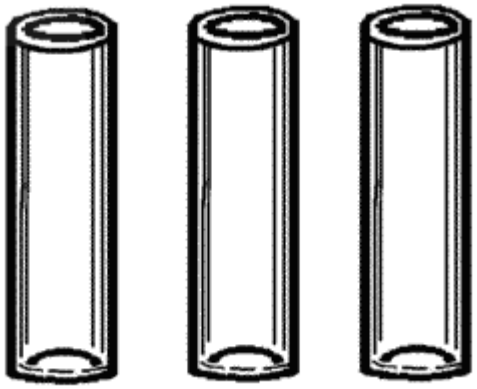
022-001 Service Tools

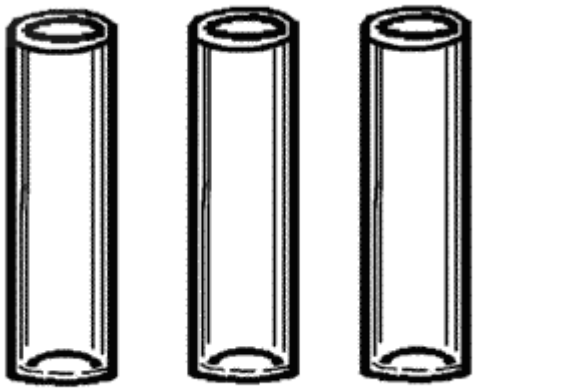
Cooling System

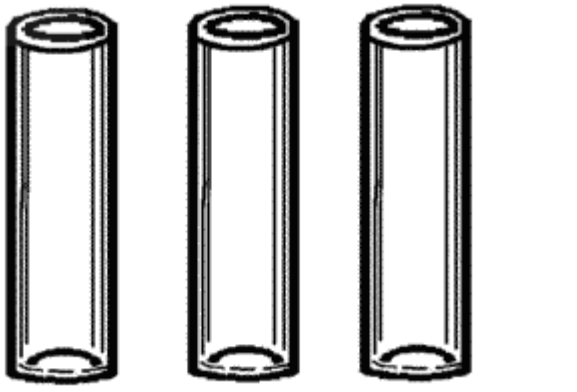
Tool Number CC-2602	**Cooling System Test Kit** The Fleetguard® Coolant Test Kit is used to check the concentration of coolant additives in the cooling system.	
Tool Number CC-2800	**Refractometer** The Fleetguard® Refractometer is used to measure the freezing point protection and antifreeze concentration.	
	Thermostat Seal	

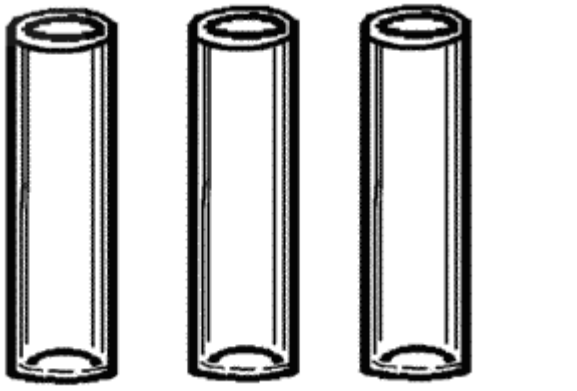
Tool Number 3375411	**Mandrel (All K Series)** Install the thermostat seal in the thermostat housing.	 th2togb

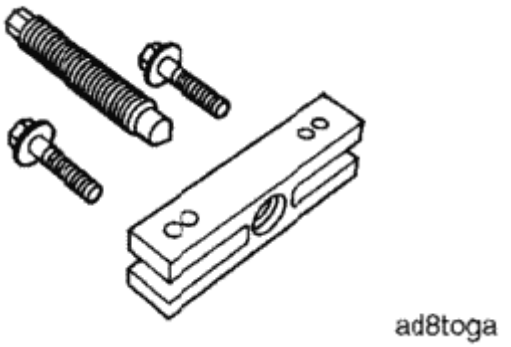
Tool Number 3824833	**Thermostat Seal Mandrel (Low Temperature Aftercooler thermostat driver Q19)** Install the thermostat seal in the thermostat housing.	 th2togb

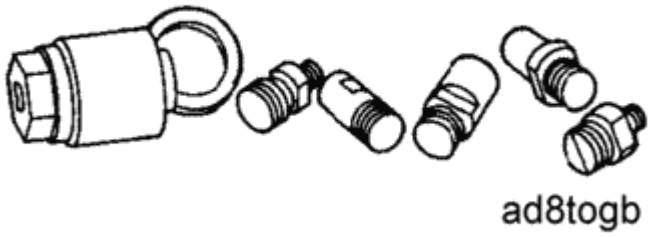
Tool Number 3377405	**Cooling System Sight Glass, [1 inch] O.D.** Used to troubleshoot the engine cooling system.	 3377410

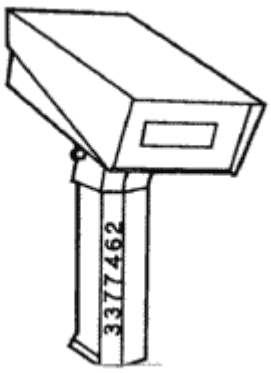
Tool Number 3377406	**Cooling System Sight Glass, [1 1/4 inch] O.D.** Used to troubleshoot the engine cooling system.	 3377410

Tool Number 3377406	**Cooling System Sight Glass, [1 3/4 inch] O.D.** Used to troubleshoot the engine cooling system.	 3377410

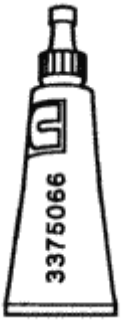
Tool Number 3377410	**Cooling System Sight Glass, [2 3/4 inch] O.D.** Used to troubleshoot the engine cooling system.	 3377410

Tool Number		
ST-647	**Puller** Remove the alternator and accessory drive pulleys.	

Tool Number		
3376326	**Pulley Installation Tool** Install the alternator and accessory drive pulleys.	

Tool Number		
3377462	**Digital Optical Tachometer** Used to measure rpm of a viscous fan. Use with reflective tape, Part Number 3377464.	

Tool Number		
	Pipe Sealant Use when installing	

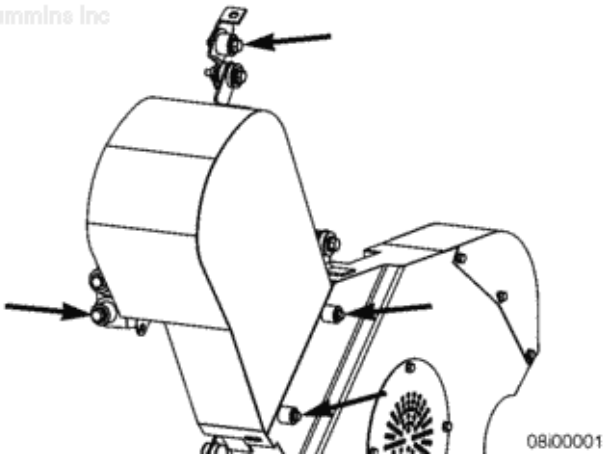
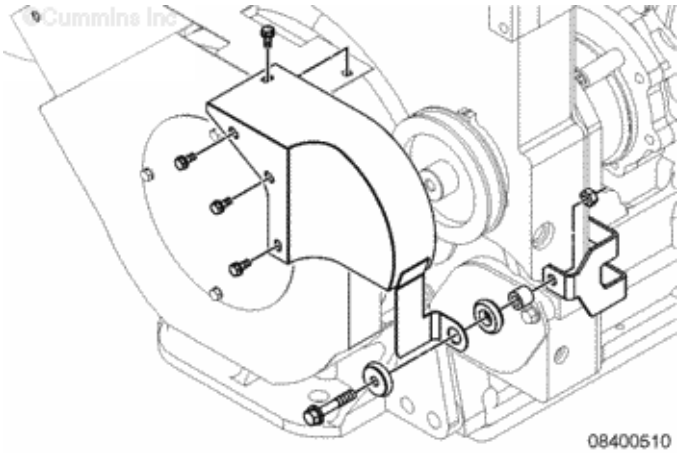
3375066	pipe plugs, cup plugs, or pipe fittings in order to prevent leaks.	©Cummins Inc  ew8togc

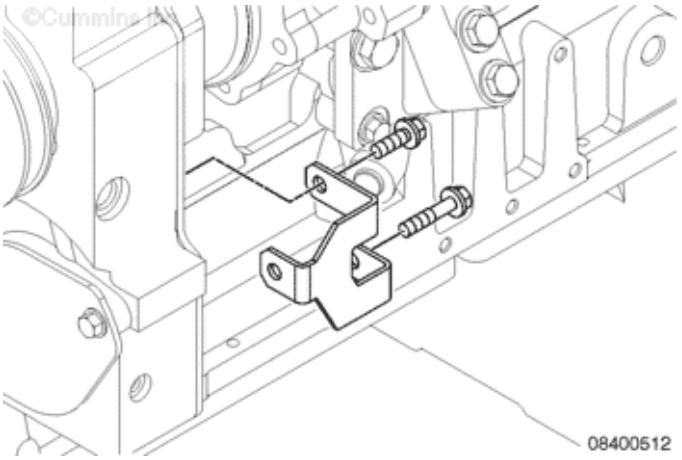
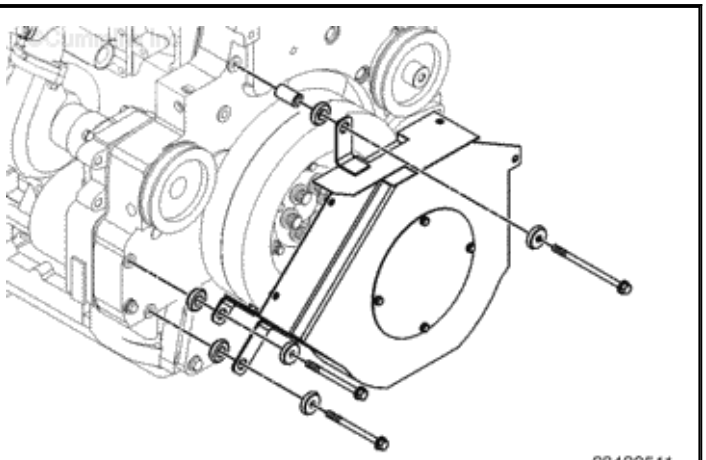
Last Modified: 25-Oct-2004

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008-001 Belt Guard

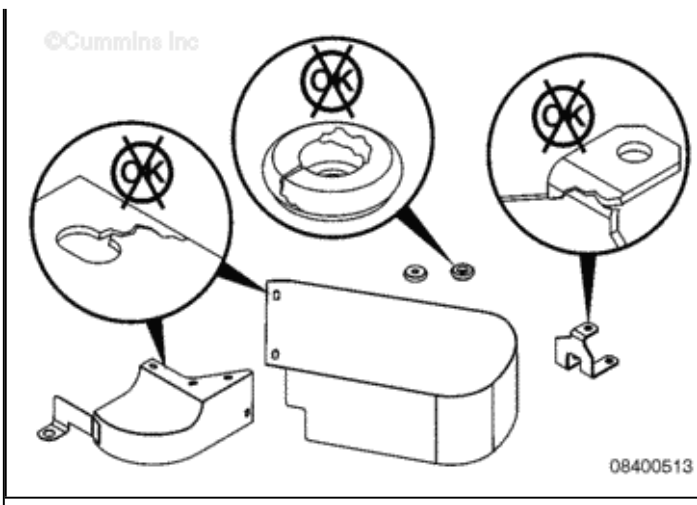
Remove

NOTE: The alternator guard may appear different than illustrated depending on the alternator option. Although different in apperance, the procedure remains the same. Remove the alternator belt guard assembly. If equipped, use **only** the captive-washer capscrews.		
Remove the four capscrews and washers from the accessory drive pulley and the belt guard, if installed. Remove the capscrew, isolator, and spacer. Remove the belt guard.		
Remove the two		

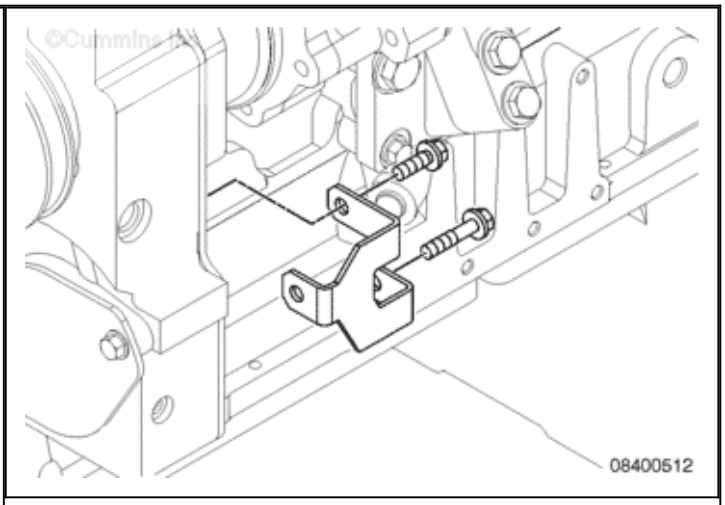
mounting capscrews and the belt guard bracket.		
Remove the three capscrews, isolators, and spacer from the upper bracket. Remove the belt guard.		

Inspect for Reuse

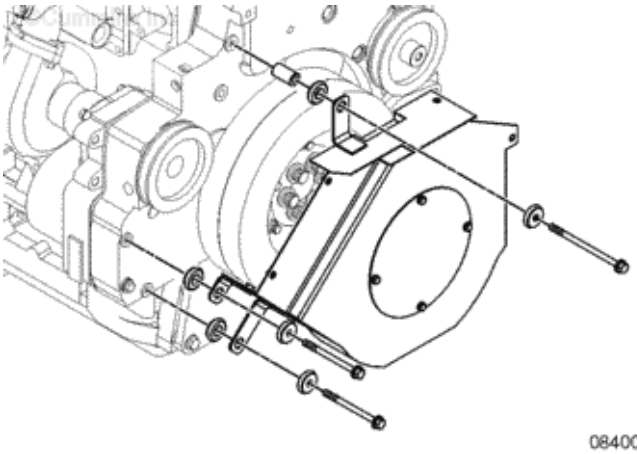
Inspect the belt guard and bracket for cracks or other damage. If damaged, they **must** be replaced. Inspect the isolators for damage. If the		

isolators are hard and brittle, they **must** be replaced. If damaged or bent, replace the belt guard studs.		

Install

Install the belt guard and mounting bracket. Tighten the two capscrews **Torque** **Value:** 40 n.m [30 ft-lb]		
Install the belt guard. Install the three capscrews, isolators, and spacer into the upper bracket. **Torque** **Value:** 25 n.m [221 in-		

lb]



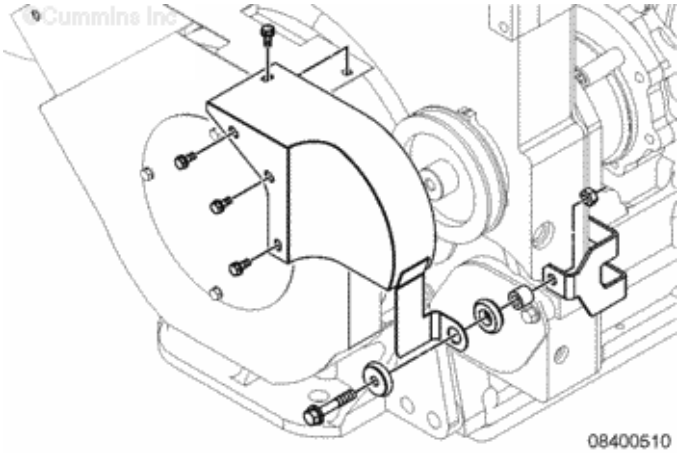
Install the accessory drive pulley and belt guard, if installed.

Install the four capscrews and washers.

Torque Value: 15 n.m [133 in-lb]

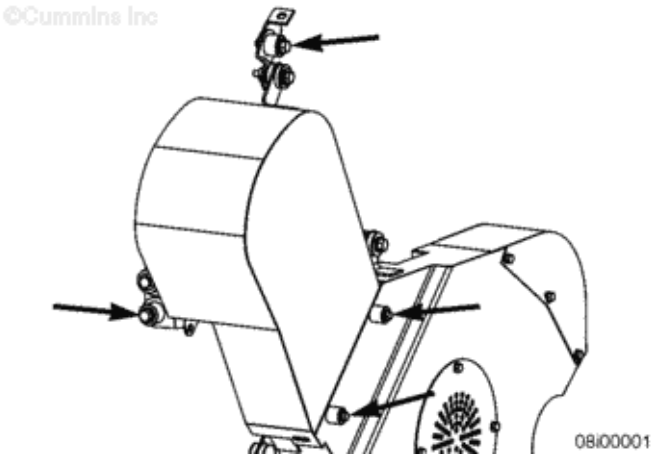
Install the one capscrew, isolator, and spacer.

Torque Value: 25 n.m [221 in-lb]



NOTE: The alternator guard may appear different than illustrated depending on the alternator option. Although different in apperance, the procedure remains the same.

Install the alternator belt guard assembly.



Tighten the captive-washer capscrews. **Torque Value:** 3/8 inch Capscrew 40 n.m [30 ft-lb] Install the two captive-washer capscrews. **Torque Value:** 1/4 inch Capscrew 10 n.m [89 in-lb]		

Last Modified: 06-Jan-2011

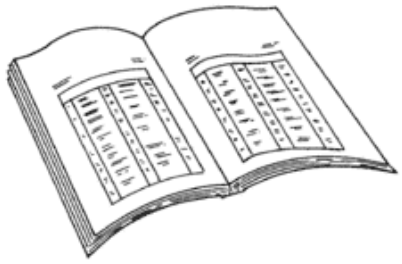
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008-002 Drive Belt, Cooling Fan

Preparatory Steps

NOTE: In some applications the cooling fan drive belt is long enough to clear the fan blades and the removal of the fan and spacers is not required.

- Remove the cooling fan and spacers. Refer to Procedure 008-040.



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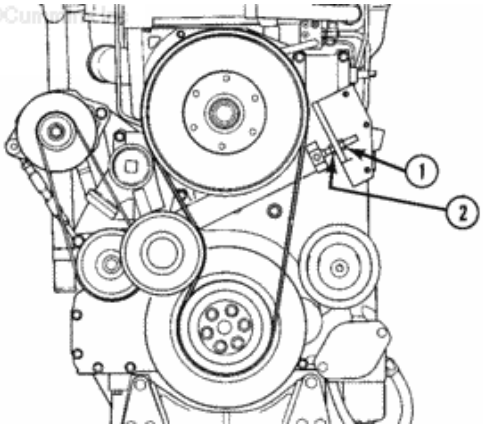
Remove

WARNING

The fan belt idler is under tension. To reduce the possibility of personal injury do not place hands between the idler and the fan belt or the fan hub.

Three types of fan belt tensioning arrangements are used on the K19 engines:

- Enclosed spring
- Control rod with spring (turnbuckle).



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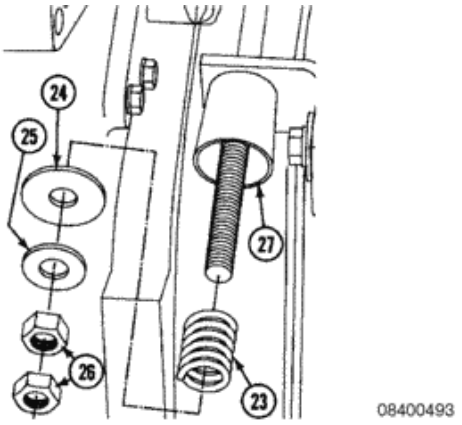
- Shock absorber

For the enclosed spring style of fan belt tensioner, turn the nut (1) **counterclockwise** to the end of the threaded rod, to relieve fan belt tension.

Loosen nut (2).

NOTE: The parts are not removed, the graphic is for clarity.

For the control rod with spring style, loosen the two jam nuts (26) to relieve the fan belt tension.

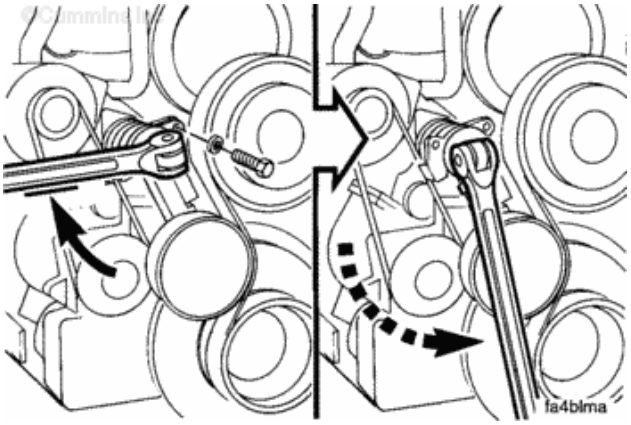


WARNING

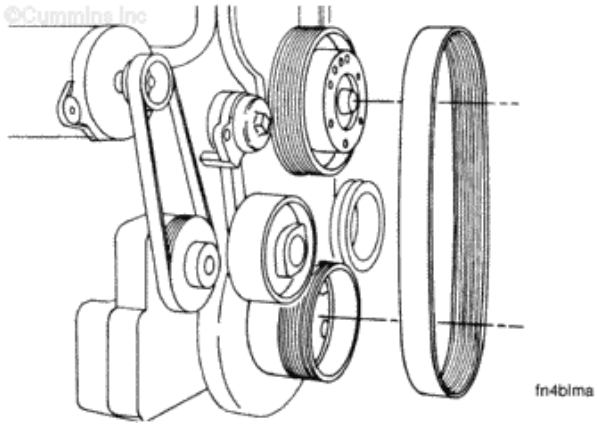
The fan belt idler is under tension. To reduce the possibility of personal injury do not place hands between the idler and the fan belt or the fan hub.

For the shock absorber style, use an 8-point socket and breaker bar or a large wrench on the lug on the idler cap to turn the arm against the spring tension. Remove the capscrew.

Slowly turn the breaker bar or wrench until the tension is relieved.



Remove the fan belt.

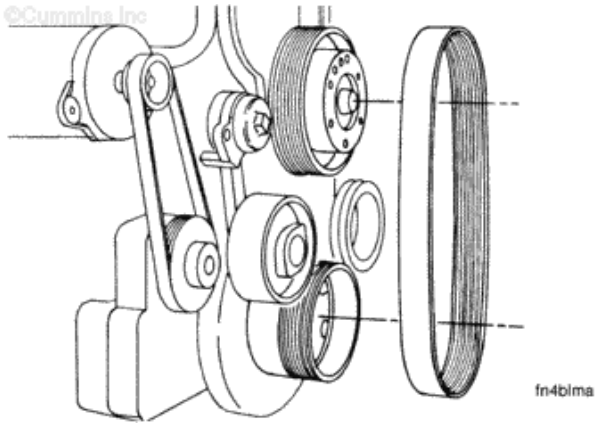
		

Inspect for Reuse

Inspect the fan belt for: • Cracks • Glazing • Tears or cuts. The fan belt **must** be replaced if damaged.		

Install

Install the fan belt.		



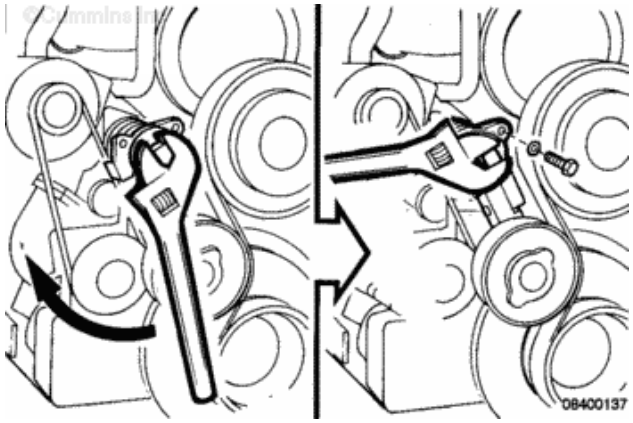
The shock absorber style of belt tensioner does **not** have an adjustment.

For the shock absorber style, use an 8-point socket and a breaker bar or a large wrench on the lug on t he idler cap to rotate the idler against the spring tension until the capscrew holes are aligned.

Install and tighten the capscrew.

Torque
Value: 45 n.m [33 ft-lb]

Slowly turn the wrench until the idler is against the belt.



Adjust

For the enclosed spring style of belt tensioner, pull the belt tensioner until the idler pulley contacts the fan belt.

Tighten nut (1) finger-tight.

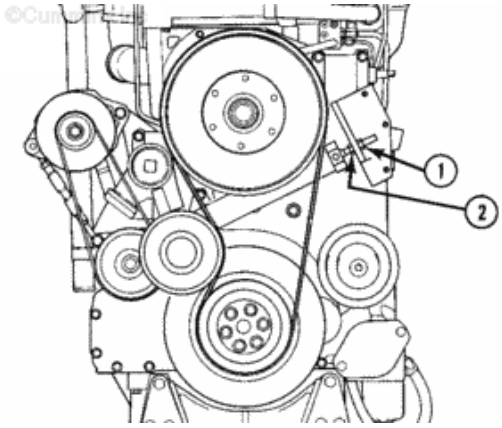
Use a wrench to tighten nut (1) nine revolutions.

Tighten nut (2).

Torque
Value: 81 n.m [60 ft-lb]

If the fan belt was replaced, operate the engine for 10 minutes at high idle.

Adjust the belt tension.

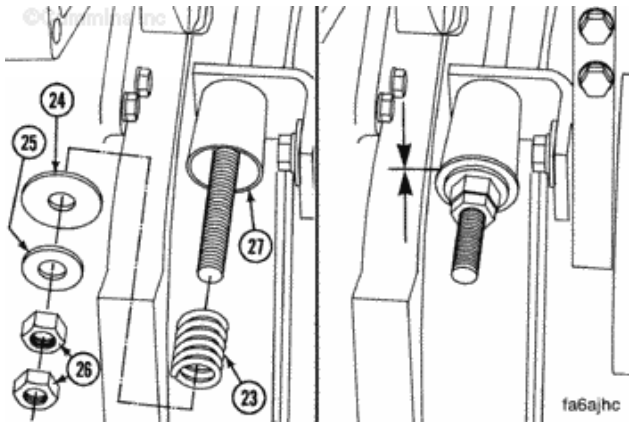


CAUTION

Do not tighten the inner jam nut more than one revolution after the spring retainer contacts the cup or the cup will be bent allowing a loose belt. Tighten the inner jam nut until the washer (24) contacts the cup on the bracket. Use two wrenches and tighten the outer jam nut to the inner jam nut.

For the control rod with spring belt tensioner, tighten the inner jam nut until the washer (24) contacts the cup on the bracket.

Use two wrenches and tighten the outer jam nut to the inner jam nut.

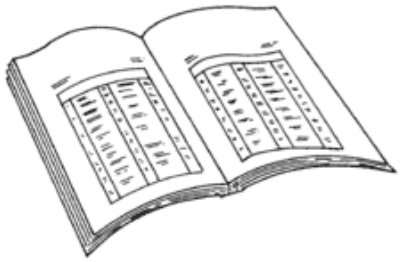


Finishing Steps

- Install the cooling fan and spacers. Refer to Procedure 008-040.



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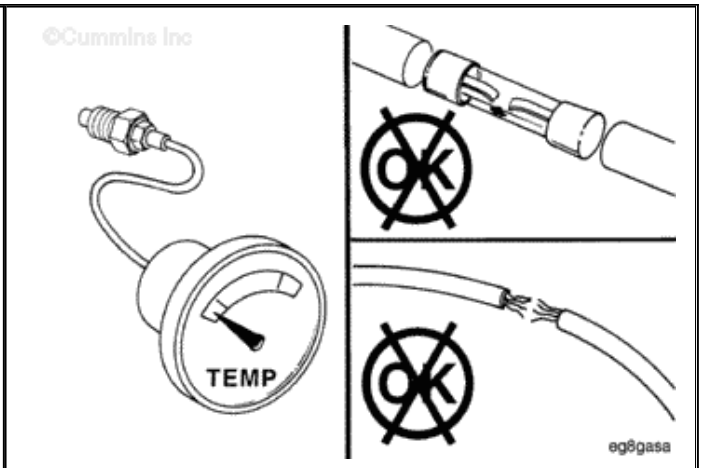
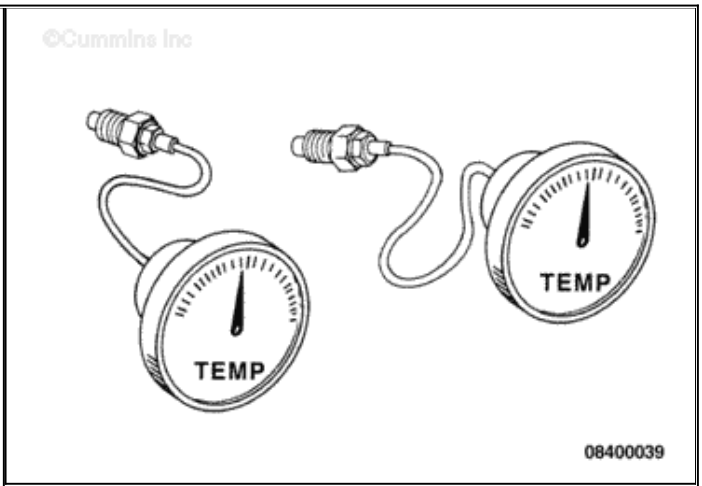
ck800wa

Last Modified: 28-Jul-2006

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008-004 Coolant Temperature Gauge

Maintenance Check

Check for a blown fuse. Check the wiring from the gauge to the sending unit for broken connection(s).		
Use a temperature gauge of known accuracy to check the existing gauge. Replace the faulty gauge.		

Last Modified: 23-Jul-2004

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008-006 Coolant Filter

Remove

WARNING

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

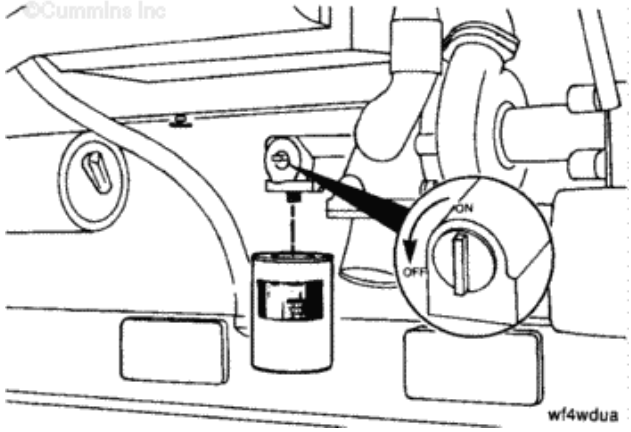
WARNING

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.

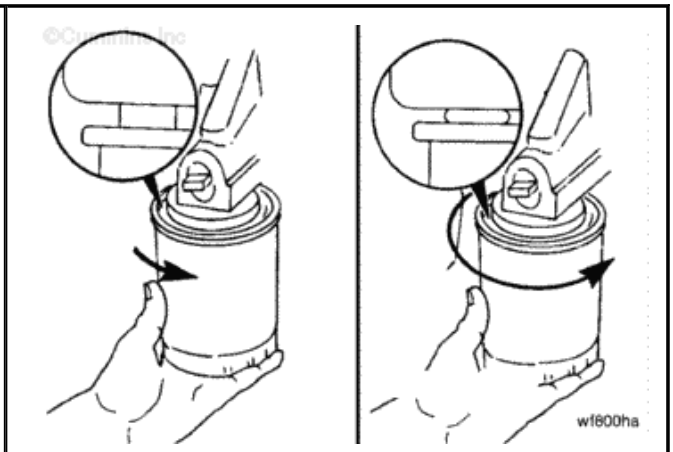
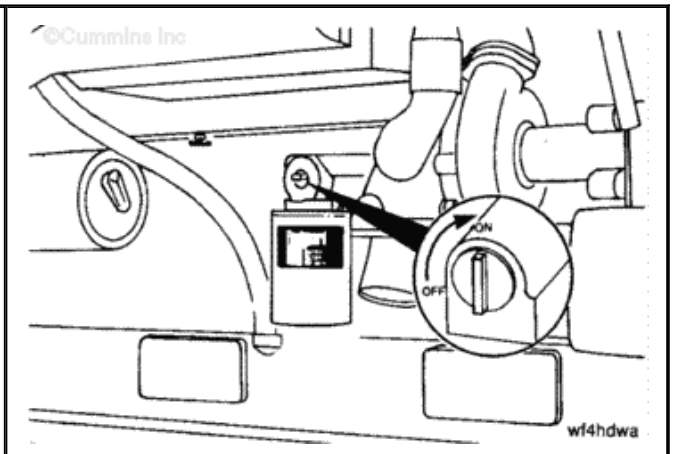
NOTE: The valve does not completely stop the flow of coolant from the filter head. It is recommended to have the new filter ready to install before removing the old filter.

Turn the valve on the filter head to the OFF position.

Remove and discard the coolant filter.



Install

Do **not** allow oil to get in the filter. It will break down the SCA. Lubricate the seal on the filter with clean engine oil.		
Install the coolant filter. Turn the filter until the seal touches the filter head. Turn an additional ½ to ¾ of a turn after contact.		
Turn the valve to the ON position.		

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008-008 Coolant Filter Head (Remote-Mounted)

Preparatory Steps

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.

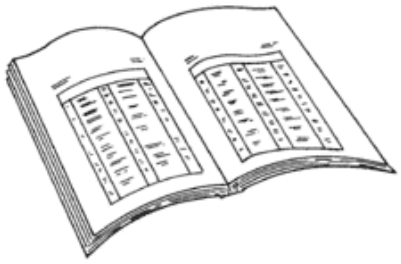
WARNING

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

NOTE: Some engines will have valves on the engine end of the coolant hoses. If the coolant hoses have valves it is not necessary to drain all of the coolant. The valves can be closed.

- Drain the cooling system. Refer to Procedure 008-018.
- Remove the coolant filters. Refer to Procedure 008-006.



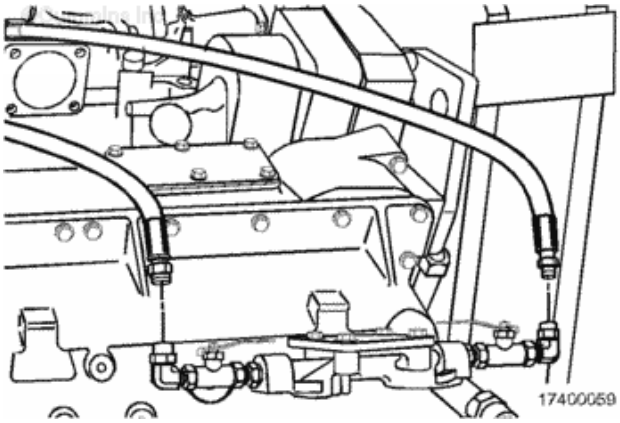


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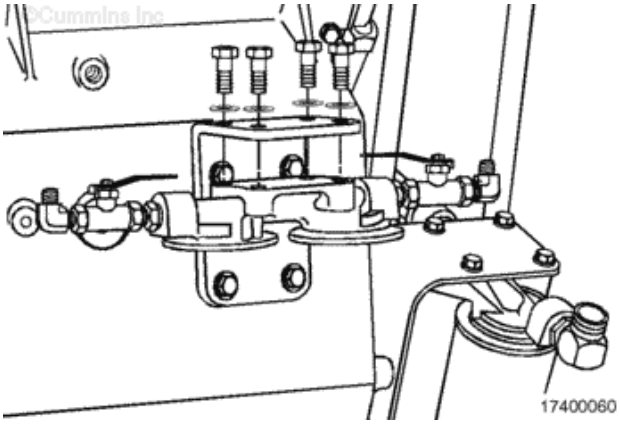
Remove

NOTE: The graphic illustrates a typical remote mounted coolant filter. This can be different depending on the engine serviced.

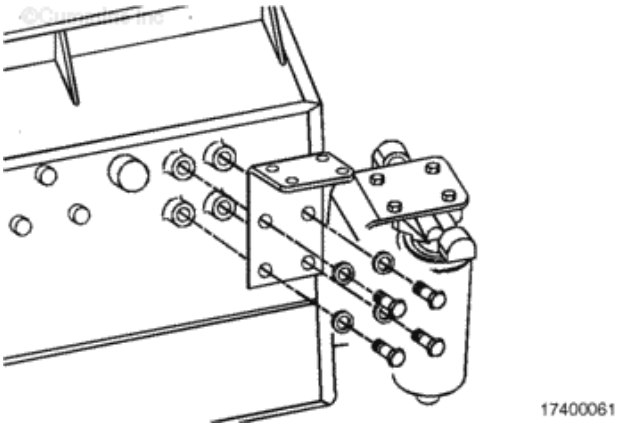
Disconnect the coolant inlet and outlet hoses from the coolant filter head valve fittings.



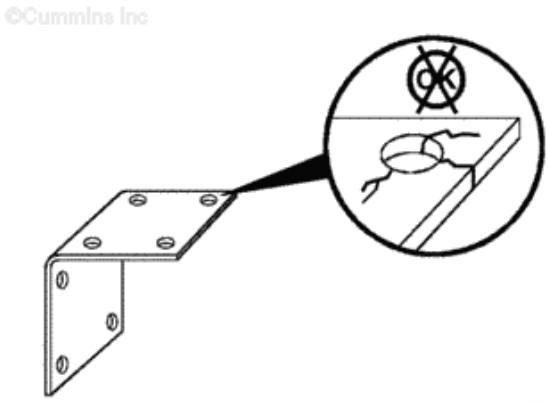
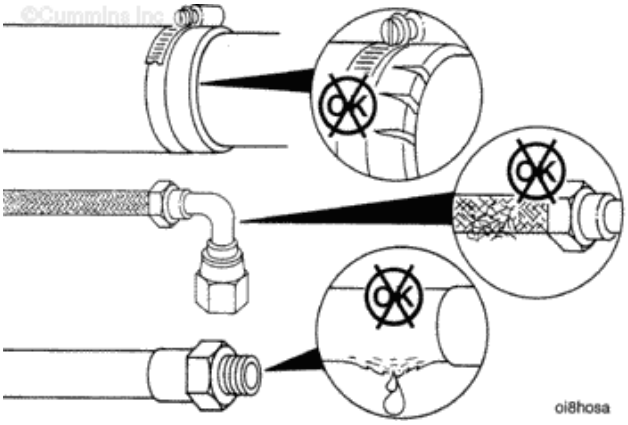
Remove the four capscrews, washers and the coolant filter head from the bracket.



Remove the four capscrews, washers and coolant filter head bracket.

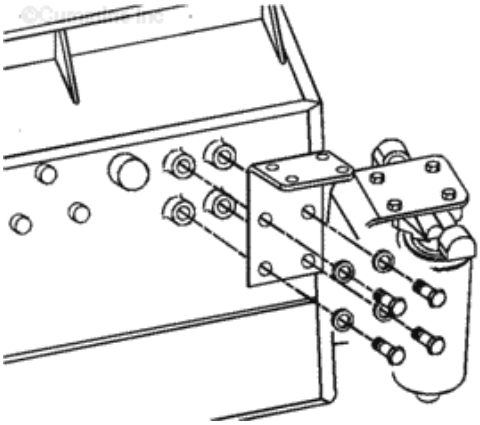


Inspect for Reuse

Inspect the coolant filter head and coolant filter head bracket for cracks or damage. If the coolant filter head or coolant filter head bracket is cracked or damaged, it **must** be repaired or replaced.		
Check the coolant hoses for cracks. If a coolant hose is cracked, it **must** be replaced.		

Install

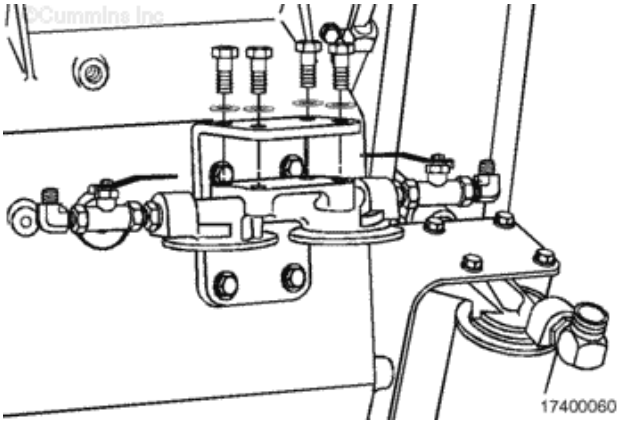
Install the bracket, four washers and capscrews. Tighten the capscrews. Refer to the capscrew markings and torque values, Procedure 018-009 for the appropriate torque value.	 	



Install the coolant filter head, four washers and capscrews.

Tighten the capscrews.

Torque
Value: 25 n.m [20 ft-lb]

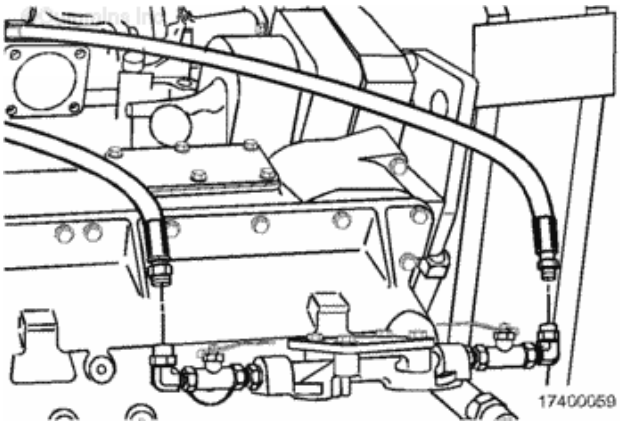


Install the face seal o-rings.

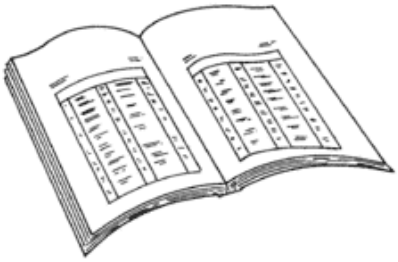
Connect the coolant inlet and outlet hoses to the coolant filter valve fittings.

Tighten the fittings.

Torque
Value: 25 n.m [20 ft-lb]



Finishing Steps

• Install the coolant filters. Refer to Procedure 008-006. • Fill the cooling system. Refer to Procedure 008-018.		 ck800wa

Last Modified: 19-Oct-2004

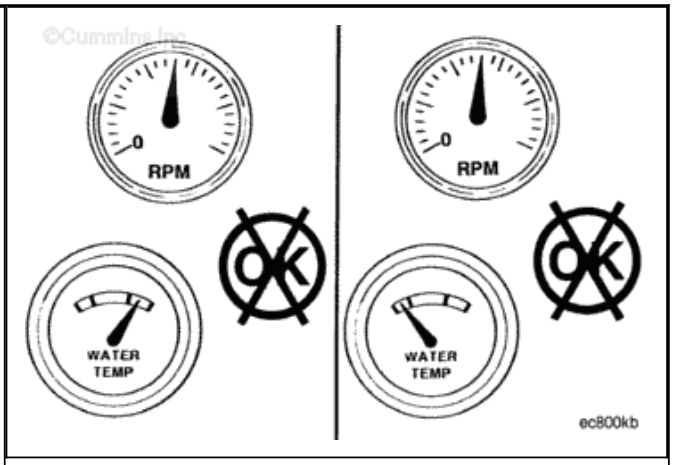
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008-013 Coolant Thermostat

Initial Check

All Applications

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.

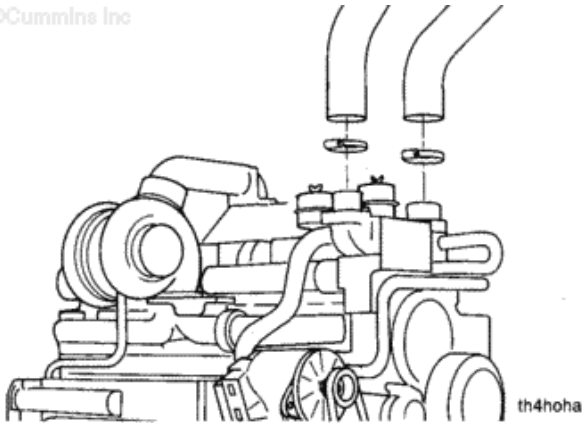


WARNING

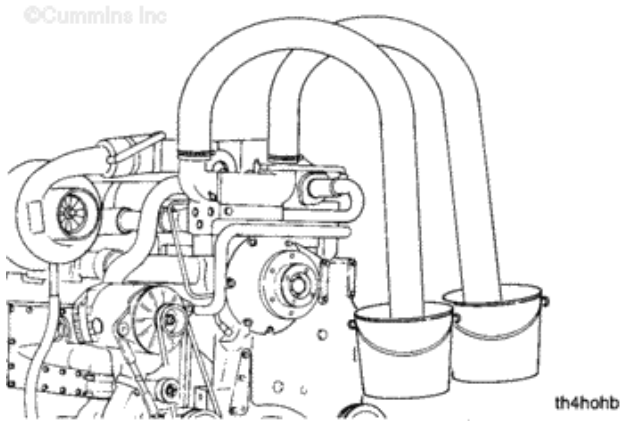
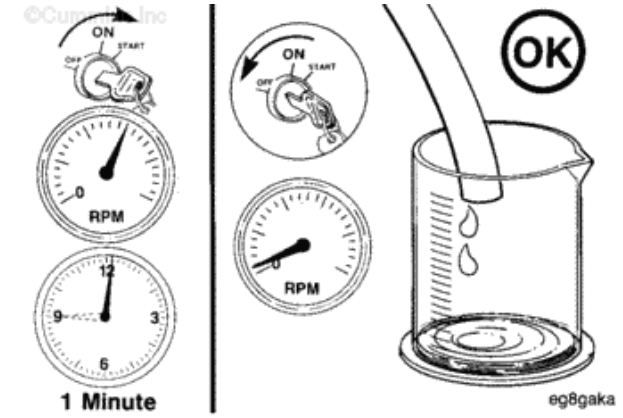
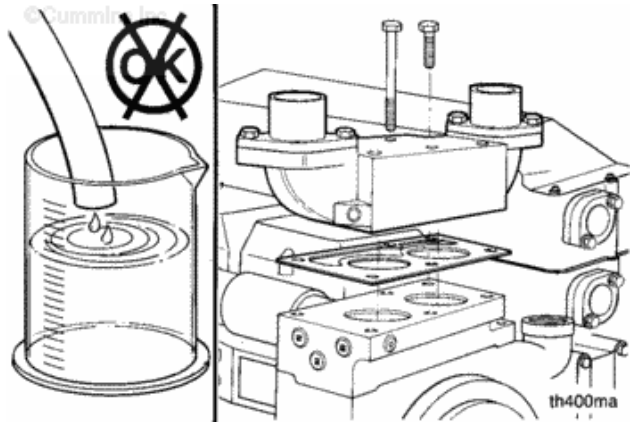
Complete this test with the engine coolant temperature below 50°C [120°F]. Hot steam can cause serious personal injury.

If the engine coolant temperature is below normal, perform the steps below.

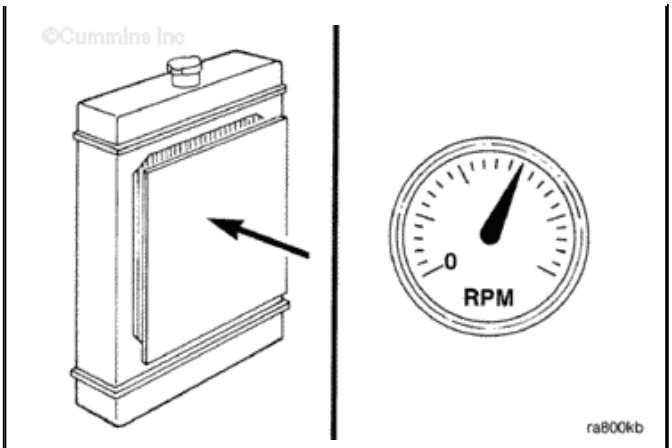
Remove the upper engine radiator hoses from the thermostat housing.



Install two hoses of the same size on the thermostat housing outlets long enough to reach a remote dry container.

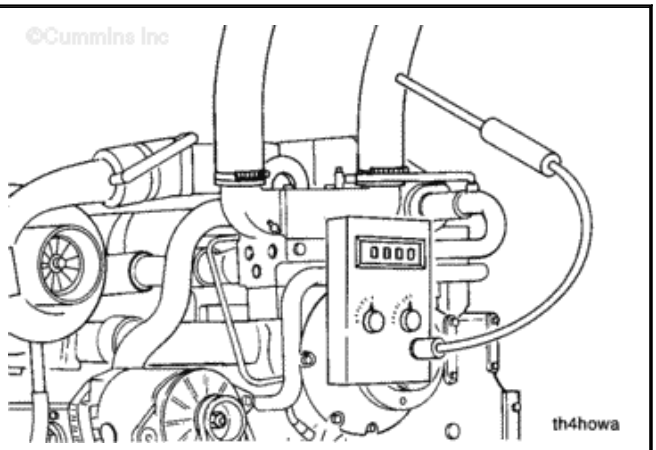
Install and tighten hose clamps on the housing outlets. Place the end of the hoses in two dry containers.		
Operate the engine at rated rpm for 1 minute. Shut the engine off, and measure the amount of coolant collected in each container. The amount of coolant collected **must not** be more than 100 cc [3.3 fl oz].		
If more than 100 cc [3.3 fl oz] of coolant is collected, the thermostat or the thermostat seal is leaking. Remove and test the thermostat.	 	
If the engine coolant temperature is above normal, perform the steps below		

Restrict the radiator air flow. Operate the engine until the coolant temperature rises to 90 to 93°C [195 to 200°F].

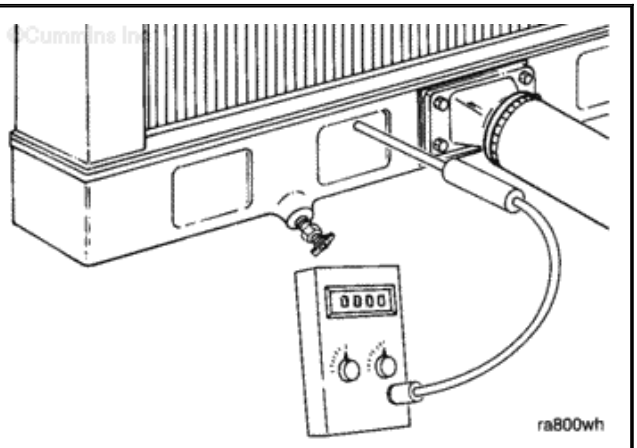


Record the temperature of the coolant outlet hoses. An increase in temperature indicates the thermostats have started to open.

Use a contact pyrometer (shown) or install a temperature gauge in the desired locations prior to operating the engine.



Record the temperature of the radiator bottom tank or coolant out tube.

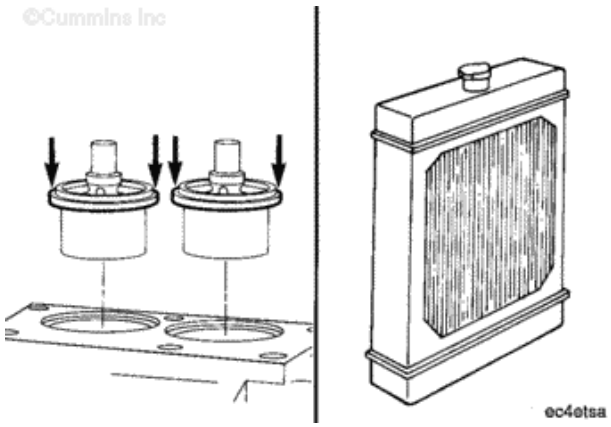


If the difference in temperature is more than 8° C [15°F], either the thermostats are **not** fully

open or the radiator core is plugged.

Replace the thermostats.

To check the radiator, Refer to Procedure 008-042 in Section 8.



Preparatory Steps

All Applications

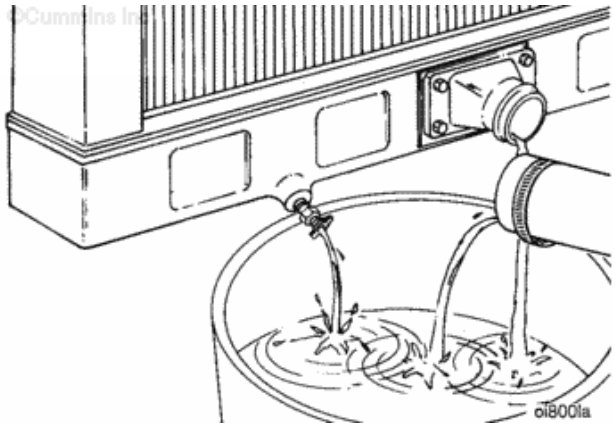
WARNING

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

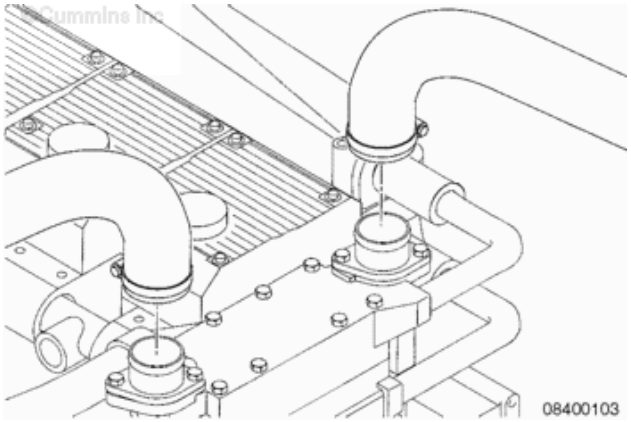
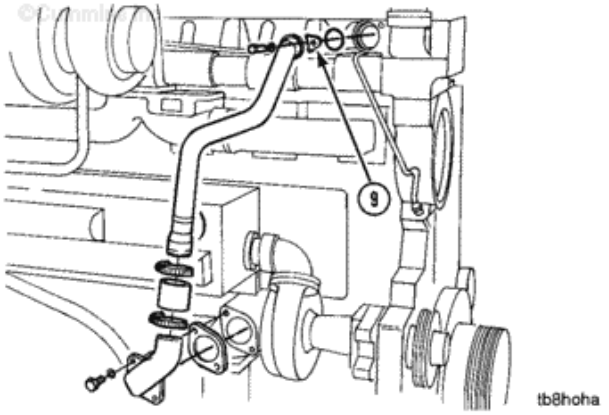
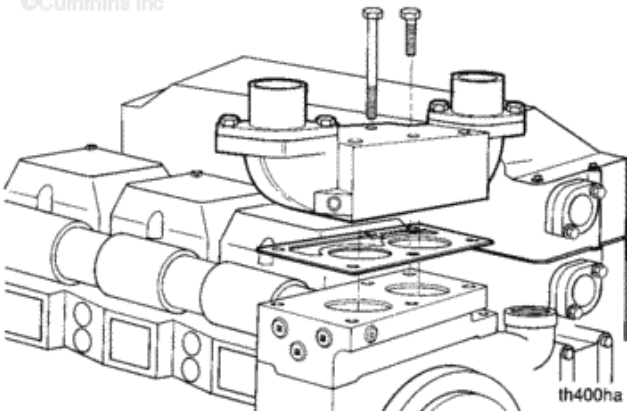
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

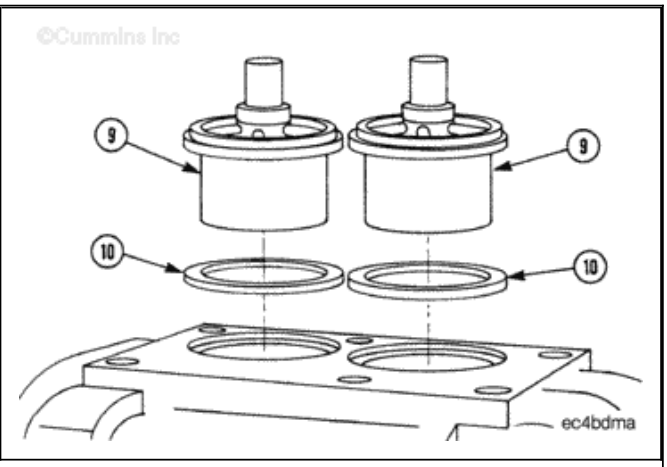
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.



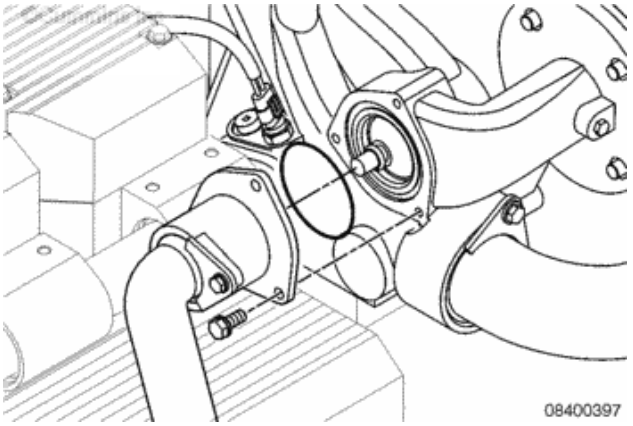
Remove

Industrial Applications

Remove both upper radiator hoses from the thermostat housing. Remove the vent lines from the top of the thermostat housing.		
If the engine is equipped with an air compressor, remove the air compressor coolant return tube. Remove bypass tube clip (9). Loosen both hose clamps. Remove the bypass tube.		
Remove the eight long capscrews. Remove the thermostat housing. Remove and discard the gasket.		

Remove the thermostats (9). Remove the seals (10). Refer to Procedure 008-016 in Section 8.		

Marine Applications

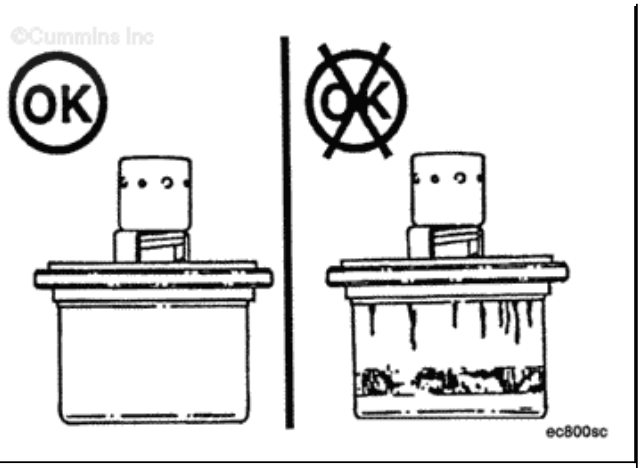
Remove the three captive washer capscrews from the water transfer connection. Pull the water transfer connection away from the thermostat housing. The pipe will rotate around the lower end. Discard the o-ring. Remove the thermostat. Remove the thermostat seal. Refer to Procedure 008-016 in Section 8.		

Inspect for Reuse

All Applications

Inspect the thermostat for damage. If the thermostat is damaged, it **must** be		

replaced.



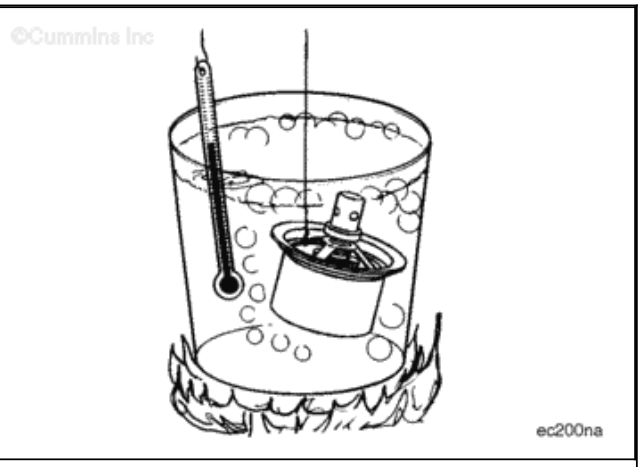
Test

Industrial Applications

Suspend the thermostat and a 100°C [212°F] thermometer in a container of water.

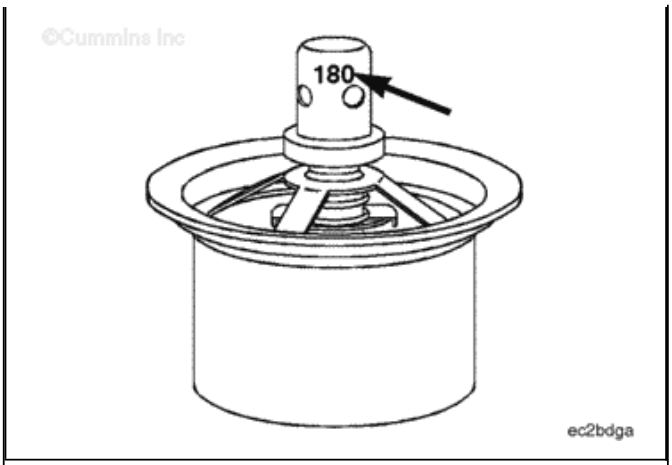
Do **not** allow the thermostat or thermometer to touch the container.

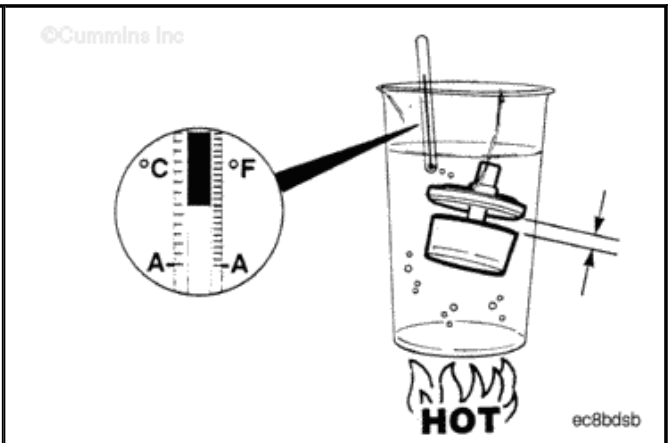
Heat the water and check the thermostat as follows.



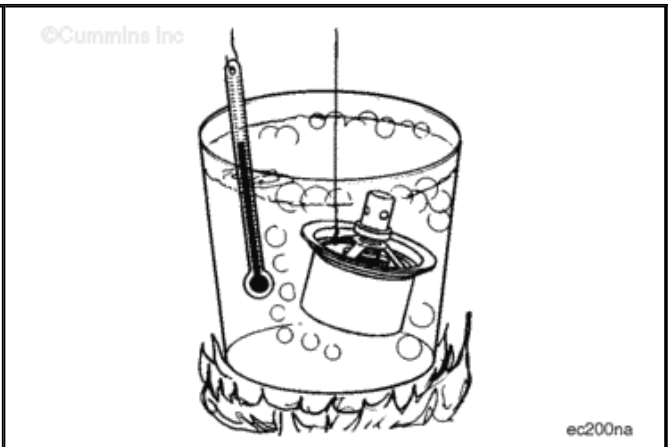
The nominal operating temperature is stamped on the thermostat.

- 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.		

Marine Applications

Suspend the thermostat and a 100°C [212°F] thermometer in a container of water. Do **not** allow the thermostat or thermometer to touch the container.		

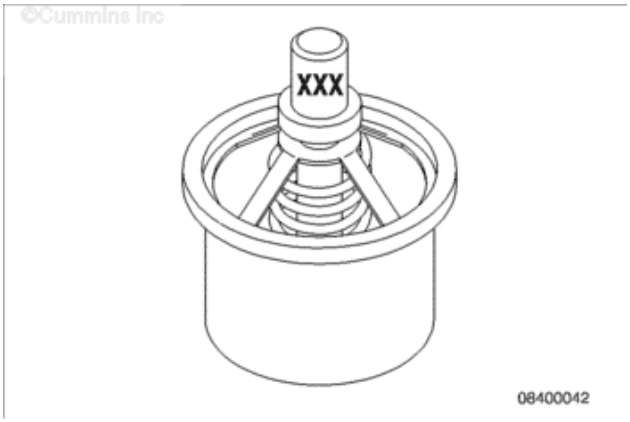
Heat the water and check the thermostat as follows:		

Nominal temperature is 66°C [150°F].

Measurements		
	celsius	fahrenheit
Thermostat begins to open:	63 to 67	145 to 152

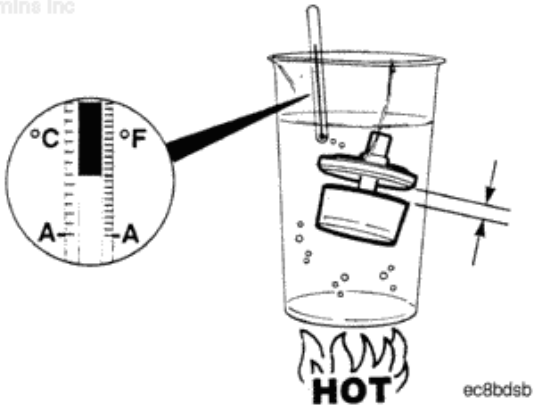
Measurements		
	celsius	fahrenheit
Thermostat fully open:	79	175

The fully open distance is 9.5 mm [0.375 in].



Remove the container from heat.

Make sure the thermostat returns to the closed position.

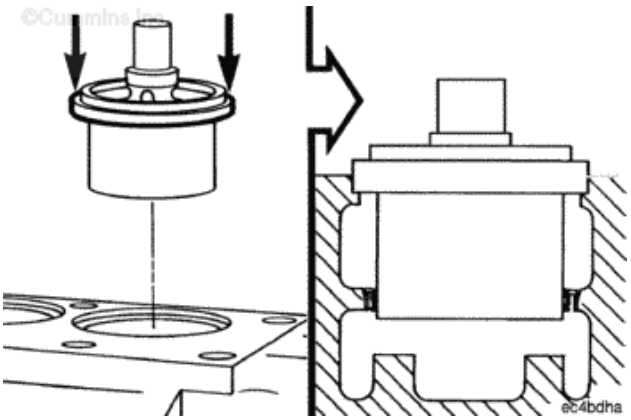


Install

Industrial Applications

Install the thermostat seals. Refer to Procedure 008-016 in Section 8.

Install the thermostat by pushing on the outer rim.

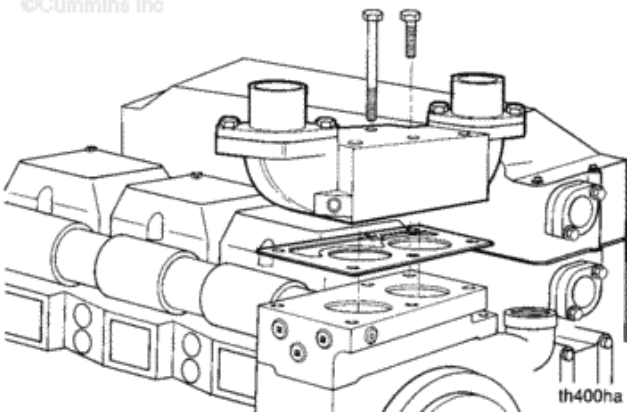


Install a new gasket.

Install the thermostat housing and capscrews.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]



Use vegetable oil to lubricate the o-ring on the bypass tube.

Install the bypass tube.

Install the retainer (9) and capscrew.

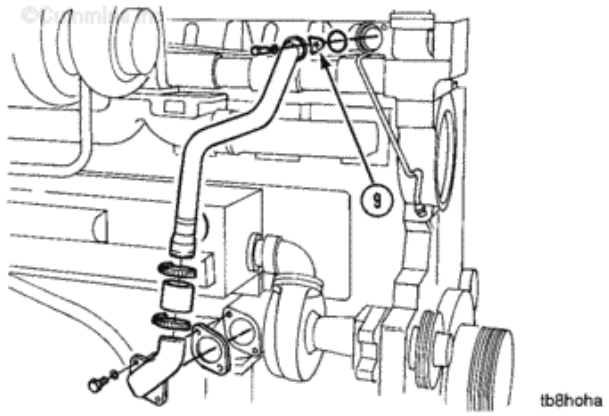
Tighten the capscrew and the hose clamps.

Torque Value:
Capscrew

1. 45 n.m [35 ft-lb]

Torque Value:
Hose Clamps

1. 6 n.m [50 in-lb]



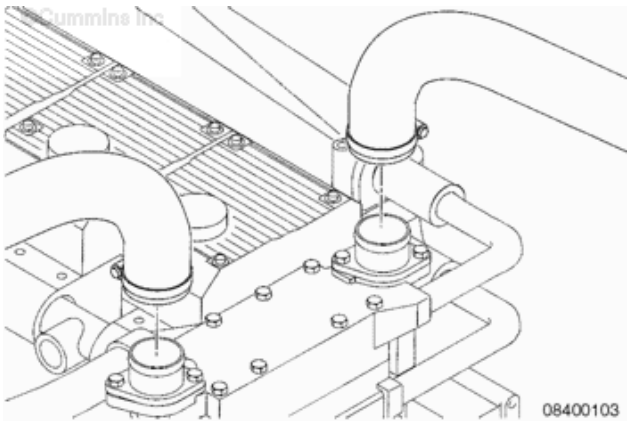
Install the two upper radiator hoses.

Tighten the hoses clamps.

Torque
Value: 6 n.m [50 in-lb]

Install the vent lines.

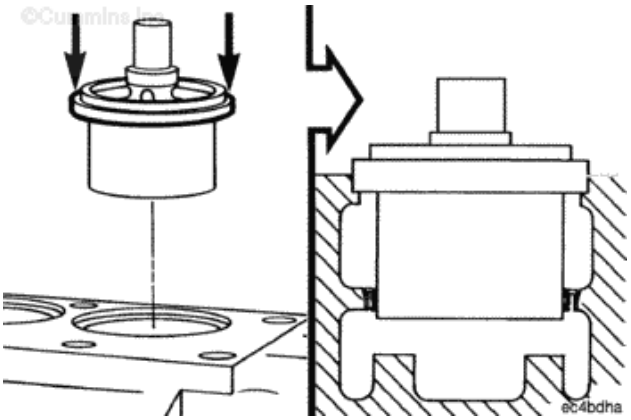
If the engine is equipped with an air compressor, install the air compressor coolant return tube.



Marine Applications

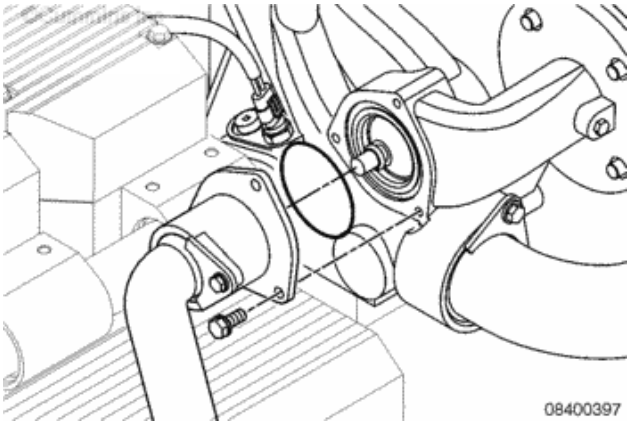
Install the thermostat seal. Refer to Procedure 008-016 in Section 8.

Install the thermostat by pushing on the outer rim until it seats.



Use a new o-ring and fasten the thermostat housing supply pipe to the thermostat housing with three captive washer capscrews.

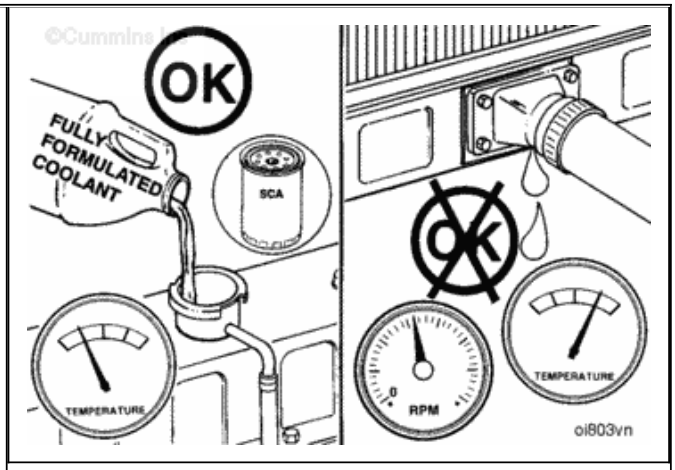
Torque
Value: 40 n.m [30 ft-lb]



Finishing Steps

All Applications

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine to 70°C [160°F] coolant temperature and check for leaks.



Last Modified: 13-Jan-2011

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008-015 Coolant Thermostat Housing Support

Preparatory Steps

WARNING

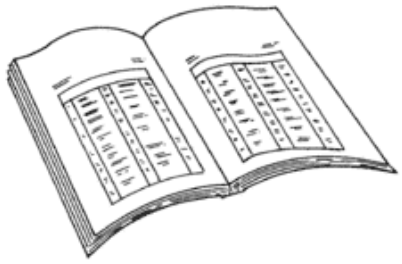
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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.





ck800wa

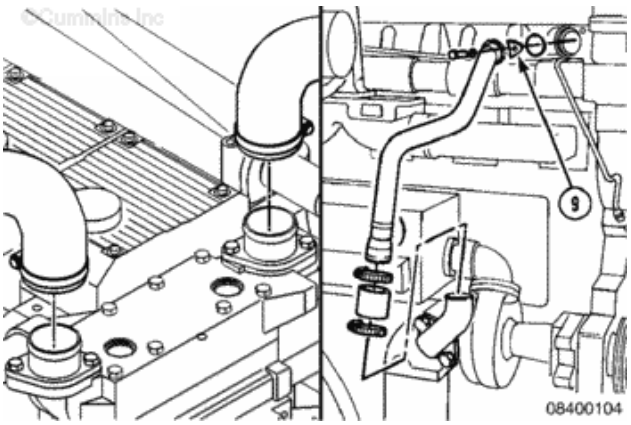
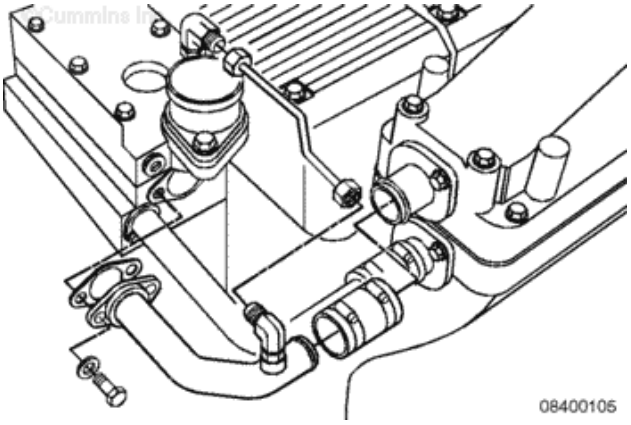
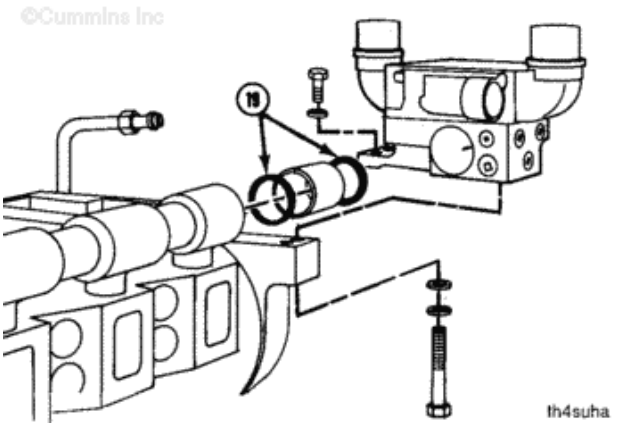
Remove

Aftercooled Engines

Remove both upper radiator hoses from the thermostat housing.

Remove the bypass tube clip (9).



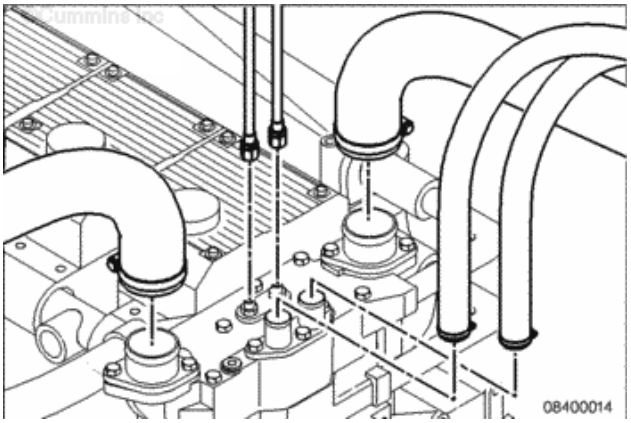
Loosen both bypass tube hose clamps. Remove the bypass tube.		
Remove the aftercooler coolant return tube, aftercooler coolant supply tube, gasket, and hoses from the thermostat housing support.		
If the engine is equipped with an air compressor, disconnect the air compressor water outlet tube from the thermostat housing. Disconnect the coolant temperature sensor wire. Remove the four mounting capscrews and thermostat housing assembly. Remove the water transfer tube. Remove and discard the two o-rings (19).		

LTA

Remove both of the upper radiator hoses from the thermostat housing.

Remove both of the upper low temperature aftercooling radiator hoses from the thermostat housing.

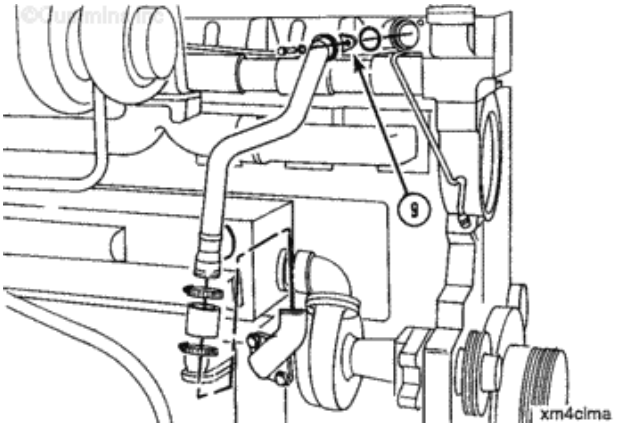
Remove both of the vent hoses from the thermostat housing.



Remove the bypass tube hold down clamp (9).

Loosen both hose clamps.

Remove the bypass tube, hose and water connection.



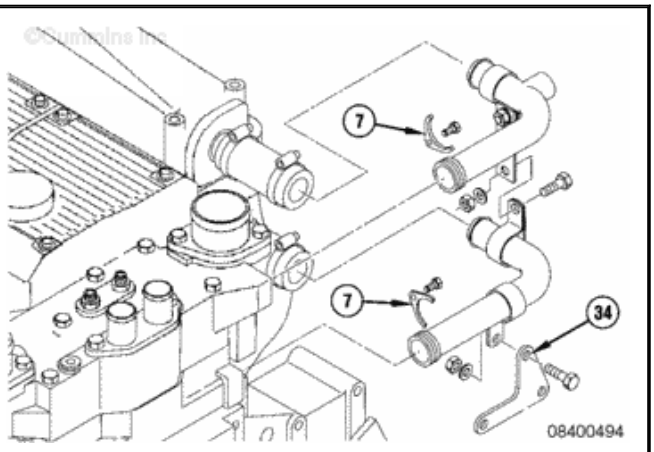
Remove the water inlet and outlet tube clips (7).

Loosen the hose clamps.

Remove the aftercooler water tube support bracket (34).

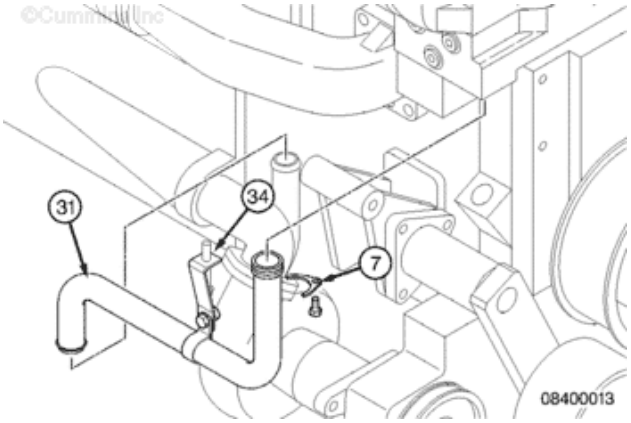
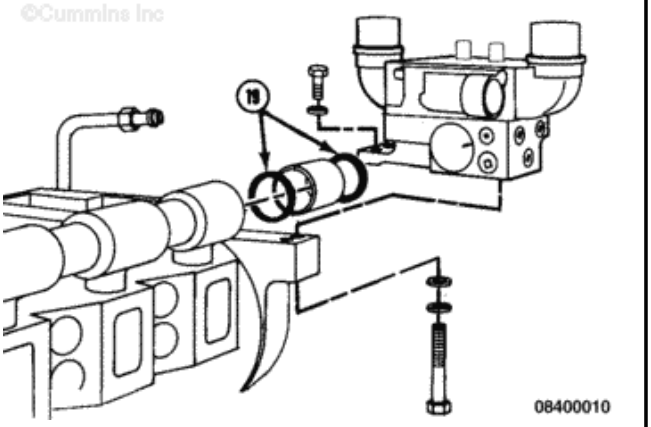
Remove the aftercooler water tubes.

Remove and discard the o-rings.

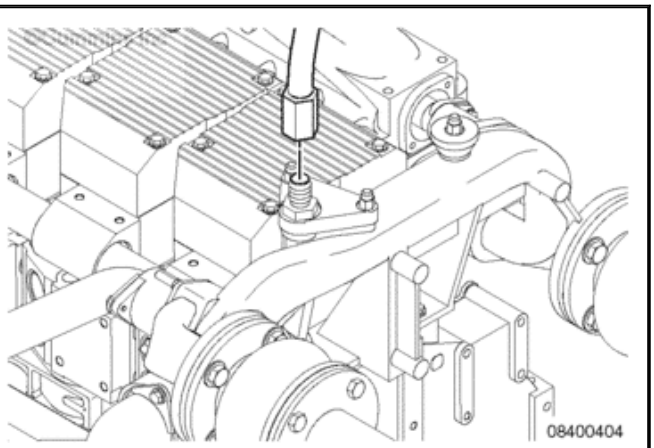


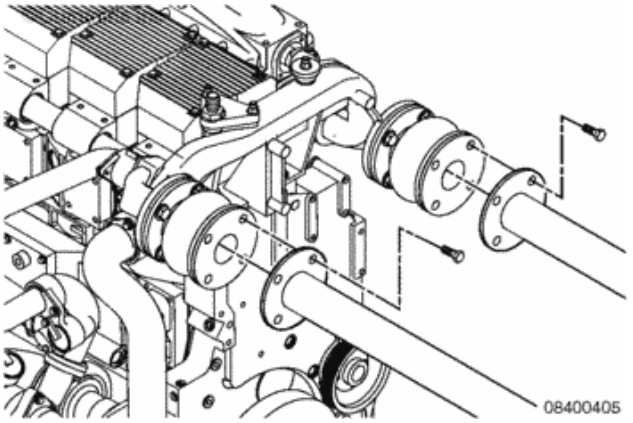
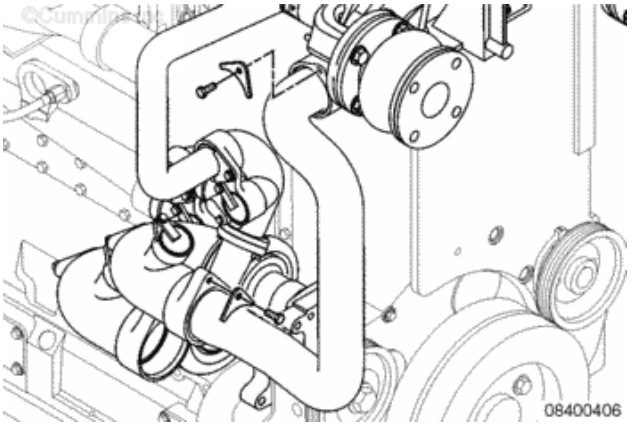
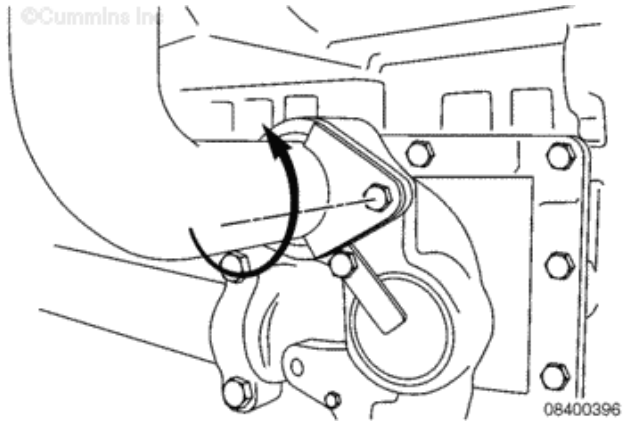
Remove the aftercooler water supply tube clip (7).

Loosen the hose clamps.

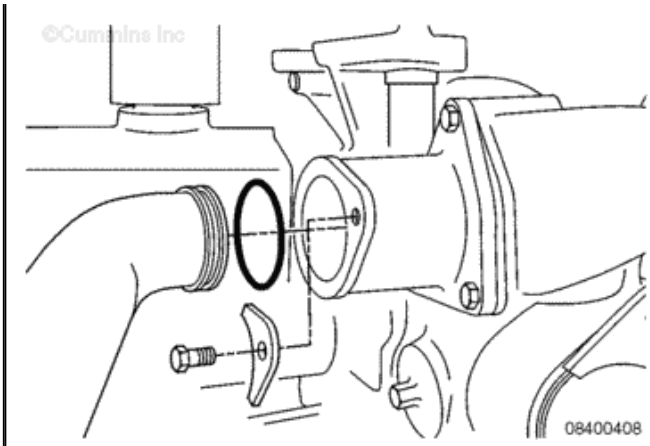
Remove the support bracket (34). Remove the tube (31). Remove and discard the o-ring.		
Remove the four thermostat housing mounting capscrews. Remove the thermostat housing assembly. Remove the water transfer tube. Remove and discard the two o-rings (19).		

Marine Applications

Disconnect the supply and vent hoses.		
Disconnect the keel cooler supply and return pipes.		

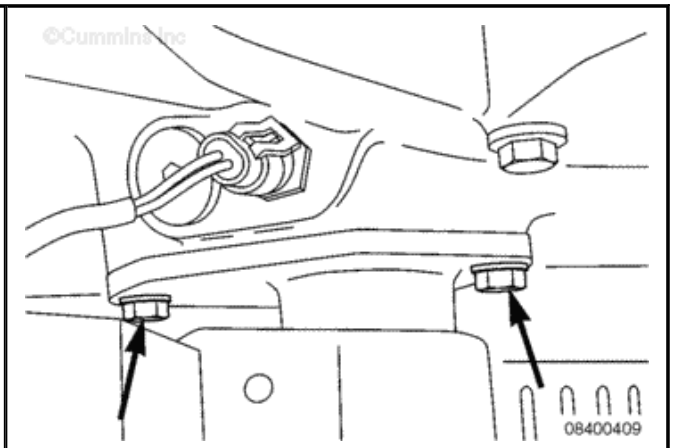
Remove the flexible connections if necessary.		
Remove the retaining clips from the water pump inlet pipe at the water pump and at the thermostat housing. Remove the water pump inlet pipe.		
Loosen the retaining clip on the lower end of the LTA supply pipe.		
Remove the retaining clip at the thermostat housing and pull the LTA supply pipe out of the thermostat housing.		

The pipe will rotate around the lower end.



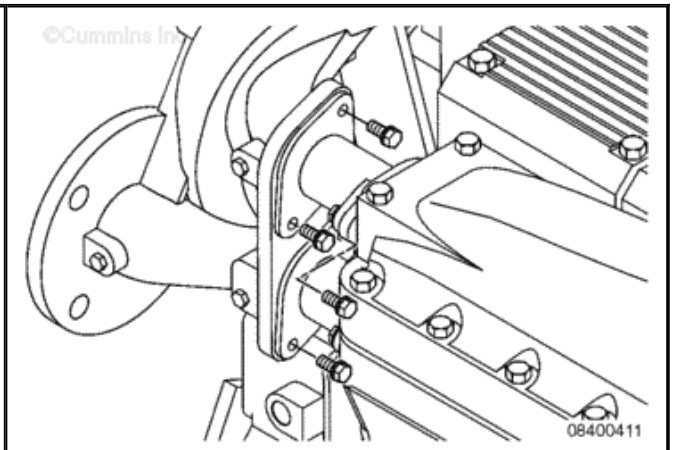
Remove the two capscrews holding the water rail flange to the thermostat housing.

Discard the o-ring.

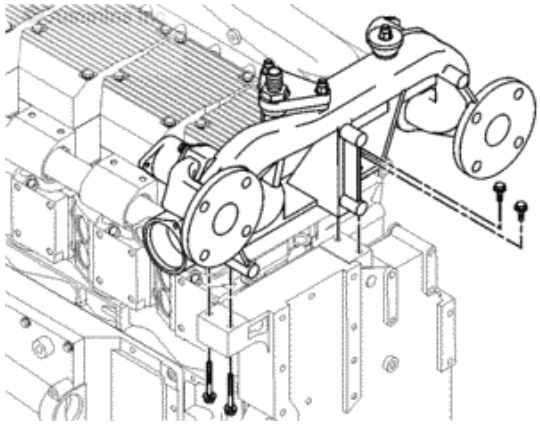


Remove the four capscrews from the aftercooler supply and return tubes.

Discard the o-rings.

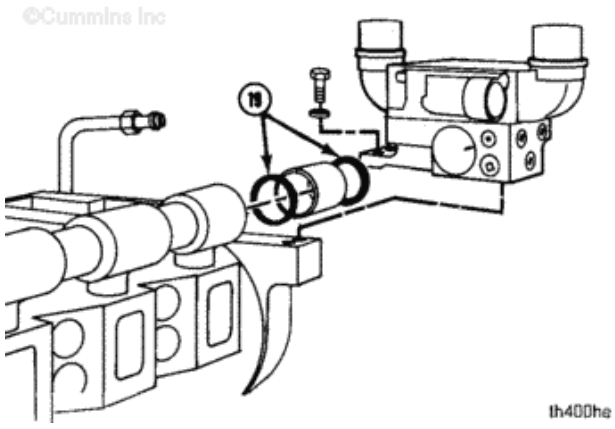


Remove the four capscrews holding the thermostat housing to the gear cover.

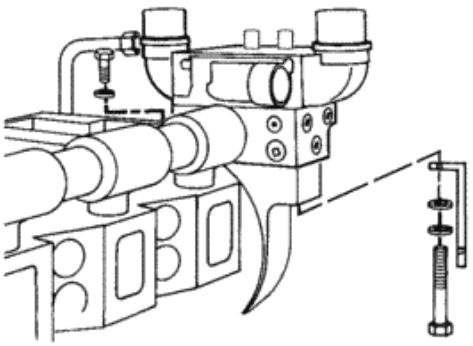
Remove the thermostat housing.		

Install

Aftercooled Engines

Install the o-rings (19) onto the water transfer tube. Lubricate the o-rings with vegetable oil. Install the transfer tube in the bore of the rocker lever housing. Align the bore in the thermostat housing support with the transfer tube. Push the support into position.	 	
The outside capscrew holds a clip for the aftercooler water inlet tube. Install the four lock washers and capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]	 	

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Connect the aftercooler coolant return tube, the aftercooler coolant supply tube, gaskets and hose(s) to the aftercooler.

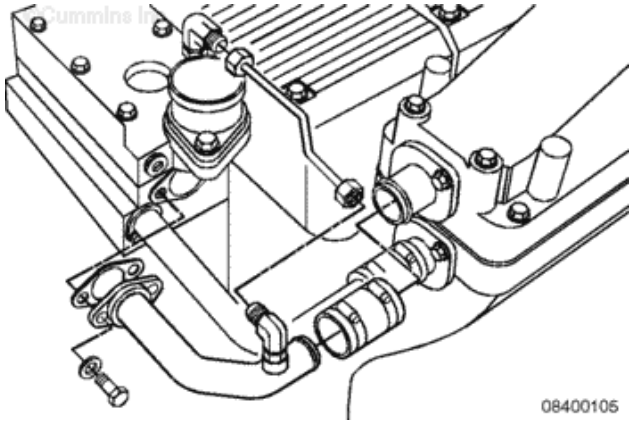
Install the gasket, coolant return tube, and capscrews.

Tighten the capscrews.

Torque
Value: 6 n.m [50 in-lb]

Connect the coolant temperature sensor wire.

If the engine is equipped with an air compressor, install the air compressor coolant return tube.



Install the o-ring onto the bypass tube.

Lubricate the bypass tube o-ring with vegetable oil.

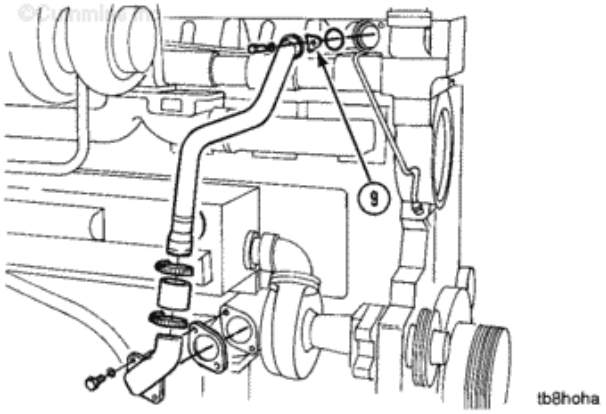
Install the bypass tube.

Tighten the capscrew.

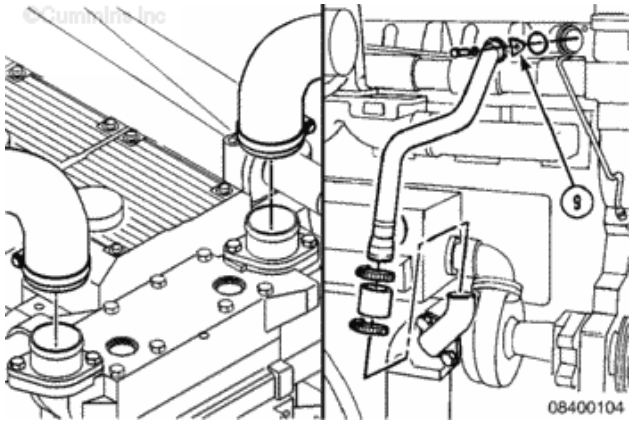
Torque
Value: 45 n.m [33 ft-lb]

Tighten the hose clamps.

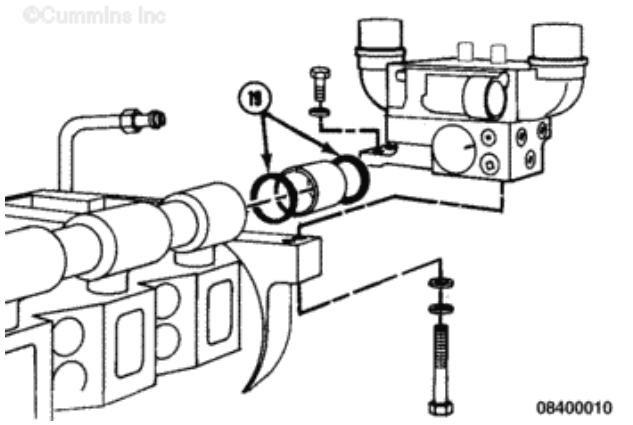
Torque

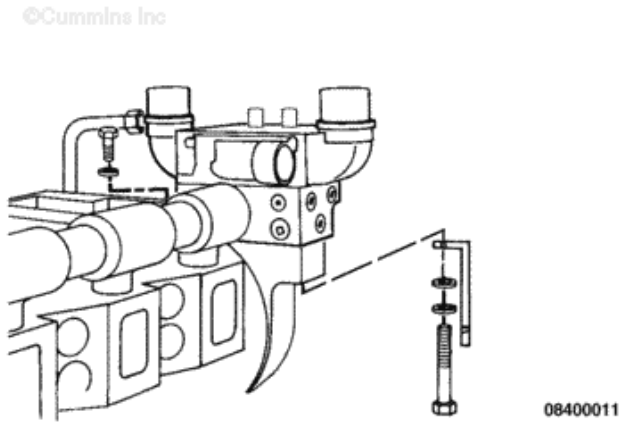


Value: 6 n.m [50 in-lb]		

Install the two upper radiator hoses. Tighten the hose clamps. **Torque** **Value:** 6 n.m [50 in-lb] Install the vent lines.		

LTA

Install the o-rings (19) onto the water transfer tubes. Lubricate the o-rings with vegetable oil. Install the water transfer tube into the bore of the rocker lever housing. Align the bore in the thermostat housing support with the water transfer tube. Push the support into place.		

The outside capscrew holds a clip for the aftercooler water inlet tube. Install the four lock washers and capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]		

Install the o-ring onto the bypass tube.

Lubricate the o-ring with vegetable oil.

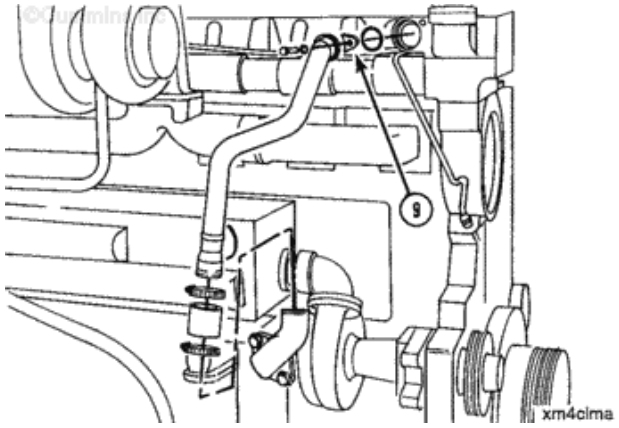
Install the retainer (9) and capscrew.

Tighten the capscrew.

Torque
Value: 45 n.m [33 ft-lb]

Tighten the hose clamps.

Torque
Value: 6 n.m [50 in-lb]



The raised lip on the retainer (7) **must** point toward the thermostat housing.

Lubricate the new o-rings with vegetable oil.

Install the new o-ring on the aftercooler water supply tube (31).

Install the aftercooler water supply tube into the bore of the thermostat housing.

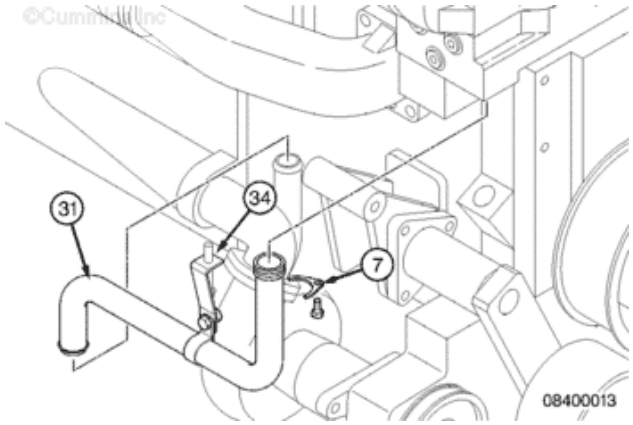
Install the retainer clips (7) and the capscrews.

Torque
Value: 20 n.m [15 ft-lb]

Tighten the hose clamps.

Torque
Value: 6 n.m [50 in-lb]

Attach the support clip bracket (34).



The raised lip on the retainer (7) **must** point toward the thermostat housing.

Lubricate the new o-rings with vegetable oil.

Install the o-rings on the aftercooler water inlet and outlet tubes.

Install the aftercooler water inlet and outlet tubes, retainer clips (7) and capscrews.

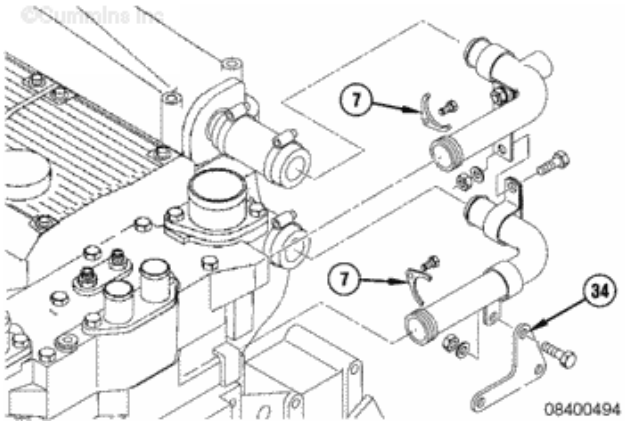
Tighten the capscrews.

Torque
Value: 20 n.m [15 ft-lb]

Tighten the hose clamps.

Torque
Value: 6 n.m [50 in-lb]

Attach the support clips to the bracket (34).



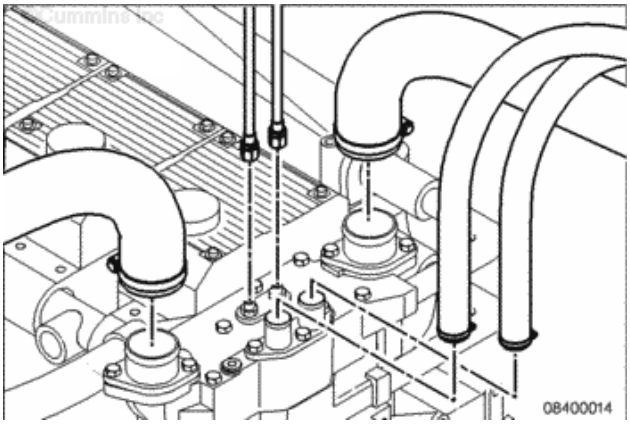
Install both of the radiator vent lines.

Install the upper low temperature aftercooling radiator hose.

Install both of the upper engine radiator hoses.

Tighten the clamps.

Torque
Value: 6 n.m [50 in-lb]



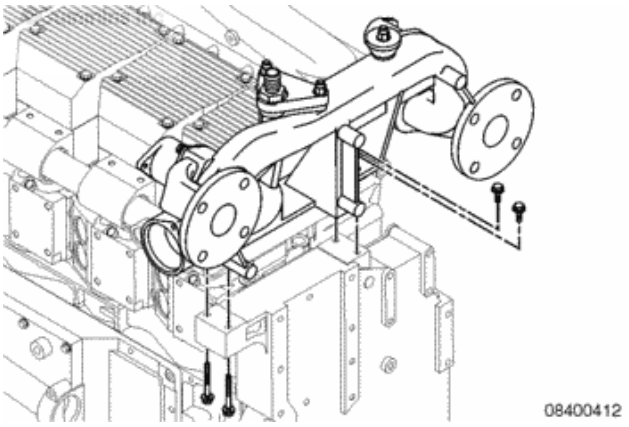
Marine Applications

Install the o-rings at the water rail flange and the aftercooler supply and return tubes.

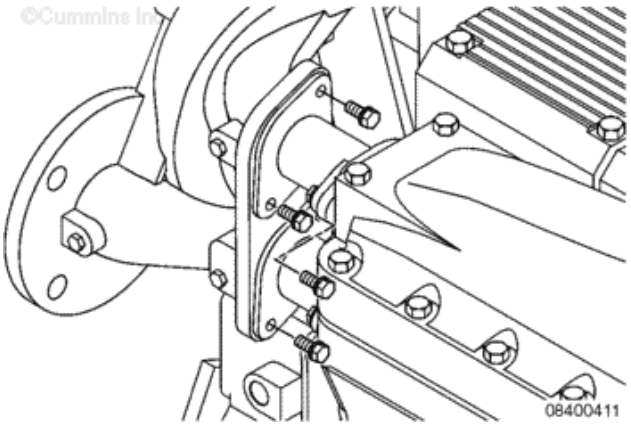
Install the thermostat housing to the top of the gear cover with four capscrews.

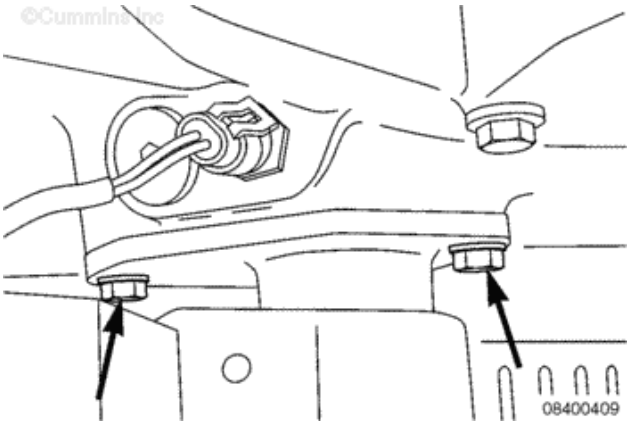
Make sure the o-rings are in place.

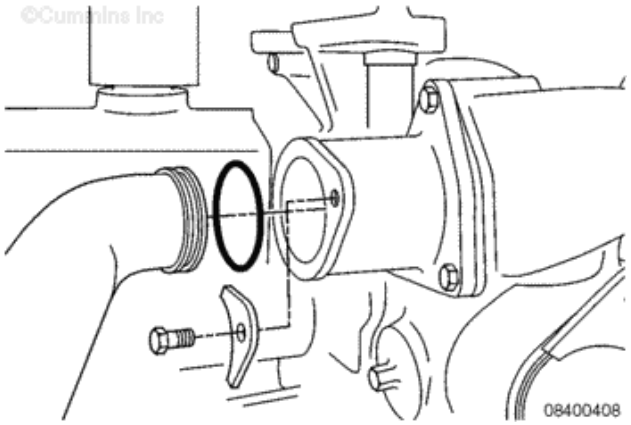
Tighten the capscrews.



Torque **Value:** 40 n.m [30 ft-lb]		

Install the four capscrews at the aftercooler supply and return tubes. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb]		

Install the two capscrews at the water rail flange to the thermostat housing. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb]		

Install a new o-ring on the LTA supply pipe. Insert the LTA supply pipe into the thermostat housing. Install the upper and lower retaining clips. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb]		

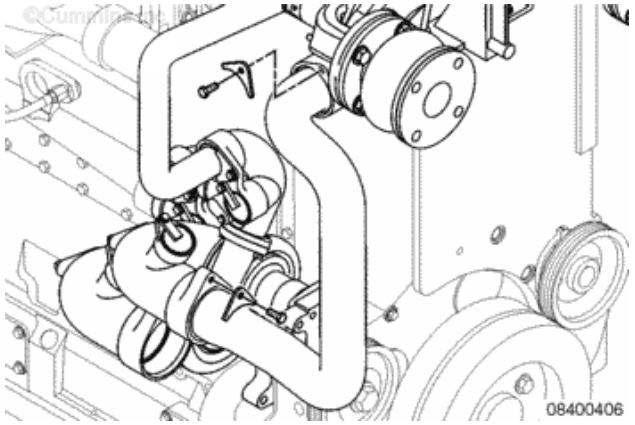
Install new o-rings on the water pump inlet pipe.

Insert the water inlet pipe into the water pump inlet and thermostat housing at the same time.

Install the upper and lower retaining clips.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

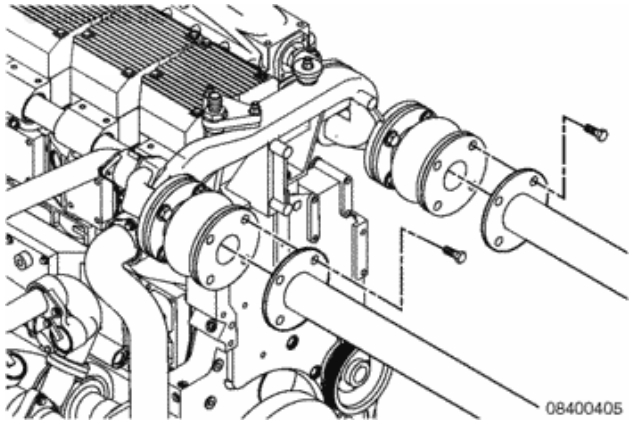


Install the flexible connections with four capscrews, if removed.

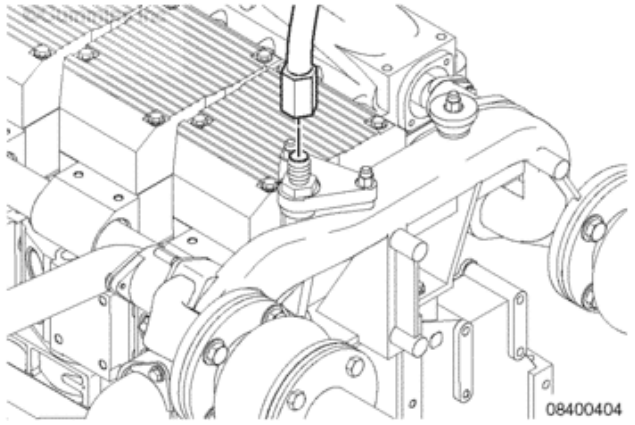
Tighten the capscrews.

Torque
Value: 180 n.m [135 ft-lb]

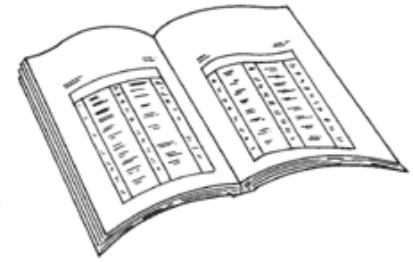
Connect the keel cooler supply and return pipes.



Connect the supply and vent hoses.



Finishing Steps

• Fill the cooling system. Refer to Procedure 008-018. • Operate the engine to 70°C [160°F] coolant temperature and check for leaks.		

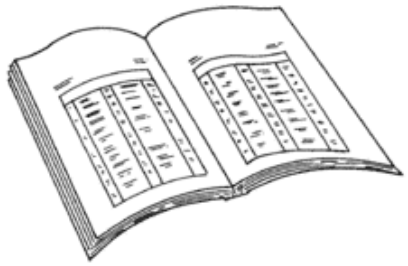
Last Modified: 19-Oct-2004

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008-016 Coolant Thermostat Seal

Preparatory Steps

All Applications

Remove the thermostats. Refer to Procedure 008-013 in Section 8.		 ck800wa

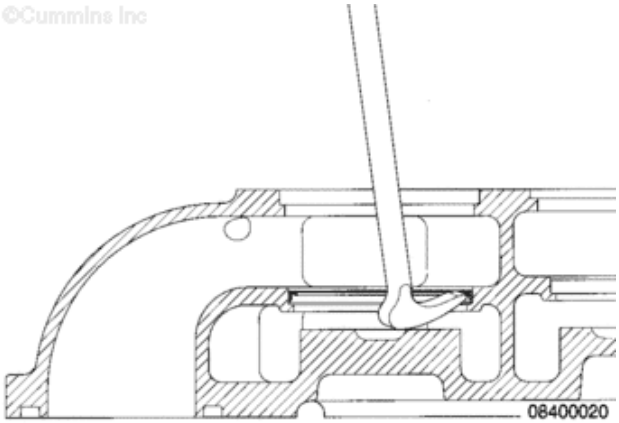
Remove

All Applications

CAUTION

Do not damage the thermostat housing when removing the thermostat seals.

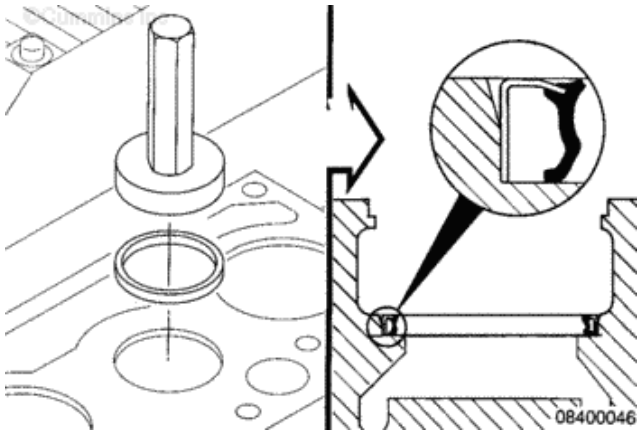
The thermostat housing has a machined counterbore to locate the seals.



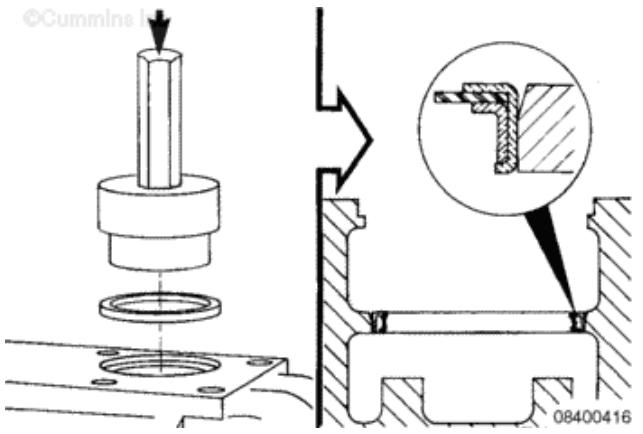
Use a rolling head pry bar. Position the pry bar tip under the top flange of the seal and pry upward. Remove the seals from the housing. Use a Snap-On® pry bar, Part Number 1650 or equivalent. Remove the engine thermostat seals.		

Install

Industrial Applications

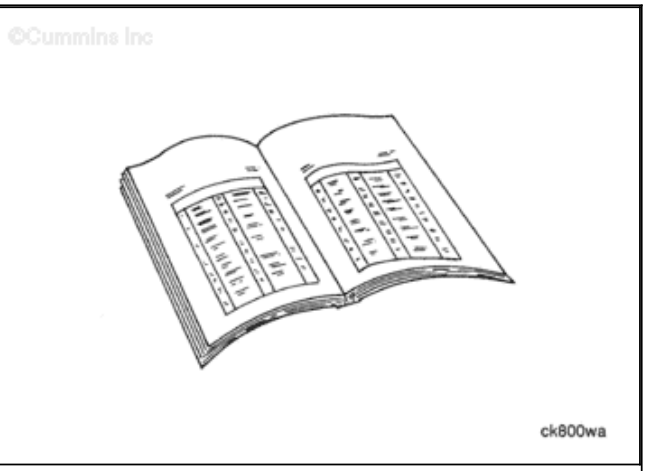
The seal **must** be installed with the part number positioned upward. Use a mallet and seal driver, Part Number 2892254, to install the seal. Make sure the seals seat in the bottom of the counterbore.		

Marine Applications

The seal **must** be installed with the seal lip positioned towards the mandrel. Use a mallet and seal driver, Part Number 2892254, to install the seal.		

Finishing Steps

All Applications

Install the thermostats. Refer to Procedure 008-013 in Section 8.		

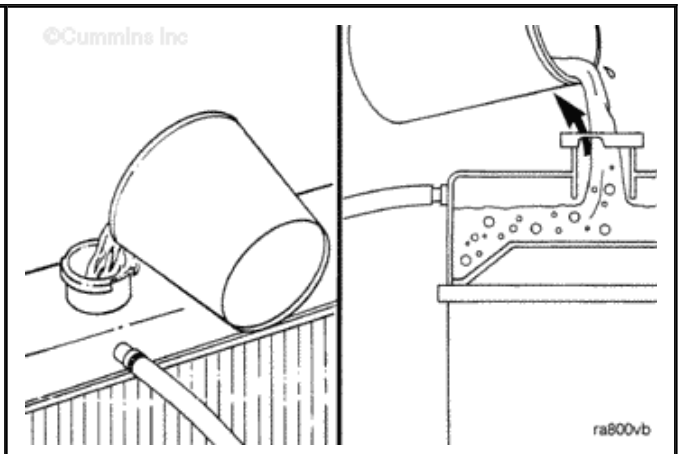
Last Modified: 13-Jan-2011

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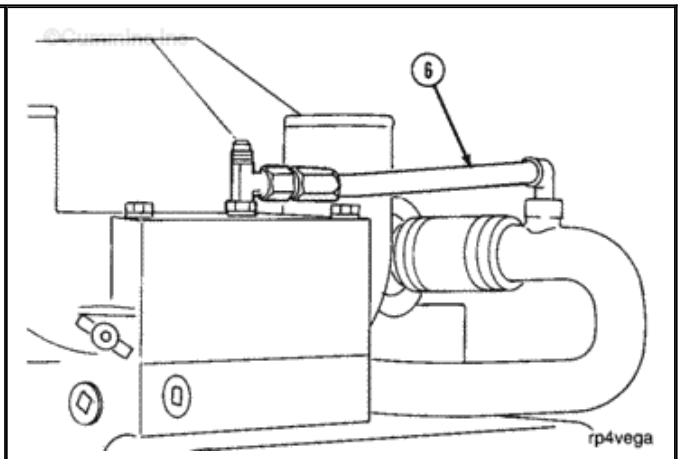
008-017 Coolant Vent Lines

General Information

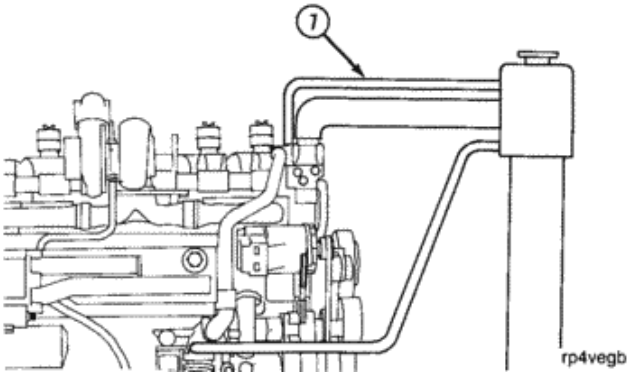
The cooling system **must** be designed to allow the air to escape while filling the radiator.



The aftercooler vent line is routed from the aftercooler outlet tube to the top of the thermostat housing (6).



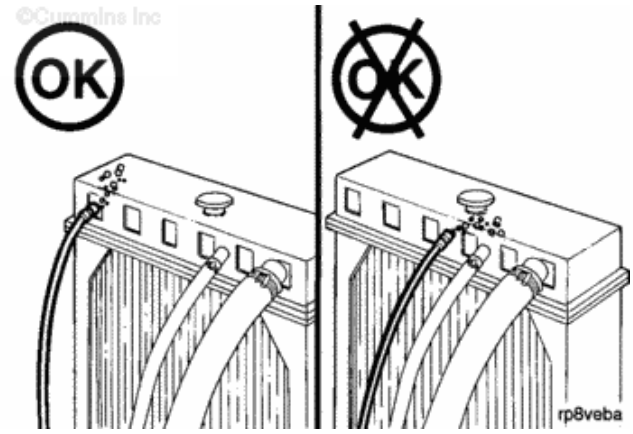
A second vent line (7) is routed from the top of the thermostat housing to the radiator top tank expansion space above the water level.



CAUTION

Do not route the fill or vent line in a manner that will allow air to be trapped in the system.

- 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.



Last Modified: 29-Nov-2004

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008-018 Cooling System

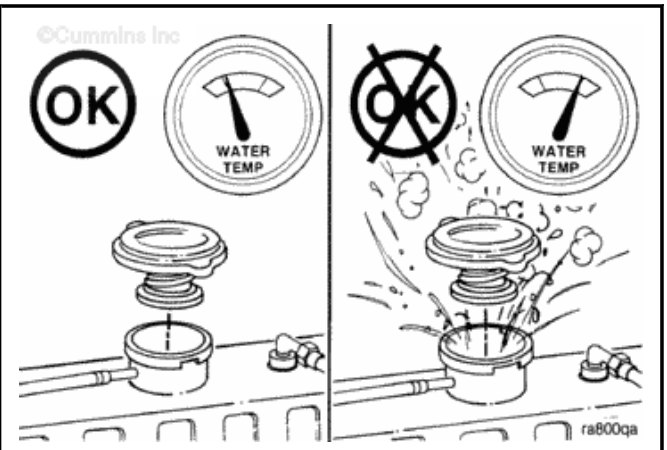
Drain

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.

NOTE: Marine engines will have a heat exchanger or keel coolers instead of a radiator.

Remove the radiator pressure cap after the engine is cool.



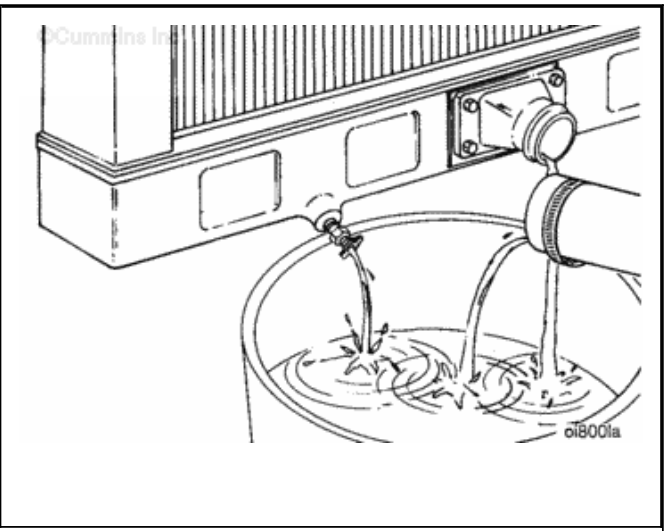
WARNING

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.

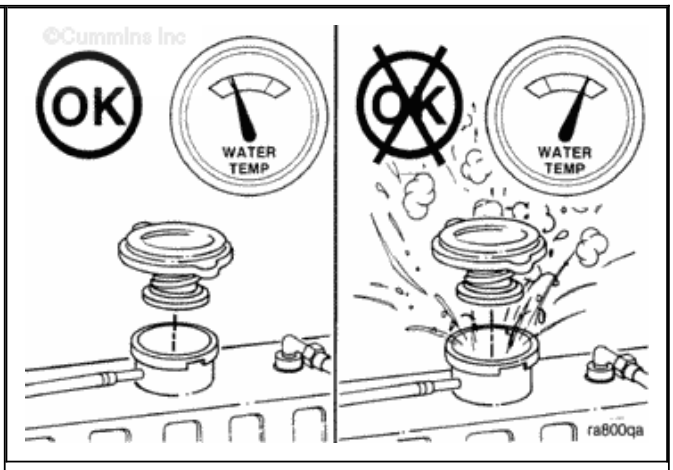


Flush

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.

Remove the radiator pressure cap after the engine is cool.



The performance of RESTORE™ cleaning solution is dependent on time, temperature, and concentration levels.

An extremely scaled or flow restricted system can require higher concentrations of cleaners, higher temperatures, or longer cleaning time.

RESTORE™ cleaning solution can be safely used up to twice the recommended concentration levels.

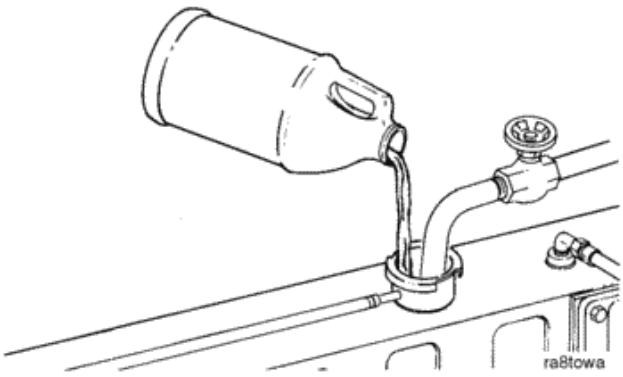
Extremely scaled or fouled systems can require more than one cleaning.



CAUTION

Fleetguard RESTORE® cleaning solution does not contain antifreeze. Do not allow the cooling system to freeze during the cleaning operation.

Immediately add 3.8 liters [1 gal] of Fleetguard RESTORE™, cleaning solution



or equivalent, for each 38 to 57 liters [10 gal] of cooling system capacity.

Fill the cooling system with plain water.

Turn the heater temperature to HIGH to allow maximum coolant flow through the heater core.

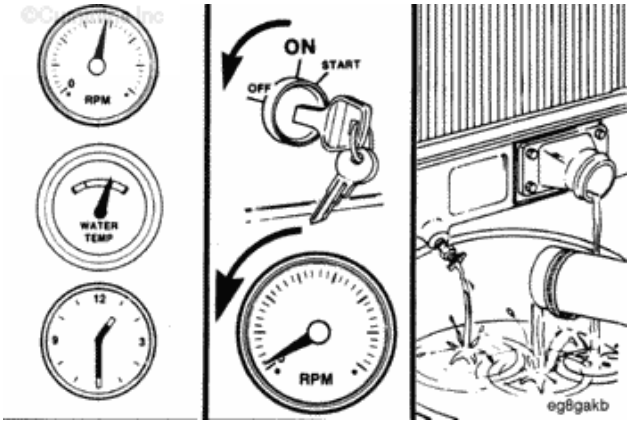
The blower does **not** have to be on.

WARNING

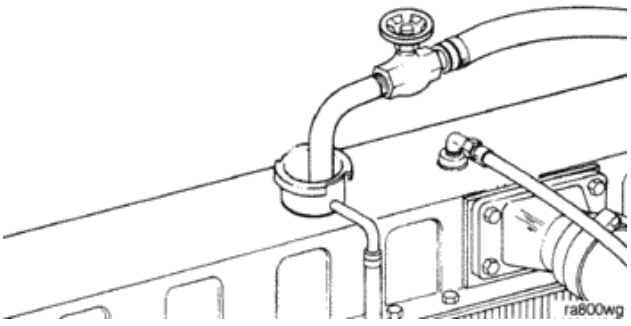
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Operate the engine to a minimum coolant temperature of 85°C [185°F] for 1 to 1½ hours.

Shut the engine off and drain the cooling system.



Fill the cooling system with clean water.



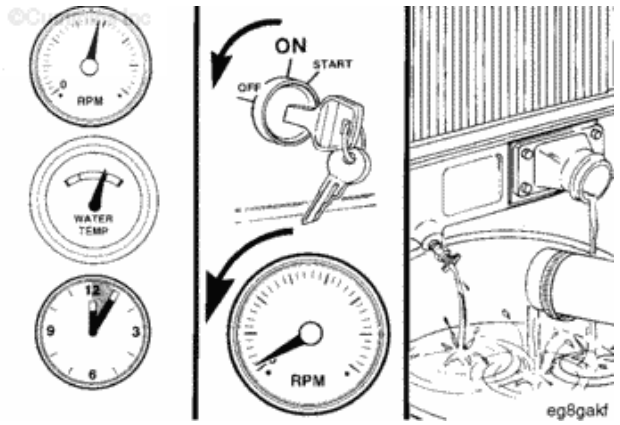
WARNING

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 high idle for five minutes with the coolant temperature above 85°C [185° F].

Shut the engine off and drain the cooling system.

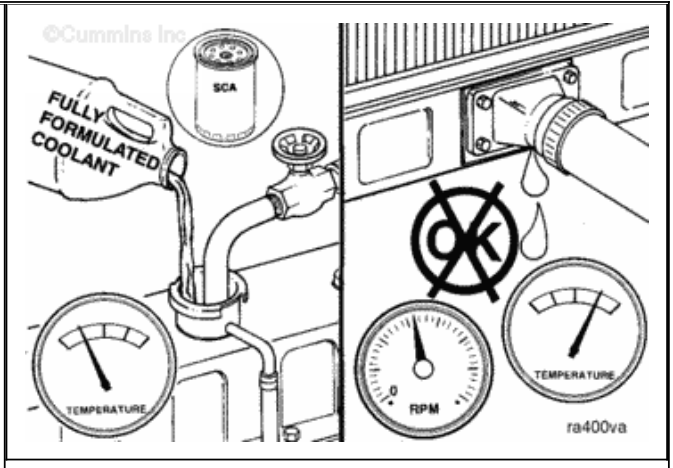
If the water drained is dirty, the system **must** be flushed again until the water is clean.



Install a new coolant filter. Refer to Procedure 008-006.

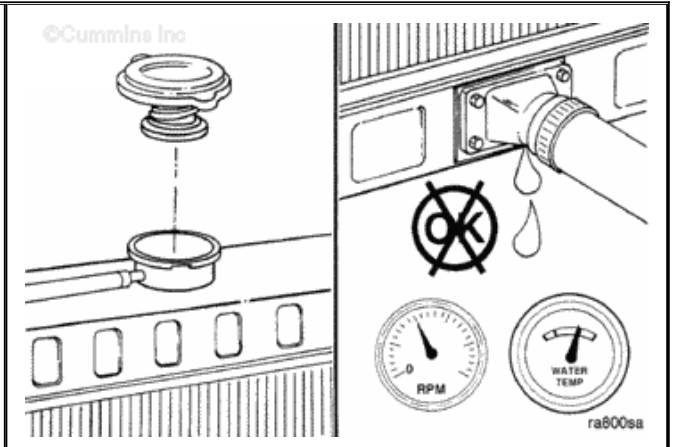
Fill the cooling system with fully formulated coolant.

Use additional SCA to bring the coolant to the correct SCA concentration level. Refer to Procedure 008-046.



Install the pressure cap.

Operate the engine until the coolant reaches a temperature of 70°C [160°F], and check for coolant leaks.



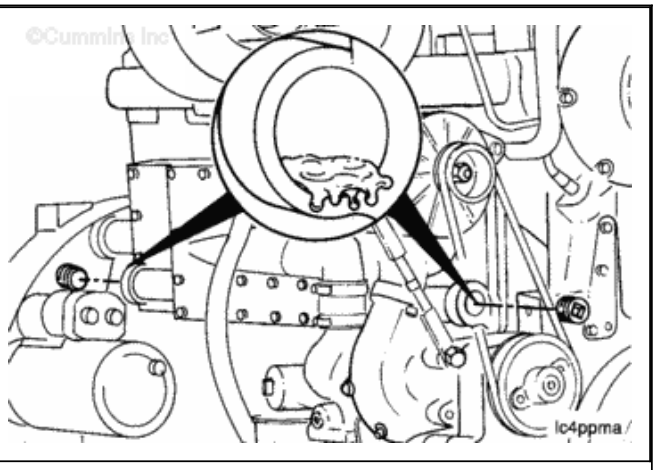
Pressure Test

Internal

Remove the plugs from the oil cooler housing and check for coolant.

If coolant is present, replace the oil cooler elements. Refer to Procedure 007-007.





WARNING

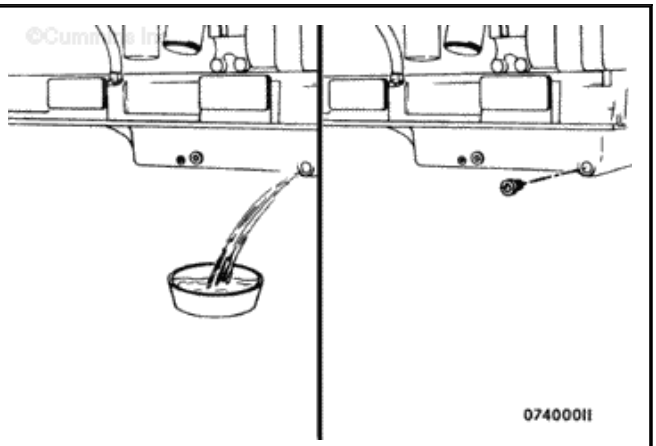
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

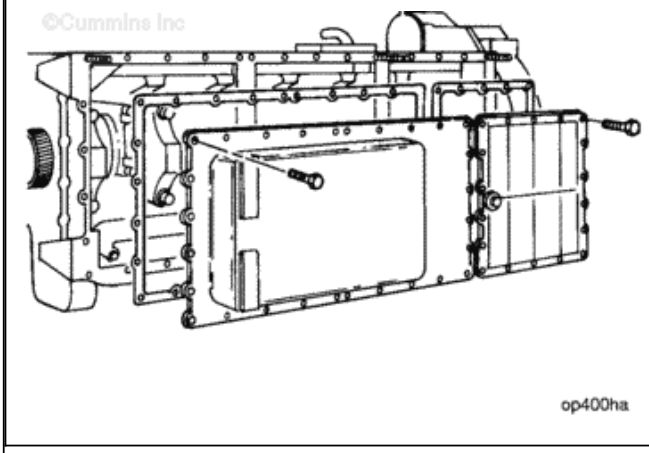
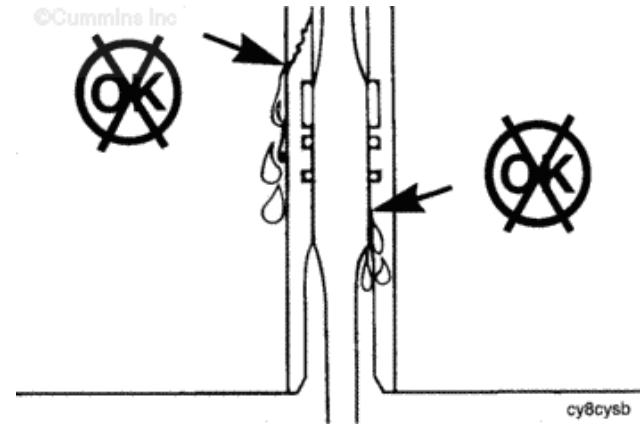
WARNING

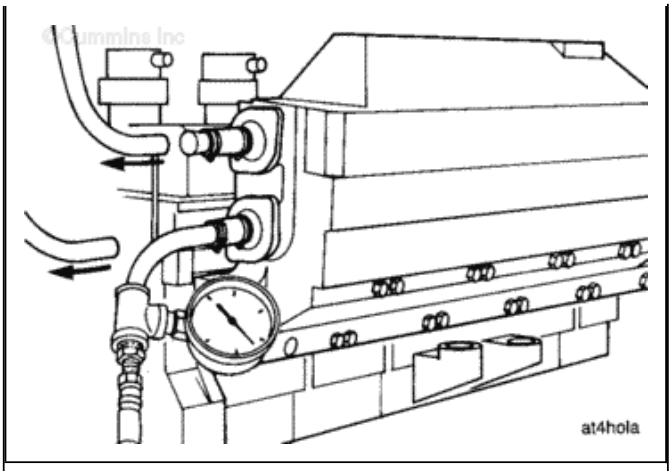
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused dispose of in accordance with local environmental regulations.

If the oil cooler elements are **not** leaking, drain the oil. Refer



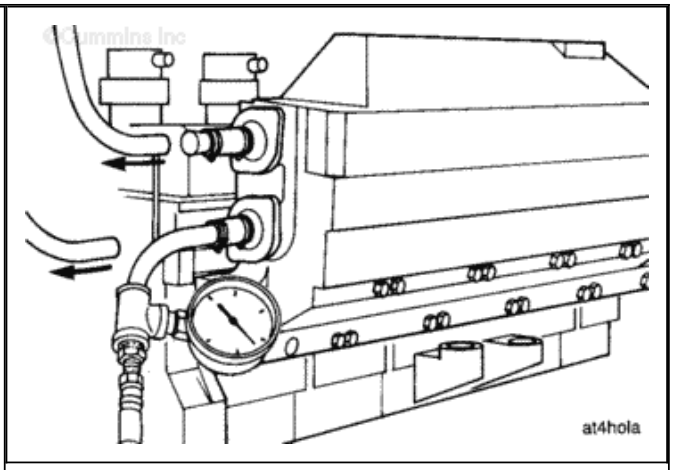


to Procedure 007-037. Check for coolant in the oil. If the oil does **not** contain coolant, check the aftercooler. Refer to Procedure 010-008.		
If the oil contains coolant: • Remove the lubricating oil pan. Refer to Procedure 007-025. • Remove the lubricating oil pan adapter cover. Refer to Procedure 007-026.		
Check for leakage on the inside and outside of the cylinder liners. Replace all cylinder liners that are leaking. If the cylinder liners are **not** leaking, check the aftercooler element.		
Disconnect the aftercooler coolant hoses. Plug one hose and apply 415 kPa [60 psi] of air pressure. If the air pressure decreases, replace the aftercooler element. Refer to Procedure 010-008.		



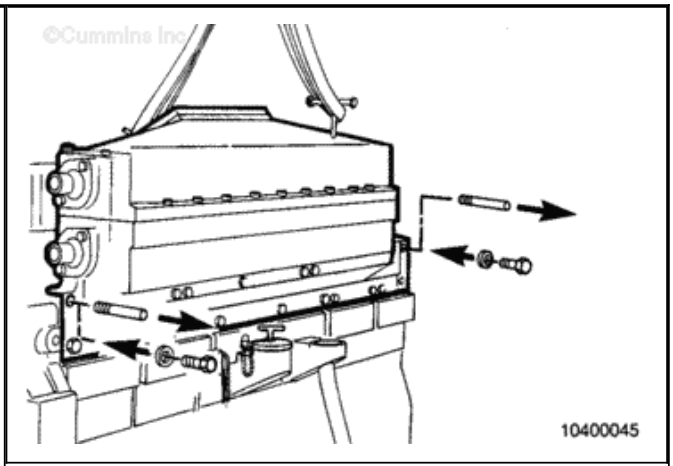
Remove the test equipment. Remove the plug from the overflow tube.

Replace the pressure cap.



If the aftercooler element is **not** leaking, check the cylinder heads.

Remove the aftercooler housing. Refer to Procedure 010-002.

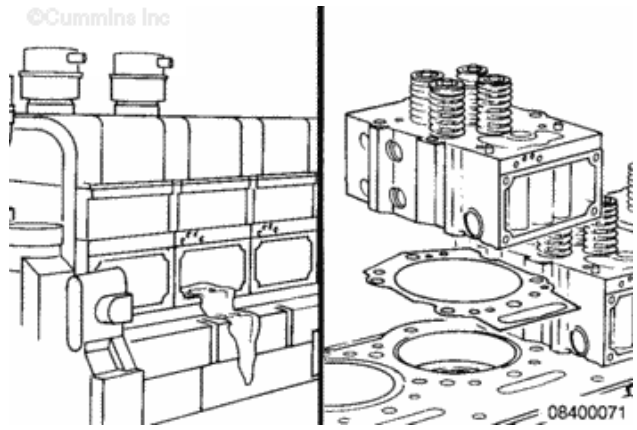


Check the intake ports in the cylinder head for coolant.

If the intake ports have

coolant, replace the cylinder head.

Refer to Procedure 002-004.

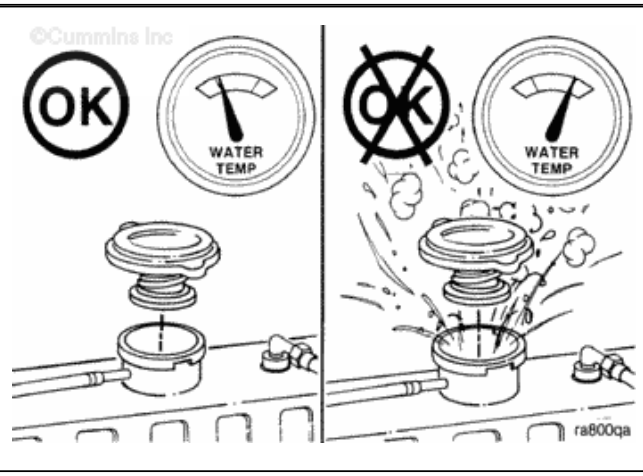


External

WARNING

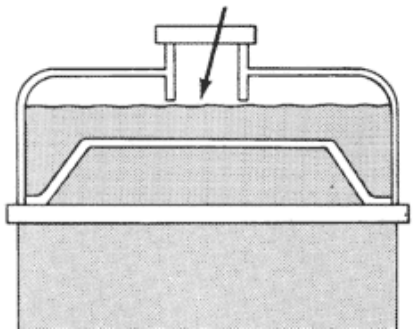
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

To confirm and locate external coolant leaks, it is **not** necessary to warm the engine.



Check the coolant and fill with heavy duty coolant if necessary.

To confirm and locate external coolant leaks that occur during normal operation, complete testing while the engine is warm.



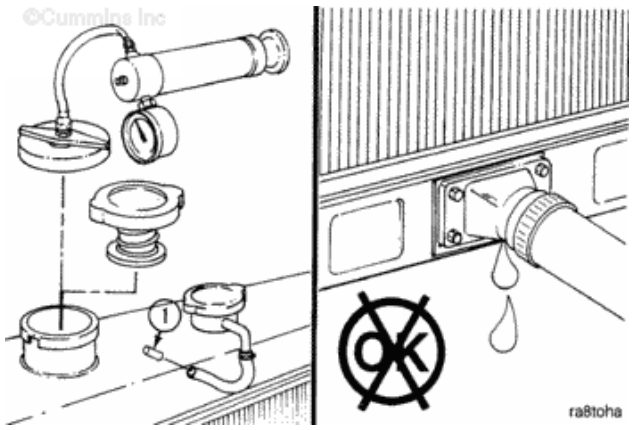
CAUTION

Do not apply more than 140 kPa [20 psi] of 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 a maximum of 140 kPa [20 psi] air pressure.

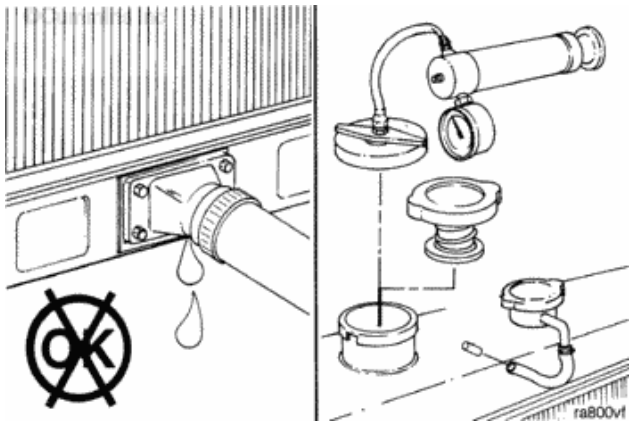


Maintain the air pressure for a minimum of five minutes.

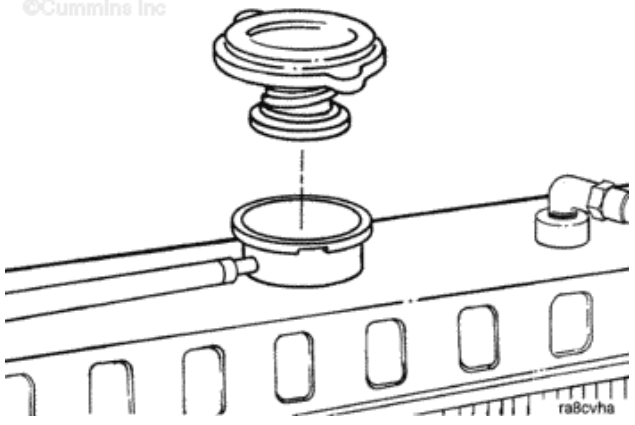
Check for leaks. Any leaks **must** be repaired.

Remove the pressure test equipment.

Remove the plug from the overflow tube (if equipped).



Replace the coolant system pressure cap.



Fill

Close the radiator draincocks.

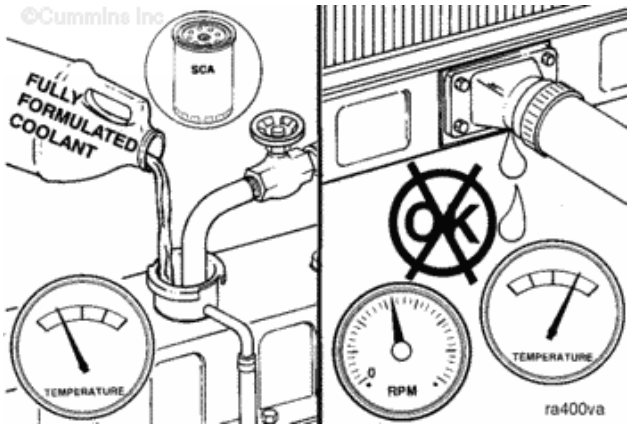
Install the lower radiator hose(s).

Tighten the hose clamps.

Torque
Value: 5 n.m [40 in-lb]

Use fully formulated coolant to fill the coolant system.

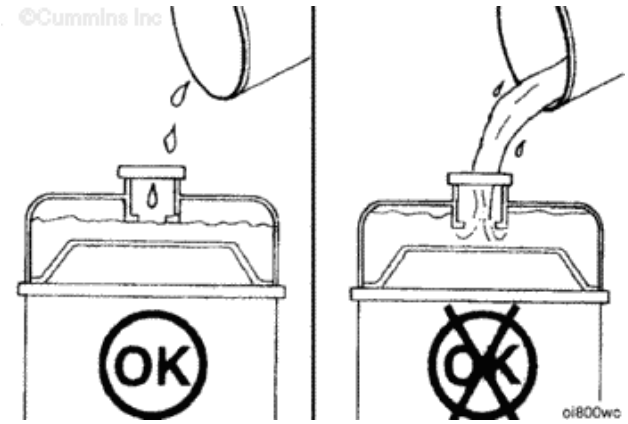
Use the correct units of SCA to obtain the correct cooling system protection. Refer to Procedure 008-046.



CAUTION

If the coolant level is above the bottom of the fill neck there will not be enough space for the air that is in the system. If the air is not trapped at the top of the radiator it can travel to the water pump inlet causing low coolant flow because of impeller cavitation. The cavitation can result in overheating of the engine.

Fill the cooling system with coolant to the bottom of the fill neck in the radiator or expansion tank.

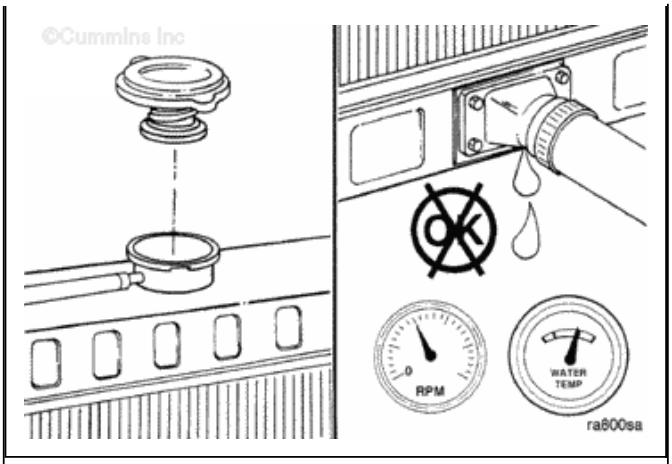


Replace the radiator or fill cap.

Operate the engine until the coolant reaches a

temperature of 70°C [160°F].

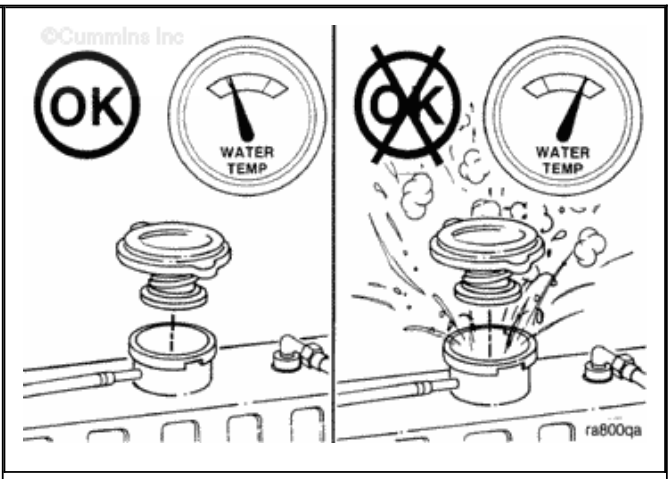
Check for leaks.



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, allow it to cool and check the coolant level.



Last Modified: 31-Jul-2006

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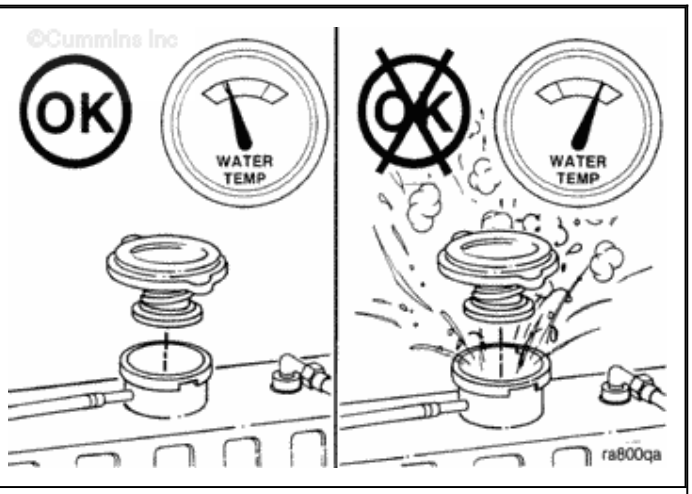
008-019 Cooling System - Air or Combustion Gas Test

Test

WARNING

Wait until the temperature is below 50°C [120°F] before removing the coolant system pressure cap. Failure to do so can cause personal injury from heated coolant spray.

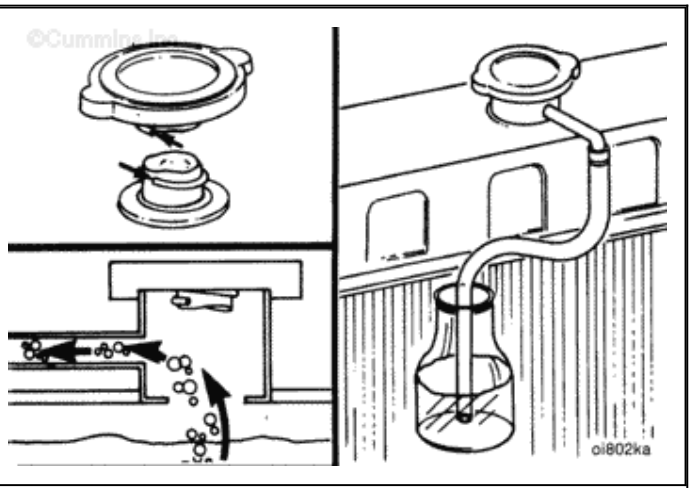
Allow the engine to cool. Remove the radiator cap.



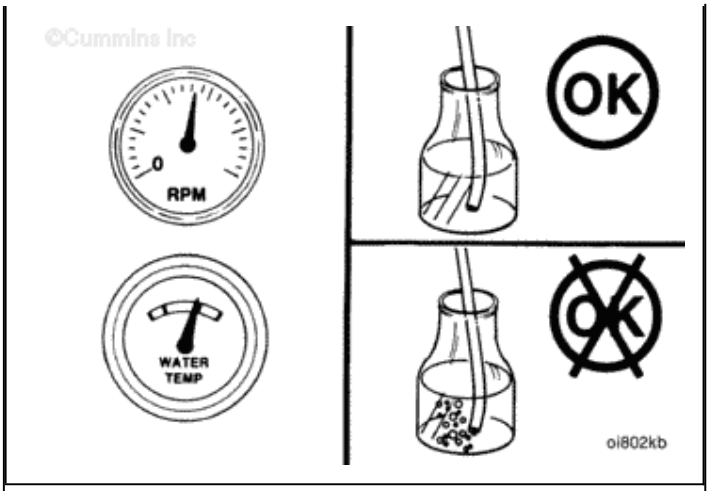
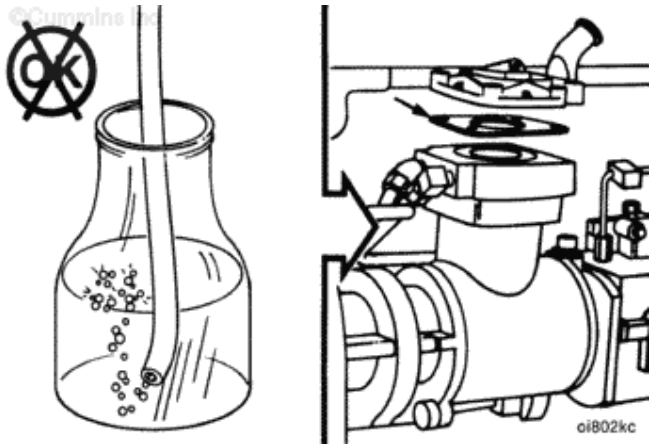
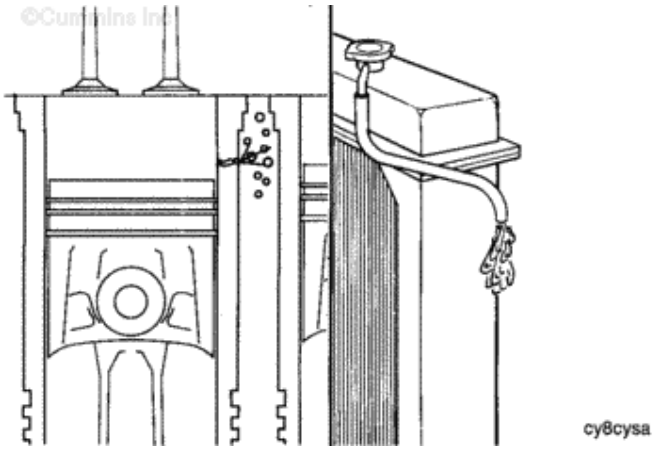
NOTE: The pressure cap must make a tight seal.

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.		
A continuous flow of air bubbles indicates: • An air compressor cylinder head leak. Inspect the air compressor head and gasket. Refer to Procedure 012-103, 012-104, or 012-106.		
• 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.		

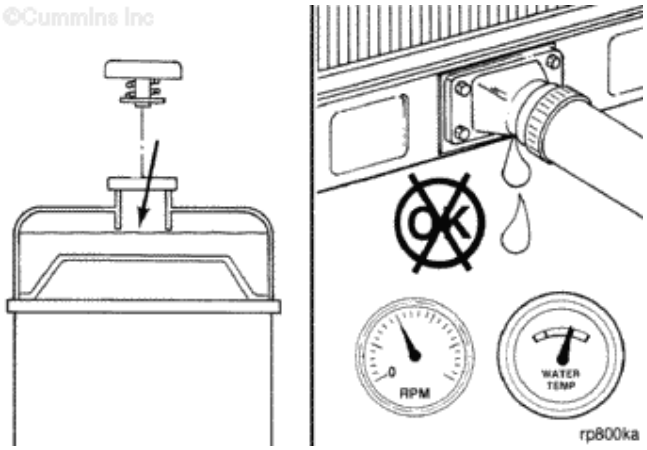
If no air is in the system, do the following.

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.



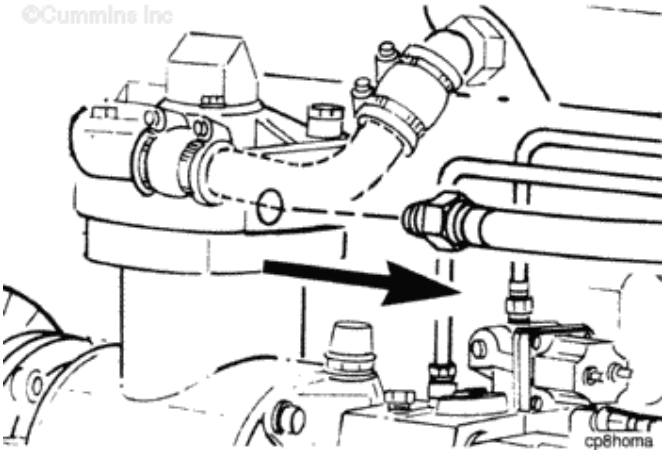
Air Compressor

CAUTION

The air compressor discharge must be disconnected at the compressor. This will allow the compressor to discharge air to the atmosphere to prevent the compressor from overheating during this test.

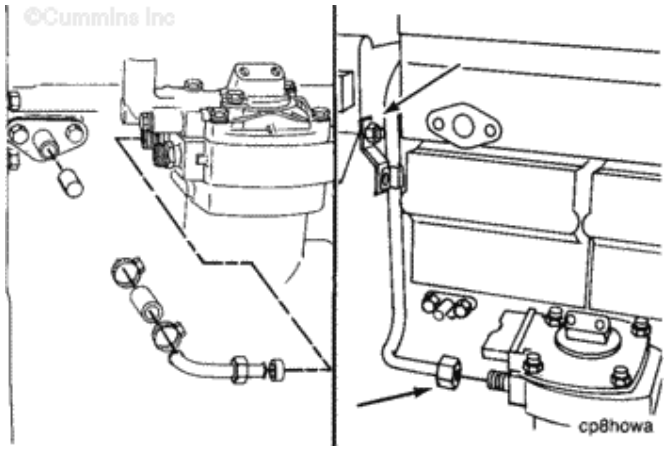
CAUTION

Do **not** operate the engine over 5 minutes with the components isolated from the cooling system. Component damage can result.

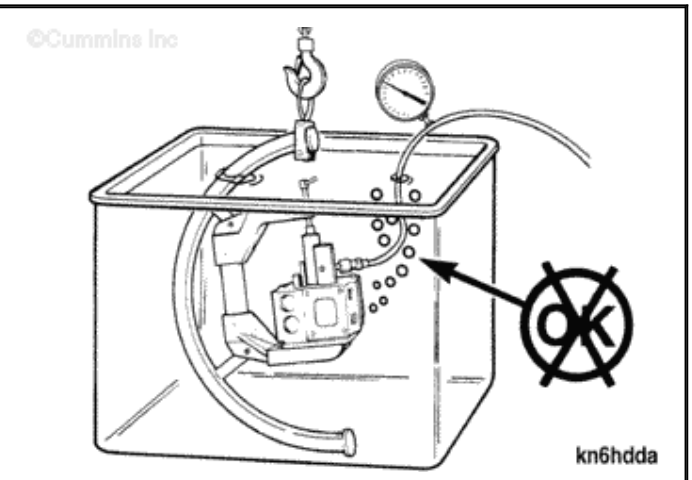
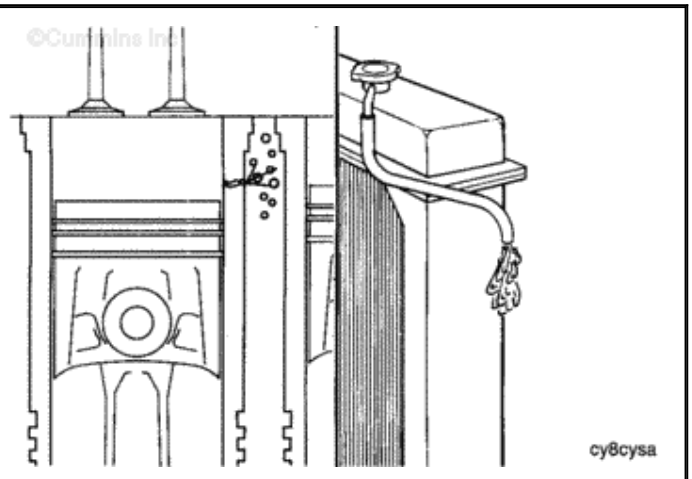


Disconnect and plug the coolant supply and coolant drain lines.

Repeat the test. If no air is found in the cooling system with the

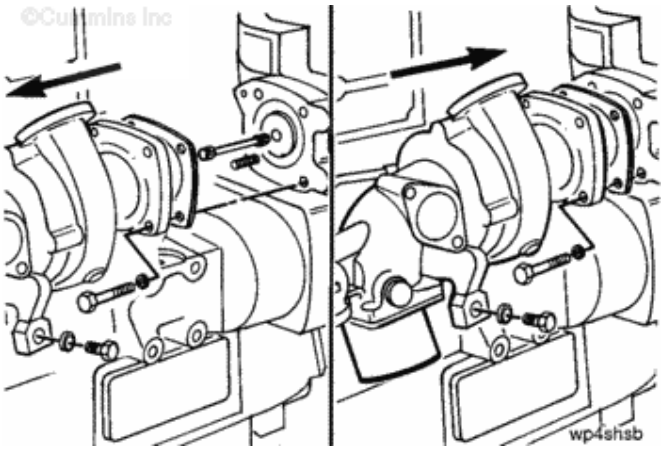
air compressor isolated, replace the air compressor head gasket. Refer to Procedure 012-007.		

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.		
A cracked or porous cylinder liner will pressurize the cooling system and force coolant out the overflow tube. Check the cylinder liner. The liner **must** be replaced if defective. Refer to Procedure 001-028.		

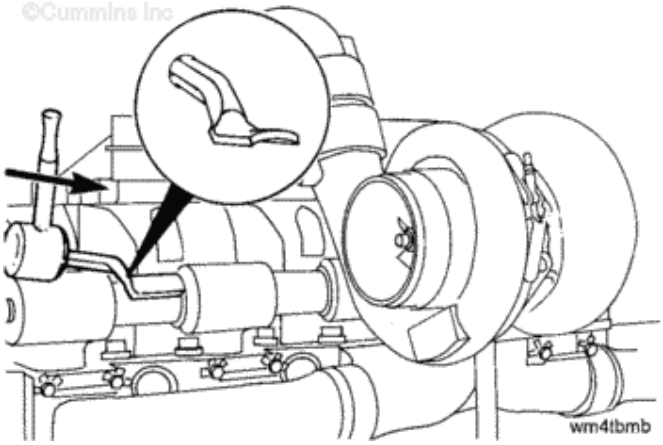
To determine the cylinder liner that is leaking, perform the following:

- Remove the water pump. Refer to Procedure 008-062.
- Remove the drive shaft.
- Install the water pump without the drive shaft.



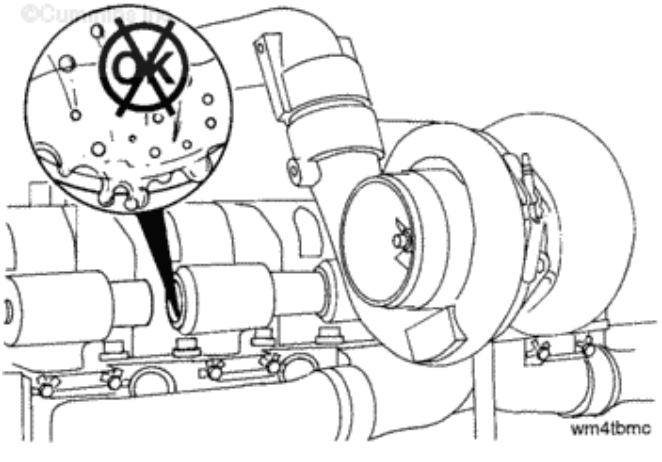
NOTE: Drain part of the coolant so the coolant level will be level with the water manifold tubes.

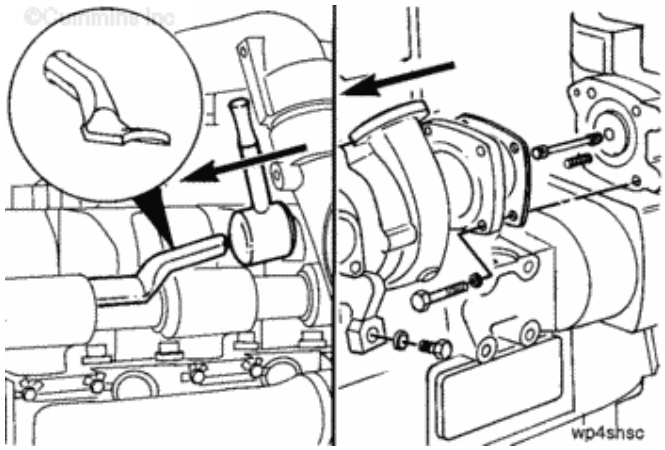
Slide the water manifold tubes into the rocker lever housing.



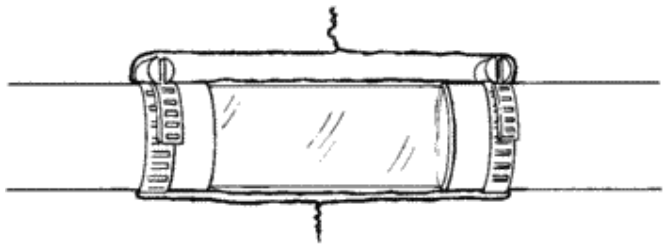
Operate the engine at low idle for a maximum of 4 minutes. Check inside the water passage of each rocker lever housing for air bubbles. Air bubbles in the coolant indicate a porous or cracked cylinder liner.

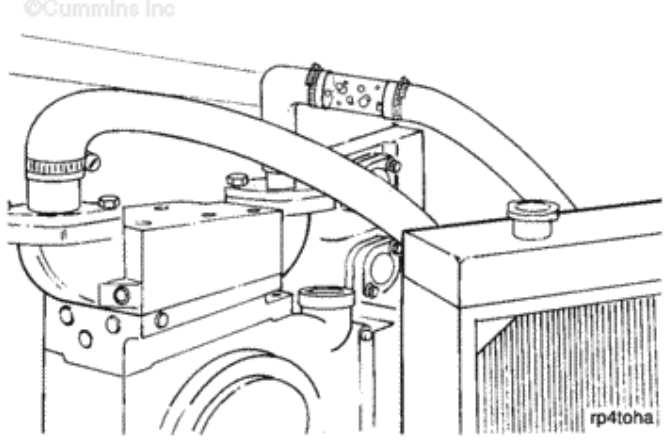
A defective cylinder liner **must** be replaced. Refer to Procedure 001-028.

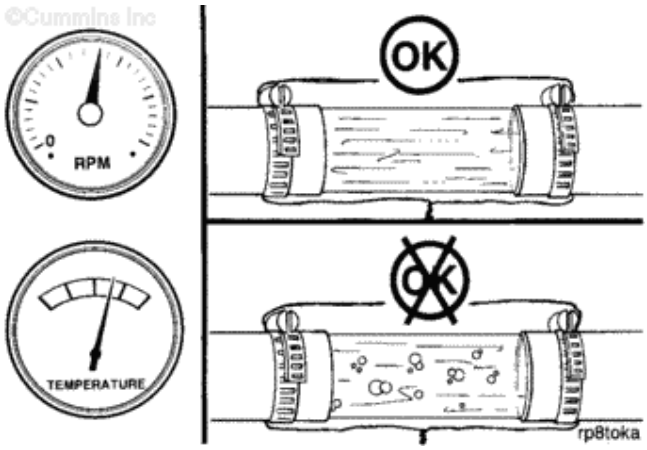
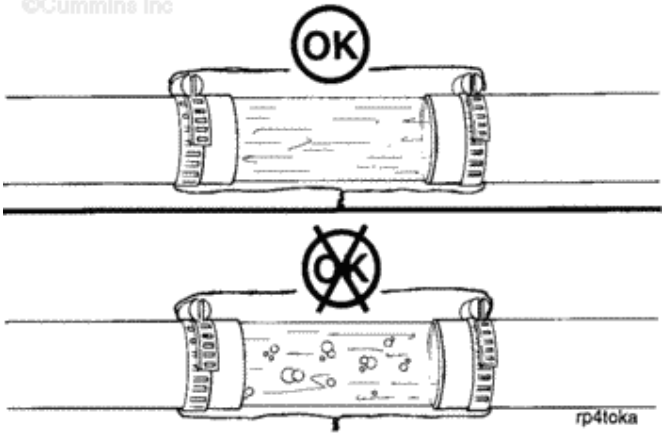


Install the water tubes and water pump drive shaft.		

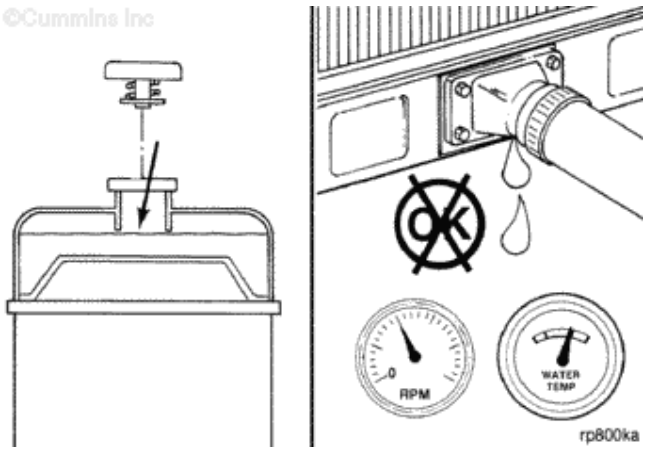
Sight Glass Method

Put a clear Pyrex® tube in the water connection between the engine radiator and the thermostat housing. **NOTE: If desired, put the Pyrex® tube in the vent line between the thermostat housing and the radiator.**		

CAUTION Use wire lace to cover the tube and hose. 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: • Air compressor cylinder head leak. Inspect the air compressor head and gasket. Refer to Procedure 012-103, 012-104, or 012-106. • 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.		

Last Modified: 12-Jan-2005

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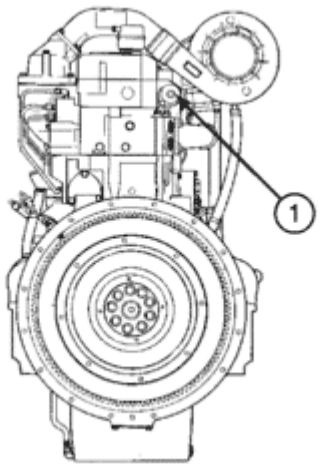
008-020 Cooling System Diagnostics

Pressure Test

Use a pressure gauge with a minimum capacity of 275 kPa [40 psi]. Measure the coolant pressure at the water manifold (1).

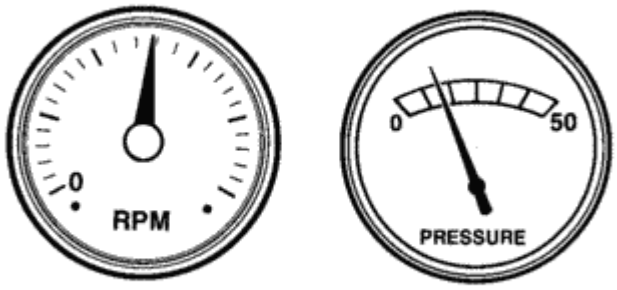
Operate the engine until the coolant temperature reaches 80°C [180°F].

The thermostats **must** be open.



Operate the engine at rated rpm. Compare the pressure readings to the following specifications.

Minimum Coolant Pressure-At-Water Manifold		
Engine rpm	kPa	psi
1800	75	11



1900	82	12
2100	89	13

Coolant Pressure (Cap Removed)

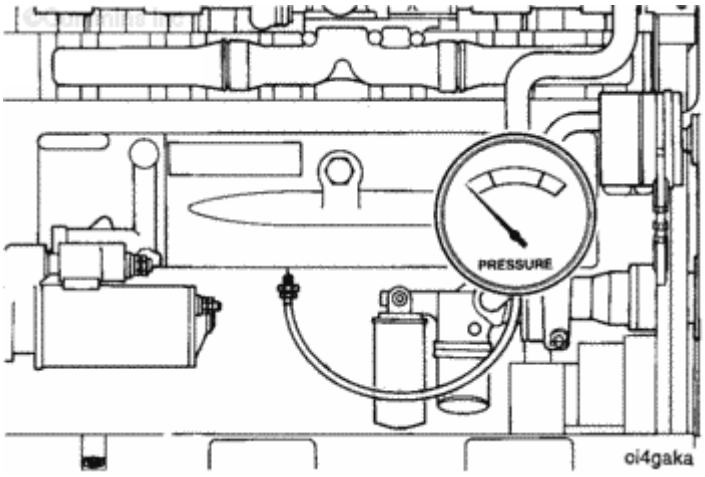
kpa		psi
241	MAX	35

If the above measurement location is **not** accessible, install the gauge in the oil cooler housing in place of the draincock.

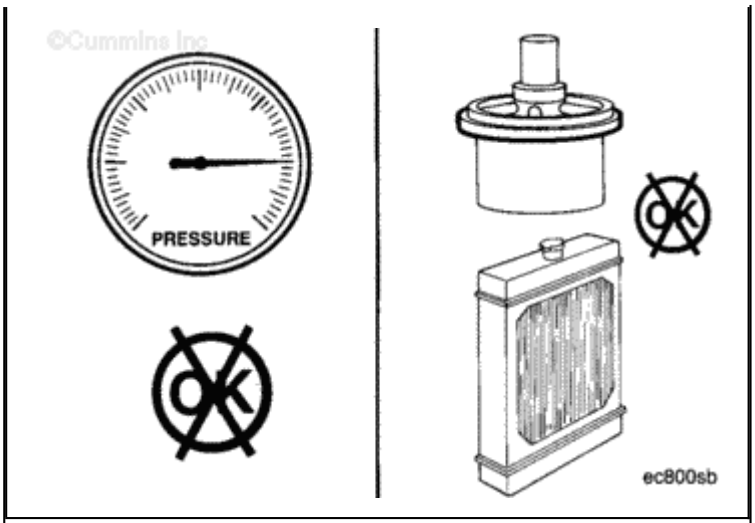
Minimum Coolant Pressure-At-Oil Cooler Housing		
Engine rpm	**kPa**	**psi**
1800	103	15
1900	117	17
2100	131	19

Coolant Pressure (Cap Removed)

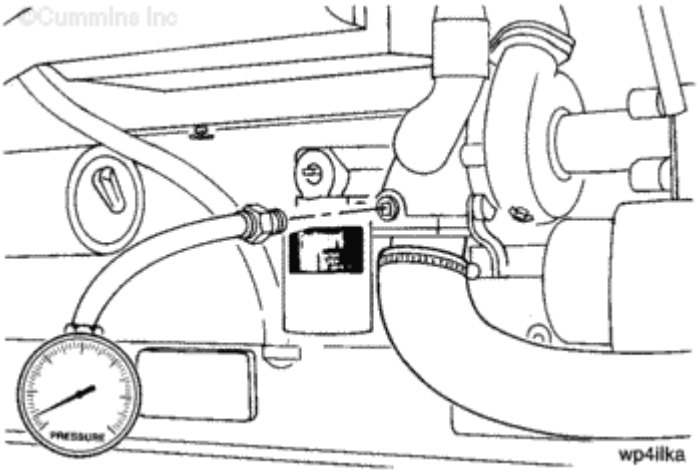
kpa		psi
241	MAX	35



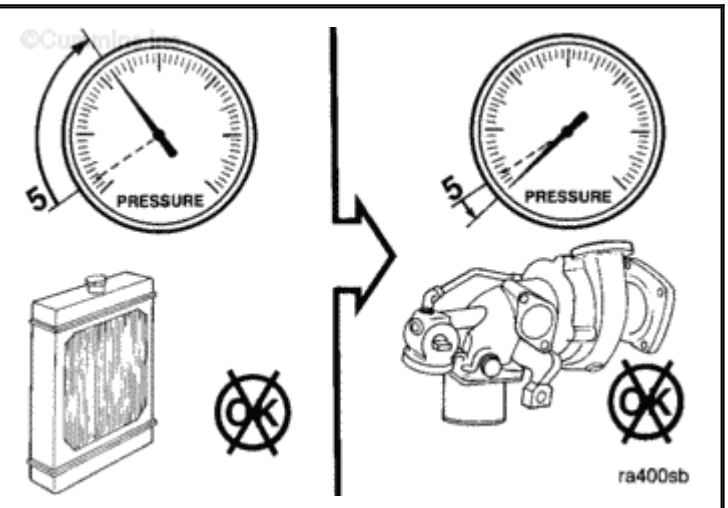
If coolant pressure is high, check the thermostat or radiator for a restriction. Refer to Procedure 008-042.

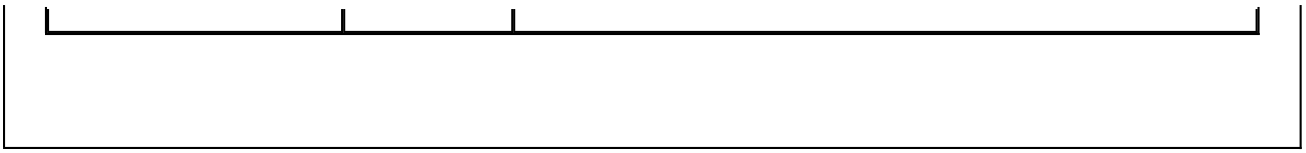


If the coolant pressure is low, install a gauge, with a maximum capacity of 69 kPa [10 psi], at the water pump inlet.



Operate the engine at rated rpm. If the gauge reads more than 35 kPa [5 psi], check the radiator. Refer to Procedure 008-042.





Last Modified: 04-Nov-2004

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008-022 Cooling System Service Requirements

General Information

Always use good quality soft water in the coolant mixture. Water added to the cooling system **must** meet the specifications given in the accompanying chart.

Mineral	Problem Cause	Max. Limit
Calcium Magnesium (hardness)	Deposits on Liners/Heads/ Coolers	170 PPM
Chloride	General Corrosion	40 PPM
Sulfate	General Corrosion	100 PPM

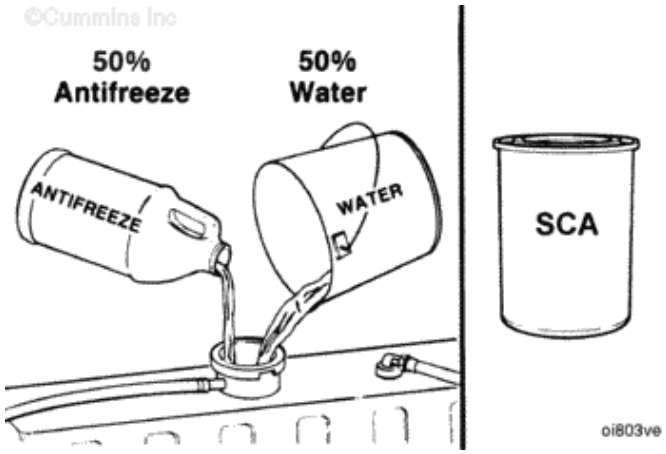
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CAUTION

Antifreeze over concentration reduces protection. Do not use more than 68 percent antifreeze or overheating can result. A mixture of 50 percent antifreeze and 50 percent water is sufficient for freeze protection to -37°C [-34°F]

CAUTION

Do not use a high silicate antifreeze. A silicate-gel (hydro-gel) formation can occur when a cooling system contains an over

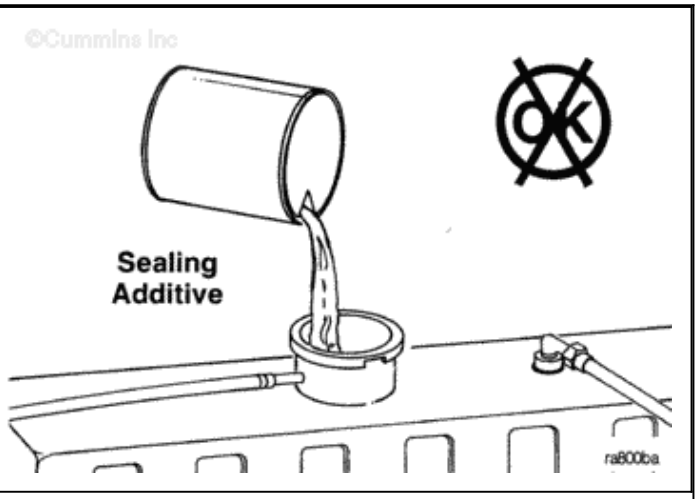


concentration of high silicate antifreeze and/or supplemental coolant additives. Engine damage will result.

Use ethylene propylene glycol antifreeze year-round to provide freeze point and boil-over protection.

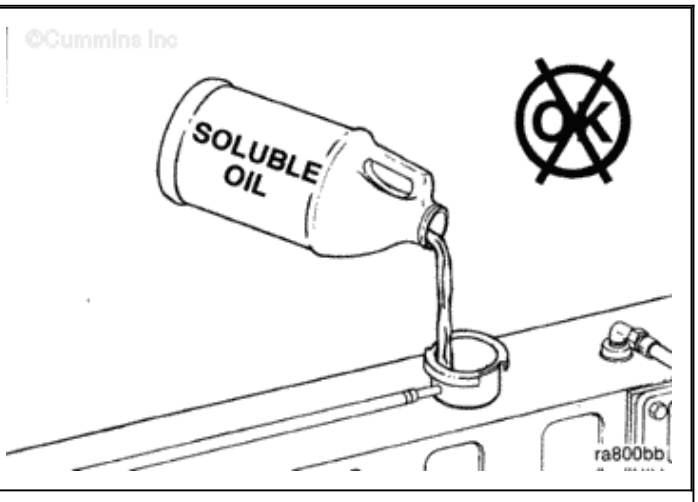
Do **not** use sealing additives in the cooling system. Using sealing additives will cause the following problems:

- Buildup in coolant low flow areas
- Clogged coolant filters
- Plugged radiator.



Do **not** use soluble oils in the cooling system. The use of soluble oil will:

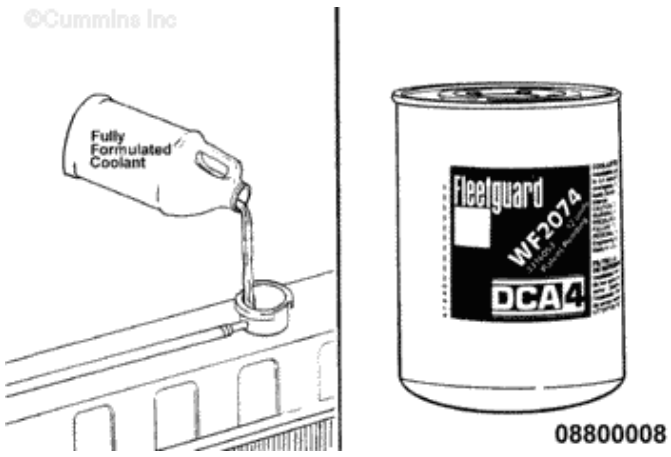
- Allow cylinder liner pitting
- Corrode brass and copper
- Damage heat-transfer surfaces
- Damage seals and hoses.



Supplemental coolant additives, SCA or equivalent are required to protect the cooling system from fouling,

solder blooming, liner pitting, and general corrosion. The coolant filter is required to protect the cooling system from abrasive material, debris, and precipitated coolant additives.

For more information refer to the Cummins Coolant Requirements and Maintenance, Bulletin 3666132.

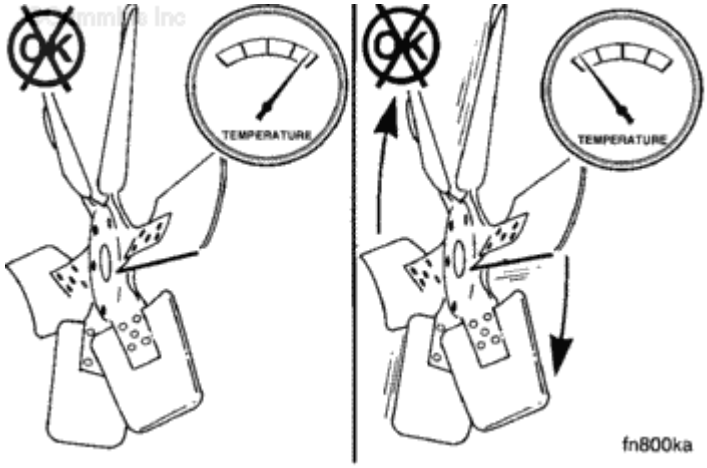
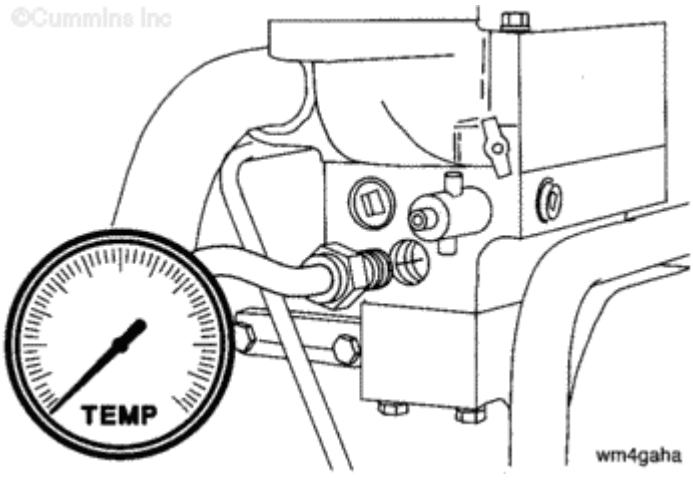


Last Modified: 20-Dec-2004

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008-025 Fan Clutch, Air-Engaged

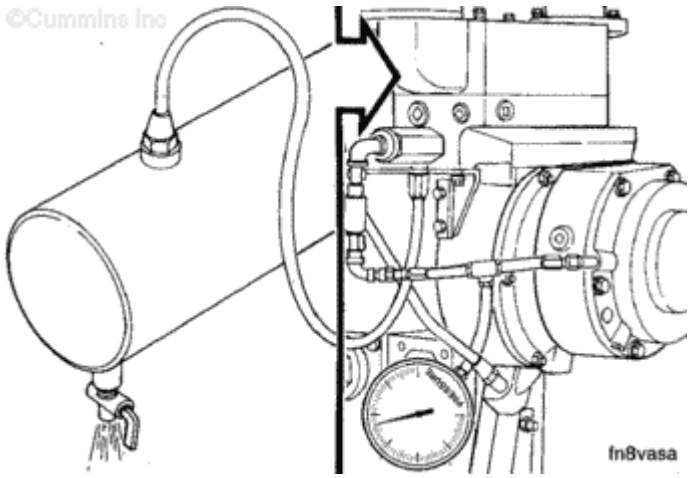
Test

This procedure assume the fan is **not** turning at the correct rpm. Refer to Procedure 008-040. At idle, on a cold engine, the fan will turn less than 350 rpm. At idle on a hot engine the fan will turn at the correct ratio to engine speed.		
Install a master temperature gauge, which is known to be accurate, into the thermostat housing.		
On a cold engine		

there will be air pressure in the line between the thermal control valve and fan clutch.

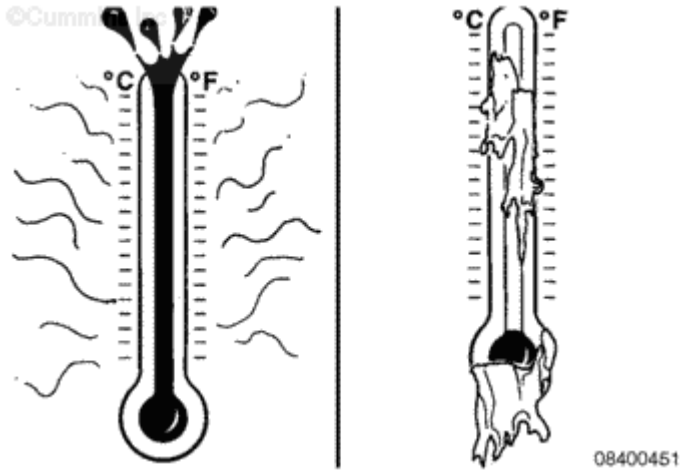
Drain the pressurized air in the tank the supplies air to the control valve.

Install a pressure gauge, with the minimum capacity of 1035 kPa [150 psi], in the line between the thermal control valve and the fan clutch.



The two fan clutch complaints are:

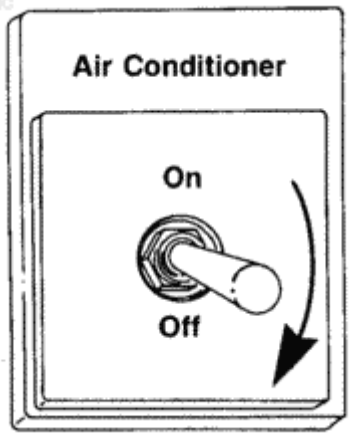
- Engine coolant below normal (fan clutch engaged)
- Engine coolant above normal (fan clutch **not** engaged).



For the complaint of, the engine coolant is below normal (fan clutch engaged), perform the following steps.

If the vehicle is air conditioned, make

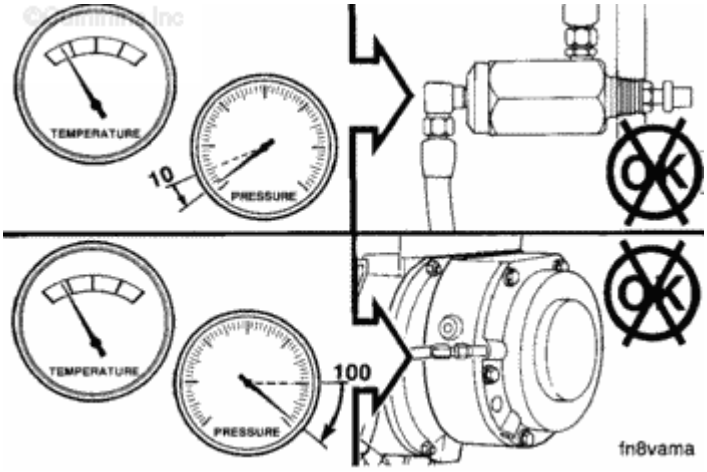
sure the air conditioning is turned off to prevent continuous operation of the fan.



Operate the engine and read the pressure gauge.

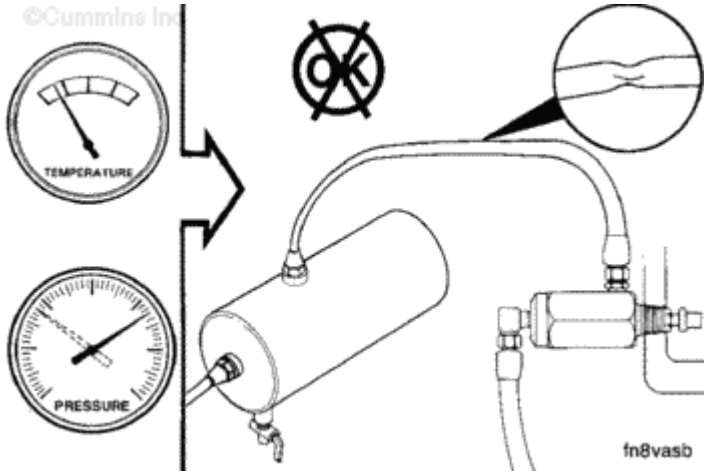
If the air pressure is less than 69 kPa [10 psi], replace the thermal control valve.

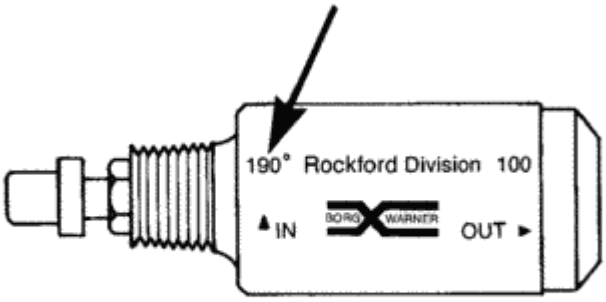
If the air pressure is greater than 690 kPa [100 psi], replace the fan clutch.

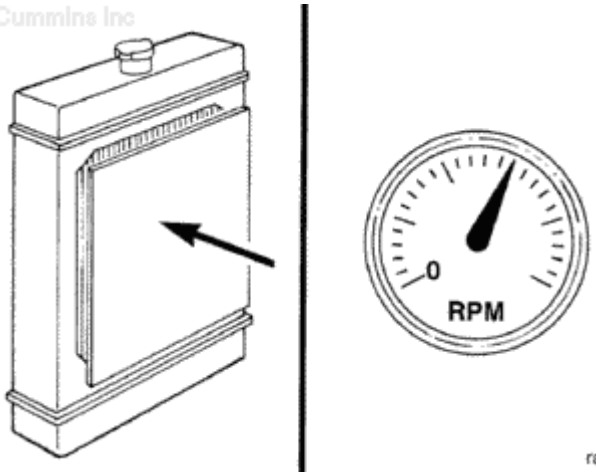


If the air pressure is more than 83 kPa [12 psi] but less than 690 kPa [100 psi], the air supply line is restricted.

Check the air line for a restricted component.

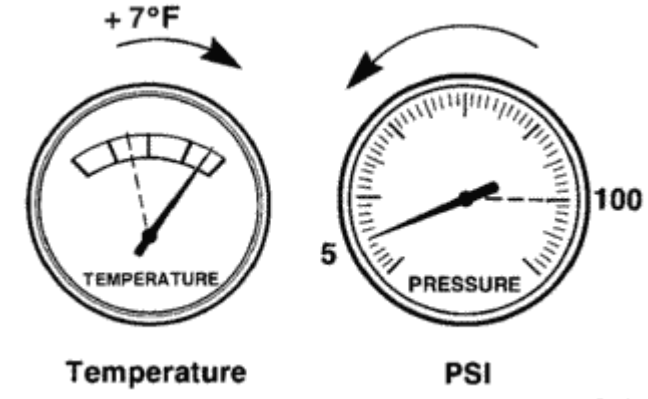


For the complaint of, the engine coolant is above normal (fan clutch **not** engaged), perform the following steps. Record the temperature setting on stamped on the thermal control valve. This temperature **must** be at least 2.78°C [5°F] higher than the engine thermostats (standard thermostats are 85°C [185°F]). If shutters are installed in the system, this temperature **must** be 2.78°C [5°F] higher than the temperature on the shutter control.		©Cummins Inc  fn8vaga
Restrict the radiator air flow. Operate the engine until the coolant temperature rises to the temperature stamped on the thermal control valve.		



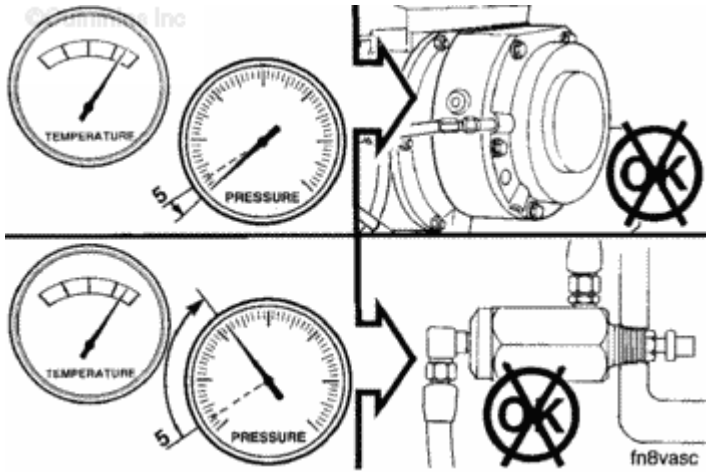
Continue to operate the engine allowing the coolant temperature to rise another 3.89°C [7°F].

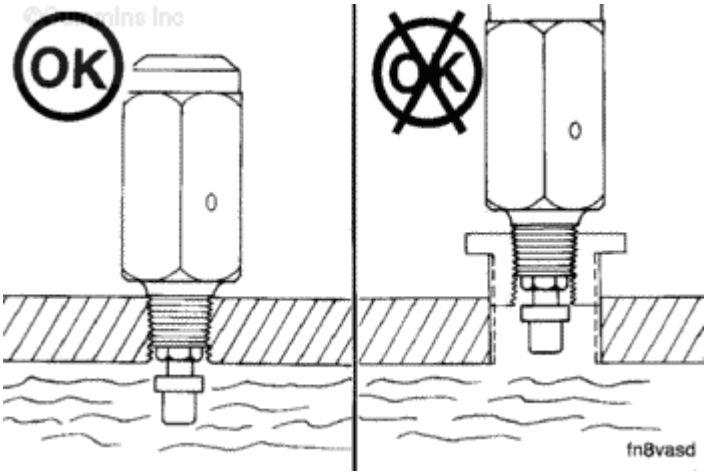
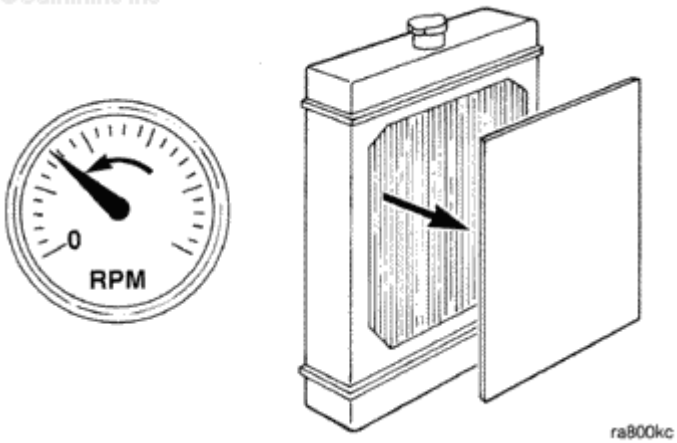
The air pressure **must** smoothly decrease to less than 34 kPa [5 psi].

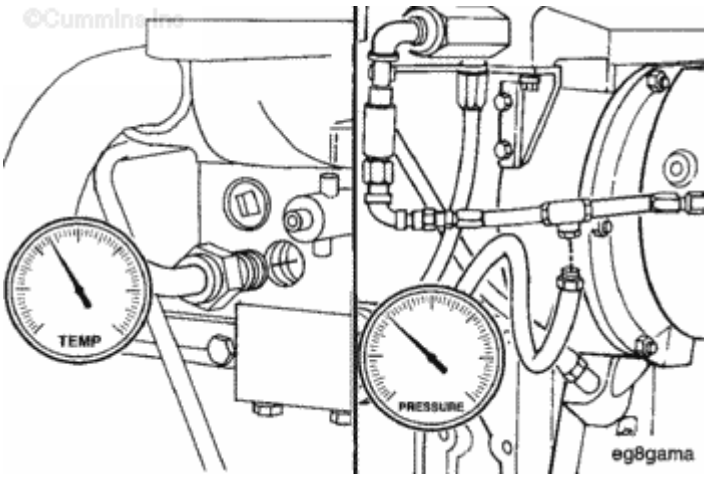


If the air pressure decreases to less than 34 kPa [5 psi], replace the fan clutch.

If the air pressure is more than 34 kPa [5 psi] replace the thermal control valve.



Check to be sure the tip of the thermal control valve is in the coolant. Do **not** use a reducer bushing when installing the thermal control valve. Using a reducer will prevent the tip from contacting the coolant, as illustrated in the graphic.		
Remove the radiator cover. Operate the engine at idle for three to five minutes to allow the engine to cool down.		
Remove the test components.		



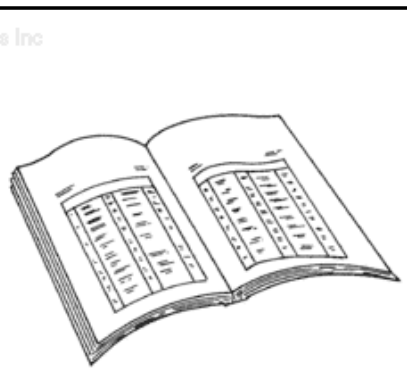
Last Modified: 10-Dec-2004

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008-029 Fan Drive Idler Arm Assembly

Preparatory Steps

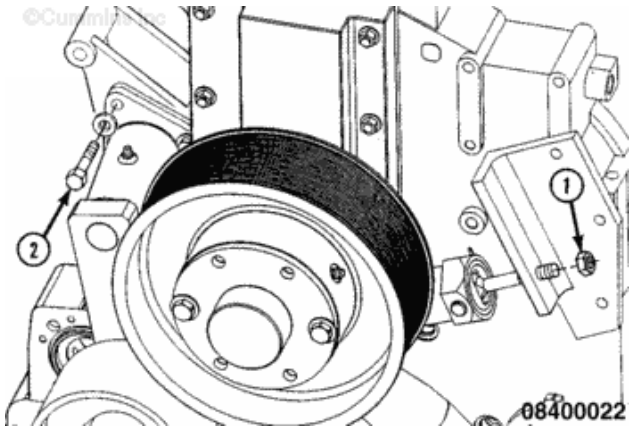
- Remove the fan belt. Refer to Procedure 008-002.



Remove

WARNING

The belt tensioner and pivot arm assembly will rotate during removal. To reduce the possibility of personal injury, use a hoist or get assistance to remove the belt tensioner and pivot arm assembly.



Three types of fan belt tensioning arrangements are used on K19 engines:

- Shock absorber

- Control rod with spring (turnbuckle)
- Enclosed spring.

Only the enclosed spring style is shown. The procedure is the same for all types of arrangements except where indicated.

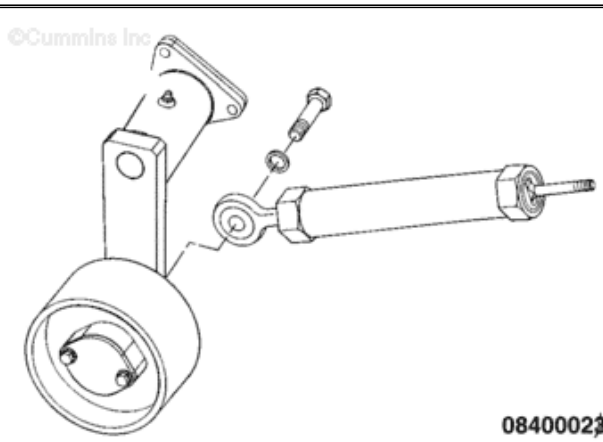
Remove the belt adjusting nut (1) from the tensioner assembly.

Remove the three capscrews (2) from the pivot arm assembly.

Remove the pivot arm and belt tensioner as an assembly.

Remove the belt tensioner from the idler arm assembly.





Inspect for Reuse

Rotate the idler pulley to check for rough bearings.



Inspect the grease seal for damage.

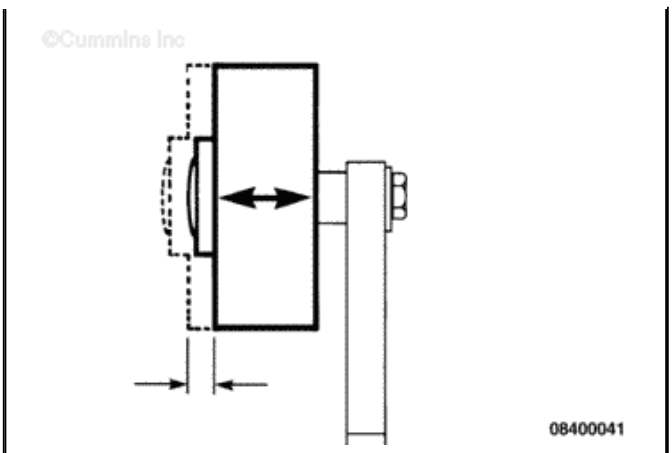


Check the bearing end clearance.

Idler Pulley Bearing End Clearance

mm		in
0.08	MIN	0.003
0.25	MAX	0.010

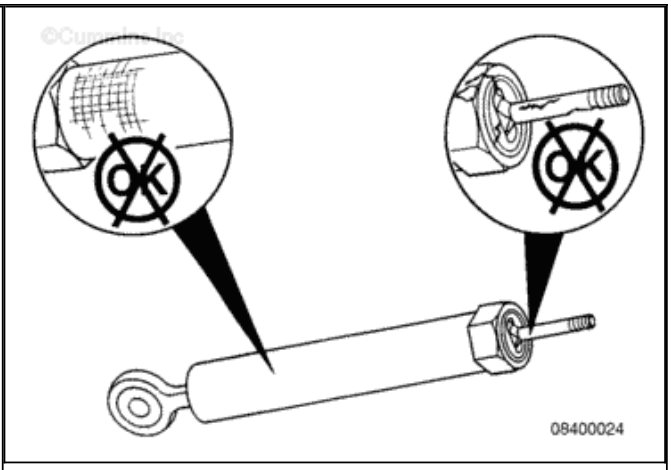
If the pulley is **not** within specifications, the pulley **must** be replaced.



Inspect the belt tensioner assembly for cracks for excessive wear.

Check the rod ends for excessive wear.

If the belt tensioner assembly is cracked or worn, it **must** be replaced.

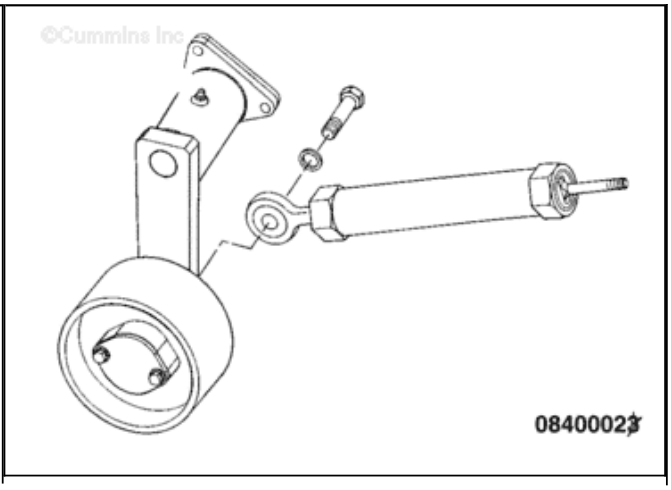


Install

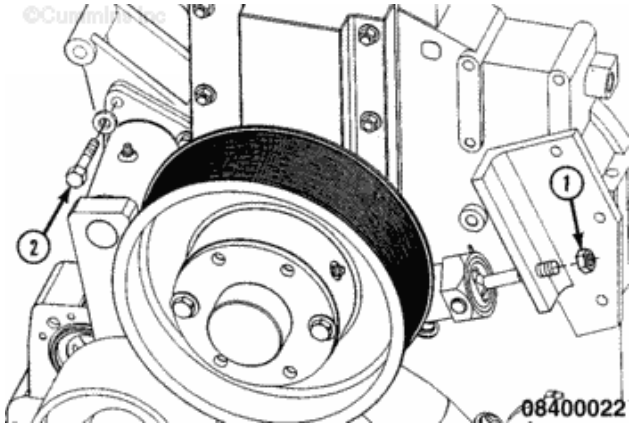
Install the belt tensioner onto the idler arm.

Tighten the capscrew.

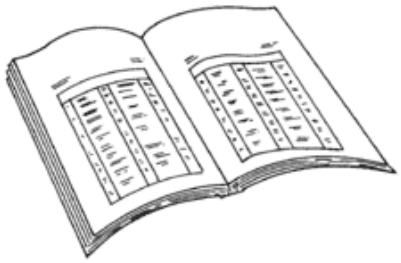
Enclosed Spring Style	201 n.m	[75 ft-lb]
Shock Absorber and Control	45 n.m	[33 ft-



Rod with Spring Style lb]		

Install the idler arm assembly and capscrews (2). Tighten the capscrews. **Torque Value:** 45 n.m [33 ft-lb] Install the belt tensioning nut (1). Do **not** tighten the nut.	 	

Finishing Steps

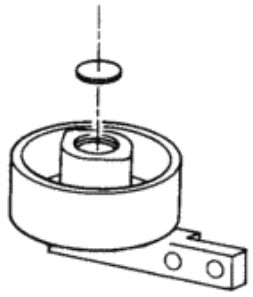
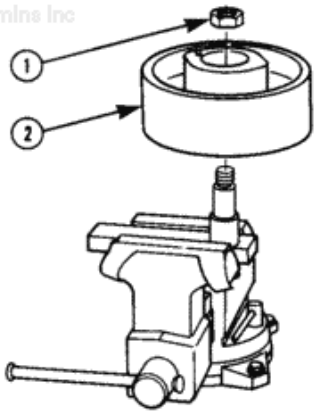
• Install the fan belt. Refer to Procedure 008-002.	 	

Last Modified: 28-Jul-2006

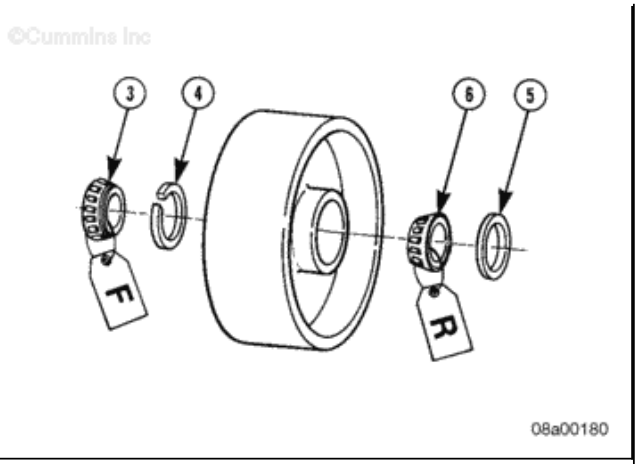
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008-030 Fan Drive Idler Pulley Assembly

Disassemble

Remove the expansion plug from the pulley. **NOTE: Some pulleys have a plate and gasket instead of the expansion plug.** Remove the plate and gasket.		 08a00178
The locknut has a left hand thread. To loosen the nut turn to the right. Remove the locknut (1). Lift out the pulley (2) off the shaft.		 08a00179
Remove the seal (5). Remove the bearings (3) and (6). Mark them for location. Remove the inner bearing spacer (4).		

NOTE: The bearings and spacers are part of a kit. All parts must be replaced if any part is worn or damaged.



Clean and Inspect for Reuse

WARNING

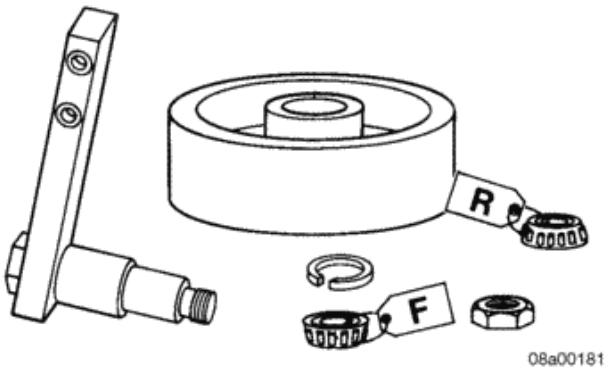
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION

Do not allow the force of the compressed air to turn the bearing when cleaning. Bearing damage will result due to lack of lubrication.



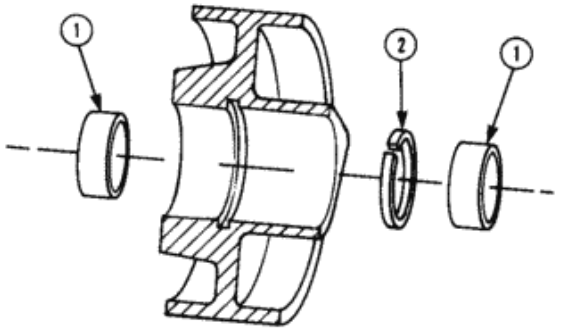
Clean the parts with solvent and dry with compressed air.

Inspect the parts for damage.

Use a hammer and a drift. Remove the bearing races (1).

Remove the retaining ring (2).

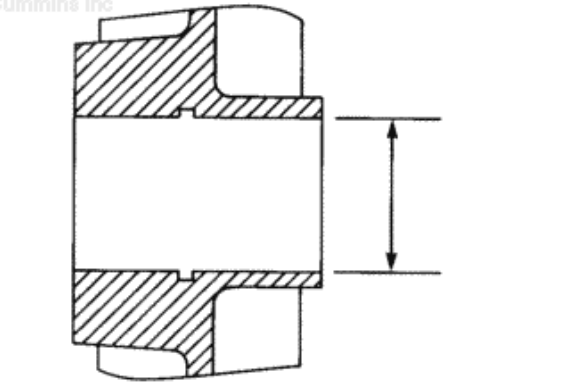
The thickness of the retaining ring has an affect on the bearing end clearance. The bearing kit contains a new retaining ring.



Measure the pulley bore inside diameter.

Pulley Bore Inside Diameter		
mm		in
45.936	MIN	1.8085
45.961	MAX	1.8095

If the pulley bore inside diameter is **not** within specifications, the pulley **must** be replaced.

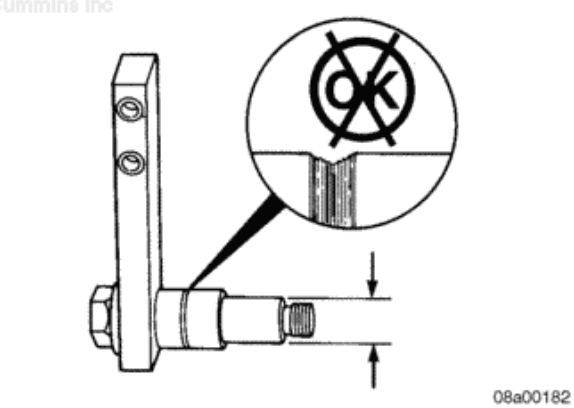


Check the shaft for wear at the seal location.

If the shaft shows any wear at the seal surface, the shaft assembly **must** be replaced.

Measure the outside diameter.

Shaft Outside Diameter		
mm		in
21.961	MIN	0.8646
21.974	MAX	0.8651



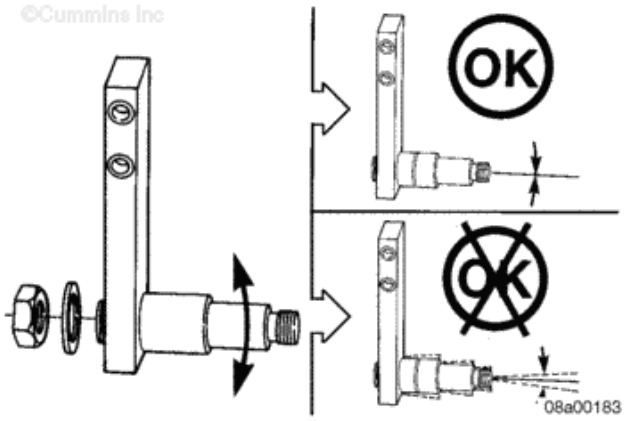
If the shaft is **not** within specifications, it **must** be replaced.

Remove the shaft locknut and the lock washer.

Be sure the shaft is tight in the bracket. If the shaft is loose, replace both pieces.

Install the parts.

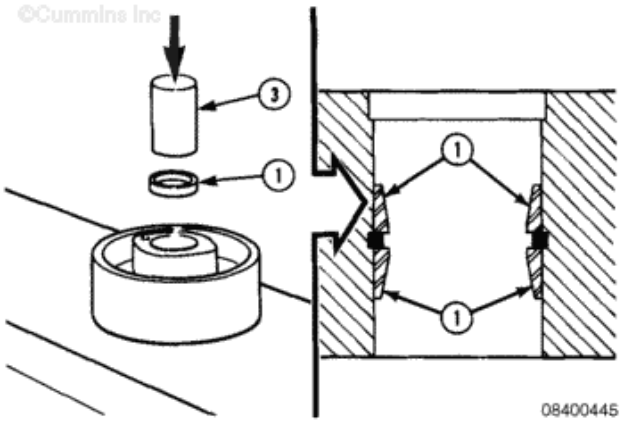
Torque
Value: 150 n.m [110 ft-lb]



Assemble

Install the retaining ring.

Use a mandrel (3). Use an arbor press. Install the bearing races (1). They **must** be in tight contact with the retaining ring.



CAUTION

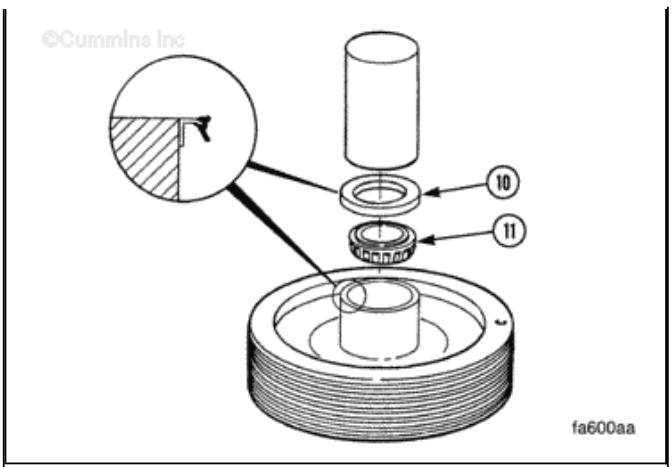
Do not lubricate the seal or the seal surface of the shaft. The seal and seal surface must be clean and

dry.

Use water pump type grease. Lubricate the rear bearing (11) and the bearing race.

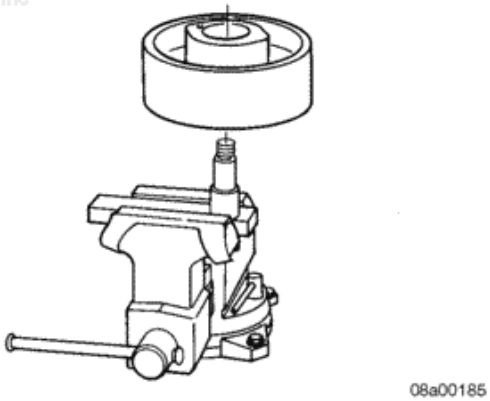
Place the bearing on the race.

Use a mandrel (7). Install the seal (10). The seal must be no more than 0.51 mm [0.020 in] below the top surface.



Place the pulley on the shaft.

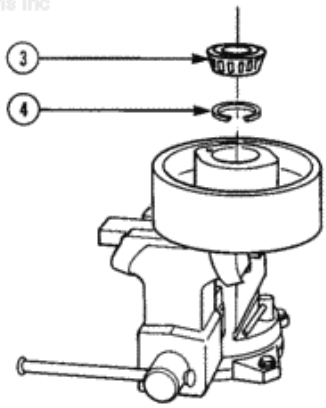
The bearing **must** slide easily over the shaft. If it does **not** check for chips or burrs.



Install the inner bearing spacer (4).

Use water pump type grease. Lubricate the bearing and the bearing race.

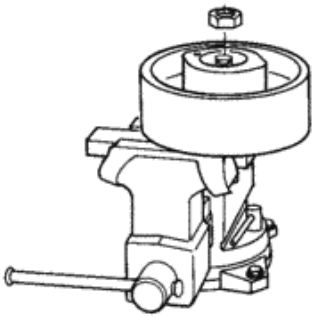
Install the bearing (3).



The locknut has a left hand thread. To tighten the locknut turn to the left.

Install the part.

Torque
Value: 150 n.m [110 ft-lb]



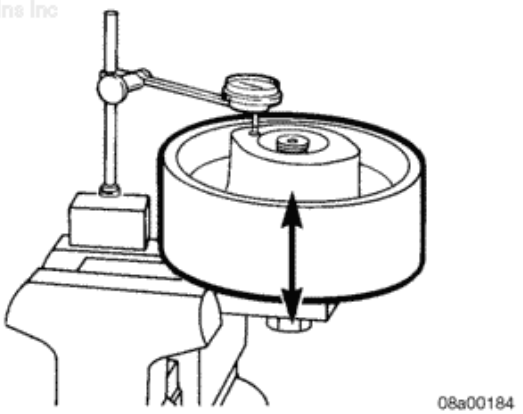
Use a dial indicator to measure the clearance.

Bearing End Clearance		
mm		in
0.08	MIN	0.003
0.25	MAX	0.010

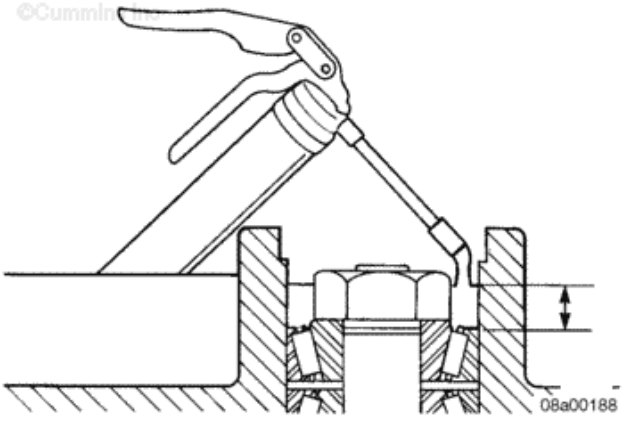
If the clearance is **not** within specifications, be sure the spacer has been installed correctly.

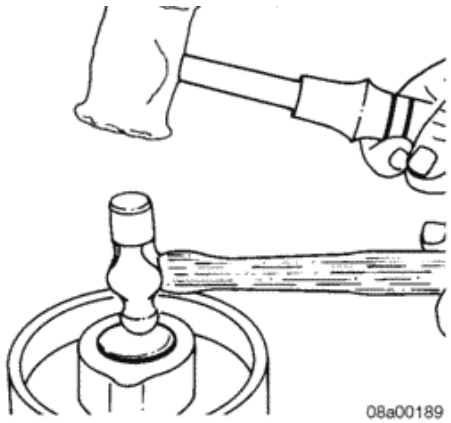
Remove the locknut and inspect the assembly.

The bearings **must** touch the spacer. The bearing races **must** touch the retaining ring.



Fill the front cavity 2/3-full with a water pump type grease.



Install the sealing plug.		

Last Modified: 20-Dec-2004

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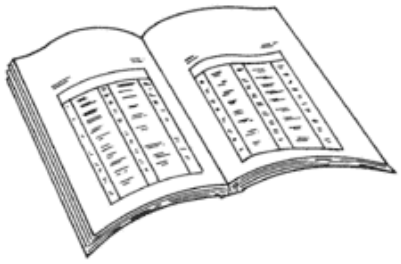
008-036 Fan Hub, Belt Driven

Preparatory Steps

- Remove the cooling fan. Refer to Procedure 008-040.
- Remove the cooling fan drive belt. Refer to Procedure 008-002.







ck800wa

Remove

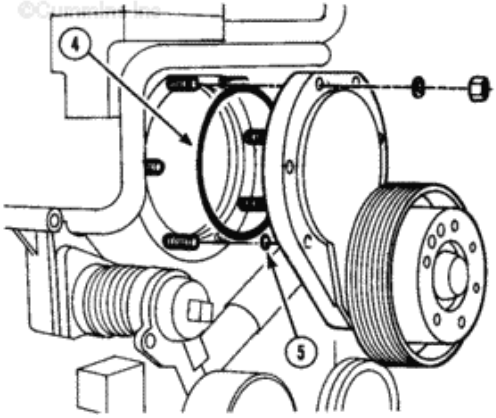
WARNING

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 seven fan hub mounting nuts and remove the fan hub.

Remove the o-ring (4) and seal (5).





fa4bdha

Discard the o-ring and seal.		

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 fan hub with solvent.

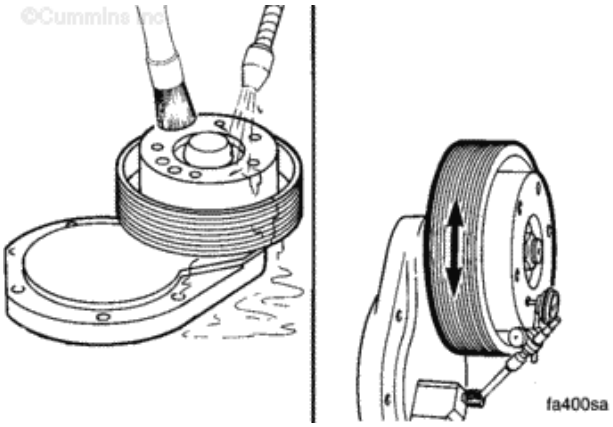
Rotate the pulley to check for rough or damaged bearings.

Check the grease seals for damage.

Check the bearing end clearance.

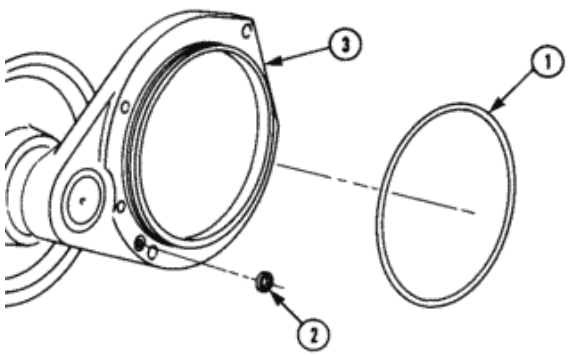
Belt Driven Fan Hub Bearing End Clearance		
mm		in
0.08	MIN	0.003
0.41	MAX	0.016

If the fan hub is **not** within specifications, the fan hub **must** be reconditioned



Make sure the o-ring (1) and seal (2) are removed.

Check the support (3) for damage.



Remove the pipe plugs (4).

Install a grease fitting in one of the pipe plug holes.

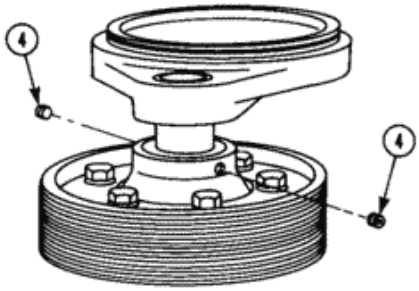
Using a grease gun, pump water pump grease into the fan hub until it begins to come out of the open hole.

Remove the grease fitting.

Install pipe plugs (4).

Tighten the pipe plugs.

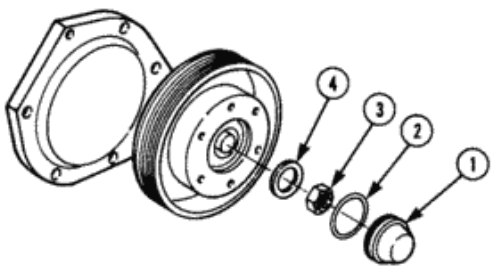
Torque
Value: 15 n.m [120 in-lb]



Disassemble

Remove the listed parts:

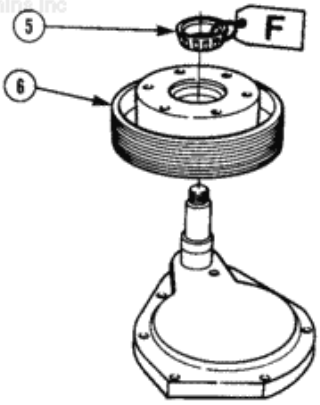
(1) Dust cover
(2) O-ring
(3) Locknut
(4) Washer.



08400452

Remove the pulley assembly (6).

Remove and tag the front roller bearing (5).

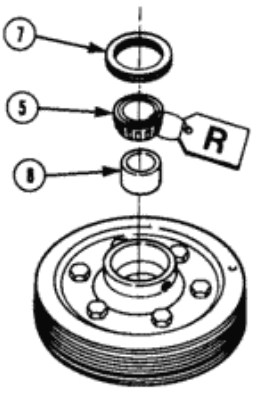


08400453

Turn the pulley assembly over and remove the listed parts:

(7) Seal
(5) Inner roller bearing
(8) Inner bearing spacer.

NOTE: The outer bearing spacer can not be removed until the outer bearing race is removed.



08400454

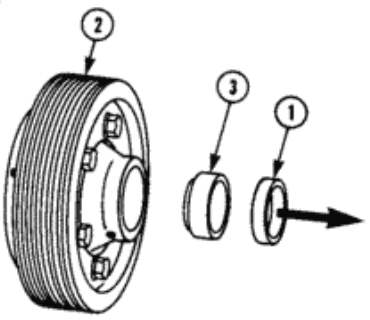
WARNING

To reduce the possibility of personal injury, wear eye and face protection when removing the bearing races. The bearing races are hardened and can chip.

NOTE: Do not remove the bearing race unless replacing the bearing.

Use a hammer and a drift to drive the rear bearing race (1) out of the pulley (2).

Remove the outer bearing spacer (3).



08400466

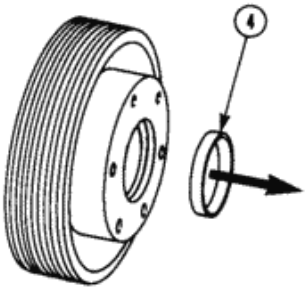
WARNING

To reduce the possibility of personal injury, wear eye and face protection when removing the bearing races. The bearing races are hardened and can chip.

NOTE: Do not remove the bearing race unless replacing the bearing.

Turn the pulley over.

Use a hammer and drift to drive the front bearing race (4) out of the pulley.



08400467

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.

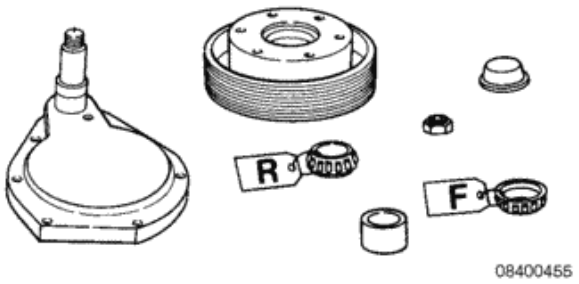
CAUTION

Do not allow the force of the compressed air to turn the bearing when cleaning. Bearing damage will result because of the lack of lubrication.

Clean the parts with solvent and dry with compressed air.

Inspect the bearings for wear.

If the bearings are worn, the bearings and bearing races **must** be replaced.



08400455

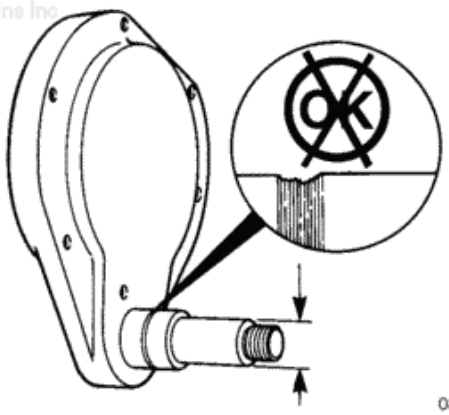
Check for shaft wear at the seal location.

If the shaft is worn, it **must** be replaced.

Measure the shaft in the bearing location.

Fan Hub Shaft Outside Diameter		
mm		in
34.912	MIN	1.375
34.925	MAX	1.378

If the shaft is **not** within specifications, it **must** be replaced.

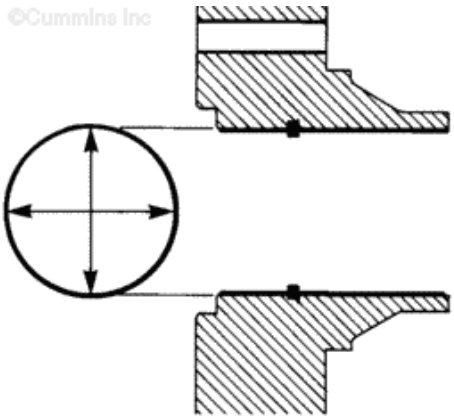


08400456

If the bearing races were removed, measure the inside diameter of the fan hub pulley at each side of the retaining ring.

Fan Hub Pulley Bore Inside Diameter		
mm		in
65.039	MIN	2.561
65.075	MAX	2.562

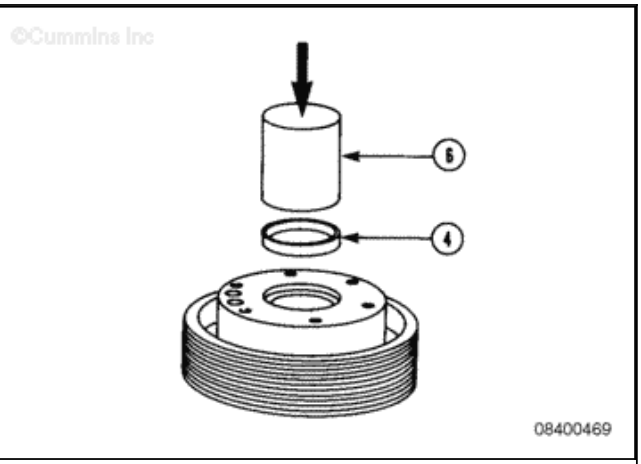
If the fan hub pulley is **not** within specifications, it **must** be replaced.



Assemble

If the front bearing race was removed, use a mandrel (6) and a arbor press to install the front bearing race (4).

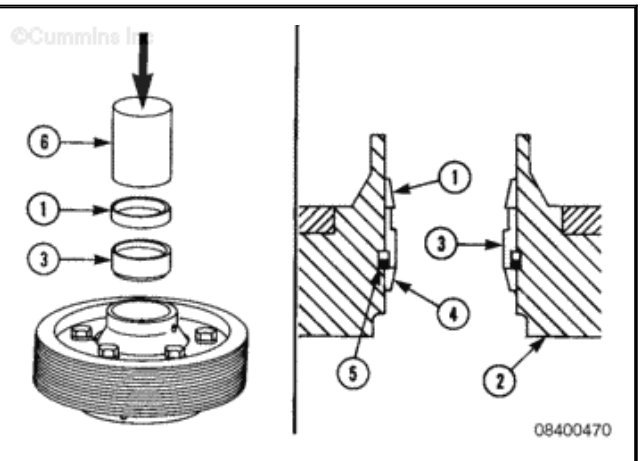
Push the bearing race into the bore until it touches the retaining ring.



If the rear bearing race was removed, install the outer bearing spacer (3). Push the spacer until it touches the front bearing race (4).

Use a mandrel (6) and an arbor press to install the rear bearing race (1).

Push the race until it touches the spacer (3).



The spacer will **not** turn when the race is in the proper position.

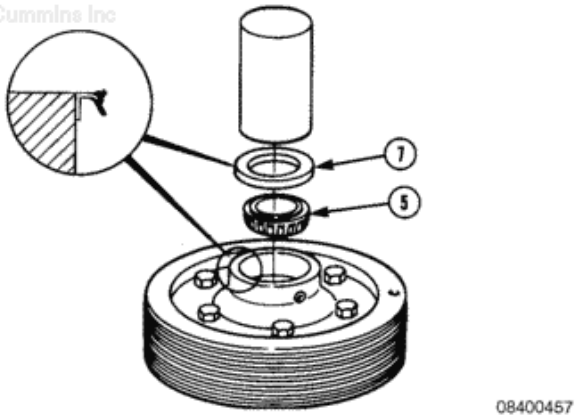
CAUTION

Do not lubricate the seal surface of the shaft. The seal and seal surface must be clean and dry.

Lubricate the bearing (5) with wheel bearing type grease and install it into the fan hub pulley.

Install the seal (7) with a mandrel.

The seal **must** be **not** more than 0.51 mm [0.020 in] below the top surface of the pulley.

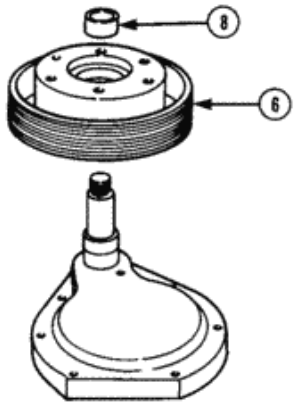


Turn the pulley (6) over and install it onto the shaft. The rear bearing **must** slide easily onto the shaft.

If it does **not** check the shaft for chips or burrs.

Install the inner bearing spacer (8).

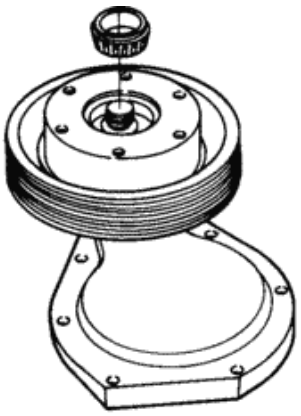
Fill the cavity between the spacer and the pulley with water pump type grease.



Lubricate the front bearing with water pump type grease.

Install the front bearing into the fan hub.

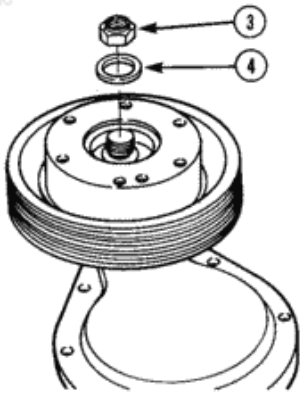
The bearing **must** slide easily over the shaft. If it does **not** check the shaft for chips or burrs.



Install the washer (4) and locknut (3).

Tighten the locknut.

Torque
Value: 205 n.m [150 ft-lb]

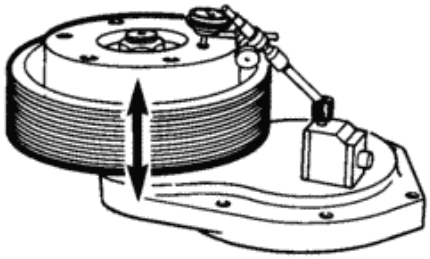


Measure the bearing end clearance with a dial indicator.

Belt Driven Fan Hub Bearing End Clearance		
mm		in
0.08	MIN	0.003
0.41	MAX	0.016

If the clearance is **not** within specifications, make sure the spacer has been installed correctly.

The bearings **must** touch both of the bearing spacers.



CAUTION

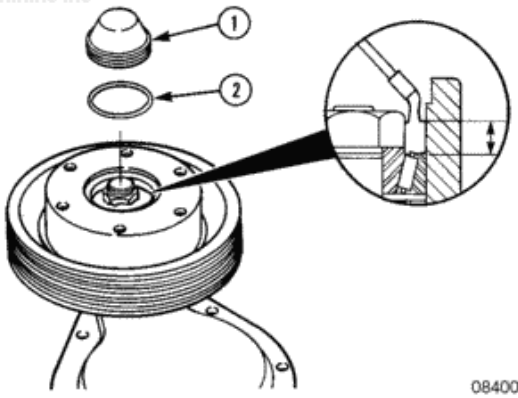
Do not use more grease than specified. Too much grease will cause overheating and failure.

Fill the cavity of the pulley to the top of the locknut with water pump type grease.

Install the o-ring (2) onto the dust cover (1).

Lubricate the o-ring with vegetable oil.

Install the dust cover.



Install

WARNING

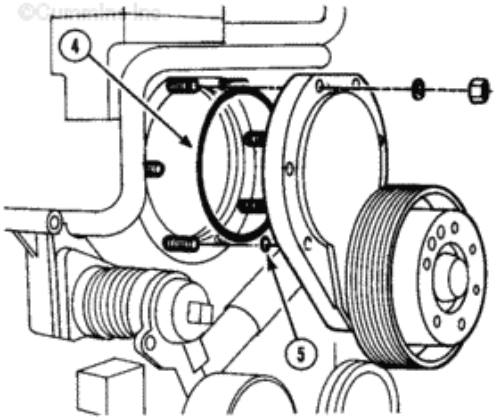
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

If the studs have been removed check the protrusion.

Stud Protrusion From Front Cover		
mm		in
50.17	MIN	1.975
51.44	MAX	2.025

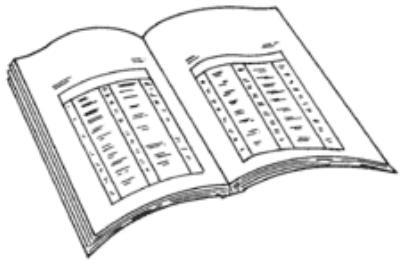
Lubricate the o-ring (4) and seal ring (5) with vegetable oil.

Install the o-ring and seal ring into the fan hub.



Install the fan hub and seven lock washers and nuts. Tighten the nuts. **Torque Value:** 35 n.m [25 ft-lb]		

Finishing Steps

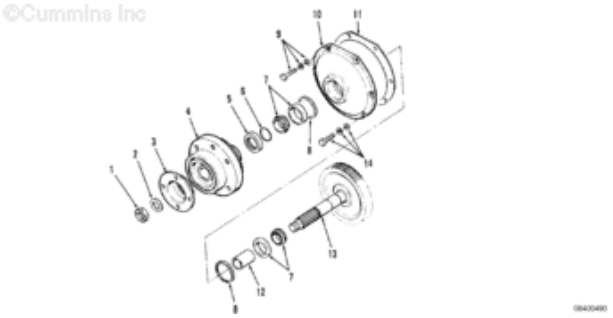
• Install the cooling fan drive belt. Refer to Procedure 008-002. • Install the cooling fan. Refer to Procedure 008-040.		

Last Modified: 31-Jul-2006

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008-037 Fan Hub, Gear Driven

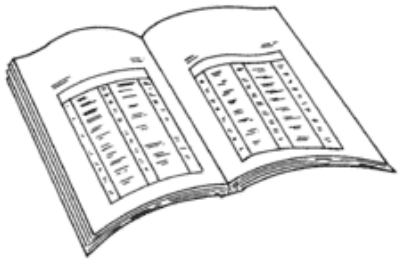
Exploded View



1. Locknut
2. Clamping washer
3. Retainer
4. Fan hub
5. Oil seal
6. O-ring
7. Roller bearing
8. Retaining ring
9. Capscrew, lock washer, and plain washer
10. Fan hub support
11. Fan hub support gasket
12. Inner bearing spacer
13. Gear and shaft assembly
14. Capscrew, lock washer, and plain washer.

Preparatory Steps

• Remove the cooling fan. Refer to Procedure 008-040.		



ck800wa

Remove

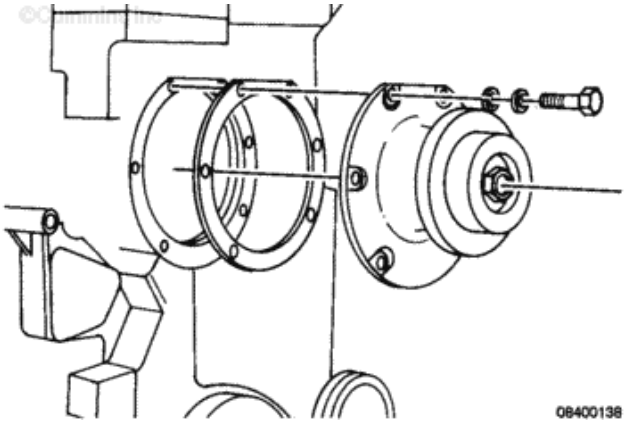
WARNING

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.

Two of the capscrews contain a nut on the back side of the gear cover plate.

Remove the capscrews, nuts and fan hub.

Remove and discard the gasket.



08400138

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.

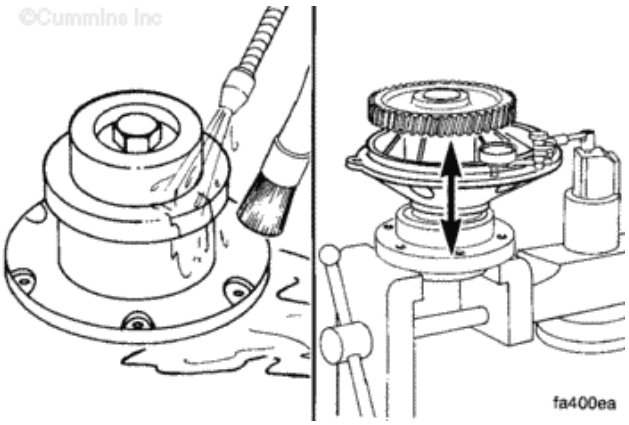
Clean the fan hub with solvent.

Rotate the fan hub and check for rough bearings.

If the fan hub has rough bearings, the fan hub **must** be reconditioned.

Check the bearing end clearance.

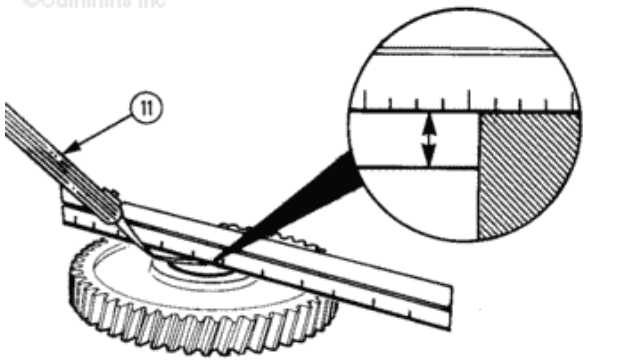
Gear Driven Fan Hub Bearing End Clearance		
mm		in
0.08	MIN	0.003
0.25	MAX	0.010



Measure the shaft depth in the gear with a feeler gauge (11).

Gear Driven Fan Hub Gear Shaft Depth		
mm		in
0.00	MIN	0.00
0.51	MAX	0.020

If the shaft depth is **not** within specifications, replace the shaft and gear as an assembly. The bearing assembly **must** be replaced if the shaft and gear are replaced.



NOTE: Some hubs require the removal of the retainer before checking the index marks.

Check the retainer to hub clearance (9).

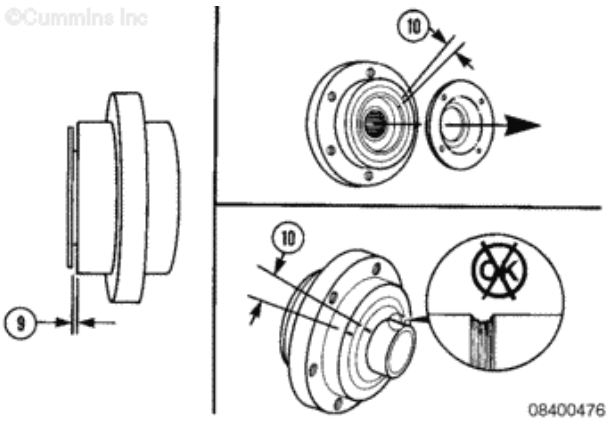
Gear Driven Fan Hub Retainer to Hub Clearance		
mm		in
2.5	MAX	0.10

Check the index mark misalignment (10).

Gear Driven Fan Hub Index Mark Misalignment		
mm		in
3.3	MAX	0.13

Check for wear at the seal locations.

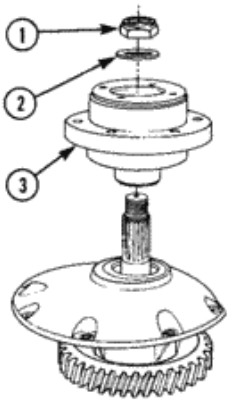
If the fan hub is **not** within specifications or the seal location is worn, it **must** be reconditioned.



Disassemble

Remove the locknut (1) and washer (2).

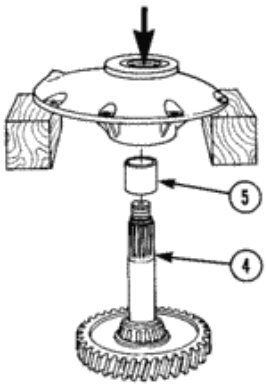
Lift the fan hub off of the shaft.



Place the fan support in an arbor press, with mounting surface contacting the press.

Push on the end of the shaft to remove the bearing and shaft assembly.

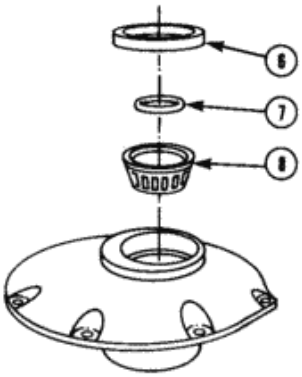
Lift the spacer (5) off of the shaft (4).



08400474

Remove the listed parts:

(6) Seal
(7) O-ring
(8) Outer bearing.



08400475

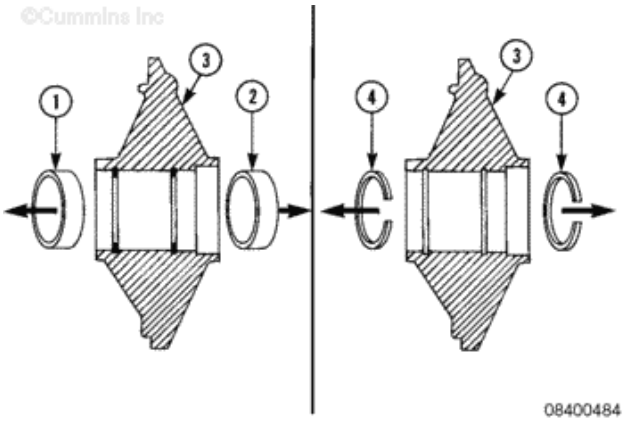
WARNING

To reduce the possibility of personal injury, wear eye protection when removing the bearing races. The bearing races are hardened and can chip.

The bearings, races, and retaining rings are a complete set. All parts **must** be replaced if any are damaged or worn.

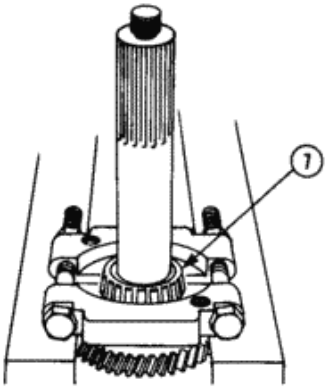
Remove the retaining rings (4) from the housing (3).

Using a brass drift and hammer, remove the front bearing race (1) and rear



08400484

bearing race (2) from the housing (3).		

Remove the inner bearing (7) from the shaft and gear assembly with the water pump bearing separator, Part Number 3375326, or equivalent.		

Clean and Inspect for Reuse

WARNING

Do not remove the gear from the shaft. Personal injury and damage to the assembly or press can result.

WARNING

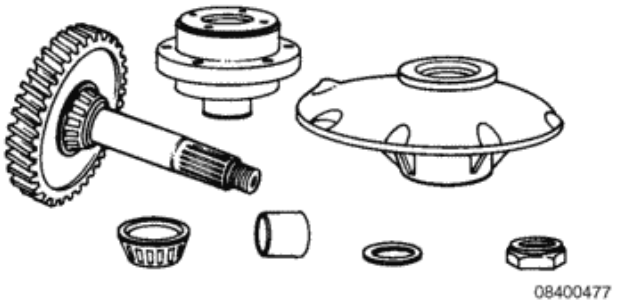
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying







debris and dirt can cause personal injury.

Clean the parts and dry with compressed air.

Inspect the parts for damage.

If either bearing requires replacement, replace the entire bearing kit.

NOTE: Some hubs require the removal of the retainer before checking the index marks.

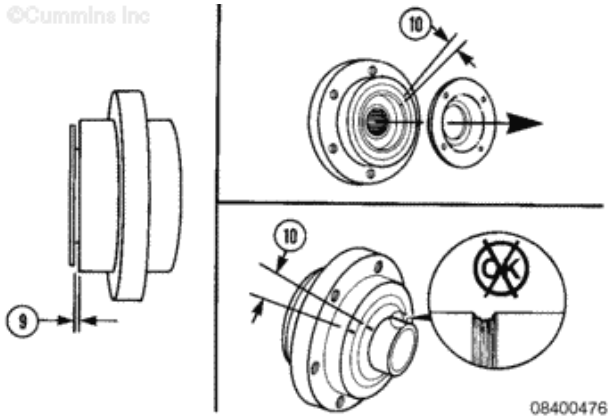
Check the retainer to hub clearance.

Retainer to Hub Clearance		
mm		in
2.5	MAX	0.10

Check the index mark misalignment.

Index Mark Misalignment		
mm		in
3.3	MAX	0.13

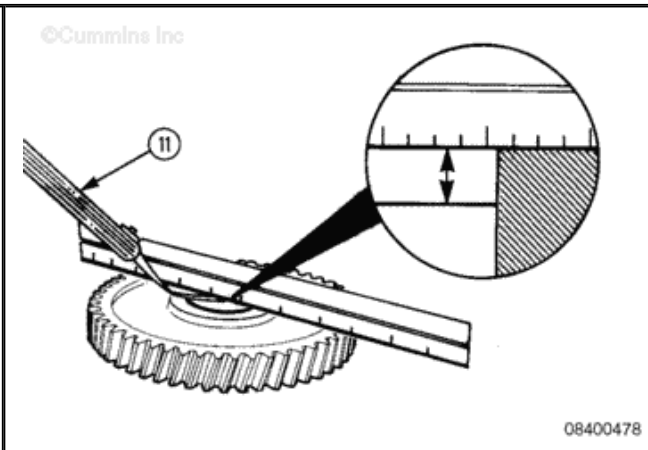
If the hub is **not** within specifications, it **must** be reconditioned or replaced.



Use a feeler gauge (11). Measure the shaft depth in the gear.

Gear Shaft Depth		
mm		in
0.00	MIN	0.000
0.51	MAX	0.020

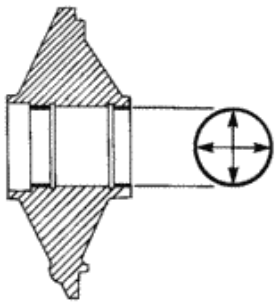
If the shaft depth is **not** within specifications. The shaft and gear **must** be replaced as an assembly.



Measure the inside diameter of the bearing race bore.

Bearing Race Bore Inside Diameter		
mm		in
64.99	MIN	2.559
65.02	MAX	2.560

If the bearing race bore diameter is **not** within specifications, the bearing assembly **must** be replaced.



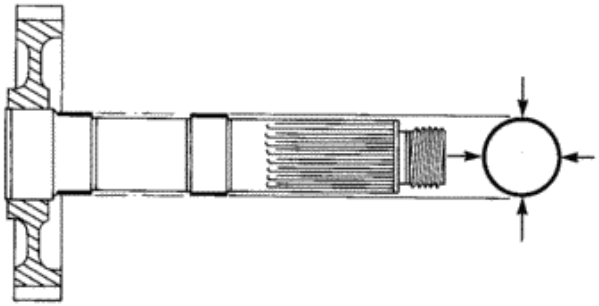
©Cummins Inc

08400485

Measure the outside diameter of the shaft at the bearing location.

Shaft Outside Diameter (Bearing Location)		
mm		in
34.950	MIN	1.376
34.983	MAX	1.377

If the shaft is **not** within specifications, the shaft and gear **must** be replaced as an assembly.



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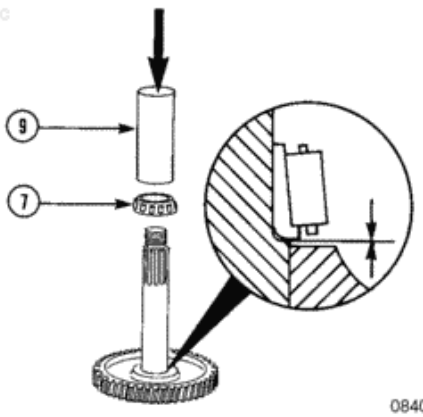
08400488

Assemble

CAUTION

To reduce the possibility of bearing damage, make sure the mandrel makes contact with the center of the bearing and not the retaining cage.

Using a mandrel (9) and an arbor press, push the bearing (7) onto the shaft until the



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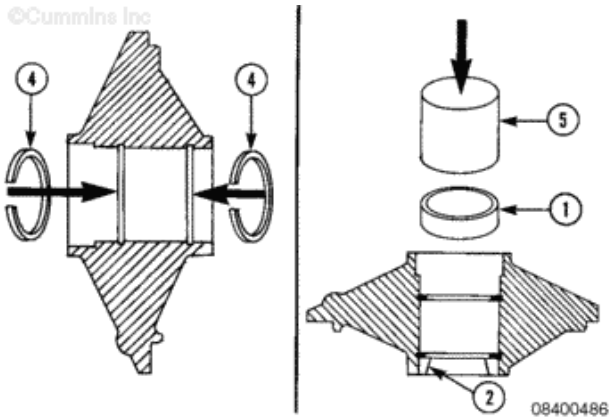
08400489

inside diameter of the bearing touches the shoulder on the shaft.

Install the retaining rings (4).

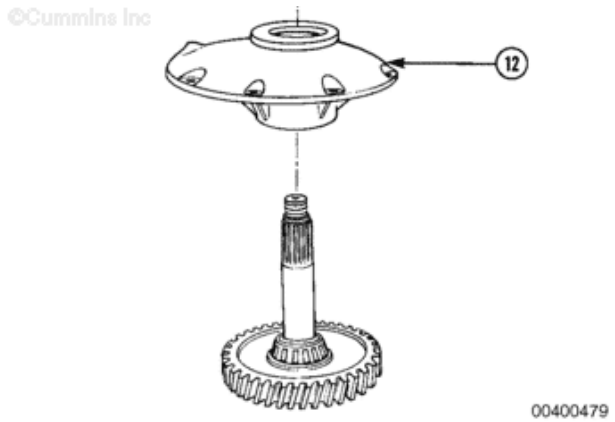
Using a mandrel (5) and an arbor press, push the bearing race (1) in until it touches the retaining ring (4).

Repeat the process for the other bearing race.



Lubricate the bearing and bearing race with clean engine oil.

Install the support onto the gear and shaft assembly.

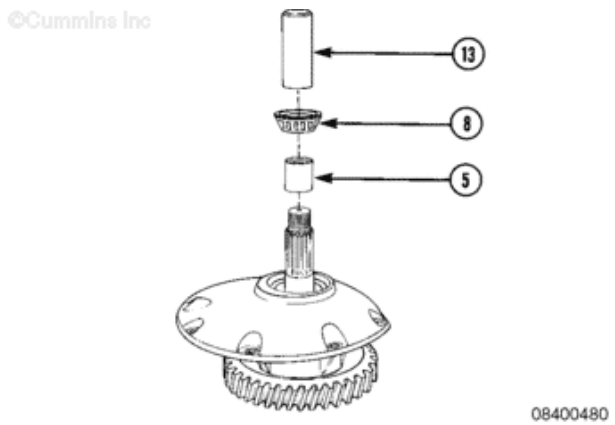


CAUTION

To reduce the possibility of bearing damage, make sure the mandrel makes contact with the center of the bearing and not the retaining cage.

Support the shaft in an arbor press and install the bearing spacer (5).

Using a mandrel (13) and an



arbor press, push the bearing (8) onto the shaft until it touches the spacer.

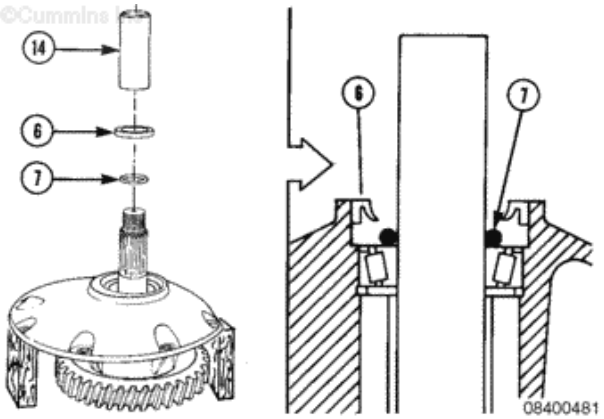
CAUTION

To reduce the possibility of damage to the seal, do not lubricate the seal or seal surface. The seal and seal surface must be clean dry.

Put the fan support in an arbor press, making contact on the support mounting surface.

Install the o-ring (7).

Install the seal (6) with a mandrel (14) and arbor press.



CAUTION

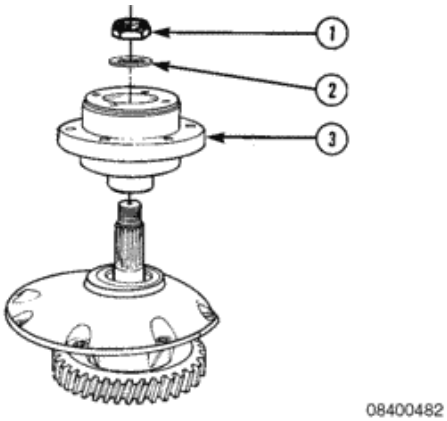
To reduce the possibility of damage to the seal, do not lubricate the seal or seal surface. The seal and seal surface must be clean dry.

CAUTION

The dust lip on the shaft must not be folded under when the hub is installed. To prevent the dust lip from folding under, bend the lip outward by running a finger around it eight to ten times applying gentle pressure. Avoid touching the sealing lip. The dust lip will remain bent approximately one minute, and slowly return to the operating position.

Place the bearing assembly (3) onto the support.

Install the washer (2) and nut



(1).

Tighten the nut.

Torque
Value: 205 n.m [150 ft-lb]

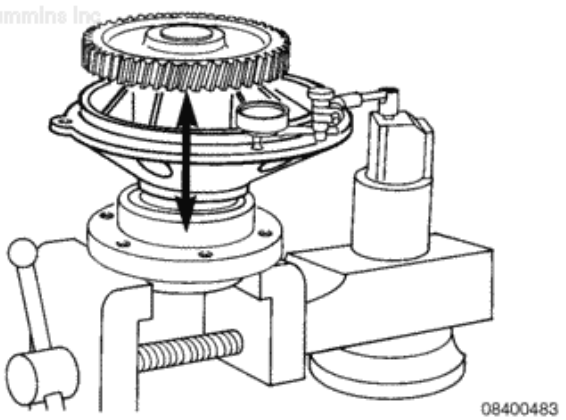
Place the fan support in vise with brass jaws.

Rotate the assembly and check for rough bearings.

Measure the bearing end clearance with a dial indicator.

Bearing End Clearance		
mm		in
0.08	MIN	0.003
0.25	MAX	0.010

If the end clearance is **not** within specifications, the fan hub **must** be reconditioned.



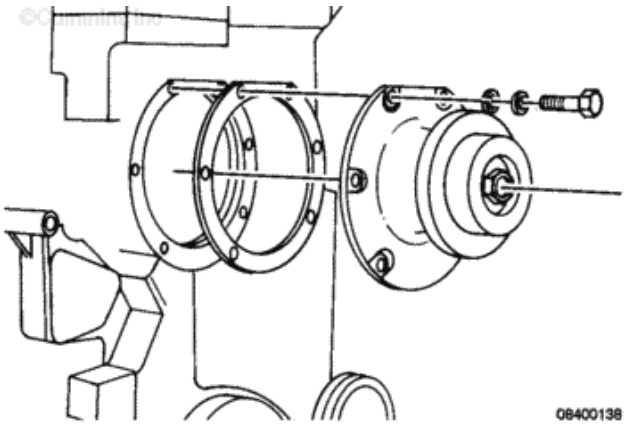
Install

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.

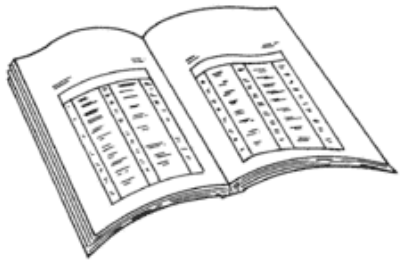
NOTE: For installation and operation of a clutch driven assembly, use the K-1150 Operation and Installation, Bulletin 3387082.

Align the hole in the gasket for the oil passage with the oil hole in the front cover.



Install the gasket, fan hub, and capscrews. Tighten the capscrews. **Torque Value:** 45 n.m [33 ft-lb]		

Finishing Steps

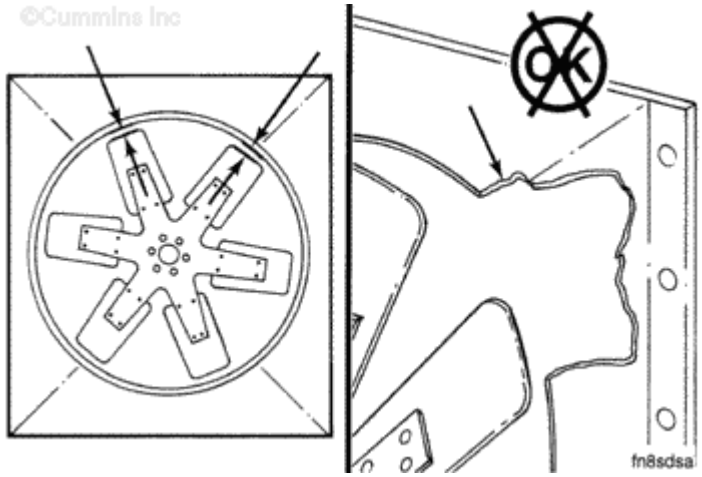
• Install the cooling fan. Refer to Procedure 008-040.		

Last Modified: 31-Jul-2006

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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 shroud if damaged. Refer to the manufacturer's instructions.		

Last Modified: 16-Aug-2004

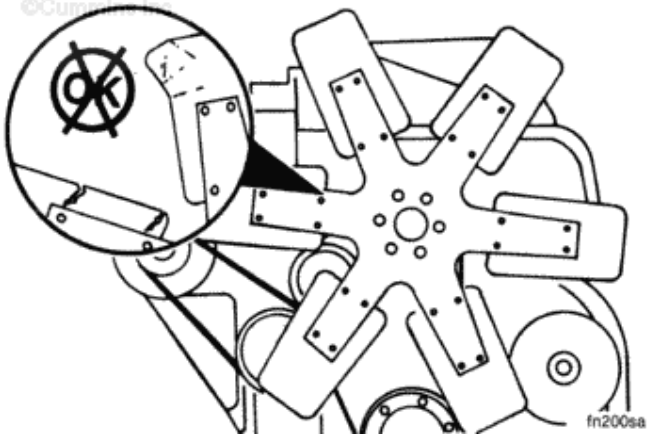
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008-040 Fan, Cooling

Initial Check

Inspect the fan for cracked, bent or broken blades.

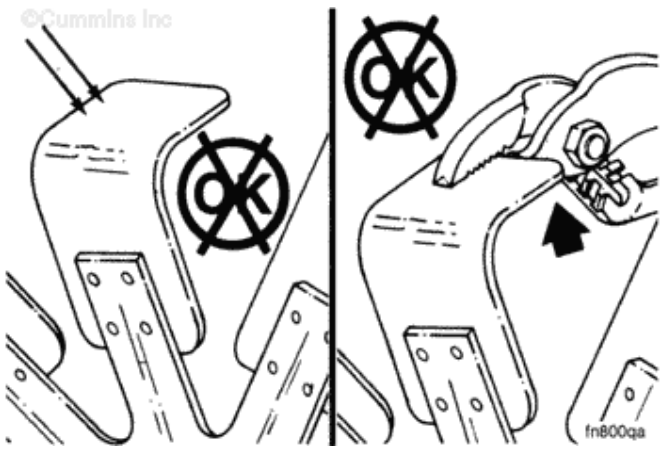




WARNING

Do not straighten a bent fan blade, or continue to use a damaged fan. A bend or damaged blade can fail during operation and cause serious personal injury or property damage.

If blade is damaged, it **must** be replaced.

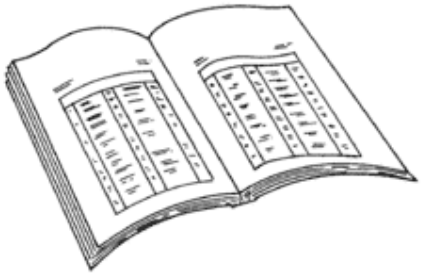


Preparatory Steps

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 to the air starter to prevent accidental starting.

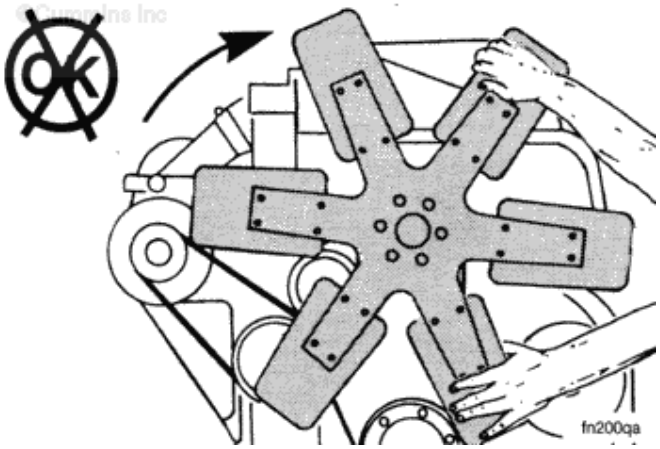


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Remove

CAUTION

Do not pry or pull on the fan. The fan blades can be damaged.

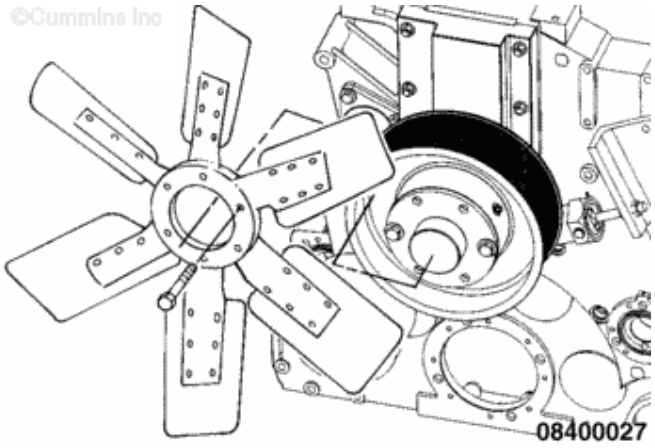


fn200qa

NOTE: Fans can be installed as either a blower or suction type. Make a note of how the fan is installed to prevent

an assembly error.

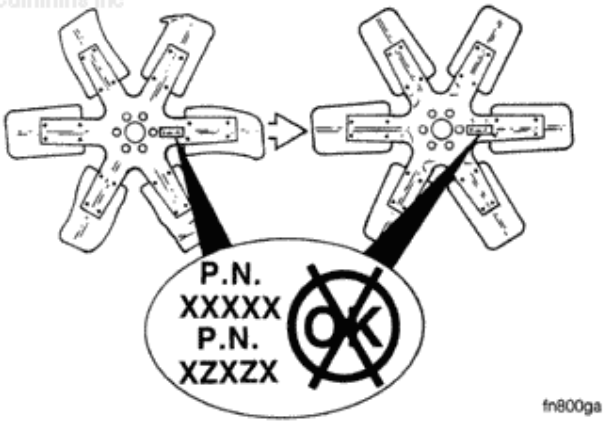
Remove the capscrews, fan and fan spacer.



Install

CAUTION

To reduce the possibility of equipment damage, replace the original equipment fan with a fan of the identical part number. Cummins Inc. must approve of any fan changes.

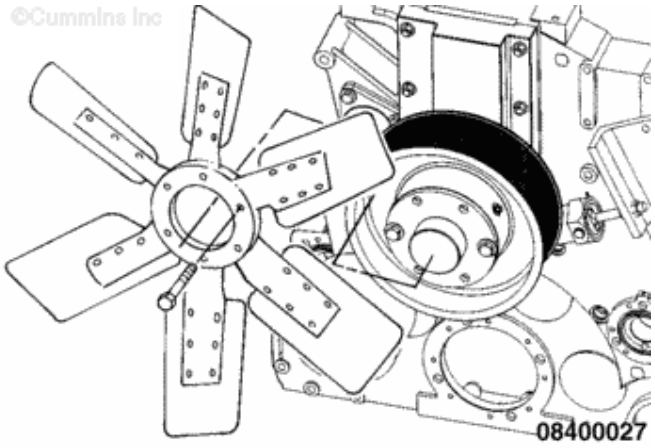


A minimum of 19.05 mm [¾ in] of capscrew threads **must** be engaged in the fan hub.

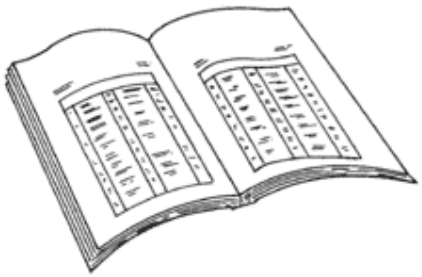
Install the spacer, fan, and capscrews.

Tighten the capscrews.

Torque

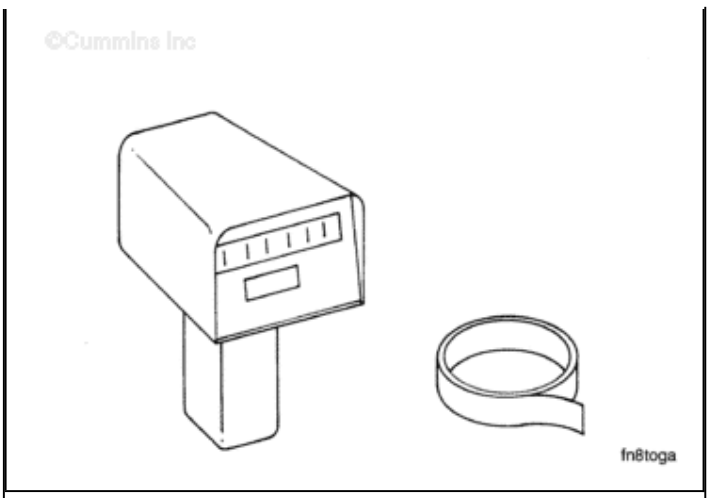
Value: 135 n.m [100 ft-lb]		

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. • Connect the batteries or air starter supply.		

Rotation Check

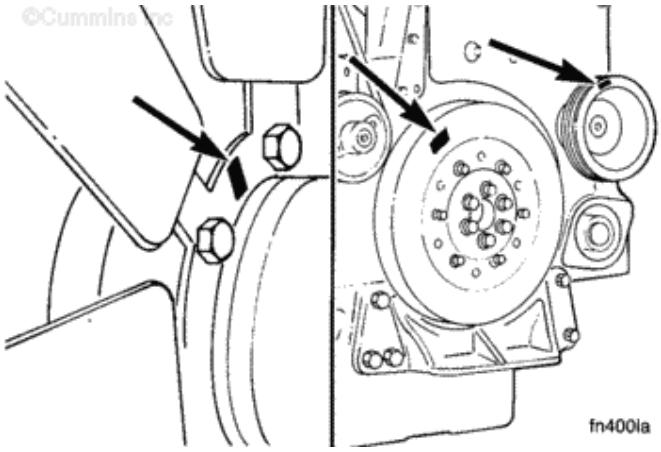
Use optical tachometer, Part Number 3377462, or a strobe light to measure the fan rpm.



NOTE: When using Cummins optical tachometer, use a piece of reflective tape, Part Number 3377462, to mark the spot.

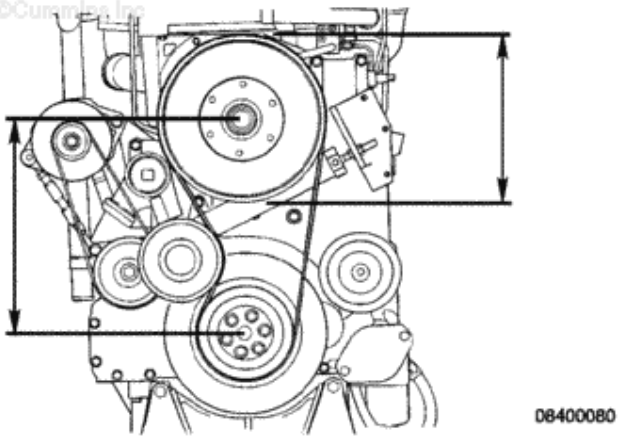
Mark a spot on the fan, so the fan rpm can be measured.

Mark another spot on the vibration damper or accessory drive pulley to measure engine rpm.



Measure the diameter of the fan belt pulley to determine the drive ratio.

Belt Drive Fan	
Fan Pulley Diameter	**Fan RPM**
239 mm [9.4 in]	0.85 x engine rpm
289 mm [11.4 in]	0.70 x engine rpm
388 mm	0.60 x engine



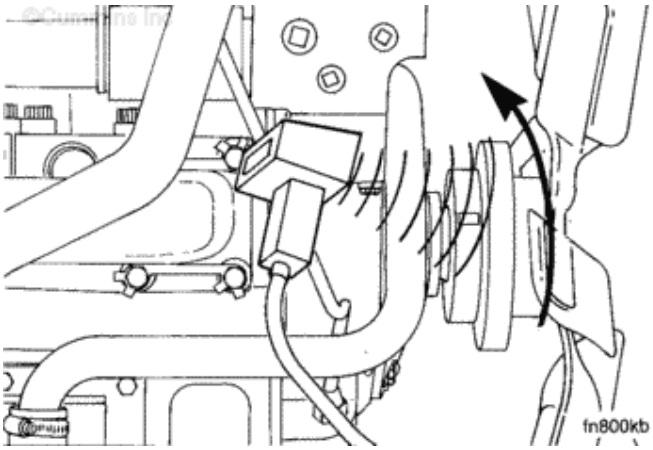
[13.3 in]	rpm

The fan center distance is the distance between the center of the fan hub and the center of the crankshaft.

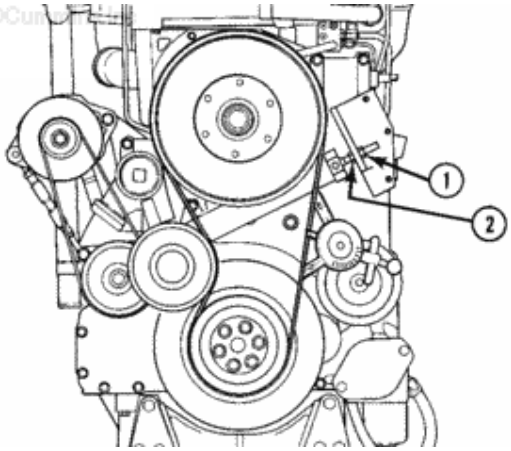
Operate the engine.

Read and compare the fan rpm to the engine rpm.

Compare the fan rpm to the specification.



If the fan rpm is **not** correct, check the belt tension. Refer to Procedure 008-002.



Last Modified: 20-Dec-2004

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008-041 Marine Gear Oil Cooler

Preparatory Steps

WARNING

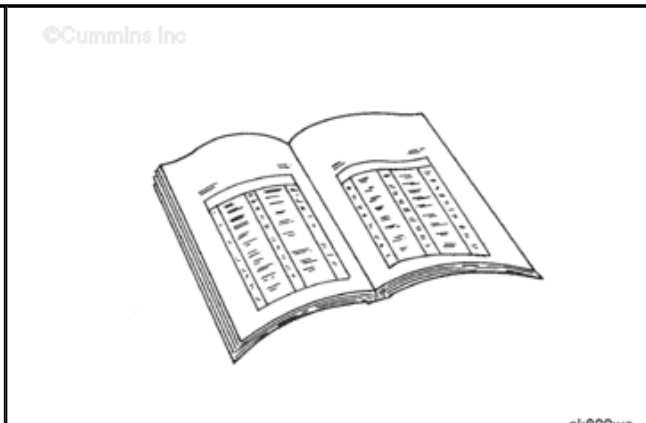
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

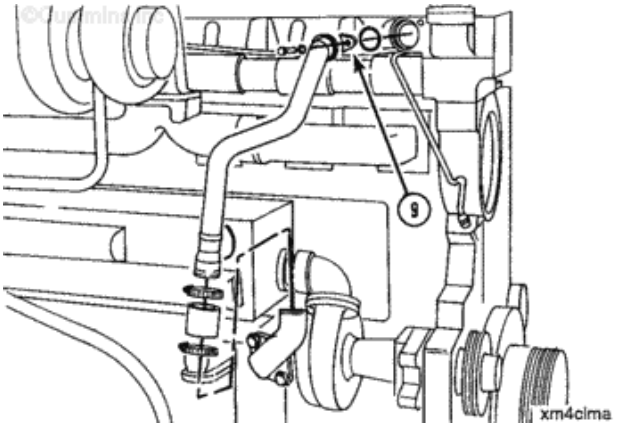
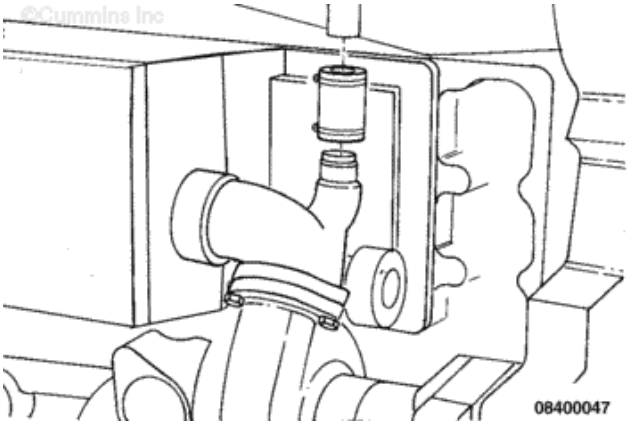
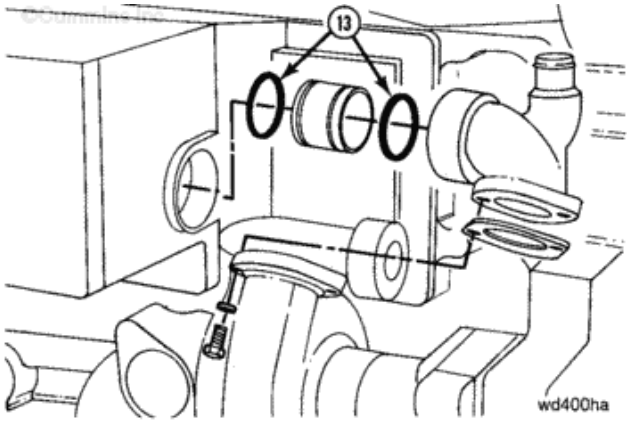
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

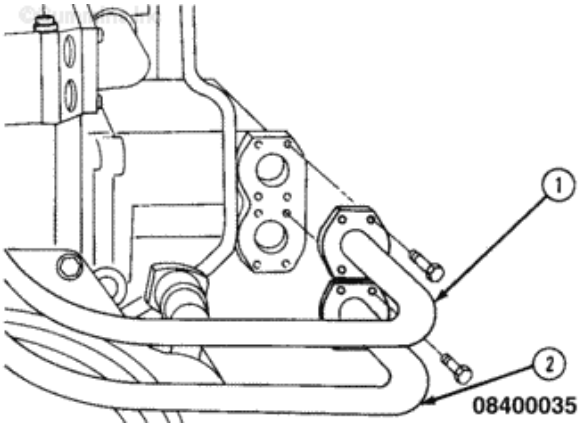
- Drain the cooling system. Refer to Procedure 008-018.
- Drain the coolant from water pump and oil cooler housing by opening and closing draincocks.
- Remove the turbocharger oil drain tube. Refer to Procedure 010-045.
- Remove the turbocharger coolant supply hose. Refer to Procedure 010-037.





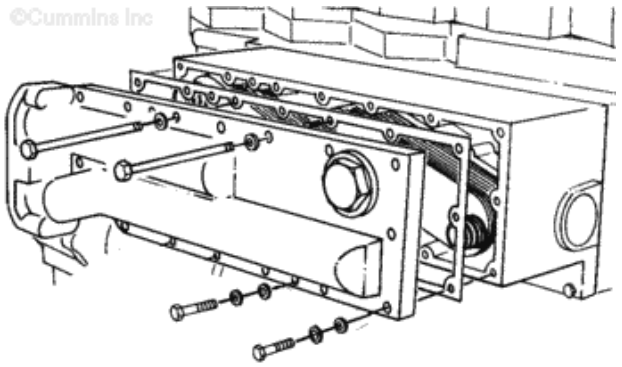
Remove

Remove the water bypass tube clamp (9). Loosen both lower bypass tube clamps. Remove the water bypass tube and discard the o-ring.		
Disconnect the aftercooler supply hose from the water pump outlet connection.		
Remove the water pump outlet connection assembly. Remove the water transfer tube from the water outlet connection. Remove and discard the to o-rings (13) and the gasket.		
Remove the oil supply (1) and oil return (2) tubes from the marine gear oil cooler.		



Remove the marine gear oil cooler cover mounting capscrews.

The cover **must** be pried from the housing because of the tight fit between the cover and the o-rings on the elements.



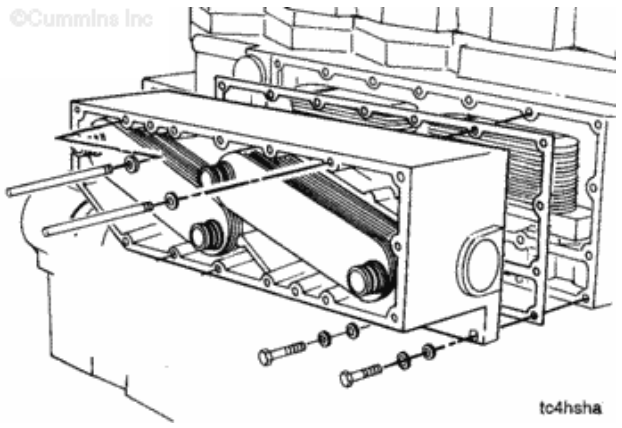
WARNING

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 two 3/8-16 x 12-in guide studs to support the housing while the capscrews are being removed.

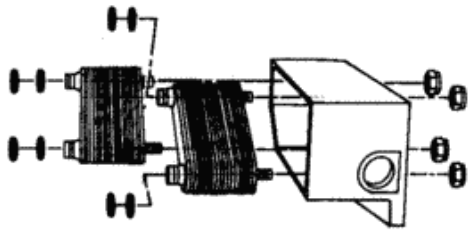
Remove the remaining marine gear oil cooler housing capscrews.

Remove the marine gear oil cooler housing and the gasket.

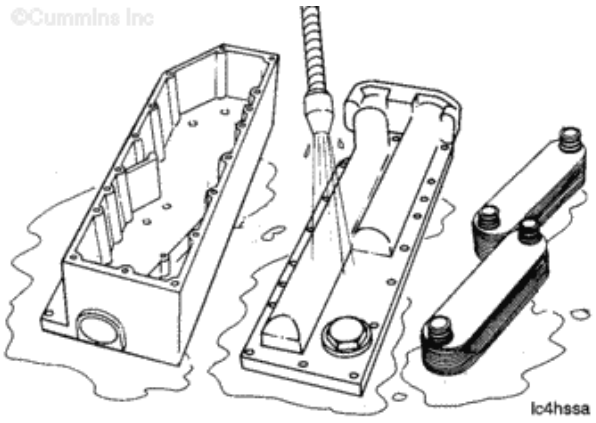


Discard the gasket.		

Disassemble

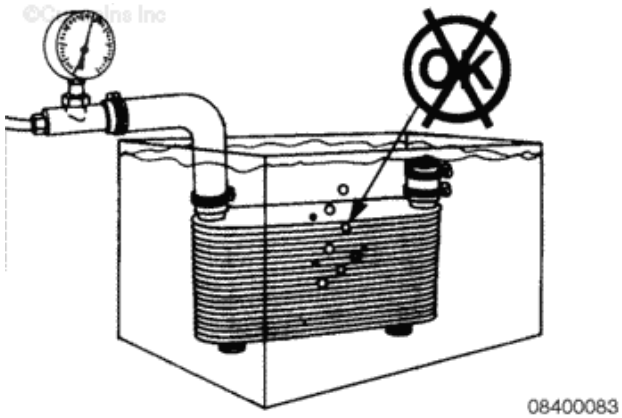
Remove the marine gear oil cooler element mounting nuts. Remove the elements. Remove and discard the o-rings.		 tc400fa

Clean and Inspect for Reuse

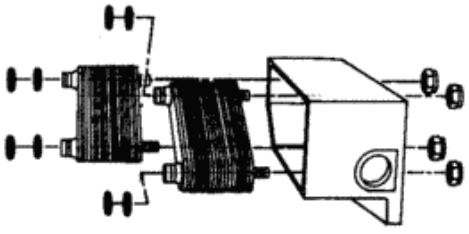
WARNING When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury. Clean the parts with a solvent that will **not** harm aluminum. Inspect the parts for cracks and other damages. If the parts are damaged they		 lc4hssa

must be replaced or repaired.		

Pressure Test

NOTE: Heating the water in the tank ot 50°C [120°F] will improve the test results. Pressure test the elements and check for leaks. **Measurements** kpa psi Air Pressure 415 60 If an element leaks, it **must** be replaced.		

Assemble

Install the elements into the housing. Install the self-locking nuts and tighten. **Torque** **Value:** 130 n.m [95 ft-lb] Lubricate new o-rings with vegetable oil and install them onto the elements.		

Install

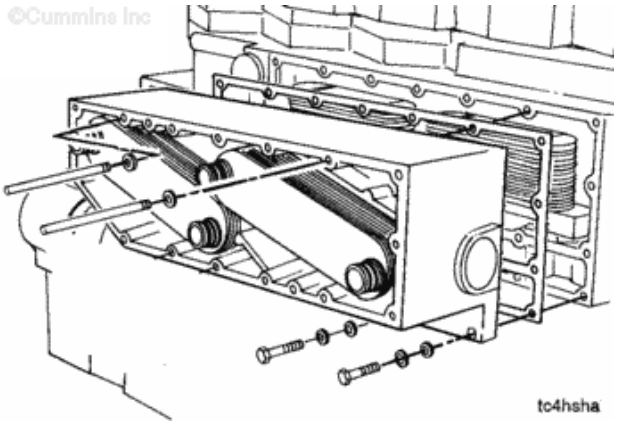
WARNING

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 two 3/8-16 x 12-in guide studs to support the housing during installation.

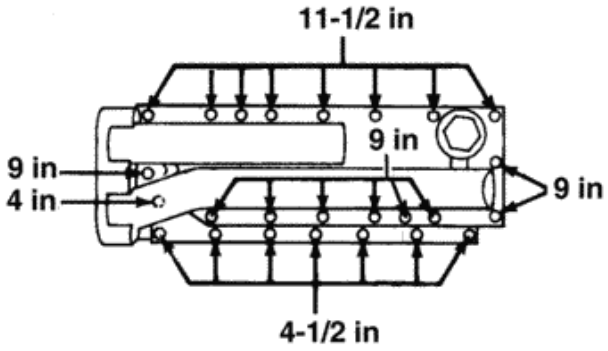
Install the gasket and the housing.

Install the capscrews in the bottom row of holes on the housing. These capscrews are all 101.6 mm [4 in] long.



The length and location of all the capscrews on the marine gear oil cooler and cover are shown. Make sure the capscrews are the correct length.

Do **not** tighten any of the capscrews until all of them have been installed.

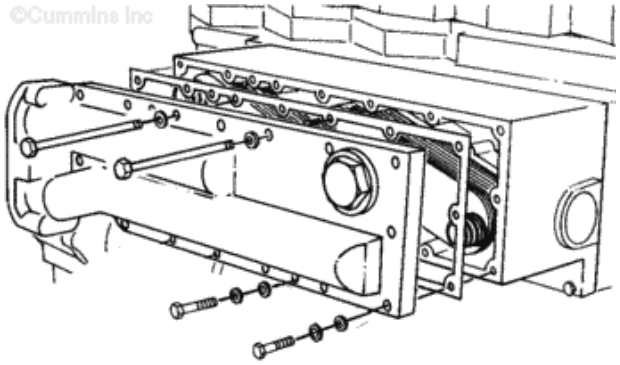
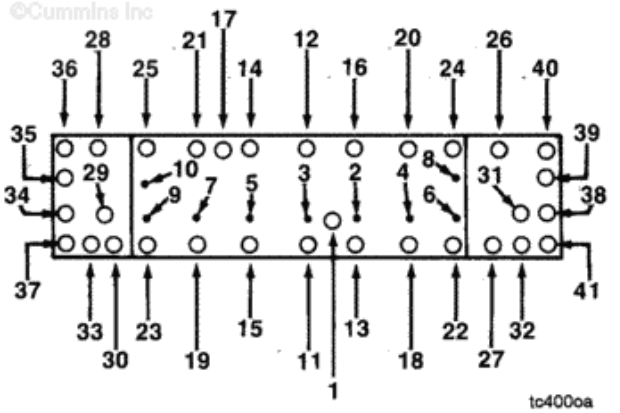
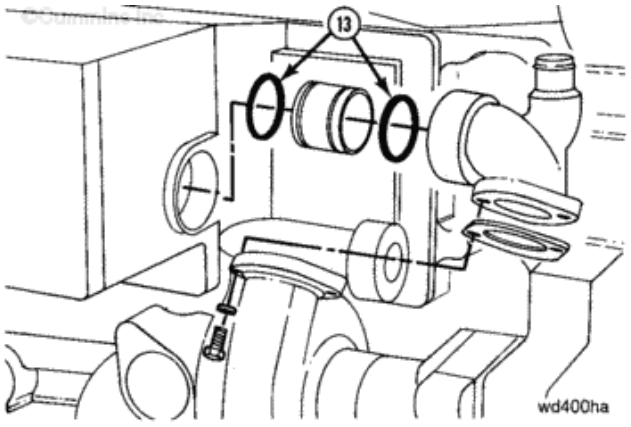


Make sure the capscrews are the correct length.

Lubricate the o-rings on the elements and the bores in the covers with vegetable oil.

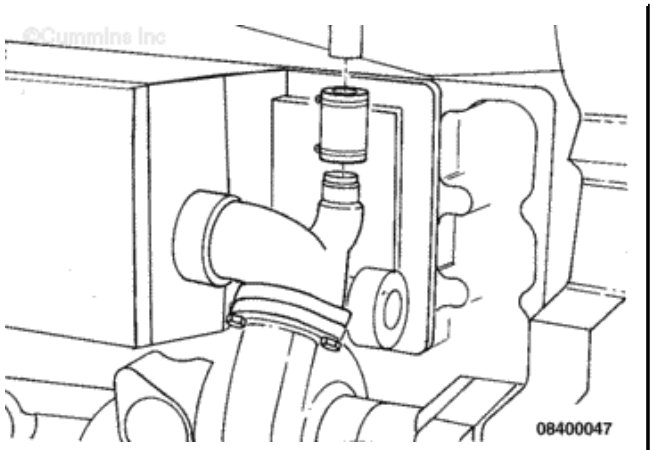
Install the gasket and cover.

Push the cover over the o-rings until the cover is against the housing.

Install the remaining capscrews.		
Tighten the capscrews in the sequence shown in the graphic. **Torque** **Value:** 45 n.m [33 ft-lb]		
Lubricate the o-rings (13) with vegetable oil. Install the transfer tube in the water pump outlet connection. Install the water pump outlet connection, gasket, and capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]		
Connect the aftercooler supply hose to the water pump outlet connection.		

Tighten the clamps.

Torque
Value: 5.6 n.m [50 in-lb]



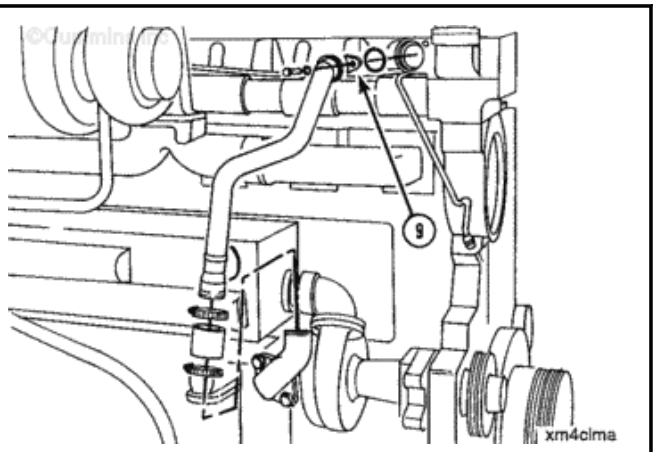
Lubricate the o-ring on the water bypass tube with vegetable oil.

Install the bypass tube.

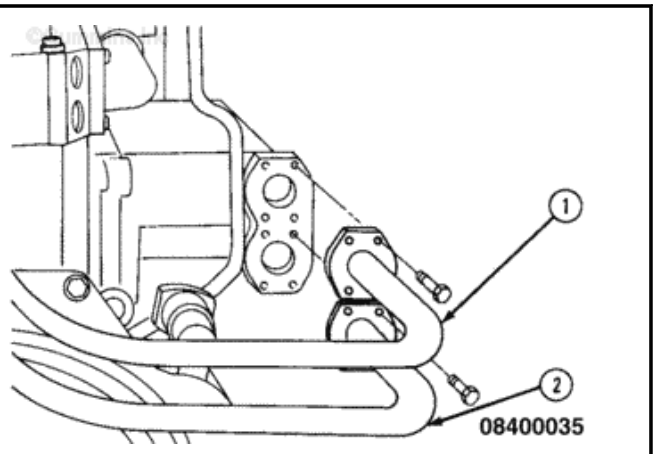
Install the retainer (9) and capscrew.

Tighten the capscrew and hose clamp.

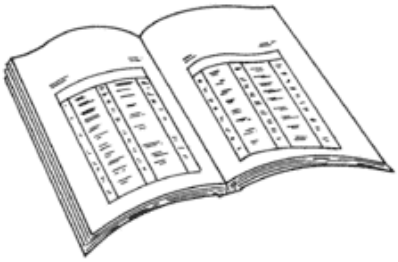
Capscrew	45 n.m	[33 ft-lb]
Clamp	6 n.m	[50 in-lb]



Connect the marine gear oil cooler oil tubes to the marine gear oil cooler.



Finishing Steps

• Install the turbocharger coolant supply hose. Refer to Procedure 010-037. • Install the turbocharger oil drain tube. Refer to Procedure 010-045. • Fill the cooling system. Refer to Procedure 008-018. • Operate the engine to 70°C [160°F] coolant temperature and check for leaks.		

Last Modified: 16-Aug-2004

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008-042 Radiator

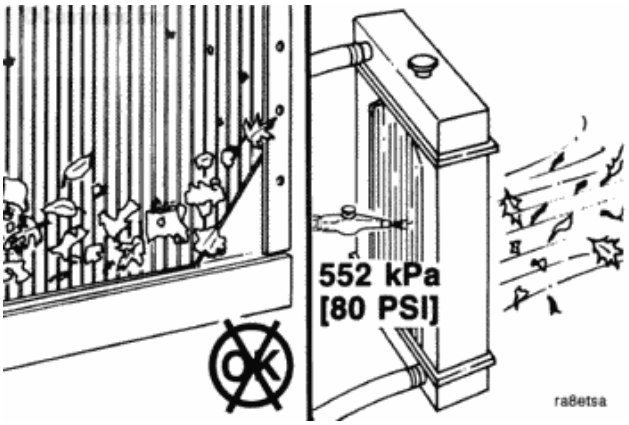
Maintenance Check

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Inspect the radiator for plugged fins.

If the radiator fins are plugged, use 552 kPa [80 psi] of compressed air to blow through the radiator in the opposite direction of fan air flow.

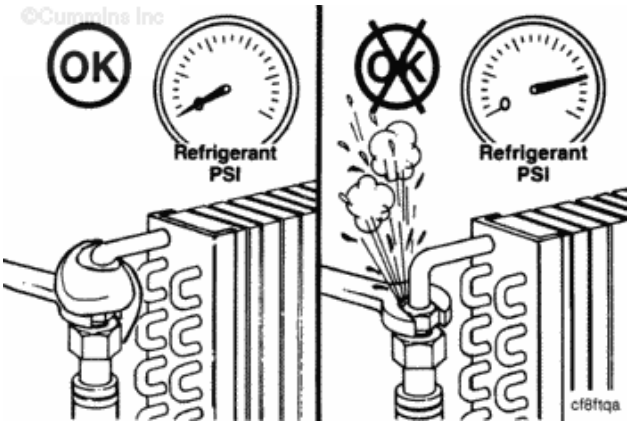


WARNING

If a liquid refrigerant system (air conditioning) is used, wear eye and face protection, and wrap a cloth around the fittings before removing. Liquid refrigerant can cause serious eye and skin injuries.

WARNING

To protect the environment, liquid refrigerant 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.

Make sure the liquid refrigerant system is drained before removing the radiator.

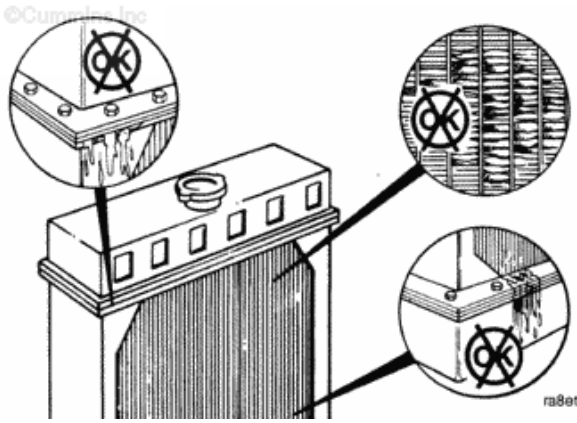
Check the radiator for bent or broken fins.

Check the radiator core and gasket for leaks.

Replace the radiator if the core is leaking. Refer to the manufacturer's instructions.



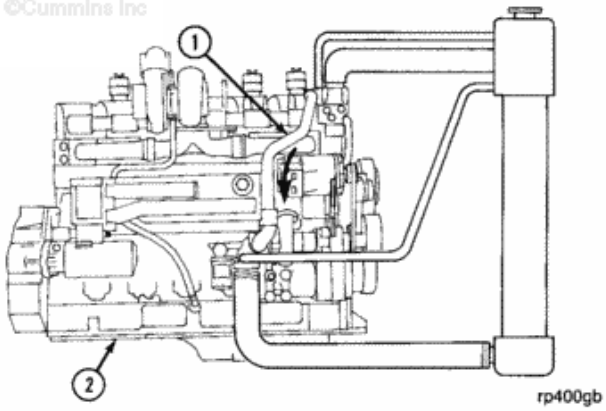




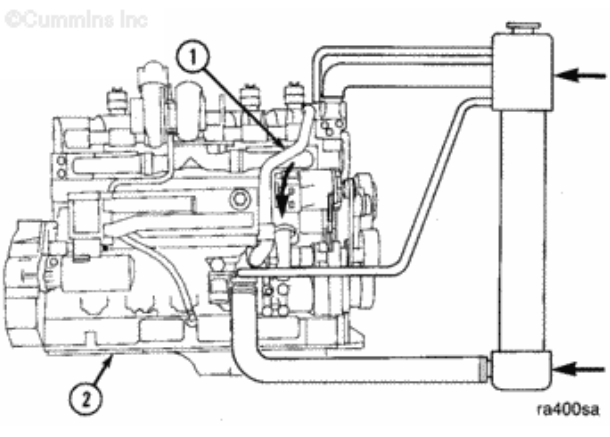
The reverse flow test **must** be performed with the cooling system completely full and the coolant at ambient temperature.

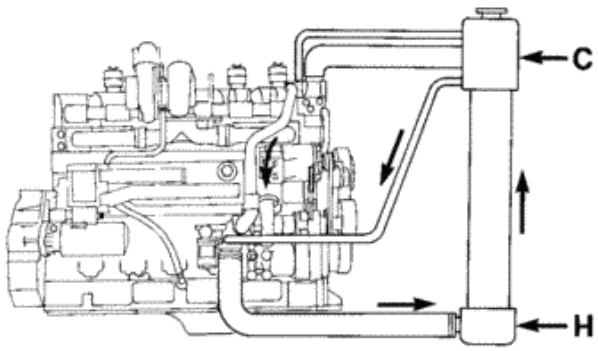
Operate the engine at a medium to high idle.

With the coolant at ambient temperature the thermostats are closed and coolant is flowing through the bypass line (1) and the engine (2).

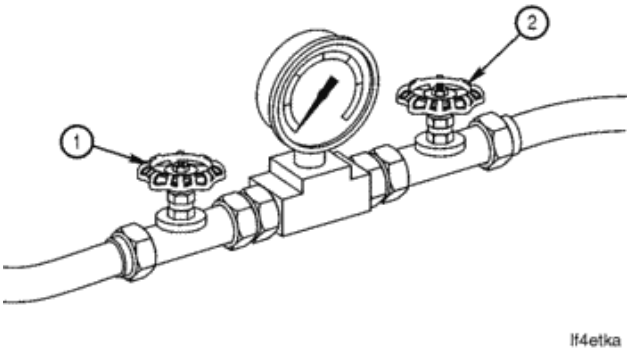


As the engine is warming up, use the back of the hand, contact pyrometer, or a infrared thermometer Part Number 3164487, or equivalent to check the temperature of the radiator top and bottom tanks.

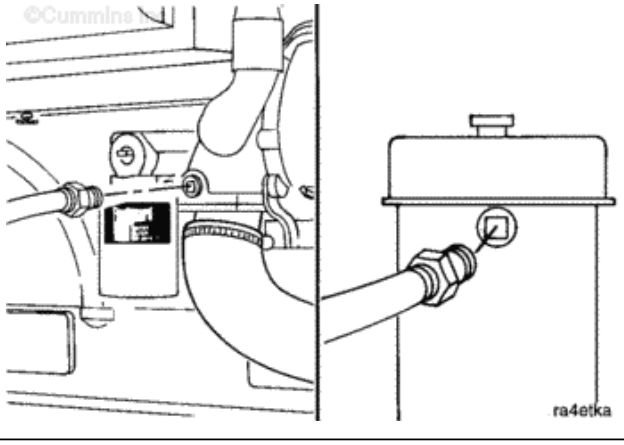


If the bottom tank begins to warm to the touch and the top tank remains cold, the radiator has reverse flow. Make sure the piping is the correct size and routed to specifications. Refer to the manufacturer's instructions and the appropriate installation bulletin.		

Pressure Differential Test

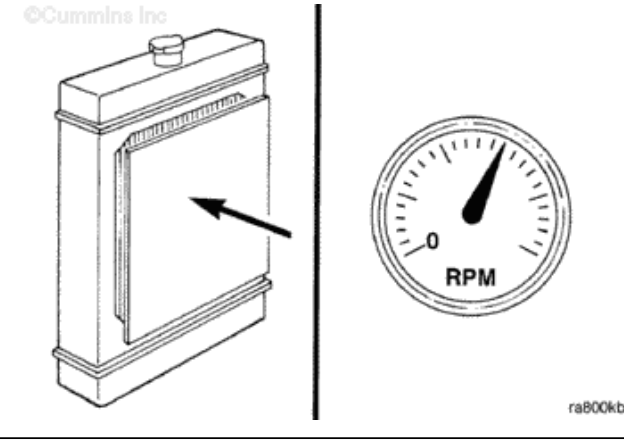
Install a valve on each side of a gauge designed to measure 0 to 100 kPa [0 to 15 psi].		

Install one line into the water pump inlet connection. Install the other line into the thermostat return line on the top of the radiator core. Bleed the air from the gauge lines.		



Restrict the radiator air flow.

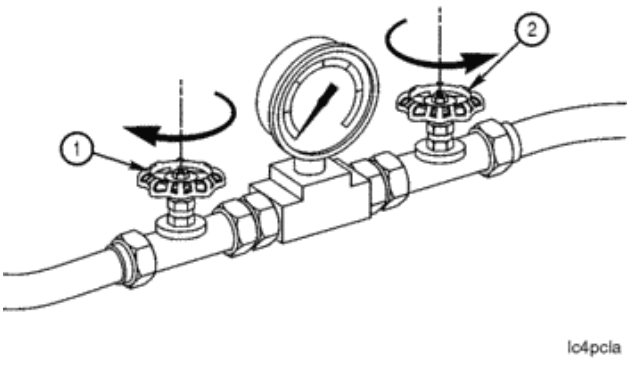
Operate the engine until the coolant temperature reaches 88 to 90°C [190 to 195°F].



Operate the engine at rated rpm.

Close valve (1) and open valve (2).

Record the pressure at the top of the radiator.

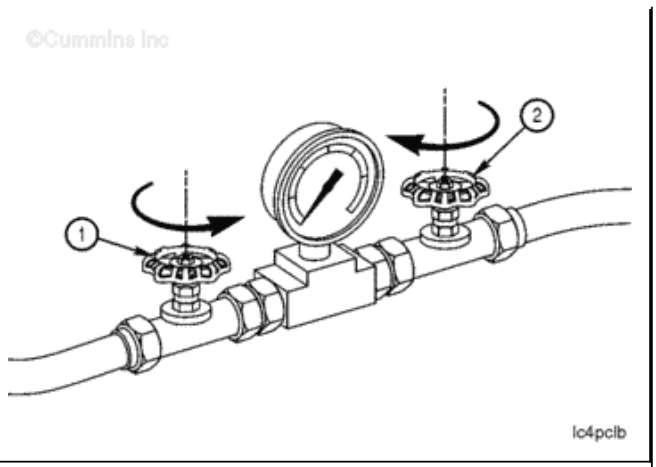


Close valve (2) and open valve (1).

Record the pressure at the

water pump inlet.

Compare the two pressure readings. If they differ more than 35 kPa [5 psi], the radiator core or piping is obstructed.



Last Modified: 19-Oct-2004

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008-045 Radiator Hoses

Preparatory Steps

WARNING

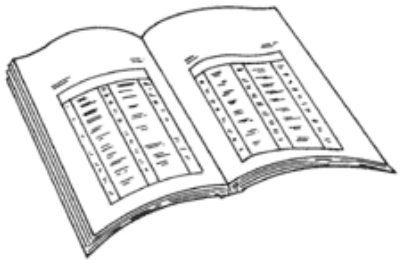
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

- Drain the cooling system. Refer to Procedure 008-018.





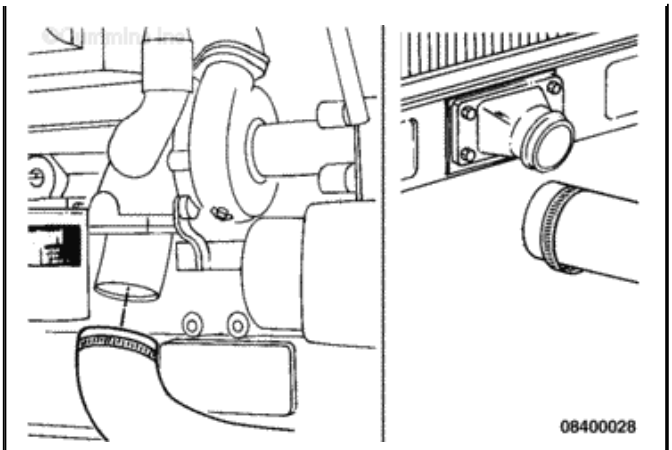
ck800wa

Remove

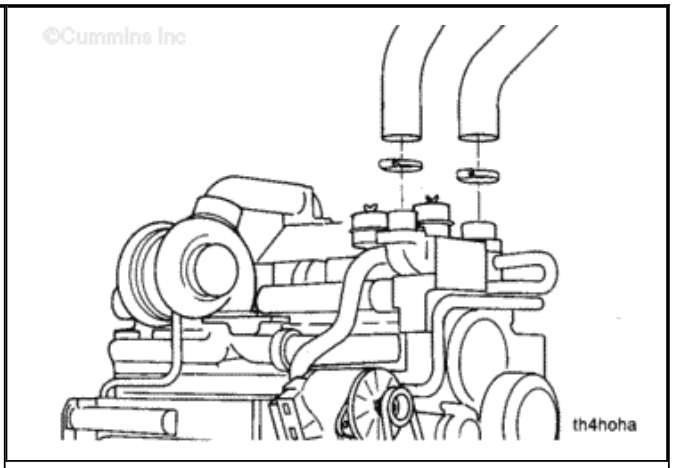
Disconnect the lower radiator hose from the water pump inlet.

Disconnect the lower radiator hose from the radiator bottom tank. Remove the lower radiator hose.

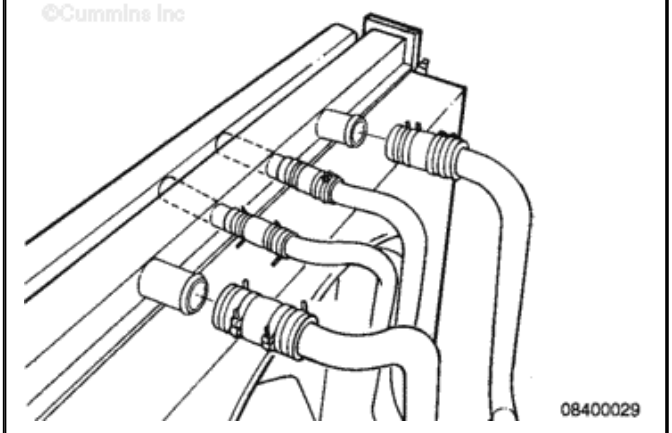




Remove the upper radiator hoses from the thermostat housing.



Remove the upper radiator hoses from the top tank of the radiator.



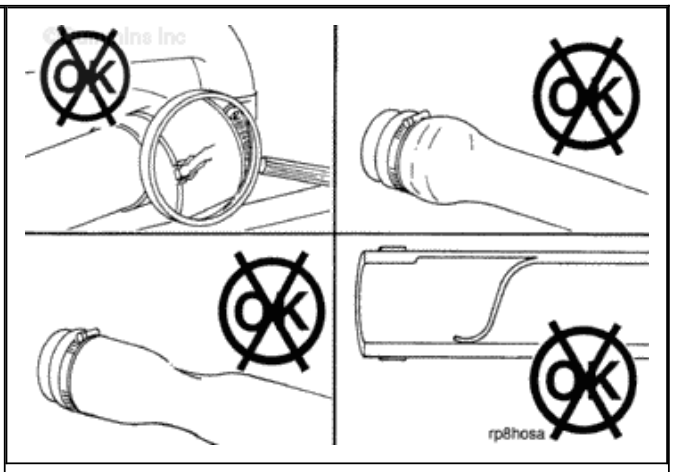
Inspect for Reuse

CAUTION

Do not bend or deform the hoses during inspection. This can cause the hoses to crack.

Check all hoses for cracks, cuts, or collapsing.

The silicone engine coolant hose will exhibit swelling due to the elasticity of the hose.

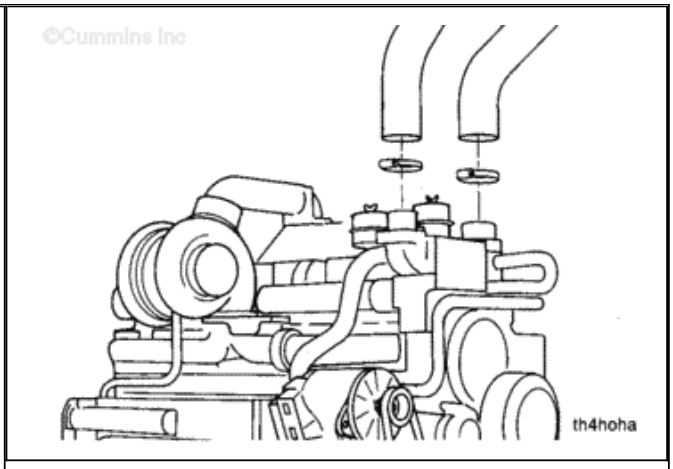


Install

Install the upper radiator hoses to the thermostat housing.

Tighten the clamps.

Worm Clamp	5 n.m	[50 in-lb]
T-Bolt Clamp	8 n.m	[70 in-lb]



Install the lower radiator hose to the water pump inlet.

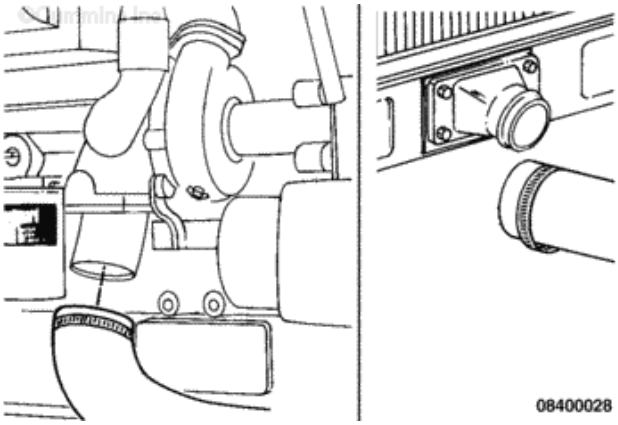
Tighten the clamps.

Worm Clamp	6 n.m	[50 in-lb]
T-Bolt Clamp	8 n.m	[70 in-lb]

Install the lower radiator hose to the radiator bottom tank.

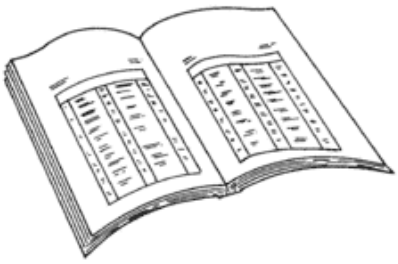
Tighten the clamps.

Worm Clamp	6 n.m	[50 in-lb]
T-Bolt Clamp	8 n.m	[70 in-lb]



Finishing Steps

- Fill the cooling system. Refer to Procedure 008-018.
- Operate the engine to 70°C [160°F] coolant temperature. Check for leaks.



Last Modified: 29-Nov-2004

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008-046 Supplemental Coolant Additive (SCA) and Antifreeze Concentration

Maintenance Check

Supplemental Coolant Additive (SCA)

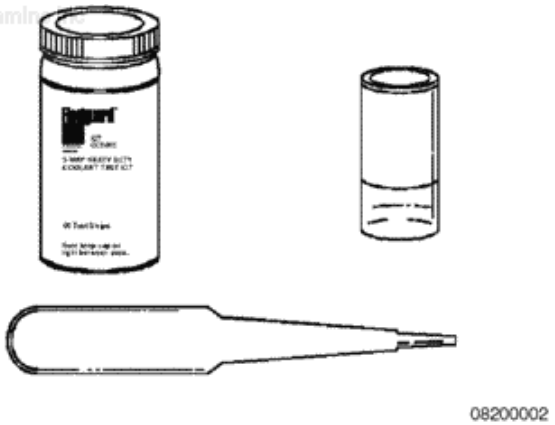
CAUTION

Failing to maintain the required SCA concentration level can cause engine damage.

Check the SCA concentration level

- At least twice a year
- At every subsequent oil drain interval if the concentration is above 3 units
- Whenever coolant is added to the cooling system between filter changes.

Use Fleetguard® coolant test kit, Part No. CC2602, to check the SCA concentration level. Instructions are included with the test kit. Use the Coolant Recommendations and Specifications in Maintenance Specifications (Section V) for the correct SCA and antifreeze level.



Antifreeze

CAUTION

Overconcentration of antifreeze or use of high-silicate antifreeze can damage the engine.

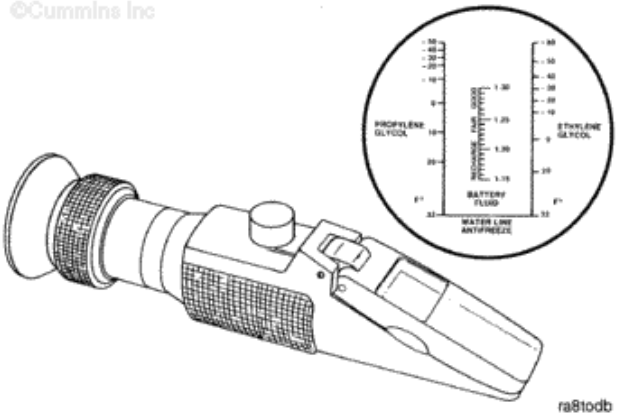
Check the antifreeze concentration. Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol-based antifreeze to protect the engine to -32°C [-26°F] year-around.

The Fleetguard® refractometer, Part Number C2800, provides a reliable, easy-to-read, and accurate measurement of freezing point protection and glycol (antifreeze) concentration.

Antifreeze is essential in every climate.

Antifreeze broadens the operating temperature range by lowering the coolant freezing point and by raising its boiling point.

The corrosion inhibitors also protect the cooling system components from corrosion and prolong component life.

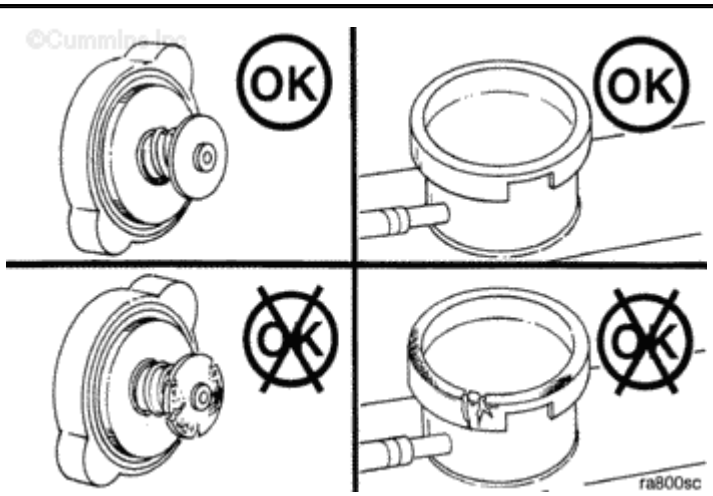


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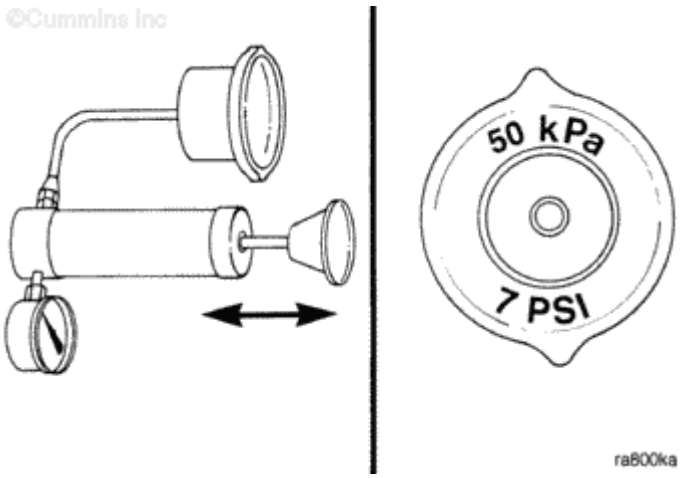
008-047 Radiator Pressure Cap

Inspect for Reuse

Inspect the rubber seal of the pressure cap for damage. Inspect the radiator fill neck for cracks or other damage. Refer to the radiator manufacturer's instructions if the fill neck is damaged. **NOTE: Be sure the correct radiator cap is being used. The pressure rating must be 48 kPa [7 psi] or greater.**		

Pressure Test

Pressure test the radiator cap.		

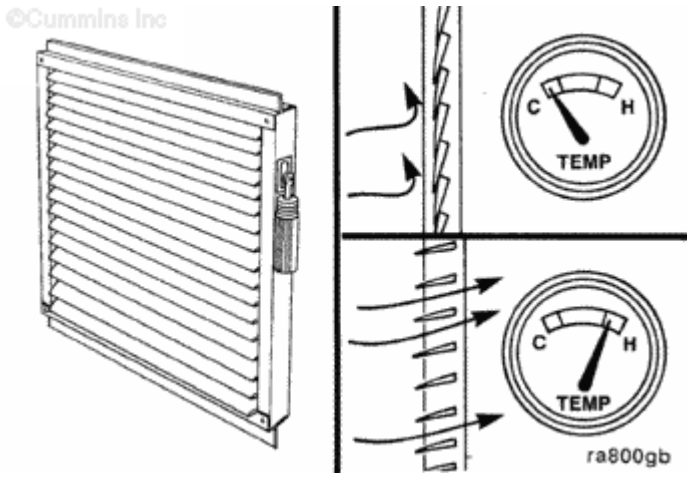
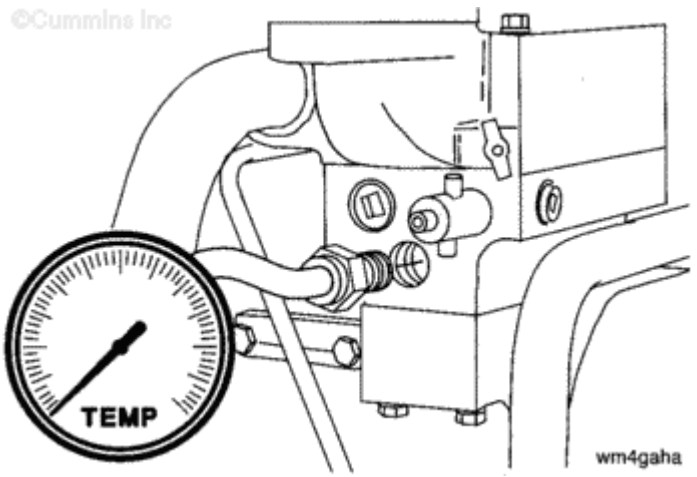
The pressure cap **must** seal within 14 kPa [2 psi] of the value printed on the cap, or it **must** be replaced.		

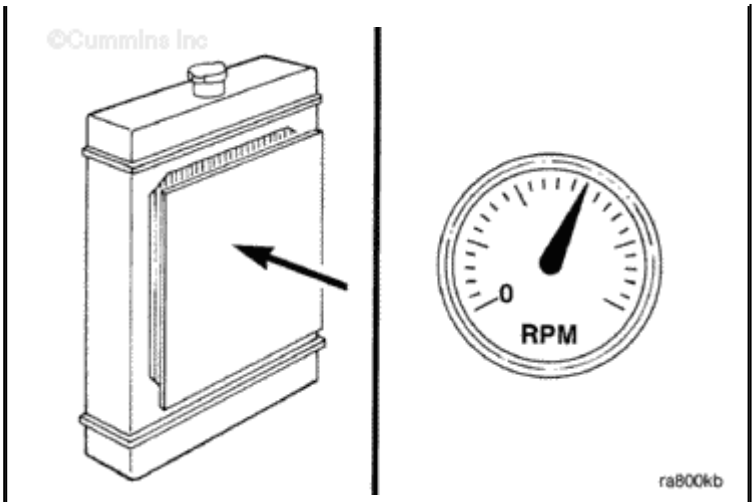
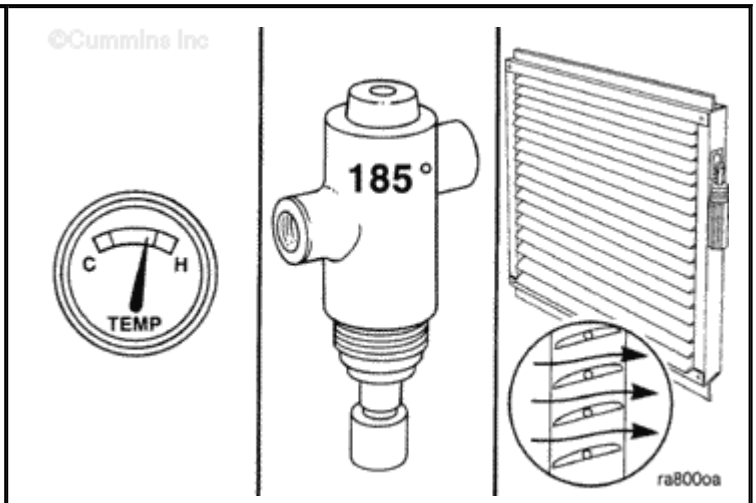
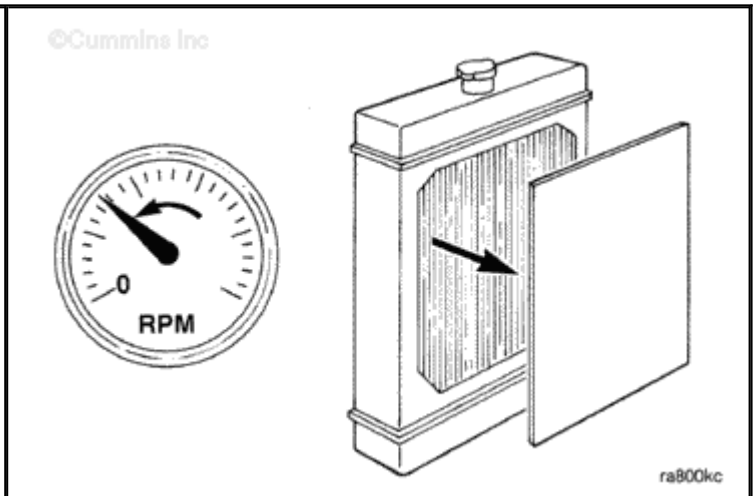
Last Modified: 16-Aug-2004

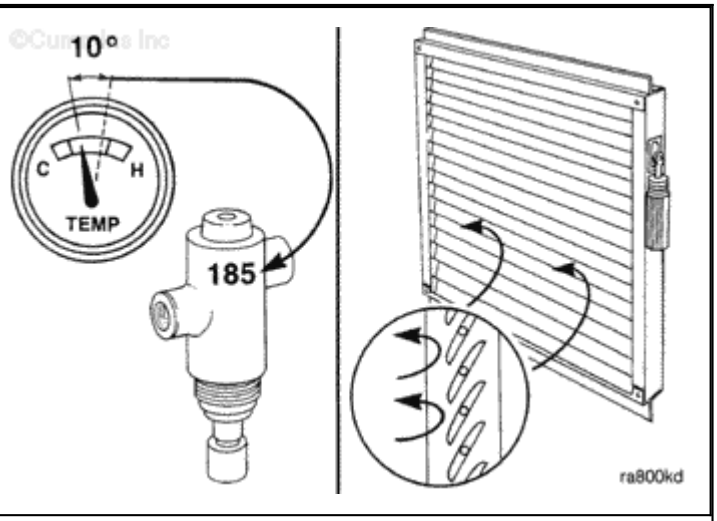
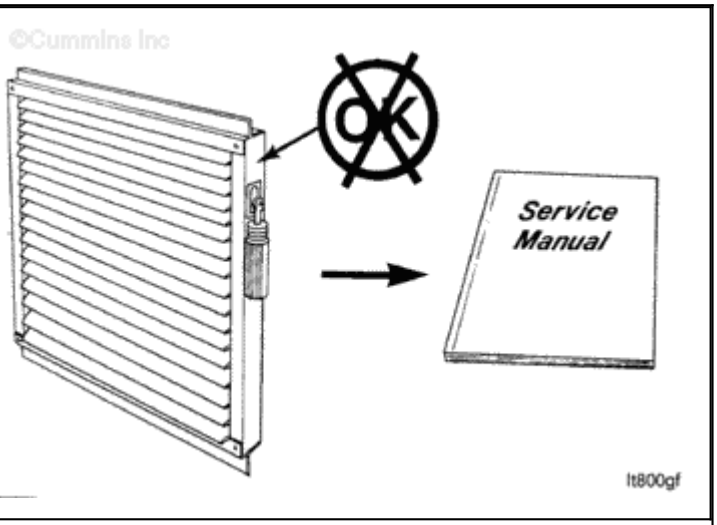
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008-049 Radiator Shutter Assembly

Response Test

The radiator shutters will be fully closed when the vehicle air pressure reaches 380 kPa [55 psi]. The shutters will remained closed until the coolant temperature reaches the value stamped on the control.		
Install a known accurate reference temperature gauge into the thermostat housing. A thermocouple can also be used.		
Restrict the radiator air flow.		

Operate the engine at rated rpm.		
When the coolant temperature reaches the temperature stamped on the control check the shutters to see if they are open. The shutters **must** be fully open.		
Return the engine to idle and remove the radiator air restriction.		

When the coolant temperature drops to approximately 6° C [10°F] below the temperature stamped on the control, the shutters will be fully closed.		
If the shutters do **not** operate correctly, refer to the shutter manufacturer's instructions.		

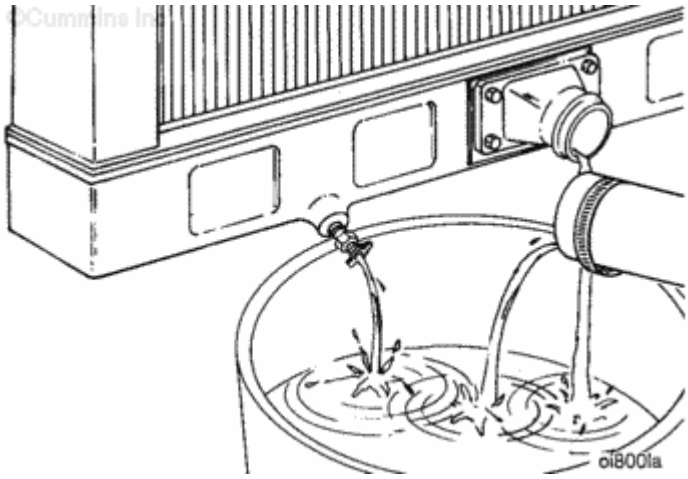
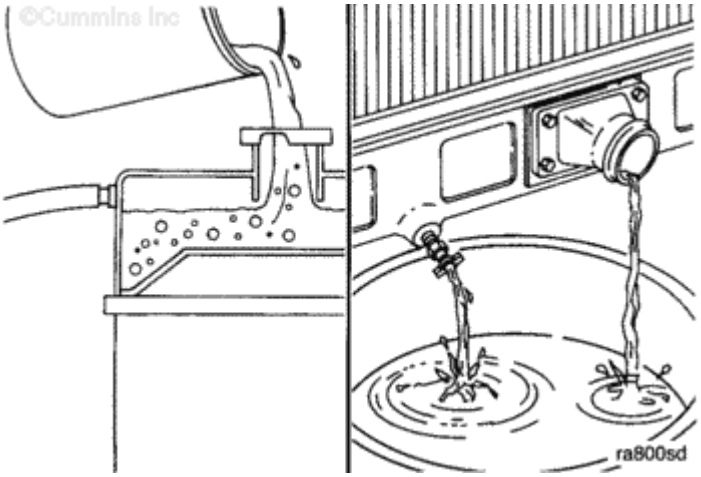
Last Modified: 16-Aug-2004

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008-051 Radiator Top Tank

Leak Test

Aftercooled Engines

Drain the cooling system. Refer to Procedure 008-018.		
Plug the radiator fill line outlet. Fill the top tank within 5 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: 16-Aug-2004

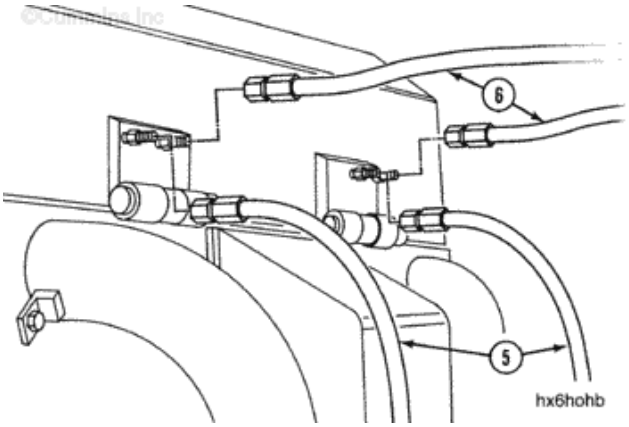
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008-052 Expansion Tank

Remove

NOTE: Not all engines are equipped with this option.

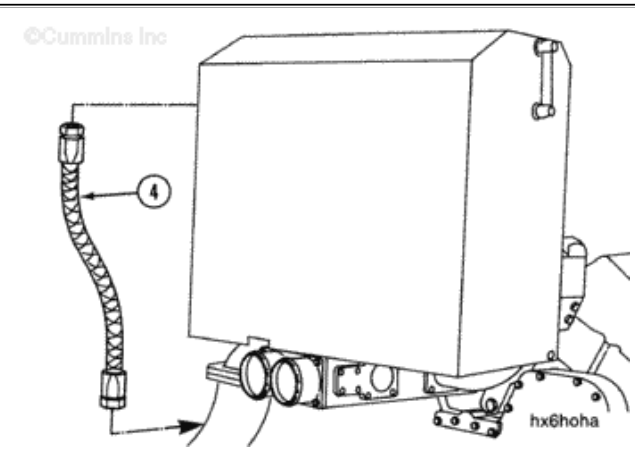
Detach the coolant vent hoses (6) and (5).



Detach both ends of the coolant make-up hose (4). Remove the hose.

Check the hose for damage.

Discard the hose if it is damaged.



WARNING

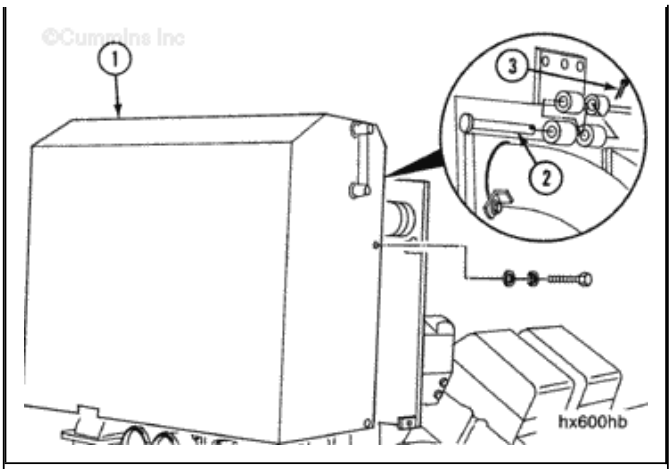
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get

assistance to lift this component.

Remove the four capscrews and washers.

Remove the cotter pins (3) and the two hinge pins (2).

Remove the expansion tank (1).

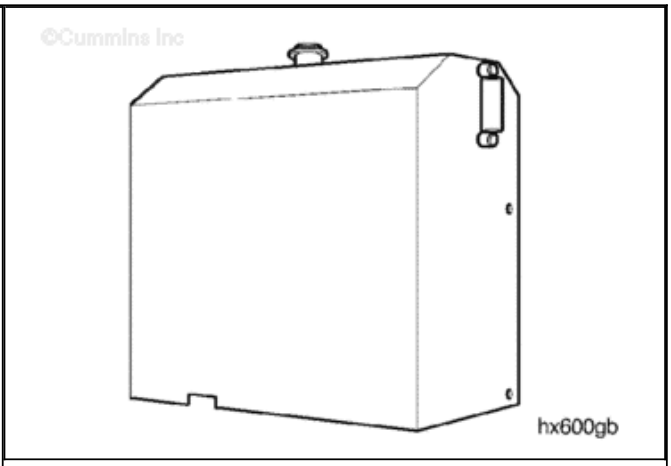


Clean and Inspect for Reuse

Use the same method to clean the tank as for any radiator top tank.

Pressure test the tank with water at 172 kPa [25 psi].

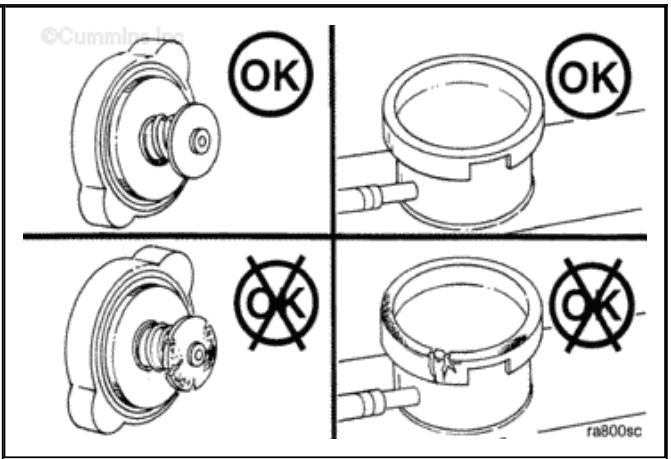
Repair any leaks.

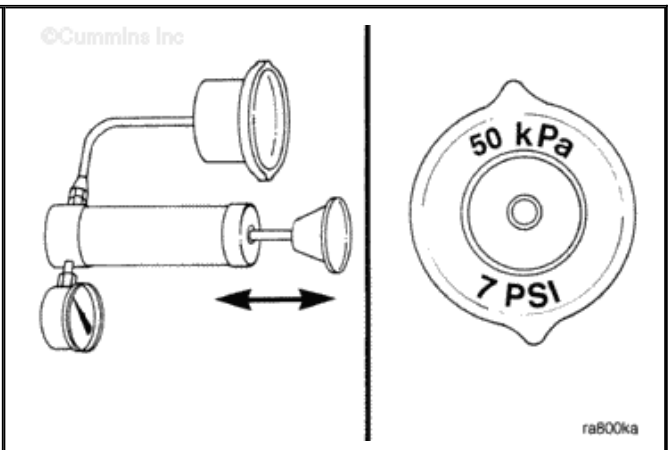


Check the rubber seal of the pressure cap for damage.

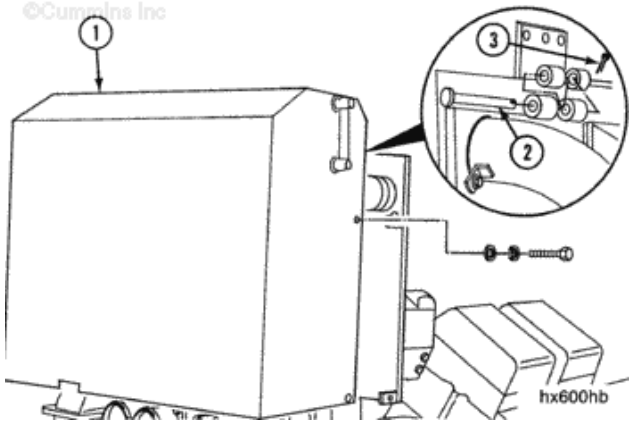
Check the fill neck of the tank for cracks or other damage.

If the fill neck is damaged, it can be replaced by a qualified radiator repair shop.

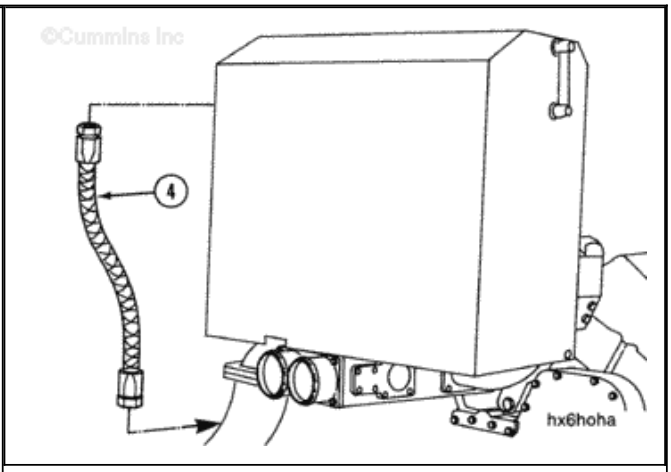


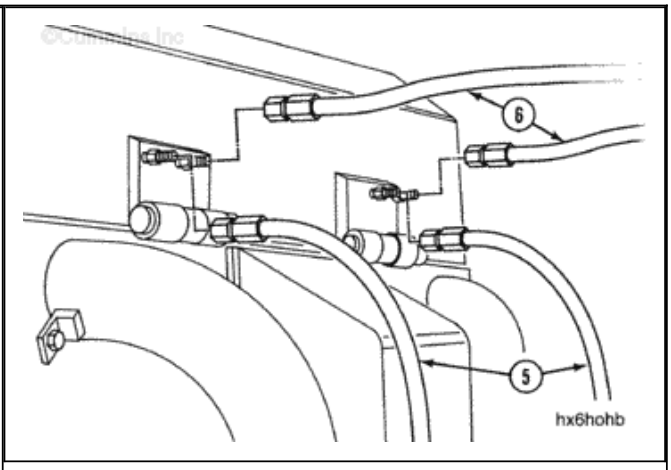
Pressure test the cap. The pressure cap **must** seal within 14 kPa [2 psi] of the value stated on the cap, or it **must** be replaced.		

Install

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. **NOTE: The expansion tank is only on an engine that is equipped with heat exchangers.** Put the tank (1) in position and install the two hinge pins (2). Install the cotter pins (3) in the hole in the hinge pins. Install the four flat washers, lock washers, and capscrews through the expansion tank to the brackets on the support. Tighten the capscrews. **Torque Value:** 40 n.m [30 ft-		

lb]		

Connect the coolant make-up hose (4) to the fitting on the expansion tank and to the fitting in the water pump inlet housing.		

Connect the two coolant vent hoses (5) to the fittings in the expansion tank and to the fittings on the top of the thermostat housing. If the engine is equipped with a center mount type aftercooler, connect the two vent hoses (6) to the fittings on the top of the aftercooler coolant outlet fittings and to the fittings on the expansion tank.		

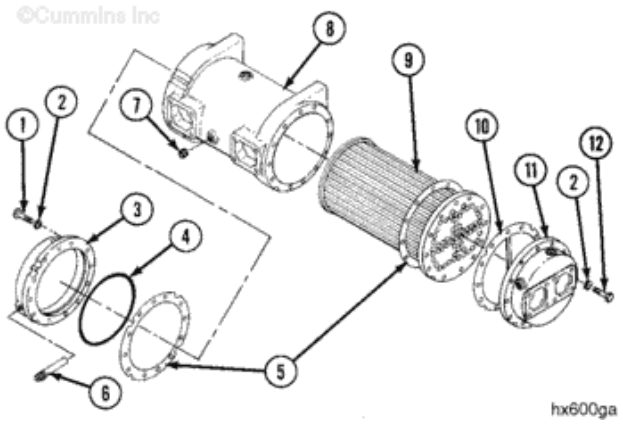
Last Modified: 29-Nov-2004

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008-053 Heat Exchanger

Exploded View

Tube Type



Tube Type Heat Exchanger

1. Socket head capscrew
2. Lock washer
3. Heat exchanger cover (closed end)
4. O-ring seal
5. Heat exchanger gasket
6. Zinc electrode plug
7. Pipe plug
8. Heat exchanger housing
9. Cooler core
10. Heat exchanger gasket
11. Heat exchanger cover (open end)
12. Socket head capscrew.

Plate Type

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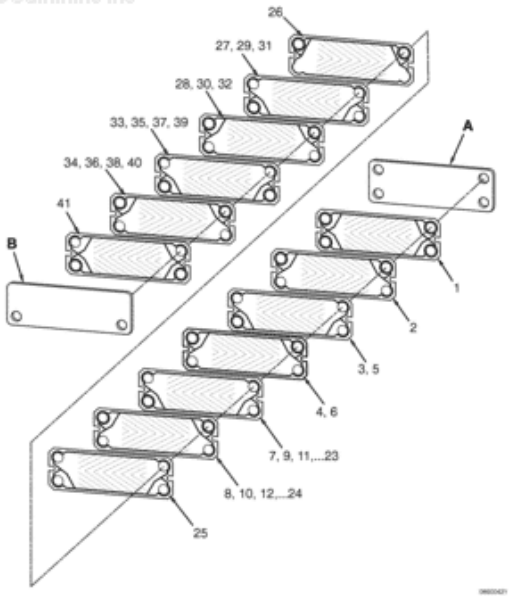


Plate Type Heat Exchanger

A. Lower Manifold
B. Tank

1. 395014-8243 Plate Location Number
2. 364141-4403 Plate Location Number
3. 364241-4403 Plate Location Number
4. 364141-4403 Plate Location Number
5. 364241-4403 Plate Location Number
6. 364141-4403 Plate Location Number
7. 364141-4403 Plate Location Number
8. 364141-4403 Plate Location Number
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22. 364141-4403 Plate Location Number
23. 364141-4403 Plate Location Number
24. 364141-4403 Plate Location Number
25. 395028-6501 Plate Location Number
26. 395028-6602 Plate Location Number
27. 364141-4403 Plate Location Number
28. 364141-4403 Plate Location Number
29. 364141-4403 Plate Location Number
30. 364141-4403 Plate Location Number
31. 364141-4403 Plate Location Number
32. 364141-4403 Plate Location Number
33. 364241-4403 Plate Location Number
34. 364141-4403 Plate Location Number

35. 364241-4403 Plate Location Number
36. 364141-4403 Plate Location Number
37. 364241-4403 Plate Location Number
38. 364141-4403 Plate Location Number
39. 364241-4403 Plate Location Number
40. 364141-4403 Plate Location Number
41. 364241-0482 Plate Location Number .

Preparatory Steps

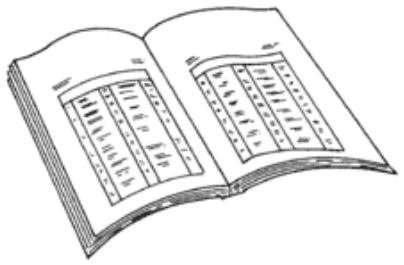
WARNING

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.



ck800wa

Remove

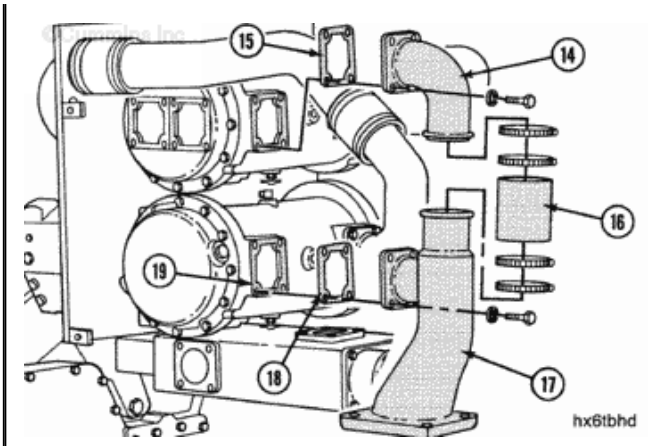
Tube Type

Remove the water pump inlet connection to heat exchanger outlet pipe (17).

Loosen the heat exchanger outlet pipe hose clamps.

Remove the eight outlet pipe capscrews and the outlet pipe (14).

Remove and discard the hose (16).

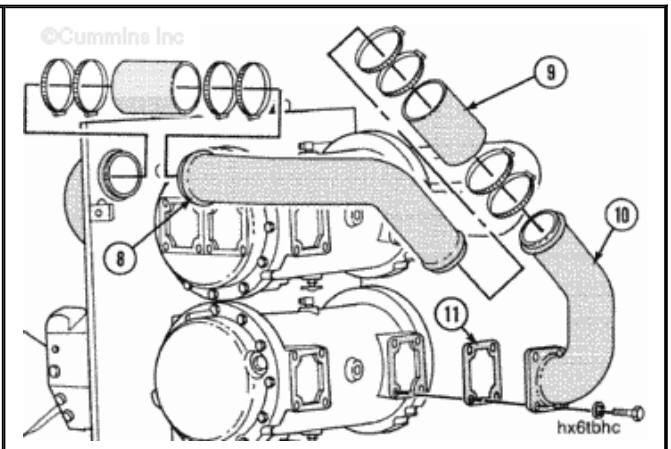


Loosen the eight hose clamps.

Remove the four capscrews.

Remove the pipes (8) and (10) and the gasket.

Discard the gasket and hoses.

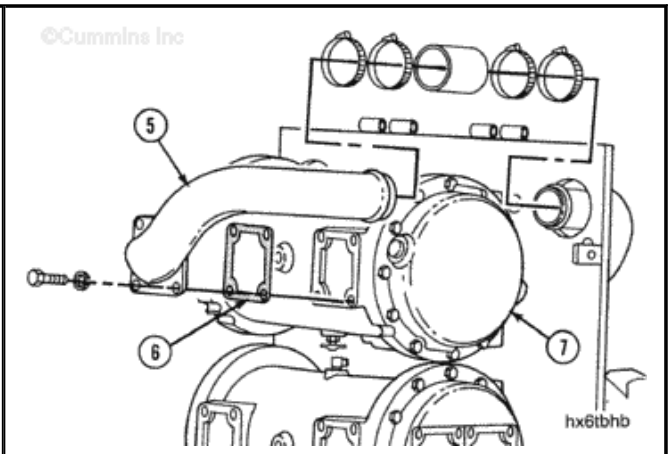


Loosen the hose clamps.

Remove the four capscrews.

Remove the pipe (5) and gasket.

Discard the hose and gasket.



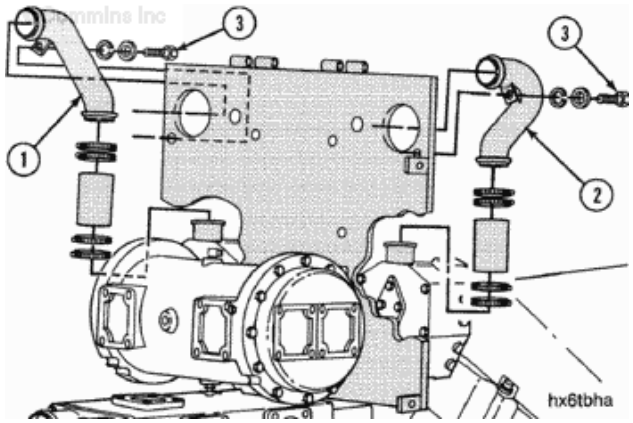
NOTE: A portion of the heat exchanger support is not shown for clarity.

Loosen the hose clamps.

Remove the two capscrews (3).

Remove the engine outlet pipes (2) and (1).

Discard the hoses.



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.

NOTE: Not all engines are equipped with the upper and lower heat exchanger option.

Remove the capscrews.

Remove the upper heat exchanger (2).

Remove the lower heat exchanger (1).

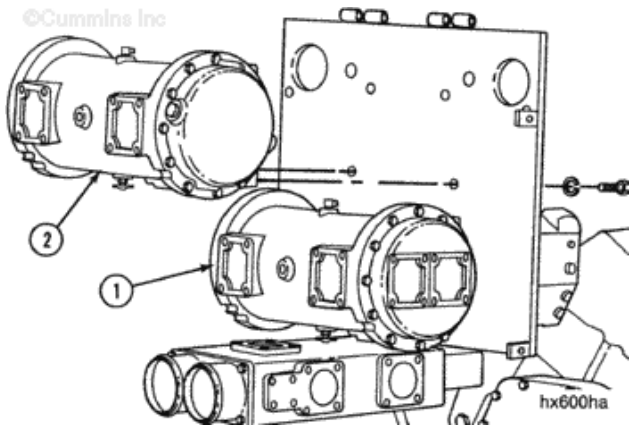
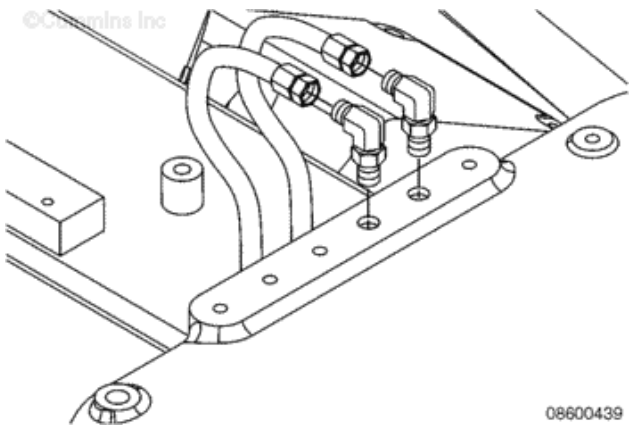
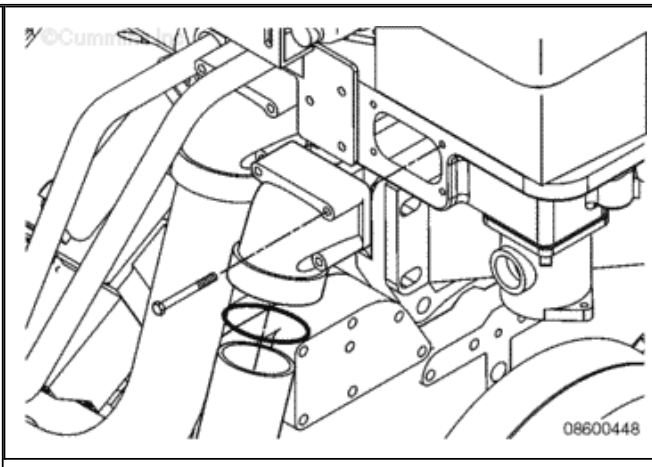
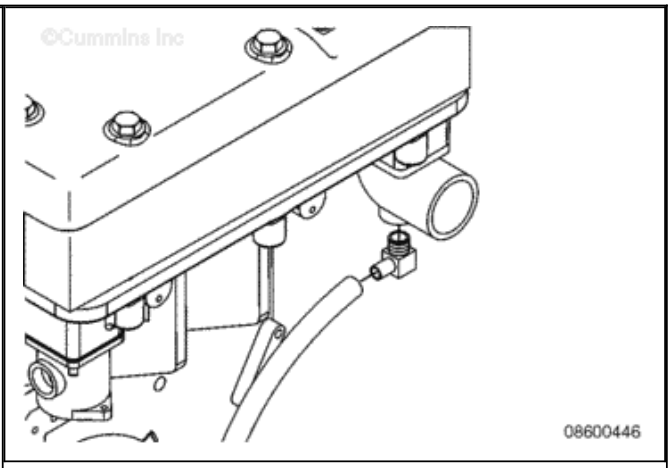


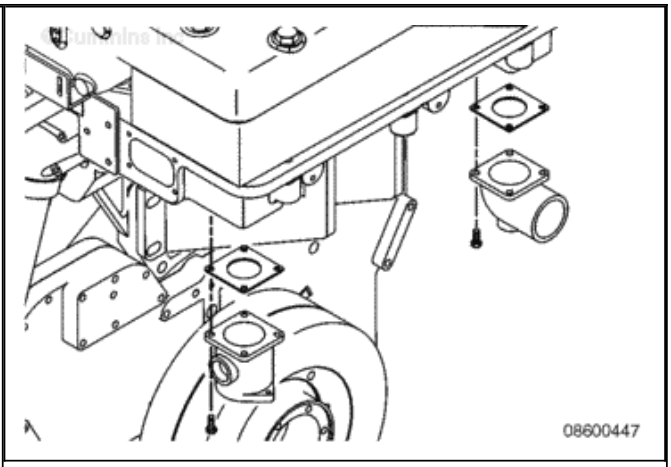
Plate Type

Remove the vent lines from the expansion tank.



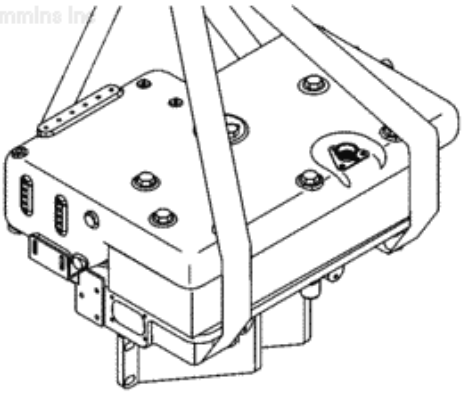
Disconnect and remove the coolant outlet tube.		

Disconnect the sea water pump prime discharge line from heat exchanger sea water outlet connection.		

Disconnect the sea water inlet and outlet tube.		

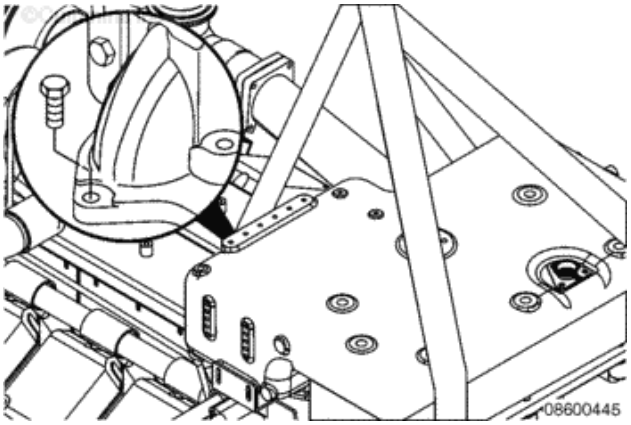
Attach a chain fall or other		

lifting equipment with straps around the heat exchanger assembly as shown.

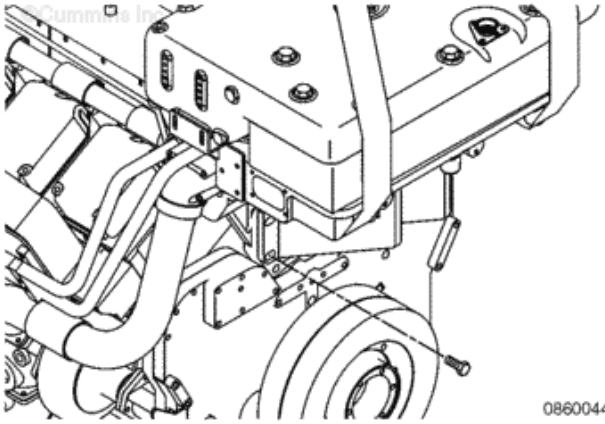


Remove the six jacket water manifold capscrews that hold the jacket water manifold to the thermostat housing.

Remove the four LTA transfer tube mounting capscrews that hold the tubes to the thermostat housing.



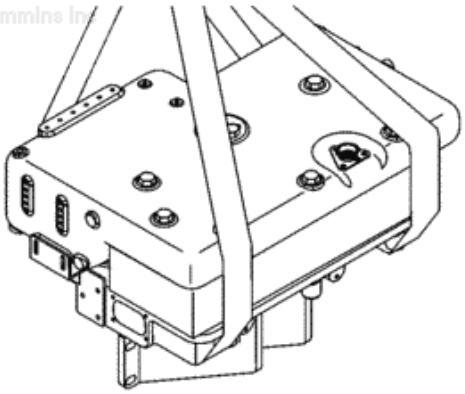
Disconnect the lower mounting bracket capscrews that fasten the bracket to the engine block.



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.

Lift the heat exchanger assembly away from the engine.



Inspect for Reuse

Tube Type

WARNING

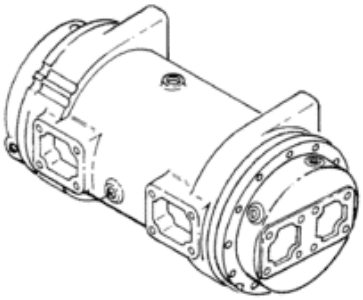
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

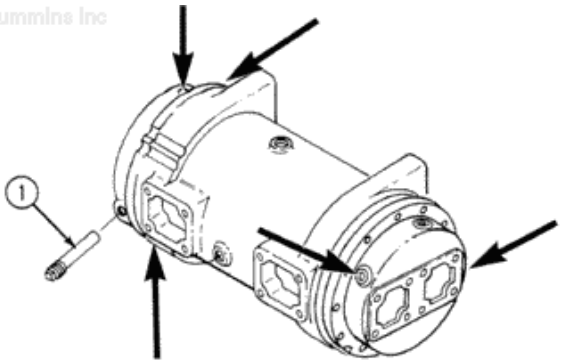
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause personal injury.

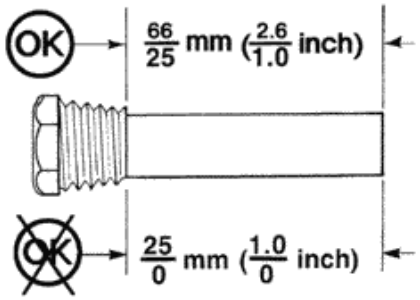
Clean all of the gasket surfaces and the exterior of the heat exchanger with solvent or steam.

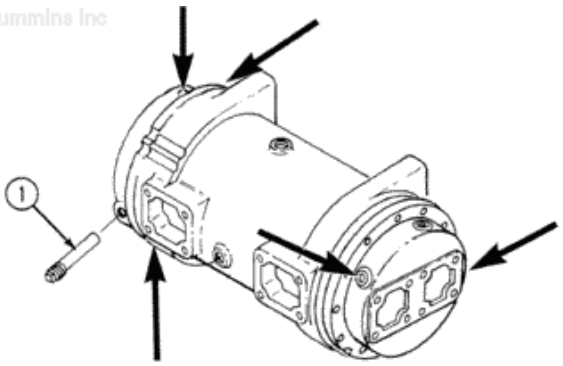
Flush the engine coolant and



raw water passages of the heat exchanger. Check the raw water passages for dirt or debris.		

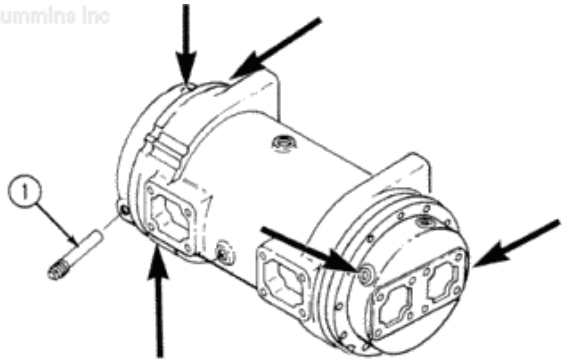
Remove the six zinc electrode plugs (1).		

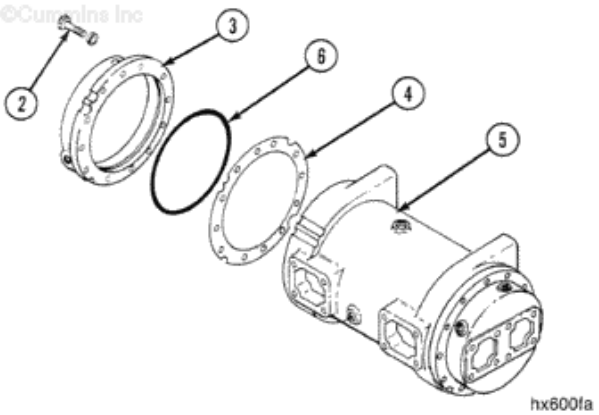
Check the length of the each electrode. If more than 12.7 mm [0.500 in] of the length is missing, the electrode **must** be replaced.		

Install the six zinc electrode plugs (1). Tighten the zinc electrode plugs. **Torque** **Value:** 55 n.m [40 ft-lb]	 	

Disassemble

Tube Type

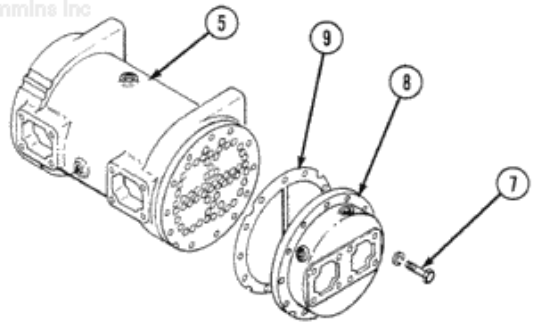
Remove the six zinc electrode plugs (1).		

CAUTION Do not damage the housing or cover when separating the parts. If parts are damaged a leak will result. The closed end of the housing has two notches. Turn the closed end of the cover so the notches are not aligned with the notches in the housing. Use a mallet and brass drift to move the o-ring seal from the core. Remove the 12 capscrews (2), lock washers, closed end cover (3), and gasket (4) from the housing (5). Remove the o-ring seal (6) from the cover. Discard the o-ring seal.		

CAUTION

Do not damage the housing or cover when separating the parts. If the parts are damaged, a leak will result. The open end of the housing has one notch. Turn the open end cover so the notch is aligned with the notch in the housing. Use a mallet and a brass drift to move the o-ring seal from the core.

Remove the 12 capscrews (7), lock washers, open end cover (8), and gasket (9) from the housing (5).



Remove the cooler core (10) and the gasket (4) from the housing (5).

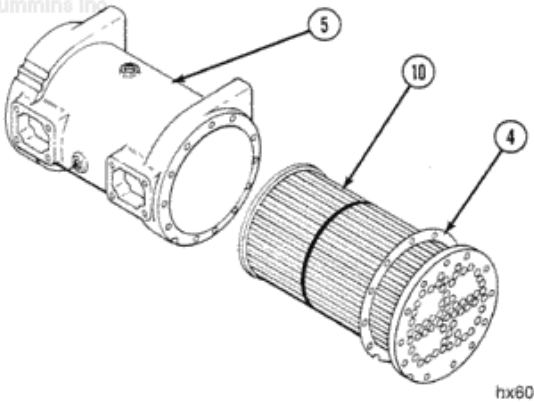
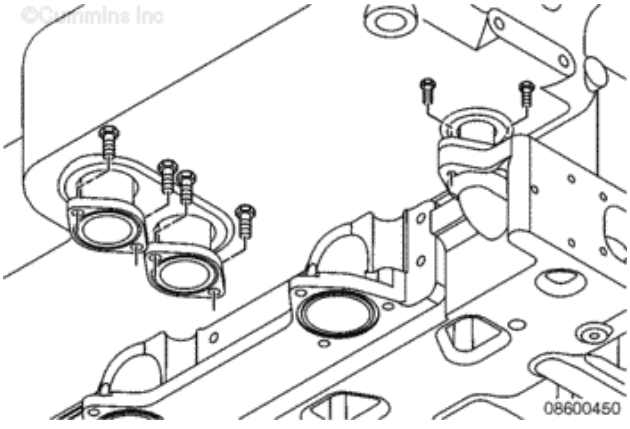
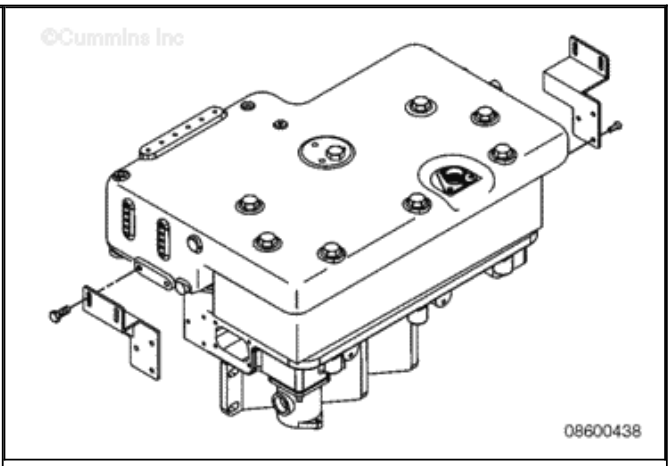
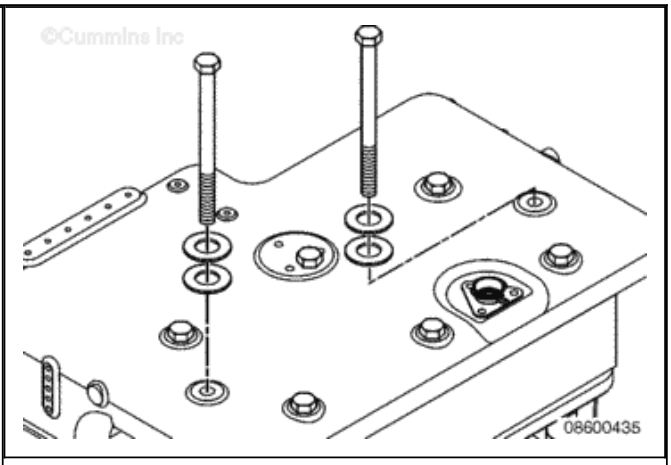
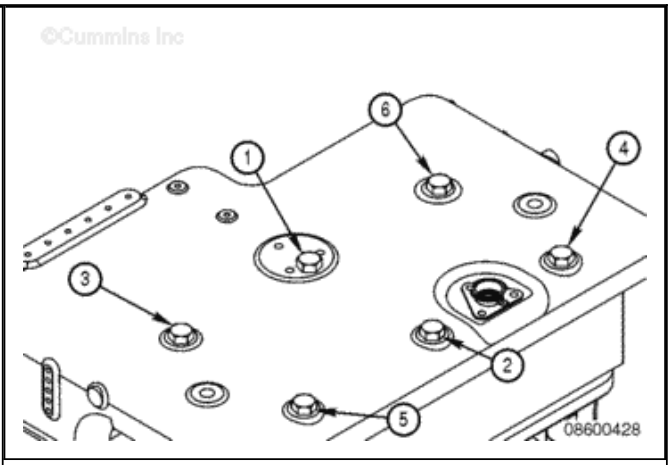


Plate Type

Remove the two flange capscrews from the drain tube. The drain tube will stay in the expansion tank during the disassembly process.

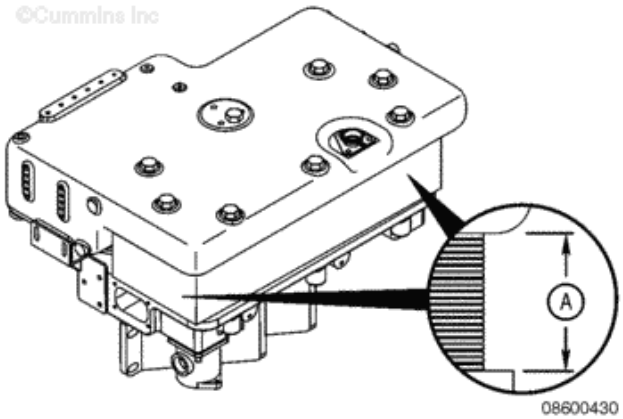


If installed, remove the support brackets from both sides of the expansion tank. More current versions of the heat exchanger assembly, with cast front support brackets, do **not** have the side brackets installed.		
Remove the two end top spacer capscrews from the top of the expansion tank.		
Loosen the capscrews 1 through 6 that hold the expansion tank against the plate pack, in the sequence shown.		

CAUTION

Do not loosen each bolt completely. The expansion tank must not be more than 12 mm [0.50 in] from level; as this will cause the plate pack and tank to bind on the Low Temperature Aftercooled (LTA) tubes and the drain tubes causing damage to them and the o-rings.

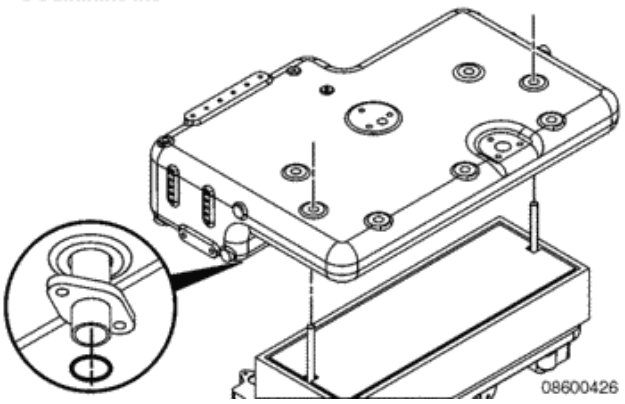
Remove the capscrews.



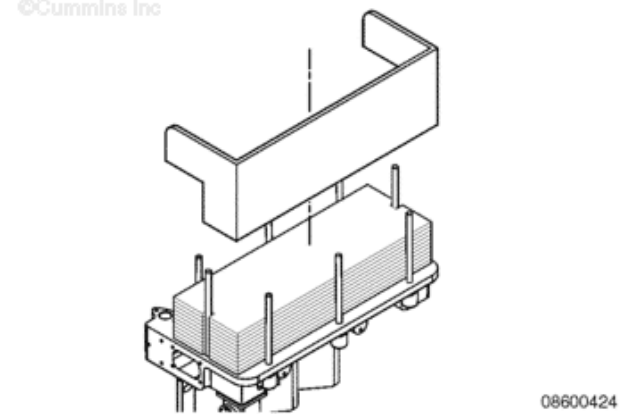
WARNING

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 tank from the assembly.



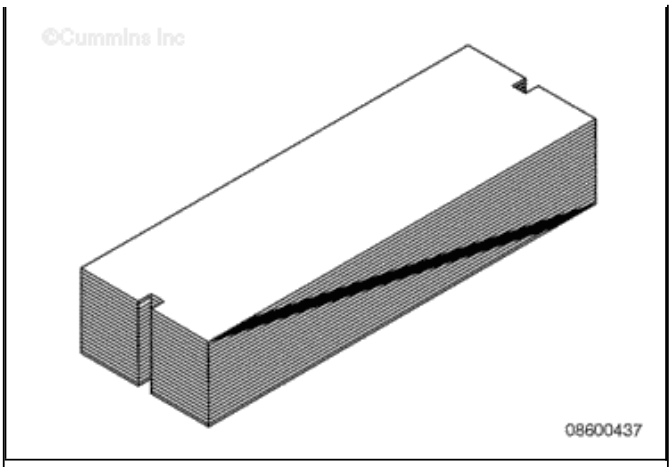
Remove the shield by removing the 10 capscrews that mount the shield to the spacers.



Use a paint marker to draw a diagonal line across the plate

pack as shown.

The line will help identify plate arrangement and benefit the assembly procedure.

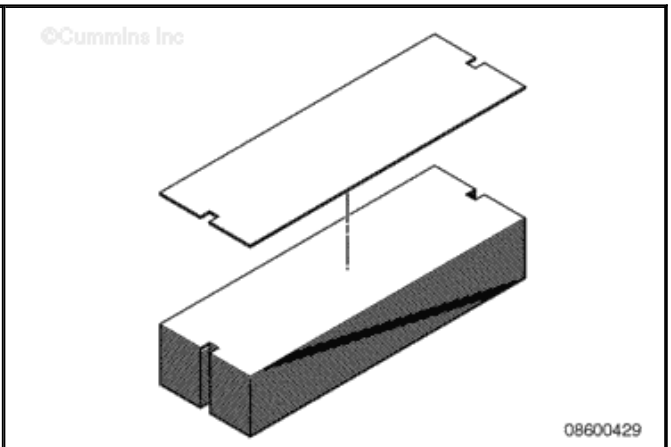


WARNING

Wear protective gloves for protection against sharp edges.

Remove the plates from the assembly.

The plates have sharp edges.



Clean and Inspect for Reuse

Tube Type

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.

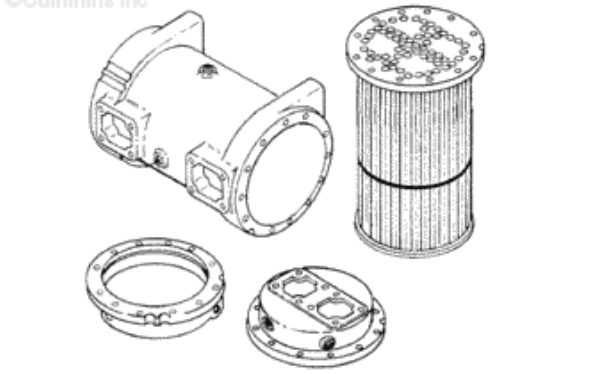
WARNING

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

Clean all of the parts with solvent or steam.

Make sure all gasket surfaces are clean.

Inspect parts for cracks and other damage. Replace any damaged parts.



Use a brass or copper rod that has an outside diameter of 8 mm [5/16 in] to clean the tubes.

If more than 5 percent of the tubes are plugged or have been closed by an earlier repair, the core **must** be replaced.

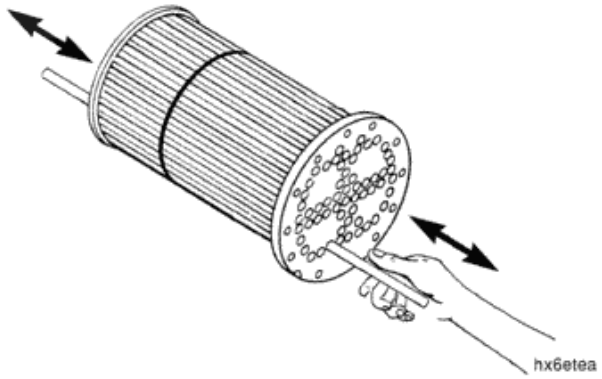


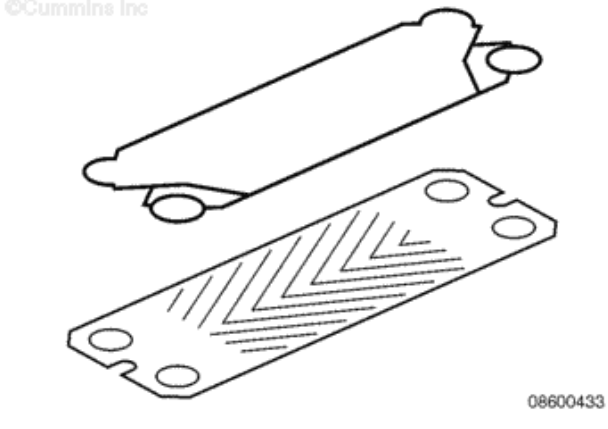
Plate Type

CAUTION

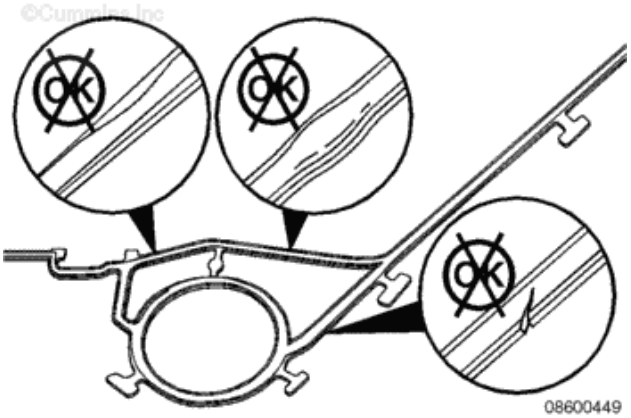
Incorrect orientation of the gaskets can cause overheating and sea water to enter the cooling system.

Observe the orientation of the gasket for assembly accuracy.

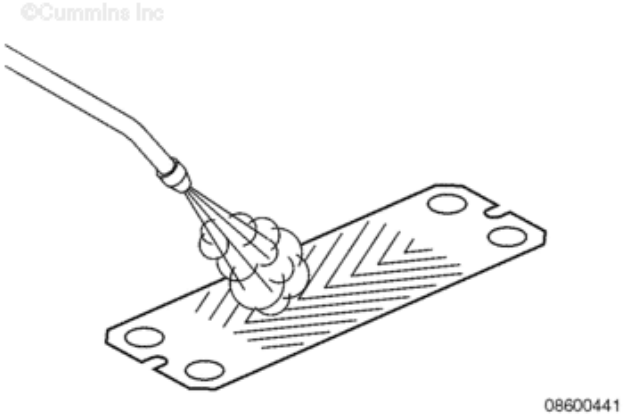
Remove each gasket from the plate one at a time.



Clean each plate.		

Inspect the gasket. If gaskets are swollen, cracked, or deformed, they **must** be replaced.		

Clean the plate with a soft brush and running water.		

If deposits are present that are difficult to remove, spray the plate with a high pressure water hose. If brushing and high pressure water does **not** properly clean the plates, the deposits on the plates can be evaluated. Use the information in the following lists to determine what solvents to use. **Incrustation** • Calcuim carbonate		

(corrosion products - clean with nitric acid).
- Calicum sulphate (metal ozides - clean with sulfamic acid).
- Silicates (silt - clean with citric acid, alumina - clean with phosphric acid, diatomic organisms and their excrement of various colors - clean with complexing agents EDT, A, and NTA).

Biological Growth

- Slime - Clean with alkaline cleaning agents.
- Bacteria - Clean with sodium hydroxide.
- Nematodes - Clean with sodium hydroxide.
- Protozoa - Cleaning effect can be considerably increased by the addition of small quantities of hypochlorite or agents for the formation of complexes and surfactants.

Concentration maximum: Four Percent.

Temperature maximum: 60° C [140° F].

Solvents That Can Not be Used

- Ketones (acetone, methyletylketone, methylisobutylketone)
- Esters (ethylacetate, butylacetate)
- Halogenated hydrocarbons (chloro-thene, carbon tetrachloride, freons)
- Aromatics (benzene, toluene).

Pressure Test

Tube Type

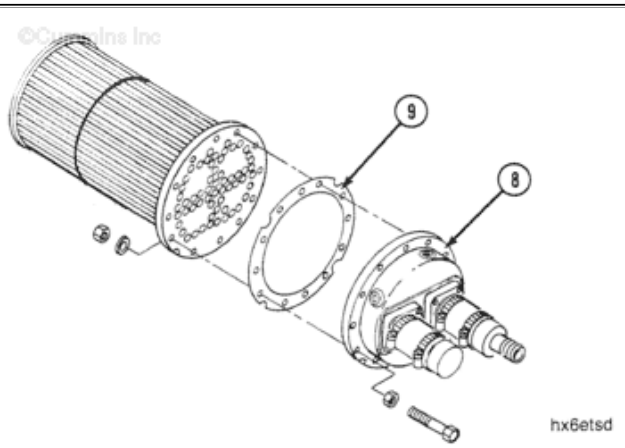
CAUTION

Install heavy washers between the nuts and flange on the core to reduce the possibility of damage to the sealing surface of the core.

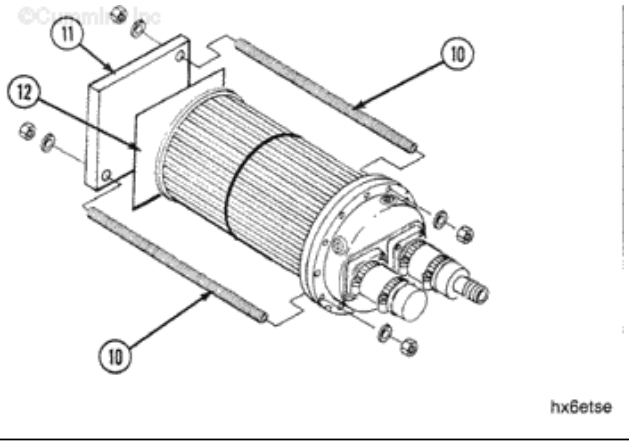
Install the connections, hoses, clamps, plug, and reducer on the open end cover.

The two capscrew holes that are 180 degrees apart **must** remain open.

Install the cover (8) and gasket (9) on the flange of the core using at least four capscrews, nuts, and washers.



Use two lengths of threaded rod (10), a plate with holes for the rod (11), a piece of gasket material (12), nuts and flat washers to seal the open end of the core.

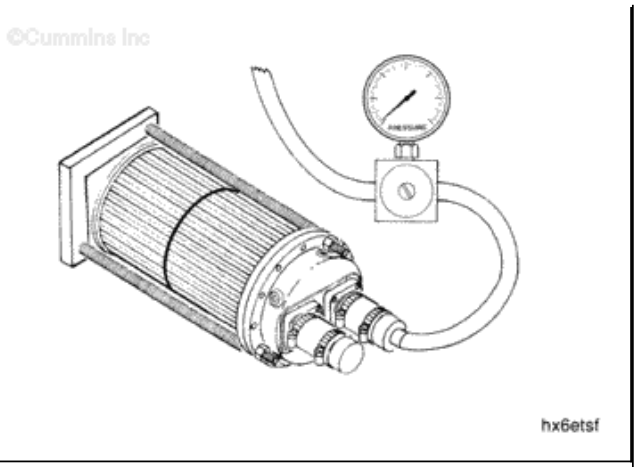


CAUTION

Tighten the nuts only enough to seal the gaskets. Do not tighten the nuts

excessively or damage to the core will result, preventing its use.

Connect a regulated compressed air supply to the fitting in the reducer as illustrated in the graphic.



Immerse the core and testing items in a container of water.

Adjust the regulator to apply 275 kPa [40 psi] of air pressure to the core.

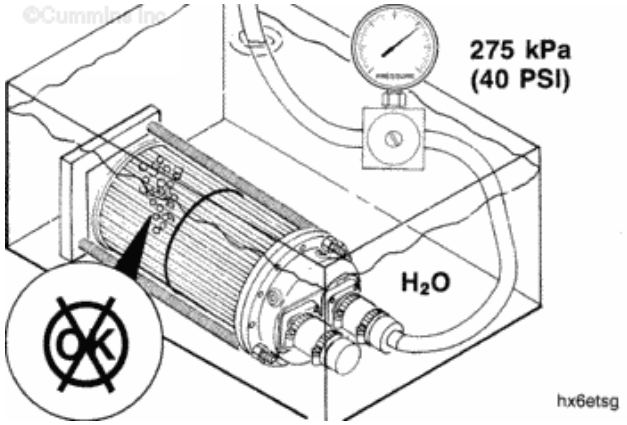
Check for air bubbles escaping from the core. Make sure bubbles are **not** escaping from the area of the testing plate.

Some air will be trapped between the tubes of the core when the core is immersed. Move the core around to allow the trapped air to escape.

If the core is leaking a steady stream of bubbles will be visible.

If the core is leaking, it **must** be replaced.

After completing the test, remove the testing items from the heat exchanger core.



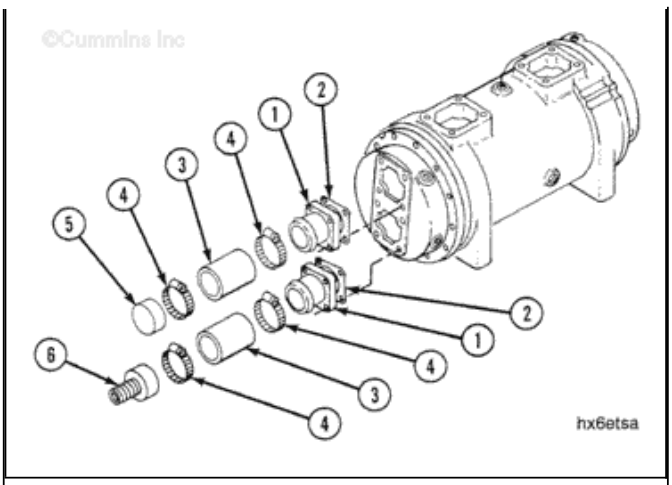
An alternate method of pressure testing the heat exchanger core is to pressure test the core with the heat exchanger assembled.

It is necessary to use two of the heat exchanger piping connections (1), gaskets (2), hoses (3), and hose clamps (4).

Install the connections, gaskets, and hoses on the open end cover plate.

Install a plug (5) into one of the hoses using a hose clamp.

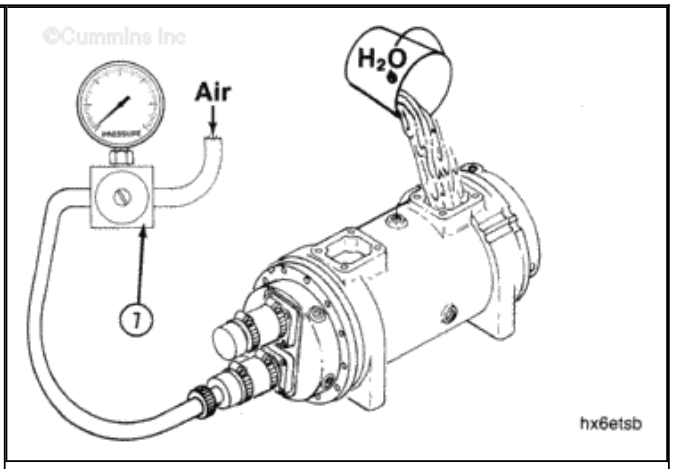
Install a reducer (6) to connect a source of compressed air supply in the other hose.



Connect an air supply to a regulator and gauge assembly (7).

Connect the outlet hose of the regulator to the fitting on the reducer.

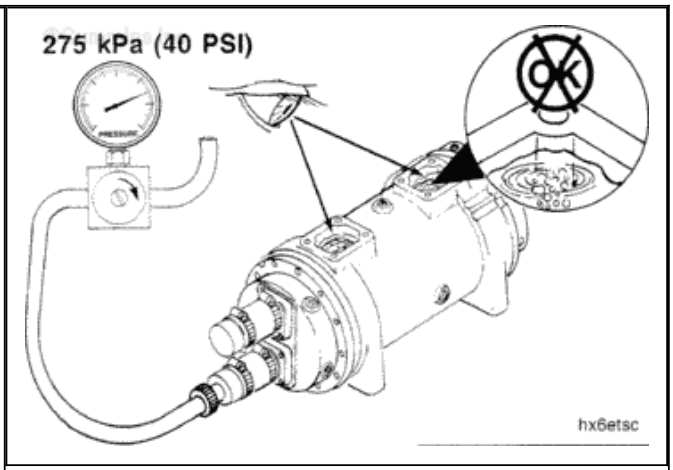
Fill the heat exchanger with clear water.



Adjust the regulator to apply 275 kPa [40 psi] air pressure to the core.

Check for air bubbles in the engine coolant side of the heat exchanger.

If air bubbles are visible, the core has a leak and **must** be replaced.

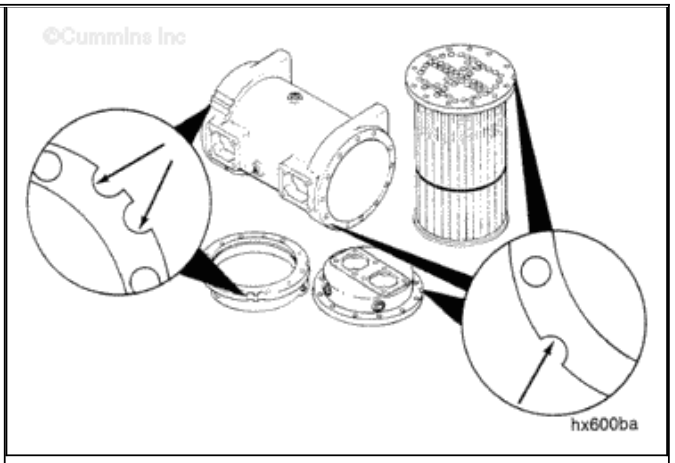


Assemble

Tube Type

CAUTION

One end of the housing has one notch, and one end has two notches. The cooler core and the open end cover must be installed on the end that has only one notch. If the heat excluder is not assembled correctly, the engine will overheat because the water pipe will not be connected correctly.



CAUTION

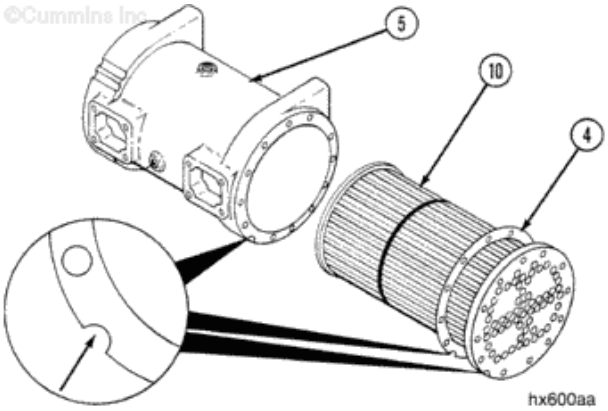
The notch in the core and the notch on the housing must be in alignment. If the parts are not in alignment, the coolant flow through the heat exchanger will be faulty and the engine will overheat.

Install the gasket (4).

Align the notch in the gasket with the notch on the core. The capscrew holes will also be aligned.

Install the cooler core (10) in the housing (5).

Align the notches on the core, gasket, and housing.



CAUTION

A notch in the gasket and the notch on the cover must

be in alignment with the notch in the housing. If the parts are not in alignment, the coolant flow through the heat exchanger will be faulty and the engine will overheat.

Install the gasket (9) and align the notches.

Make sure the center rib on the gasket is in the proper position on the center rib of the cover.

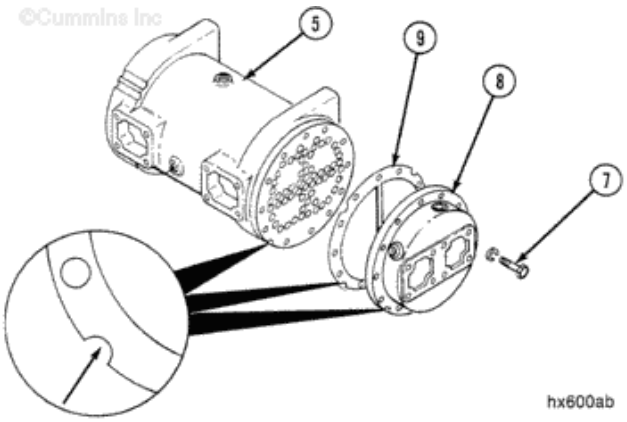
Install the open end cover (8) and align the notches.

Install capscrews that are 44 mm [1 ¾ in] in length for this end assembly.

Install 12 capscrews (7) and lock washers.

Tighten the capscrews.

Torque
Value: 60 n.m [45 ft-lb]



Install the gasket (4) on the housing (5).

Align the notch in the gasket with the notch in the housing, this will provide for correct capscrew alignment.

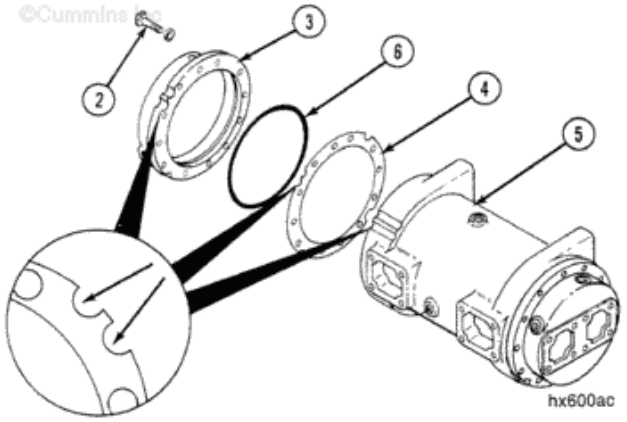
Install the new o-ring seal (6) in the groove in the closed end cover.

Lubricate the o-ring seal with vegetable oil.

Install the closed end cover (3) and o-ring seal on the housing.

Push the o-ring seal over the core until the cover touches the gasket.

Align the two notches in the cover with the two notches in



the housing. Install the capscrews that are 38 mm [1½ in] in length for this end assembly. Install the 12 capsizes (2) and lock washers. **Torque** **Value:** 60 n.m [45 ft-lb]		

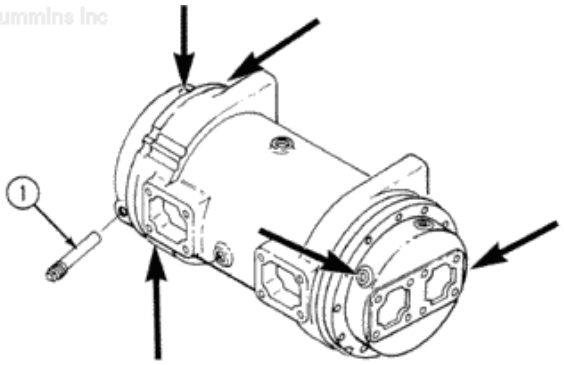
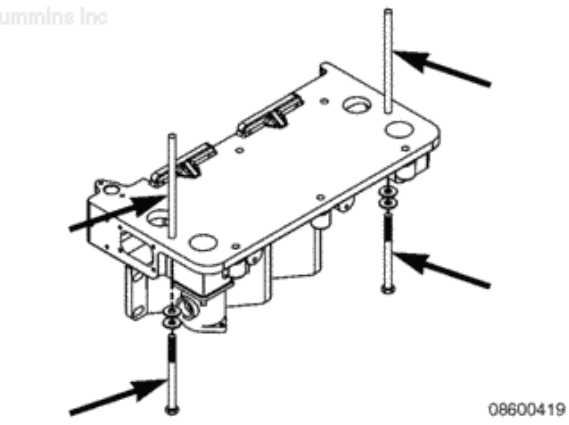
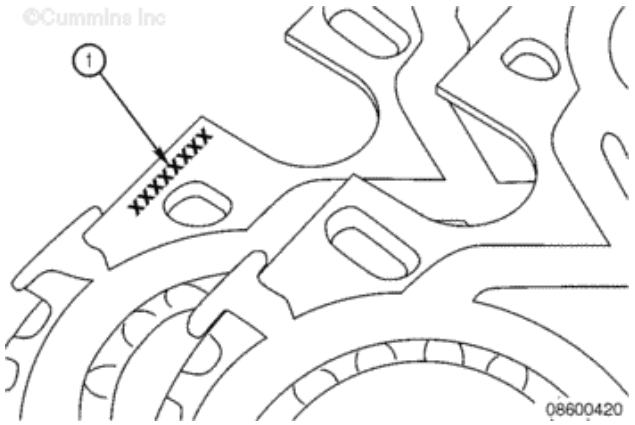
Install the six zinc electrode plugs (1). **Torque** **Value:** 55 n.m [40 ft-lb]		

Plate Type

Make sure the two guide pins are in place on the lower manifold. Install the guide pin lower capscrews with Nord-Lock® washers as sown. The longer serrations, or cams, of each Nord-Lock® washer **must** be oriented toward the other in order for the assembly to work properly. Torque the capscrews to the guide pins. Guide Pin Capscrews 256 n.m [190 ft-lb]		

The orientation of the plates is check the 10 digit identification number. During the plate assembly		

process, make sure the ribs on alternating plates are pointing in opposite directions, as shown in Figures 1 and 2.



CAUTION

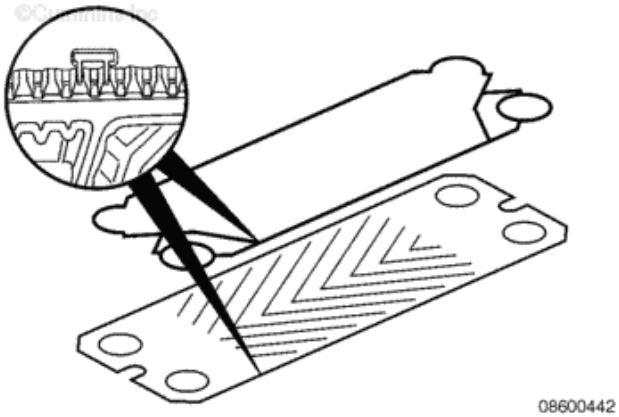
Incorrect orientation of the gaskets can cause overheating and sea water to enter the cooling system.

Place the gaskets back onto the plates one at a time.

Make sure the tabs are locked into the slots and orientated correctly.

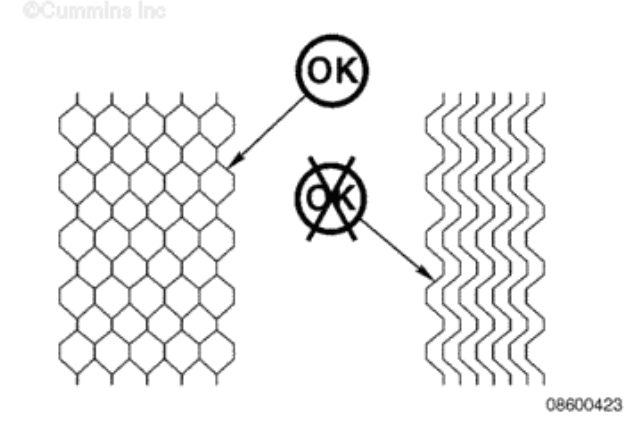
Gaskets will **always** be facing up during the plate assembly process.

Refer to Figures 1 and 2 for plate orientation and identification numbers.



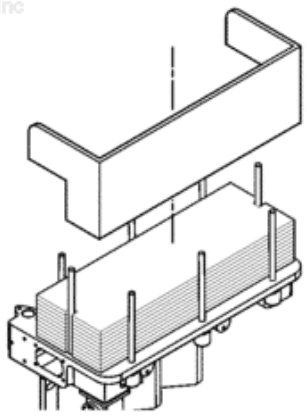
After the plates are assembled in the engine, make sure the profile shows a honey-comb pattern and the gasket tabs alternate position.

If this pattern is **not** shown throughout the entire plate pack, the plates **must** be rearranged.



Install the spacers and the shield.

Torque
Value: 9 n.m [80 in-lb]

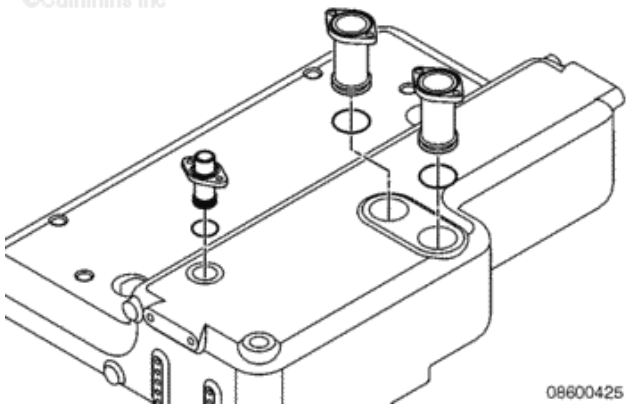


CAUTION

Pushing the LTA tubes too deep into the expansion tank, can damage the tube's o-ring.

Remove the drain and LTA tubes.

Install the o-ring and crevice seal onto the drain and LTA tubes and install them into the expansion tank assembly approximately 25 mm [1 in] deep.

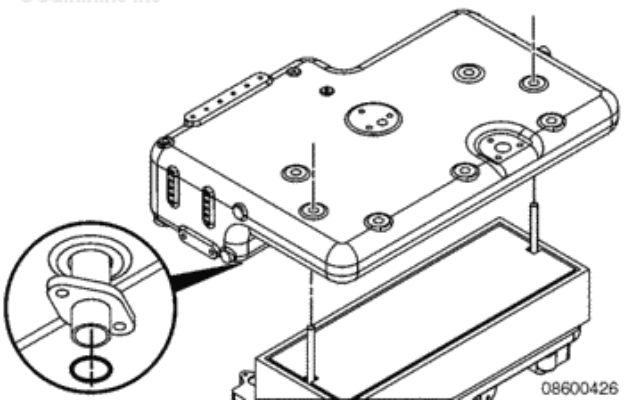


WARNING

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.

Place the expansion tank on top of the assembly.

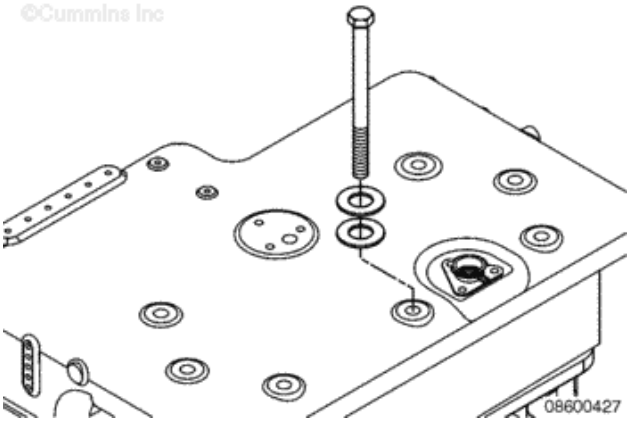
Install the o-ring onto the bottom of the drain pipe flange.



Make sure the drain tube fits into the lower manifold as the tank and plate pack are tightened down.

Install the six-plate pack clamping capscrews with the Nord-Lock® washers as shown.

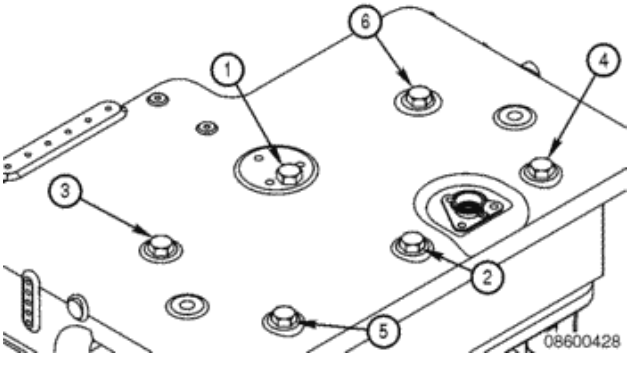
The longer serrations, or cams, of each Nord-Lock® washer **must** be oriented toward the other in order for the assembly to work properly.



Finger tighten the capscrews in the sequence pattern shown until the plate pack begins to compress.

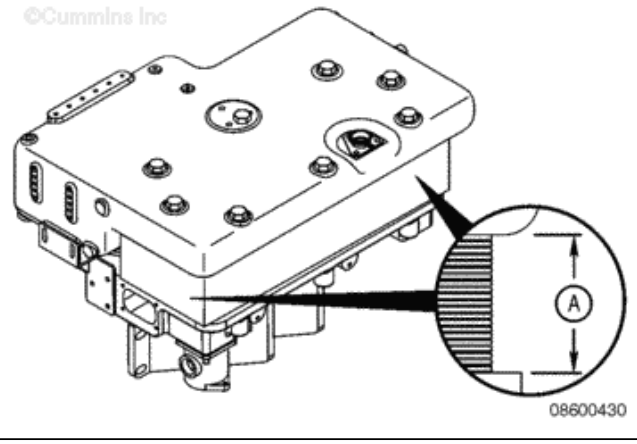
Tighten capscrews, one through six, in 14 N•m [124 in-lb] increments in the sequence shown so the expansion tank comes down evenly.

Stop tightening capscrews when expansion tank is touching all 6 spacers.



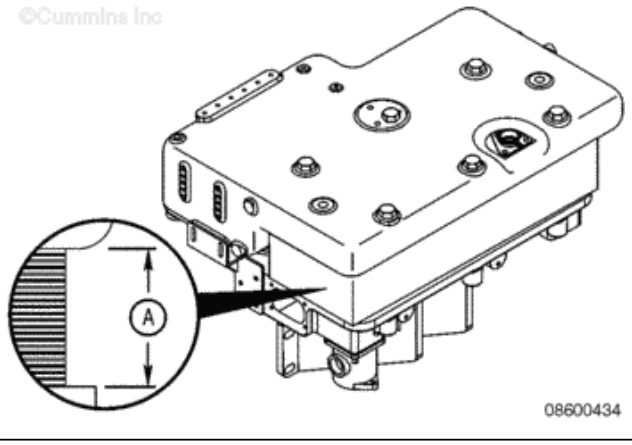
CAUTION

During the tightening process the expansion tank must not be more than 12 mm [0.500 in] from level; otherwise the plate pack and tank may bind on the Low Temperature Aftercooled (LTA) drain tubes and damage the o-rings.



Measure the plate stack distance, as a double-check. The plate stack distance **must** match what is on the data sticker on the heat exchanger bracket.

Measurements		
	mm	in
Plate Thickness	142 to 147	5.6 to 5.8

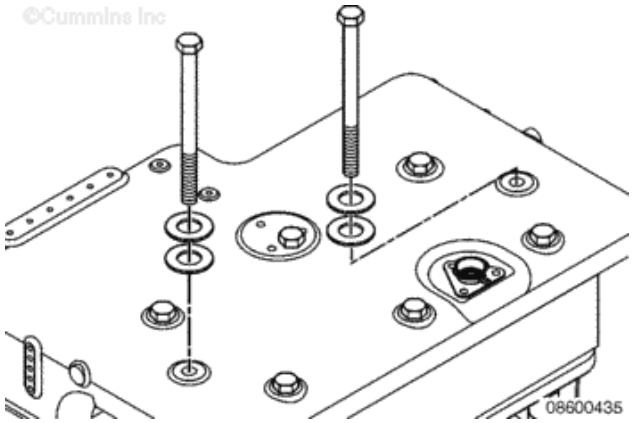


Install two end-guide top capscrews with Nord-Lock® washers.

The longer serrations, or cams, of each Nord-Lock® washer **must** be oriented toward the other in order for the assembly to work properly.

Tighten all eight top capscrews.

Torque
Value: 256 n.m [190 ft-lb]

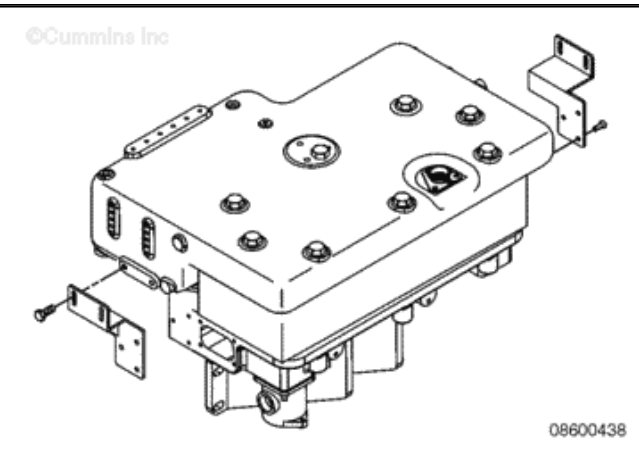


NOTE: Engines with cast iron front support brackets do not need the side brackets installed.

Install the side brackets, if they were installed initially.

Tighten the capscrews.

Torque
Value: 31 n.m [23 ft-lb]



Install

Tube Type

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.

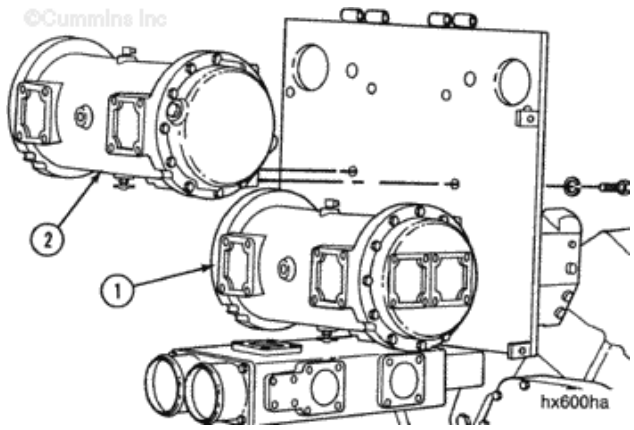
NOTE: All engines are not equipped with a upper and a lower heat exchanger option.

Install the lower heat exchanger (1) and the upper heat exchanger (2) as illustrated in the graphic.

Install four lock washers and capscrews in each heat exchanger.

Tighten the capscrews.

Torque
Value: 135 n.m [100 ft-lb]



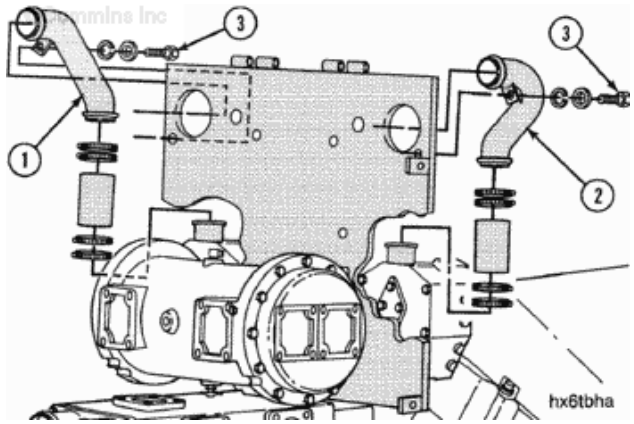
The engine coolant pipes are **always** connected to the side of the heat exchanger.

Always tighten the capscrews before tightening the hose clamps.

Two clamps are installed on each end of each hose. Make sure the hose is centered over the gap between the pipes. Tighten the capscrews for the pipe before tightening the clamps.

The upper heat exchanger and a portion of the heat exchanger support are **not** shown for clarity.

The engine outlet pipes (1)



and (2) are different for the right bank and the left bank.

Install the outlet pipes (1) and (2) on the outlets of the thermostat housing, using hoses and clamps as shown.

Install a flat washer, lock washer, and capscrew (3) through the tab on each pipe to the heat exchanger support.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 in-lb]

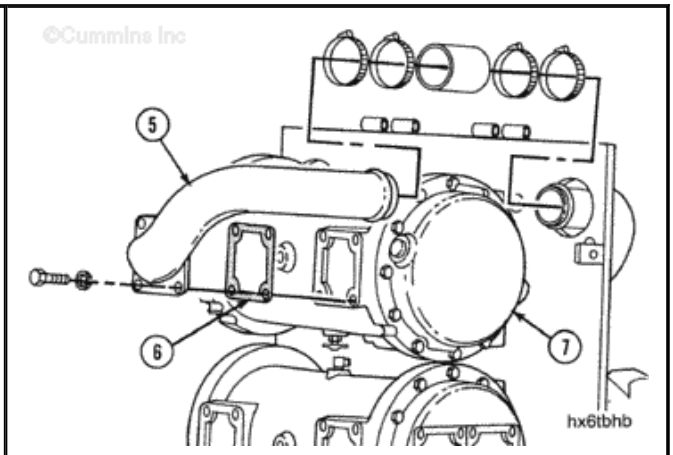
Connect the pipe (5) to the outlet pipe for the left bank as shown. Install the gasket (6), four lock washers, and capscrews to the upper heat exchanger (7) inlet.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 in-lb]

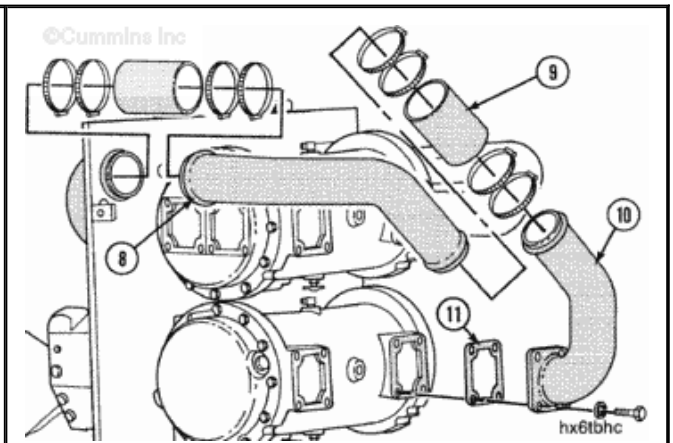


Connect the pipe (8) to the outlet pipe for the right bank as shown. Install the hose (9) and the pipe (10).

Install the gasket (11), four lock washers, and capscrews to the lower heat exchanger inlet.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]



Tighten the hose clamps.

Torque
Value: 5 n.m [50 in-lb]

Install the gasket (15), upper heat exchanger outlet pipe (14), four lock washers, and capscrews to the upper heat exchanger outlet.

Install the hose (16), and the clamps on the lower heat exchanger outlet pipe (17). Install the hose on the upper heat exchanger outlet pipe.

Install the gasket (18), lock washers, and capscrews to the lower heat exchanger outlet (19).

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Tighten the hose clamps.

Torque
Value: 5 n.m [50 ft-lb]

NOTE: A large pipe (not shown) with a flange and gasket must be installed to the lower heat exchanger outlet pipe (17) and to the engine water pump inlet. The pipe is not installed at this time because the pipe is routed under a crossmember of a base rail on engines equipped with base rails.

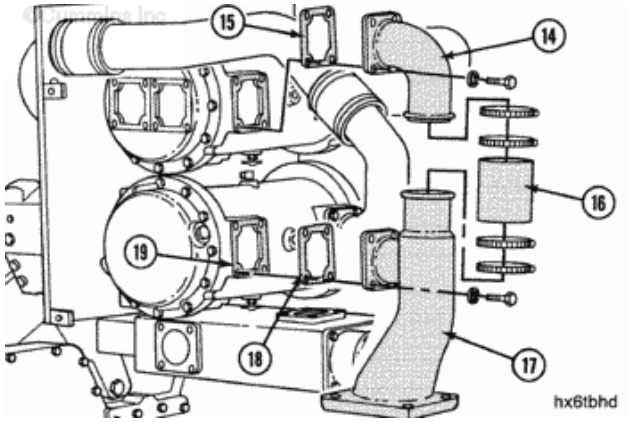


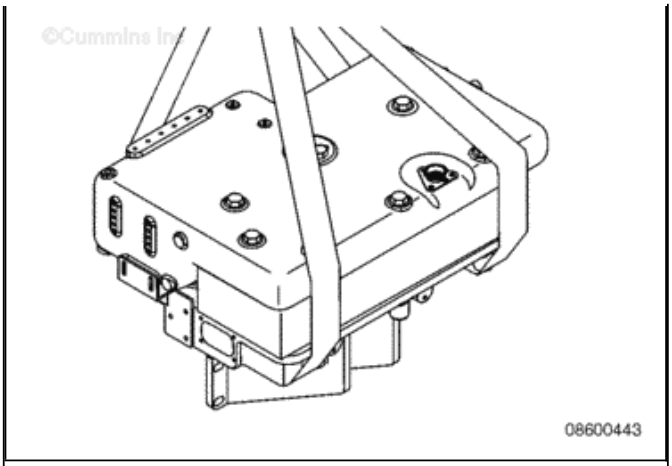
Plate Type

WARNING

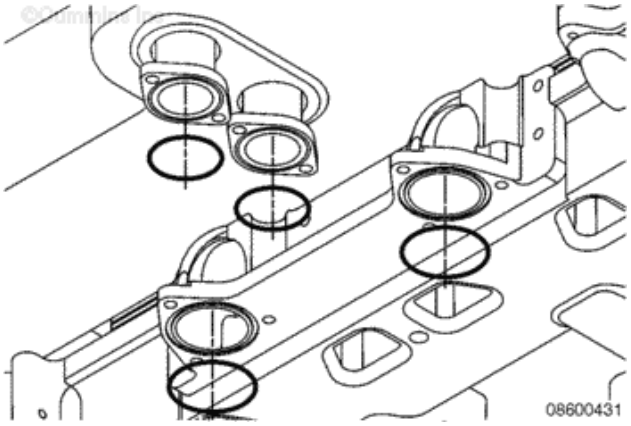
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get

assistance to lift this component.

Use a chain fall or other lifting equipment to lift heat exchanger into position in front of the engine with the jacket water manifold over the thermostat housing.

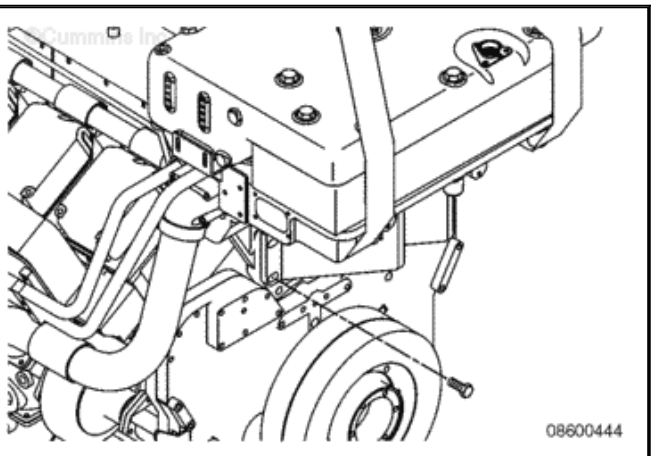


Install the o-rings onto the bottom flange of the LTA tubes and the jacket water manifold as the assembly is lowered into place.

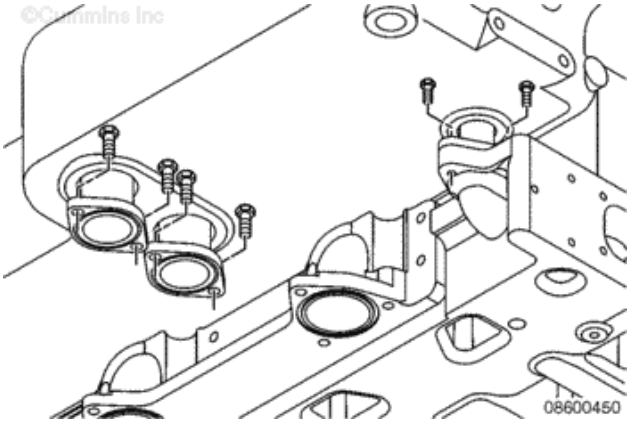
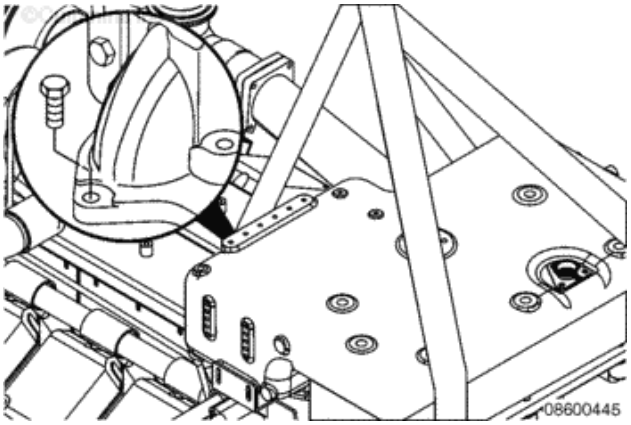
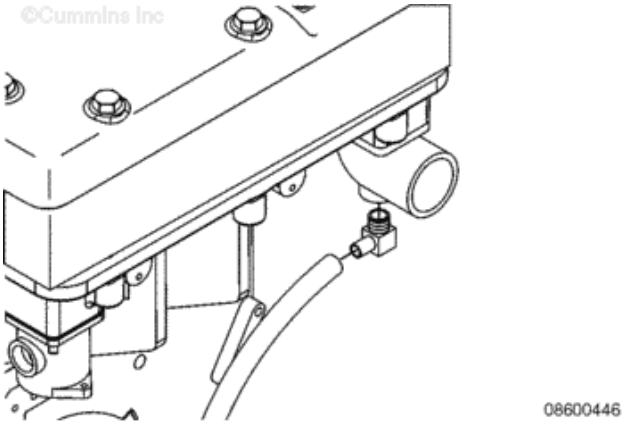


Install the lower mounting bracket capscrews that fasten the bracket to the engine block.

Torque
Value: 35 n.m [25 ft-lb]

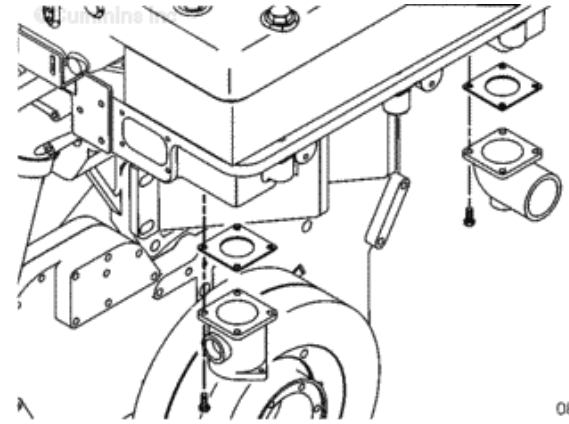


Install the four capscrews that hold the Low Temperature Aftercooled (LTA) tube to the thermostat

housing Tighten the capscrews. **Torque** **Value:** 78 n.m [57 ft-lb] Install the clips and bolt and tighten. Install the ring retainer clip from the drain pipe and tighten the clips. **Torque** **Value:** 17 n.m [144 in-lb]		
Install the jacket water manifold capscrews that fasten the manifold to the thermostat housing. Tighten the capscrews. **Torque** **Value:** 31 n.m [23 ft-lb]	 	
Connect the sea water pump prime discharge line from the heat exchanger sea water outlet connection.		
Connect the sea water inlet and outlet connections.		

Tighten the capscrews.

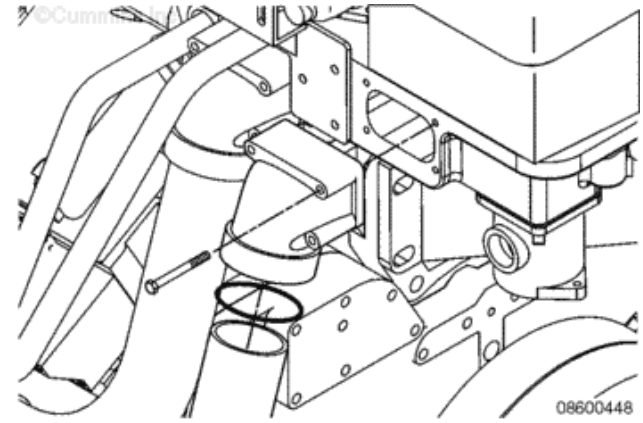
Torque
Value: 31 n.m [23 ft-lb]



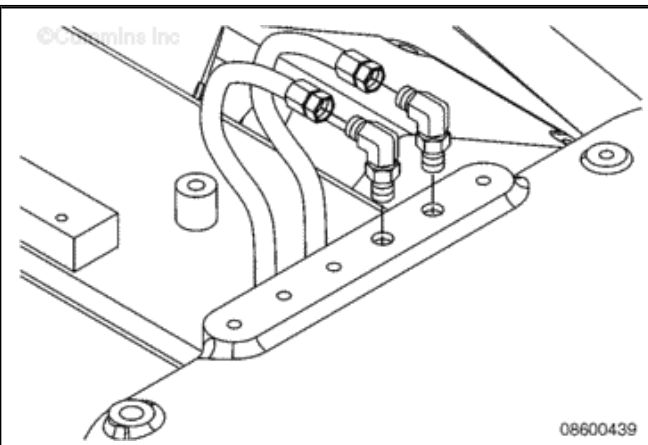
Connect the coolant outlet tube and connector.

Tighten the capscrews.

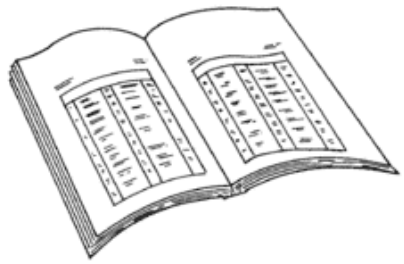
Torque
Value: 31 n.m [23 ft-lb]



Connect the vent lines to the expansion tank.



Finishing Steps

• Fill the cooling system. Refer to Procedure 008-018.		 ck800wa

Last Modified: 04-Nov-2004

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008-057 Sea Water Pump

General Information

The sea water pumps on marine series engines contain a paddle type impeller that allows the pump to function in either a **clockwise** or **counterclockwise** rotation. When viewed from the front of the engine, the sea water pump on the right bank rotates in a **counterclockwise** direction. The sea water pump on the left bank rotates in a **clockwise** direction. The inlet for the sea water pump is the port nearest to the front gear cover.

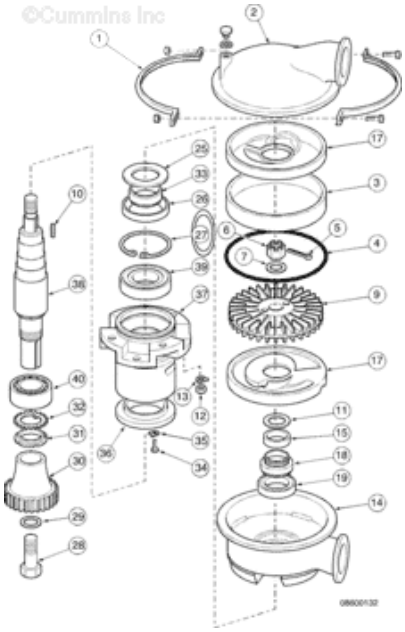
The bearings in the marine series engines sea water pumps are lubricated by engine oil through drillings in the front gear cover and the pump supports.

The marine series engines sea water pumps are limited to engine speeds of 2000 rpm or less. Cummins Inc., does **not** provide sea water pump gears for engine speeds in excess of 2000 rpm.

Gilbert Gilkes & Gordon Ltd.
Kendal, Cumbria
England
LA9 7B2

Exploded View

Gear Driven



1. Vee-band clamp
2. Nondrive end body
3. Distance ring
4. O-ring seal
5. Cotter pin
6. Slotted nut (heavy) [¾-16 inch]
7. Plain washer (heavy)
8. Type “P” (paddle) impeller
9. Square key
10. Impeller shim
11. Nut [7/16-14 inch] (can be a capscrew and lock washer)
12. Lockplate (can be a capscrew and lock washer)
13. Drive end body
14. Seal spacer
15. Port plate
16. Mechanical water seal
17. Contact ring
18. Water slinger
19. Oil seal
20. Retaining ring
21. Capscrew [3/8-16 x 2.500 inch]
22. Plain washer (heavy)
23. Sea water pump drive gear
24. Bearing lock nut
25. Bearing spacer
26. Capscrew [¼-20 x 0.750 inch]
27. Lockplate
28. Bearing retainer
29. Bearing housing
30. Shaft
31. Rear bearing (roller type)
32. Drive end bearing (spherical roller type).

Preparatory Steps

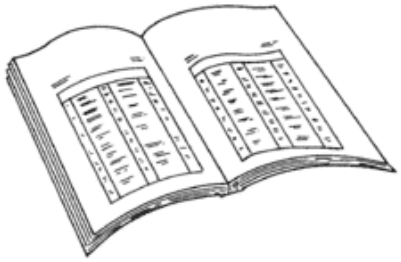
WARNING

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 in Section 8.



ck800wa

Remove

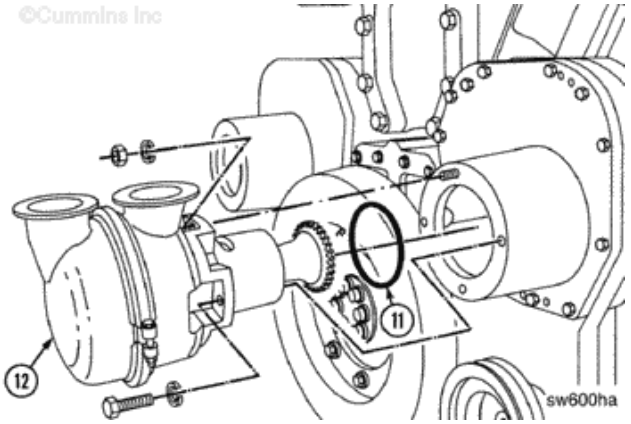
WARNING

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.

NOTE: Not all engines are equipped with this option.

Remove the three capscrews and the nut.

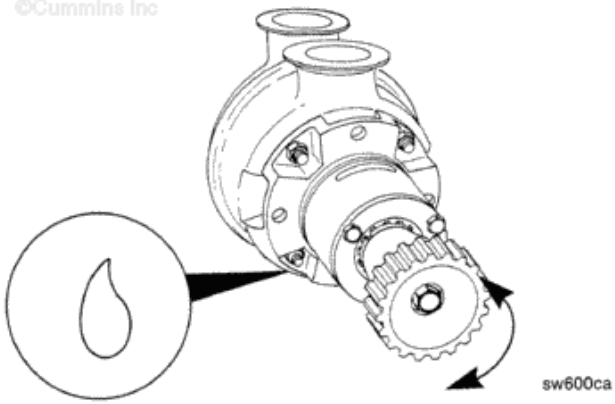
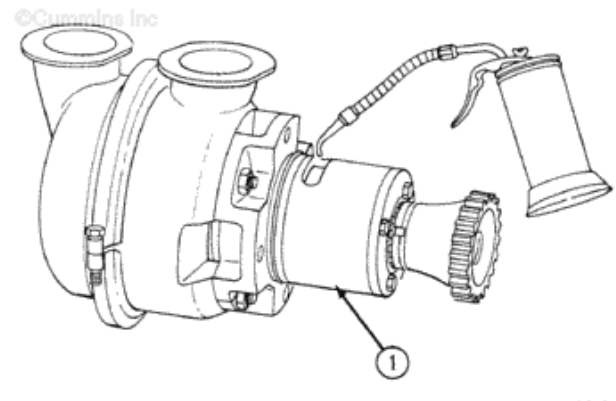
Remove the sea water pump



sw600ha

(12) and the o-ring seal (11). Discard the seal. Remove the outer pump.		

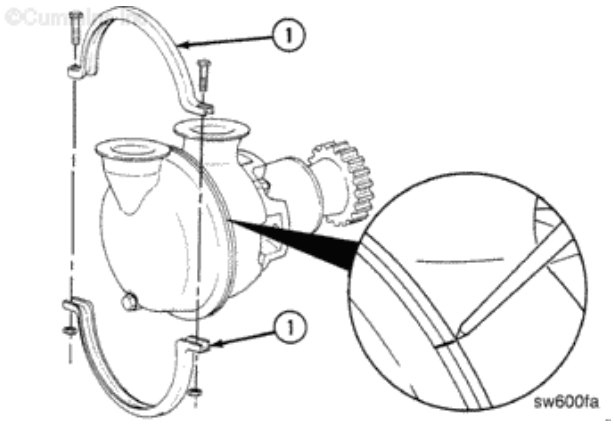
Disassemble

Rotate the shaft to check for damaged bearings or parts that are rubbing.		
While turning the shaft, put clean 15W-40 engine oil in the oil passage to lubricate the bearings.		
This procedure can also apply to check or replace the seal when the pump is installed on the engine. If the work is being performed with the pump installed, the hoses for the pump **must** be		

removed.

Remove the vee band clamp (1).

Use a scribe or a center punch. Put a mark on both sections of the water pump body so they can be assembled correctly.



NOTE: The spacer ring (3) can be a tight fit in the nondrive end of the body. It is not necessary to remove the spacer ring if it is secure in the body (2).

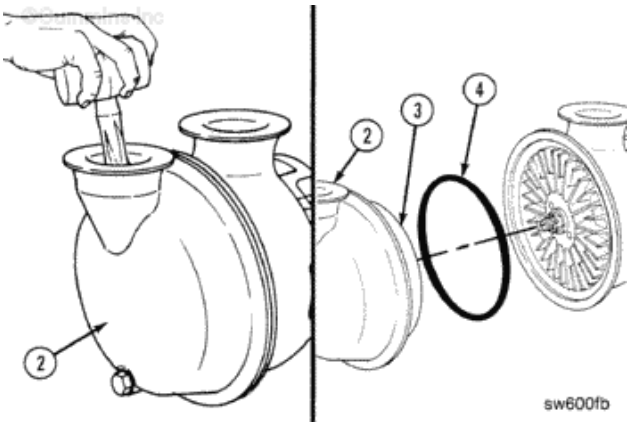
The body is a tight fit. If necessary, use a wooden wedge to aid in the separation of the parts. Put the wedge in the space between the inlet and outlet ports.

Insert a wooden hammer handle through the part until the handle is touching the end of the shaft.

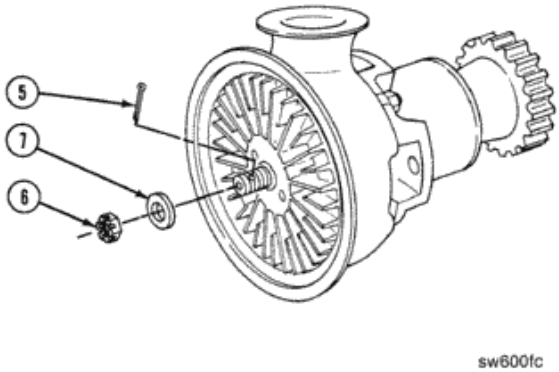
Pry on the handle.

Remove the nondrive end of the body (2).

Remove the o-ring seal (4).

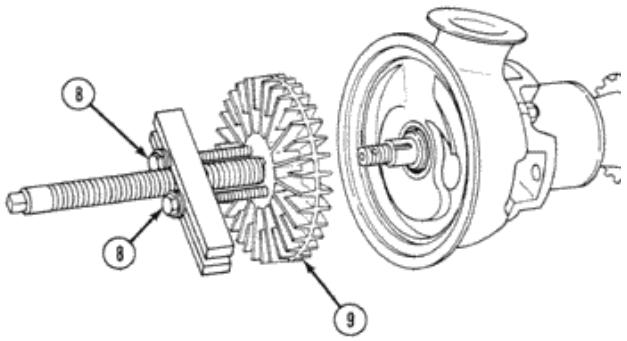


Remove the cotter pin (5), slotted nut (6), and washer (7).



Use standard puller, Part Number ST-647, or equivalent, and two 8-1.25 x 70 mm capscrews (8).

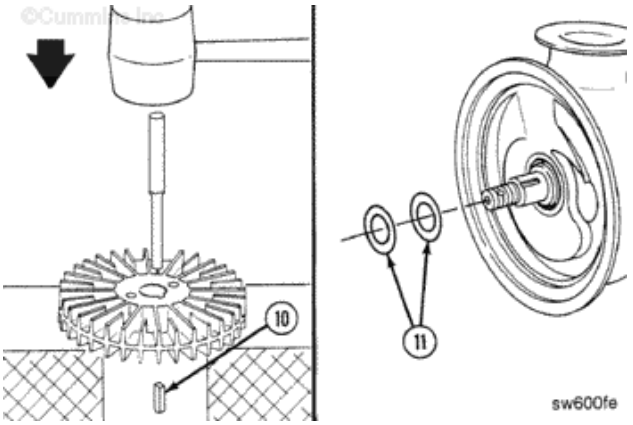
Remove the impeller (9).



Use a drift and a mallet. Remove the key (10) from the impeller.

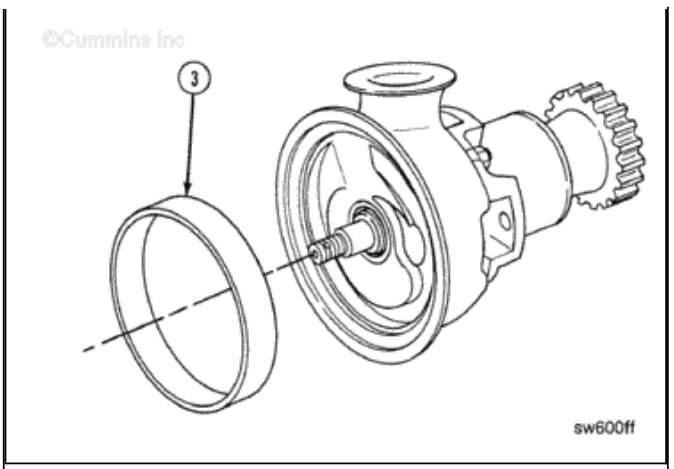
Remove the shims (11).

Keep the shims together for future assembly. The thickness of the shims is critical for the performance of the pump.



The spacer ring can be a tight fit in the body. If necessary, use two pry bars to remove the ring.

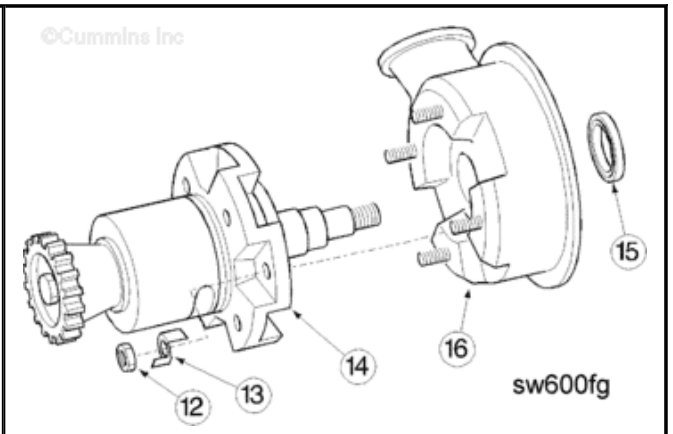
Remove the spacer ring (3).



Bend the lockplates. Remove the four nuts (12) and the lockplates (13).

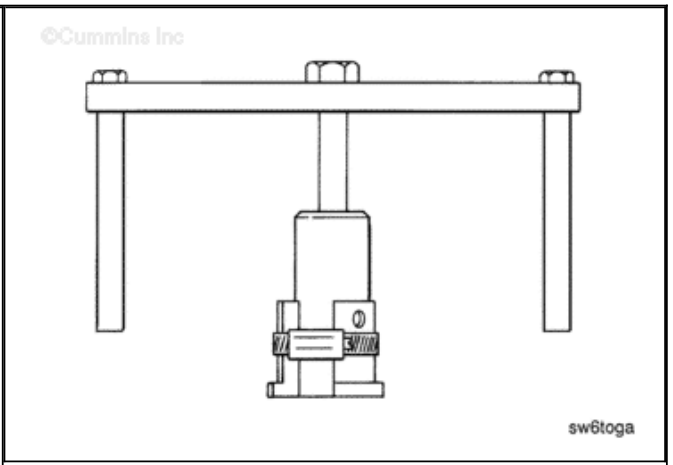
It will be necessary to use a mallet to separate the parts, because of the tight fit between the shaft and the water seal and spacer.

Remove the drive end of the body (14), and spacer (15), from the bearing housing and shaft assembly (16).

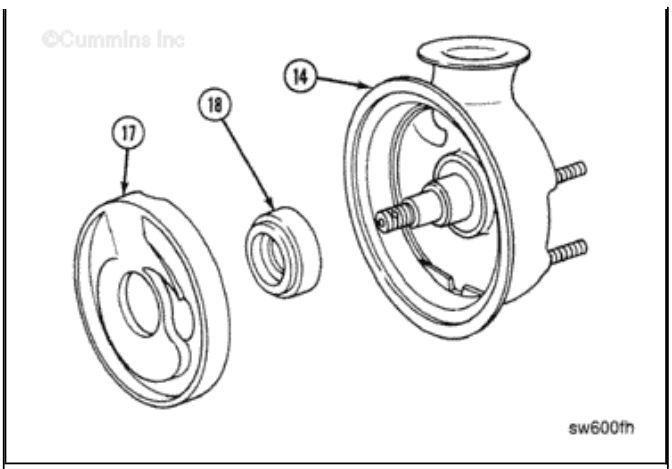


The port plate can be a tight fit in the body after many hours of operation. If necessary, use the special tool available from Gilbert Gilkes and Gordon Ltd.

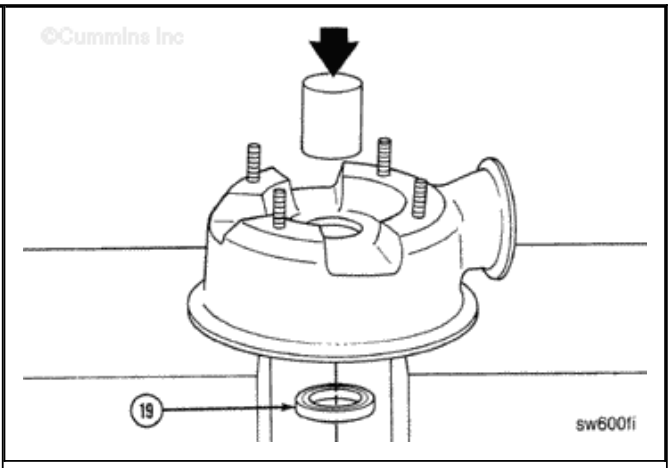
This tool can also be used to remove the port plate from the nondrive end of the body.



Remove the port plate (17) and mechanical seal (18) from the drive end of the pump body (14).



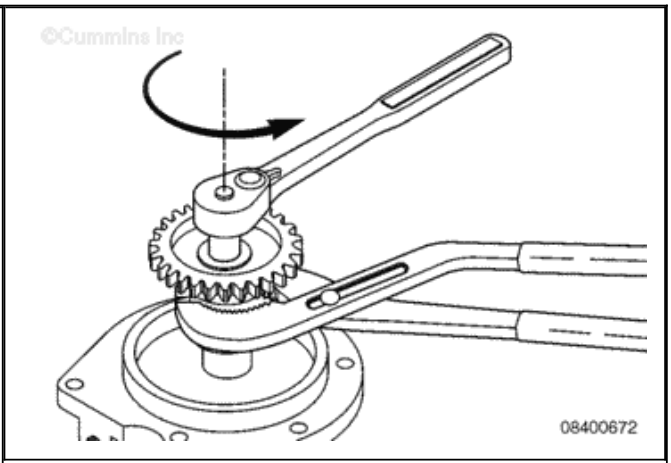
Use a press and an appropriate mandrel to remove the contact ring (19) from the body.



NOTE: A vise may be needed to prevent the shaft from rotating while removing the capscrew.

Hold the drive gear with locking pliers. Remove the capscrew and washer from the pump shaft.

Use a gear puller to remove the gear from the pump shaft.

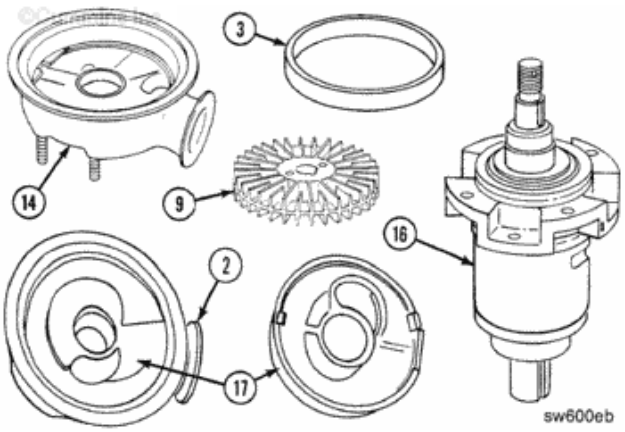


Clean and Inspect for Reuse

WARNING

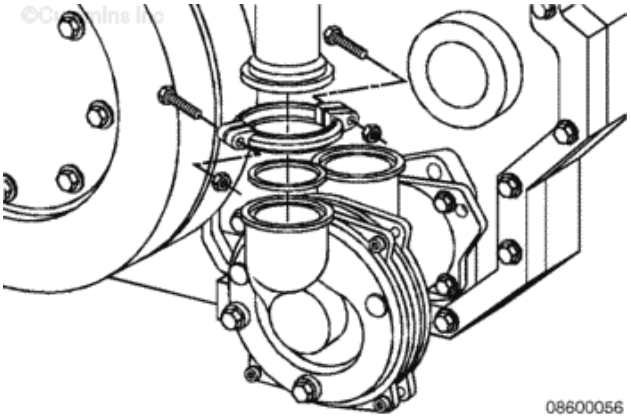
When using detergents for cleaning, follow the manufacturers recommendations for use. Wear goggles and protective clothing to avoid personal injury.

Use a 5 percent detergent solution to clean the parts. It is important to eliminate all of the grease and dirt from the surfaces that contact the contact ring and the mechanical seal.



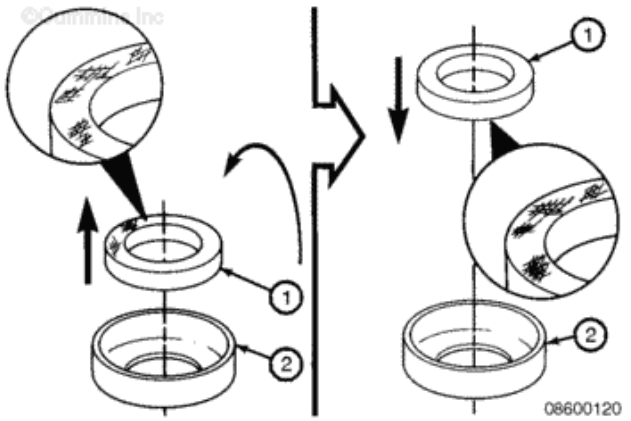
Check the impeller (3) and port plate (2) for damage from cavitation.

If necessary, replace the parts.



Gilbert Gilkes and Gordon Ltd. recommends the replacement of the mechanical seal **only** when the contact ring is replaced at the same time.

NOTE: This is only a temporary repair for an emergency situation. Cummins Inc., does not recommend the use of this procedure for a permanent repair. The correct repair procedures must be



followed as soon as possible.

For an emergency repair, the contact ring (1) can be reversed so that the side of the ring that is **not** worn touches the mechanical seal.

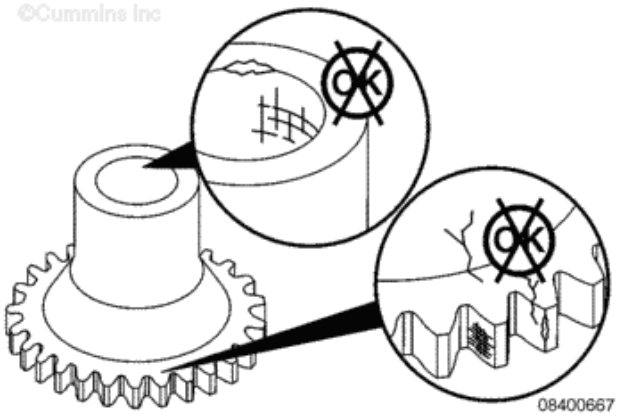
Reverse the ring and install it in the rubber boot (2).

Visually inspect the gear for wear on the gear teeth. Replace the gear if any of the teeth are damaged or heavily worn.

Visually inspect the pump shaft and inner surface of the drive gear for wear, which indicates slipping in the press fit joint between the drive gear and the shaft.

The gear **must** be replaced if indications of slipping are present.

Inspect the capscrew and washer for wear or other damage. If damage is observed, replace the capscrew and washer.

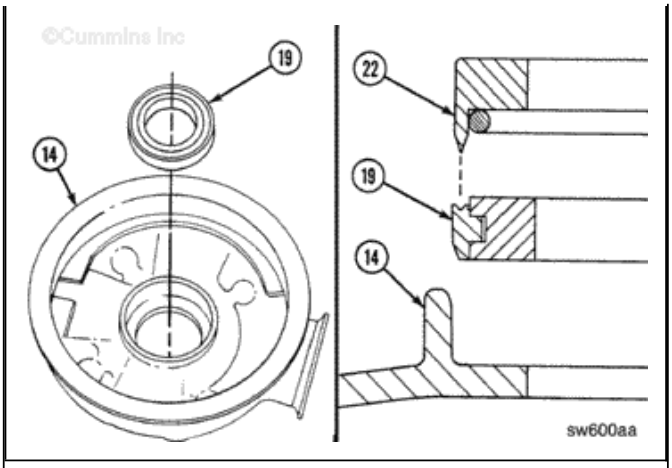


Assemble

Use a 5 percent detergent solution to lubricate the rubber boot. Do **not** use grease.

Use the special tool (22) that is available from Gilbert Gilkes and Gordon Ltd. or use your hands to install the contact ring (19) in the drive end of the body (14).

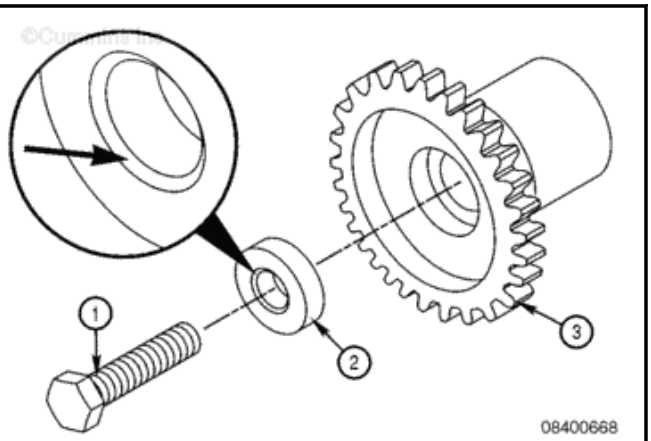
Be sure the ring touches the bottom of the bore in the body.



NOTE: The plain washer has a chamfer on one side. Make sure the chamfer side of the washer is installed against the head of the capscrew.

Install the hexagon head capscrew (1) into the plain washer (2) with the chamfer side toward the capscrew head.

Insert the capscrew and washer into the water pump drive gear (3).

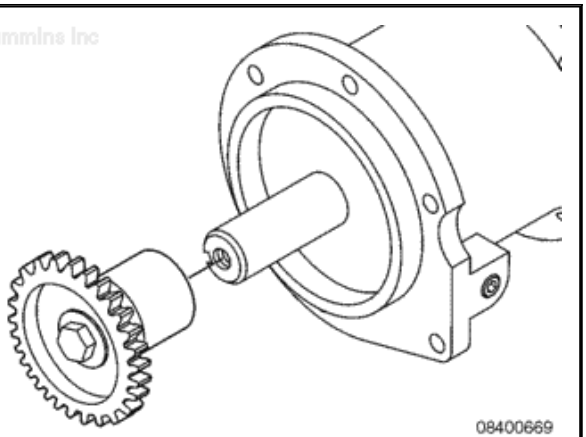


NOTE: It is recommended to use a press to assemble the gear or use the following method.

Install the drive gear onto the pump drive shaft.

Hand tighten the capscrews.

Check the alignment of the gear on the shaft.



Seat the drive gear on the shaft. It is recommended to use a press to assemble the gear on the pump, however,

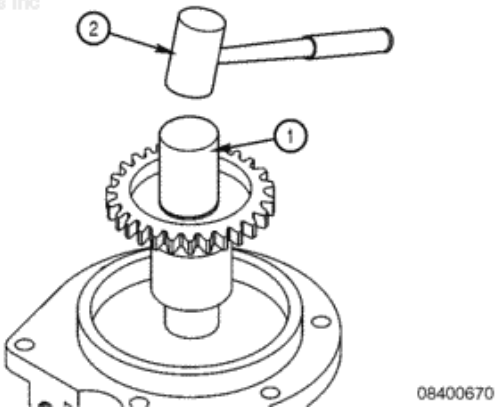
the following method can also be used.

NOTE: Complete the following steps for the drive gear installation on the pump shaft twice, to make sure that the gear is seated properly on the water pump. If this is not done, the gear lash may not be correct when installed on the engine.

NOTE: The drive tool (1) must have the same outside diameter as the washer. The inside diameter of drive tool must be larger than the capscrew.

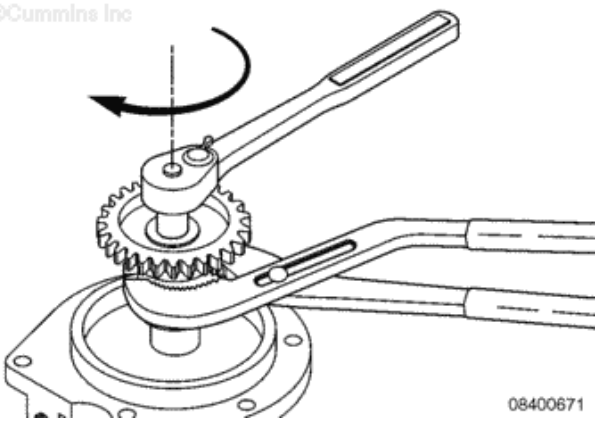
Place the appropriate drive tool (1) over the capscrew and against the face of the plain washer.

Use a brass hammer (2) and firmly strike the drive tool (1) twice to seat the drive gear.



Hold the drive gear with locking pliers and torque the capscrew.

Torque
Value: 68 n.m [50 ft-lb]



Use a 5 percent detergent solution to lubricate the inside diameter of the contact ring.

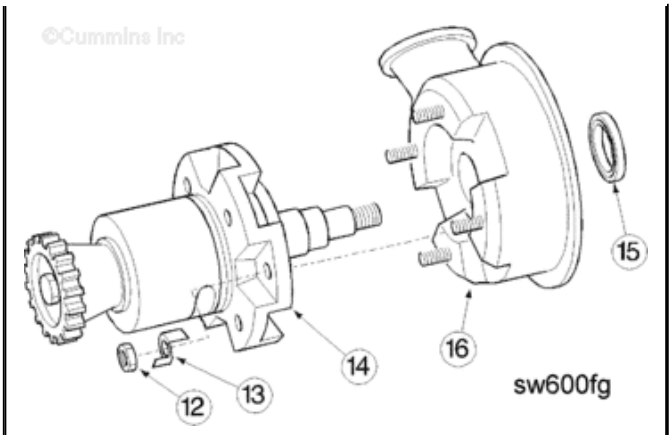
Install the drive end of the body (14) on the bearing housing and shaft assembly

(16).

Install the lockplates (13) and the nuts (12).

Torque
Value: 34 n.m [25 ft-lb]

Bend the lockplate tabs over the nuts and the edge of the housing.



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 touch the sealing surface of the seal. The oil from the hands can cause the seal to fail.

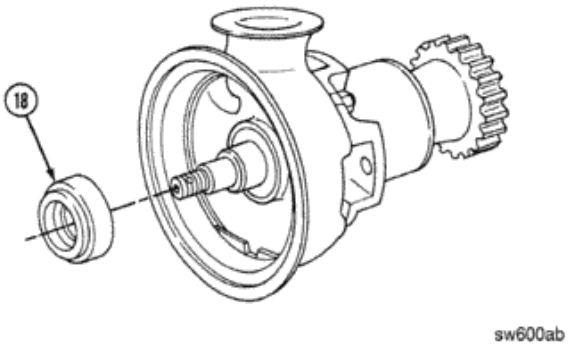
Use solvent to clean the shaft and the contact ring.

Use a 5 percent detergent solution to lubricate the shaft.

The largest diameter of the seal **must** touch the contact ring.

Install the mechanical seal (18).

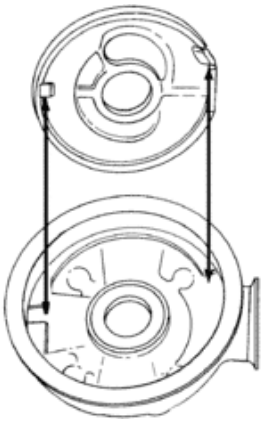
Push the seal until it touches the contact ring.



CAUTION

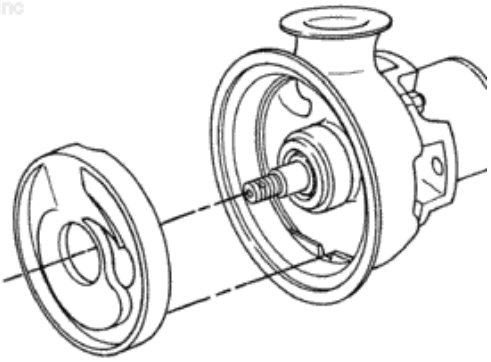
The lugs on the back of the port plate must enter the slots in the body.

The port plates are identical and interchangeable.



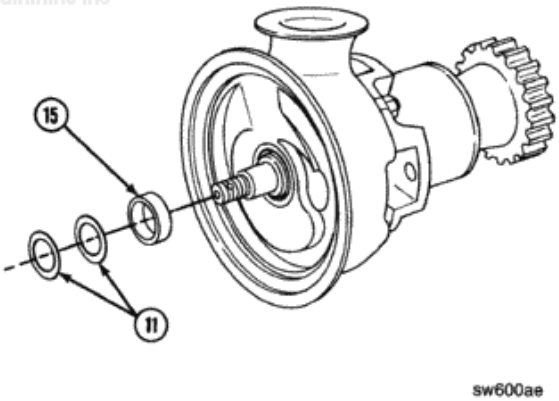
Install the drive end of the port plate.

The port plate will be approximately 13 mm [0.512 in] below the chamfer when the plate is installed correctly.



Install the spacer (15).

Install the shims (11). The shims **must** touch the drive end of the port plate.



The thickness of the shims is critical to the performance of the pump.

Use a straight edge (23) or ring that will touch the step in the shaft.

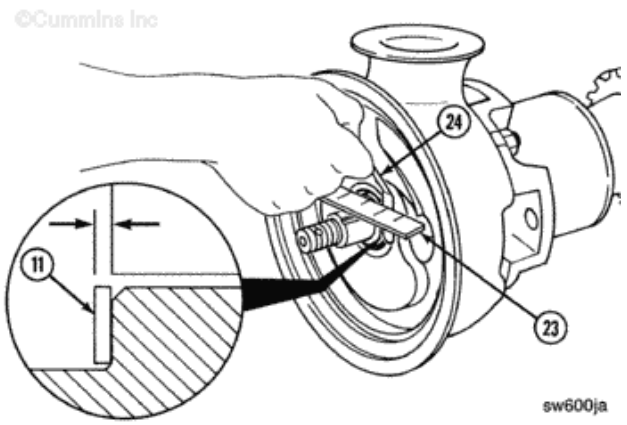
Use a feeler gauge (24), to measure the distance from the step on the shaft and the shims (straight edge) to the port plate.

This distance is the impeller side clearance.

Sea Water Pump Impeller Side Clearance		
mm		in
0.18	MIN	0.007
0.23	MAX	0.009

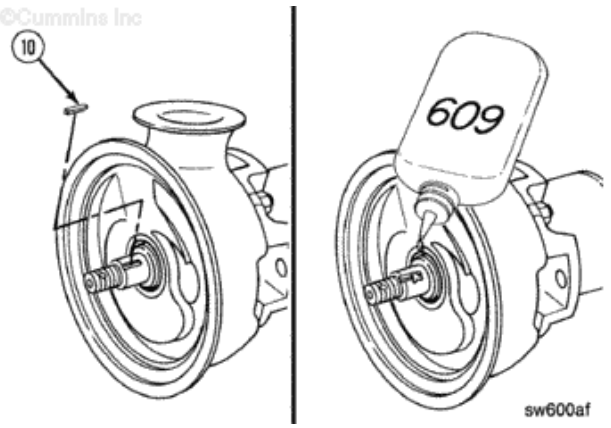
If the side clearance is **not** within specifications, remove or install shims (11) until the side clearance is correct.

Make sure the contact ring, seal, and port plate are seated properly.



Install the shaft key (10).

Apply Loctite™ 609 retaining compound, or equivalent, to the shaft and key.



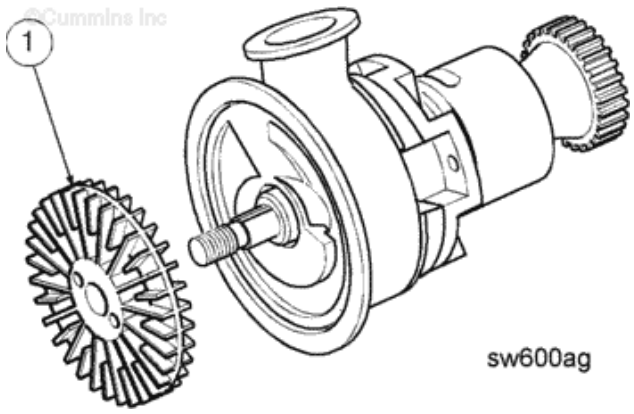
CAUTION

Do not use a hammer and mandrel to install the impeller. The bearings in the pump will be damaged.

Be sure the puller holes in the impeller are positioned toward the nondrive end of the pump.

Align the slot in the impeller with the key. Install the impeller on the shaft.

Use a mallet with a soft nose. Tap the impeller (1) **only** until it is straight on the shaft.



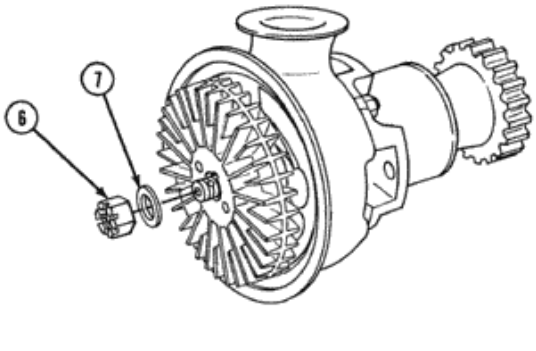
CAUTION

Do not use too much grease or antiseize compound. If the grease touches the seal, the seal will fail.

Use water pump grease or antiseize compound. Apply a light layer to the threads on the shaft.

Install the washer (7) and the nut (6).

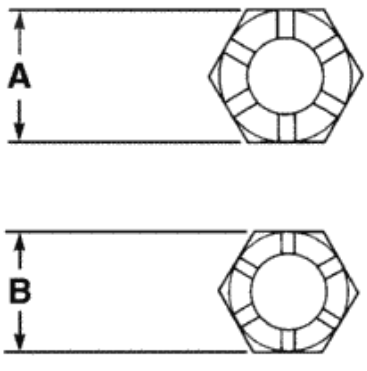
Use the nut to push the impeller on the shaft. The impeller will stop when it contacts the shims.



CAUTION

Use this illustration to identify the torque specification for the nut being installed. If the older, smaller nut is torqued to the higher specification, the nut will fail.

If the nut requires a [1.250 in] wrench (A):



Torque
Value: 160 n.m [118 ft-lb]

If the nut requires a [1.125 in] wrench (B):

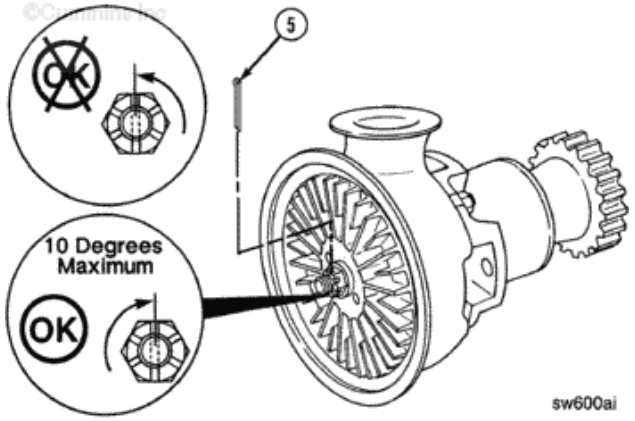
Torque
Value: 110 n.m [81 ft-lb]

The larger nut is recommended.

CAUTION

Do not loosen the nut to align the slots in the nut with the hole in the shaft. Tighten the nut no more than 10 degrees to align the holes. If the slots and holes are not in alignment, change the washer or reduce the thickness of the washer slightly so that a slot and the hole are in alignment at the proper torque.

Install the cotter pin (5). Bend the ends of the pin over the nut.

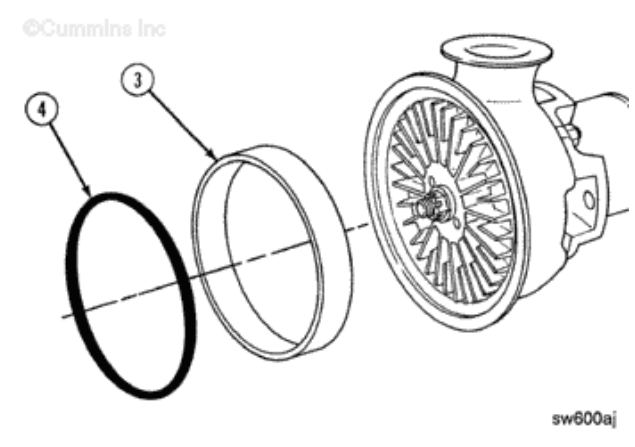


Install the o-ring seal (4) on the spacer ring (3).

Install the spacer ring and o-ring seal.

Push the o-ring seal under the lip for the vee-band clamp.

If the nondrive end of the port plate was removed, install the plate in the body so that the lugs on the plate engage the slots in the body.



Install the nondrive end of the body (2).

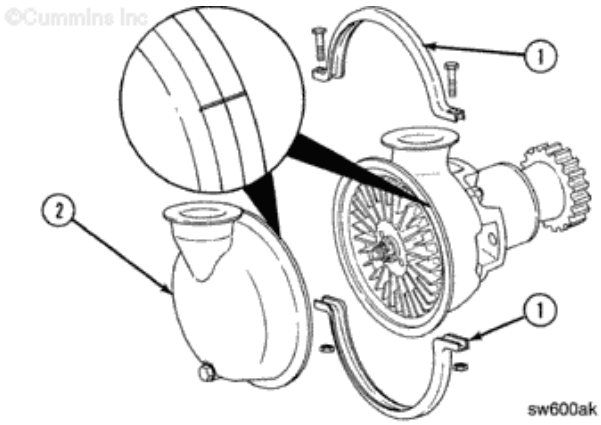
Align the marks scribed on the bodies during disassembly. The center of the inlet and outlet ports **must** be in alignment within 3 degrees.

Install the vee-band clamp (1).

Tighten the clamp.

Torque
Value: 20 n.m [177 in-lb]

Use a plastic hammer. Tap around the vee-band clamp completely. Torque the clamp fasteners again. Continue this step until the fasteners remain at the correct torque after tapping the clamp.



Install

WARNING

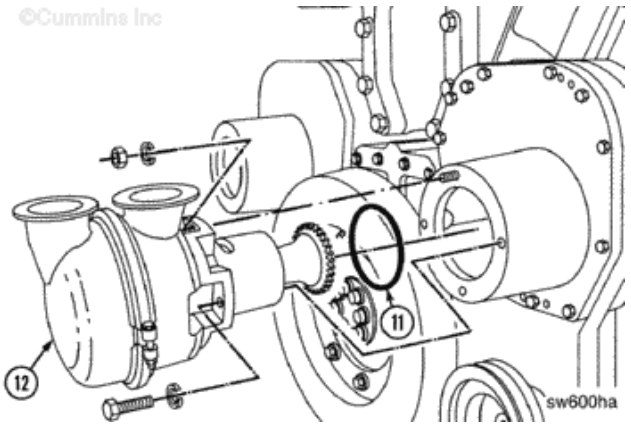
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Make sure the stud is installed as shown in the illustration.

Install the o-ring seal (11), pump (12), four lock washers, three capscrews, and the nut.

Tighten the capscrews and nut.

Torque Value: 60 n.m [44 ft-lb]

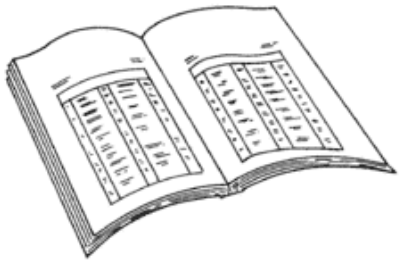


Finishing Steps

WARNING

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

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine and check for leaks.



ck800wa

Last Modified: 01-Apr-2009

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008-062 Water Pump

Preparatory Steps

WARNING

Batteries can emit explosive gasses. To reduce the possibility of personal injury, always ventilate the compartment before servicing batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

WARNING

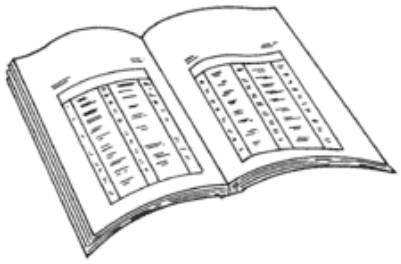
Do not remove the pressure cap from a hot engine. Wait until the coolant is below 50° C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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 to prevent accidental engine starting.
- Drain the cooling system. Refer to Procedure 008-

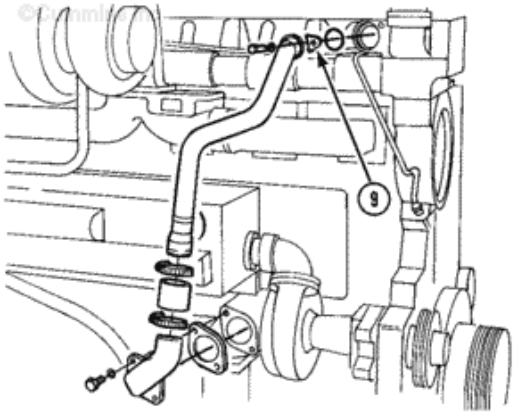
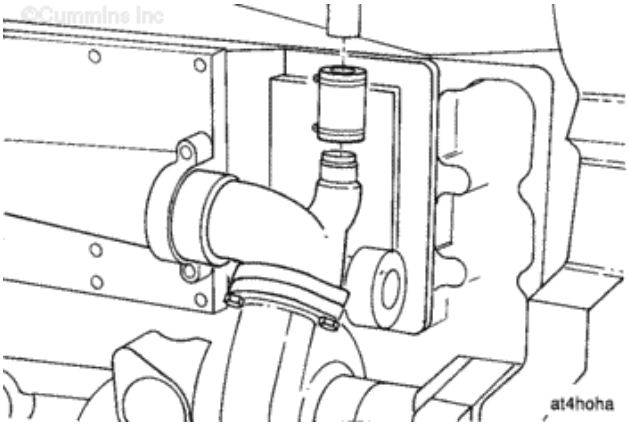
©Cummins Inc



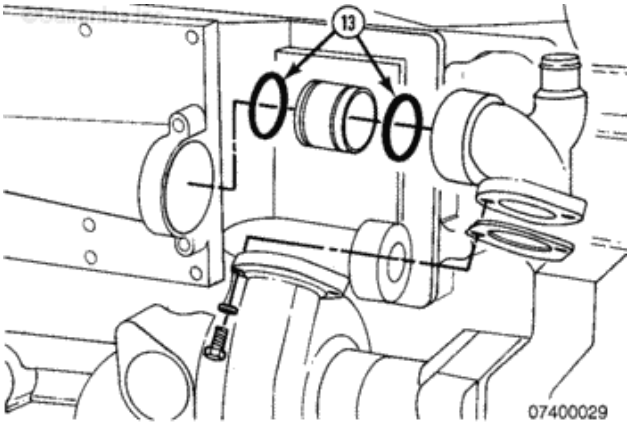
ck800wa

018. • Remove the coolant filter. Refer to Procedure 008-006.		

Remove

Remove the water bypass tube clamp (9). Loosen both hose clamps. Remove the water bypass tube.		
Disconnect the aftercooler supply hose from the water pump outlet connection.		
Remove the water pump outlet connection assembly. Remove the water transfer tube from the water connection. Remove and discard the two		

o-rings (13) and the gasket.



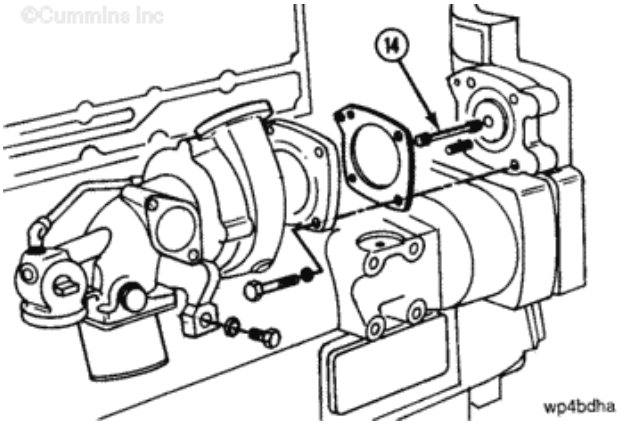
Remove the capscrew from the water pump support bracket.

Remove the three capscrews and the nut from the water pump mounting flange.

Remove the water pump and gasket.

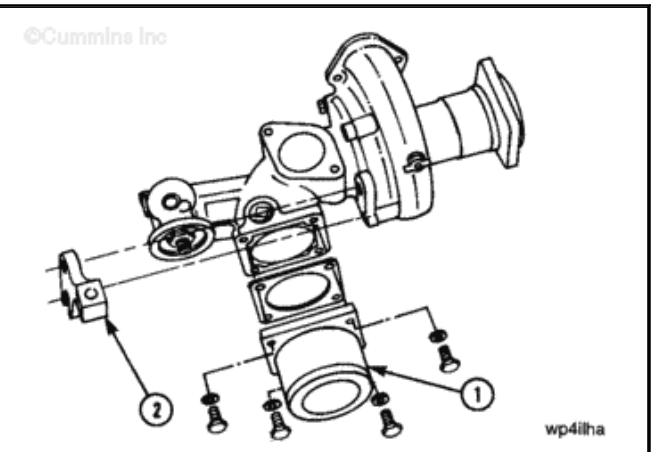
Discard the gasket.

Remove the water pump drive shaft (14).



Remove the water inlet connection and gasket (1).

Remove the support bracket (2).



Clean and Inspect for Reuse

WARNING

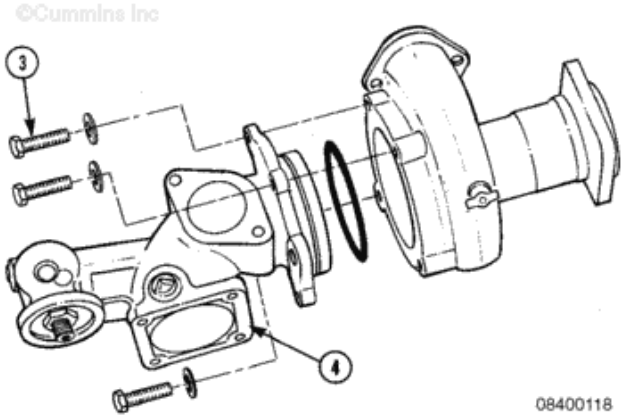
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

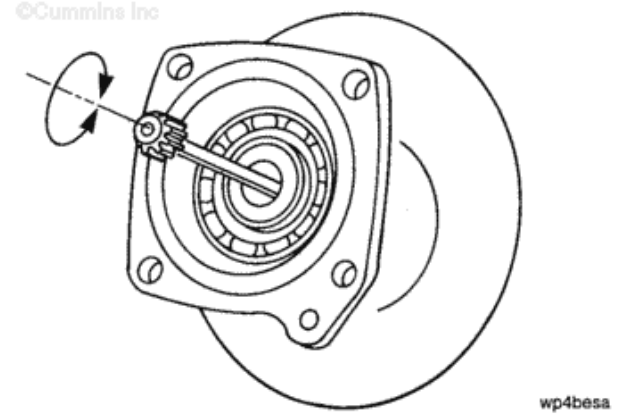
Clean the parts with solvent, Part Number 3824421, or equivalent.

Dry with compressed air.



Rotate the shaft and inspect for rough or damaged bearings.

If the bearings are rough or damaged, the water pump **must** be replaced.

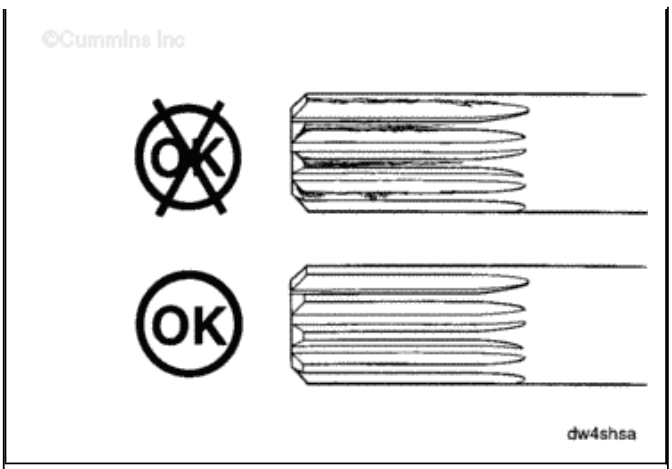


Inspect the drive shaft for wear.

If the drive shaft splines are worn, check the female splines in the pump and in

the water pump drive.

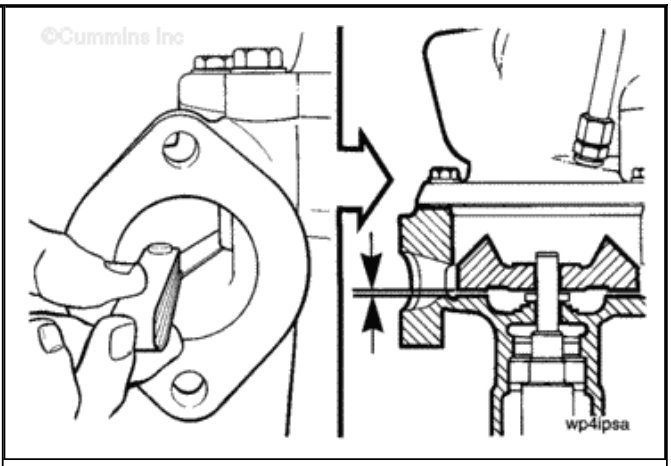
Replace worn parts as necessary.



Use a feeler gauge to measure the impeller to water pump body clearance.

Impeller to Pump Body Clearance		
mm		in
0.84	MIN	0.033
1.02	MAX	0.040

If the pump is **not** within specifications, it **must** be replaced.



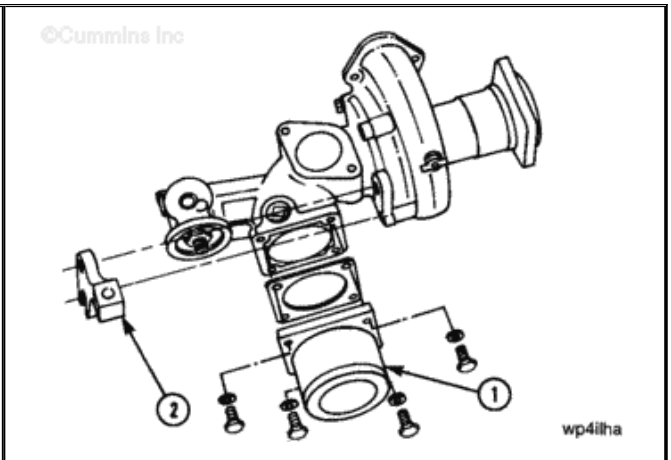
Install

Install the gasket, inlet connection (1) and capscrews.

Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Do **not** tighten the support bracket until the water pump is assembled to the engine. Use a heavy, plain washer on the capscrew that



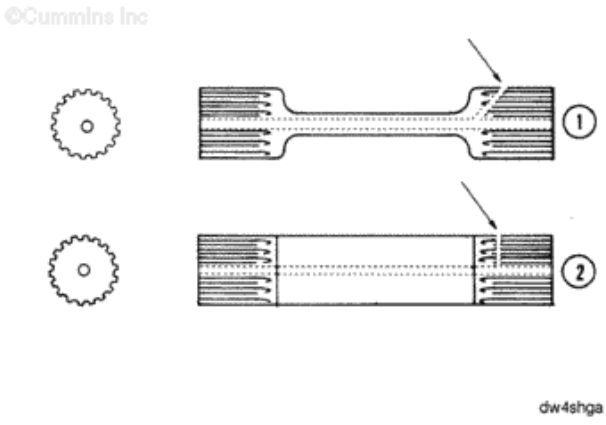
attaches through the slotted hole.

Failure of the water pump drive shaft will result if the wrong shaft is used.

The phenolic (plastic) plastic impeller has been discontinued. It is no longer available for production or service. The shaft (2) is also no longer available for production or service.

Use shaft (1) with cast iron impeller pumps. Use shaft (2) with phenolic (plastic) impeller pumps.

Install the shaft with the oil hole at the side of the shaft toward the water pump.



Lubricate the shaft with clean engine oil.

Install the shaft in the splined hole in the water pump drive.

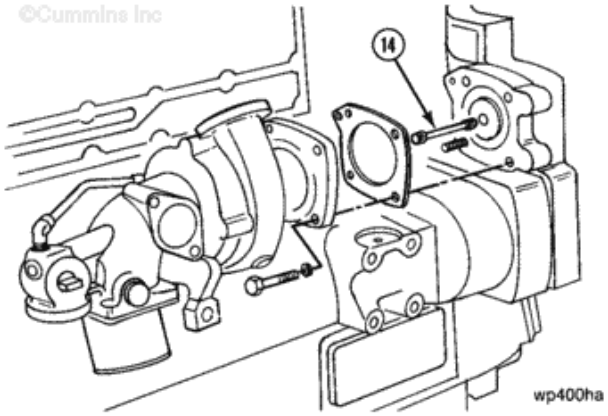
Do **not** tighten the capscrews and nut until the support bracket is aligned with the cylinder block.

Install the gasket and water pump.

Install the three capscrews and nuts.

Tighten the capscrews and nuts.

Torque
Value: 45 n.m [33 ft-lb]



The support bracket **must** be flat against the water pump and the cylinder block.

Align the bracket before tightening the capscrews.

Install the capscrew through the bracket.

Tighten the capscrew.

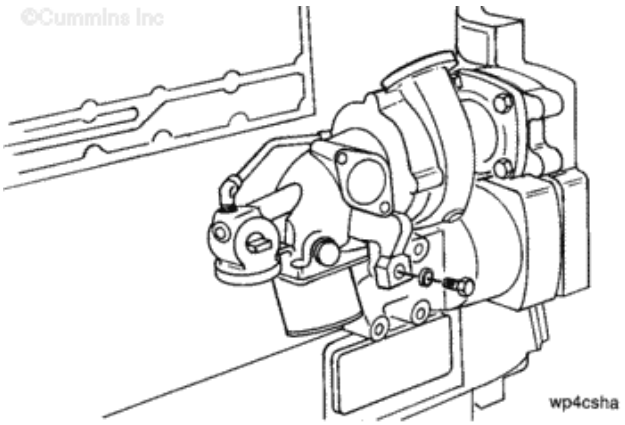
Torque
Value: 206 n.m [150 ft-lb]

Check the alignment between the support bracket and the water pump.

Loosen the capscrew and adjust if necessary.

Tighten the capscrews holding the support bracket to the water pump.

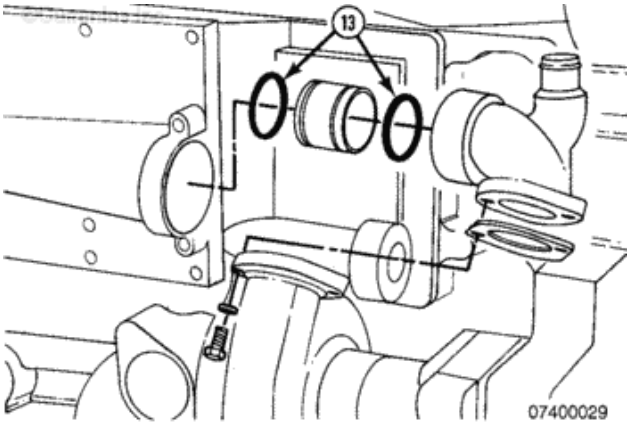
Torque
Value: 45 n.m [33 ft-lb]



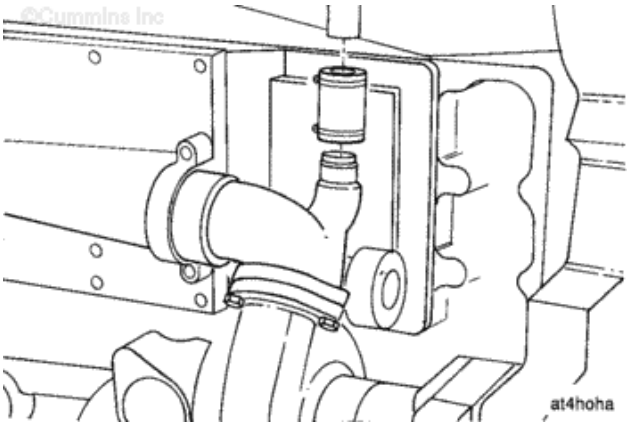
Lubricate the o-rings (13) with vegetable oil and install them onto the transfer tube.

Install the transfer tube into the water outlet connection.

Install the water outlet connection assembly.

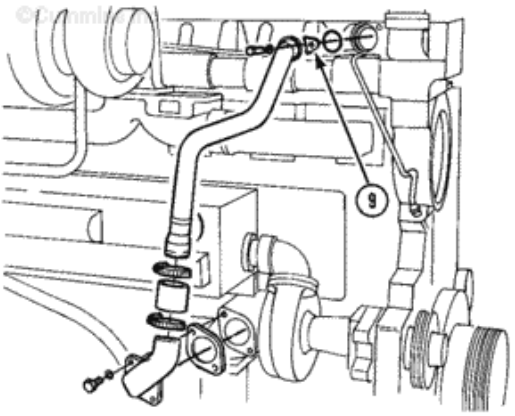


Connect the water pump outlet connection to the aftercooler supply hose.



Install the water bypass tube.

Install the water bypass tube clamp and capscrew.

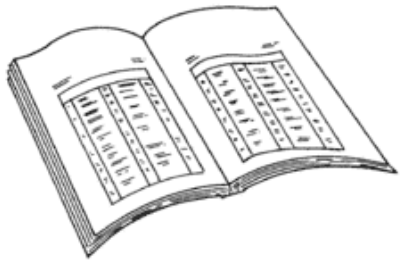


Finishing Steps

WARNING

Batteries can emit explosive gasses. To reduce the possibility of personal injury, always ventilate the compartment before servicing batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Install the coolant filter. Refer to Procedure 008-006.
- Fill the cooling system. Refer to Procedure 008-018.
- Connect the batteries or air starter supply line.

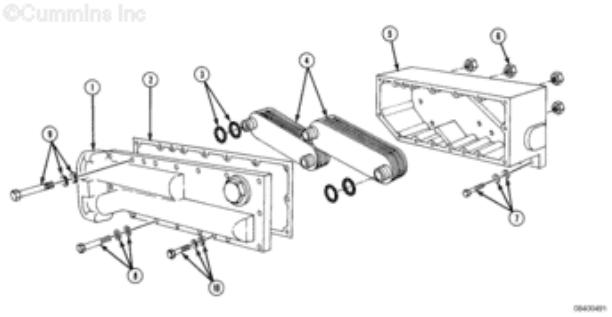


Last Modified: 31-Jul-2006

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008-065 Torque Converter Cooler

Exploded View



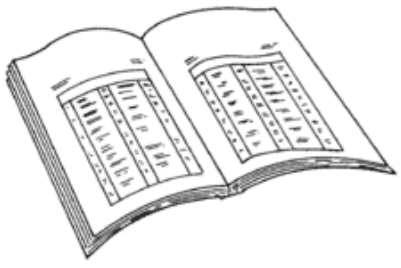
1. Torque converter oil cooler cover
2. Torque converter oil cooler cover gasket
3. O-ring
4. Torque converter oil cooler element
5. Torque converter oil cooler housing
6. Self-locking nut
7. Capscrew, lock washer, and plain washer
8. Capscrew and lock washer
9. Capscrew, lock washer, and plain washer
10. Capscrew, lock washer, and plain washer.

Preparatory Steps

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.





ck800wa

WARNING

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

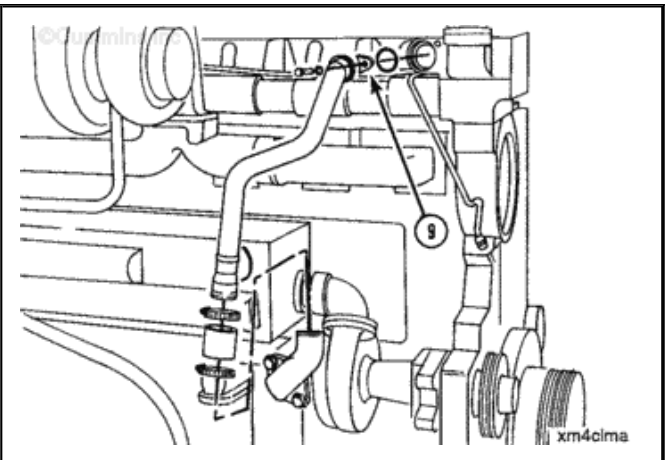
- Drain the cooling system. Refer to Procedure 008-018.
- Drain the coolant from water pump and oil cooler housing by opening and closing draincocks.
- Remove the turbocharger oil drain tube. Refer to Procedure 010-045.
- Remove the turbocharger coolant supply hose. Refer to Procedure 010-037.

Remove

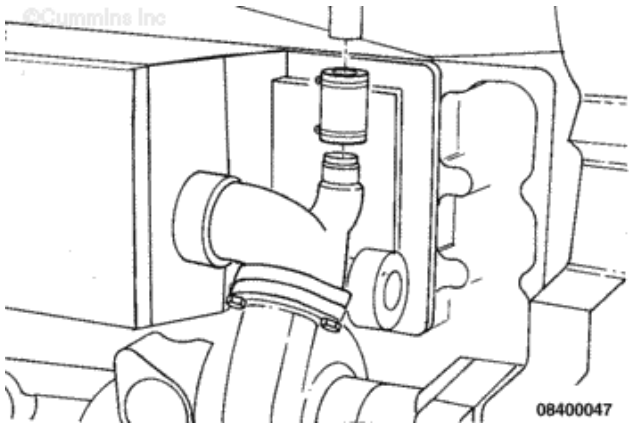
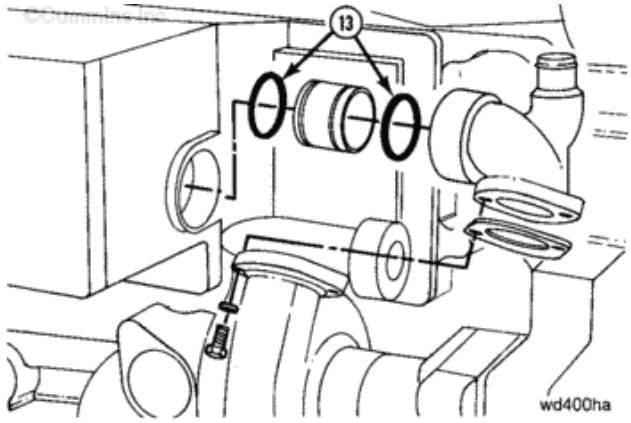
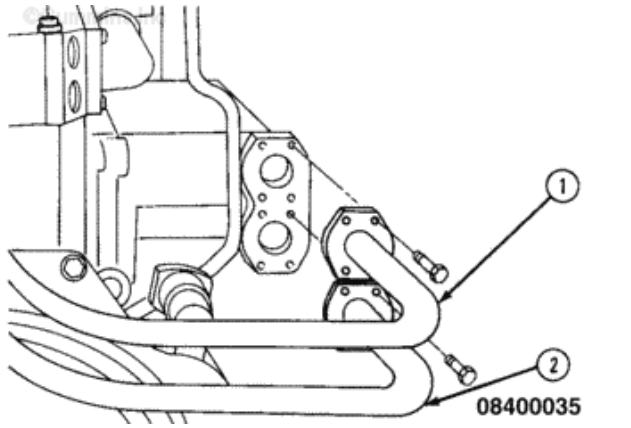
Remove the water bypass tube clamp (9).

Loosen both lower bypass tube clamps.

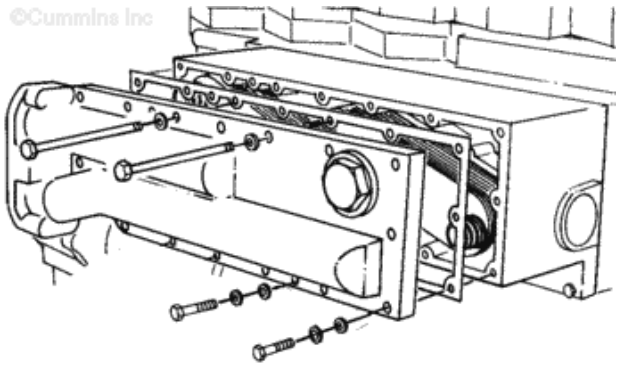
Remove the water bypass tube and discard the o-ring.



Disconnect the aftercooler supply hose from the water pump outlet connection.

		
Remove the water pump outlet connection assembly. Remove the water transfer tube from the water outlet connection. Remove and discard the to o-rings (13) and the gasket.		
Remove the oil supply (1) and oil return (2) tubes from the torque converter cooler.		
Remove the torque converter cooler cover mounting capscrews.		

The cover **must** be pried from the housing because of the tight fit between the cover and the o-rings on the elements.



WARNING

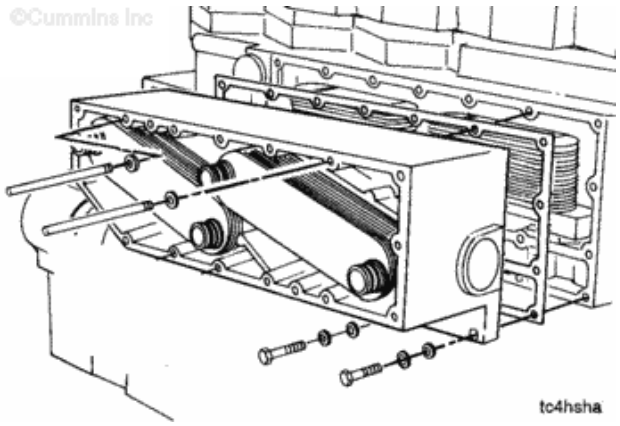
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Install two 3/8-16 x 12-in guide studs to support the housing while the capscrews are being removed.

Remove the remaining torque converter cooler housing capscrews.

Remove the torque converter cooler housing and the gasket.

Discard the gasket.

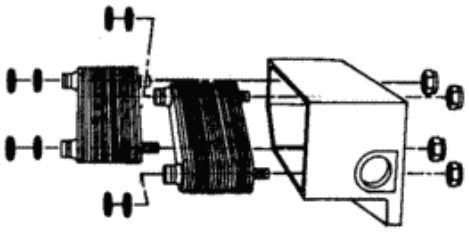


Disassemble

Remove the torque converter cooler element mounting nuts.

Remove the elements.

Remove and discard the o-rings.



tc400fa

Clean and Inspect for Reuse

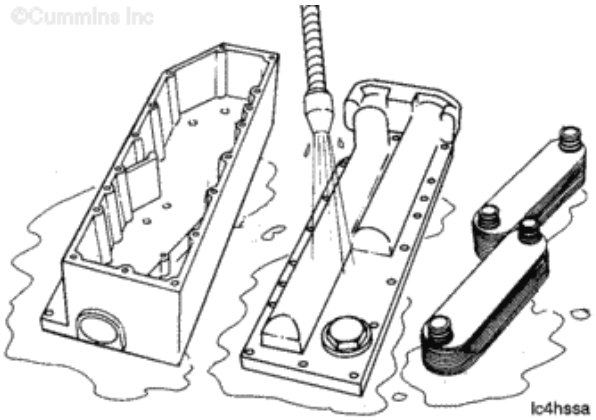
WARNING

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 parts with a solvent that will **not** harm aluminum.

Inspect the parts for cracks and other damages.

If the parts are damaged they **must** be replaced or repaired.



lc4hssa

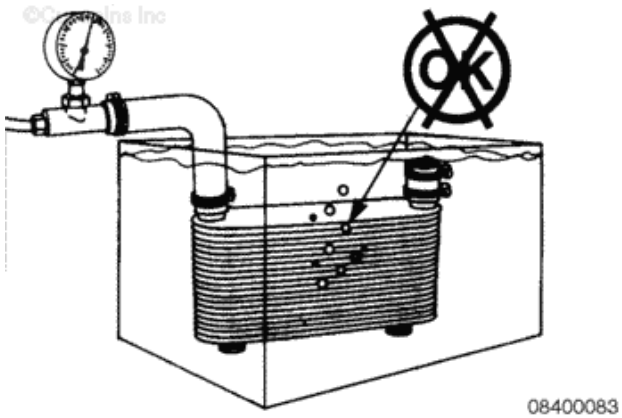
Pressure Test

NOTE: Heating the water in the tank ot 50°C [120°F] will improve the test results.

Pressure test the elements and check for leaks.

Measurements		
	kpa	psi
Air Pressure	415	60

If an element leaks, it **must** be replaced.



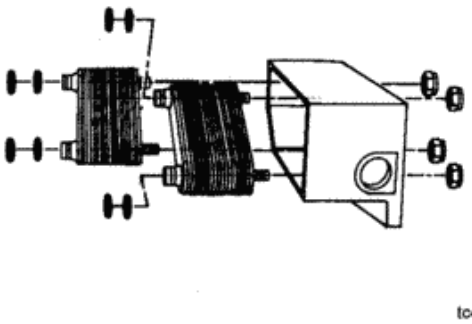
Assemble

Install the elements into the housing.

Install the self-locking nuts and tighten.

Torque
Value: 130 n.m [95 ft-lb]

Lubricate new o-rings with vegetable oil and install them onto the elements.



Install

WARNING

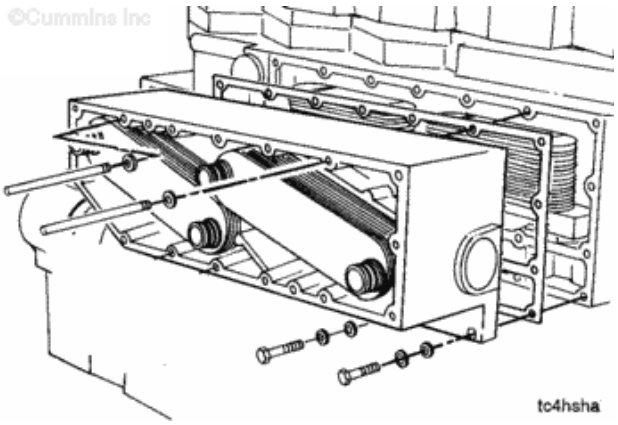
This assembly weighs 23 kg

[50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this assembly.

Install two 3/8-16 x 12-in guide studs to support the housing during installation.

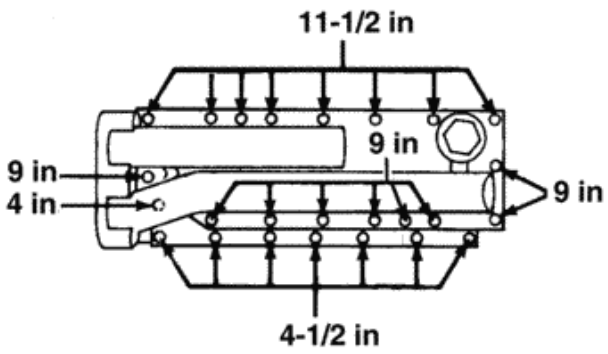
Install the gasket and the housing.

Install the capscrews in the bottom row of holes on the housing. These capscrews are all 101.6 mm [4 in] long.



The length and location of all the capscrews on the torque converter cooler and cover are shown. Make sure the capscrews are the correct length.

Do **not** tighten any of the capscrews until all of them have been installed.



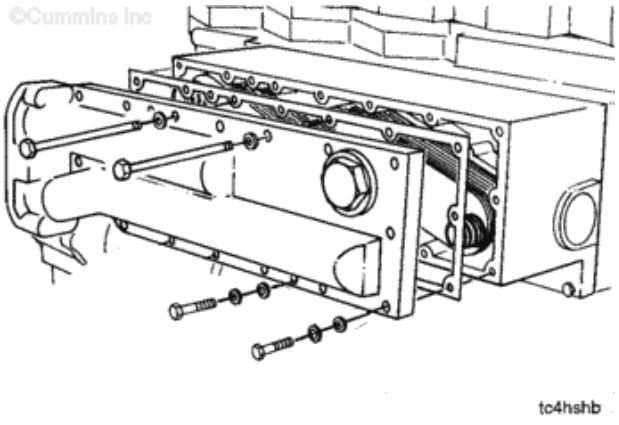
Make sure the capscrews are the correct length.

Lubricate the o-rings on the elements and the bores in the covers with vegetable oil.

Install the gasket and cover.

Push the cover over the o-rings until the cover is against the housing.

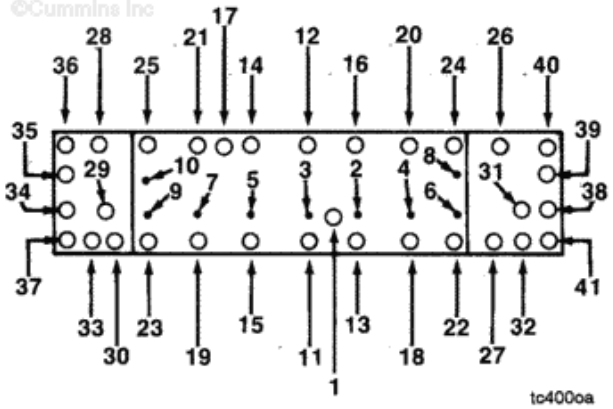
Install the remaining capscrews.



Tighten the capscrews in the sequence shown in the

graphic.

Torque
Value: 45 n.m [33 ft-lb]



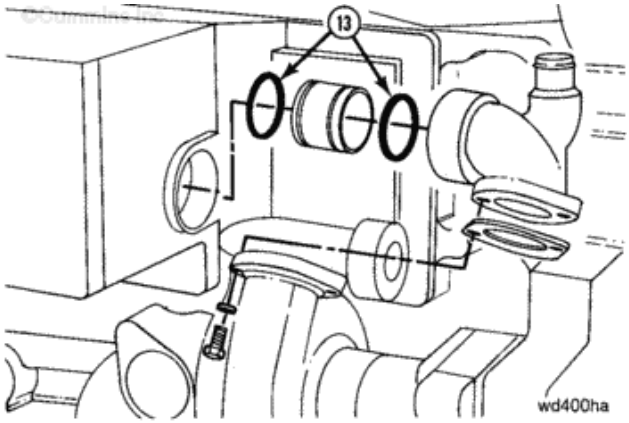
Lubricate the o-rings (13) with vegetable oil.

Install the transfer tube in the water pump outlet connection.

Install the water pump outlet connection, gasket, and capscrews.

Tighten the capscrews.

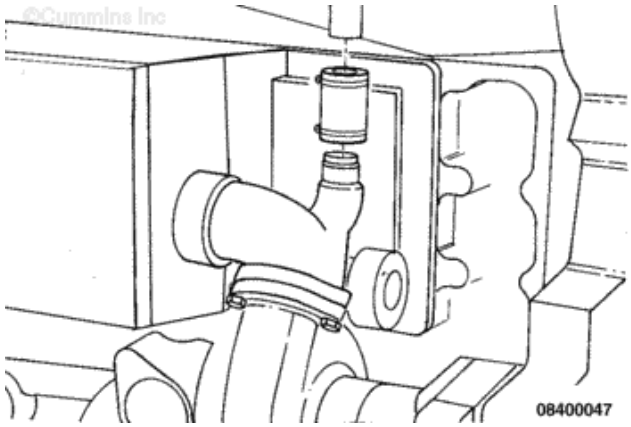
Torque
Value: 45 n.m [33 ft-lb]



Connect the aftercooler supply hose to the water pump outlet connection.

Tighten the clamps.

Torque
Value: 5.6 n.m [50 in-lb]



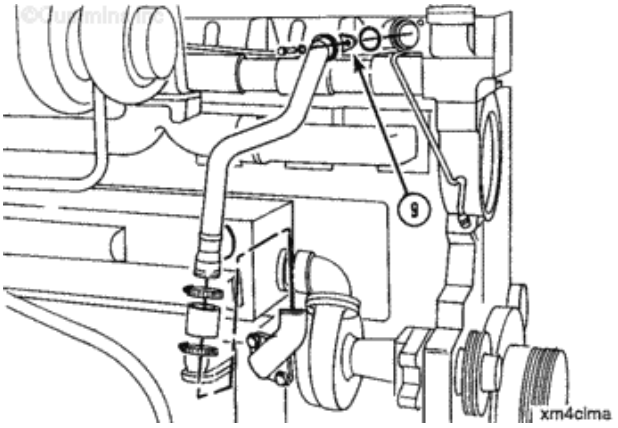
Lubricate the o-ring on the water bypass tube with vegetable oil.

Install the bypass tube.

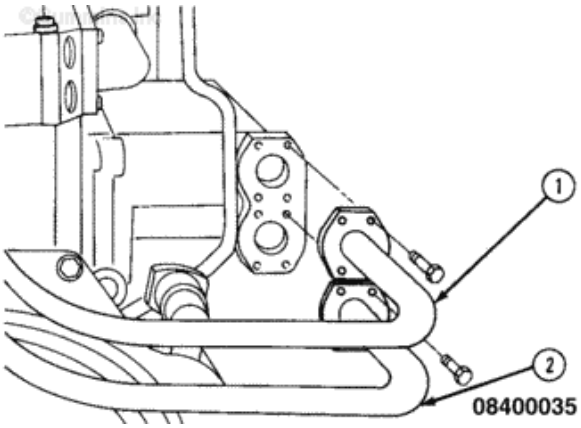
Install the retainer (9) and capscrew.

Tighten the capscrew and hose clamp.

Capscrew	45 n.m	[33 ft-lb]
Clamp	6 n.m	[50 in-lb]

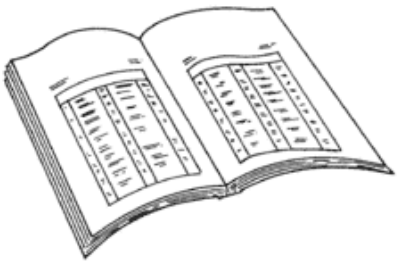


Connect the torque converter cooler oil tubes to the torque converter cooler.



Finishing Steps

- Install the turbocharger coolant supply hose. Refer to Procedure 010-037.
- Install the turbocharger oil drain tube. Refer to Procedure 010-045.
- Fill the cooling system. Refer to Procedure 008-018.
- Operate the engine to 70°C [160°F] coolant temperature and check for leaks.



Last Modified: 19-Oct-2004

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008-087 Cooling Fan Belt Tensioner

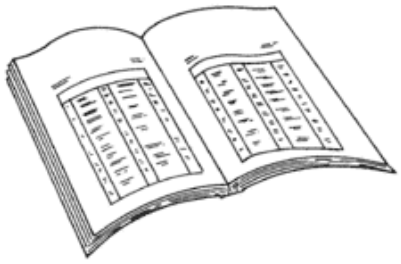
Preparatory Steps

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. Refer to the OEM service manual.
- Remove the cooling fan and spacers. Refer to Procedure 008-040 in Section 8.
- Remove the cooling fan and spacers. Contact a Cummins® Authorized Repair Location.
- Remove the fan belt. Refer to Procedure 008-002 in Section 8.
- Remove the fan belt. Refer to Procedure 008-002 in Section A.

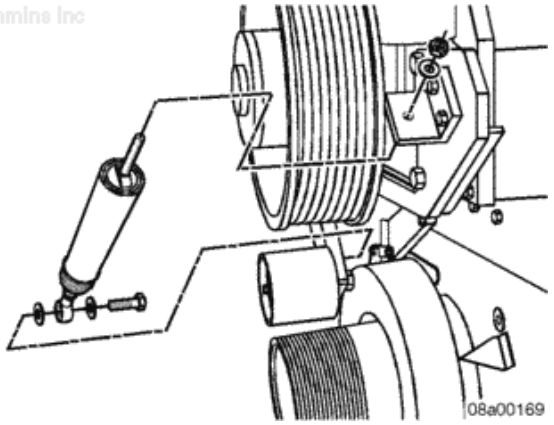




ck800wa

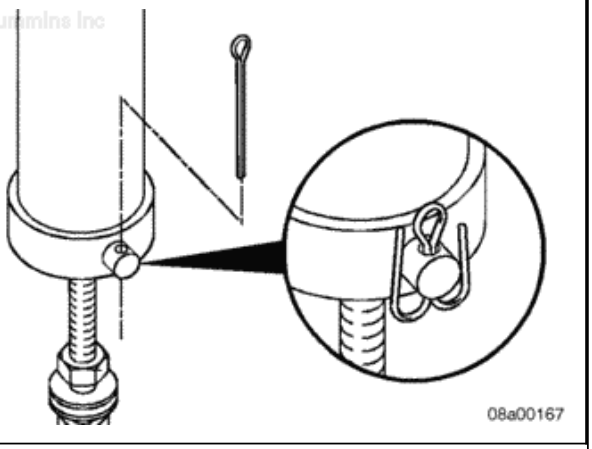
Remove

Linear Tensioner System

Remove the capscrews and washers from the lower clevis and idler arm. Remove the nut and the capscrews from the threaded rod end of the tensioner at the upper anchor bracket. Remove the fan belt tensioner.		

Disassemble

Linear Tensioner System

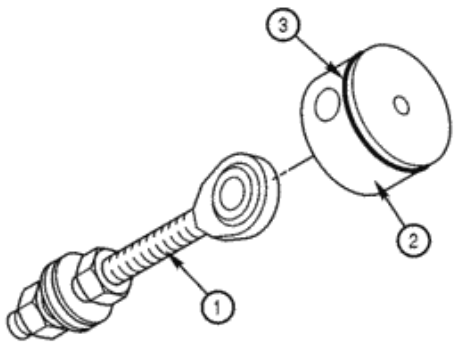
Remove the cotter pin from the clevis pin. Remove the clevis pin from the control rod and belt tensioner housing and separate.		
Remove the control rod (1) from the control rod retainer (2). Remove and discard the o-ring (3) from the control rod retainer (2), if present. Remove the first nut from the control rod threaded end. Remove the flat washers		

from the control rod threaded end.

NOTE: The number of washers can vary. Record the number of washers removed so the same number is reassembled, if required,

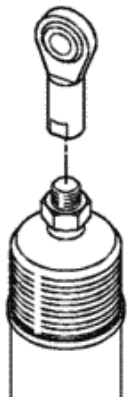
Remove the remaining nut from the control rod threaded end.

NOTE: Engines built on or after 01-Aug-2011 and ESN first 37250458 have an o-ring in a groove on the control rod retainer.



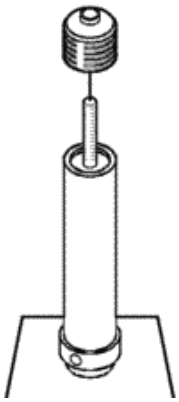
Remove the control rod from the capscrew threaded end.

Remove the nut holding the dust seal to the capscrew.

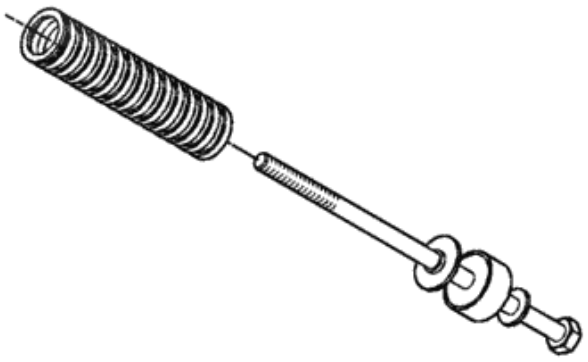


Cut the wire tie to remove the dust seal from the belt tensioner housing.

Remove the dust seal from the threaded end of the capscrew and the belt tensioner housing.



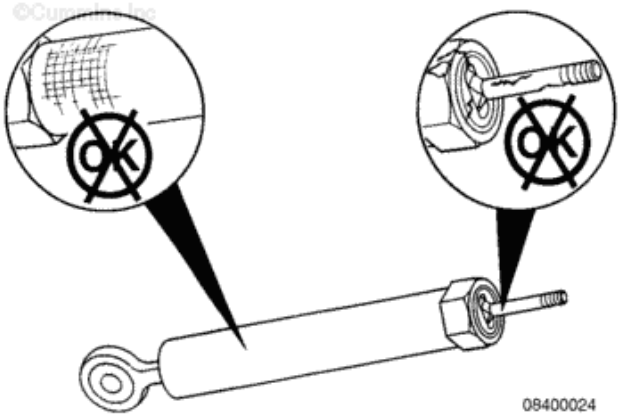
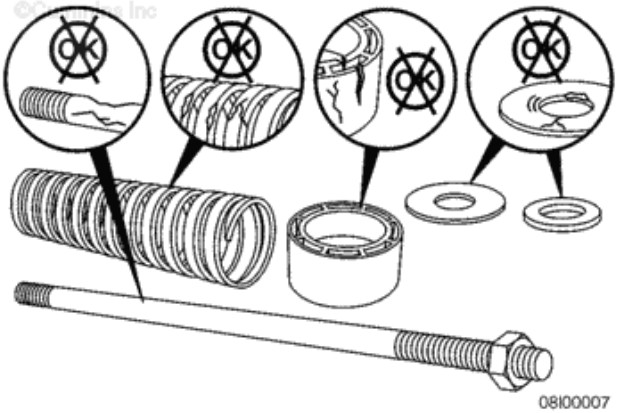
NOTE: It is not necessary

to use a build fixture to disassemble or assemble, as shown in the illustration. This is an aid to clarify the steps in the procedure. Remove the belt tensioner housing from the belt tensioner assembled parts.		 08a00157
Remove the compression spring from the spring retainer. Remove the spring retainer from the spring guide. Remove the spring guide from the flat washer. Remove the flat washer from the capscrew.		 08a00155

Inspect for Reuse

Linear Tensioner System

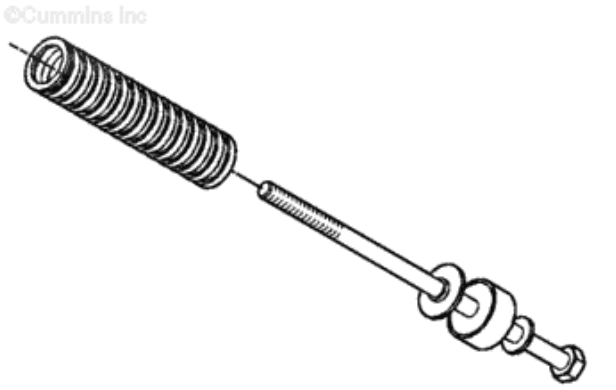
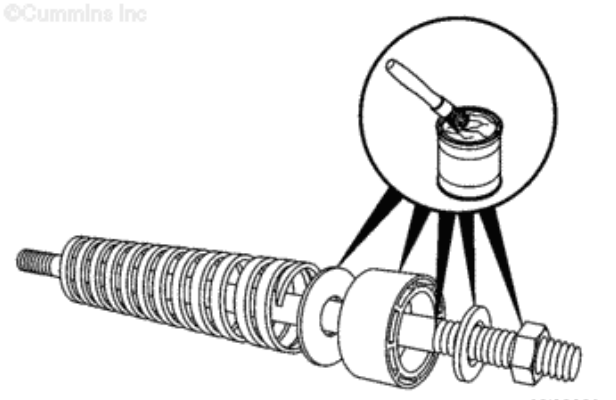
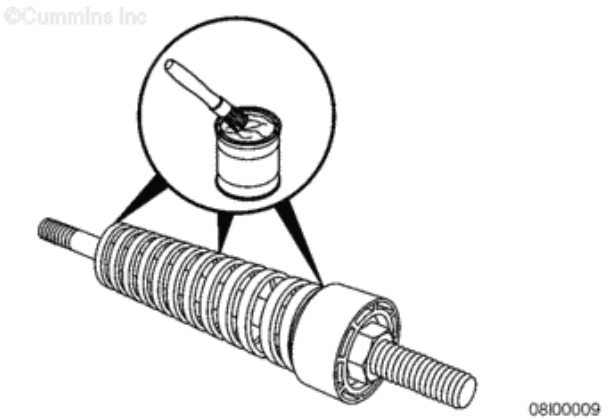
Inspect the tensioner assembly and ends for cracks or excessive wear. If the tensioner assembly is cracked or worn, it **must** be replaced.		

		
If the tensioner is disassembled, inspect the components for corrosion. All corroded parts **must** be replaced.		

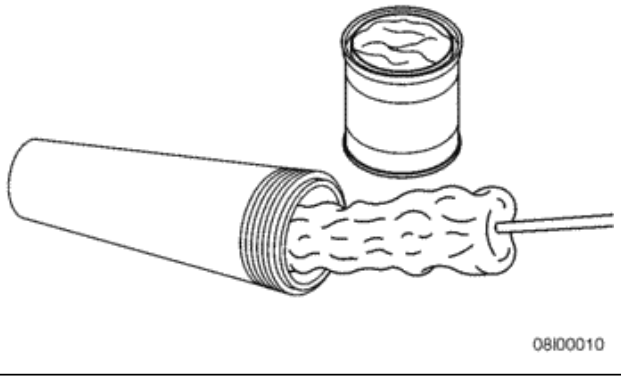
Assemble

Linear Tensioner System

Install a washer on the capsrew so that the round side of the washer faces the capscrew head. Install the spring guide with the recessed/indented side next to the flat side of the washer. Install the spring retainer with the larger flat surface		

against the spring guide.		
Use Lubriplate™ 105, Part Number 3163087, or equivalent, to grease the spring guide, washers, retainer, and top of the capscrew between the washers, retainer, and spring.		
Install the compression spring against the spring retainer. Use Lubriplate™ 105, Part Number 3163087, or equivalent, to grease the outside of the compression spring. Make sure to grease both contacting end surfaces.		
Use Lubriplate™ 105, Part Number 3163087, or equivalent, to grease the inside of the fan belt		

tensioner housing.



NOTE: It is not necessary to use a build fixture to diassemble or assemble as shown in the illustration. This is an aid to clarify the steps in the procedure.

Install the belt tensioner housing over the assembled parts and allow the bottom of the housing to sit on the build fixture with the threads of the capscrews protruding out of the belt tensioner housing.

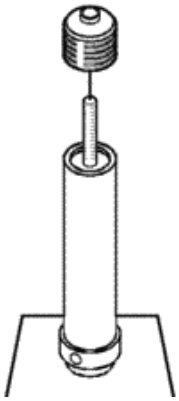


Slip the dust seal over the end of the capscrew and the edge of the belt tensioner housing.

NOTE: Use a ratchet to prevent the capscrew from moving while pushing the dust seal into place.

Use a wire tie and fasten around the dust seal where it overlaps the belt tensioner housing.

Pull the tie until tight and cut off the excess of the tie.



Push the dust seal down over the threads of the

capscrew and install the nut.

Back the nut against the control rod and tighten.

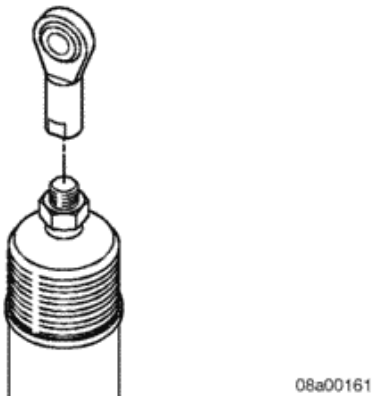
Use a 3/4-inch open-end wrench to tighten the nut.

NOTE: Make sure to tighten the nut just far enough to get clearance for the following part to be installed. Do not completely tighten at this time.

Install the control rod end on the threaded end of the capscrew.

Back the nut against the control rod and tighten.

Torque
Value: 68 n.m [50 ft-lb]



Apply Lubriplate™ 105, Part Number 3163087, or equivalent, to the o-ring groove (3) in the control rod retainer (2) and the spring guide.

Install the o-ring (3) on the control rod retainer (2) and install in the housing.

Install the nut on the control rod end (1).

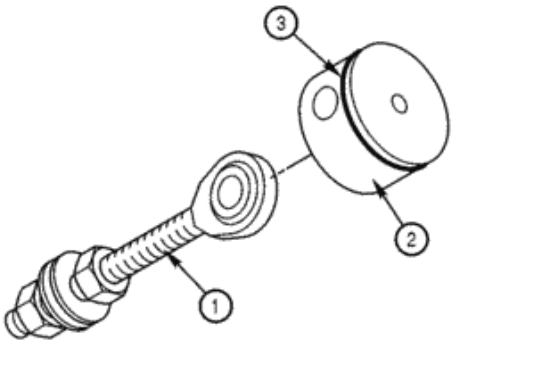
Install the flat washers onto the control rod end.

NOTE: Make sure to install the same number of washers that were removed earlier.

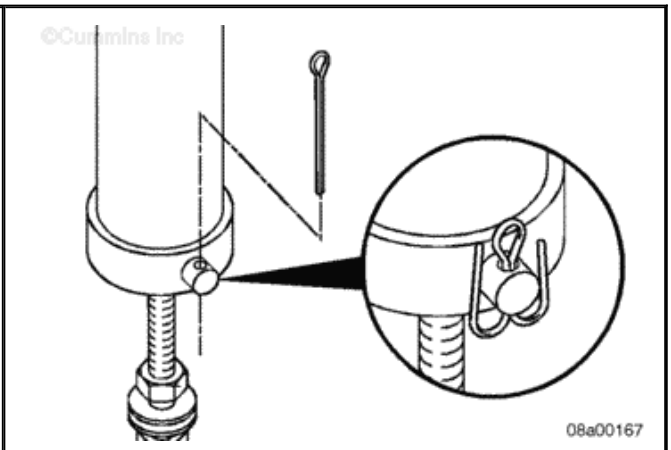
Install a second nut onto the control rod end.

NOTE: Do not tighten completely. Leave the washers loose.

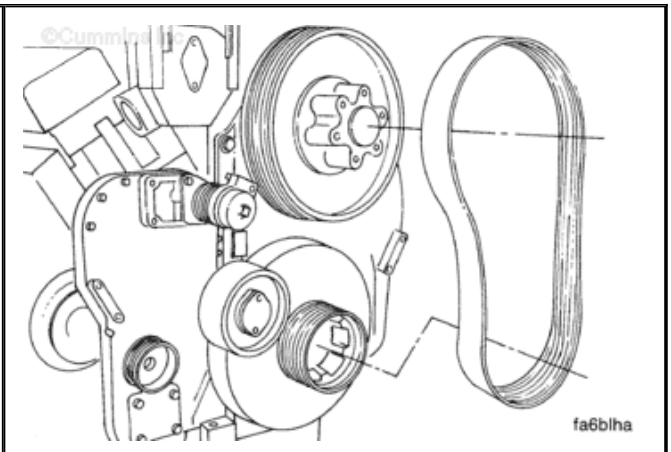
Install the assembled control rod end on the control rod



retainer on the slotted end.		

Use a non-metallic mallet, or equivalent, to install the retainer into the belt tensioner housing. Align the holes and install the clevis pin to hold the parts together. Use a cotter pin to secure the clevis pin to the housing. Bend the cotter pin around the clevis pin to keep it from falling out during operation.		

Install

NOTE: The fan hub pulley and the fan belt are shown removed in the illustrations below for clarity. Install the fan belt. Refer to Procedure 008-002 in Section 8. Install the fan belt. Refer to Procedure 008-002 in Section A.		

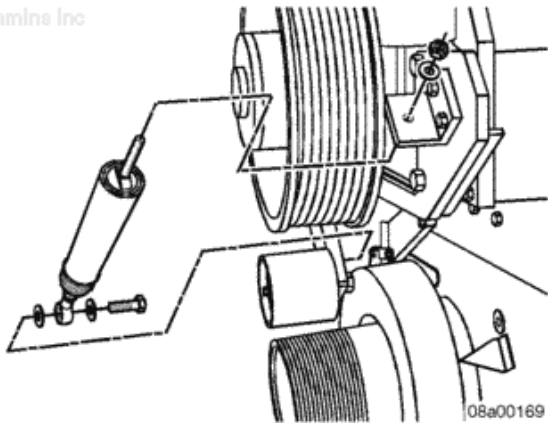
Linear Tensioner System

Attach the lower clevis end of the tensioner to the idler arm with capscrews and washers. Tighten the capscrews. **Torque** **Value:** 102 n.m [75 ft-lb]		

Slide the threaded-rod end of the tensioner through the hole in the upper anchor bracket and secure it with a washer and nut.

Pull the belt tensioner until the idler pulley contacts the fan belt. Tighten the top nut hand-tight.

NOTE: Do not tighten the nut. It will be tightened later to adjust the belt tension.

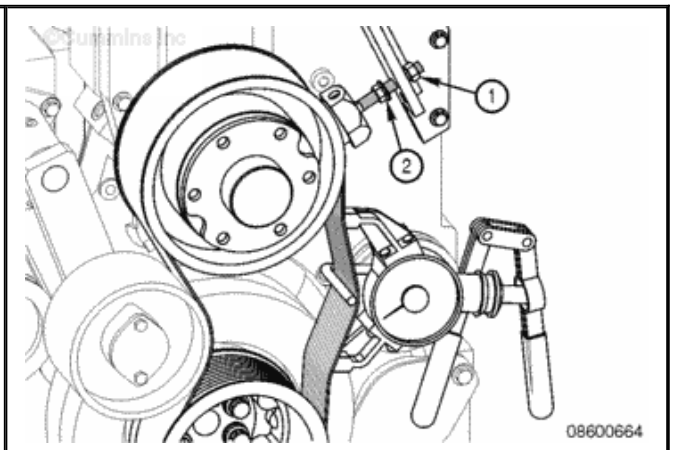


Adjust

Linear Tensioner System

Adjust the fan belt and check belt tension. Refer to Procedure 008-002 in Section 8.

Adjust the fan belt and check belt tension. Refer to Procedure 008-002 in Section A.

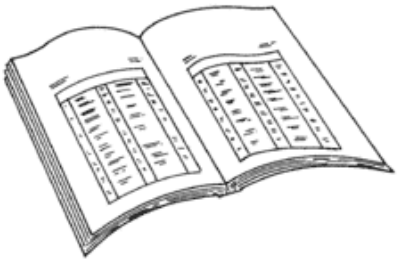


Finishing Steps

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 cooling fan and spacers. Refer to Procedure 008-040 in Section 8.
- Install the cooling fan and spacers. Contact a Cummins® Authorized Repair Location.
- Connect the batteries. Refer to the OEM service manual.



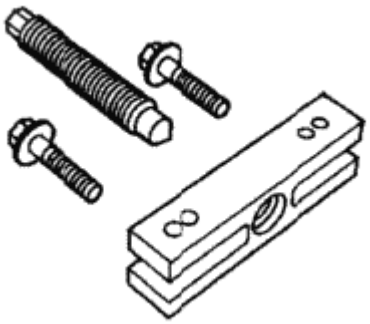
ck800wa

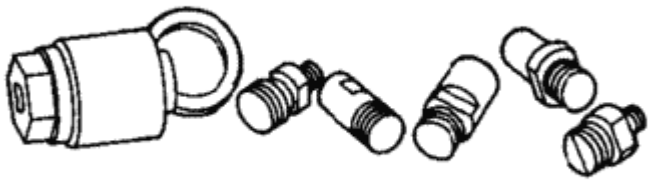
Last Modified: 28-Sep-2011

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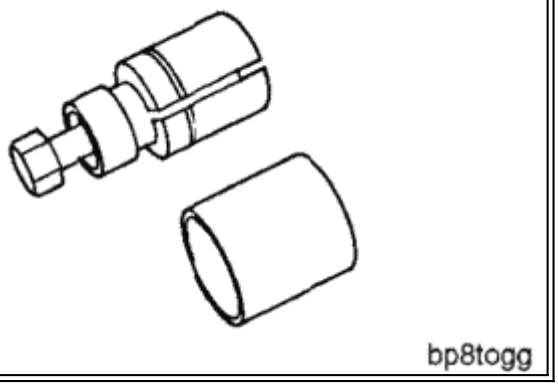
022-001 Service Tools

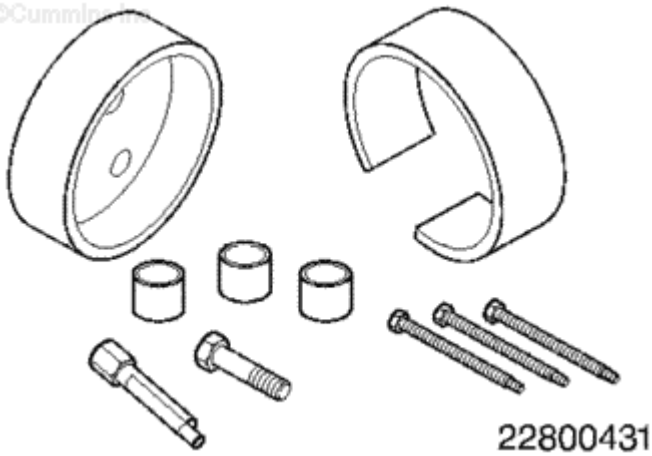
Drive Units

Tool Number ST-647	**Gear Puller** Use to remove the drive pulleys and impellers.	©Cummins Inc  ad8toga

Tool Number 3376326	**Pulley Installation Tool** Use to install drive pulleys.	©Cummins Inc  ad8togb

Tool Number	**Coupling Puller** Use to remove	

3376663	accessory drive coupling.	 bp8togg

Tool Number 3824760	**Oil Seal Remover/Installer** Use to remove small bushings, oil seals, and bearings.	 22800431

Last Modified: 15-Nov-2004

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009-004 Accessory Drive Pulley

Remove

CAUTION

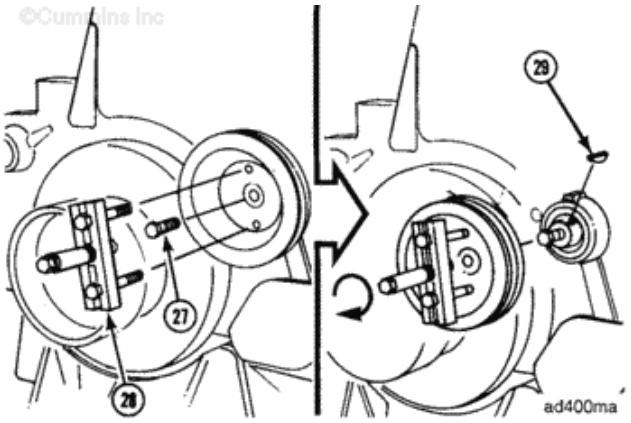
To reduce the possibility of damage to the shaft, make sure a capscrew in the shaft.

Install a 7/16-20 x 1 inch capscrew (27) in the shaft.

Remove the accessory drive pulley with standard puller, Part Number ST-647, or equivalent (28).

Remove the woodruff key (29) from the shaft with a brass drift.

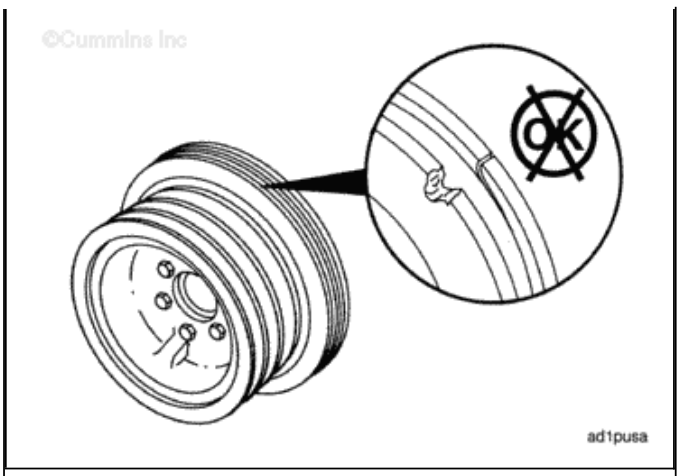
Remove the capscrew from the shaft.



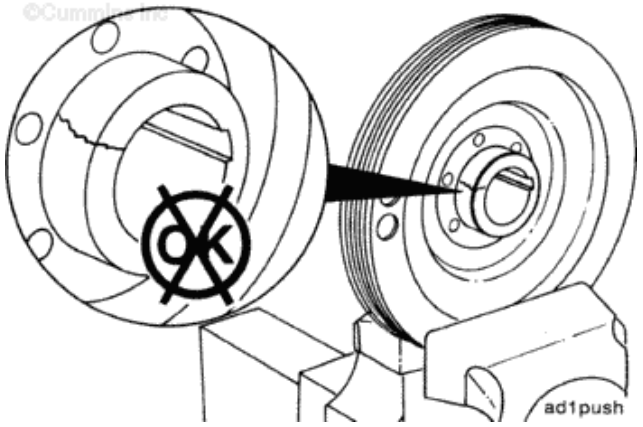
Inspect for Reuse

Inspect the pulley for cracks, wear in the belt grooves, or other damage.

If the pulley is cracked or damaged it **must** be replaced.

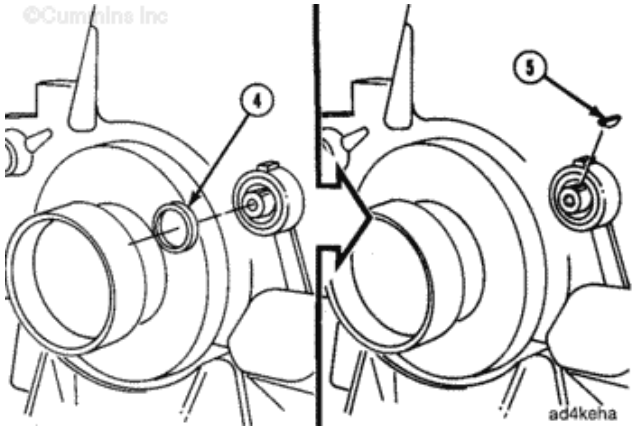


Inspect the mating surface and pulley bore areas for damage.



Install

Install the woodruff key (5).



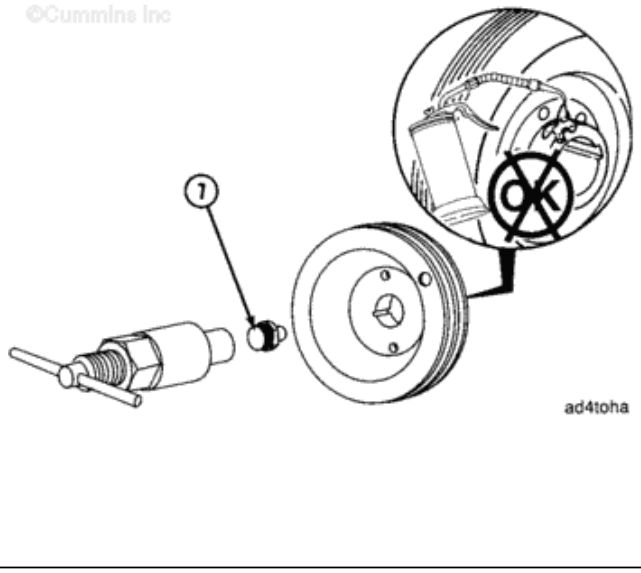
CAUTION

Do not use a hammer to drive the pulley into position. Damage to the thrust bearing will result.

Do **not** lubricate the pulley. The lips on the seal and the seal surface on the pulley wear sleeve **must** be clean and dry.

Use the pulley installation tool kit, Part Number 3376326.

Install the appropriate adapter (7) in the pusher.

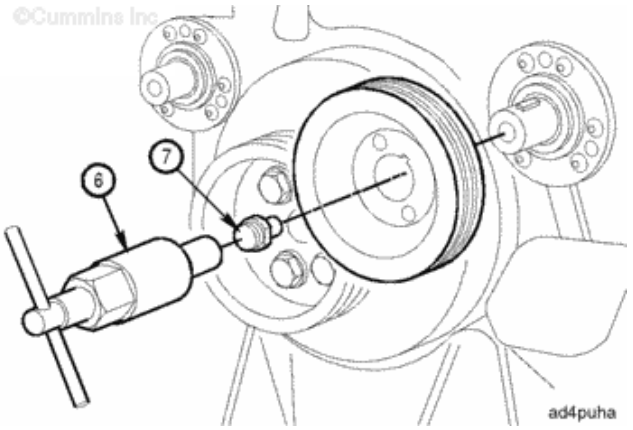


CAUTION

The dust lip on the accessory drive seal must be folded under when the pulley is installed. To reduce the possibility of the dust lip (yellow lip) from folding under, bend the lip outward by running a finger around it 8 to 10 times applying gentle pressure. Avoid touching the sealing lip. The dust lip will remain bent approximately one minute, then return slowly to the operating position.

Align the keyway in the pulley with the key in the shaft.

Use the tool to push the pulley onto the shaft until it touches the step on the shaft.



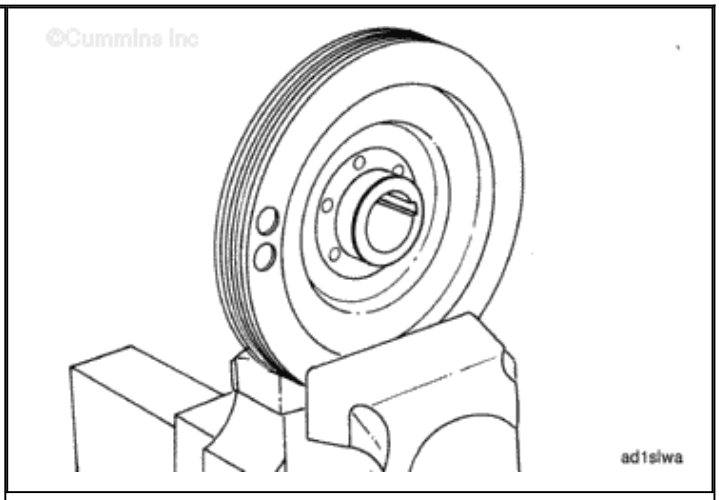
009-005 Accessory Drive Pulley Wear Sleeve

Disassemble

CAUTION

The jaws of the vise must have copper plates to reduce the possibility of damage to the pulley.

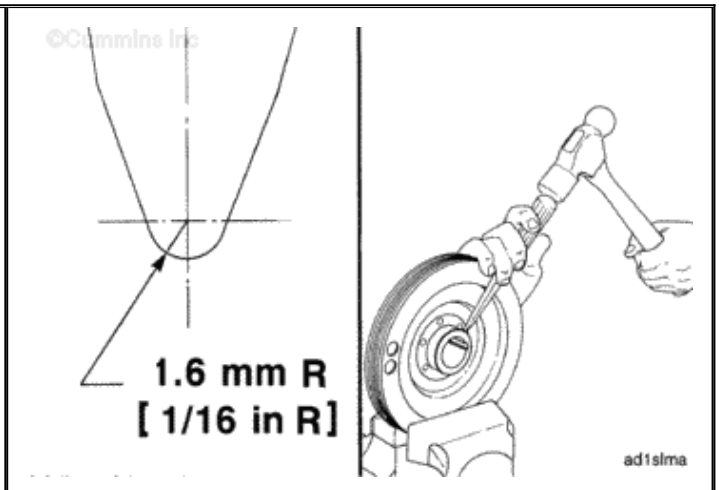
Place the accessory drive pulley in a vise.



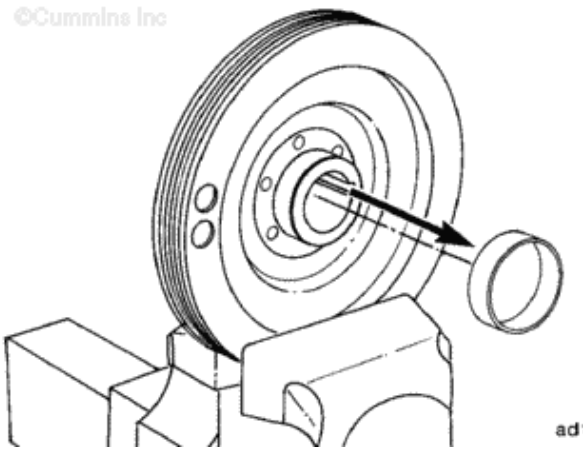
Grind a 1.5 mm [1/16 in] radius on the cutting edge of a 19 mm [¾ in] chisel.

Position the chisel as illustrated in the graphic and strike the wear sleeve in four places.

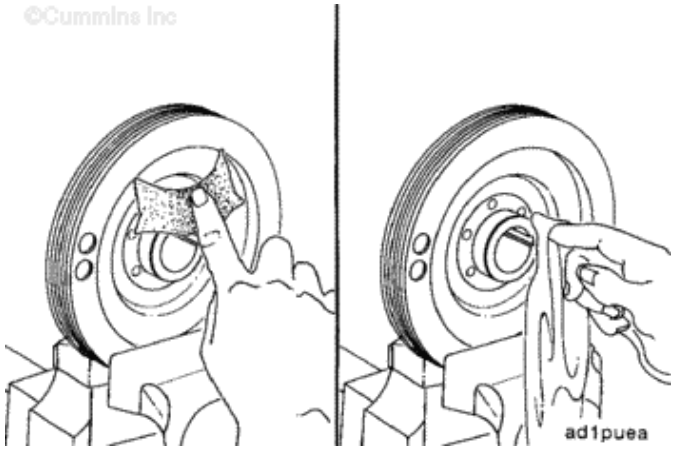
This will relieve the press fit and allow the wear sleeve to be removed.

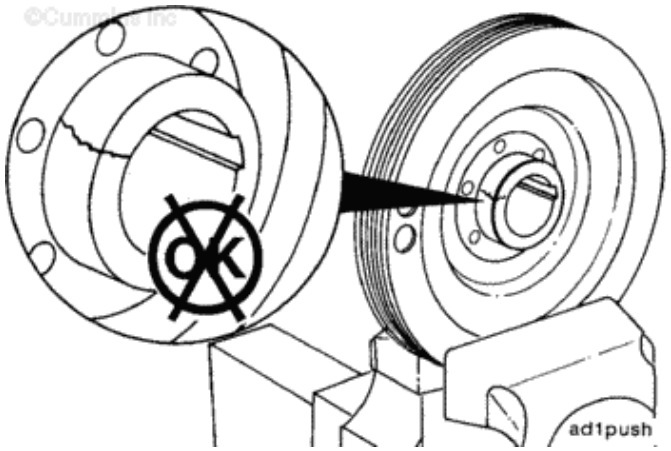


Remove the wear sleeve.

Clean and Inspect for Reuse

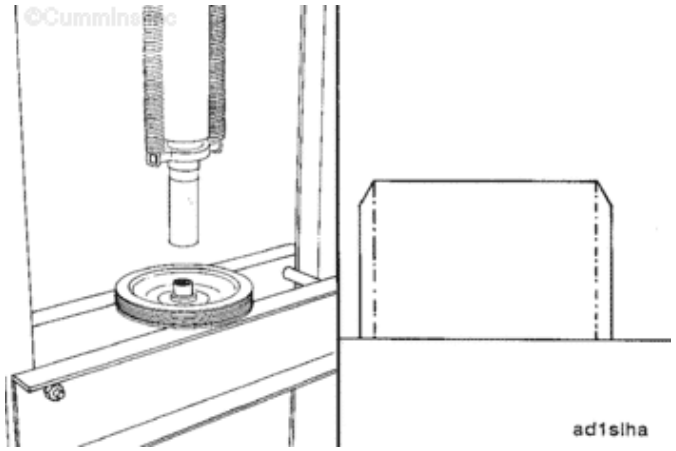
Use crocus cloth to clean the wear sleeve area of the pulley.		
Inspect the sleeve wear surface for damage.		



Assemble

Support the accessory drive pulley in an arbor press.

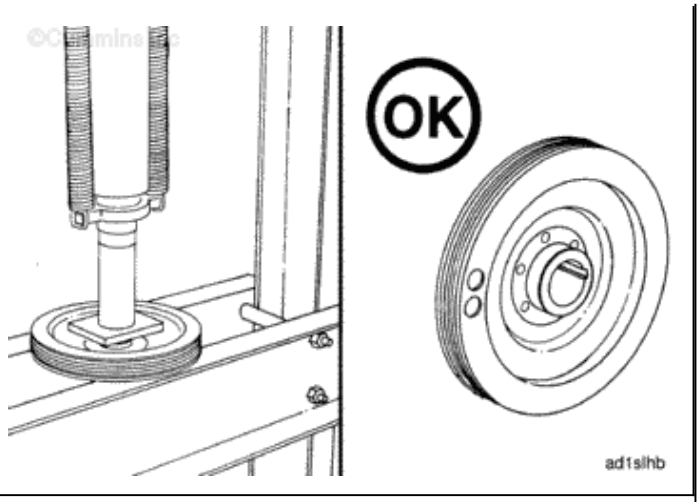
Install the wear sleeve on the pulley with the chamfer on the outside diameter of the sleeve facing away from the pulley.



Place a flat steel plate on top of the wear sleeve.

Press the sleeve onto the pulley until the steel plate contacts the pulley.

Inspect the wear

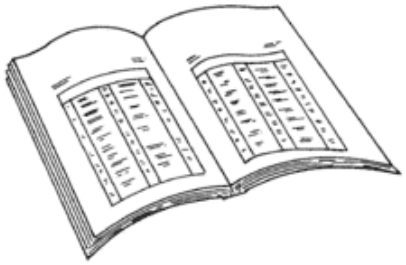
sleeve for damage or burrs.		

Last Modified: 11-Nov-2004

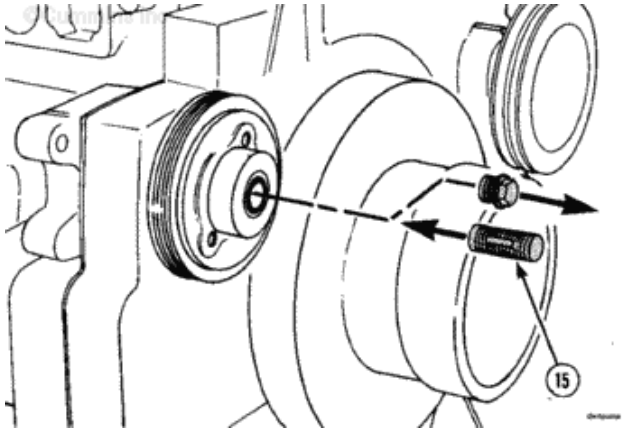
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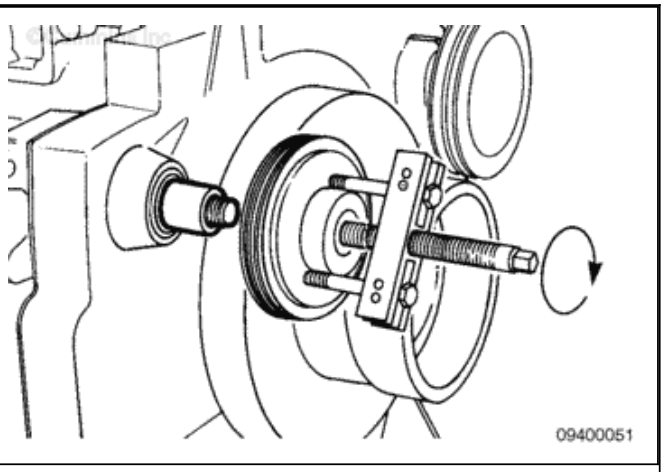
009-010 Alternator Drive Pulley

Preparatory Steps

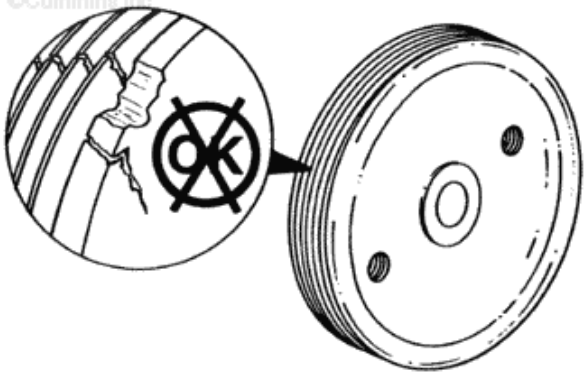
• Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.		 ck800wa

Remove

Remove the plastic plug at the end of the shaft. Insert the adapter (15), Part Number 3376089, into the shaft to prevent damage. The adapter is included with the pulley installation kit, Part Number 3376326. If the adapter is **not** available, a ¾-16 inch capscrew with the head ground smaller than the pulley inside diameter can be used.		

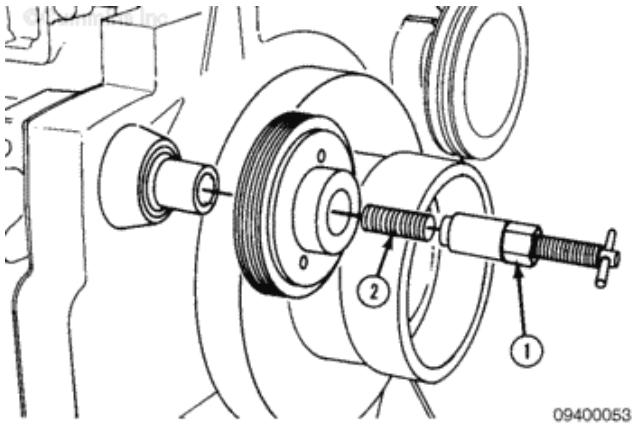
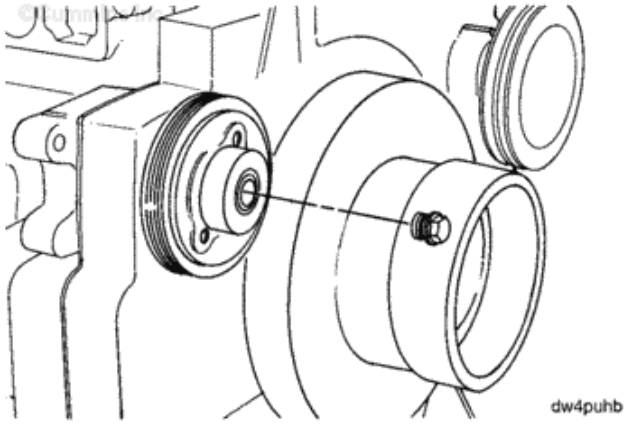
Attach standard puller, Part Number ST-647, to the drive pulley using the two supplied capscrews. Remove the pulley. Remove the adapter. **NOTE: Standard Puller, Part Number ST-647, includes two capscrews that measure 7/16-20x1 inch.**		

Inspect for Reuse

Inspect the pulley for nicks, cracks, excessive wear in the belt grooves, or other damage. Replace the pulley if excessively worn or damaged.		

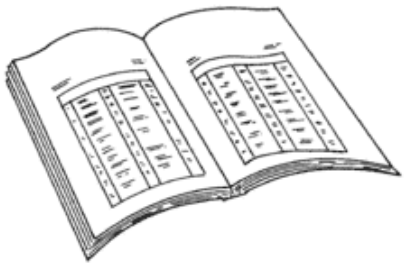
Install

CAUTION		

Do not use a hammer to drive the pulley into position. The thrust washers will be damaged. Install the alternator drive seal. Refer to Procedure 001-001 in Section 1. Insert the adapter (2), Part Number 3376089, into the shaft to prevent damage. The adapter is included with the pulley installation kit, Part Number 3376326. Press the pulley onto the shaft with the installation tool (1). The pulley **must** touch the step on the shaft. Remove the tool (1) and adapter (2).		
If a capscrew with the head ground was used instead of an adapter, remove the capscrew from the water pump drive. Install the plastic plug that protects the threads.		

Finishing Steps

• Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.		



ck800wa

Last Modified: 17-Dec-2008

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009-011 Fuel Pump Drive

General Information

CAUTION

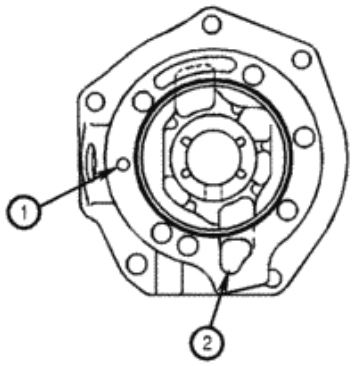
Installation of an air compressor on a fuel pump drive housing will result in failure because a lack of lubrication.

The fuel pump drive housing can be manufactured from aluminum or cast iron. The aluminum housing does **not** contain a bushing, and does **not** require thrust washers.

The housings are available in two designs, with and without provisions for mounting an air compressor. Those without provisions for mounting an air compressor do **not** have provisions for air compressor oil supply (1) and drain back (2). The housing with an air compressor drive has provisions for a splined sleeve type coupling. The procedures are identical for both designs.

The fuel pump/compressor drive gear have stamped marks. The stamped marks **must** be aligned properly with the camshaft idler gear so the valve and injector adjustment marks on the accessory drive pulley are oriented correctly.

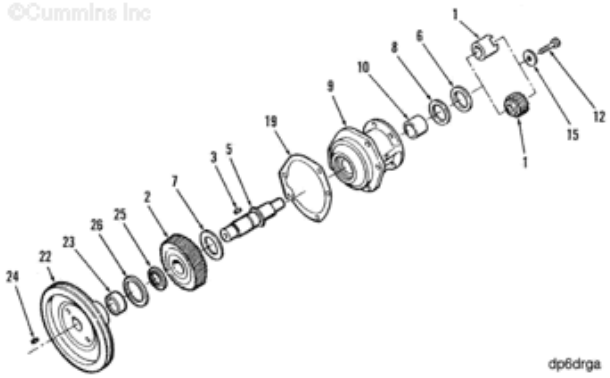
The retainer capscrew on the air compressor drive (splined half coupling) is special. It has a drilling in it that provides



09400012

lubrication of the splined coupling. The retainer capscrew on the fuel pump drive (lovejoy half coupling) does **not** have an oil drilling.		

Exploded View



1. Lovejoy type coupling (upper)
1. Spline type coupling (lower)
2. Air compressor and fuel pump drive gear
3. Plain woodruff key
5. Accessory drive shaft
6. Clamping washer
7. Thrust bearing
8. Thrust bearing
9. Fuel pump drive housing
10. Fuel pump drive bushing
12. Special capscrew
15. Plain washer
19. Fuel Pump support gasket
22. Accessory drive pulley
23. Wear sleeve
24. Plain woodruff key
25. Oil slinger
26. Oil seal.

Preparatory Steps

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.

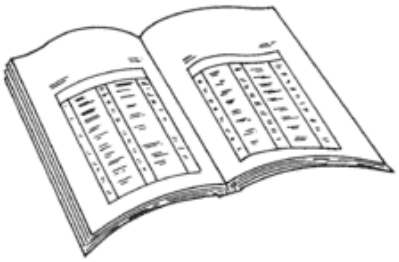
WARNING

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

NOTE: It is not necessary to drain the cooling system if an air compressor not mounted on the engine.

- Drain the cooling system. Refer to Procedure 008-018.
- Remove the fuel pump. Refer to Procedure 005-016.
- Remove the air compressor. Refer to Procedure 012-014.
- Remove the accessory drive pulley. Refer to Procedure 009-004.
- Remove the accessory drive seal. Refer to Procedure 001-003.

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ck800wa

Remove

CAUTION

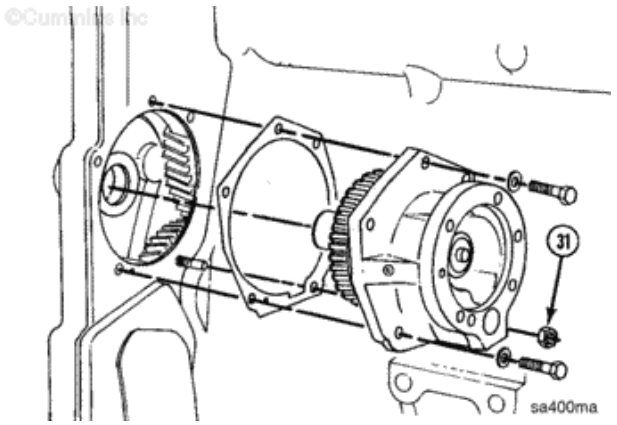
The woodruff key must be

removed before removing the fuel pump drive assembly. The bushing will be damaged if the woodruff key is not removed.

Remove the woodruff key.

Remove the four capscrews and nut (31).

Remove the fuel pump drive assembly.

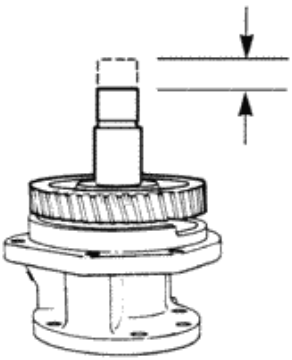


Inspect for Reuse

Measure the fuel pump drive end clearance.

Fuel Pump Drive End Clearance		
mm		in
0.05	MIN	0.002
0.30	MAX	0.012

If the fuel pump drive end clearance is **not** within specifications, the fuel pump drive **must** be reconditioned.



Disassemble

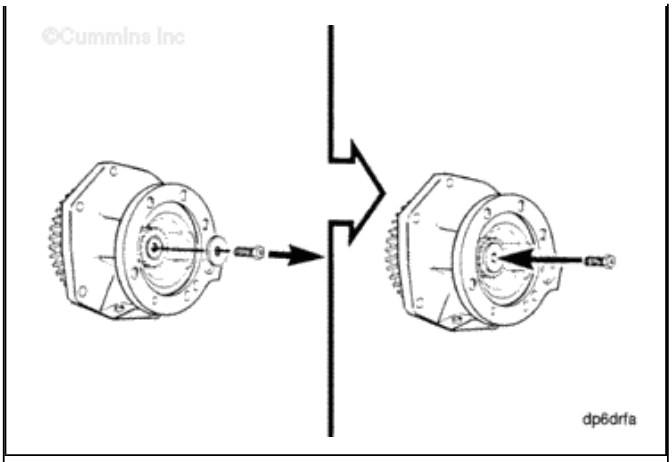
CAUTION

To reduce the possibility of

damage to the shaft, the capscrew must be installed without the washer.

Remove the special capscrew and washer.

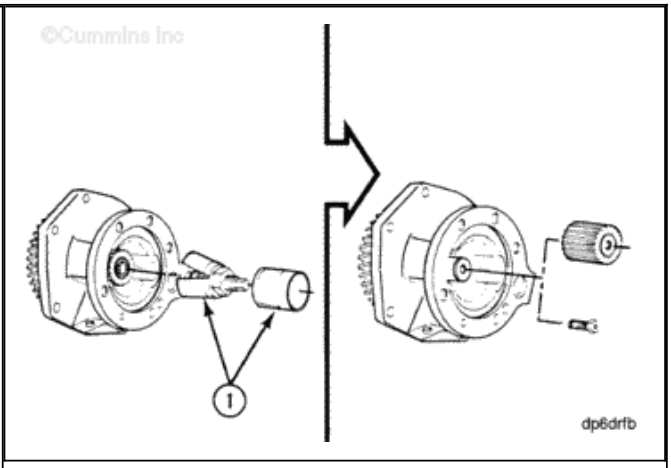
Install the capscrew into the shaft.



Remove the splined coupling with coupling puller, Part Number 3376663, or equivalent.

Remove the lovejoy type coupling with a 3-jaw puller.

Remove the capscrew.



NOTE: Aluminum housings do not contain thrust bearings.

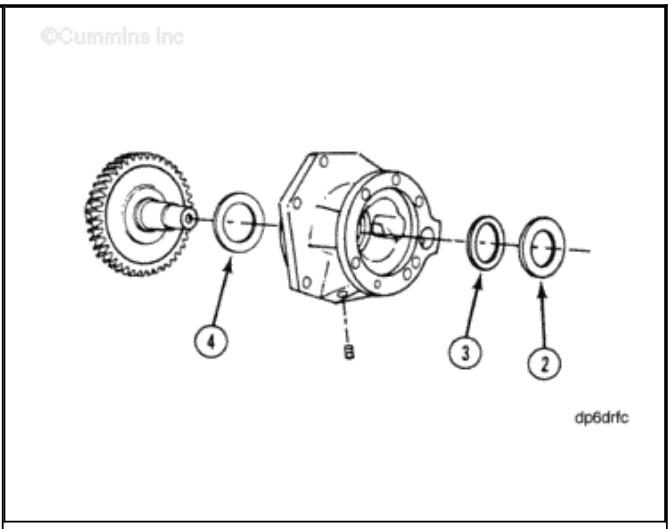
Remove the clamping washer (2).

Remove the inner thrust bearing (3).

Remove the gear and shaft assembly.

Remove the outer thrust bearing (4).

Remove the pipe plug from the housing.



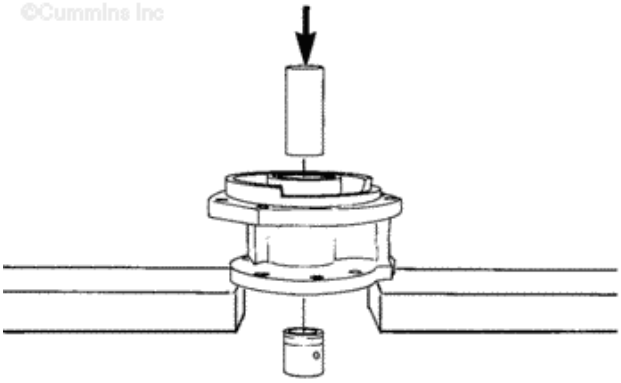
NOTE: Aluminum housings do not contain a

bushing.

Only remove the bushing if it is **not** within specifications or damaged.

Support the housing in a arbor press.

Remove the bushing with a mandrel and an arbor press.



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 parts with solvent.

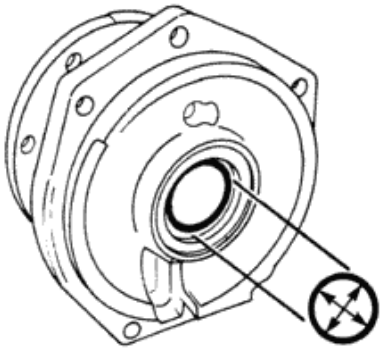
Inspect the parts for damage.

Damaged parts **must** be replaced.

NOTE: An aluminum housing does not contain a bushing. The inside diameter is identical to the bushing diameter in the cast iron housing.

Measure the inside diameter of the bushing.

Fuel Pump Drive Bushing



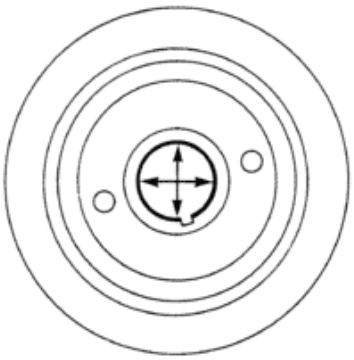
Inside Diameter		
mm		in
33.43	MIN	1.316
33.50	MAX	1.319

If the bushing is **not** within specifications, it **must** be replaced. For aluminum housings, the housing **must** be replaced.

Measure the inside diameter of the pulley.

Pulley Inside Diameter		
mm		in
34.912	MIN	1.375
34.938	MAX	1.376

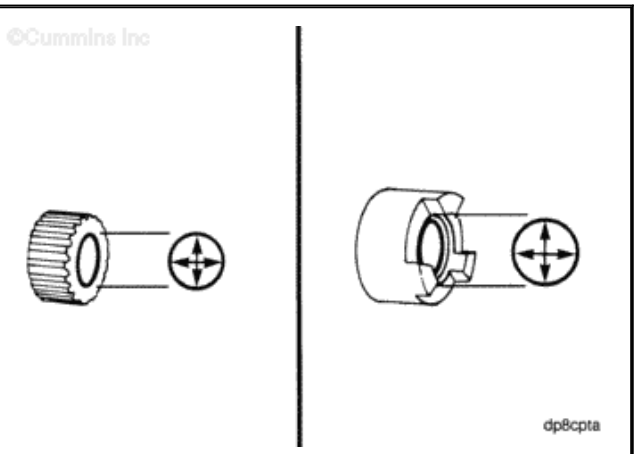
If the pulley is **not** within specifications, it **must** be replaced.



Measure the inside diameter of the coupling.

Lovejoy Coupling Inside Diameter		
mm		in
25.425	MIN	1.001
25.438	MAX	1.002

Spline Coupling Inside Diameter		
mm		in
25.400	MIN	1.000
25.425	MAX	1.001



Check the thrust bearing grooved surface for damage.

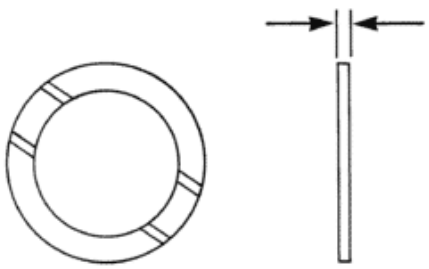
The thrust bearing **must** be replaced if the surface is damaged.

Measure the thickness of the

thrust bearing.

Thrust Bearing Thickness		
mm		in
2.36	MIN	0.093
2.41	MAX	0.095

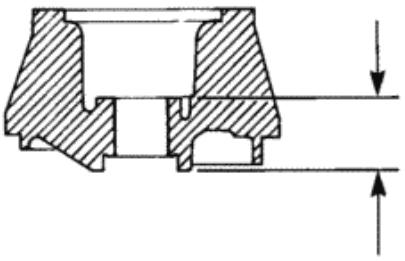
If the thrust bearing is **not** within specifications, it **must** be replaced.



On aluminum housings **only** check the two machined surfaces for damage and measure the depth.

Aluminum Housing Machined Surface Depth		
mm		in
45.54	MIN	1.793
45.67	MAX	1.798

If the housing is damaged or **not** within specifications, it **must** be replaced.

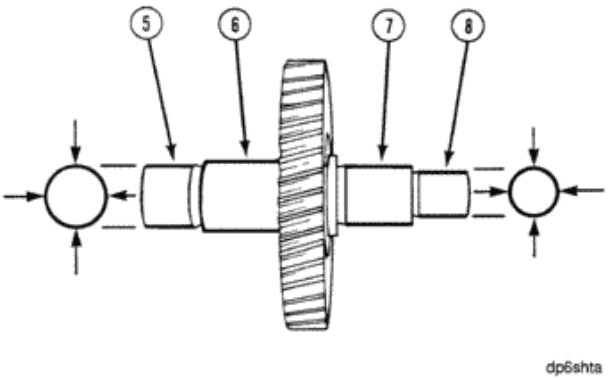


Check the gear teeth for damage.

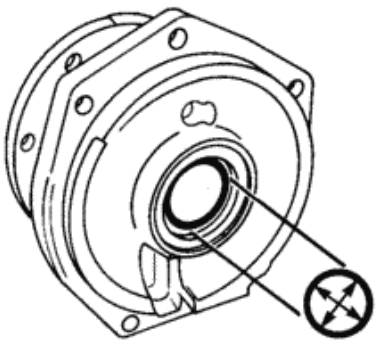
If the gear teeth are damaged, the gear **must** be replaced. Refer to Procedure 009-013.

Measure the shaft outside diameter.

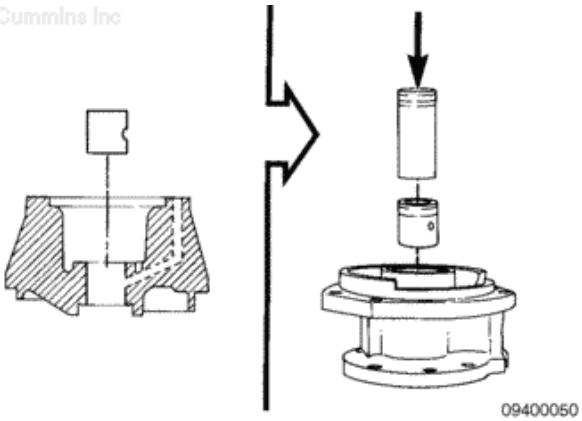
Shaft Outside Diameter			
	mm		in
(5)	34.963	MIN	1.3765
	34.976	MAX	1.3770
(6)	34.662	MIN	1.5616
	39.674	MAX	1.5620
(7)	33.300	MIN	1.3000
	33.330	MAX	1.3120



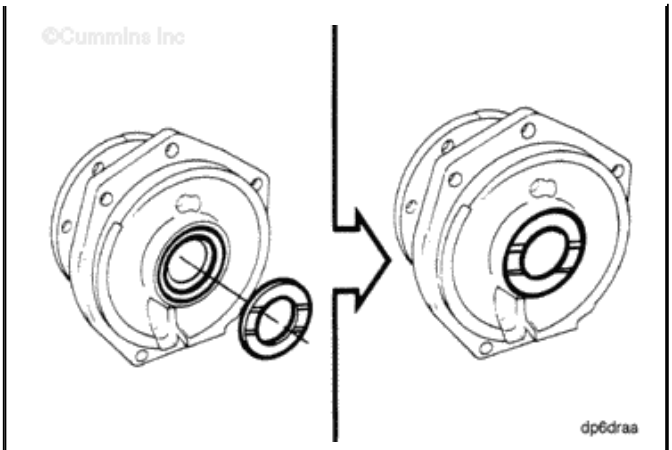
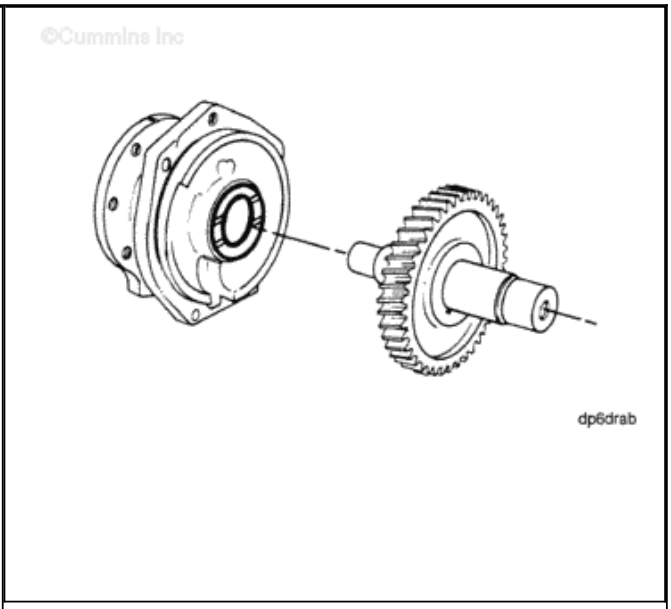
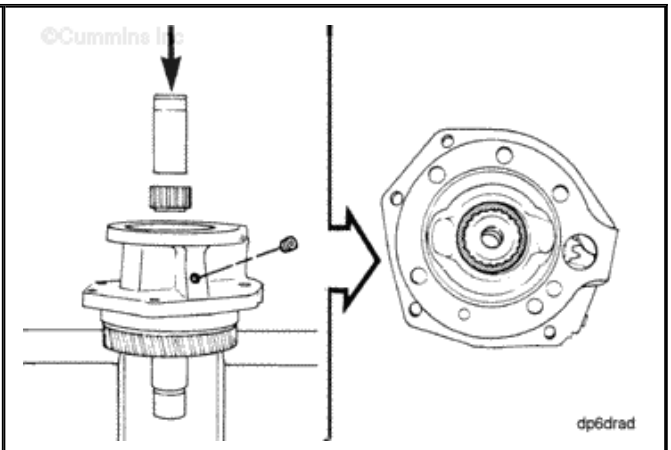
(8) 25.476 MIN 1.0030 25.489 MAX 1.0035 If the shaft is **not** within specifications, it **must** be replaced.		

Measure the inside diameter of the cast iron housing bushing bore. Bushing Bore Inside Diameter without Bushing mm in 36.73 MIN 1.446 36.75 MAX 1.447 If the bushing bore is **not** within specifications, the housing **must** be replaced.		 09400049

Assemble

Support the housing in an arbor press. Align the oil hole in the bushing with the oil drilling in the housing. Press the bushing with a mandrel and the arbor press. Both ends of the bushing **must** be positioned even with, or below the surface of the housing.		 09400050

NOTE: Aluminum housings do not contain thrust bearings. Position the grooved surface		

of the thrust bearing on the housing as illustrated in the graphic.		
Lubricate the grooved surface of the thrust bearing with Lubriplate®, Number 105, Part Number 3163086, or equivalent. For aluminum housings, lubricate the machined thrust surface. Install the gear and shaft assembly into the shaft. With the grooved surface positioned up, slide the thrust bearing over the shaft. Install the clamping washer with the bevelled edge pointing down towards the thrust bearing.		
Support the gear or the shaft in an arbor press. Use a mandrel and arbor press to press the coupling on the shaft until it touches the clamping washer. The clamping washer **must** be positioned tightly between the coupling and the shoulder of the shaft. Install the pipe plug into the housing. Tighten the pipe plug.		

Torque
Value: 8 n.m [75 in-lb]

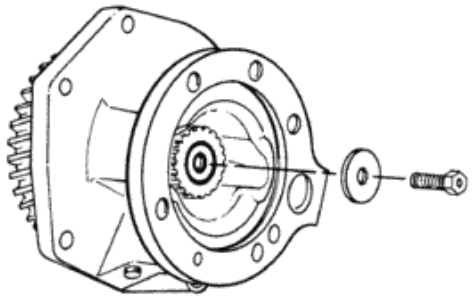
CAUTION

To reduce the possibility of engine damage the coupling capscrew must contain an oil drilling if an air compressor is to be mounted on the engine.

There two lengths of coupling capscrews. The capscrew torque depends on the length.

Install the washer and capscrew.

9.5 mm [3/8 in]	45 n.m	[33 ft-lb]
12.7 mm [½ in]	100 n.m	[75 ft-lb]



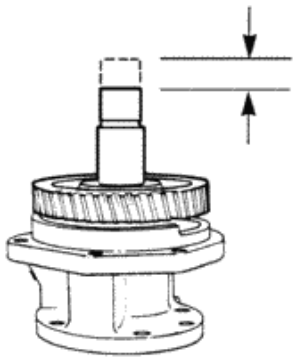
Rotate the shaft to verify correct assembly.

Measure the end clearance with a dial indicator.

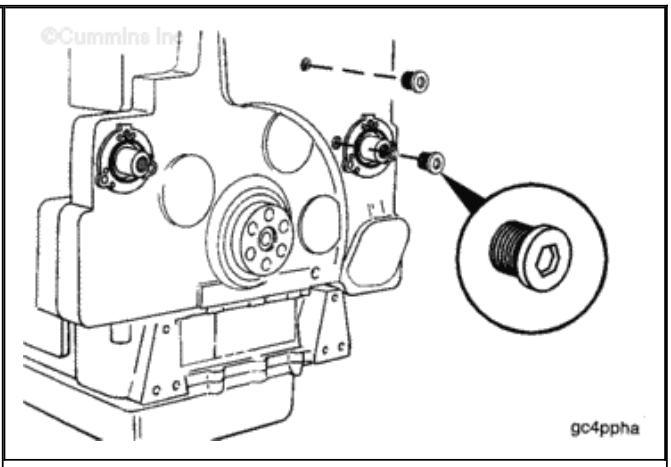
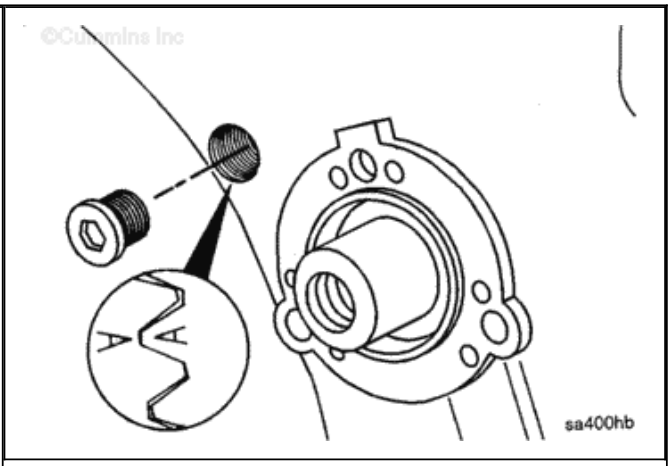
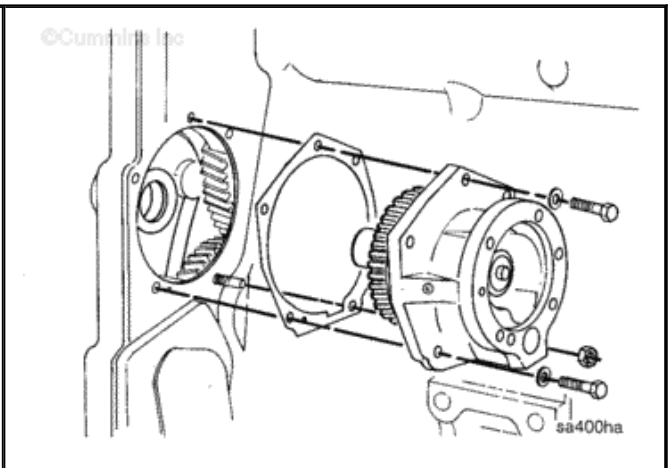
Fuel Pump Drive End Clearance		
mm		in
0.05	MIN	0.002
0.30	MAX	0.012

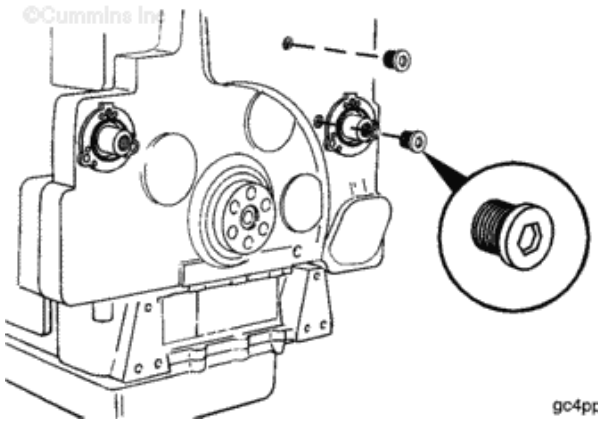
If the end clearance is **not** within specifications, make sure the coupling is positioned tightly against the clamping washer.

Oversize thrust bearings are available to adjust the end clearance.

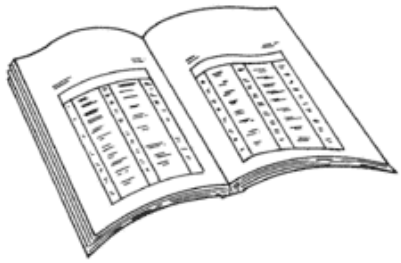


Install

Remove the two straight threaded o-ring plugs from the timing holes in the front cover. Check the index mark alignment.		
Do not use the “A” on the camshaft idler gear for the accessory drive alignment unless the “X” marks on the camshaft and the camshaft idler gears are aligned and centered in the upper timing plug hole. If the “X” marks are not visible in the upper plug hole, rotate the engine until the “X” marks on the camshaft gear and the camshaft idler gear are centered in the upper timing plug hole.		
Install the fuel pump drive gasket. Install the fuel pump drive so the “A” on the fuel pump drive gear is centered in the lower timing plug. Install the capscrews and nut. Tighten the capscrews and nut. **Torque** **Value:** 45 n.m [33 ft-lb]		

Install the straight threaded o-ring plugs. Tighten the o-ring plugs. **Torque** **Value:** 25 n.m [20 ft-lb]		

Finishing Steps

• Install the accessory drive seal. Refer to Procedure 001-003. • Install the accessory drive pulley. Refer to Procedure 009-004. • Install the air compressor. Refer to Procedure 012-014. • Install the fuel pump. Refer to Procedure 005-016. • Fill the cooling system. Refer to Procedure 008-018. • Operate the engine to 70°C [160°F] and check for leaks.		

Last Modified: 10-Dec-2004

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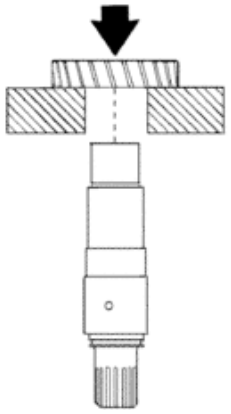
009-013 Fuel Pump Drive Gear and Shaft

Disassemble

Support the gear.

Remove the shaft from the gear with an arbor press.





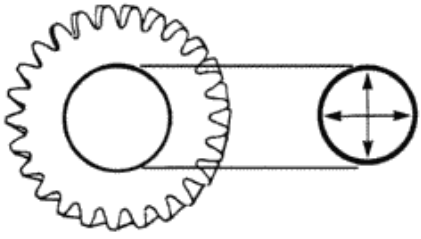
Inspect for Reuse

Measure the gear inside diameter.

Fuel Pump Drive Gear Inside Diameter		
mm		in
39.73	MIN	1.564
39.75	MAX	1.565

If the gear is **not** within specifications, it **must** be replaced.





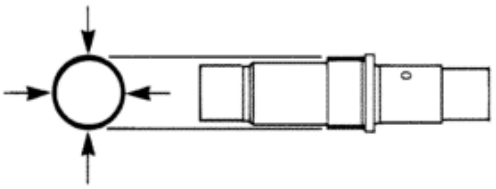
Remove the key from the shaft and inspect it for damage.

If the key is damaged, it **must** be replaced.

Measure the outside diameter of the shaft at the gear location.

Fuel Pump Drive Shaft Outside Diameter		
mm		in
39.789	MIN	1.5665
39.803	MAX	1.5670

If the shaft is **not** within specifications, it **must** be replaced.



dp6shtb

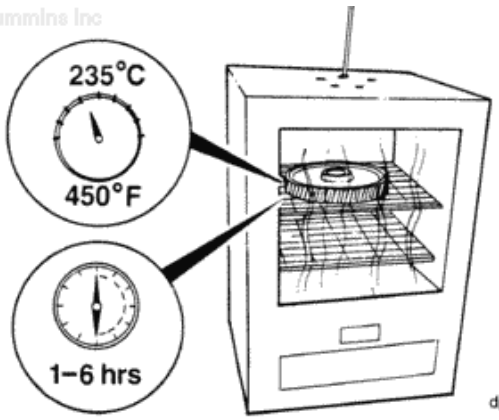
Assemble

CAUTION

Do not exceed the specified time or temperature. Damage to the gear teeth will result.

If an adequate press is **not** available, an oven can be used.

Heat the gear at 235°C [450° F] for **not** less than one hour and **not** more than six hours.



dp8gewa

WARNING

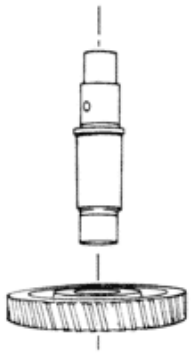
To reduce the possibility of severe burns, wear protective gloves when assembling the gear and

shaft.

Remove the gear from the oven and support the gear.

Align the key slot with the key.

Slide the shaft into the gear.



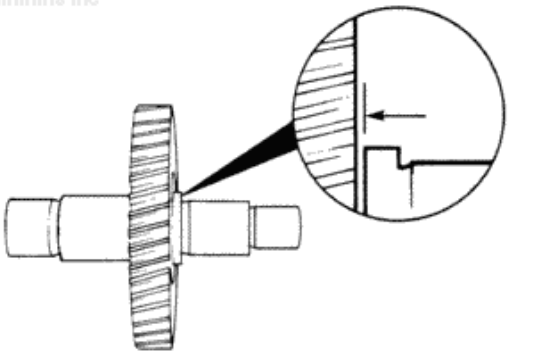
CAUTION

Allow the air to cool the gear. Do not use water or oil to reduce the cooling time. Damage to the gear can result.

Measure the distance between the shoulder of the shaft and the gear with a feeler gauge.

Fuel Pump Drive Gear to Shaft		
mm		in
0.05	MAX	0.002

If the distance between the gear and the shaft is **not** within specification. Press the gear onto the shaft until the specifications is met.

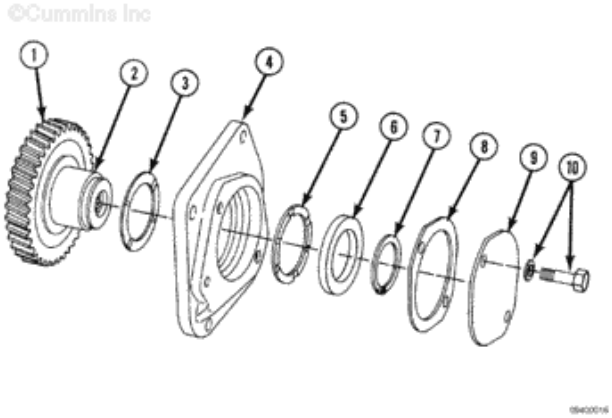


Last Modified: 19-Oct-2004

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009-016 Hydraulic Pump Drive

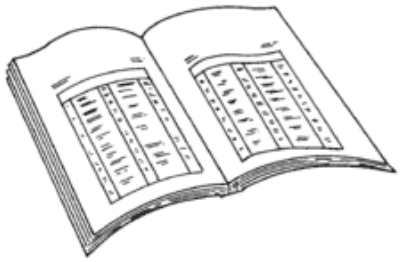
Exploded View



1. Hydraulic pump drive gear
2. Hydraulic pump drive shaft
3. Thrust bearing
4. Hydraulic pump drive housing
5. Thrust bearing
6. Clamping washer
7. Retaining ring
8. Gasket
9. Hydraulic pump cover
10. Lock washer and capscrew.

Preparatory Steps

NOTE: Some engines contain a cover plate instead of a hydraulic pump. • Remove the hydraulic pump. Use the equipment manufacturer's instructions.		

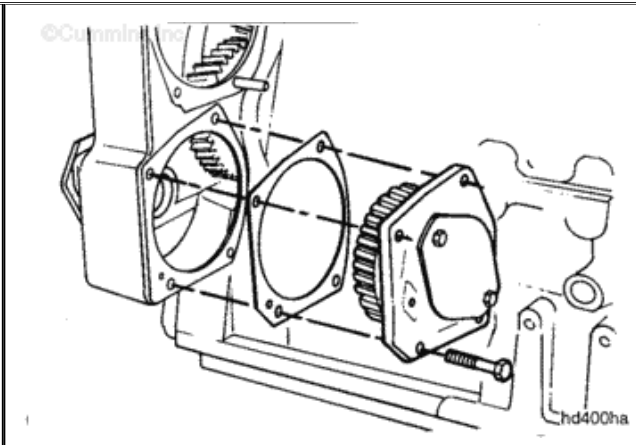


Remove

Remove the four hydraulic pump drive mounting capscrews.

Remove the hydraulic pump drive.

Remove and discard the gasket.



Inspect for Reuse

WARNING

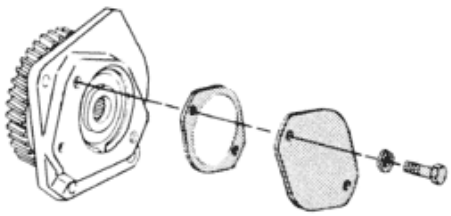
When using solvents, acids, or alkaline materials for

cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Clean the hydraulic pump drive housing and gear with solvent.

Remove the cover from the pump.

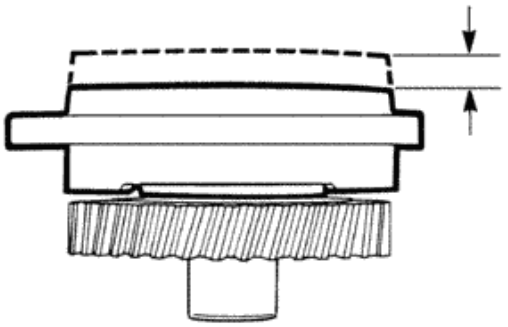
Remove and discard the gasket.



Measure the hydraulic pump drive end clearance.

Hydraulic Pump Drive End Clearance		
mm		in
0.13	MIN	0.005
0.48	MAX	0.019

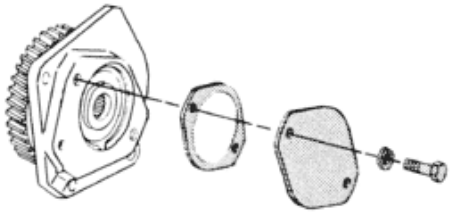
If the hydraulic pump drive is **not** within specifications, it **must** be reconditioned.



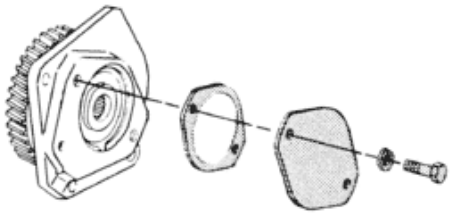
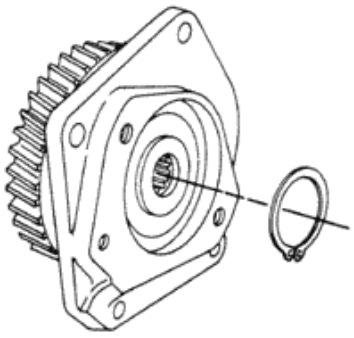
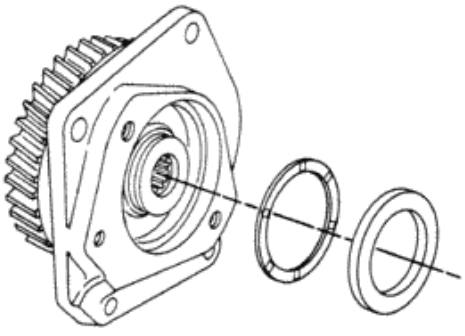
Install a new gasket.

Place the cover onto the pump drive.

Install the lock washers and capscrews.

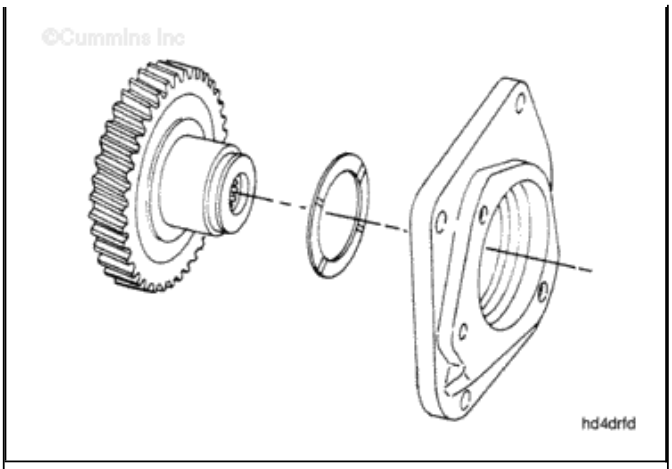


Disassemble

Remove the capscrews and washers. Remove the cover. Remove and discard the gasket.		 hd4drfa
Remove the retaining ring.		 hd4drfb
Remove the clamping washer. Remove the thrust bearing.		 hd4drfc

Remove the shaft and gear assembly from the housing.

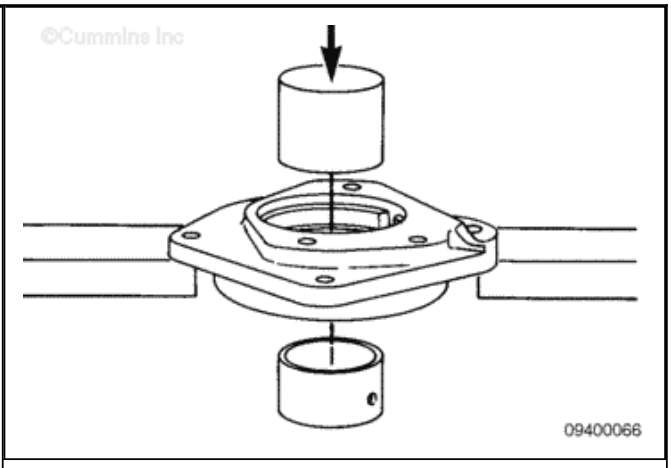
Remove the thrust bearing.



NOTE: Only replace the bushing if it is damaged, or is not within specifications.

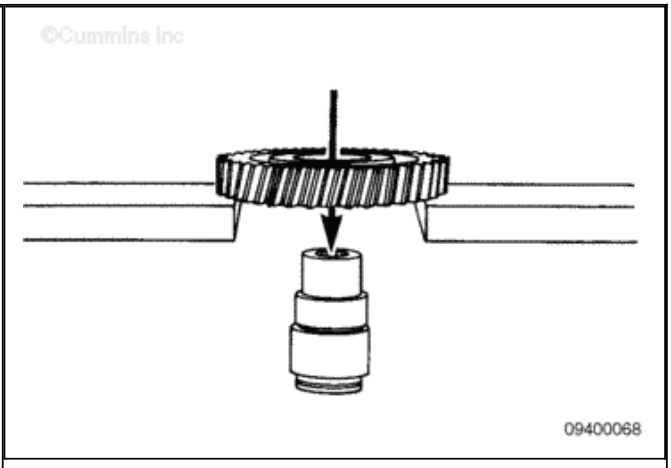
Support the housing in an arbor press.

Press the bushing out of the housing with a mandrel and arbor press.



NOTE: Only remove the gear from the shaft when the gear or the shaft must be replaced.

Remove the gear from the shaft with an arbor press.



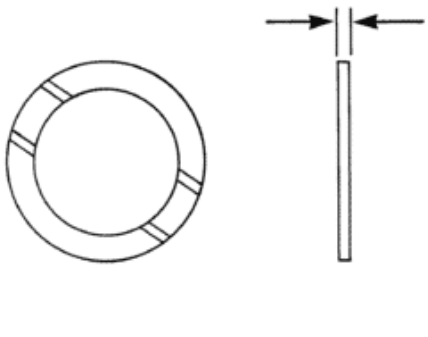
Clean and Inspect for Reuse

Check the grooved surfaces of the bearing for damage.

Measure the thrust bearing thickness.

Thrust Bearing Thickness		
mm		in
2.273	MIN	0.090
2.299	MAX	0.091

If the bearing is damaged or **not** within specifications, it **must** be replaced.



WARNING

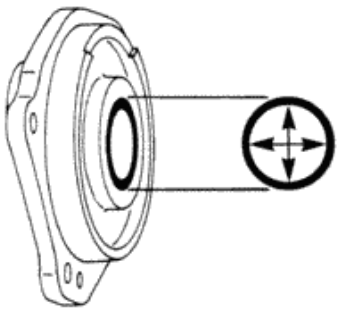
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Clean the housing with solvent.

Measure the bushing inside diameter.

Bushing Inside Diameter		
mm		in
50.813	MIN	2.001
50.902	MAX	2.004

If the bushing is **not** within specifications, 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.

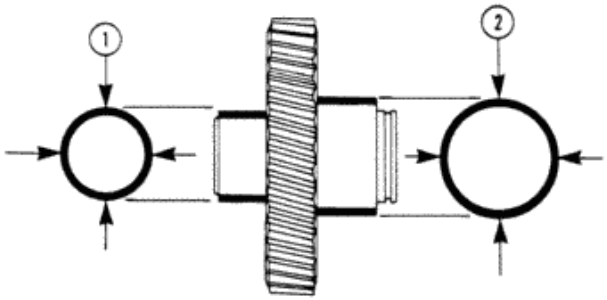
Clean the shaft and gear with solvent.

Measure the shaft outside diameter.

Shaft Outside Diameter			
	mm		in
(1)	38.062	MIN	1.4985
	38.075	MAX	1.4990
(2)	50.749	MIN	1.9980
	50.762	MAX	1.9985

If the shaft is **not** within specifications, it **must** be replaced.

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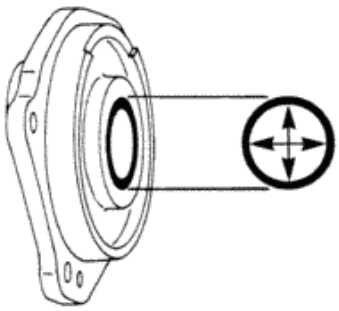
hd4shta

Measure the housing bushing bore inside diameter.

Bushing Bore Inside Diameter		
mm		in
54.00	MIN	2.160
54.03	MAX	2.161

If the bushing bore is **not** within specifications, the housing **must** be replaced.

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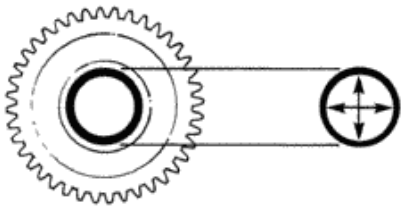


hd4hsta

Measure the gear inside diameter.

Gear Inside Diameter		
mm		in
44.399	MIN	1.748
44.425	MAX	1.749

If the gear is **not** within specifications, it **must** be replaced.

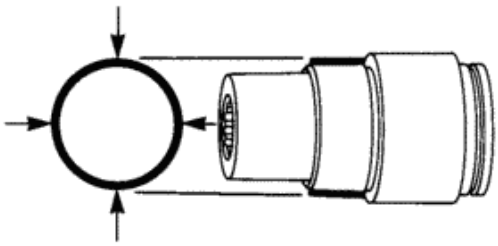


hd8geta

Measure the shaft diameter at the gear location.

Shaft Outside Diameter at Gear Location		
mm		in
44.450	MIN	1.7500
44.463	MAX	1.7501

If the shaft is **not** within specifications, it **must** be replaced.



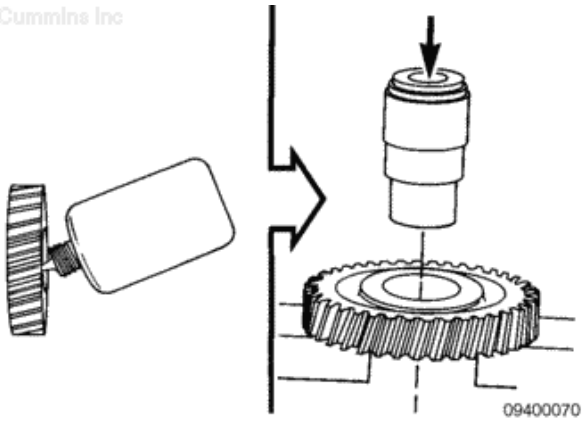
09400069

Assemble

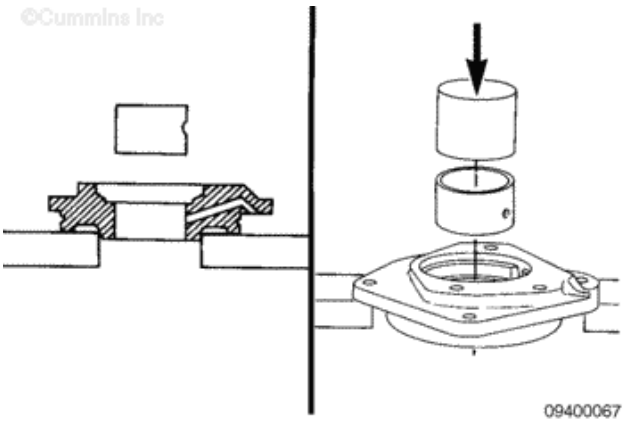
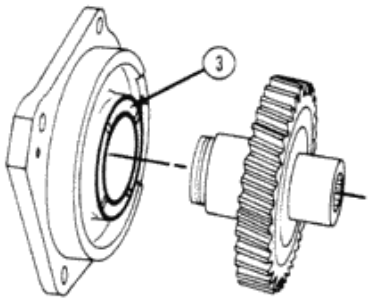
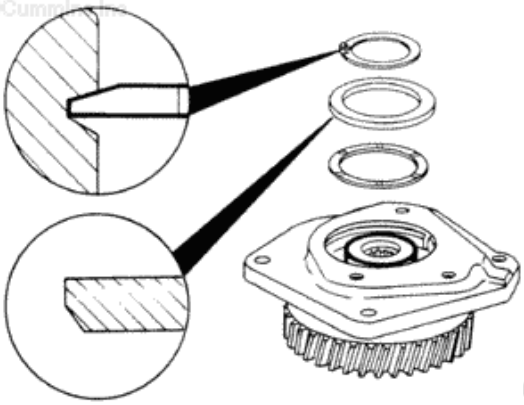
Apply a smooth coating of Loctite® 609, or equivalent to the inside diameter of the gear.

Support the gear in an arbor press with the part number down.

Press the shaft through the gear until the shoulder of the shaft touches the gear.



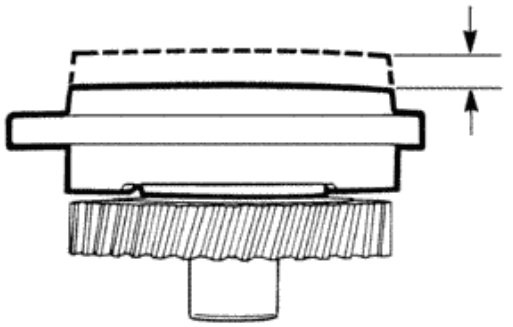
09400070

Place the housing in an arbor press. Align the oil hole in the bushing with the oil drilling in the shaft. Press the bushing into the housing with a mandrel and arbor press. Both ends of the bushing **must** be positioned even with, or below the surface of the housing.		
Lubricate the grooved surface of the thrust bearing with Lubriplate® 105 or equivalent. Position the grooved surface of the thrust bearing (3) as illustrated in the graphic. Slide the gear and shaft assembly into the housing. The gear **must** touch the thrust bearing.		
Lubricate the grooved surface of the thrust bearing with Lubriplate® 105 or equivalent. Slide the thrust bearing over the shaft with the grooved side positioned up. Slide the clamping washer over the shaft with the beveled edge positioned against the thrust bearing. Install the retaining ring with the beveled edge positioned as illustrated in the graphic.		

Measure the hydraulic pump drive end clearance.

Hydraulic Pump Drive End Clearance		
mm		in
0.13	MIN	0.005
0.48	MAX	0.019

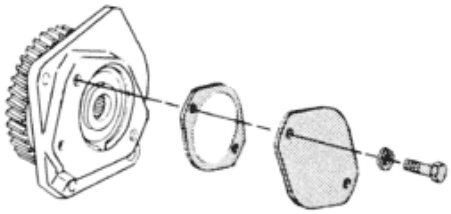
If the hydraulic pump drive is **not** within specifications, it **must** be reconditioned.



Install a new gasket.

Install the cover.

Install the lock washers and capscrews.

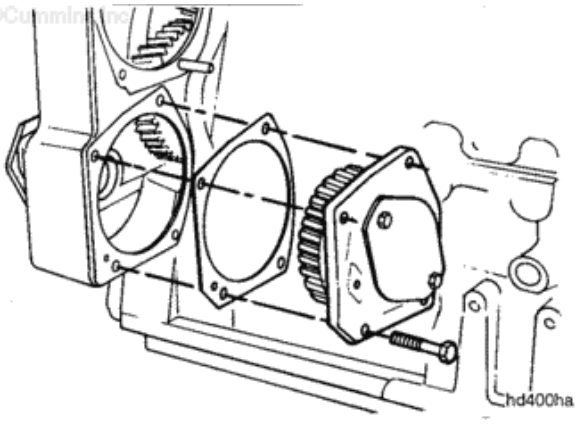


Install

The hydraulic pump drive or cover plate fro engines with a two-piece front cover **must** have an o-ring in addition to the gasket.

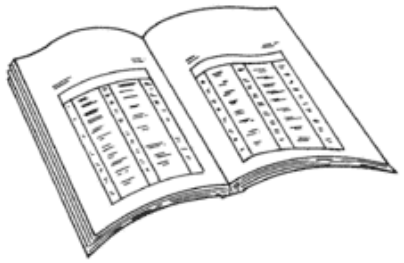
Lubricate the bushing in the front cover with clean engine oil.

Install the gasket, hydraulic pump drive, lock washers and capscrews.



Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]		

Finishing Steps

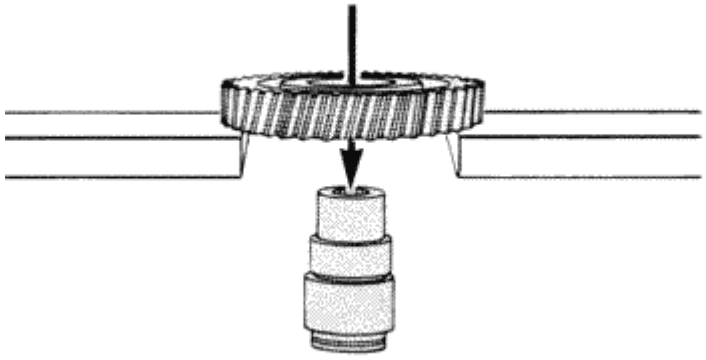
• Install the hydraulic pump. Use the equipment manufacturer's instructions.		

Last Modified: 01-Dec-2004

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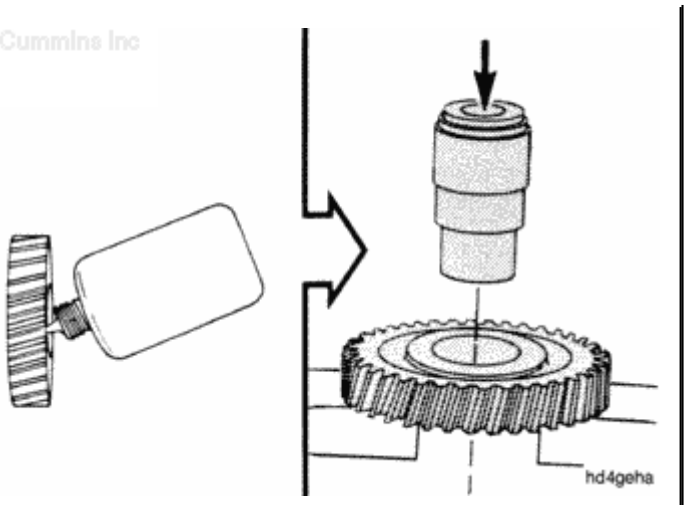
009-019 Hydraulic Pump Drive Gear and Shaft

Disassemble

Only remove the gear from the shaft when the gear or the shaft **must** be replaced. Use an arbor press to remove the gear.		

Assemble

Apply a smooth layer of Loctite® 609, or equivalent, to the inside diameter of the gear. Use an arbor press to press the sham through the gear until the shaft shoulder		

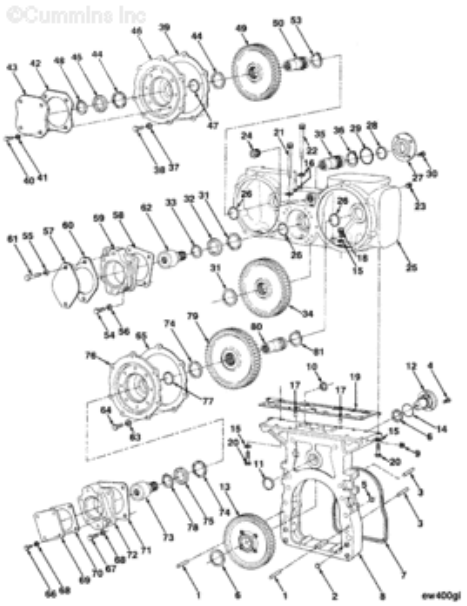
touches the gear.		

Last Modified: 11-Nov-2004

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009-023 Rear Gear Drive (Lower Assembly)

Exploded View



1. Dowel pin
2. Rectangular ring seal
3. Dowel pin
4. Hexagon head capscrew
5. Rectangular ring seal
6. Thrust bearing
7. Rectangular ring seal
8. Gear housing
9. Pipe plug
10. Rectangular ring seal
11. Expansion plug
12. Idler shaft
13. Hydraulic pump gear and bushing
14. O-ring seal
15. Lock washer
16. Plain washer
17. Dowel pin
18. Hexagon head capscrew
19. Hydraulic pump gasket
20. Hexagon head capscrew
21. Hexagon head capscrew
22. Hexagon head capscrew
23. Pipe plug
24. Pipe plug
25. Hydraulic drive housing
26. Bushing

27. Hydraulic pump support
28. Bushing
29. O-ring seal
30. Hexagon head capscrew
31. Thrust bearing
32. Bearing spacer
33. Retaining ring
34. Hydraulic pump gear
35. Shaft and plug assembly
36. Retaining ring
37. Lock washer
38. Hexagon head capscrew
39. Hydraulic support gasket
40. Hexagon head capscrew
41. Lock washer
42. Hydraulic pump flange cover gasket
43. Hydraulic pump flange cover
44. Thrust bearing
45. Bearing spacer
46. Hydraulic pump support
47. Bushing
48. Retaining ring
49. Hydraulic pump gear
50. Shaft and plug assembly
51. Expansion plug
52. Retaining ring
53. Hexagon head capscrew
54. Lock washer
55. Lock washer
56. Cover plate
57. Hydraulic pump gasket
58. Hydraulic pump adapter
59. Hydraulic pump gasket
60. Hagen head capscrew
61. Hydraulic pump adapter
62. Lock washer
63. Hexagon head capscrew
64. Hydraulic pump support gasket
65. Hexagon head capscrew
66. Hexagon head capscrew
67. Lock washer
68. Cover plate
69. Hydraulic pump gasket
70. Hydraulic pump gasket
71. Hydraulic pump adapter
72. Coupling and adapter assembly
73. Thrust bearing
74. Bearing spacer
75. Hydraulic pump gear
76. Hydraulic pump support
77. Bushing
78. Retaining Ring
79. Hydraulic pump gear
80. Shaft and plug assembly
81. Retaining ring.

Preparatory Steps

WARNING

To reduce the possibility of personal injury, avoid direct contact with hot oil with your skin.

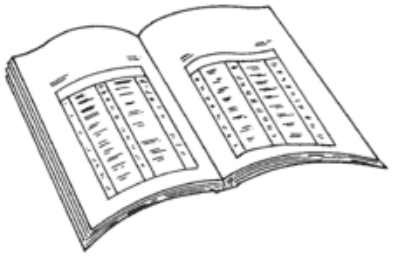
WARNING

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

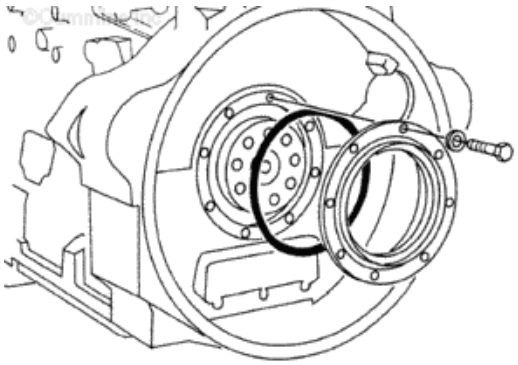
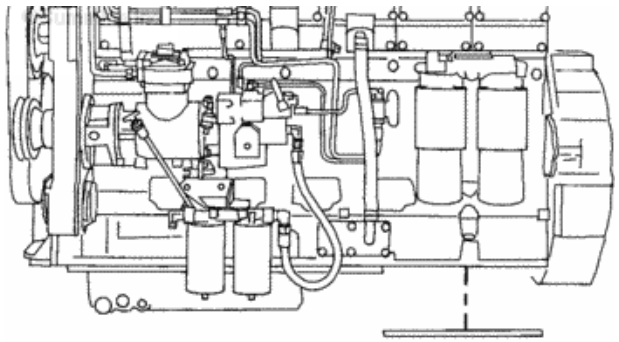
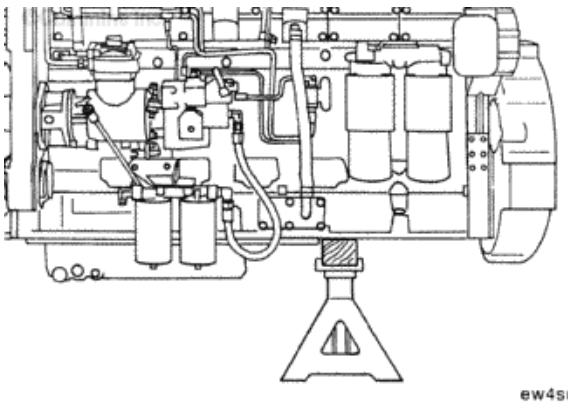
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

- Drain the lubricating oil. Refer to Procedure 007-037
- Remove the upper rear gear drive assembly. Refer to Procedure 009-024.
- Remove the transmission, clutch and all related components. Refer to the equipment manufacturer's instructions.
- Remove the starter motor. Refer to Procedure 013-020.
- Remove the flywheel. Refer to Procedure 016-005.



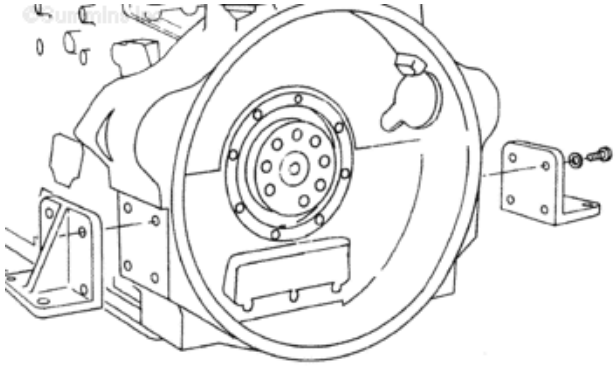
ck800wa

Remove

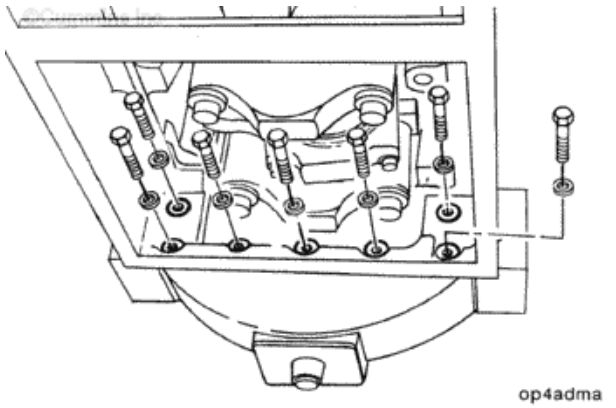
Remove the capscrews and the rear crankshaft seal. Remove and discard the o-ring and seal.		 ks4sehd
Remove the adapter cover plate or the oil pan (whichever is in the rear position). Angle the cover plate to allow the oil to drain. Remove and discard the gasket.		 ew4plhb
WARNING This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component. Put a wooden block the width of the oil pan adapter between the support and the oil pan adapter to prevent damage to the engine. Use a jack stand or a suitable lifting fixture to support the rear of the engine. Put the support in		 ew4suhb

position to allow access to the capscrews in the oil pan adapter that attach to the flywheel housing.

Remove the rear engine mounts from the flywheel housing if necessary.



Remove the two 7/16 in capscrews and the five 3/8 in capscrews that attach the oil pan adapter to the flywheel housing.

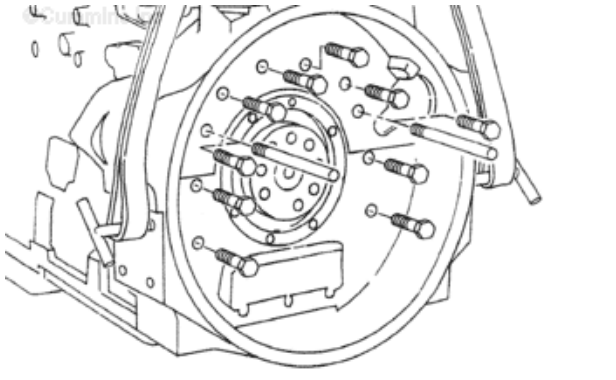


CAUTION

Be sure the rear gear train lower housing is secure before removing the flywheel housing. The lower housing rests on the guide studs and dowel pins, but is not fastened to the block.

Use two 5/8x6-1/2 in guide studs. Remove two capscrews.

Install the guide studs.



Use a hoist, a tee handle, and a lifting sling. Install the tee handle.

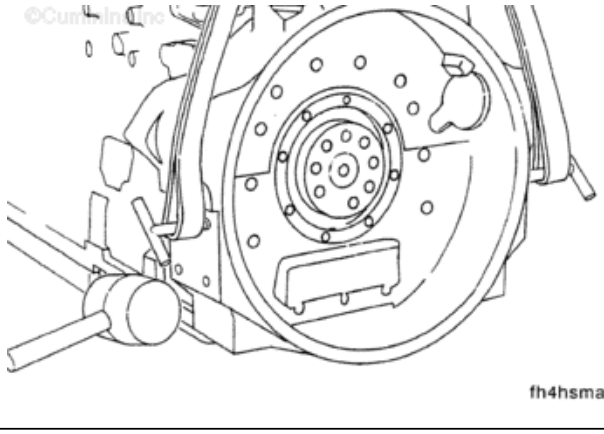
Adjust the hoist until there is tension in the lifting sling.

Remove the remaining capscrews, lock washers, and nuts.

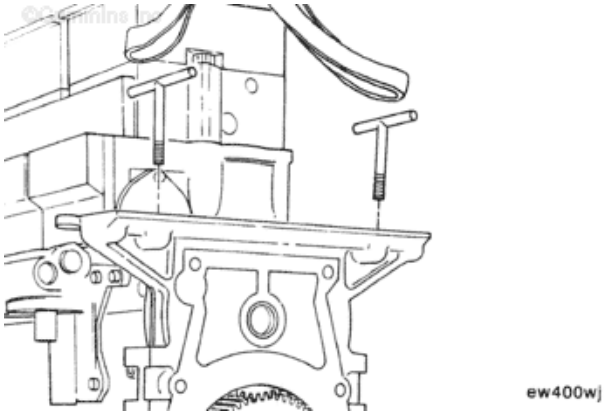
Two pry bars can be used to separate the lower housing of the rear gear train from the flywheel housing.

Use a mallet to tap the flywheel housing off the two locating dowels.

Remove and discard the rectangular seal and the bolt seals.



Use a hoist, two tee handles, and a lifting sling. Install the tee handles. Adjust the hoist until there is tension in the lifting sling.

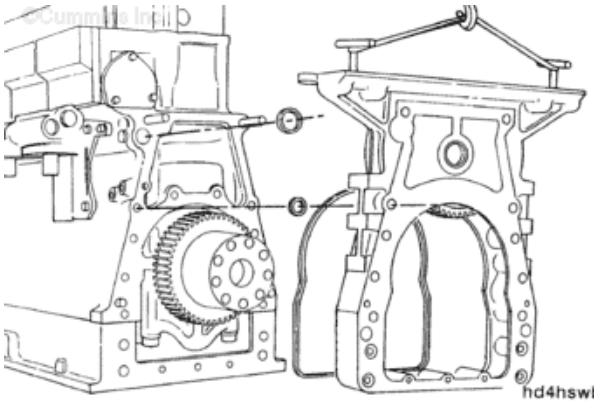


WARNING

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

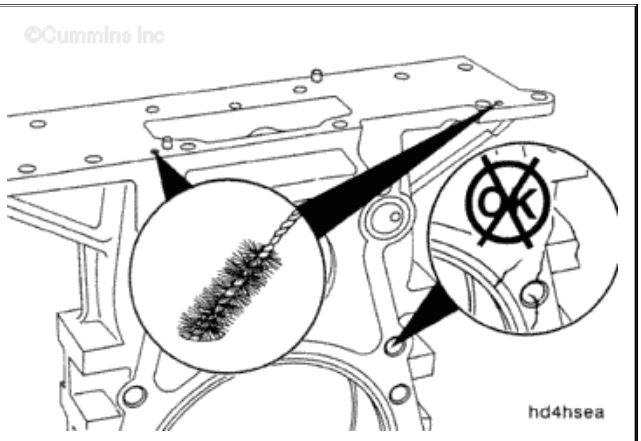
Use a mallet to tap the lower housing of the rear gear train off the two locating dowel pins in the rear face of the cylinder block.

Remove and discard the rectangular seal, bolt seals, and main oil rifle seal.

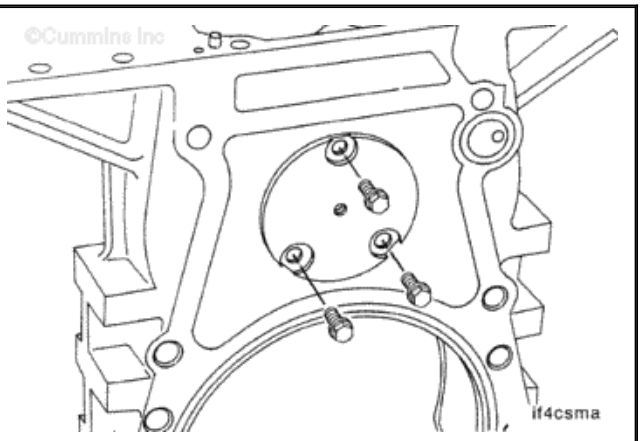


Disassemble

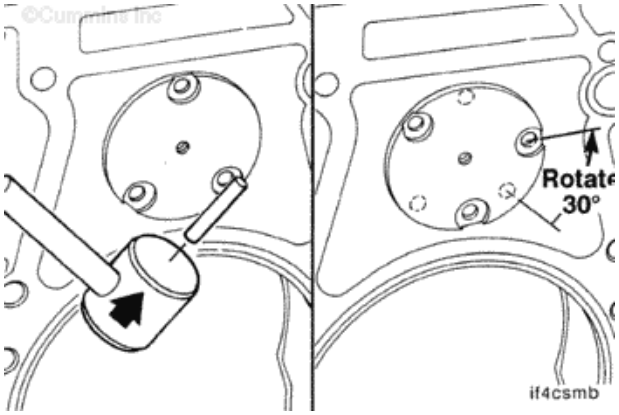
Remove all pipe plugs.



Remove the three capscrews from the idler shaft



If the idler has three holes, use a soft punch and mallet. Rotate the idler shaft 30 degrees until the capscrew holes in the housing are **not** visible through the capscrew holes in the idler shaft.

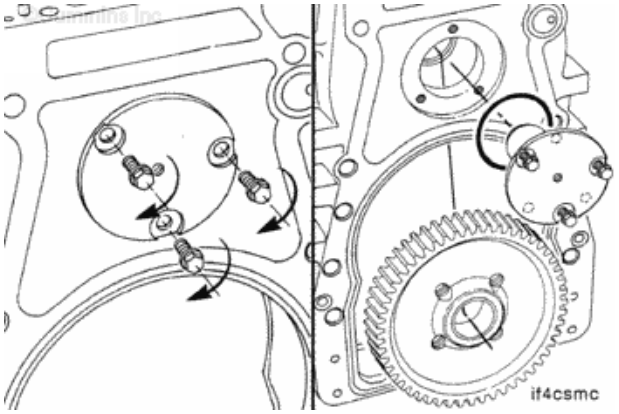


Use three 3/8-24 x 2 in capscrews. Make sure the idler gear is secure.

Alternately tighten the capscrews to pull the shaft **from** the housing.

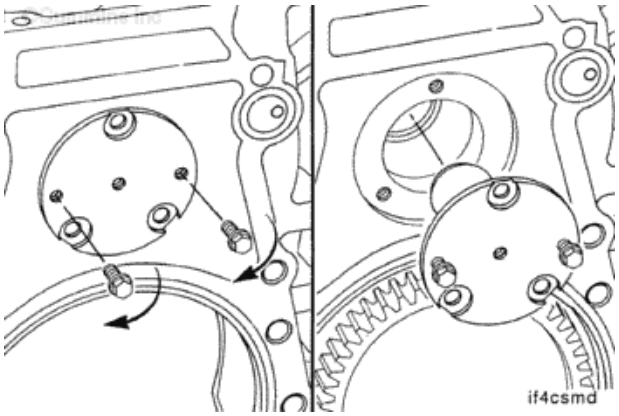
Remove the shaft, thrust washers, and gear.

Remove and discard the o-ring.



If the idler shaft has five holes, use two 3/8-24 x 2 in capscrews. Make sure the idler gear is secure.

Alternately tighten the capscrews to pull the shaft **from** the housing.



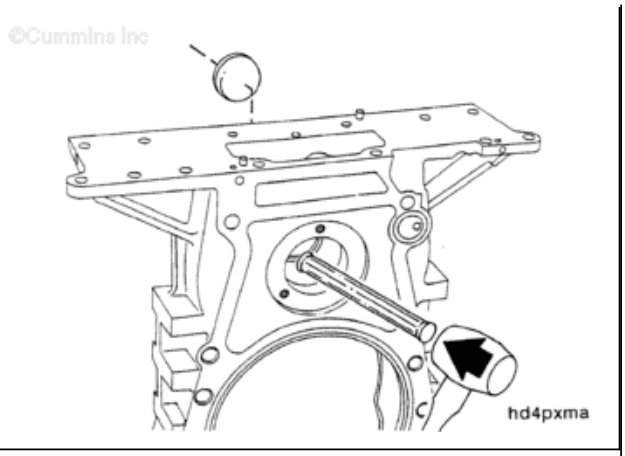
CAUTION

Do not damage the housing when using the punch to remove the expansion plug.

NOTE: Only replace the expansion plug if it was leaking.

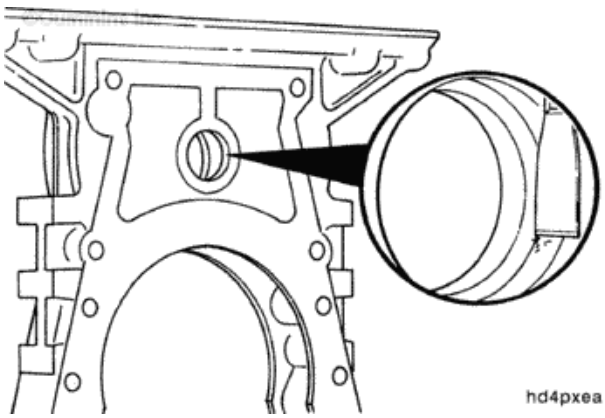
Remove the expansion plug with a punch and a mallet.

Discard the expansion plug.



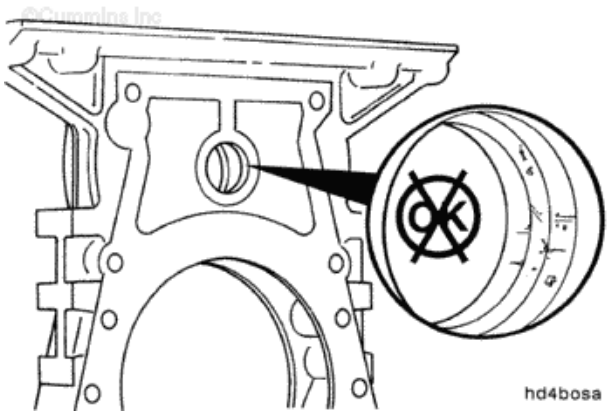
Clean and Inspect for Reuse

Lightly scrape the bore with a gasket scraping tool to remove any corrosion, carbon or sealant buildup.



Inspect the bore for damage or cracks.

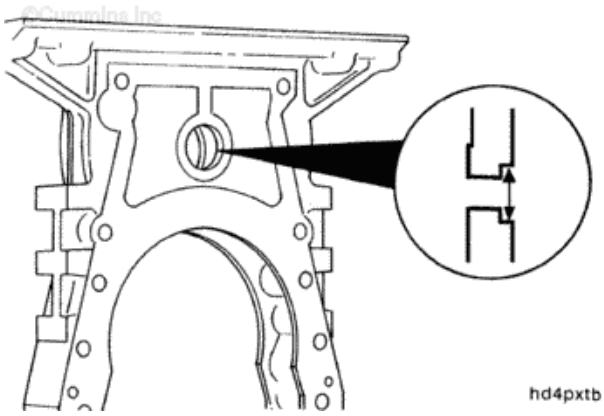
If the bore is damaged or cracked the housing **must** be replaced.



Measure the expansion plug bore inside diameter.

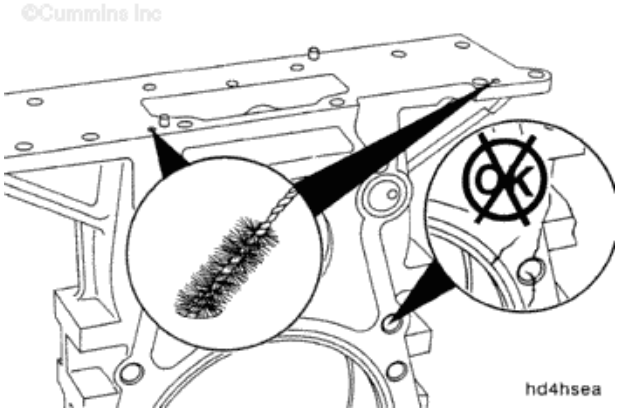
Expansion Plug Bore Inside Diameter		
mm		in
50.84	MIN	2.002
50.91	MAX	2.005

If the expansion plug bore is **not** within specifications, the housing **must** be replaced.



Clean all oil drillings. Be sure the oil drillings intersect.

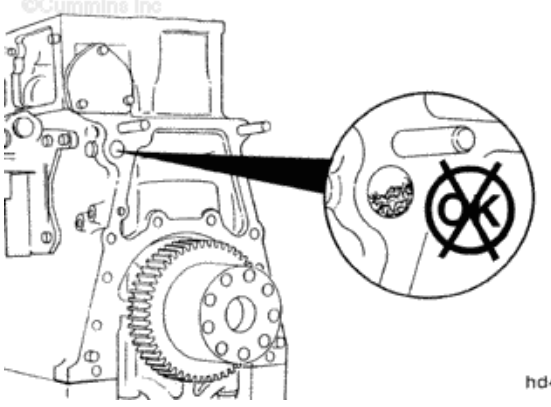
Clean and check the lower housing for damage.



CAUTION

Check for debris in the main oil rifle. Any debris will cause rear gear train damage.

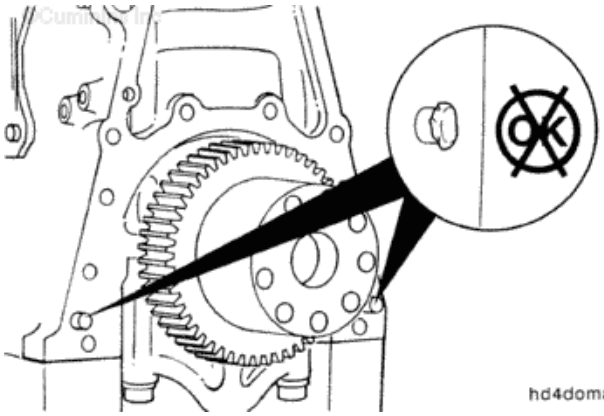
Be sure the 1-1/8 in expansion plug is **not** installed in the end of the main oil rifle in the cylinder block. The main oil rifle **must** be open to allow the oil to the rear gear train.



Inspect the two rear gear train housing dowel pins in the rear face of the cylinder block. Any damaged dowels **must** be

replaced.

Use dowel pin extractor, Part Number. ST-1143, to remove the dowel pins. Use a brass or lead hammer to install the new dowel pins.

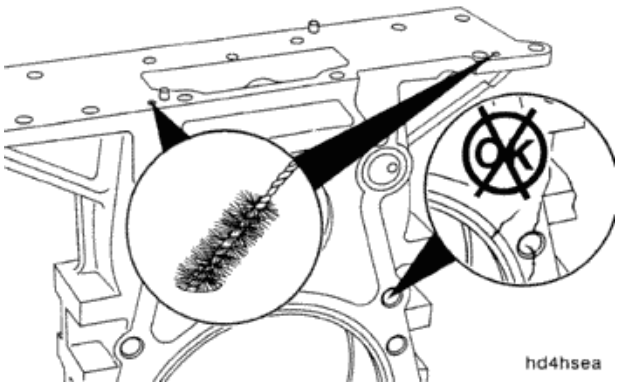


Clean the all of the oil drillings and the lower housing.

Make sure the oil drillings intersect.

Check the lower housing for damage.

The lower housing **must** be replaced if damaged.



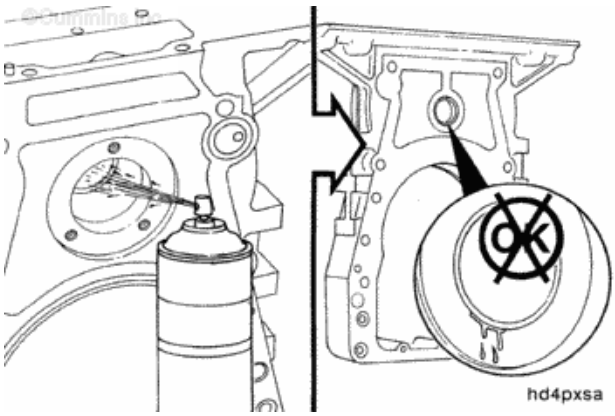
WARNING

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: Previously used lower housings did not use an expansion plug.

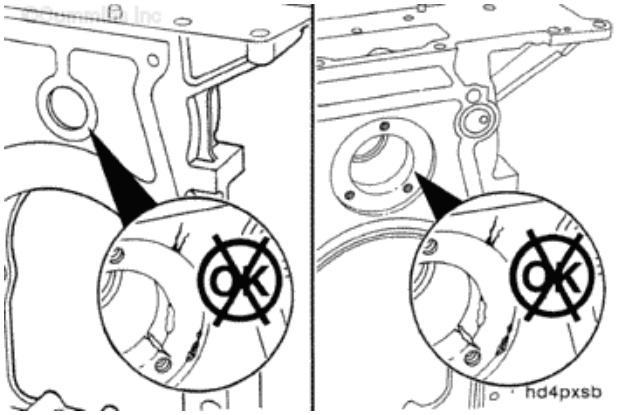
From the inside of the housing, spray solvent around the expansion plug.

If the expansion plugs leaks, it **must** be replaced.



Use dye penetrant to check for cracks on the lower housing around the expansion plug.

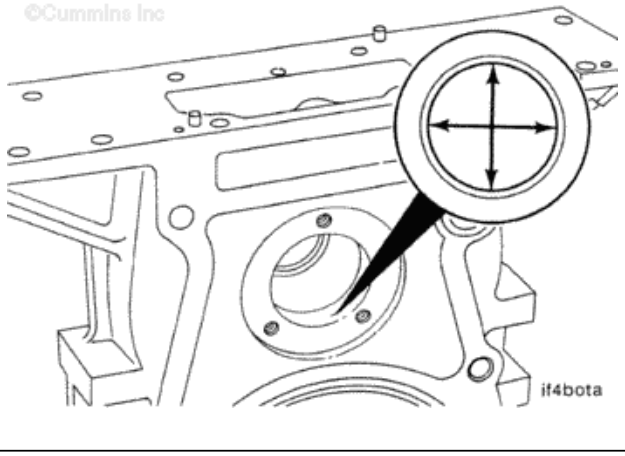
If the housing is cracked it **must** be replaced.



Measure the lower idler shaft bore inside diameter.

Lower Idler Shaft Inside Diameter		
mm		in
47.53	MIN	1.871
47.58	MAX	1.874
76.05	MIN	2.994
76.25	MAX	3.002

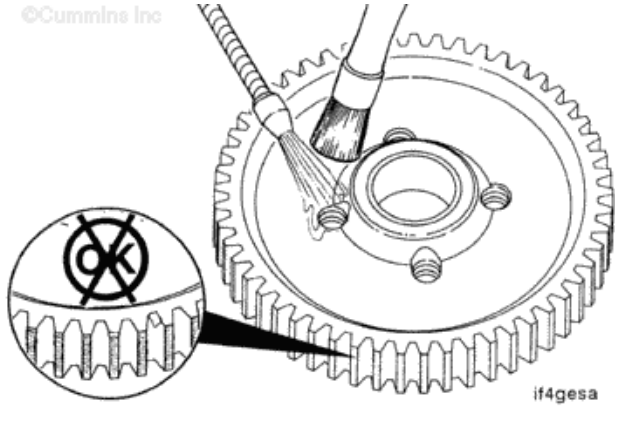
If the lower shaft idler bore is **not** within specifications, the lower housing **must** be replaced.



Clean the idler gear.

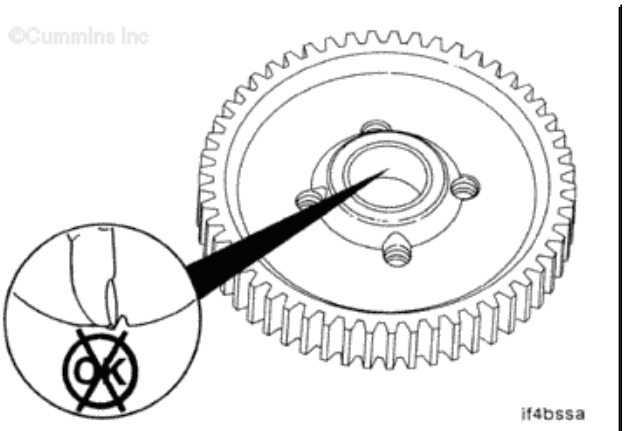
Check the gear teeth for excessive fretting.

The gear **must** be replace if the teeth have excessive fretting.



Inspect the idler gear internal bushing.

If a fingernail will catch on the scratches or grooves, replace the gear.

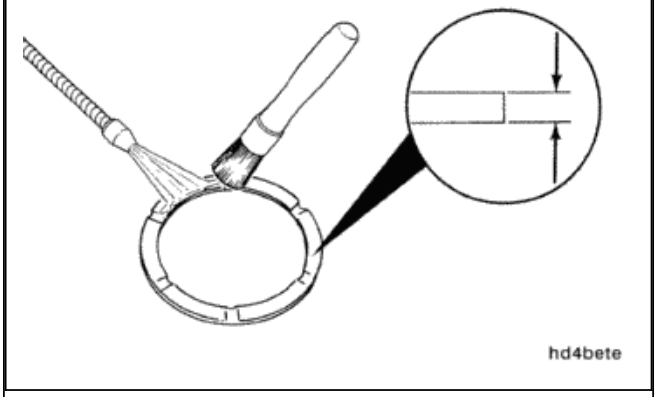


Clean the thrust bearings.

Measure the thrust bearing thickness.

Thrust Bearing Thickness		
mm		in
2.27	MIN	0.085
2.31	MAX	0.091

If the thrust bearing is **not** within specifications, it **must** be replaced.

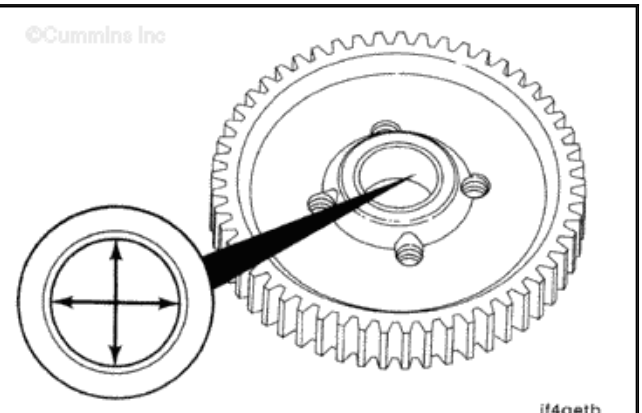


Measure the internal busing inside diameter.

Idler Gear Internal Bushing Inside Diameter		
mm		in
47.57	MIN	1.873
47.63	MAX	1.875

If the bushing is **not** within specifications, the idler gear **must** be replaced.

The idler gear bushing can **not** be replaced without precision machining to the pitch diameter of the gear teeth. The bushing is bored in-place after assembly into the gear.



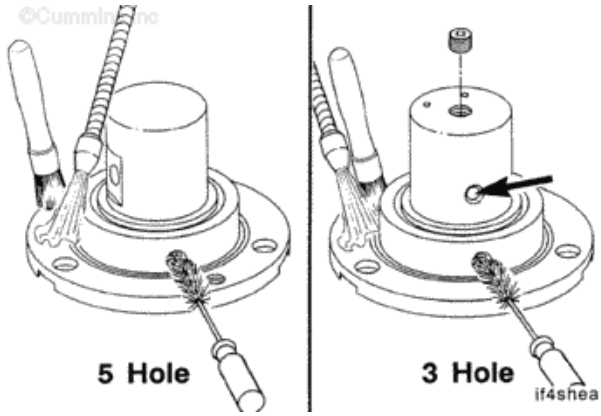
NOTE: The five hole idler

shaft does not have a pipe plug.

Clean the idler shaft.

Remove the pipe plug.

Clean the oil drillings. Inspect the intersection of the oil drillings.



Check two locations for fretting in the shaft diameter.

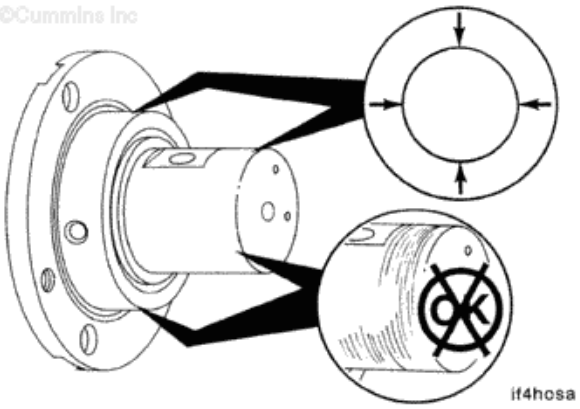
Use a crocus cloth to remove the fretting.

If the crocus cloth does **not** remove the fretting, replace the shaft.

Measure the idler shaft at two locations.

	Idler shaft diameter		
	mm		in
1	47.52	MIN	1.871
	47.55	MAX	1.872
2	76.19	MIN	3.000
	76.24	MAX	3.002

If the shaft is **not** within specifications, it **must** be replaced.



Assemble

CAUTION

Absence of the pipe plug in applications that require

one, can cause serious engine damage because a loss of oil pressure to the rear gear train bushings.

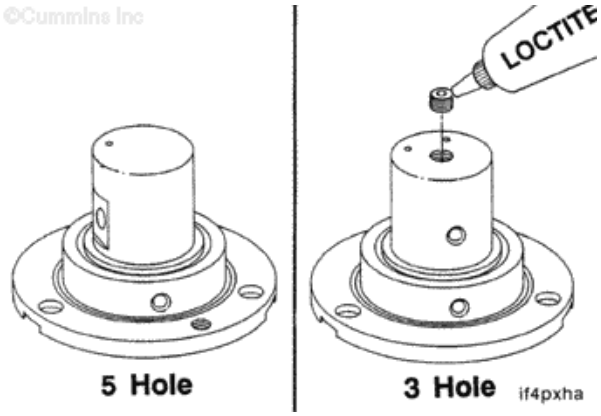
The five hole style shaft does **not** have a hole for the internal hexagon pipe plug.

Apply a thin coat of Loctite® thread locker to the pipe plug.

Install the internal hexagon pipe plug into the end of the of the idler shaft.

Tighten the pipe plug.

Torque
Value: 11 n.m [96 in-lb]

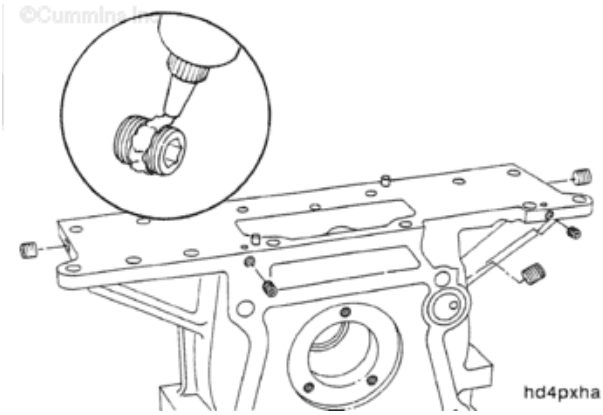


Apply a thin coat of pipe sealant, Part Number 3375066, or equivalent.

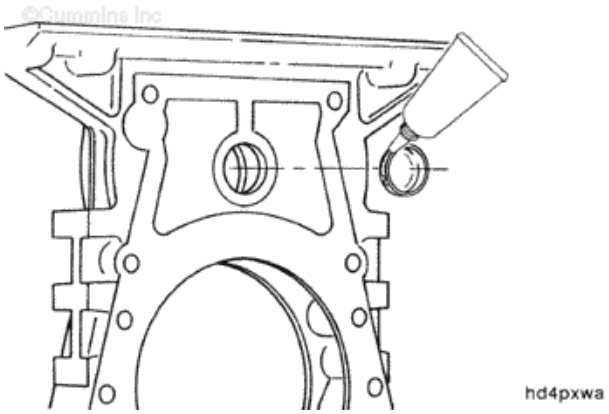
Install five 1/8 inch internal hexagon pipe plugs into the lower housing.

Tighten the pipe plugs.

Torque Value: 16 n.m [12 ft-lb]

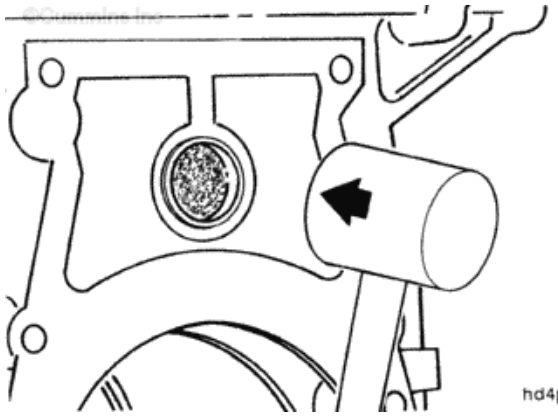


Apply thread locker and cup sealant, Part Numbers 3824038, (10mL) or 3824038 (50mL), to the expansion plug and the housing bore.



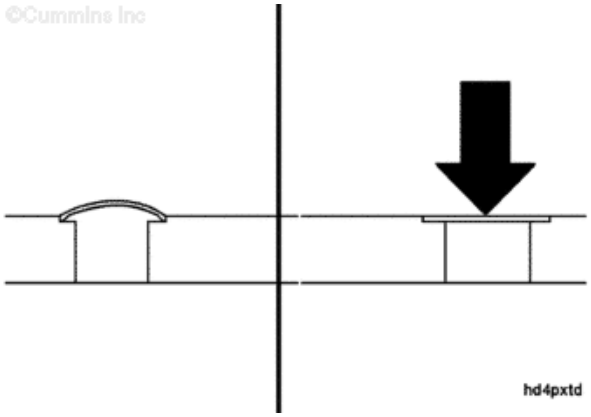
Place the plug in the housing bore.

Tap the plug around the edges with a brass hammer until the plug is seated in the counterbore.



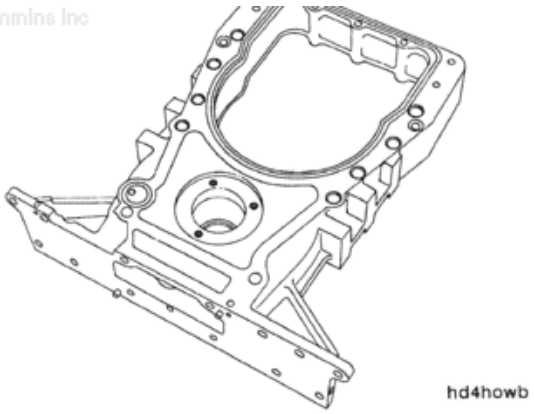
Use an arbor press to press the plug until it is flat. This locks the plug into the housing.

The plug **must** be 0 to 1.27 mm [0 to 0.050 in] above the surface of the housing.

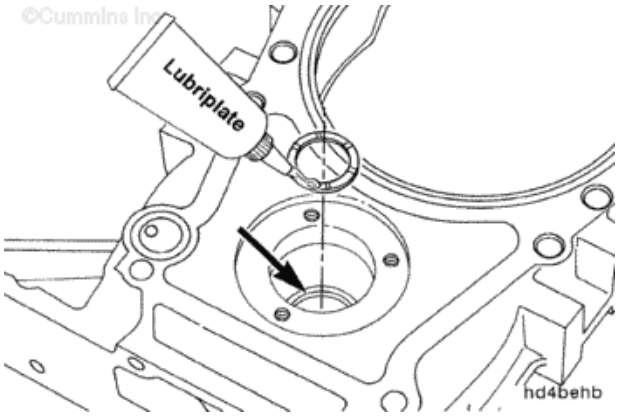
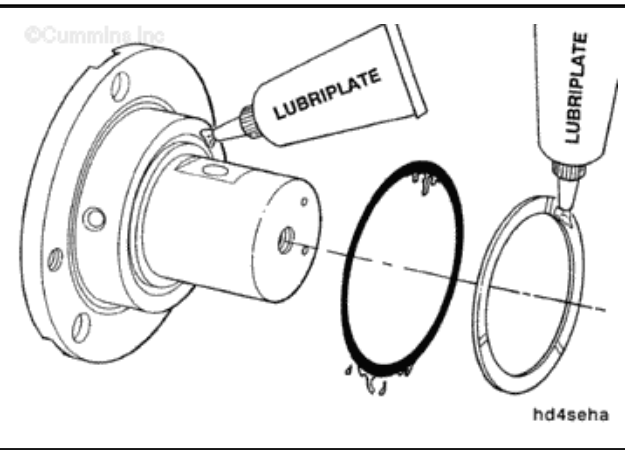
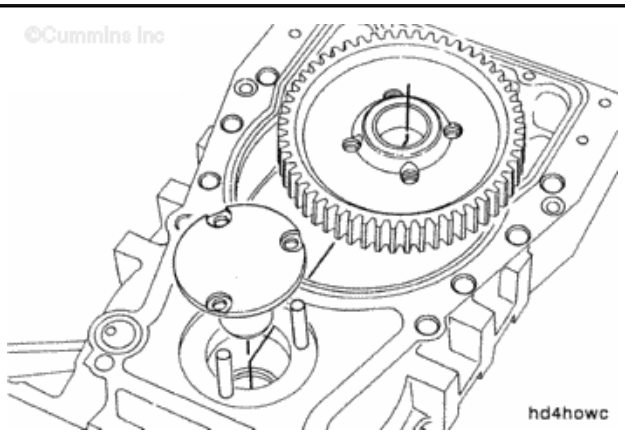


Position the lower housing horizontally with the block mating surface facing up.

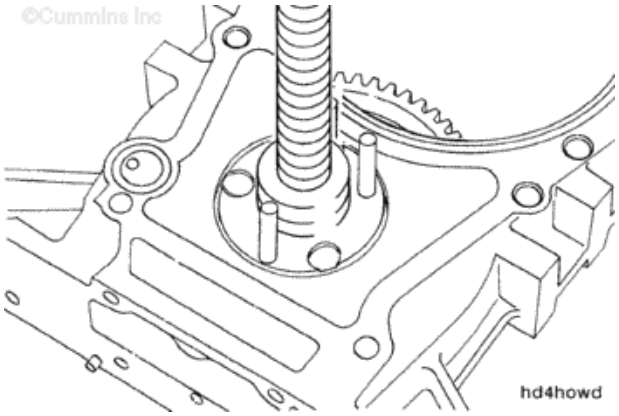
Attempting to install the gear and idler shaft with the housing vertical can result in binding of the thrust bearings.



Lubricate one thrust bearing and the counter bore in the lower housing near the expansion plug with Lubriplate ® 105, or equivalent.

Install the thrust bearing into the counterbore with the grooved side facing away from the housing.		
Lubricate a new idler shaft o-ring seal with clean engine oil. Install the o-ring into the groove in the idler shaft. Lubricate one thrust bearing and the pilot diameter on the idler shaft with Lubriplate® 105, or equivalent. Install the thrust bearing onto the shaft with the grooved side facing away from the idler shaft.	 	
Install 5/16-18 x 2 inch guide studs. Align the idler gear into the lower housing. Align and install the idler shaft into the idler gear and lower housing until the idler shaft pivot chamfer touches the lower housing.		
Make sure the machined surface on the back side of the lower housing is supported to prevent the housing from cracking.		

Using an arbor press to press the idler shaft into the lower housing until the mounting flange contacts the housing.

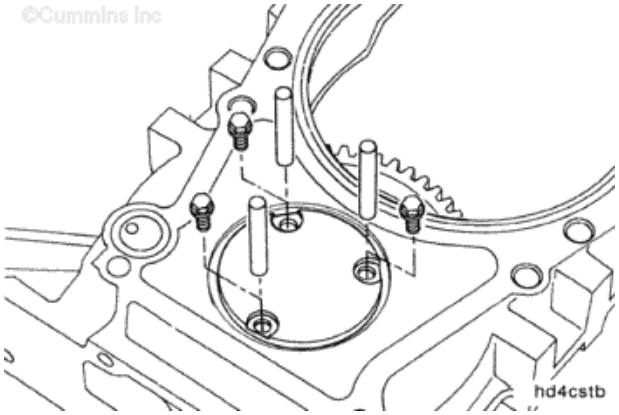


Remove the guide studs.

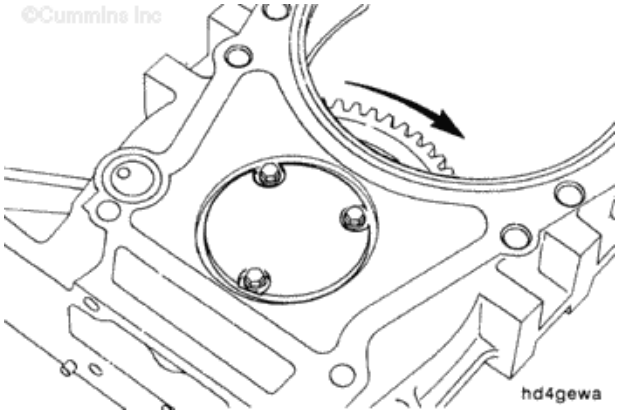
Install the three 5/16-18 x ¾ inch capscrews.

Tighten the capscrews.

Torque Value: 20 n.m [15 ft-lb]



Rotate the gear and check for binding.

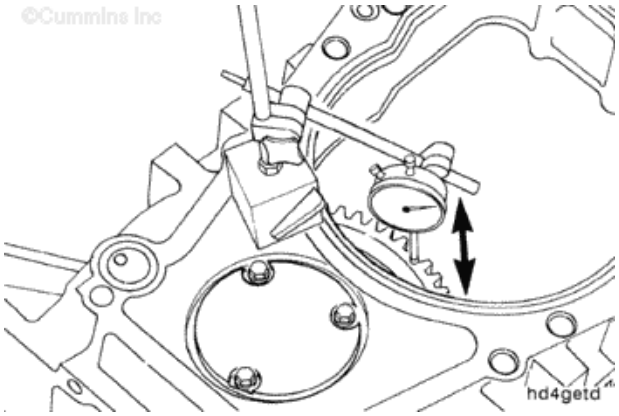


Measure the idler gear end clearance with a dial indicator.

Idler Gear End Clearance	
mm	in

0.10	MIN	0.004
0.51	MAX	0.020

If the end clearance is **not** within specifications, the thrust bearings **must** be replaced.



Install

NOTE: If an SAE 1 flywheel housing option is used, there must be two [5/8-11 x 6 1/2 in] studs, Part Number 3065777, installed in the upper holes of the cylinder block.

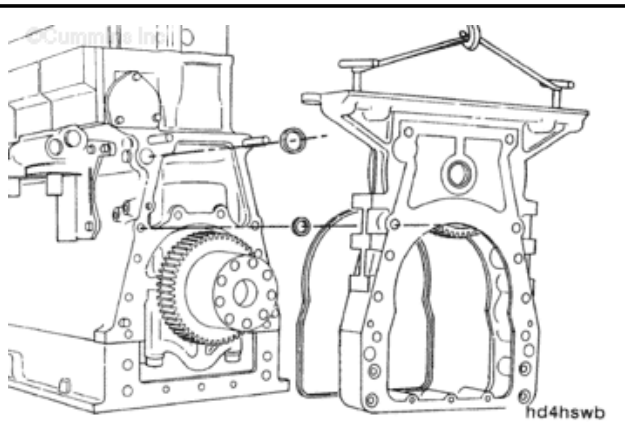
Apply a small amount of Lubriplate® 105 or gasket adhesive on the seal ring groove, the capscrew counterbores, and the dowel counterbores on the block side of the lower housing.

Install the new rectangular seal ring, with the joint at the top into the groove in the lower housing.

Install the ten new capscrew seals into the capscrew counterbores in the lower housing.

Use Lubriplate® 105 or equivalent on the main rifle seal.

Install the main rifle seal into the counterbore surrounding the main rifle drilling.

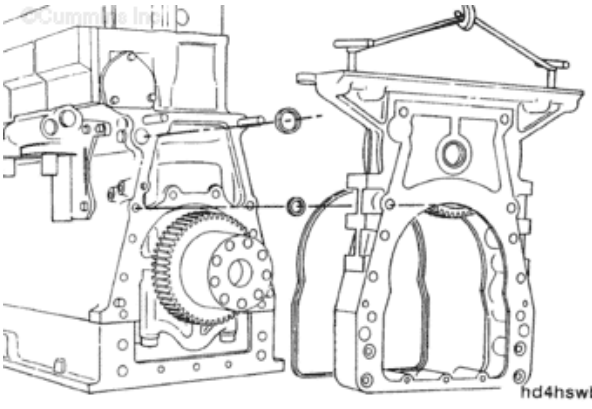


WARNING

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

Install two 5/8-11 x 1/2 inch guide studs into the rear face of the cylinder block. Use a hoist, two tee handles, and a lifting sling. Install the tee handles.

Lift the lower housing of the rear gear train.

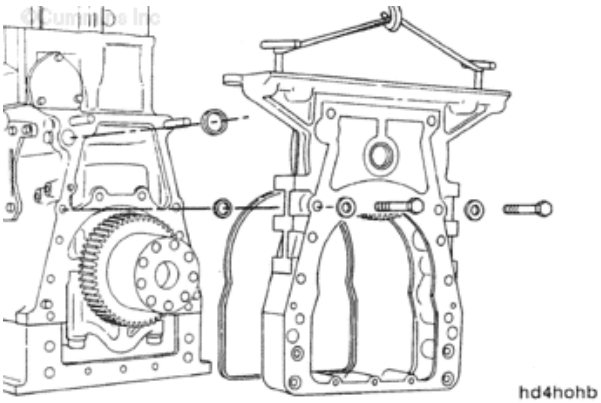


Install the lower housing of the rear gear train onto the dowel pins.

Check the alignment of all capscrews seals, rectangular seal, and the main oil rifle seal.

Use two 5/8-11 x 5 inch capscrews with flat washers in the locations shown.

Tighten the capscrews alternately to pull the lower housing to the block.



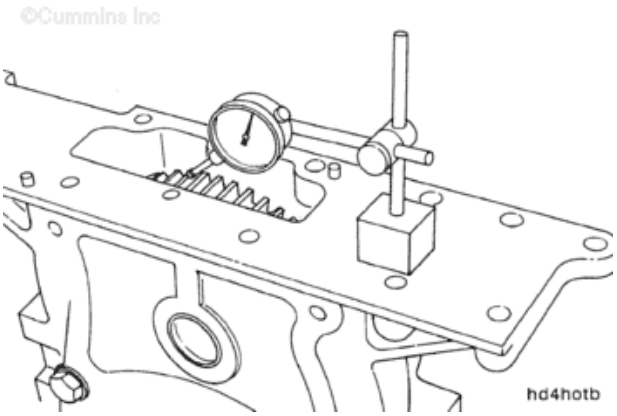
Use a dial indicator. Be sure the two capscrews are holding the lower housing firmly against the cylinder block. Check the gear lash.

Lower Housing-To-Cylinder Block Gear Backlash

mm		in
0.05	MIN	0.002
0.51	MAX	0.015

If the gear lash is above acceptable limits, the rear gear train lower idler gear or crankshaft gear **must** be replaced.

NOTE: Replace the idler gear first.

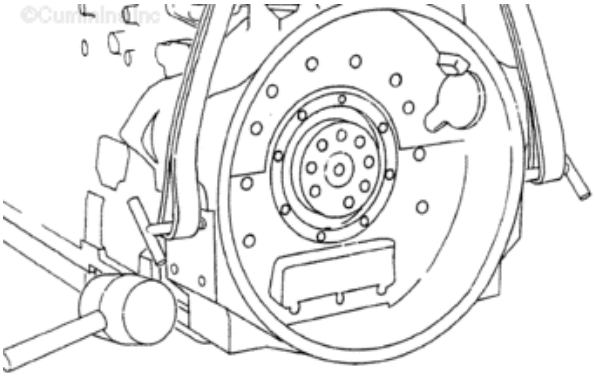


If the gear lash is below acceptable limits (or if the gear replacement does **not** correct the lash), replace the housing.

Use Lubriplate® 105 or gasket adhesive on the seal ring groove and the 10 capscrew counterbores on the rear gear train lower housing side of the flywheel housing.

Install the new rectangular seal ring, with the joint at the top, into the groove in the flywheel housing.

Install the new capscrew seals and dowel seals into the counterbores in the lower housing.

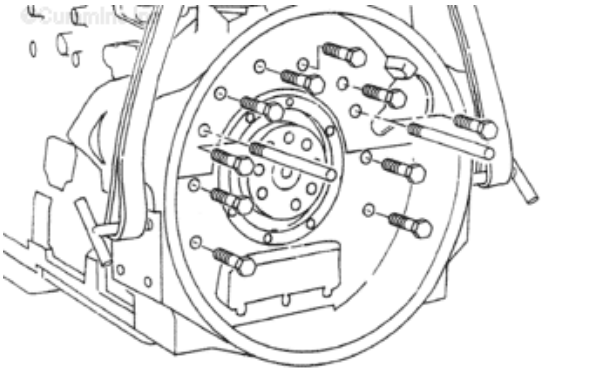


WARNING

The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to life the component.

Use two 5/8-11x6 1/2 inch guide studs. Use a hoist, tee handles, and a lifting sling. Install the flywheel housing onto the dowels in the rear gear train lower housing.

Install the lock washers, capscrews, and nuts.

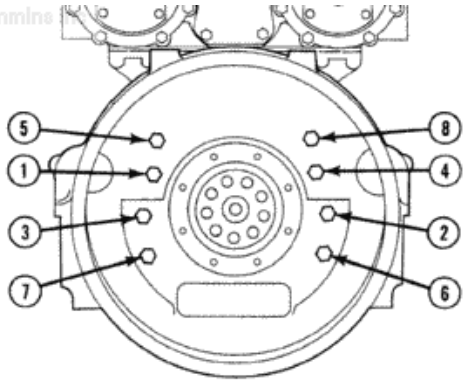


Use the following steps.

Tighten using the sequence shown.

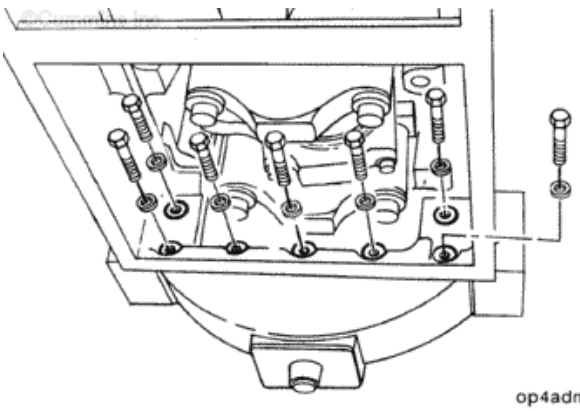
Torque Value: Step 1 100 n.m [75 ft-lb]

Step 2 205 n.m [150 ft-lb]



Install the two capscrews 7/16-14 x 4 3/4 inch, Part Number 190799, and the five capscrews 3/8-16 x 4 3/4 inch, Part Number S106-C, with flat washers and lock washers.

3/8-16 inch	45 n.m	[35 ft-lb]
7/16-14 inch	65 n.m	[50 ft-lb]

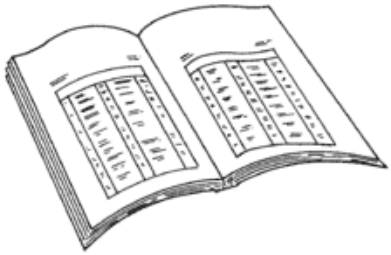


Finishing Steps

WARNING

The component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to life the component.

- Install the flywheel. Refer to Procedure 016-005.
- Install the starter motor. Refer to Procedure 013-



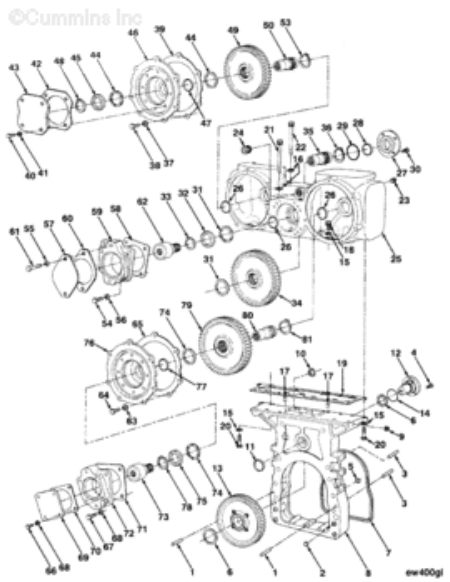
020. • Install the clutch, transmission and all related components. Refer to the equipment manufacturer's instructions. • Install the upper rear gear drive assembly. Refer to Procedure 009-024. • Fill engine with lubricating oil. Refer to Procedure 007-037.		

Last Modified: 10-Dec-2004

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009-024 Rear Gear Drive (Upper Assembly)

Exploded View



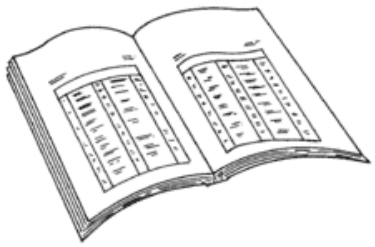
1. Dowel pin
2. Rectangular ring seal
3. Dowel pin
4. Hexagon head capscrew
5. Rectangular ring seal
6. Thrust bearing
7. Rectangular ring seal
8. Gear housing
9. Pipe plug
10. Rectangular ring seal
11. Expansion plug
12. Idler shaft
13. Hydraulic pump gear and bushing
14. O-ring seal
15. Lock washer
16. Plain washer
17. Dowel pin
18. Hexagon head capscrew
19. Hydraulic pump gasket
20. Hexagon head capscrew
21. Hexagon head capscrew
22. Hexagon head capscrew
23. Pipe plug
24. Pipe plug
25. Hydraulic drive housing
26. Bushing
27. Hydraulic pump support
28. Bushing
29. O-ring seal

30. Hexagon head capscrew
31. Thrust bearing
32. Bearing spacer
33. Retaining ring
34. Hydraulic pump gear
35. Shaft and plug assembly
36. Retaining ring
37. Lock washer
38. Hexagon head capscrew
39. Hydraulic support gasket
40. Hexagon head capscrew
41. Lock washer
42. Hydraulic pump flange cover gasket
43. Hydraulic pump flange cover
44. Thrust bearing
45. Bearing spacer
46. Hydraulic pump support
47. Bushing
48. Retaining ring
49. Hydraulic pump gear
50. Shaft and plug assembly
51. Expansion plug
52. Retaining ring
53. Hexagon head capscrew
54. Lock washer
55. Lock washer
56. Cover plate
57. Hydraulic pump gasket
58. Hydraulic pump adapter
59. Hydraulic pump gasket
60. Hagen head capscrew
61. Hydraulic pump adapter
62. Lock washer
63. Hexagon head capscrew
64. Hydraulic pump support gasket
65. Hexagon head capscrew
66. Hexagon head capscrew
67. Lock washer
68. Cover plate
69. Hydraulic pump gasket
70. Hydraulic pump gasket
71. Hydraulic pump adapter
72. Coupling and adapter assembly
73. Thrust bearing
74. Bearing spacer
75. Hydraulic pump gear
76. Hydraulic pump support
77. Bushing
78. Retaining Ring
79. Hydraulic pump gear
80. Shaft and plug assembly
81. Retaining ring.

Preparatory Steps

• Remove the outer hydraulic pump support drive. Refer to		

Procedure 009-036.
- Remove the hydraulic pump support bracket. Refer to Procedure 009-037.

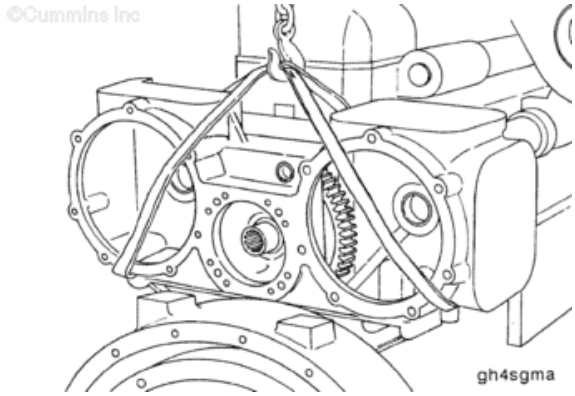


ck800wa

Remove

Install the lifting sling around both sides of the upper housing. Adjust the hoist until there is tension in the lifting sling.

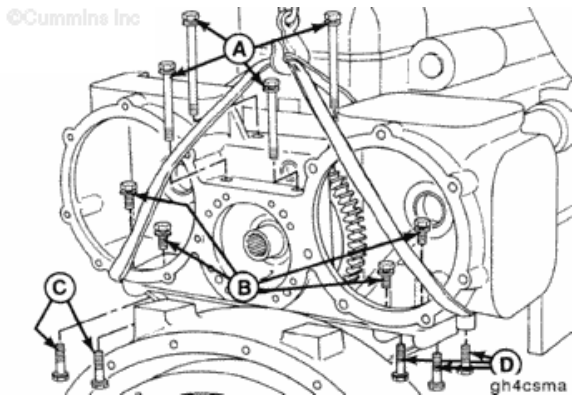




gh4sgma

Remove the four capscrews from the top of the housing (A), four internal capscrews (B), two capscrews from the bottom of the upper housing on the left side (C), and three capscrews from the bottom on the right side (D).





gh4csma

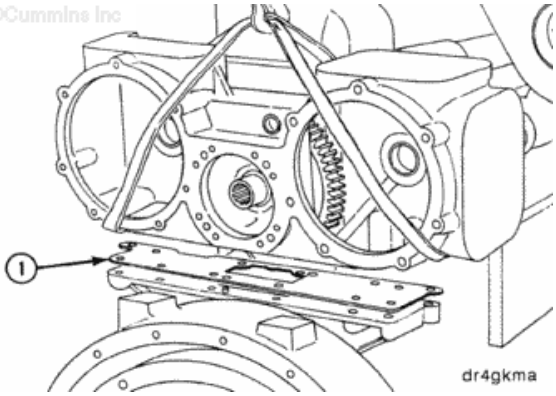
WARNING

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

CAUTION

The hydraulic gear protrudes out of the bottom of the housing. Place the upper housing upside down on a workbench to prevent damage to the gear or bushing.

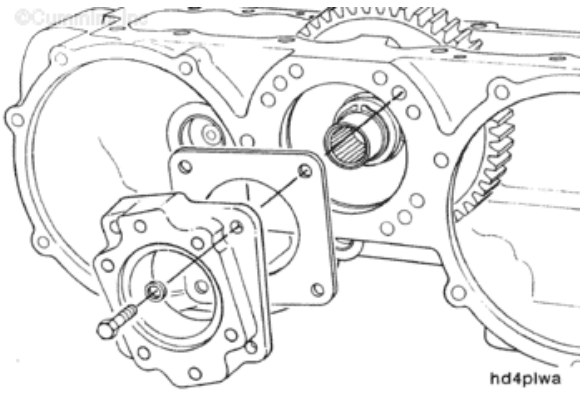
Remove the rear gear train upper housing from the lower housing. Remove the gasket (1). Keep the gasket for future use.



Disassemble

Remove the center hydraulic pump adapter and/or cover plate.

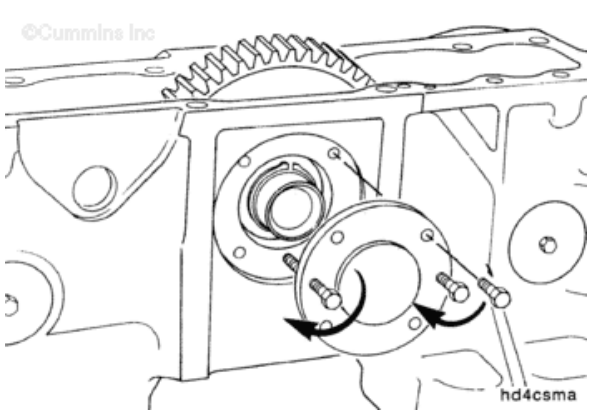
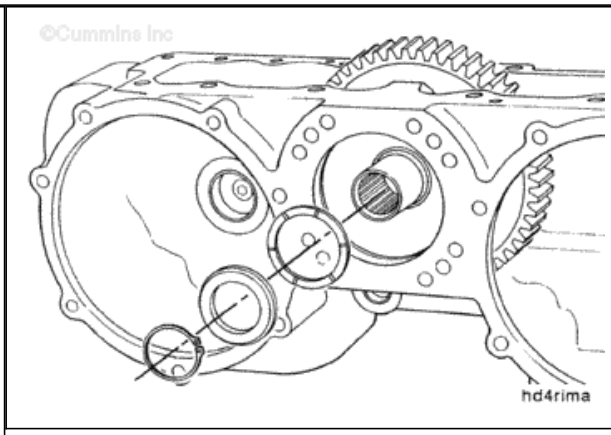
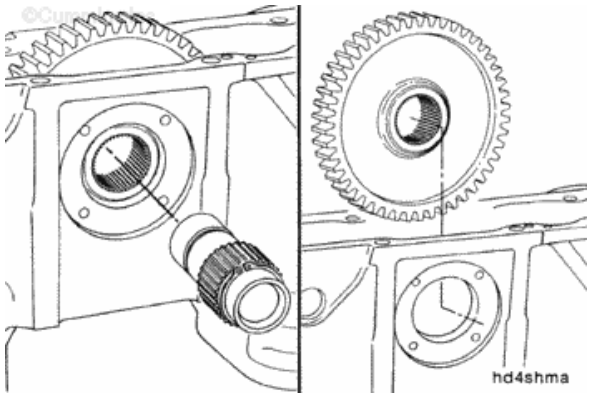
Remove and discard the gasket.

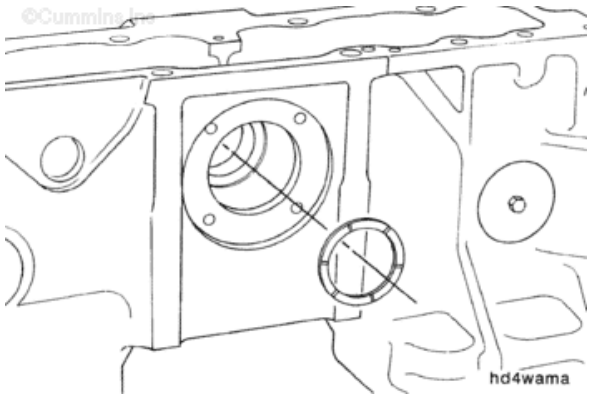


Remove the four capscrews from the hydraulic pump support on the engine side of the upper housing.

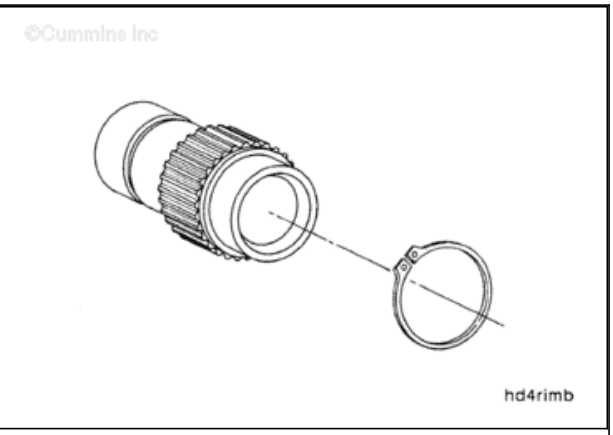
Install two ¼-20 x 2 inch to the hydraulic pump support.

Alternately tighten the capscrews to pull the support plate from the housing.

Remove and discard the o-ring.		
Remove the tapered retaining ring from the hydraulic pump drive shaft on the pump side. Remove the bearing spacer and the thrust bearing. Check the bearing spacer for wear against the shaft shoulder.		
Make sure the center drive gear will **not** drop. Remove the drive shaft from the upper housing. Remove the gear.		
Remove the thrust washer from the counterbore in the upper housing.		



Remove the square retaining ring.

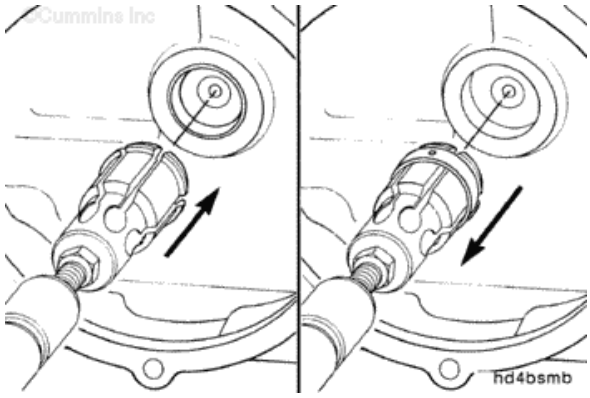


CAUTION

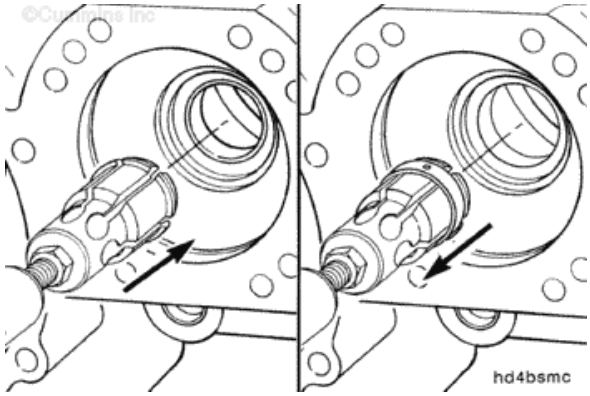
Do not pry against the back of the housing in the bore. The housing can crack or break.

NOTE: Remove the bushing only if it does not meet specifications or is damaged.

Remove the outer hydraulic pump support drive shaft bushing with a blind bushing puller.



Us an appropriate bushing mandrel and press to press the center hydraulic pump support drive shaft bushing from the housing.



Clean and Inspect for Reuse

WARNING

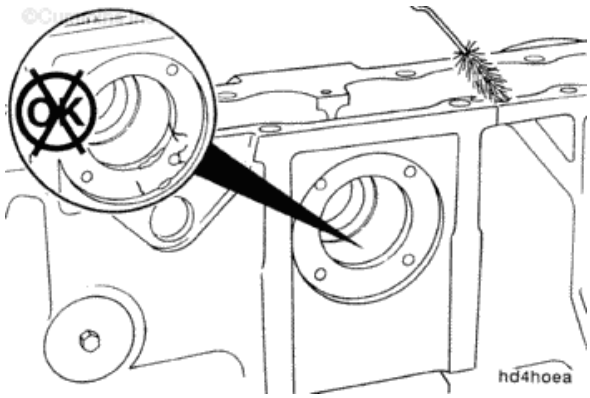
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

NOTE: Do not remove the 1 inch internal hexagon pipe plug in the upper housing near the center drive bore. Do not remove the 1/8 inch pipe plug that is on the newer housings located on the engine side of the housing to the right side outboard hydraulic bushing bore.

Clean the upper housing with solvent.

Use a bore brush and safety solvent to clean all of the oil drillings.

Make sure all oil drillings are free from debris.

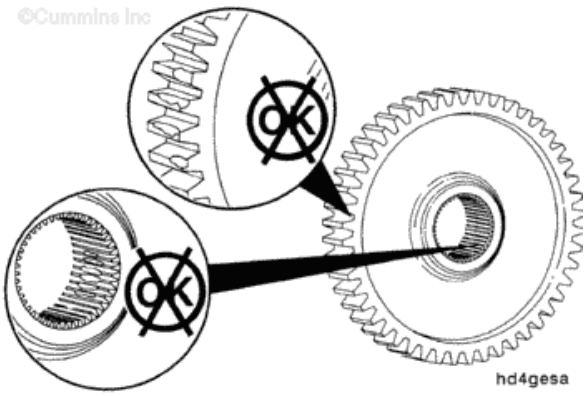


Clean the gear.

Check the teeth for excessive fretting.

Check the internal splines for wear.

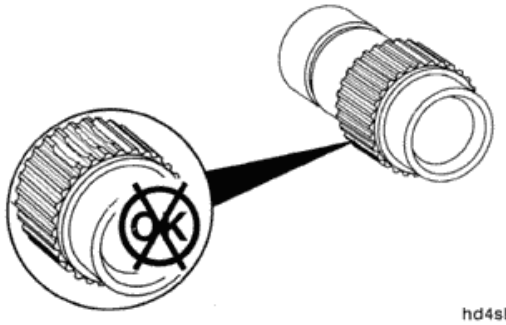
If the gear is excessive worn or damaged, it **must** be replaced.



Clean the center drive shaft.

Check the external splines for wear.

If the splines are worn the center drive shaft **must** be replaced.



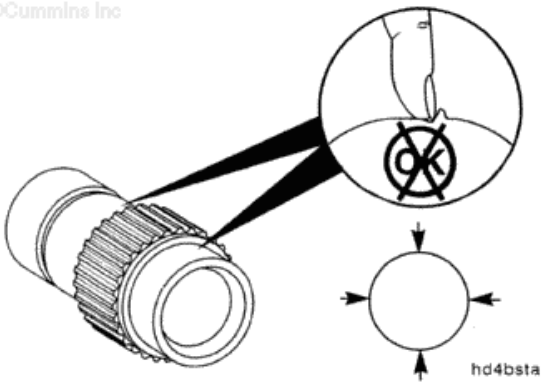
Inspect the bushing diameter areas on the center drive shaft for wear.

If a fingernail will catch on the scratches or grooves, the drive shaft **must** be replaced.

Measure the center drive shaft bushing diameter.

Center Drive Shaft Bushing Diameter		
mm		in
47.536	MIN	1.8715
47.549	MAX	1.8720

If the shaft is **not** within specifications, it **must** be replaced.



Clean the thrust bearings and check for damage.

If a thrust bearing is damaged, it **must** be replaced.

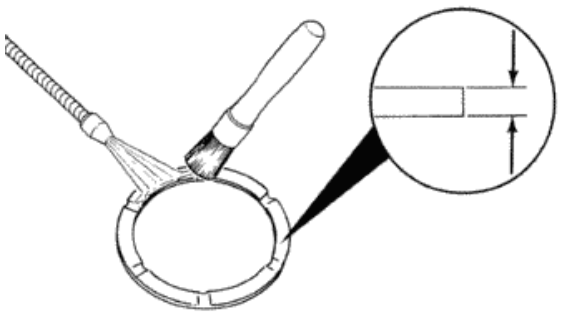
Measure the thrust bearing thickness.

Upper Housing Thrust Bearing Thickness		
mm		in
2.27	MIN	0.085
2.31	MAX	0.091

If the thrust bearing is **not** within specifications, it **must** be replaced.

Check the retaining rings and spacer bearing for damage.

If a retaining ring or spacer bearing is damaged, it **must** be replaced.



Clean the three hydraulic drive housing bushings in the upper housing.

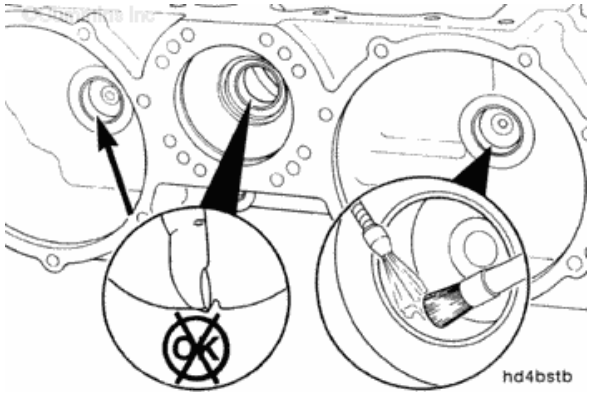
Inspect the bushing for scratches or grooves.

If a fingernail will catch on the scratches or grooves, the bushing **must** be replaced.

Measure the bushing inside diameter.

Hydraulic Drive Housing Busing Inside Diameter		
mm		in
47.60	MIN	1.874
47.68	MAX	1.877

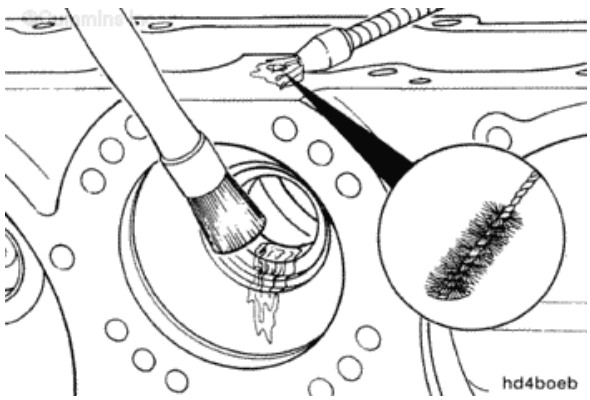
If the bushing is **not** within specifications, it **must** be repalced.



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 center hydraulic pump support drive shaft bushing bore with solvent.



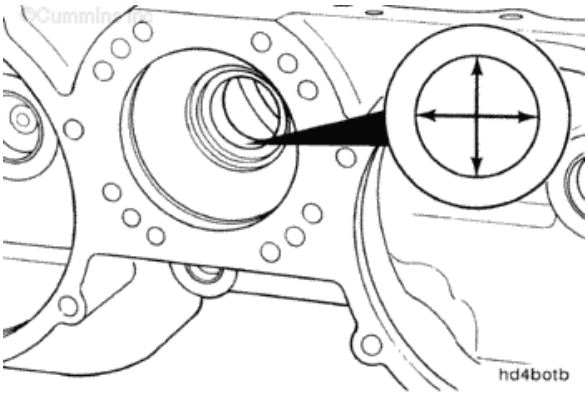
Clean the oil drillings with a bore brush.

Inspect the bushing bore and oil drillings.

Measure the center hydraulic bushing bore.

Center Hydraulic Bushing Bore		
mm		in
53.85	MIN	2.120
53.92	MAX	2.123

If the bushing bore is **not** within specifications, the housing **must** be replaced.

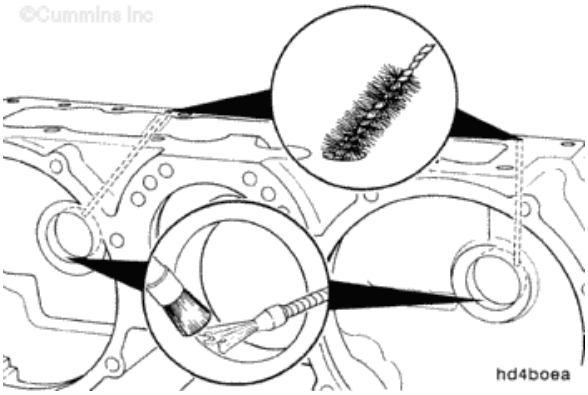


WARNING

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.

Clean the outer hydraulic pump support housing bushing bore with solvent.

Clean the oil drillings with a bore brush.

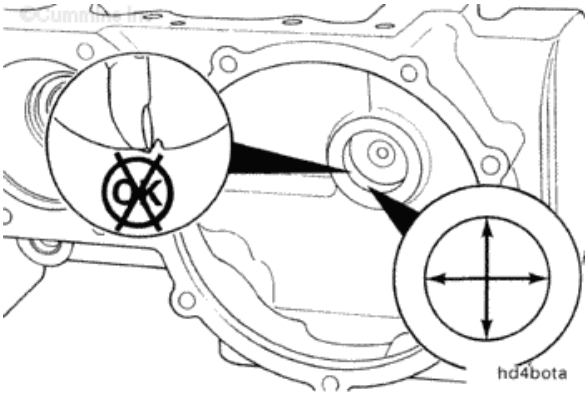


Inspect the outer hydraulic drive housing bushing bore fro scratches or grooves.

If a fingernail will catch on the scratches or grooves, the housing **must** be replaced.

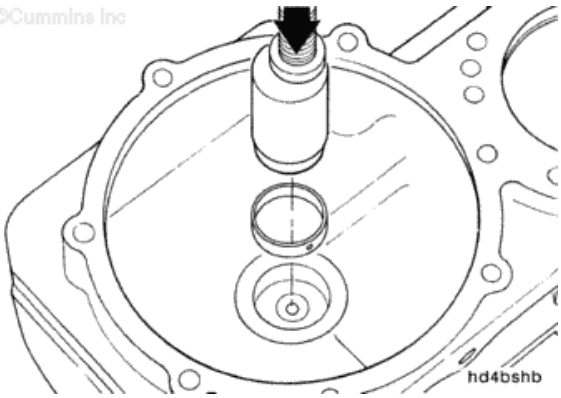
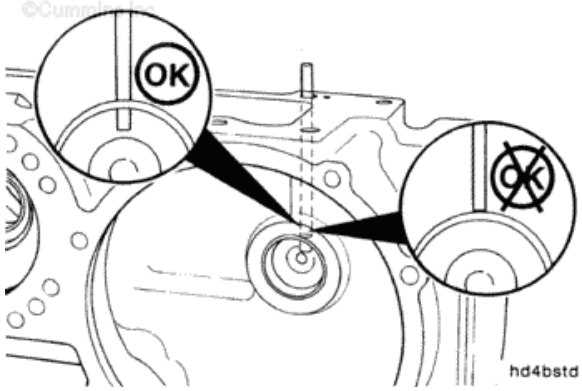
Measure the bushing bore in the housing.

Outer Hydraulic Drive Housing Bushing Bore		
mm		in
53.86	MIN	2.120



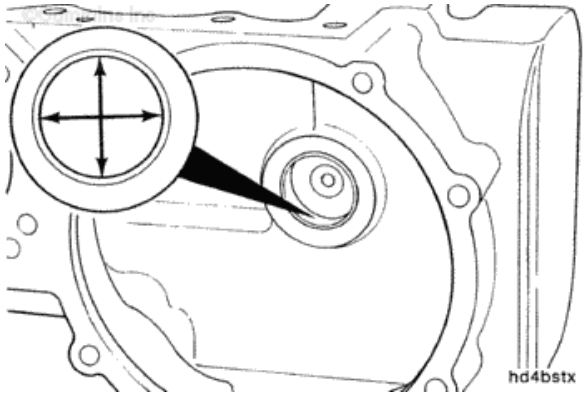
53.92 MAX 2.123 If the bushing bore is **not** within specifications, the housing **must** be replaced. **NOTE: Bushing bore sleeves can not be installed with precision machining to the bushing bore in the housing. Cummins Inc. does not recommend installing sleeves in the housing.**		

Assemble

Install the outer hydraulic drive housing bushing from the hydraulic pump side of the housing with an appropriate mandrel and press. The bushing **must** be flush or no more than 0.508 mm [0.020 in] below the housing.		
The oil feed hole located behind the bushing **must not** be plugged or restricted. A 4.76 mm [3/16 in] diameter rod **must** pass through the drilling and the bushing freely. Use a light to check the oil drilling for an unrestricted oil path.		
Measure the outer hydraulic drive housing bushing.		

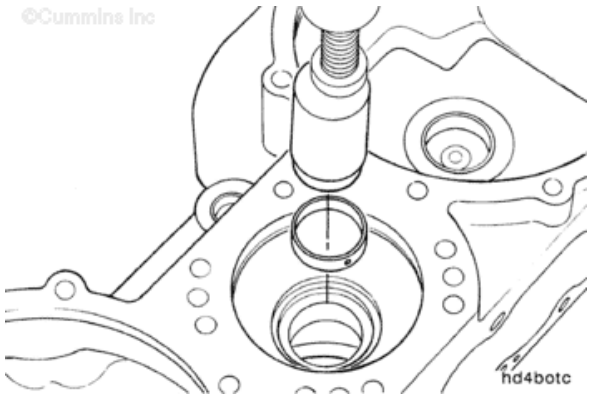
Outer Hydraulic Drive Housing Busing Inside Diameter

mm		in
47.60	MIN	1.874
47.68	MAX	1.877



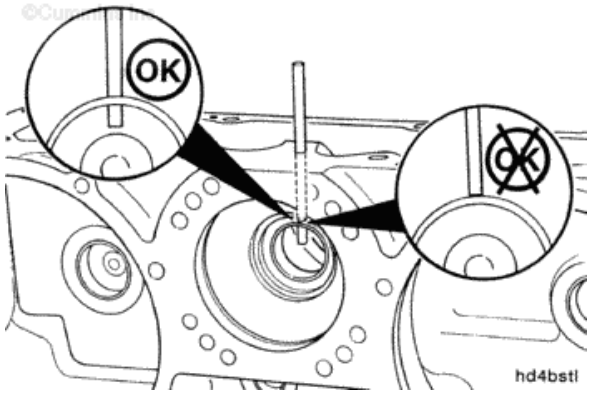
Install the center hydraulic drive bushing, from the pump side, into the housing.

The bushing **must** be flush or no more than 0.508 mm [0.020 in] below the housing.



The oil feed hole located behind the bushing **must not** be plugged or restricted. A 6.35 mm [¼ in] rod **must** pass through the drilling and the bushing freely.

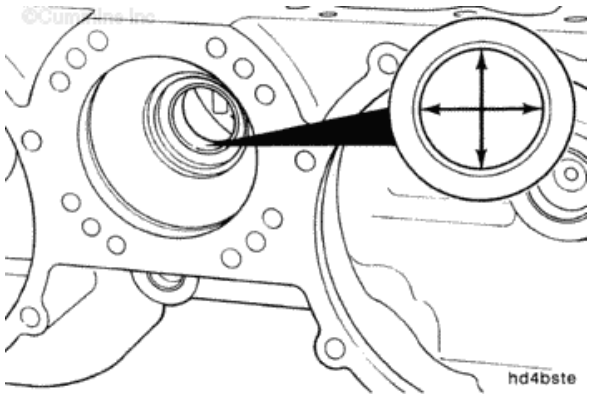
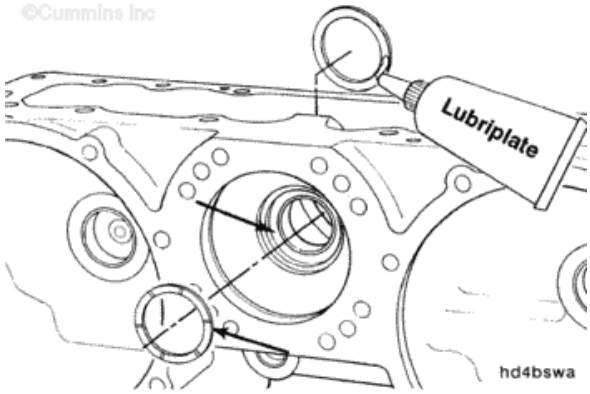
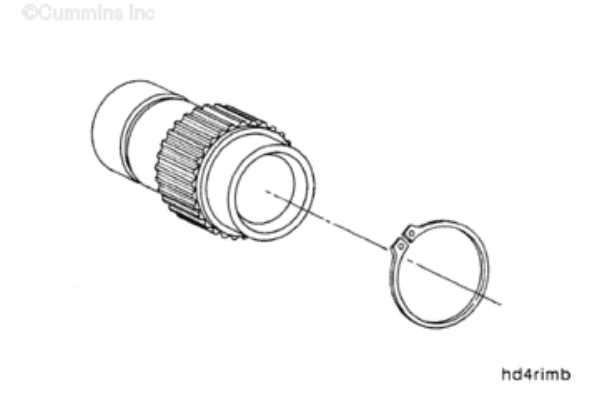
Use a light to check the oil drilling for an unrestricted oil path.

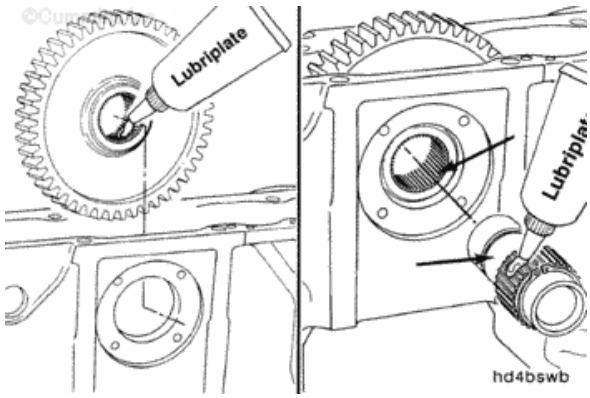
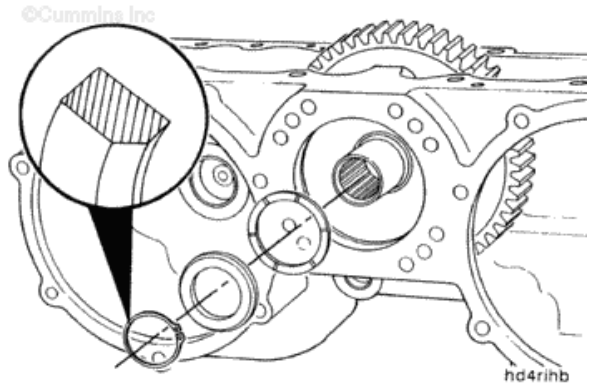
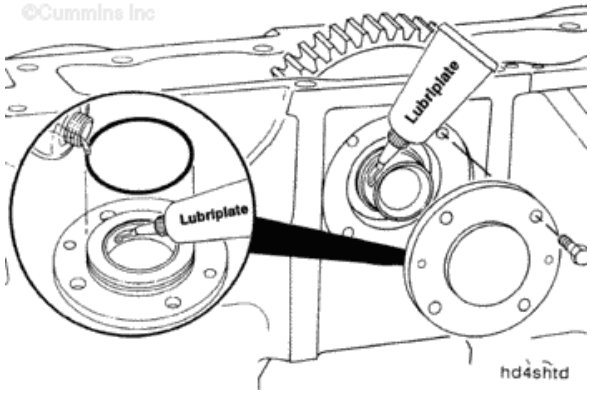


Measure the center hydraulic drive housing bushing inside diameter.

Center Hydraulic Drive Housing Busing Inside Diameter

mm		in
47.60	MIN	1.874

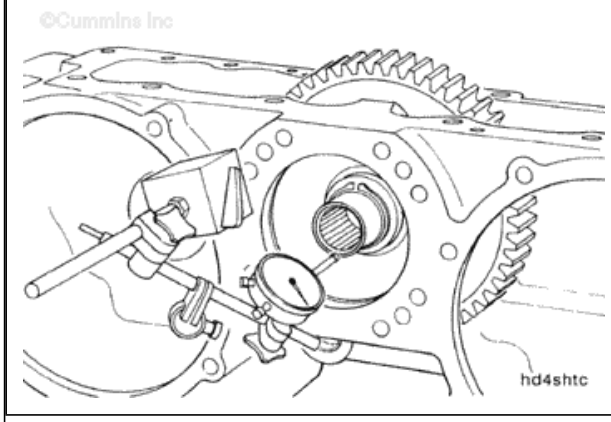
47.68 MAX 1.877		
Lubricate the center hydraulic shaft bushing, two thrust bearings, and two counterbores next to the center bushing with Lubriplate® 105 or equivalent. Install the two thrust bearings, with the grooved side facing away from the housing, into the counterbores.		
Install the non-tapered retaining ring onto the center drive shaft on the end closest to the external splines.		
Lubricate the pump side bushing surface on the center drive shaft, the external splines on the drive shaft, and the internal splines on the gear with Lubriplate® 105 or equivalent. Align the gear in the housing.		

Install the shaft into the housing and gear from the engine side of the upper housing.		
Install the bearing spacers and tapered retaining ring with the beveled side facing the pump side of the drive shaft.		
Lubricate the engine side bushing surface on the center hydraulic pump drive shaft and the bushing in the hydraulic pump drive shaft with Lubriplate® 105 or equivalent. Lubricate the o-ring with clean engine oil. Install the o-ring into the groove on the support. Install the hydraulic pump support. Install the four 5/16-18 x ¾ inch capscrews. Tighten the capscrews. **Torque Value:** 20 n.m [15 ft-lb]		
Measure the end clearance with a dial indicator.		

Center Drive End Clearance

mm		in
0.10	MIN	0.004
0.51	MAX	0.020

If the end clearance is **not** within specifications, the thrust bearings **must** be replaced.

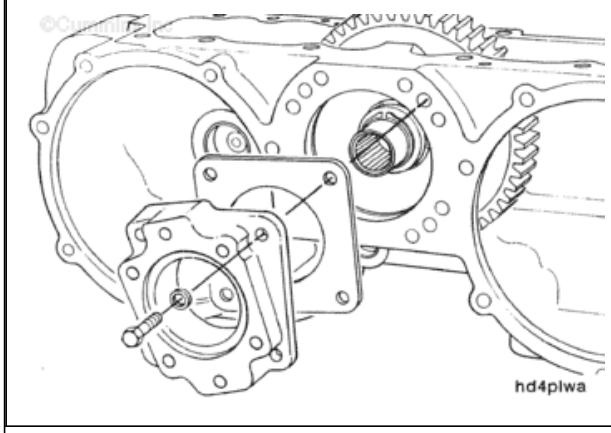


Install the hydraulic pump adapter or cover plate and gasket.

Install the four capscrews.

Tighten the capscrews.

Adapter	95 n.m	[70 ft-lb]
SAE A Drive Cover Plate	40 n.m	[33 ft-lb]
SAE B and C Drive Cover Plate	95 n.m	[70 ft-lb]



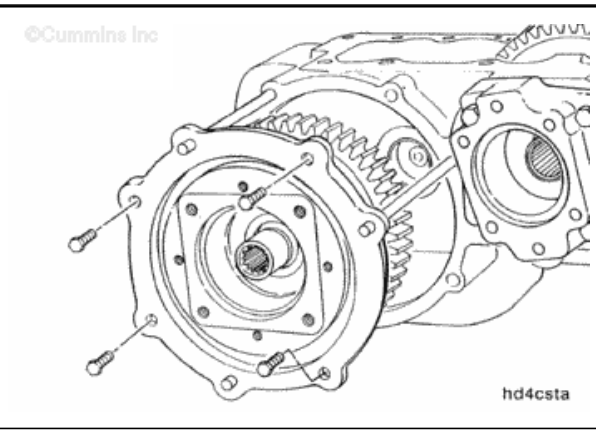
Install three 7/16-14 x 4 inch guide studs in one side of the housing.

Install the hydraulic drive assembly.

Install the capscrew.

Tighten the capscrews.

Torque Value: 70 n.m [50 ft-lb]



Prevent the outer hydraulic drive shaft from moving.

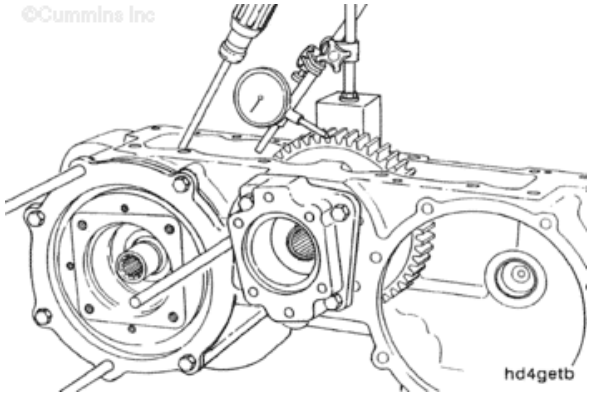
Measure the center drive gear to the outer drive gear backlash with a dial indicator.

Center Drive Gear to Outer

Drive Gear Backlash

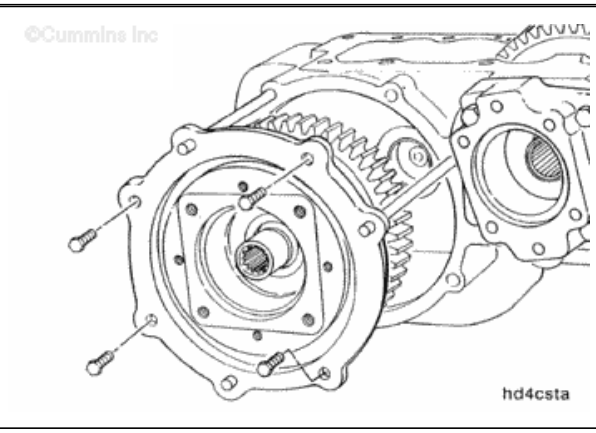
mm		in
0.10	MIN	0.004
0.51	MAX	0.020

If the gear backlash is **not** within specifications, one or both of the gears **must** be replaced.



Remove the four capscrews and the outer hydraulic drive assembly.





Install three 7/16-14 x 4 inch guide studs in the other side of the housing.

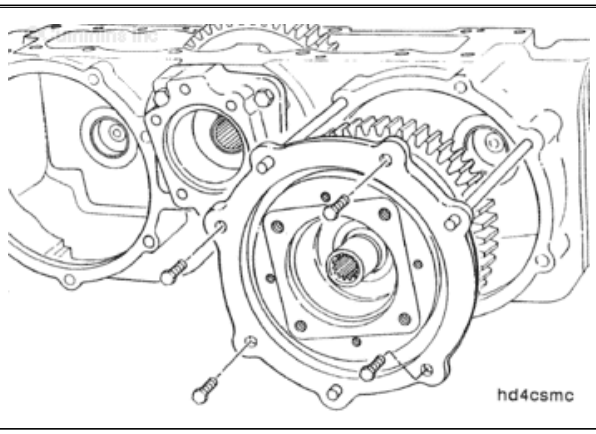
Installl the other hydraulic drive assembly and capscrews.

Tighten the capscrews.

Torque Value: 70 n.m [50 ft-lb]







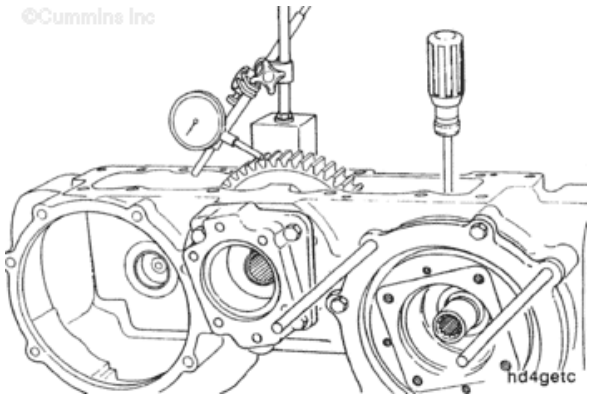
Prevent the outer hydraulic drive shaft from moving.

Measure the center drive gear to the outer drive gear backlash with a dial indicator.

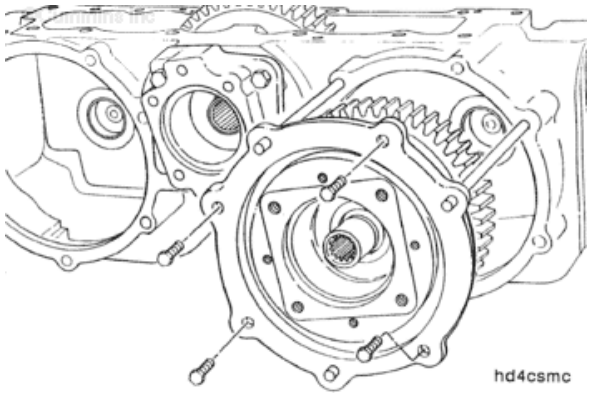
Center Drive Gear to Outer

Drive Gear Backlash		
mm		in
0.10	MIN	0.004
0.51	MAX	0.020

If the gear backlash is **not** within specifications, one or both of the gears **must** be replaced.



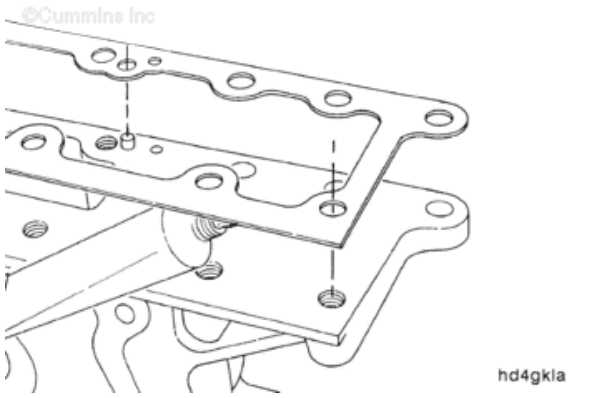
Remove the four capscrews and outer hydraulic drive assembly.



Install

Use gasket adhesive on the gasket. Do **not** use an excessive amount of adhesive on the gasket.

Align and install the rear gear train upper housing gasket to the rear gear train lower housing.

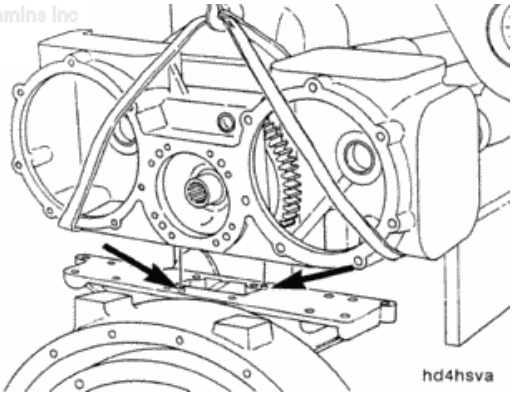


WARNING

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

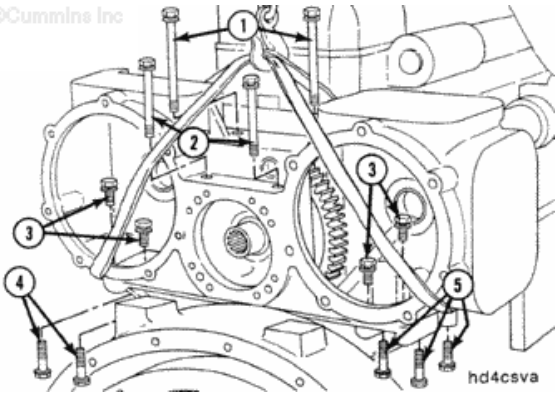
NOTE: Use extra care when aligning the upper housing onto the lower housing to prevent gasket damage.

Use the dowel pins to align the upper housing onto the lower housing.



Use **only** SAE Grade 8 capscrews to install the upper housing. Install the following capscrews according to the table below.

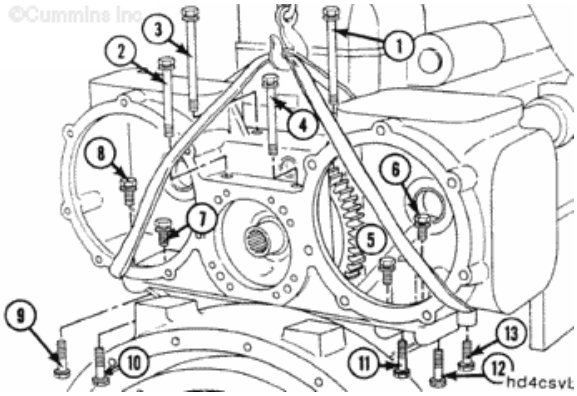
Reference	Location	Size	Quantity
1	Top-Front	½-13 x 9¼ in	2
2	Top-Rear	½-13 x 7½ in	2
3	Internal	½ - 13 x 1¼ in	4
4	Bottom-Left Side	½-13 x 1¾ in	2
5	Bottom-Right Side	½-13 x 1¾ in	3



Tighten the capscrews in the sequence shown in the illustration the graphic.

Torque Value: Step 1 70 n.m [50 ft-lb]

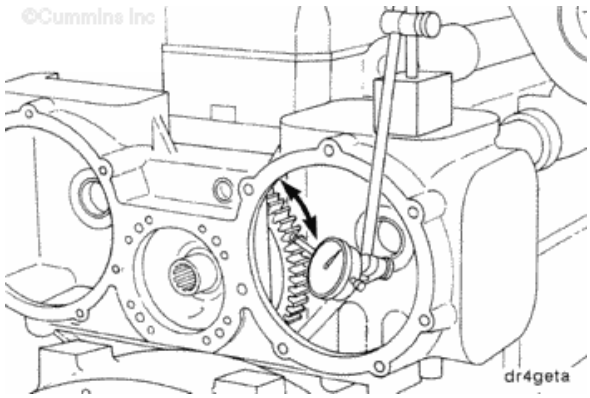
Step 2 150 n.m [110 ft-lb]



Make sure the lower idler gear is secure. If the gear is **not** secure, the indicator reading includes the lower idler gear to the crankshaft gear backlash.

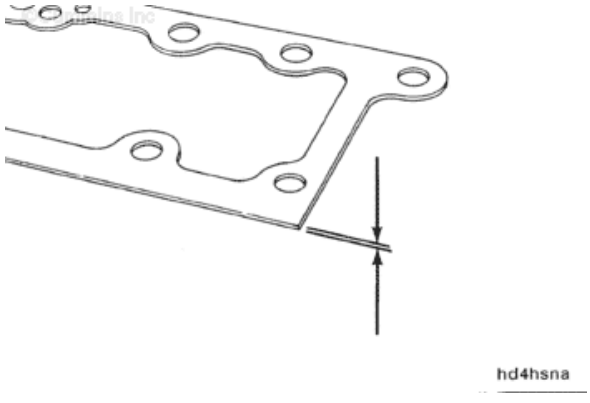
Measure the backlash between the center drive gear and the lower idler gear with a dial indicator

Idler Gear Backlash		
mm		in
0.05	MIN	0.002
0.51	MAX	0.020



If the gear lash is less than the specified limits, thicker gaskets are available. Do **not** use more than two gaskets to correct the backlash.

If the gear lash is greater than the specification and the thinnest gasket is used, the upper and lower gears **must** be replaced.



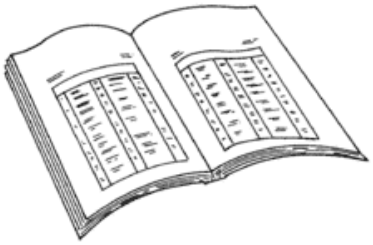
Finishing Steps

- Install the hydraulic pump support bracket. Refer to Procedure 009-037.
- Install the outer hydraulic pump support drive. Refer to Procedure 009-036.





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009-029 Water Pump Drive

Preparatory Steps

WARNING

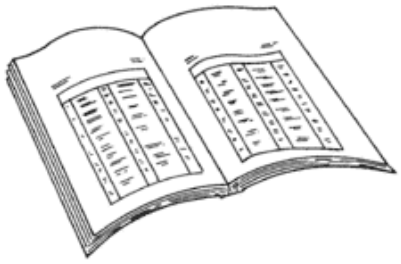
Do not remove the pressure cap from a hot engine. Wait until the temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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. Refer to Procedure 008-062.
- Remove the alternator belt. Refer to Procedure 013-005.
- Remove the water pump drive pulley. Refer to Procedure 009-032.
- Remove the alternator drive seal. Refer to Procedure 001-001.





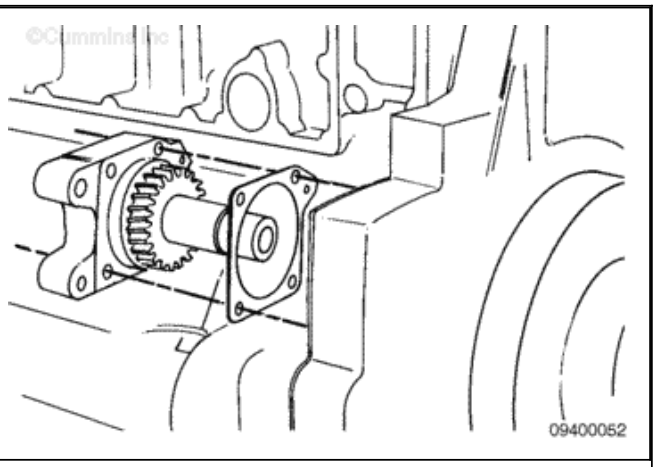
ck800wa

Remove

Remove the water pump drive assembly and gasket.

If necessary, tap on the end of the shaft with a mallet.

Discard the gasket.



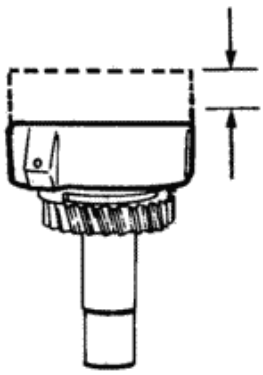
Inspect for Reuse

Measure the water pump drive end clearance.

Water Pump Drive End Clearance		
mm		in
0.23	MIN	0.009
0.33	MAX	0.013

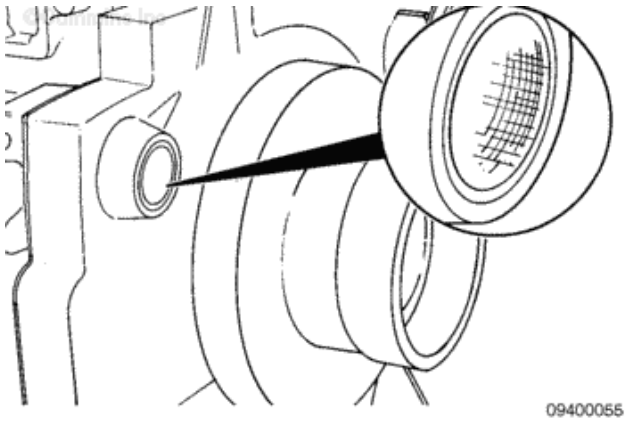
If the water pump drive end clearance is **not** within specifications, the water pump drive **must** be reconditioned or replaced.

Oversize thrust bearings are available to adjust the end clearance.

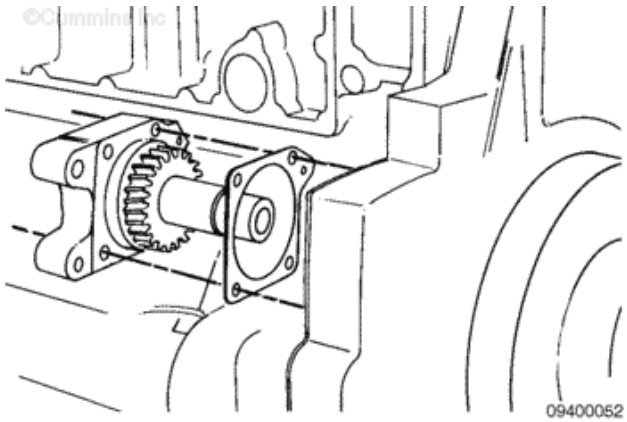


Inspect the water pump drive bushing in the front cover for excessive wear or damage. Refer to Procedure 001-031.

Inspect the alternator drive pulley for reuse. Refer to

Procedure 013-006. Inspect the water pump for reuse. Refer to Procedure 008-062.		

Install

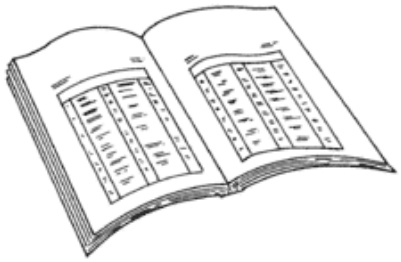
Install the water pump drive assembly gasket. Install the water pump drive assembly. The water pump drive assembly is secured in position by a stud.		

Finishing Steps

• Install the alternator drive seal. Refer to Procedure 001-001. • Install the water pump. Refer to Procedure 008-062.		

- Install the water pump drive pulley. Refer to Procedure 009-032.
- Install the alternator drive belt. Refer to Procedure 013-005.
- Fill the cooling system. Refer to Procedure 008-018.

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009-032 Water Pump Drive Pulley

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 water pump drive pulley

Check the grooves of the pulley for wear.

Check the pulley outside diameter for damage.

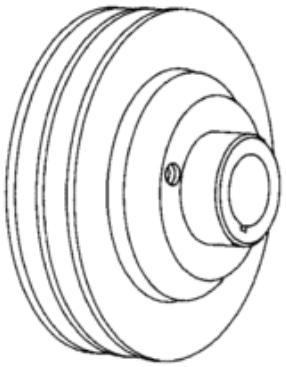
If the pulley is damaged it **must** be replaced.

Check the wear sleeve on the accessory drive pulley.

If the wear sleeve needs to be replaced, use a chisel and remove the gear sleeve.

Use an arbor press and a mandrel to install the new wear sleeve even with the end of the pulley.





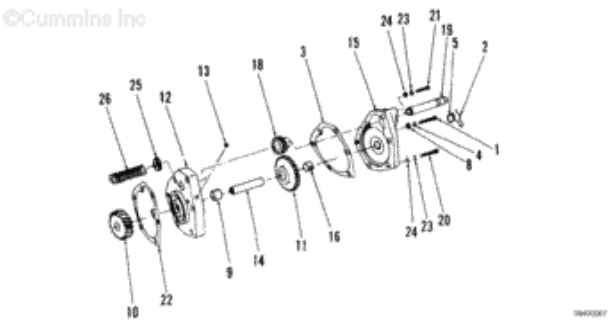
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Last Modified: 11-Nov-2004

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009-035 Engine Barring Device

Exploded View



Engine Barring Device

1. Capscrew
2. External cotter clip
3. Barring cover gasket
4. Lock washer
5. O-ring
6. Plain washer
7. Barring housing bushing
8. Engine barring gear
9. Engine barring drive gear
10. Housing and gear
11. Pipe plug
12. Barring idler shaft
13. Barring mechanism cover
14. Barring housing bushing
15. Engine barring driver gear
16. Barring drive shaft
17. Capscrew
18. Capscrew
19. Barring housing gasket
20. Lock washer
21. Plain washer
22. Spring retainer
23. Engine barring spring

General Information

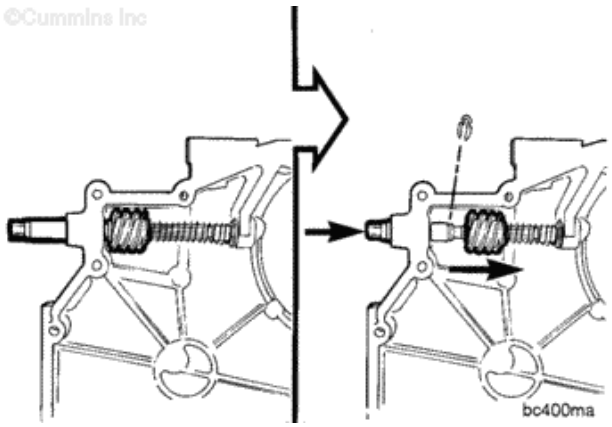
Two styles of barring devices are available. The style used depends on the front gear cover arrangement of the engine being serviced.

Engines that have a one-piece front cover arrangement use a barring device that is machined as part of the front cover as illustrated in the graphic.

Engines that have a two-piece front cover arrangement use a barring device that mounts at the rear of the gear housing. The front gear cover does **not** have to be removed from the engine to service this mechanism.

When the barring shaft is pushed in, this barring device has a spring loaded gear that engages the gear in the barring device drive assembly.

The barring mechanism consists of a shaft with a gear on each end. One engages the camshaft gear and the other engages the barring device gear. This barring device can be used to rotate the engine in either direction.

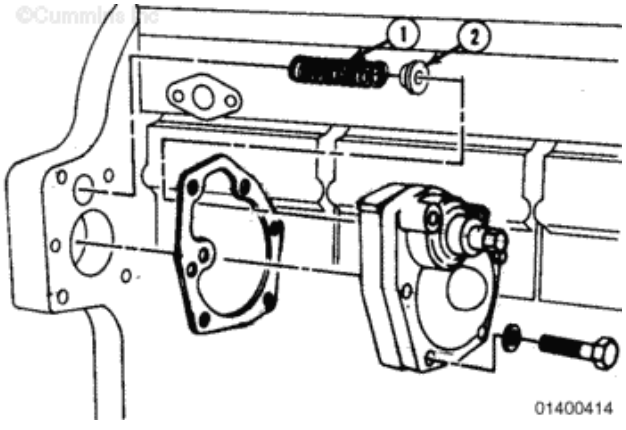


Remove

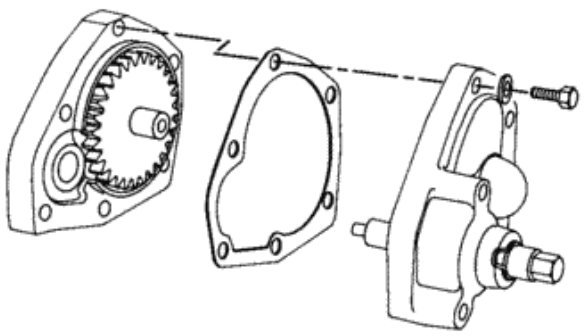
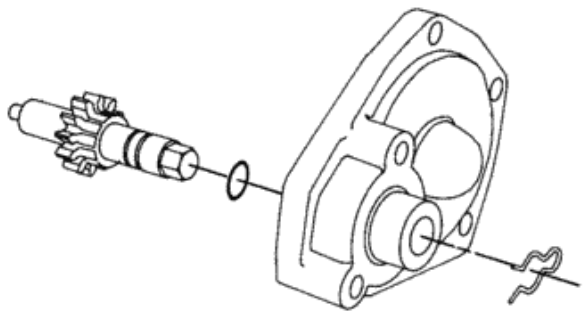
Remove the five mounting capscrews and the barring mechanism.

Remove and discard the gasket.

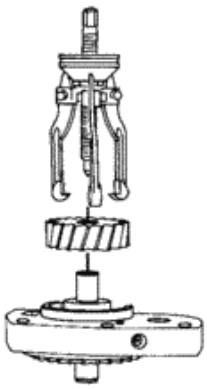
Remove the spring guide (2) and the spring (1).



Disassemble

Make sure mounting capscrews are removed from the cover. Remove the cover assembly. Remove the gasket. Discard the gasket.		 09400058
Remove the clip. Push the shaft out of the cover. Remove the o-ring. Discard the o-ring.		 09400059
CAUTION A gear puller must be used. Do not use force. The use of force will cause the aluminum housing to break. Remove the gear with a gear		

puller.

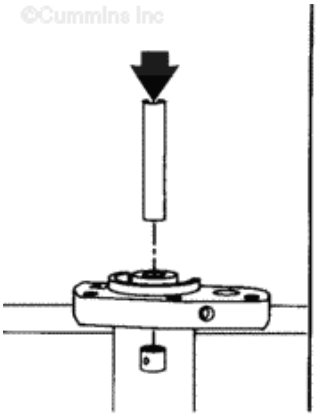


09400060

NOTE: Do not remove the bushings unless they do not meet specifications.

Remove the bushing from the housing with a mandrel and an arbor press.

Remove the bushing from the cover with a blind hole puller.

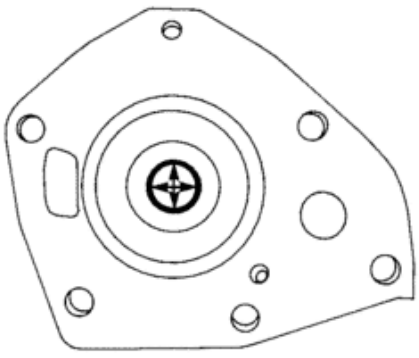


09400064

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.



09400061

Clean the housing and the

cover with solvent.

Inspect the housing and the cover for damage.

If the housing or the cover is damaged it **must** be replaced.

Measure the housing and cover bushing inside diameter.

Housing and Cover Bushing Inside Diameter		
mm		in
19.08	MIN	0.751
19.15	MAX	0.754

If the bushing in the housing or cover is **not** within specifications, the bushing **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.

Clean the gear and the shaft assembly with solvent.

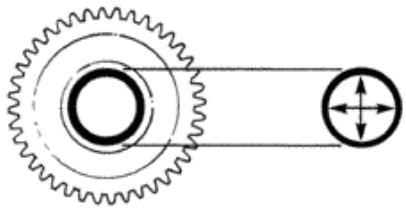
Inspect the gear and the shaft assembly for damage.

If the gear or the shaft assembly is damaged, it **must** be replaced.

Measure the inside diameter of the gear.

Gear Inside Diameter		
mm		in
18.948	MIN	0.746
18.974	MAX	0.747

If the gear is **not** within



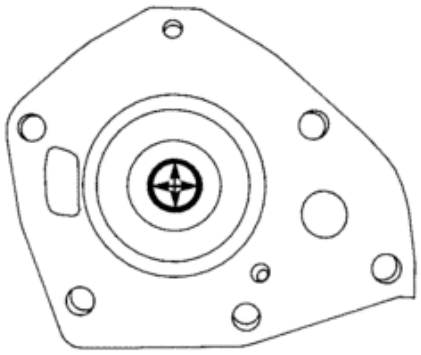
hd8geta

specifications, it **must** be replaced.

Measure the housing and cover bushing bore inside diameter.

Housing and Cover Bushing Bore Inside Diameter		
mm		in
22.23	MIN	0.875
22.25	MAX	0.876

If the housing or cover is **not** within specifications, the housing or cover **must** be replaced.



Assemble

CAUTION

To reduce the possibility of damage to the barring mechanism, the oil hole in the bushing must be aligned with the oil drilling in the housing.

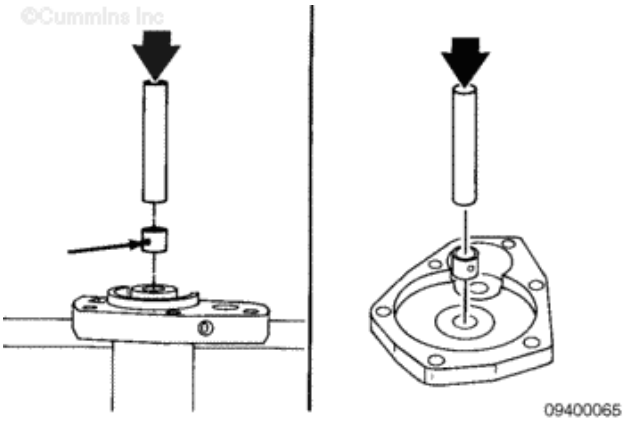
Align the oil hole in the bushing with the oil drilling in the housing.

Support the housing in an arbor press.

Press the bushing into the housing with a mandrel and arbor press.

NOTE: There is not an oil drilling for the bushing in the cover.

Support the cover in an arbor



press.

Press the bushing into the cover with a mandrel and arbor press.

The bushing **must** be even with the surface of the housing or cover.

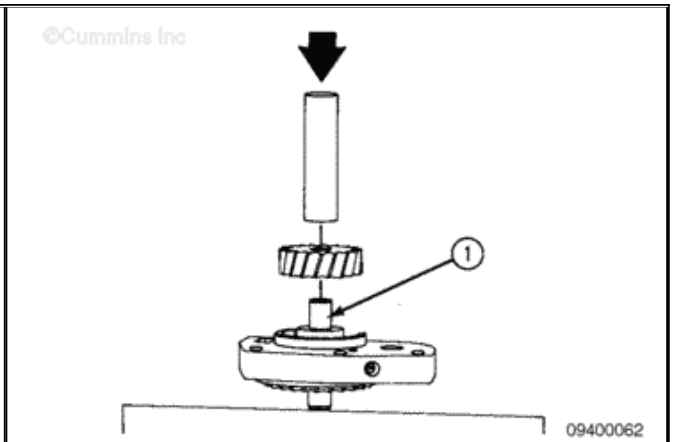
Lubricate the bushing shaft with engine oil.

Install the shaft (1) into the housing.

Lubricate the inside diameter of the gear with engine oil.

Place the gear onto the shaft with the part number positioned against the shaft.

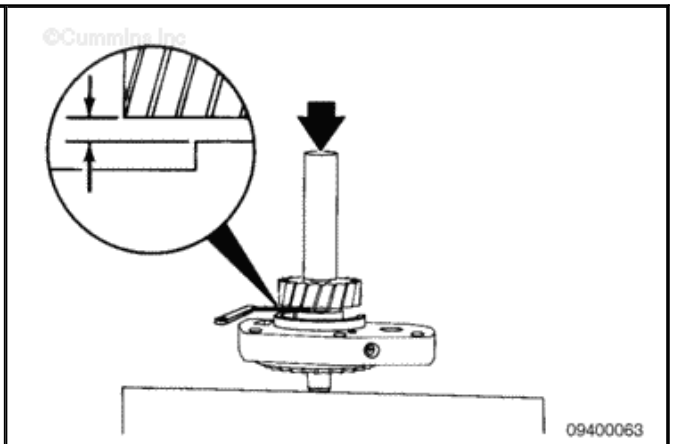
Press the gear onto the shaft with a mandrel and an arbor press.



Measure the gear to housing clearance.

Gear to Housing Clearance		
mm		in
0.18	MIN	0.007
0.38	MAX	0.015

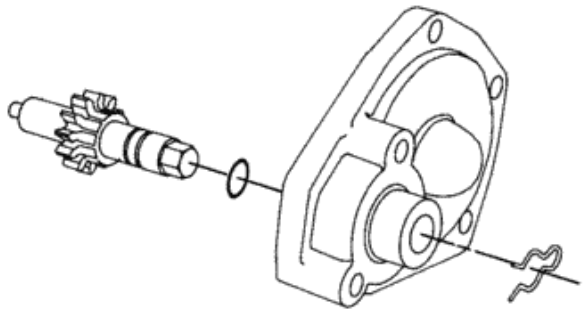
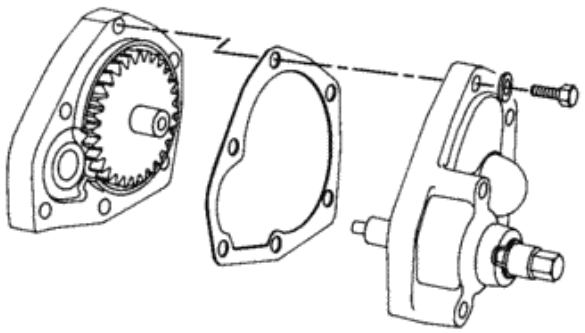
If the gear is **not** within specifications, press it on until the meets specifications.



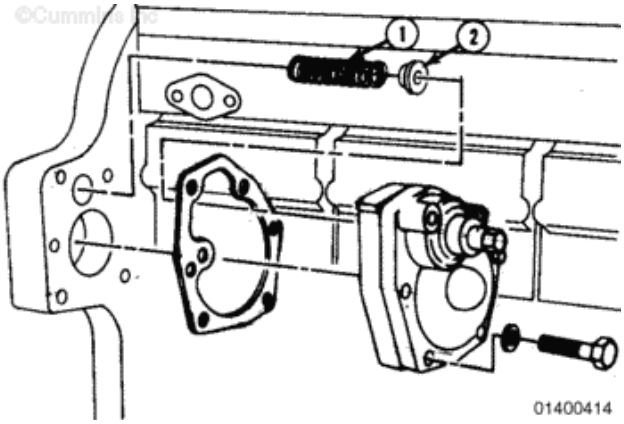
Lubricate the new o-ring with vegetable oil.

Install the o-ring onto the shaft into the groove nearest to the gear.

Lubricate the bushing in the cover with vegetable oil.

Install the shaft into the cover. Install the clip onto the shaft.		 09400059
Place a new gasket on the housing. Install the cover assembly onto the housing. Install the lock washer and capscrew. Do **not** tighten the capscrew until the assembly is mounted on the engine.		 09400058

Install

Install the spring (1) and retainer (2). Install the gasket, barring mechanism, washers and capscrews. Tighten the capscrews. **Torque** **Value:** 45 n.m [33 ft-lb]	 	 01400414

Last Modified: 11-Nov-2004

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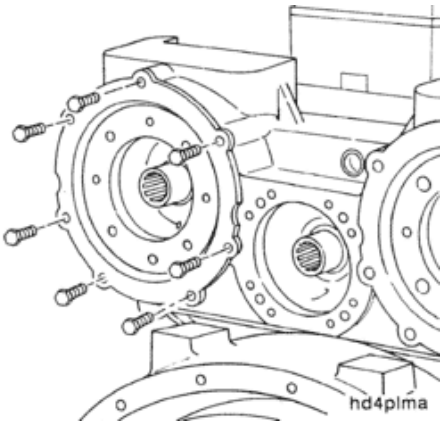
009-036 Outer Hydraulic Pump Support Drive

Remove

NOTE: Some engines will not have an outer hydraulic drive. These engines require a cover plate and a non-splined shaft, but do not use a hydraulic gear.

If a cover plate is used, remove the cover plate and non-splined shaft.

Remove the seven capscrews from the hydraulic drive.



WARNING

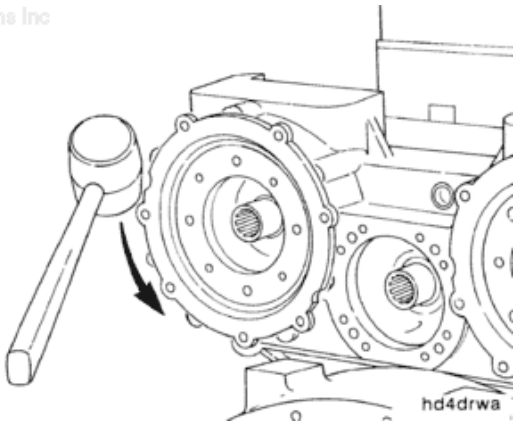
This component weighs 23 kg [50 lb] or more. Tor reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

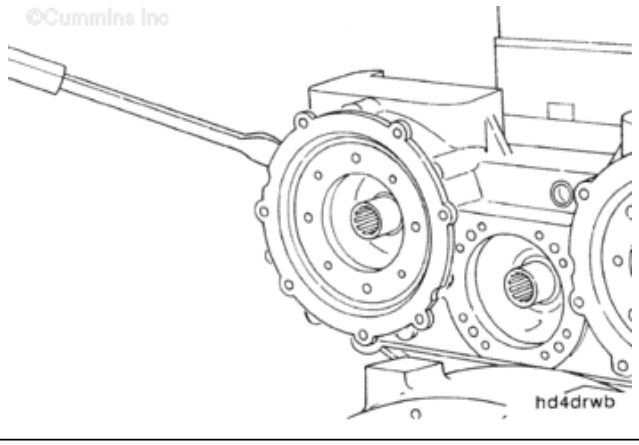
CAUTION

Care must be taken to avoid possible breakage of the capscrew mounting flanges.

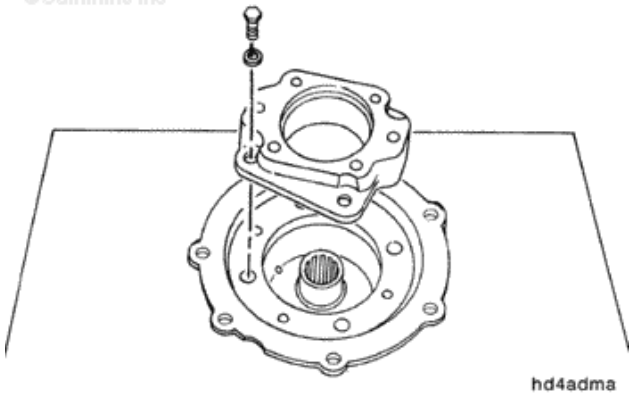
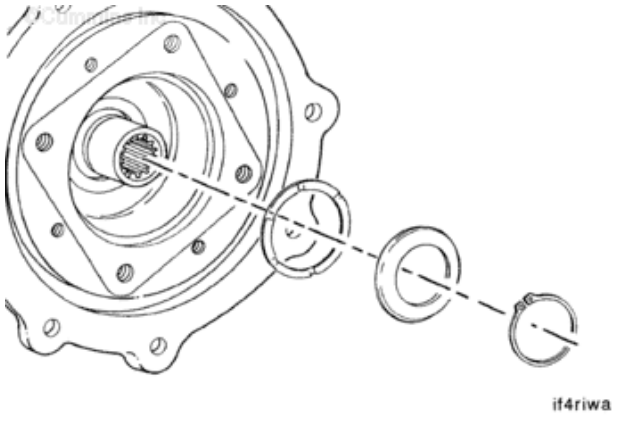
The outboard hydraulic pump supports **must** be rotated to remove them from the housing.

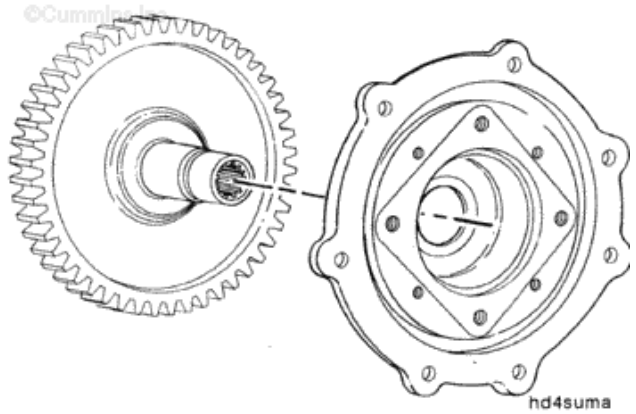
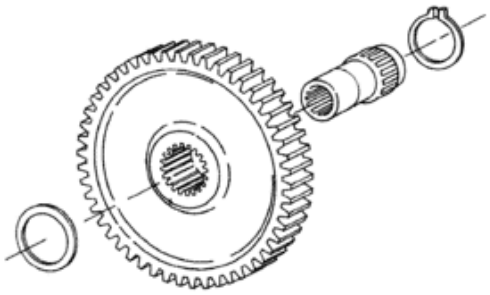
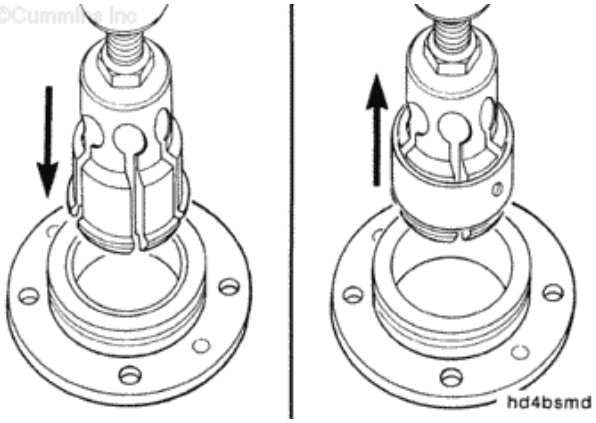
Use a mallet, and carefully tap the side of the support.



Remove the outboard hydraulic pump supports with a pry bar. Remove the gaskets. Discard the gaskets.		

Disassemble

Remove the hydraulic pump adapter and/or cover plate. Remove and discard the gasket.		
Remove the tapered retaining ring, bearing spacer, and thrust bearing. Check the bearing spacer for wear against the shaft shoulder.		

Remove the hydraulic pump support from the splined drive shaft.		 hd4suma
Remove the thrust bearing, gear, and non-tapered retaining ring from the drive shaft.		 hd4bema
NOTE: Remove the bushing only if it is not within specifications. Remove the bushing with a blind bushing puller.		 hd4bsmd

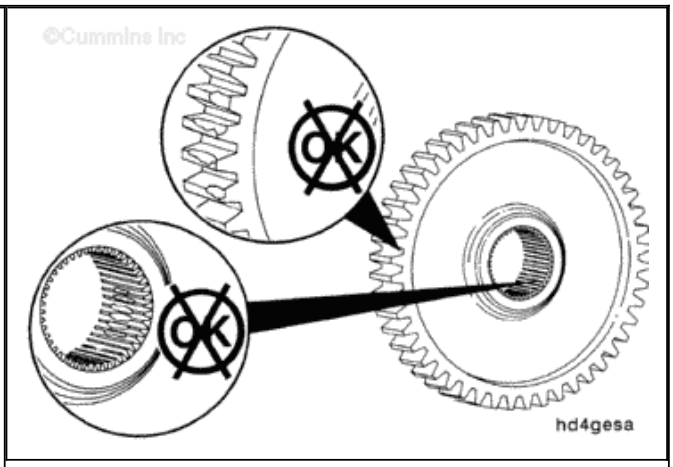
Clean and Inspect for Reuse

Clean the gear.

Inspect the idler gear for chipped, broken or cracked teeth.

Check the internal splines for wear.

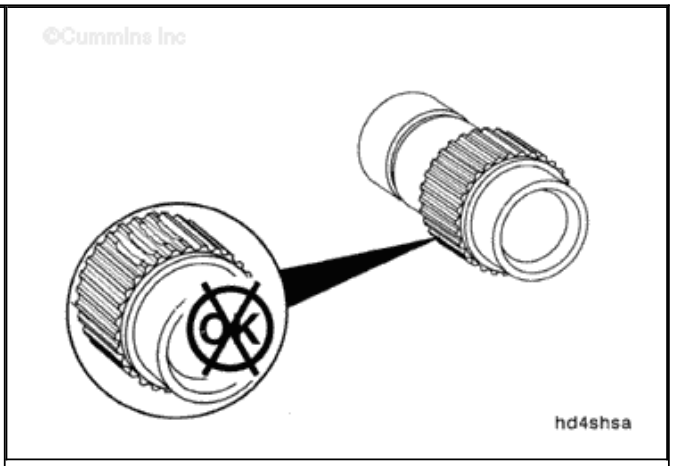
If the gear is damaged, it **must** be replaced.



Clean the hydraulic pump drive shaft.

Check the hydraulic pump drive shaft external splines for wear.

If the splines are excessively worn, the hydraulic pump drive shaft **must** be replaced.

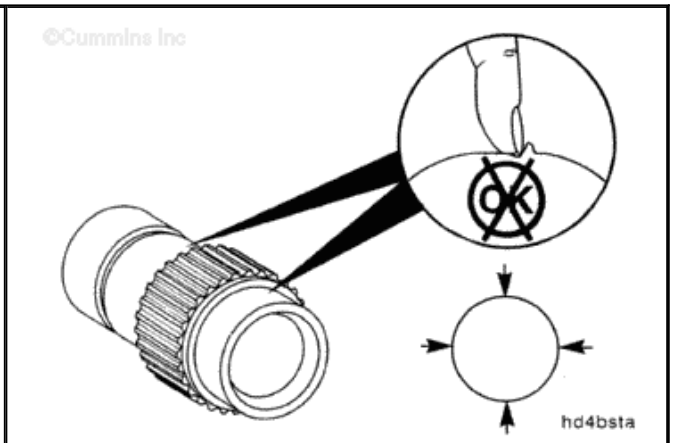


Inspect the bushing diameters on the shaft for wear.

If a fingernail will catch on scratches or grooves, the shaft **must** be replaced.

Measure the diameter of the shaft in the bushing area.

Drive Shaft Bushing Diameter		
mm		in
47.536	MIN	1.8715
47.549	MAX	1.8720



If the drive shaft is **not** within specifications, it **must** be replaced.

Check the retaining rings for damage.

If the retaining ring damaged, it **must** be replaced.

Clean the hydraulic pump support bushing.

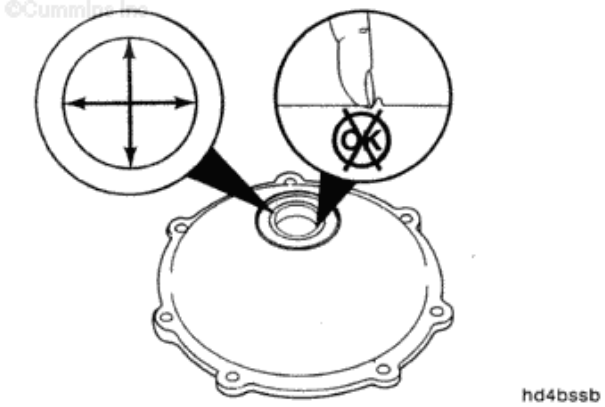
Inspect the hydraulic pump support bushing.

If a fingernail will catch on scratches or grooves, the bushing **must** be replaced.

Measure the bushing inside diameter.

Hydraulic Pump Support Bushing Inside Diameter		
mm		in
47.60	MIN	1.874
47.68	MAX	1.877

If the bushing is **not** within specification it **must** be replaced.

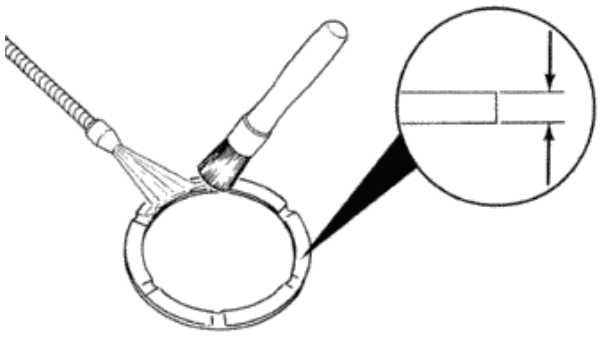


Clean the thrust bearings.

Measure the thrust bearing thickness.

Thrust Bearing Thickness		
mm		in
2.27	MIN	0.085
2.31	MAX	0.091

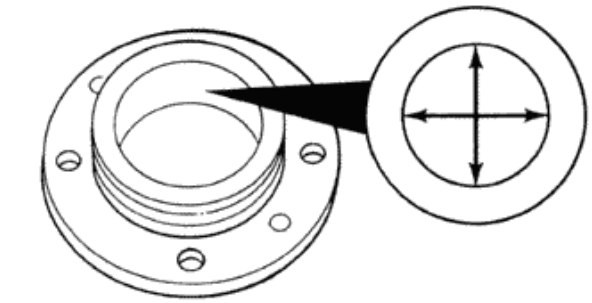
If the thrust bearing is **not** within specifications, it **must** be replaced.



Measure the hydraulic pump support bushing bore.

Hydraulic Pump Support Bore Inside Diameter		
mm		in
53.86	MIN	2.121
53.92	MAX	2.123

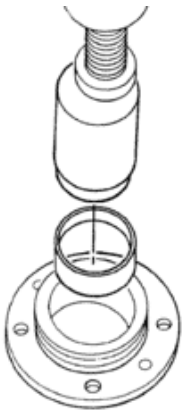
If the bushing bore is **not** specifications, the support **must** be replaced.



Assemble

Use the appropriate mandrel and press to install the bushing in the hydraulic pump support.

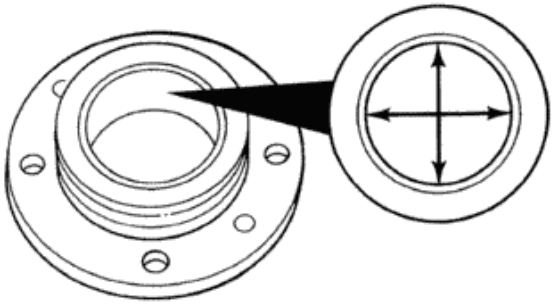
The bushing **must** be flush or **not** more than 5.08 mm [0.020 in] below the surface.

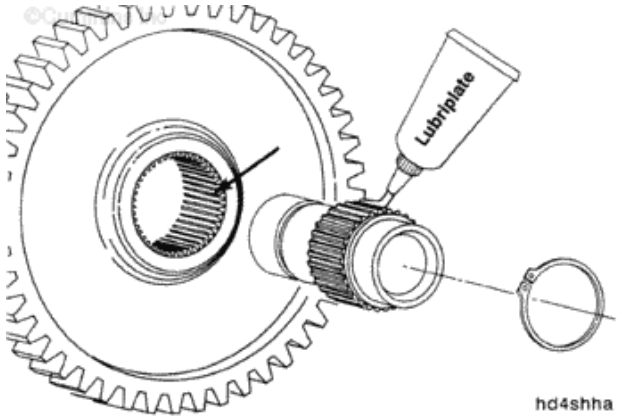
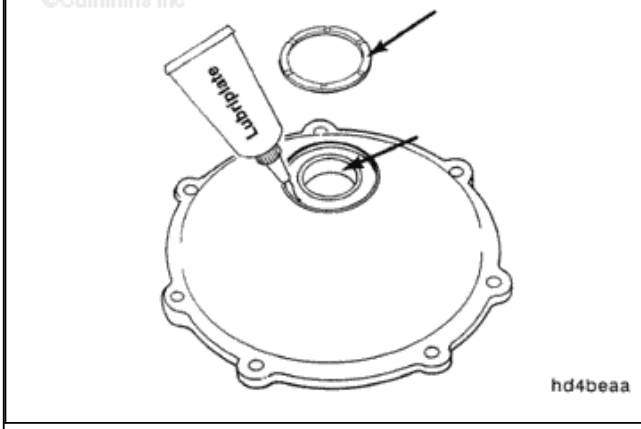


Measure the bushing inside diameter.

Hydraulic Pump Support Bushing Inside Diameter		
mm		in
47.60	MIN	1.874
47.68	MAX	1.877

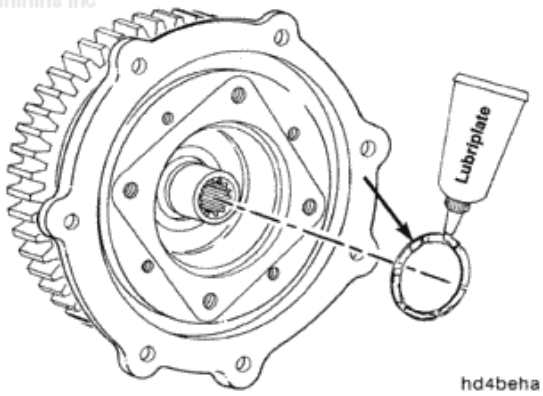
If the bushing is **not** within specifications, the support **must** be replaced.



Install the non-tapered snap ring onto the drive shaft. Lubricate the external splines on the drive shaft and the internal splines on the gear with Lubriplate® 105, or equivalent. Align and install the gear onto the drive shaft.		
Lubricate the hydraulic pump support bushing, counterbore, and one thrust bearing. Place the thrust bearing, with the grooved side up, into the counterbore of the cone shaped end of the hydraulic pump support.		
Place the gear and shaft assembly on the end with the gear end down. Align and install the hydraulic pump support cone end first onto the drive shaft and gear assembly.		
Lubricate a thrust bearing with Lubriplate® 105 or		

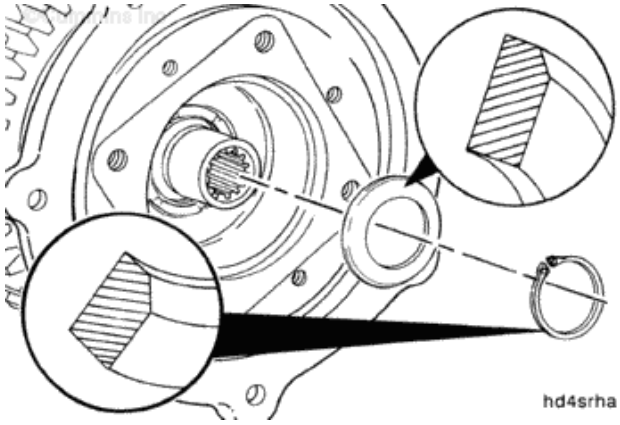
equivalent.

Install the thrust bearing into the counterbore of the hydraulic pump support with the grooved side up.



Install the bearing spacer over the drive shaft with the beveled side up.

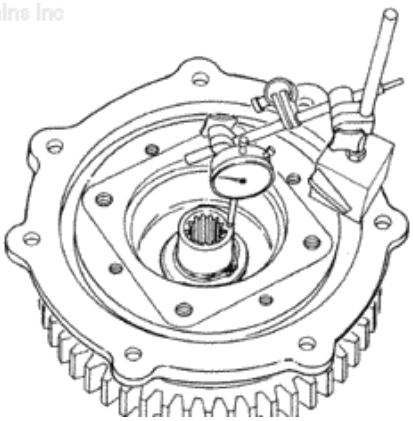
Install the tapered retaining ring into the groove of the drive shaft with the beveled side up.



Measure the gear end clearance.

Hydraulic Drive Gear End Clearance		
mm		in
0.10	MIN	0.004
0.51	MAX	0.020

If the end clearance is **not** within specifications, the thrust bearings **must** be replaced.



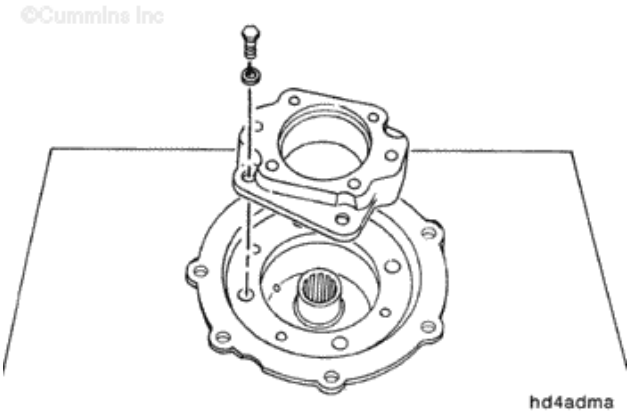
Install the hydraulic pump adapter or cover plate and gasket.

Install the capscrews.

Tighten capscrews.

Adapter	95 n.m	[70 ft-lb]
Cover Plate, SAE A Drive	40 n.m	[30 ft-lb]
Cover Plate, SAE B and C Drive	95 n.m	[70 ft-lb]



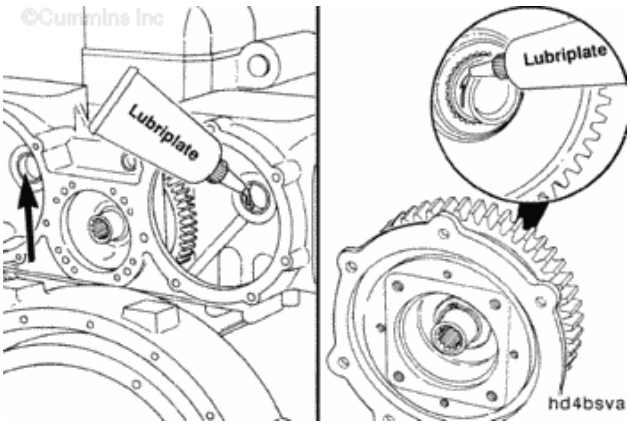


Install

Lubricate the outer hydraulic pump support bushings in the upper housing with Lubriplate® 105 or equivalent.

Lubricate the bushing surfaces on both shafts in the outer hydraulic pump support drive assemblies.



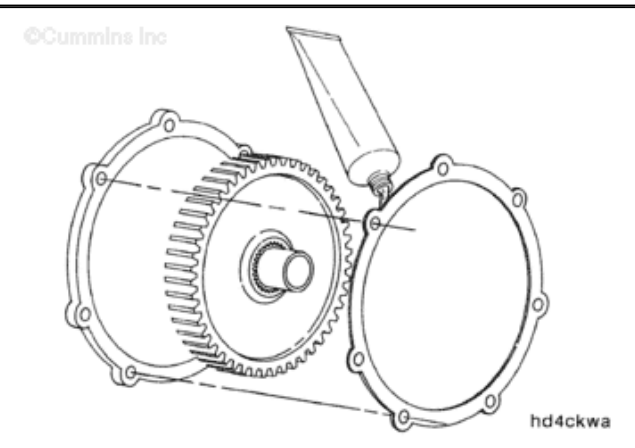


NOTE: Some engines will not have an outer hydraulic pump support drive. These engines require a cover plate and a non-splined shaft, but do not use a hydraulic gear.

Apply a thin coat of gasket adhesive to the gaskets.

Install the hydraulic support housing gaskets to both





support mounting flanges on the outer hydraulic pump support drive assemblies.

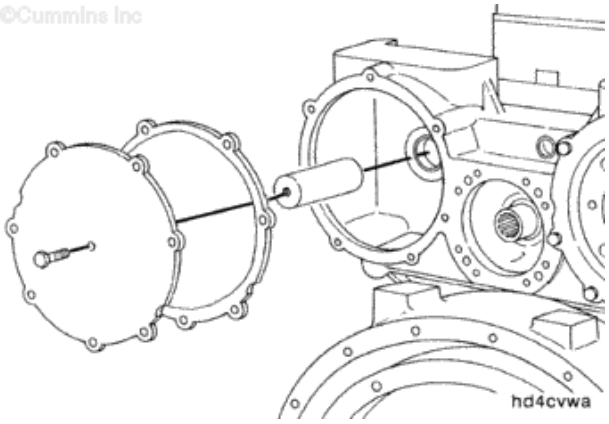
If using the outer hydraulic pump support cover plate, install the non-splined shaft onto the cover plate with a 3/8-16 x 1¼ inch capscrew.

Tighten the capscrew.

Torque
Value: 40 n.m [30 ft-lb]

Install the cover plate assembly and capscrews.

Tighten the capscrews.

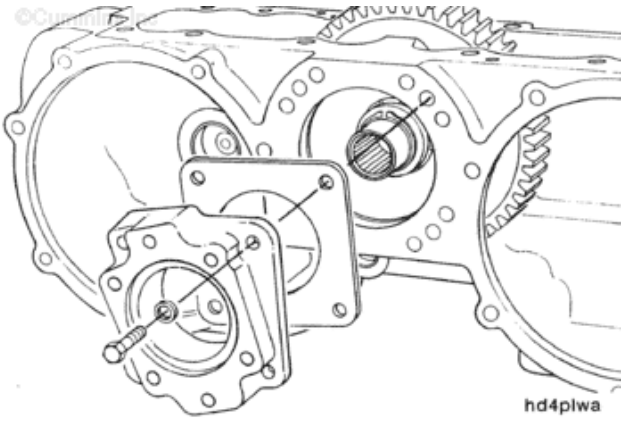


WARNING

This component weighs 23 kg [50 lb] or more. Tor reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

Install three 7/16 - 14 x 4 guide studs.

Install one outer hydraulic pump support drive assembly.



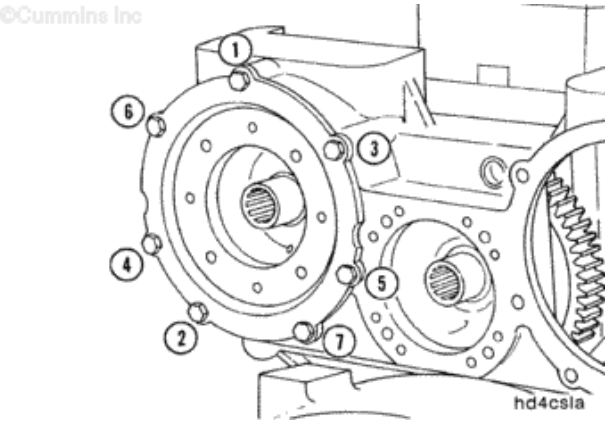
Install four capscrews.

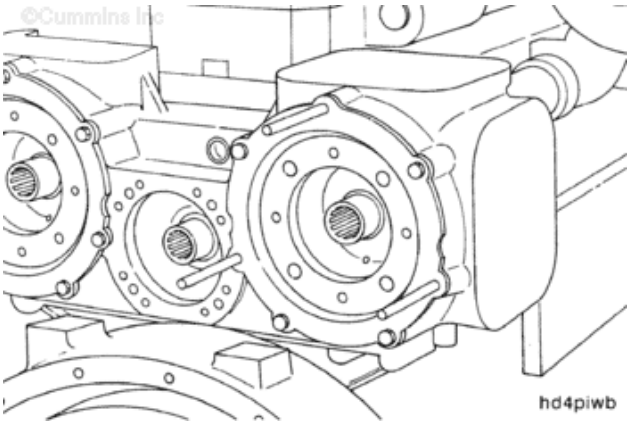
Hand tighten the capscrews.

Install the remaining three capscrews.

Tighten the capscrews in sequence.

Torque
Value: 70 n.m [50 ft-lb]



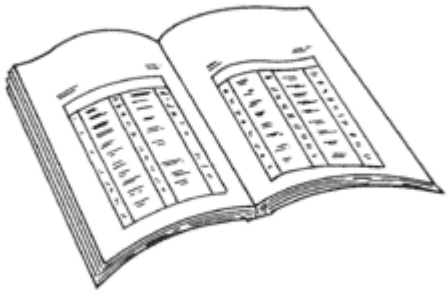
Use the same procedure to install the remaining outer hydraulic drive assembly.		

Last Modified: 11-Nov-2004

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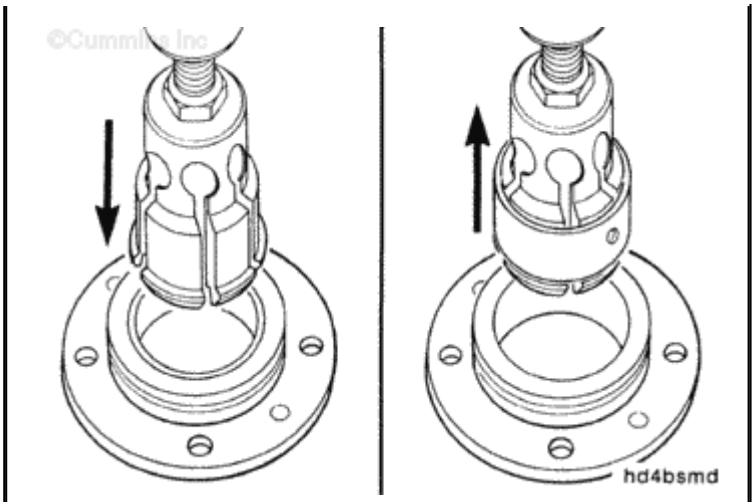
009-037 Hydraulic Pump Support Bushing

Preparatory Steps

• Remove the hydraulic pump support from the rear gear drive (upper assembly). Refer to Procedure 009-024.		©Cummins Inc  ck800wa

Disassemble

Remove the bushing with a blind bushing puller.		

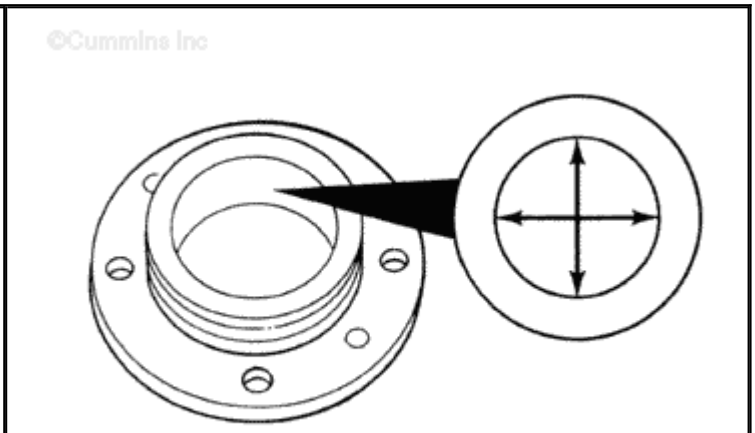


Inspect for Reuse

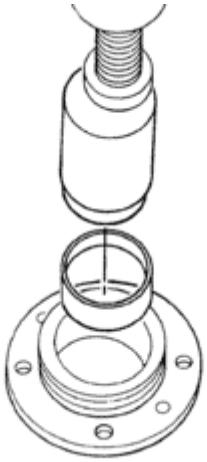
Measure the bushing bore.

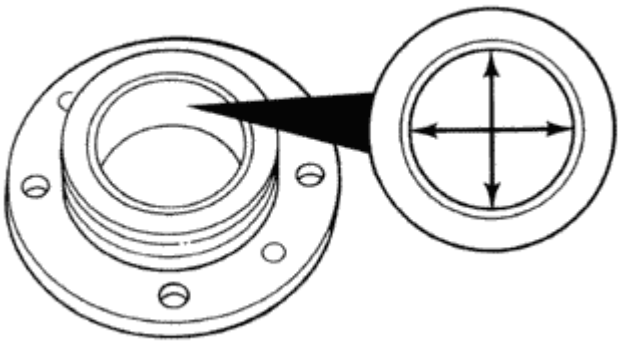
Hydraulic Pump Support Bushing Bore Inside Diameter		
mm		in
53.86	MIN	2.121
53.92	MAX	2.123

If the bushing bore is **not** within specifications, the support **must** be replaced.



Assemble

Use an appropriate bushing mandrel and a press. Install the bushing flush with the support or **not** more than 5.08 mm [0.200 in] below the surface.		 hd4bstf

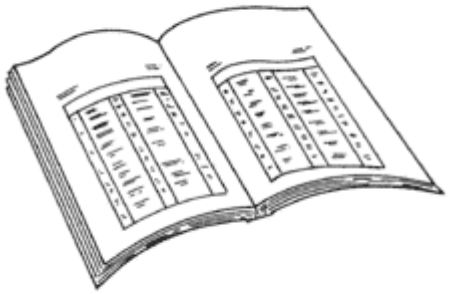
Measure the bushing inside diameter. Hydraulic Pump Support Bushing Inside Diameter mm in 47.60 MIN 1.874 47.68 MAX 1.877 If the bushing is **not** within specifications, the support **must** be replaced.		 hd4bstg

Finishing Steps

• Install the pump support into the rear gear drive (upper		

assembly). Refer to Procedure 009-024.

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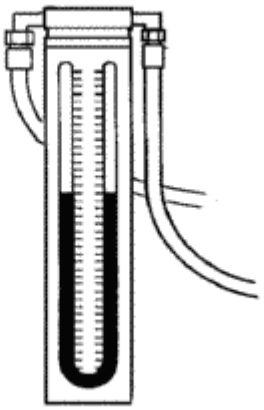
ck800wa

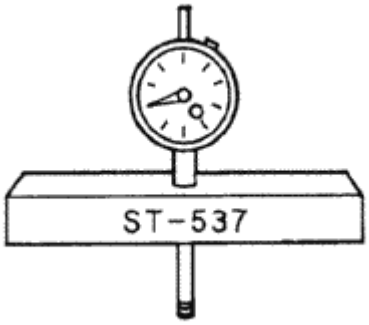
Last Modified: 29-Nov-2004

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022-001 Service Tools

Air Intake System

Tool Number		
ST-1111-3	**Manometer** Use to measure air inlet restriction.	 eg100ja

Tool Number		
ST-537	**Dial depth gauge** Use to check for proper nozzle ring crush or end clearance checks on turbochargers.	 ST-537

Last Modified: 15-Nov-2004

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010-002 Aftercooler Assembly

Preparatory Steps

WARNING

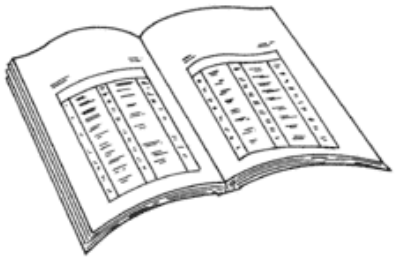
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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.





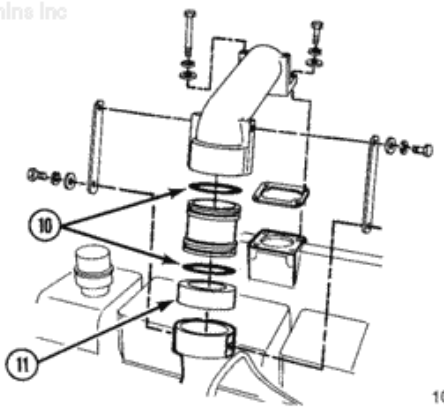
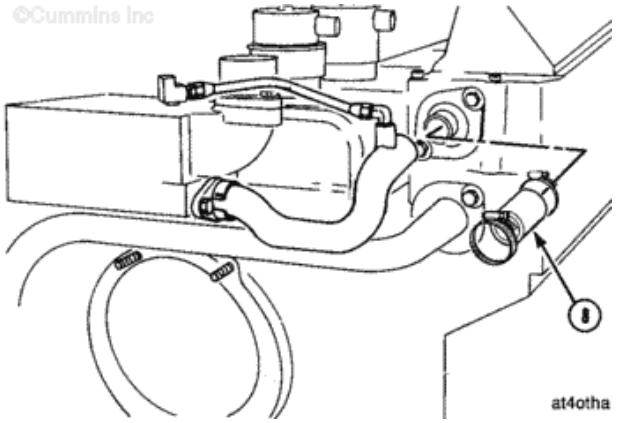
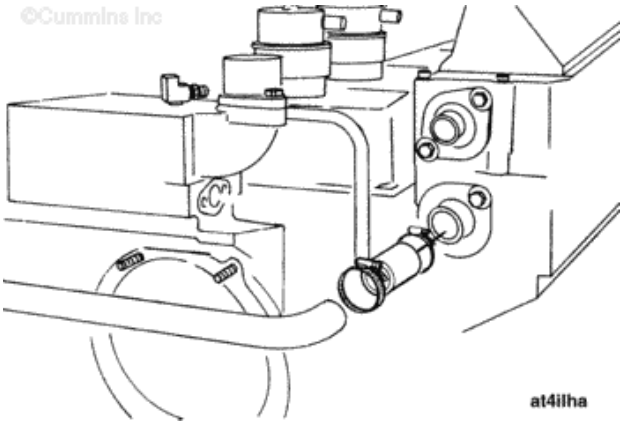
ck800wa

Remove

Remove the four mounting capscrews at the aftercooler cover.

Remove the air crossover (hose connection design).

Remove the retainer straps (o-ring connection design

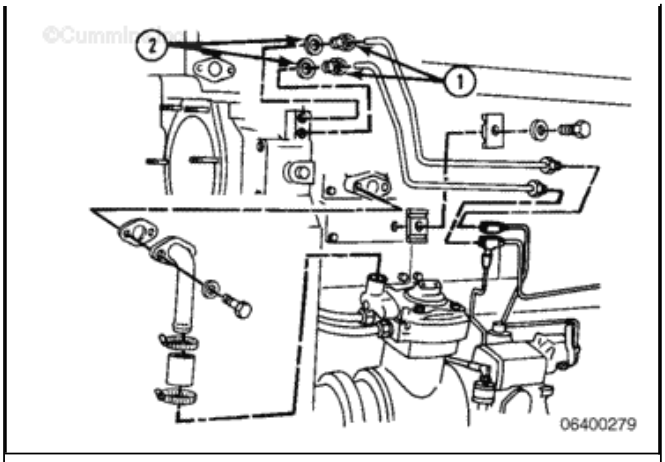
shown). Remove the air crossover. Discard the o-rings (10) and the dust seal (11).		
Loosen the two hose clamps and remove the outlet hose (8). Remove the coolant vent tube.		
Loosen the two hose clamps and remove the inlet hose.		
Remove the air compressor air inlet connection. Remove and discard the		

hose.

Loosen the fuel tubing nuts at the fuel junction block on the fuel manifold.

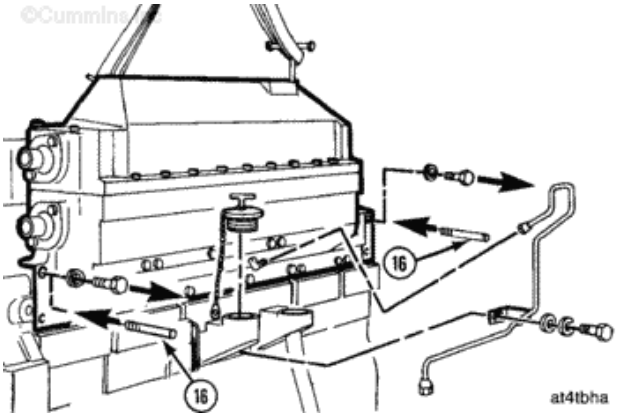
Remove the fuel tubing mounting clamp and the fuel tubes.

Remove and discard the grommets.



Remove AFC tube and oil fill cap.

If the engine contains a crankcase breather in one of the cam follower covers, remove the cam follower cover.



WARNING

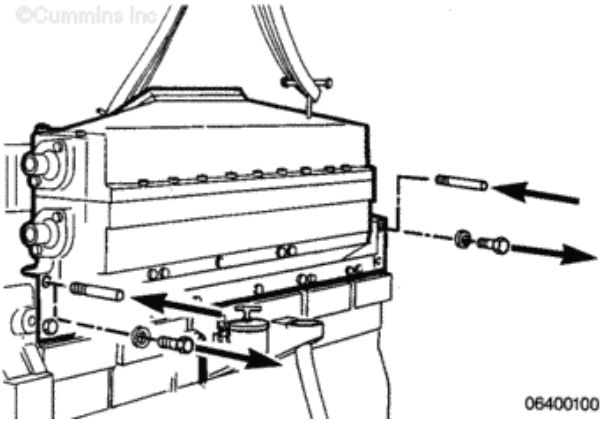
This assembly weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury use a hoist or get assistance to lift this assembly.

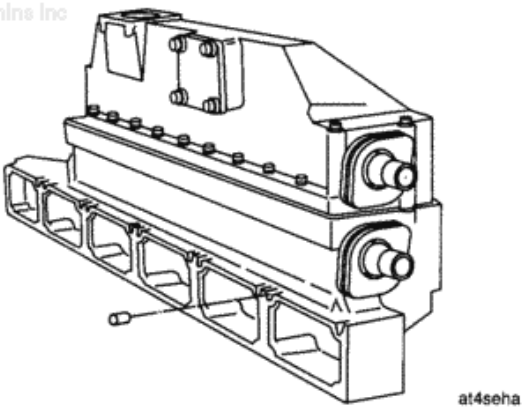
Remove two mounting capscrews.

Install two 3/8x16 in guide studs.

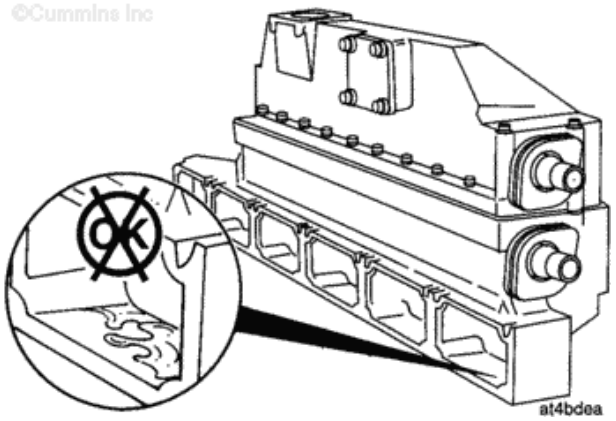
Attach two tee handles to the aftercooler housing.

Attach the sling and hoist and raise the hoist until there is



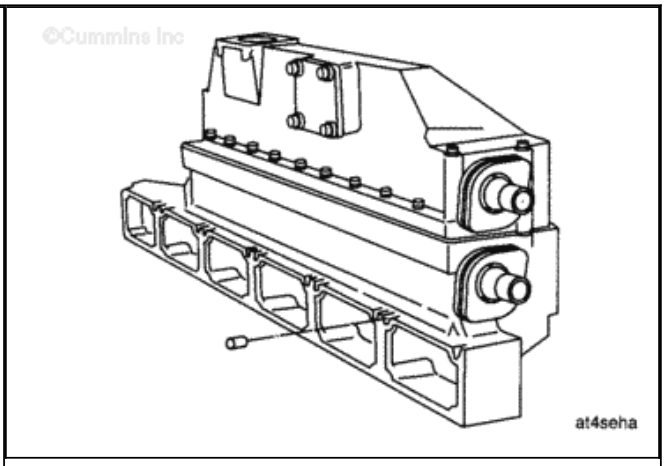
tension on the sling. Remove the remaining capscrews and aftercooler assembly. Remove and discard the gaskets.		
Remove and discard the aftercooler bolt seals from the aftercooler housing.		

Clean and Inspect for Reuse

Clean the aftercooler. Inspect the aftercooler ports for indications of coolant leakage. Inspect the cylinder head ports for indications of coolant leakage.	 	

Install

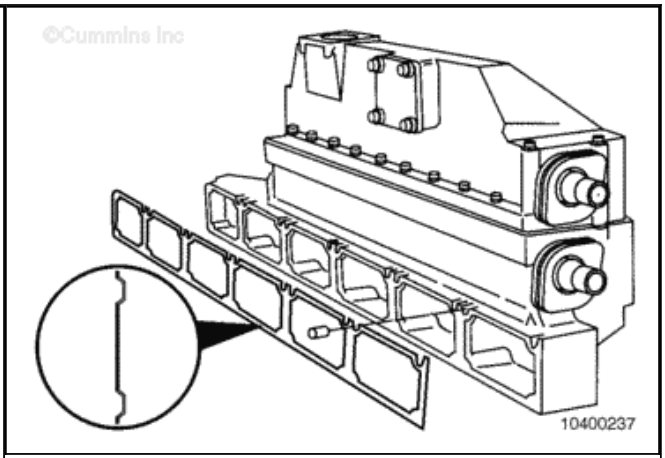
Install the bolt seals into the aftercooler housing.



Use guide studs long enough to protrude beyond the installed part.

Install 12 guide studs in the upper row of capscrew holes in the cylinder heads.

Install the gasket onto the studs with the raised bead on the gasket toward the cylinder head.



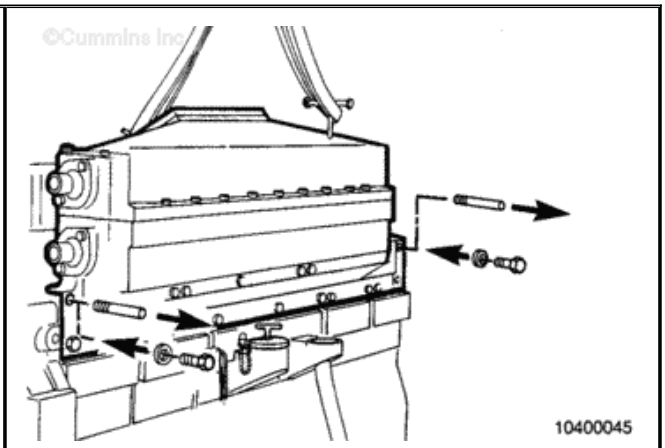
WARNING

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 aftercooler and the bottom row of capscrews.

Tighten the capscrews **only** enough to hold the part.

Remove the guide studs and



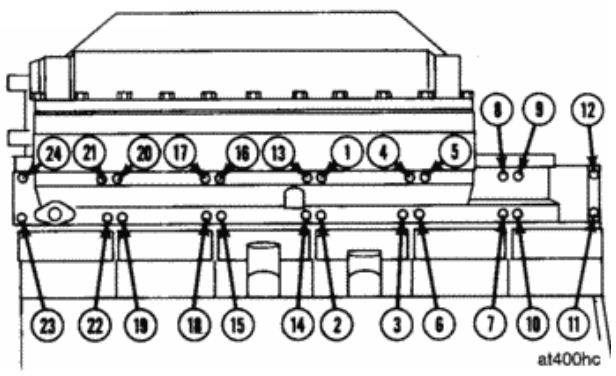
install the top row of capscrews.

Remove the hoist, tee handles, and sling.

Tighten the capscrews in the sequence illustrated in the graphic.

Torque Value: Step 1 25 n.m [20 ft-lb]

Step 2 45 n.m [33 ft-lb]



NOTE: The AFC assembly is not used on all fuel pumps.

Connect the AFC tube to the fittings on the intake manifold and the fuel pump.

Install the tube clip and tighten the capscrew.

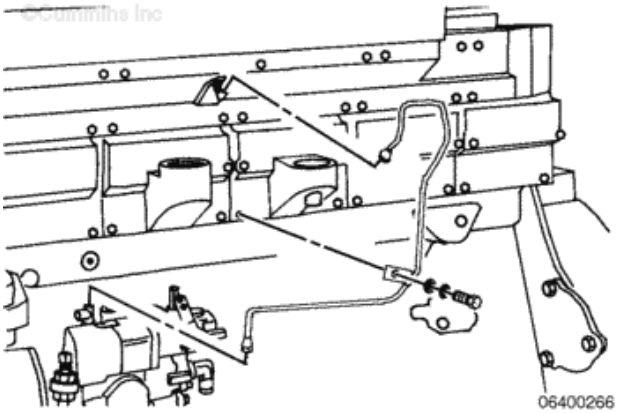
Torque Value: 45 n.m [33 ft-lb]

Install the oil fill cap.

Install any cam follower cover and gasket that were removed.

Tighten the capscrews.

Torque Value: 45 n.m [33 ft-lb]



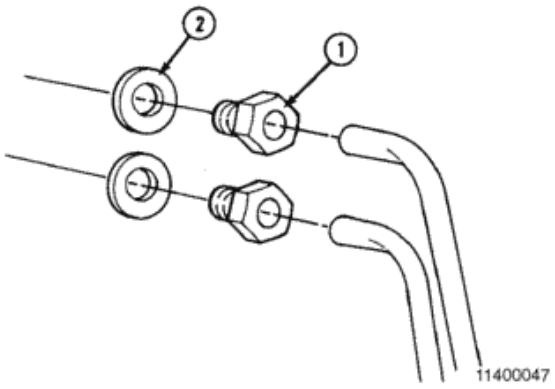
CAUTION

The tube seals (2) must be installed on the tubes

before the tubes are inserted into the junction block.

The fuel pressure tube is the lower tube and the fuel drain tube is the upper tube.

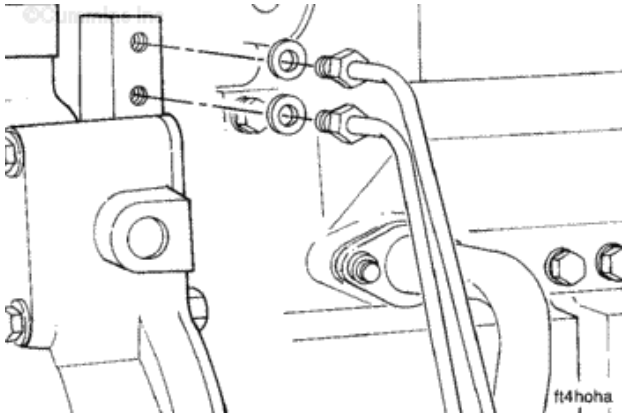
Install the tube nut (1) and the seals (2) on the fuel tubes.



CAUTION

Do not over tighten the tube nuts and the junction block. Finger tighten the tube nuts into the junction block. Turn the tube nuts an additional ¾ to 1 turn past finger tight.

Connect but do **not** tighten the fuel tubes to those that were **not** removed. Insert the fuel tubes into the junction block on the fuel manifold.



Tighten the tubing nuts at the connection with the other tubes.

Install the tube clamp to the cam follower cover.

Torque
Value: 45 n.m [33 ft-lb]

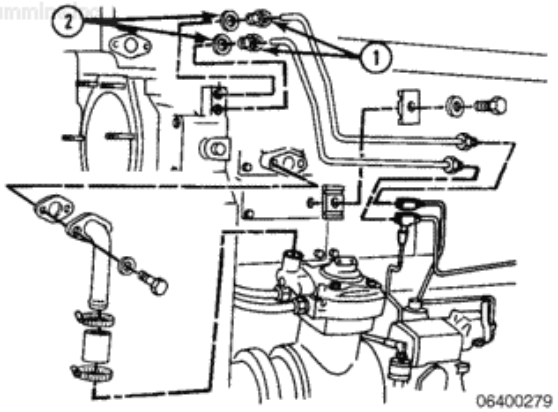
Install the air compressor inlet connection.

Tighten the capscrew.

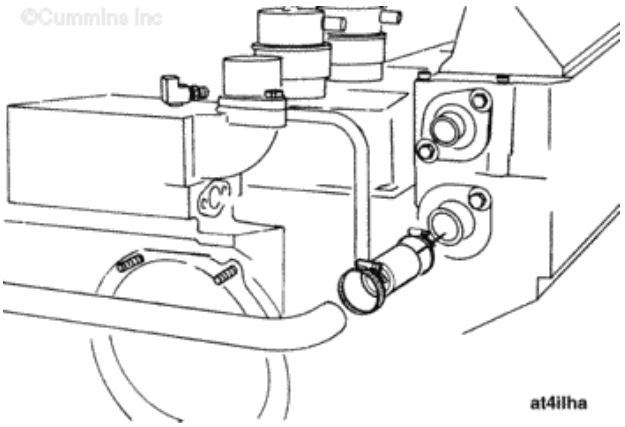
Torque
Value: 45 n.m [33 ft-lb]

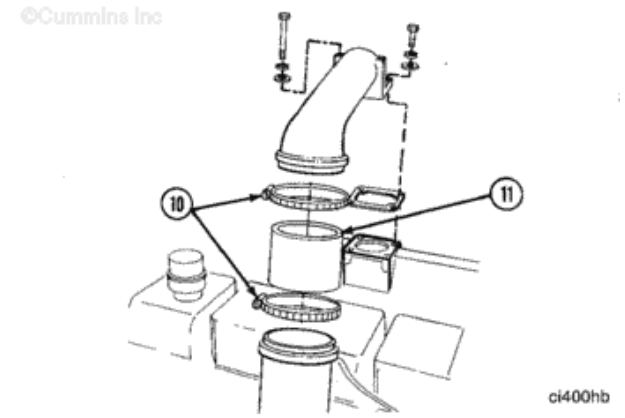
Tighten the air compressor inlet connection clamp.

Torque

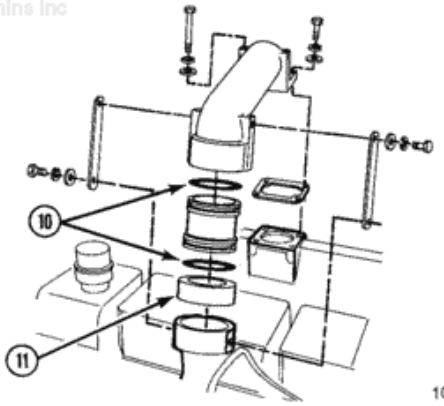


Value: 6 n.m [50 in-lb]		

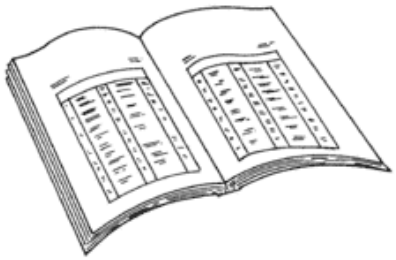
Connect the inlet hose. Tighten the clamps. **Torque** **Value:** 6 n.m [50 in-lb]		

Install the hose (connection type) air crossover. Install the hose (11) and the two clamps (10) onto the crossover tube. Install the air crossover. Slide the hose down over the turbocharger inlet. Install the gasket and capscrews. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb] Tighten the hose clamps. **Torque** **Value:** 8 n.m [75 in-lb]		

Install the (o-ring connections crossover). Lubricate the o-rings with vegetable oil and install them onto the tube. Install the tube into the crossover. Install the dust seal (11) onto		

the tube. Install the gasket, crossover and the capscrews. Tighten the capscrews. **Torque** **Value:** 40 n.m [30 ft-lb] Install the retainer straps, washers, and capscrews. Tighten the capscrews. **Torque** **Value:** 20 n.m [15 ft-lb]		©Cummins Inc 

Finishing Steps

• Fill the cooling system. Refer to Procedure 008-018. • Operate the engine to a coolant temperature of 71°C [160°F] and check for leaks.		©Cummins Inc 

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010-006 Aftercooler Coolant Tube

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.

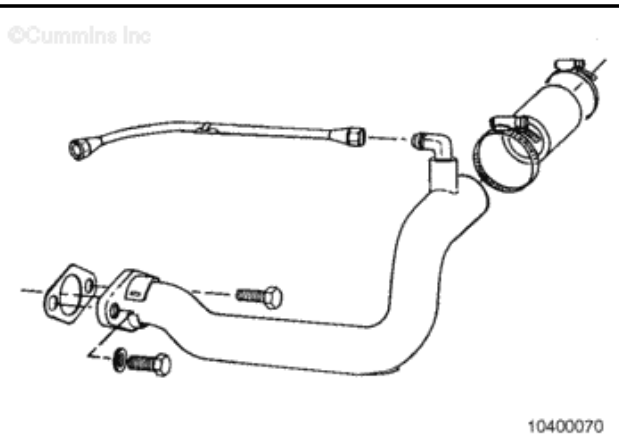
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the aftercooler water inlet and outlet tubes with solvent.

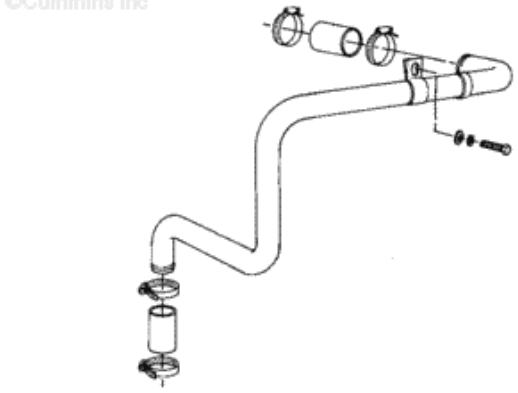
Dry with compressed air.

Use a wire brush to clean the hose sealing surfaces.



Inspect the aftercooler water tubes for damage.

If a water tube is damaged, it **must** be replaced.



Last Modified: 15-Nov-2004

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010-008 Aftercooler Element

Preparatory Steps

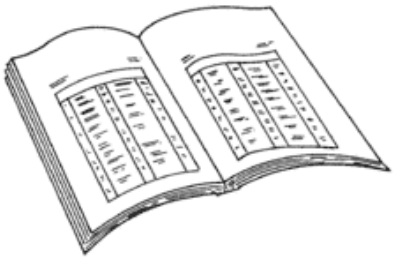
WARNING

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 or spray 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 air crossover tube. Refer to Procedure 010-019.
- Remove the aftercooler assembly. Refer to Procedure 010-002.

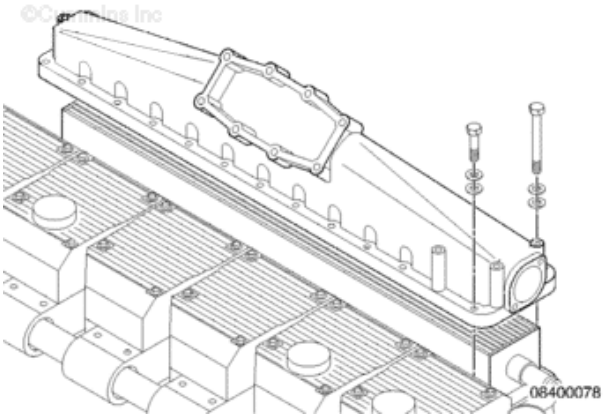
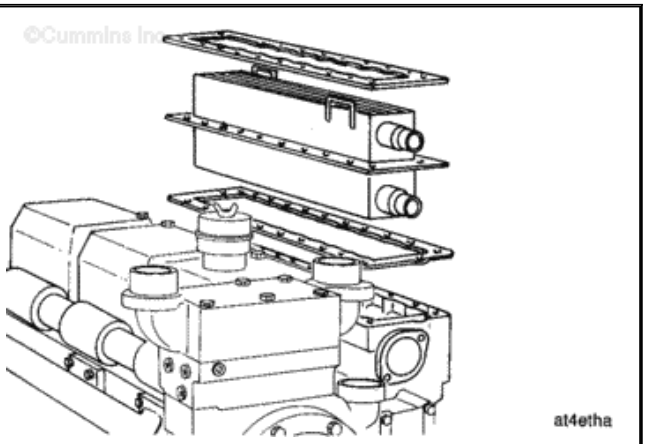


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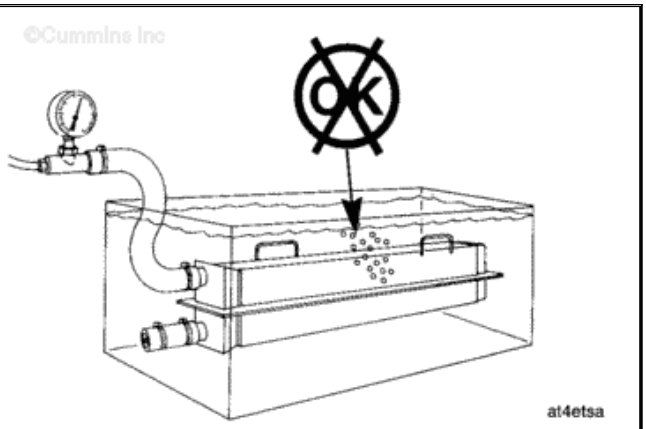
Disassemble

Remove the aftercooler cover capscrews.

Remove the aftercooler

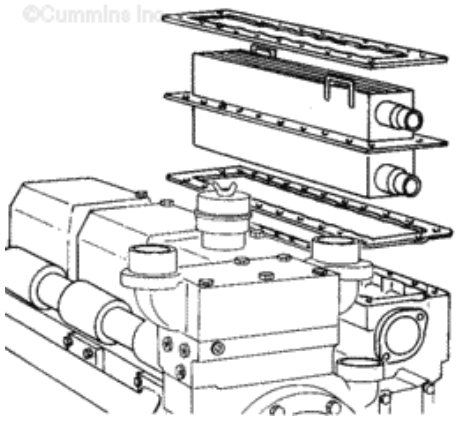
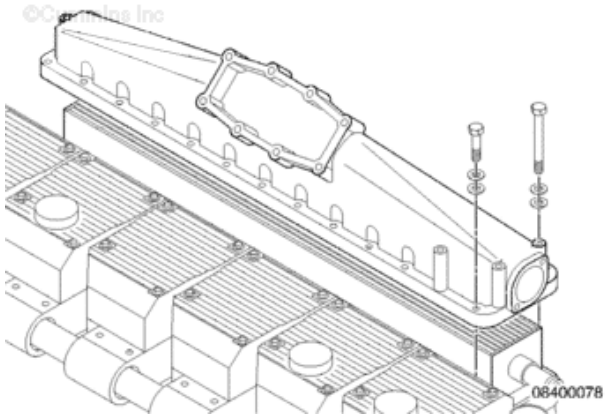
cover.		
Remove the aftercooler element and gaskets. Discard the gaskets.		

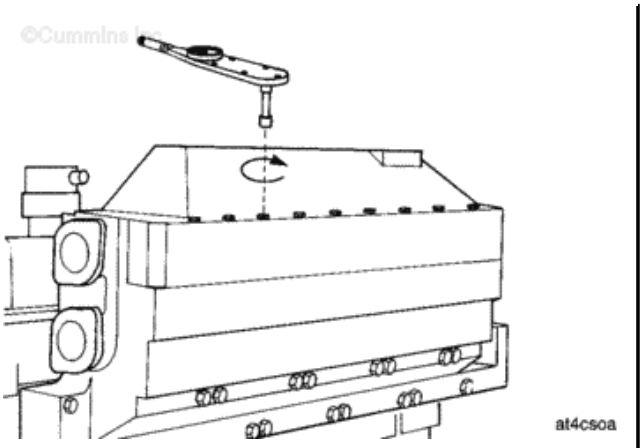
Pressure Test

Install a hose plugged with a pipe plug to one aftercooler element water tube. Attach an air line a gauge to the remaining tube. Heating the tank water to 50° [120°F] will improve test results. Place aftercooler element into a tank of water. Apply 415 kPa [60 psi] of air		

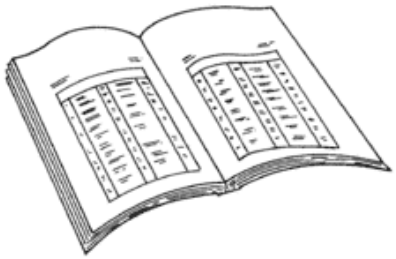
pressure and check for leaks. If the aftercooler element leaks, it **must** be replaced.		

Assemble

Install the aftercooler element and two gaskets.		
Install the aftercooler cover and capscrews. **NOTE: Do not tighten the capscrews until the inlet and outlet seals are installed.**		
After the inlet and outlet seals have been installed, tighten the capscrews. **Torque Value:** Step 1 35 n.m [25 ft-lb] 50 n.m [35 ft-		

Step 2 lb]		

Finishing Steps

• Install the aftercooler assembly. Refer to Procedure 010-002. • Install the air crossover tube. Refer to Procedure 010-019. • Fill the cooling system. Refer to Procedure 008-018.		

Last Modified: 15-Nov-2004

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010-018 Air Connection Pipe (Turbocharger to Turbocharger)

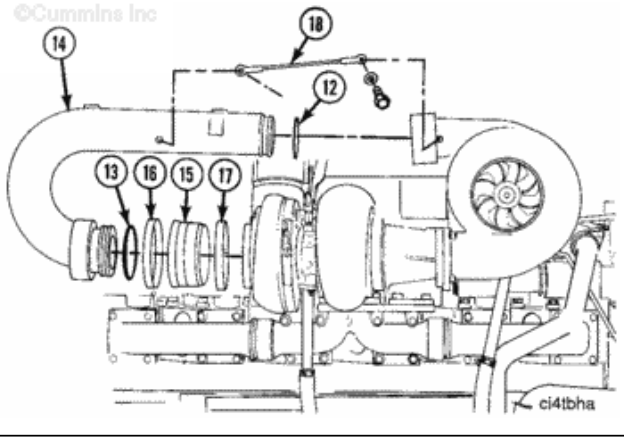
Remove

Remove the two retaining straps (18).

Loosen hose clamps (16) and (17).

Remove the air transfer tube.

Remove and discard the o-rings (12 and 13) and the dust seal (15).

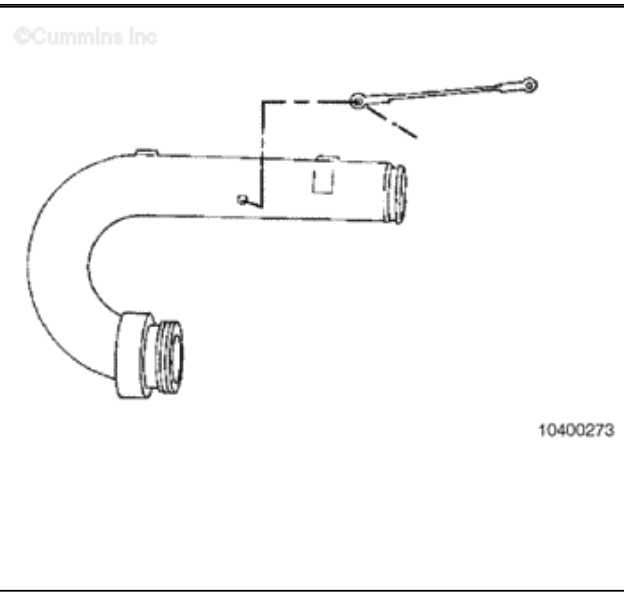


Clean and Inspect for Reuse

WARNING

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

Clean the transfer connection with solvent.



Check the air transfer pipe and two retaining straps for damage or cracks.

If the air transfer pipe is damaged or cracked, it **must** be replaced.

If a retaining strap is damaged or cracked it **must** be replaced.

Install

Use transfer tube (14) without o-rings, to check the alignment. The tube **must** slide easily onto both turbochargers.

Adjust the compressor housing on the low stage turbocharger to allow alignment if necessary.

Slide the dust seal (15), the clamps (16 and 17), on the pipe (14).

Lubricate the o-rings with vegetable oil and install them onto the pipe (14).

Install the pipe into the turbochargers. Install the dust seal and clamps.

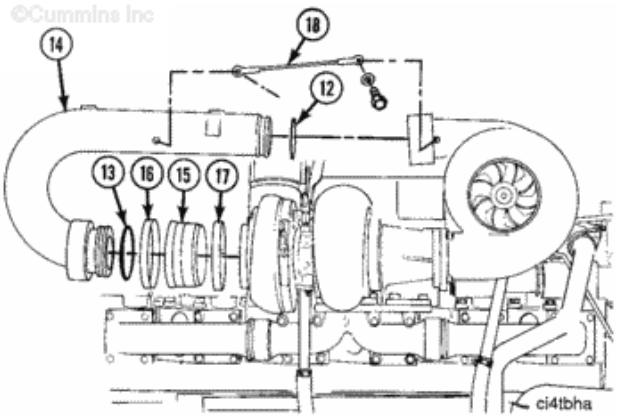
Tighten the clamps.

Torque
Value: 6 n.m [50 in-lb]

Install the two adjusting links (15), washers, and the capscrews.

Tighten the capscrews

Torque
Value: 20 n.m [15 ft-lb]



010-019 Air Crossover

Remove

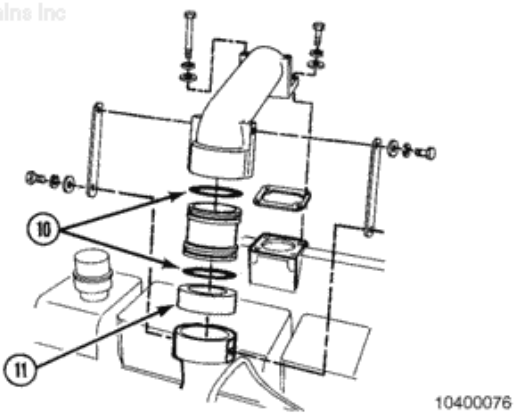
NOTE: Some engines contain a hose and clamps in place of the o-ring, dust seal, and retainer straps.

Remove the four capscrews and two retaining straps from the air crossover.

Remove the air crossover assembly.

Remove the o-rings and dust seal.

Discard the o-rings and dust seal.

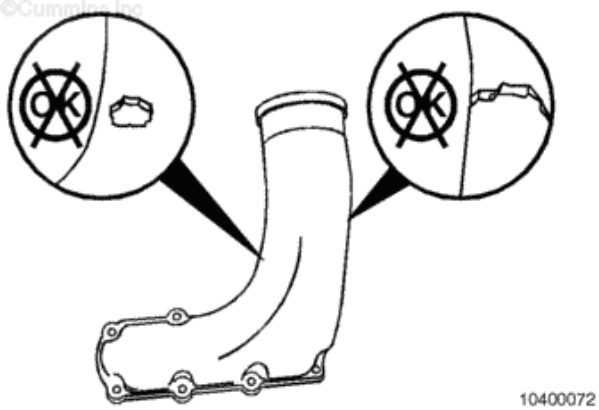


Clean and Inspect for Reuse

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 safety glasses or a face shield, as well as protective clothing, to prevent personal injury when using a steam cleaner or high pressure water.

Do **not** reuse the o-rings (1) or the dust shield (2).

Clean the parts with solvent or steam.

Check the bore of the air crossover and the o-ring grooves of the tube.

Install

Lubricate the o-rings (10) with vegetable oil.

Install the o-rings onto the tube.

Install the tube into the crossover.

Install the dust seal (11) on the tube.

Install the gasket, air crossover, and capscrews.

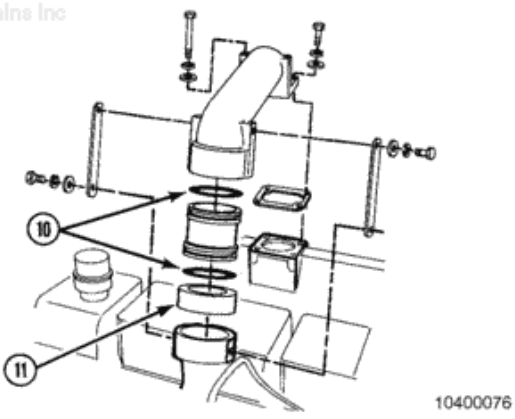
Tighten the capscrews.

Torque
Value: 40 n.m [30 ft-lb]

Install the retaining straps, washers, and capscrews.

Tighten the capscrews.

Torque
Value: 20 n.m [15 ft-lb]



010-024 Air Leaks, Air Intake and Exhaust Systems

Test

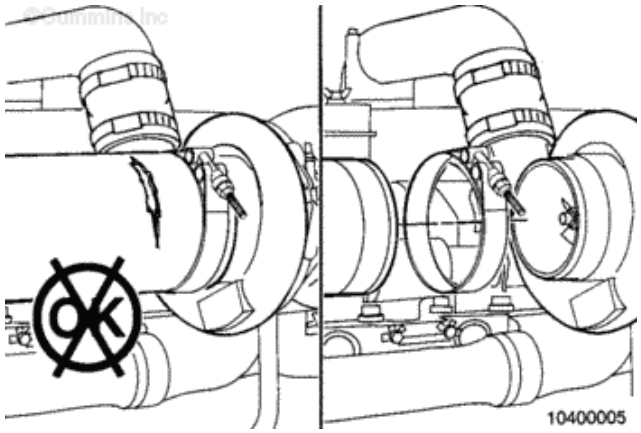
CAUTION

The engine air intake must be filtered to prevent dirt and debris from entering the engine. If 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.

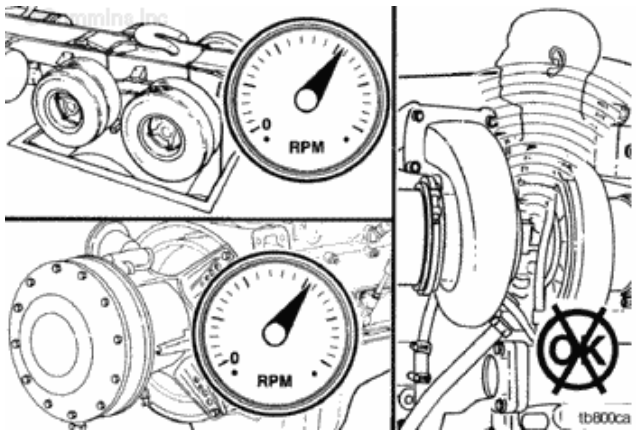
Torque Value: 8 n.m [75 in-lb]



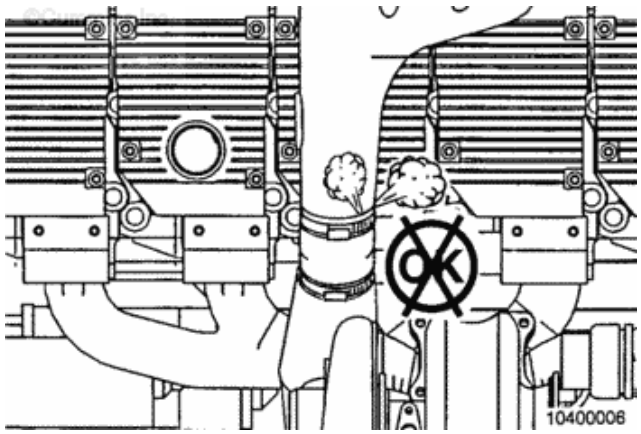
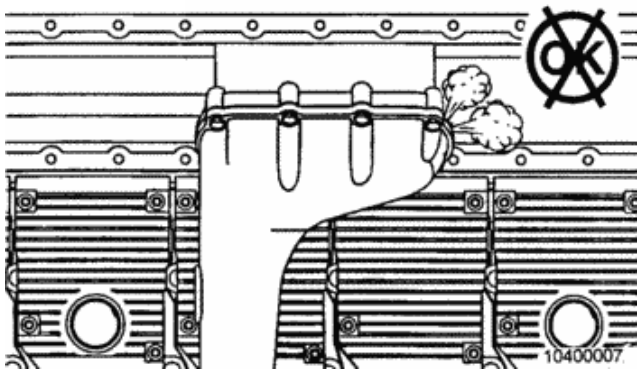
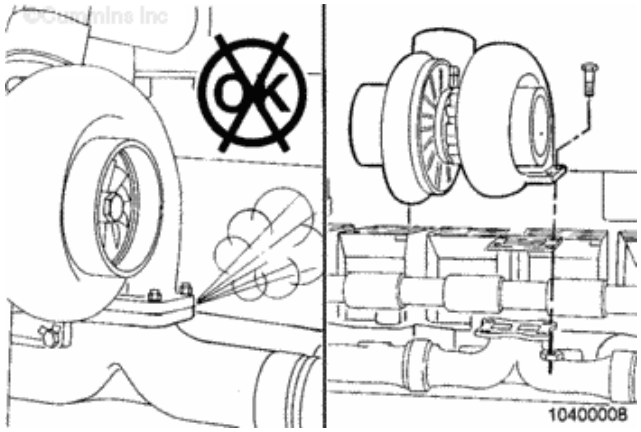
NOTE: Stall speed is not full power.

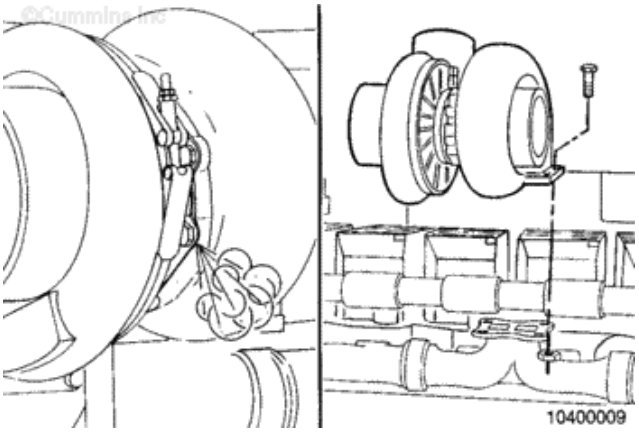
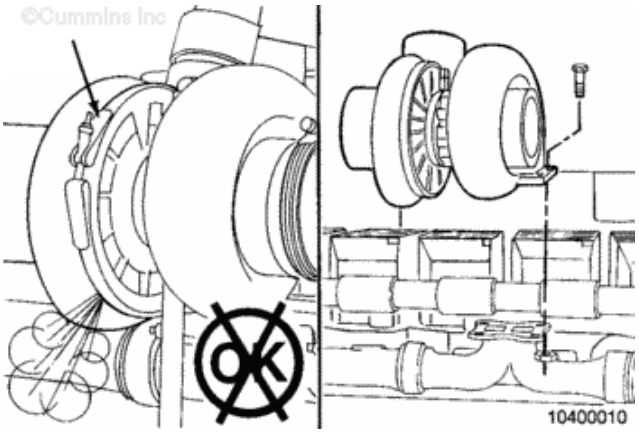
Operate the engine at rated rpm and load.

Listen for a high pitch noise from the turbocharger.



If there is a turbocharger-

to-aftercooler air supply hose leak, inspect the hose for damage. Tighten the hose clamps, refer to Procedure 010-002.		
If there is a air crossover-to-aftercooler connection leak, replace the air crossover gasket. Refer to Procedure 010-019.		
If there is a turbocharger-to-exhaust manifold leak, replace the gasket. Refer to Procedure 010-033.		
If there is a turbocharger turbine housing-to-bearing housing sealing surface		

leak, Tighten the capscrews. Tighten capscrews. **Torque** **Value:** 20 n.m [180 in-lb] If an air leak is still present, replace the turbocharger. Refer to Procedure 010-033.		
If there is a turbocharger compressor housing sealing surface air leak, tighten the V-band clamp. Tighten the V-band clamp. **Torque** **Value:** 8 n.m [75 in-lb] If an air leak is still present, remove and replace the turbocharger. Refer to Procedure 010-033.		

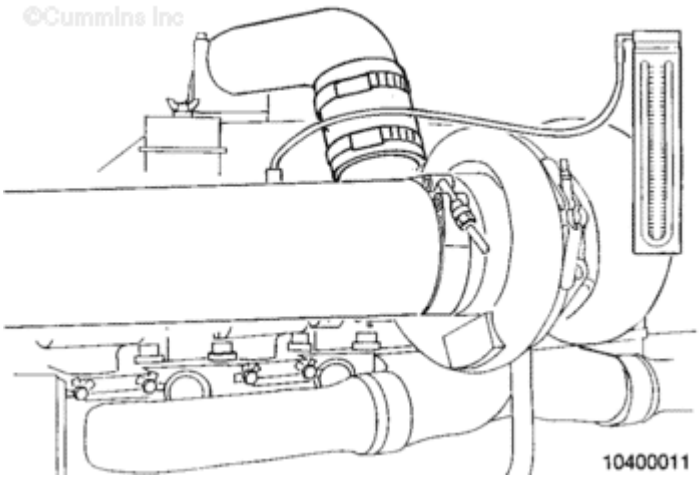
Last Modified: 29-Nov-2004

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010-031 Air Intake Restriction

Measure

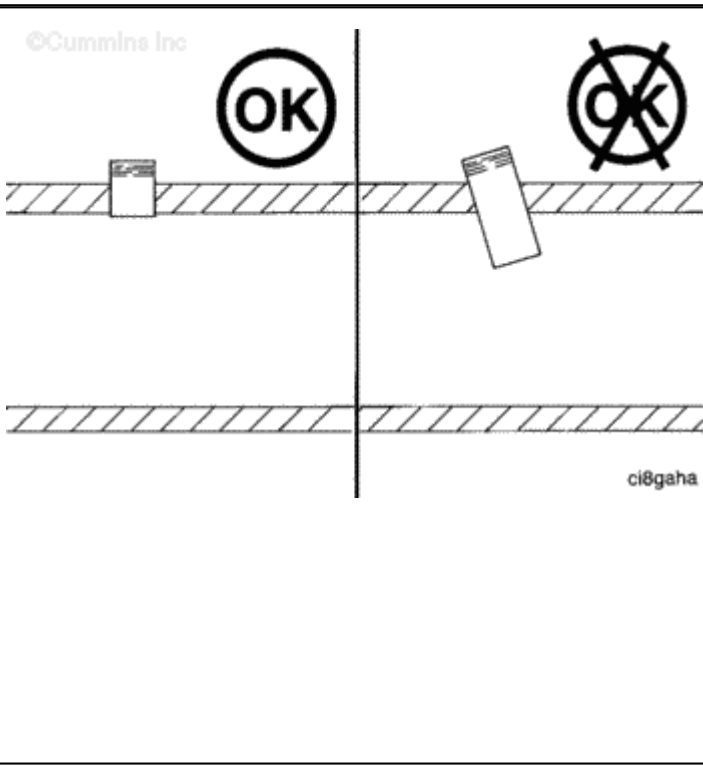
Install a vacuum gauge or water manometer in the intake piping between the turbocharger and the air filter. The gauge **must** have a capacity of 1270 mm H_2O [50 inch H_2O].



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 through the wall of the air intake tubing.

If the adapter **must** be located in a curved section of

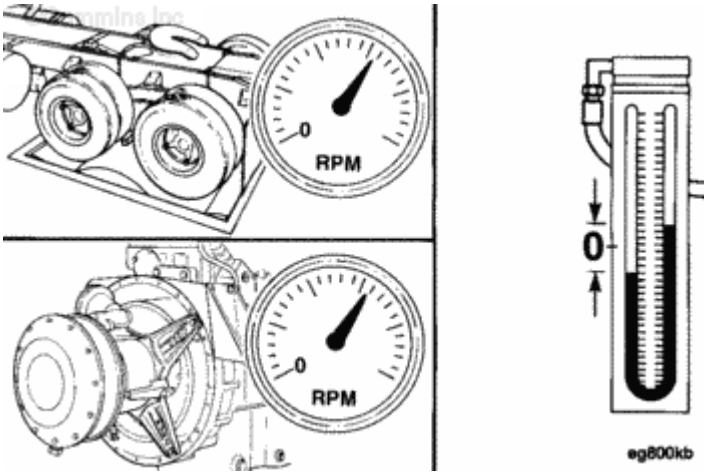


tubing, locate it on the flat side of the curve, **not** in the radius.

NOTE: Stall speed is not full power.

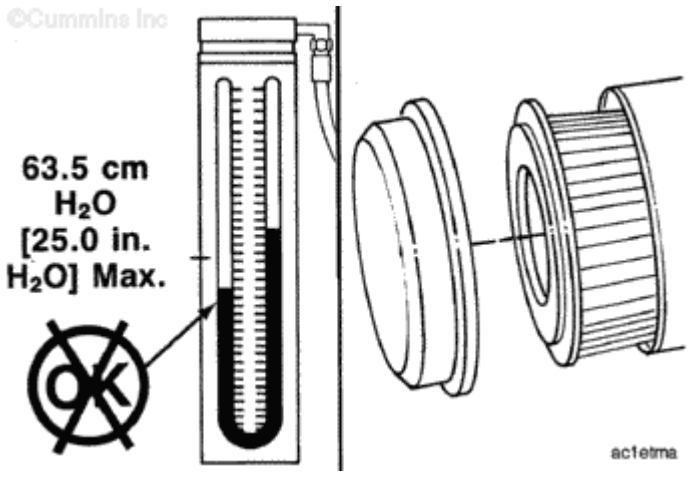
Operate the engine at full throttle and rated rpm with maximum load. Record the reading of the gauge or manometer.

Maximum Operating Air Restriction (Dirty Filter)		
mm-h2o		in-h2o
65	MAX	25

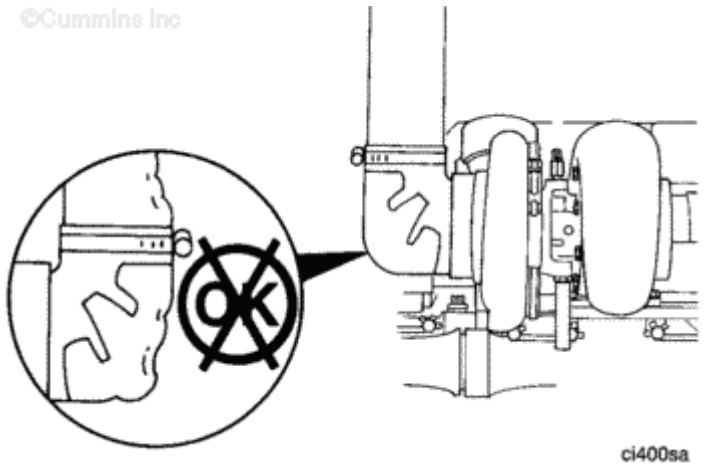
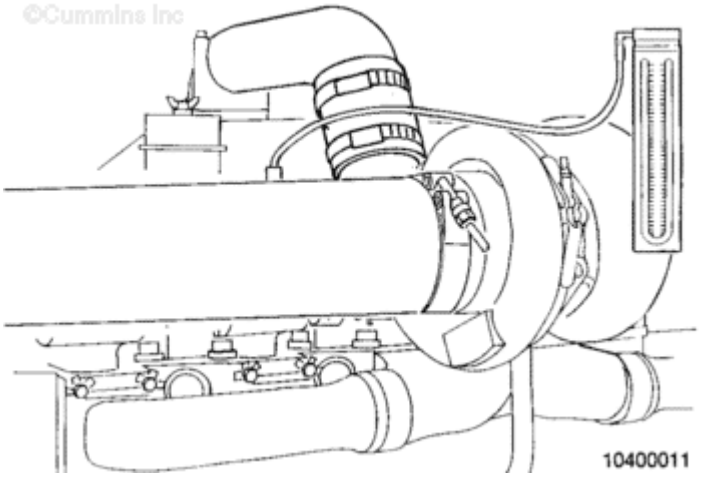


If the restriction exceeds specifications, do the following:

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 damage is **not** visible, check the size and routing of the intake air piping. Refer to the Installation Recommendations.		
Remove the test equipment.		

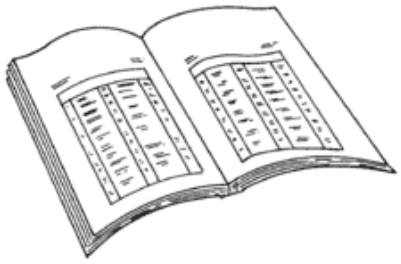
Last Modified: 29-Nov-2004

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010-033 Turbocharger

Preparatory Steps

Single Turbocharger

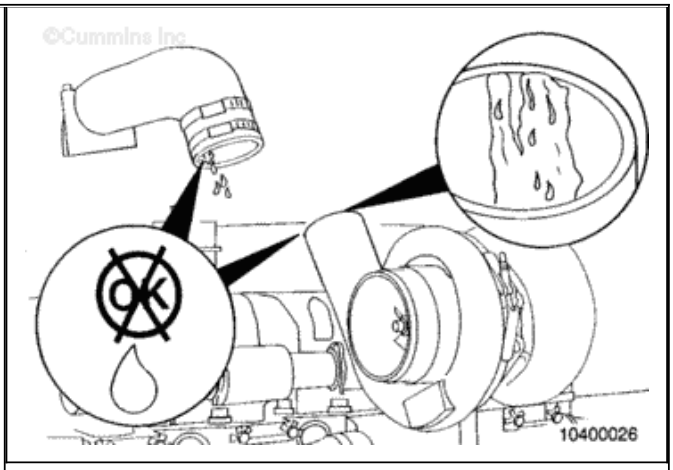
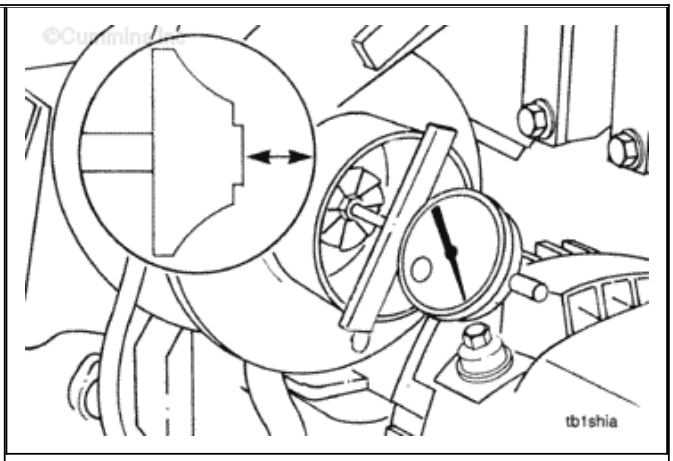
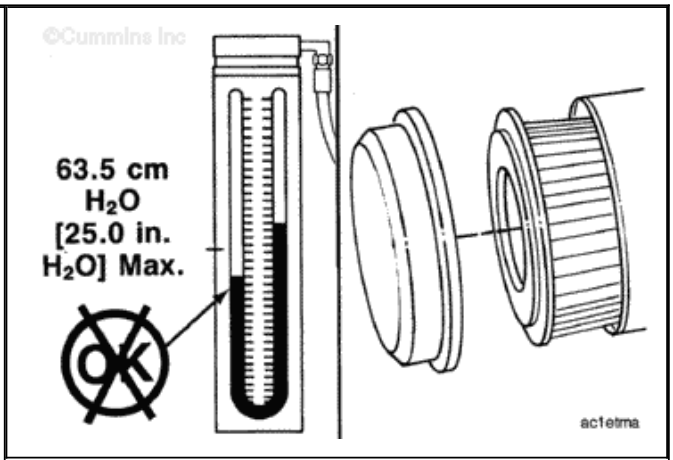
• Remove the air crossover. Refer to Procedure 010-019 in Section 10. • Disconnect the oil supply hose. Refer to Procedure 010-046 in Section 10. • Disconnect the oil drain hose. Refer to Procedure 010-045 in Section 10.		©Cummins Inc  ck800wa

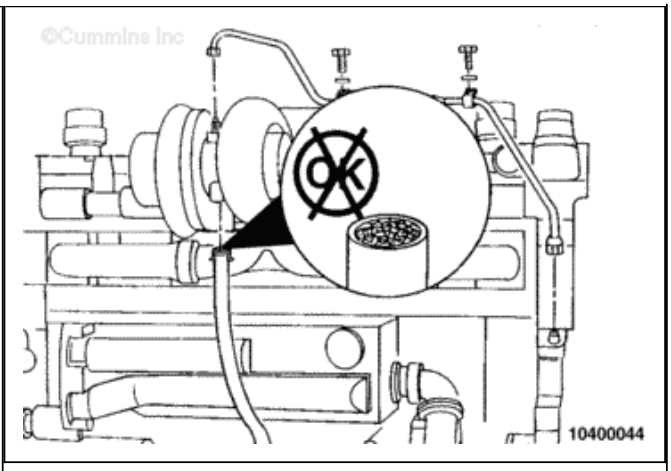
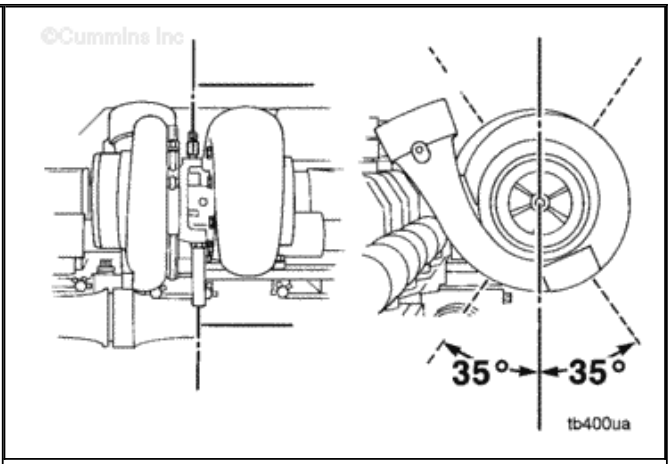
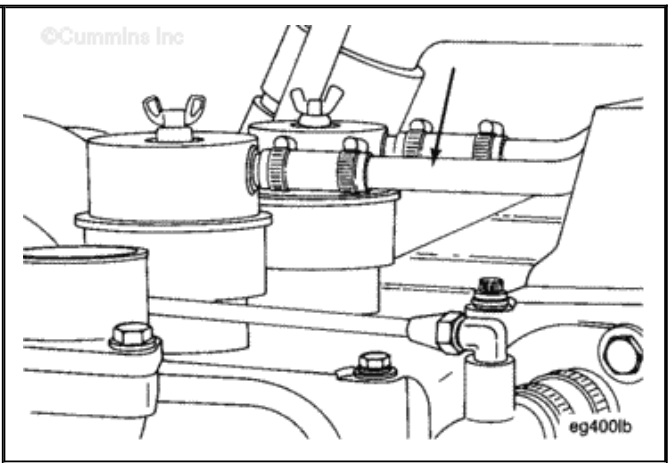
Multiple Turbochargers

• Remove the air crossover. Refer to Procedure 010-019 in Section 10. • Remove the air transfer tube. Refer to Procedure 010-018 in Section 10. • Disconnect the oil supply hose. Refer to Procedure 010-046 in Section 10. • Disconnect the oil drain hose. Refer to Procedure 010-045 in Section 10.		©Cummins Inc

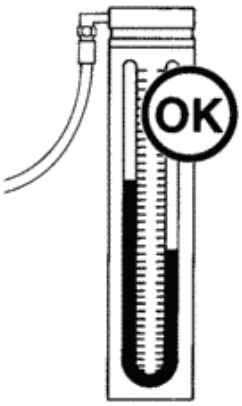
Initial Check

All Applications

Inspect the compressor discharge and air crossover piping for oil.		
If oil is found, check the axial motion and radial clearance of the turbocharger, as outlined in the Measure section of this procedure.		
Check for intake restriction. Refer to Procedure 010-031 in Section 10.		

Check the oil drain tube 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 is positioned at the correct angle, check the crankcase breathers and tubes to make sure they are **not** plugged.		
If these checks do **not** reveal the problem, measure the crankcase pressure (blowby). Refer to Procedure		

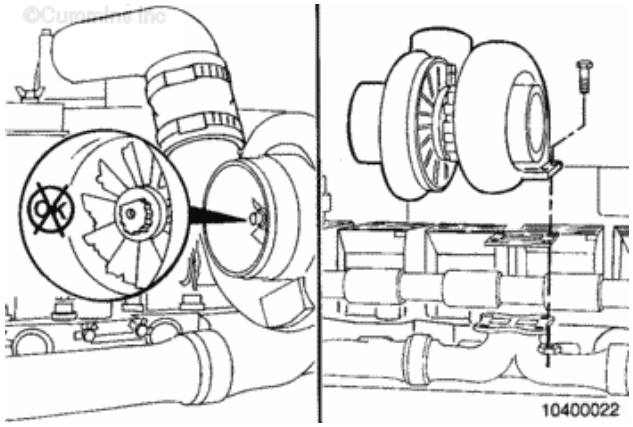
014-005 in Section 14.



10400028

Inspect the turbocharger compressor impeller blades for damage.

If the compressor impeller blades are damaged, the turbocharger **must** be replaced.

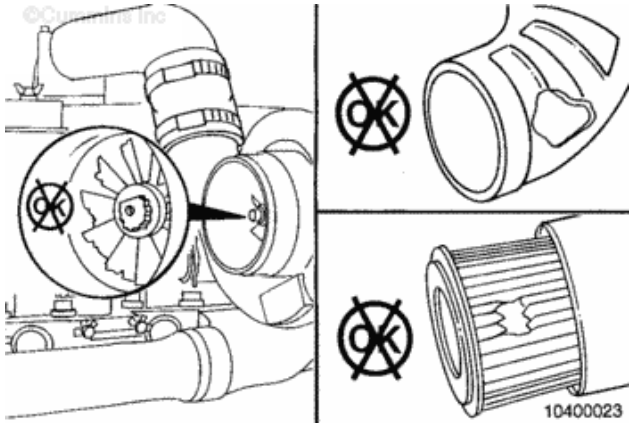


10400022

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

Inspect the compressor cover for any debris.

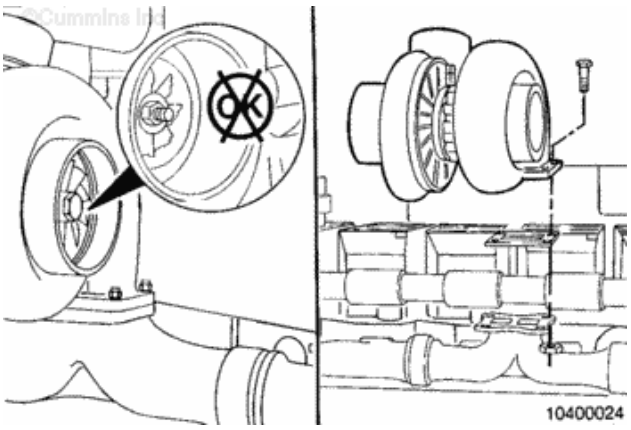
Repair any damage before operating the engine.



10400023

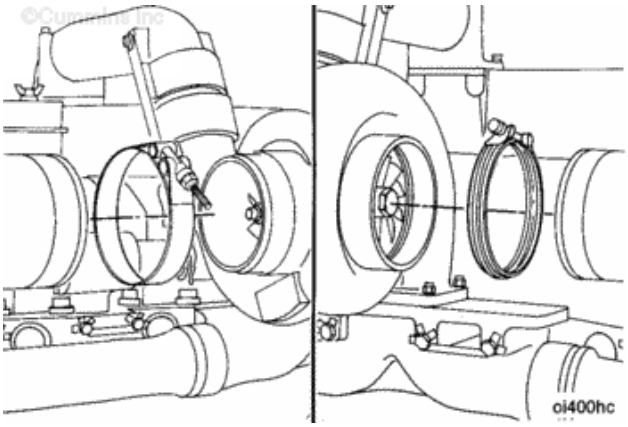
Inspect the turbine wheel for damage.

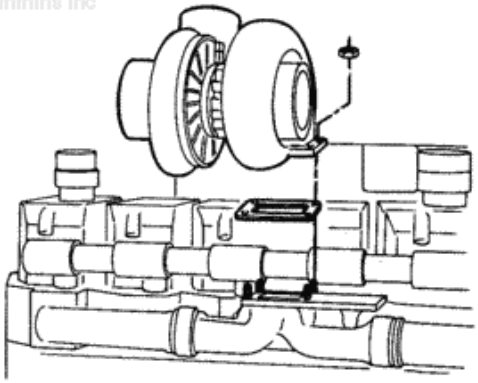
The turbocharger **must** be

replaced if the turbine blades are damaged. Check for debris stuck in the turbine housing.		

Remove

Single Turbocharger

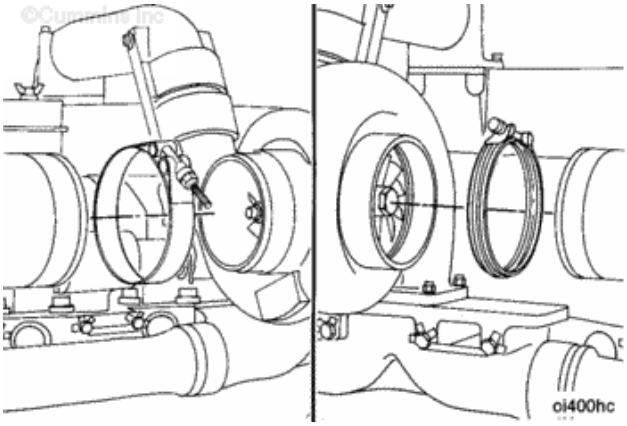
Remove the intake and exhaust pipes from the turbocharger.		
Remove the turbocharger mounting nuts and washers. Remove the turbocharger and gasket. Discard the gasket.		



Multiple Turbochargers

Remove the intake tubing from the low stage turbocharger.

Remove the exhaust connection from the low stage turbocharger.

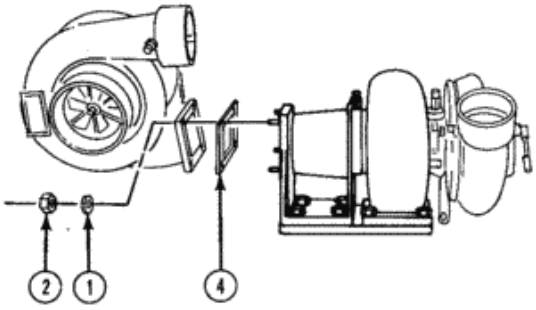


Tag the turbocharger mounting nuts and washers for future identification. The nuts are designed for high strength.

Remove the turbocharger mounting nuts (2) and washers (1).

Remove the low stage turbocharger and gasket (4).

Discard the gasket.



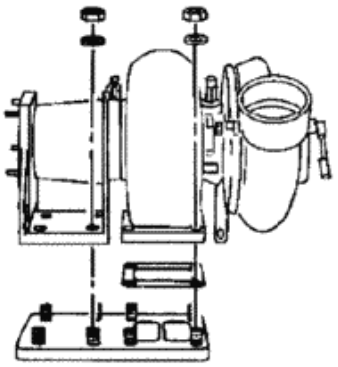
WARNING

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.

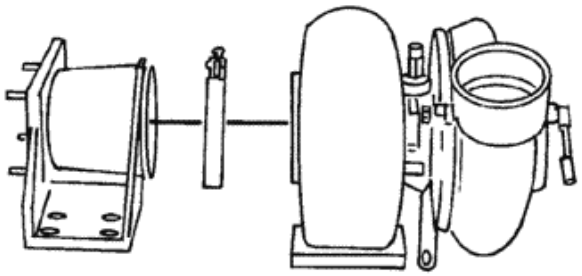
Remove the mounting nuts and washers.

Remove the high stage turbocharger and support assembly.

Remove and discard the gasket.



Loosen the v-band clamp and separate the high stage turbocharger and mounting support.



Measure

All Applications

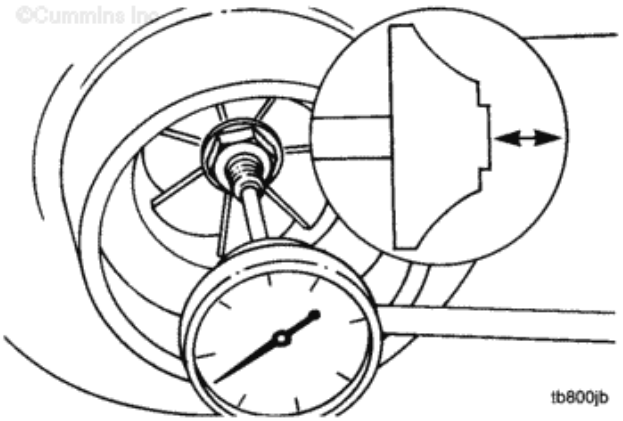
Measure the axial clearance (end-to-end) with a depth gauge, or a dial indicator, Part Number ST-537.



Axial Clearance

	mm		in
HC5A	0.025	MIN	0.001
	0.152	MAX	0.006
T18A	0.10	MIN	0.004
	0.23	MAX	0.009

If the turbocharger is **not** within specifications, it **must** be replaced.



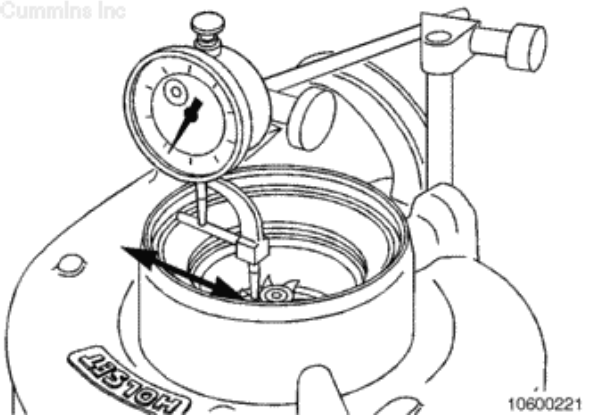
Measure the radial end play (side-to-side) at the compressor nose using a dial gauge.

Compressor Impeller Radial End Play

	mm		in
Holset® HC5, HC5A (127 mm wheel)	0.228	MIN	0.009
	0.686	MAX	0.027
Holset® HC5, HC5A (130 mm wheel)	0.228	MIN	0.009
	0.762	MAX	0.03

Make sure movement is within the MIN/MAX total indicator reading (TIR) values shown above.

NOTE: If the clearance exceeds the specifications, the turbocharger must be replaced or rebuilt. Contact a Cummins® Authorized Repair Location. See HC5 Turbocharger Shop Manual, Bulletin 3810243, for rebuild instructions.

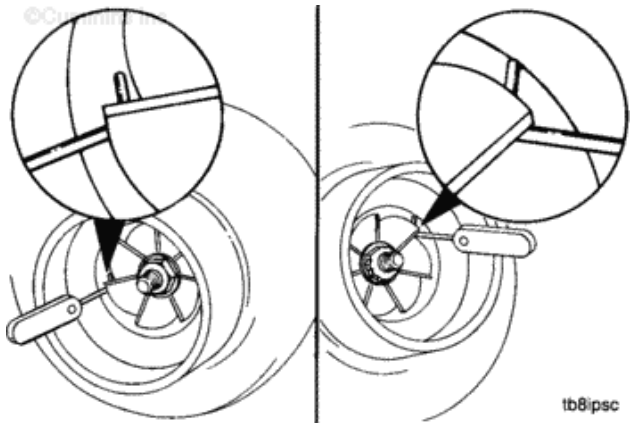


Measure the radial clearance (side-to-side) with a wire-type feeler gauge.

Compressor Impeller and Turbine Wheel Radial Clearance

	mm		in
AirResearch™ T18A	0.08	MIN	0.003
	0.18	MAX	0.007

NOTE: If the clearance exceeds the specifications, the turbocharger must be replaced or rebuilt. Contact a Cummins® Authorized Repair Location. See T35/50 VT50/ST50 Turbocharger, Bulletin 3379091, for rebuild instructions.



Install

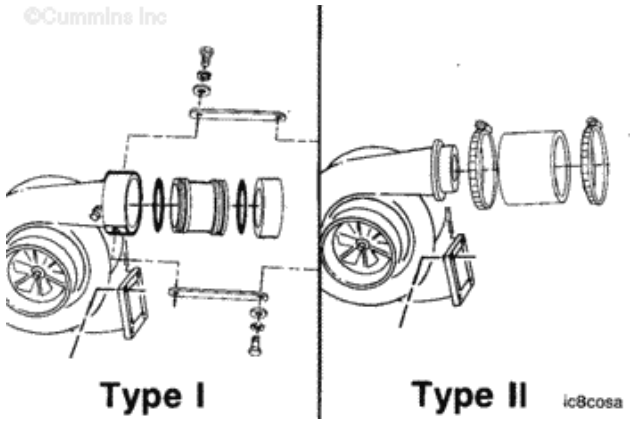
All Applications

Turbochargers are available with two types of compressor housings.

Type 1 - requires two o-rings, dust seal, connector pipe, and two retainer straps.

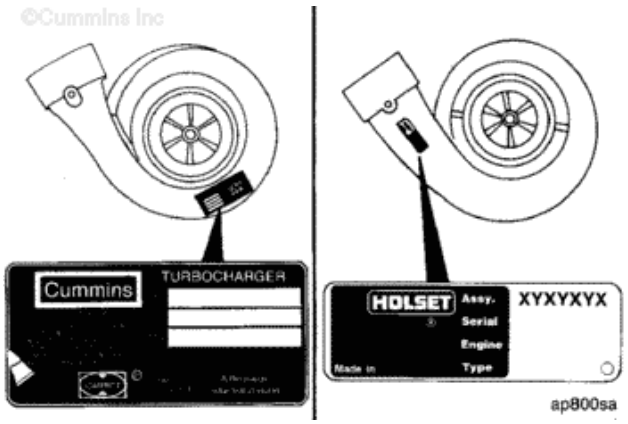
Type 2 - requires two hose clamps and a hose.

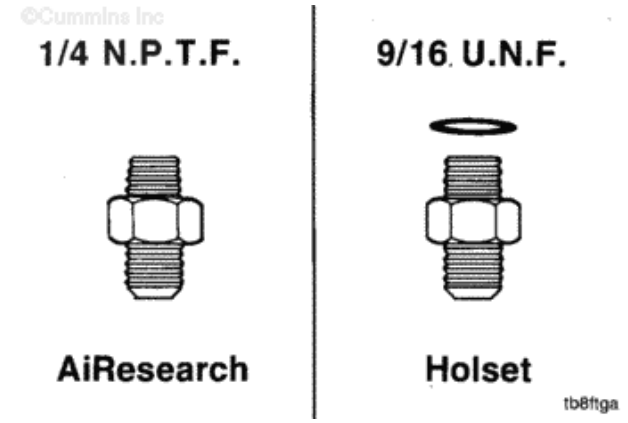
Changing from one type to another requires a new air crossover.



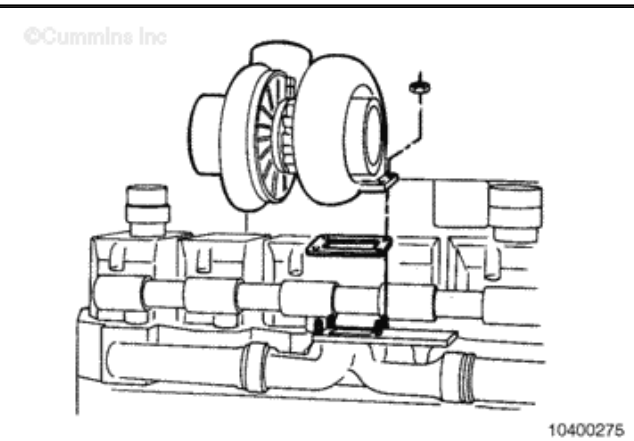
Two different turbochargers are used on the K19 engine; AiResearch™ and Holset®.

Check the data tag on the

turbocharger to determine the model. The name is also cast on the housing of each turbocharger.		

Two different types of oil supply fittings are used. The AiResearch™ turbocharger uses a ¼ NPTF (pipe plug) fitting. The Holset® turbocharger uses a 9/16-18 UNF (straight thread) o-ring type fitting. A new fitting is required if the model of turbocharger being installed is different from the original.		

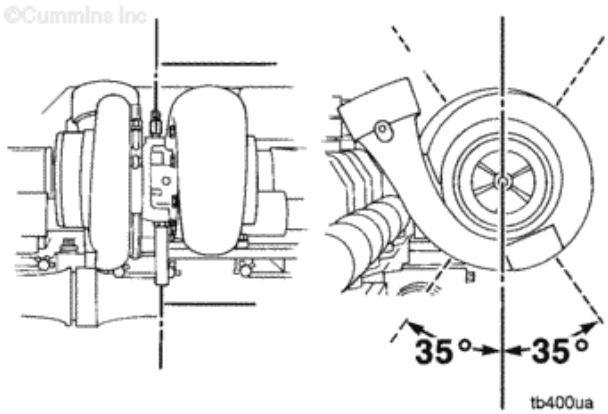
Single Turbocharger

Apply anti-sieze compound to the turbocharger mounting studs. Install the gasket with the word OUT toward the turbocharger. Install the turbocharger. Install the washer and nuts. Tighten the nuts. **Torque** **Value:** 45 n.m [33 ft-lb]		

Position the turbocharger drain tube. The drain tube **must** be		

within 35 degrees of vertical. Turn the bearing housing to align the tube, if necessary.

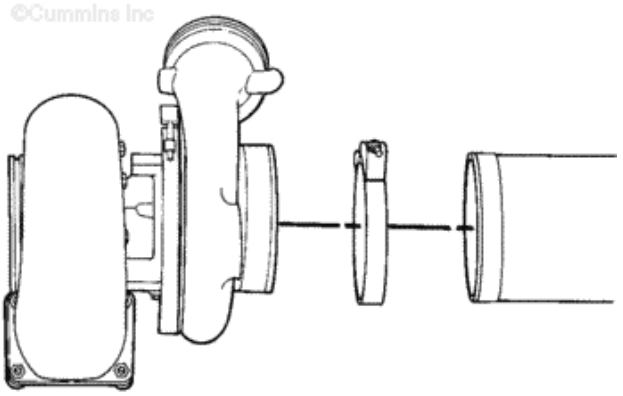
Some turbochargers use the through bolt style to attach the bearing housing to the turbine housing. Others use the clamp plate style.



Install the intake piping to the turbocharger.

Tighten the v-band clamp.

Torque
Value: 9 n.m [80 in-lb]



Connect the exhaust piping to the turbocharger.

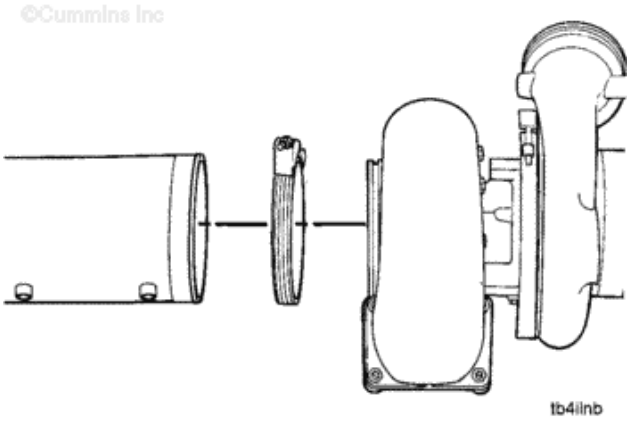
Tighten the v-band clamp.

Torque
Value: 4 n.m [35 in-lb]

Some engines contain a flanged exhaust connection.

Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]



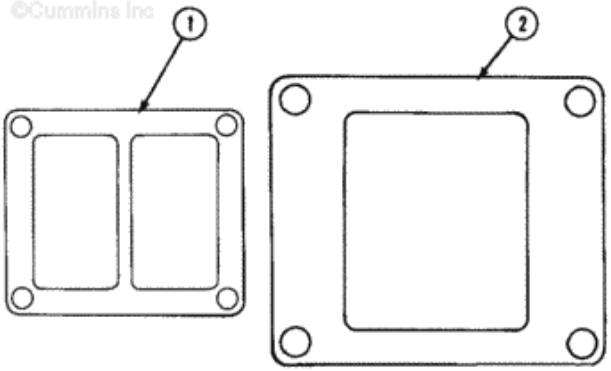
Multiple Turbochargers

CAUTION

The turbochargers and components must be installed in the sequence given. Failure to do so can result in component failure.

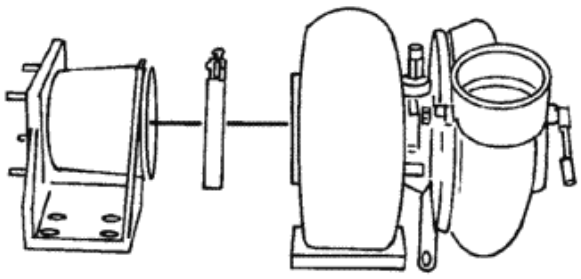
The high stage turbocharger (1) attaches directly to the exhaust manifold. This turbocharger has a divided turbine housing.

The mounting flange on the high stage turbocharger housing is much smaller than the low stage turbocharger.



Install the mounting support and v-band clamp on the high stage turbocharger.

Tighten the clamp enough to hold the parts together and allow them to rotate.



Do **not** use anti-seize compound on the mounting studs or nuts.

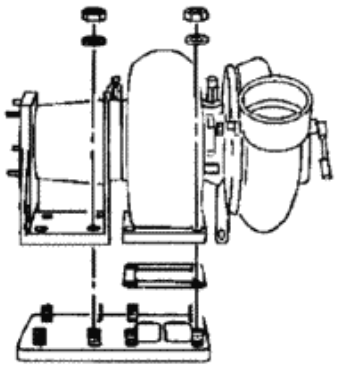
Install the gasket on the exhaust manifold with the word OUT toward the turbocharger.

Install the turbocharger and support on the manifold.

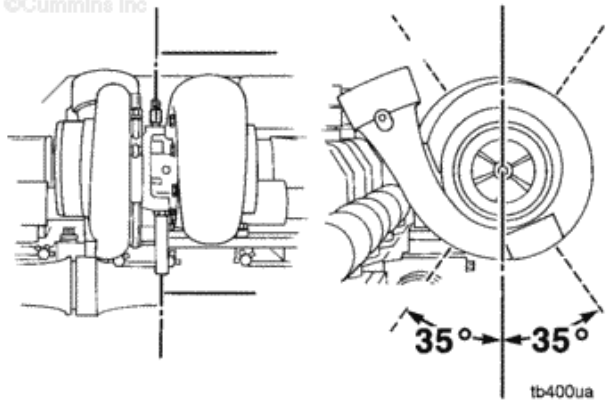
Install the washers and nuts.

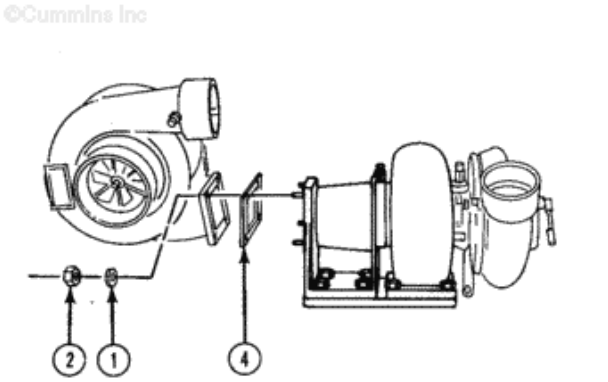
Hand-tighten the nuts **only**.

Check to make sure the turbocharger and the support



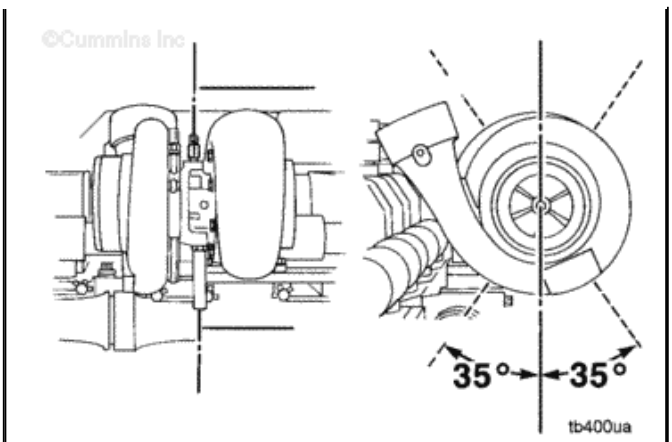
fit flatly on the manifold. Remove the v-band clamp. Check the fit between the turbocharger and the support. Both parts **must** be in contact with the manifold and without gaps. Install the v-band clamp and tighten. **Torque Value:** AiReasearch™ 7 n.m [62 in] **Torque Value:** Holset® 14 n.m [124 in-lb]		

Check the oil drain tube angle. The turbocharger drain tube **must** be within 35 degrees of vertical.		

Do **not** use anti-seize compound on the studs or nuts. Install the gasket (4) on the support assembly with the word OUT toward the low stage turbocharger. Install the low stage turbocharger, washers, and nuts. Tighten the nuts. **Torque Value:** 45 n.m [33 ft-lb]	 	

Check the oil drain tube angle.		

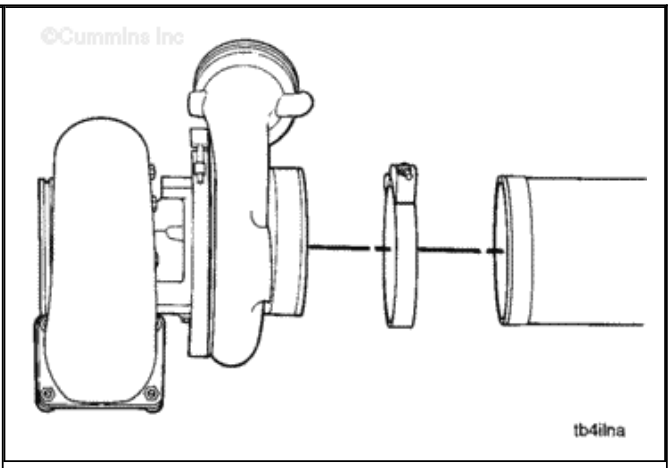
The turbocharger drain tube **must** be within 35 degrees of vertical.



Install the intake piping to the turbocharger.

Tighten the v-band clamp.

Torque
Value: 9 n.m [80 in-lb]



Connect the exhaust piping to the turbocharger.

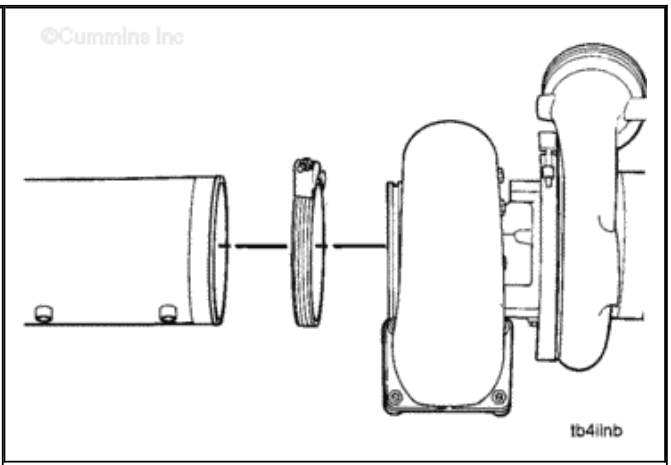
Tighten the v-band clamp.

Torque
Value: 4 n.m [35 in-lb]

Some engines contain a flanged exhaust connection.

Tighten the capscrews.

Torque
Value: 45 n.m [33 ft-lb]



Adjust

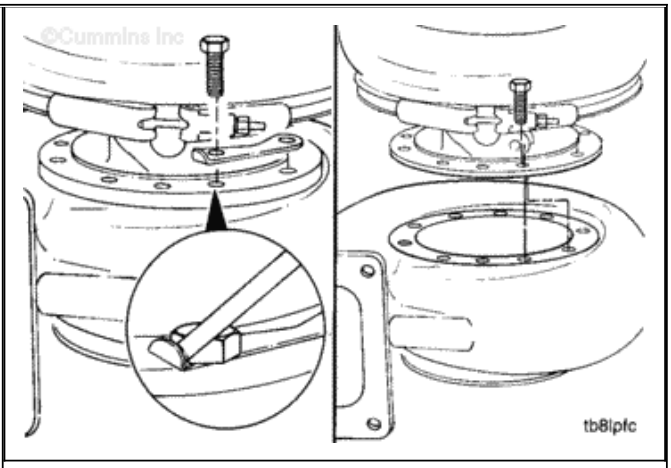
All Applications

To adjust the through bolt style of turbocharger, bend the lockplates off the capscrew heads.

Remove the capscrews.

Rotate the bearing housing to align the drain tube and capscrew holes.





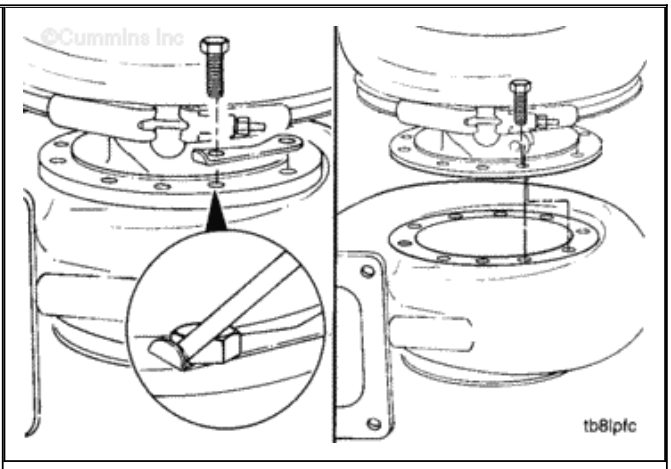
Install the lockplates and capscrews.

Tighten the capscrews.

Torque
Value: 12 n.m [106 in-lb]

Bend the lockplate tabs over the capscrew heads.

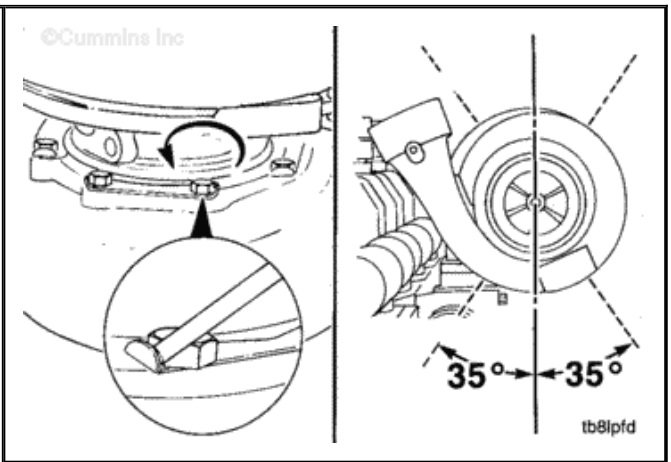


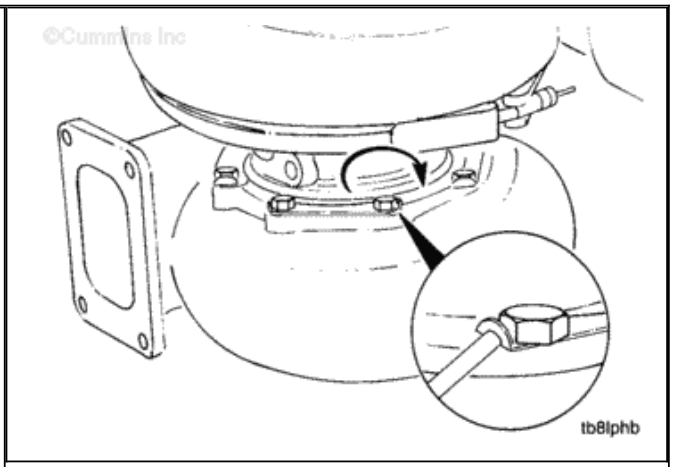


To adjust the clamping plate style turbocharger, bend the lockplates off the capscrew heads.

Loosen all capscrews.

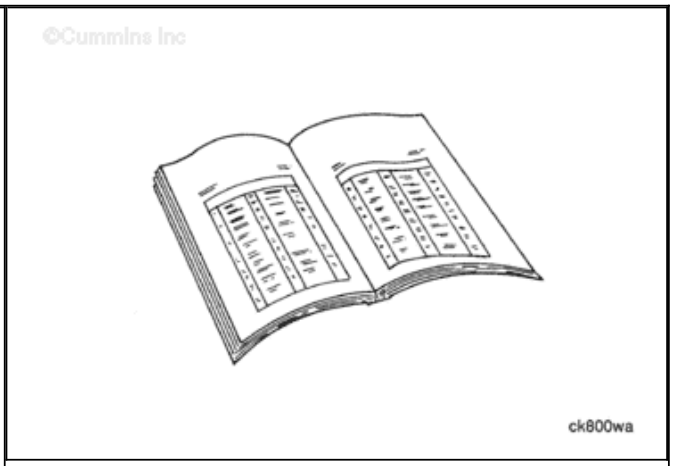
Rotate the bearing housing until the angle of the drain tube is correct.



Tighten the capscrews. **Torque** **Value:** 12 n.m [106 in-lb] Bend the lockplate tabs over the capscrew heads.		

Finishing Steps

Single Turbocharger

• Connect the oil drain hose and fill the turbocharger bearing housing with engine oil. Refer to Procedure 010-045 in Section 10. • Connect the oil supply hose. Refer to Procedure 010-046 in Section 10. • Install the air crossover. Refer to Procedure 010-019 in Section 10.		

Multiple Turbochargers

• Connect the oil drain hose and fill the turbocharger bearing housing with engine oil. Refer to Procedure 010-045 in Section 10. • Install the air transfer tube. Refer to Procedure 010-018 in		

Section 10. • Connect the oil supply hose. Refer to Procedure 010-046 in Section 10. • Install the air crossover. Refer to Procedure 010-019 in Section 10.		©Cummins Inc

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010-037 Turbocharger, Water-Cooled

Preparatory Steps

Marine Applications

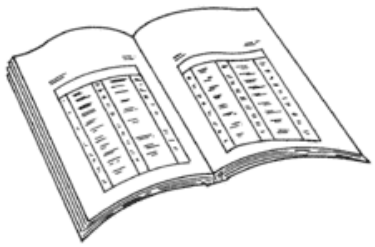
WARNING

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 in Section 8.
- Remove the air crossover. Refer to Procedure 010-019 in Section 10.
- Disconnect oil drain hose. Refer to Procedure 010-045 in Section 10.
- Disconnect oil supply hose. Refer to Procedure 010-046 in Section 10.

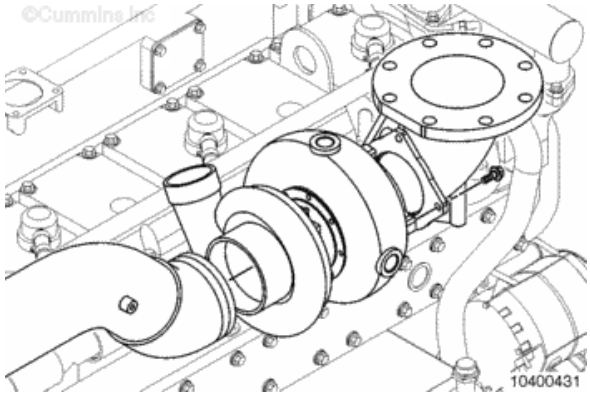
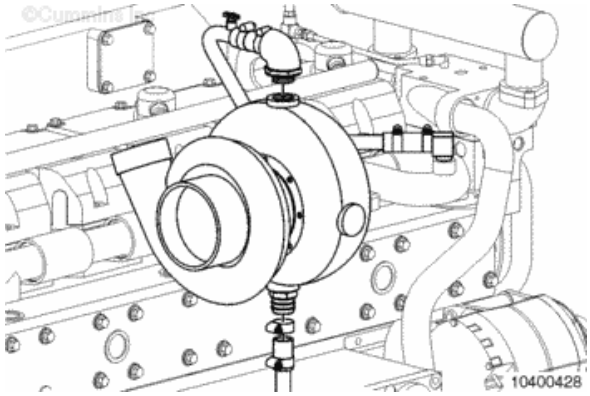
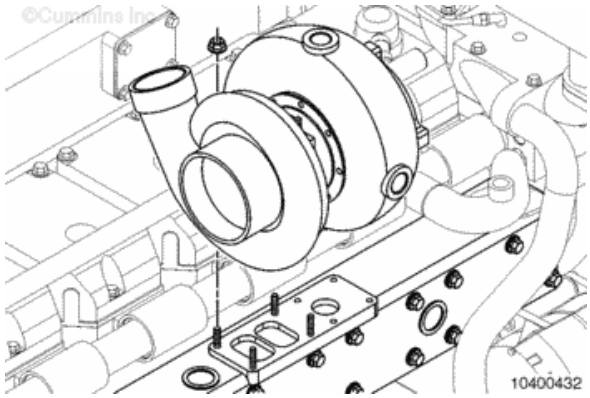


ck800wa

Remove

Marine Applications

Remove the intake and exhaust pipes from the turbocharger.

		
Disconnect the coolant supply hose and the coolant return hose from the turbocharger.		
Remove and discard the mounting nuts. The mounting nuts can **not** be reused. Remove the turbocharger. Remove and discard the gasket.		

Clean and Inspect for Reuse

Marine Applications

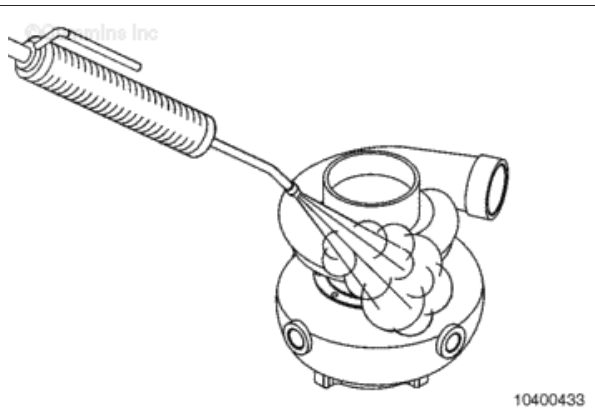
WARNING

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

To reduce the possibility of turbocharger damage, tape or plug all openings to prevent solvent or steam from entering the oil cavities of the turbocharger.

Use steam to clean the turbocharger.



Check the exterior of the turbocharger for damage.

Check the wheel for fretting and broken vanes.

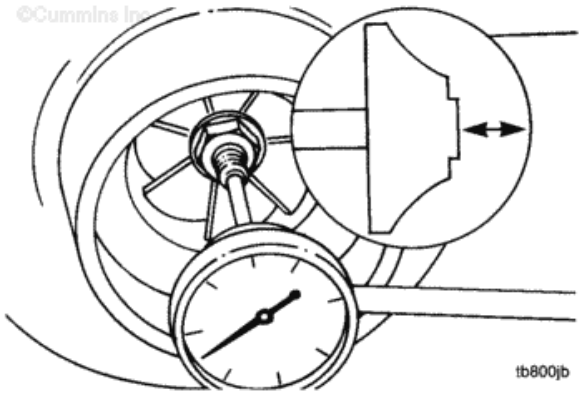
Use a dial indicator to measure the turbocharger end clearance.

Measure the end clearance.

Holset® HX82 Turbocharger
End Clearance

mm		in
0.025	MIN	0.001
0.152	MAX	0.006

If the end clearance exceeds the specifications, the turbocharger **must** be replaced.

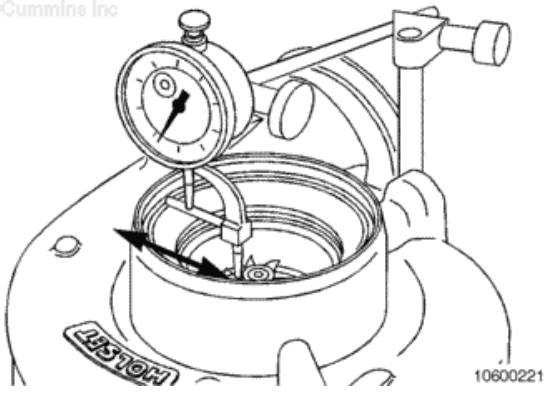


Measure the radial clearance (side to side) at compressor impeller nose using a dial gauge

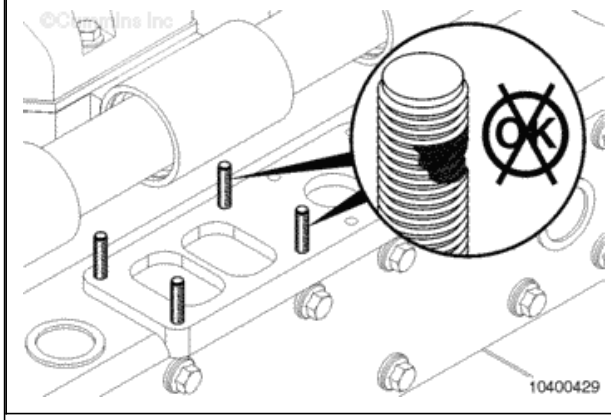
Holset® HX82 Turbocharger

	mm		in
Compressor/Impeller	0.254	MIN	0.010
	0.787	MAX	0.031

Make sure movement is within MIN/MAX Total Indicator Reading (TIR) values shown above.

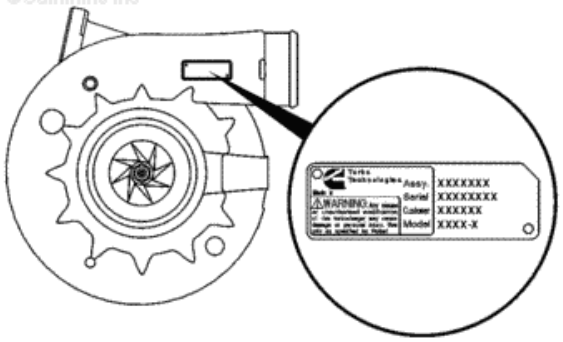


If the end clearance exceeds the specifications, the turbocharger **must** be replaced.		

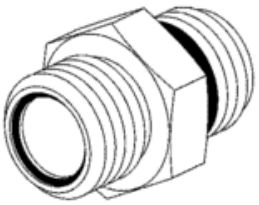
Check the condition of the turbocharger mounting studs. Replace the studs if they are broken, corroded, worn, or if any of the threads are damaged. Tighten the turbocharger mounting studs to verify they are tightened to the correct specification. **Torque Value:** 34 n.m [25 ft-lb]		

Install

Marine Applications

Reference the data tag on the turbocharger to determine the model. The name is also cast on the housing of the turbocharger.		

All turbocharger fittings are the flat face o-ring type fittings. Be sure the o-ring is in place before attaching the hose(s) to the fittings. The Holset® turbocharger uses a 9/16-18 UNF, straight thread, o-ring type oil supply fitting.		



10400015

Apply a heavy duty anti-seize compound to the mounting studs.

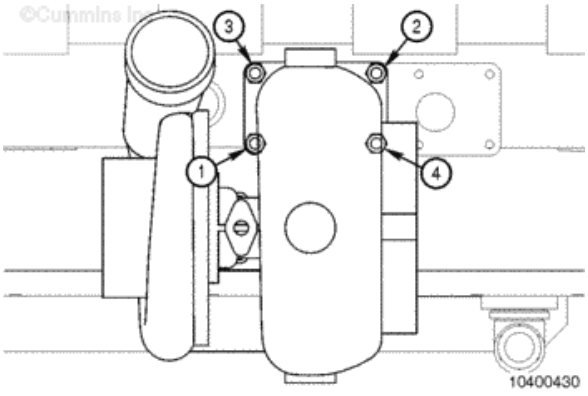
Install the gasket on the exhaust manifold with the bead up.

Install the turbocharger.

Install new turbocharger self-locking mounting nuts. Finger tighten all of the mounting nuts.

Tighten the mounting nuts in the sequence shown.

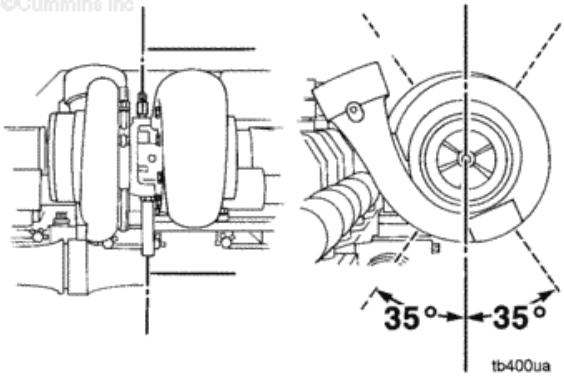
Torque Value: 57 n.m [42 ft-lb]



10400430

Position the turbocharger drain tube. The drain tube **must** be within 35 degrees of vertical. Turn the bearing housing to align the tube, if necessary.

The turbocharger uses capscrews to attach the bearing housing to the turbine housing.



tb400ua

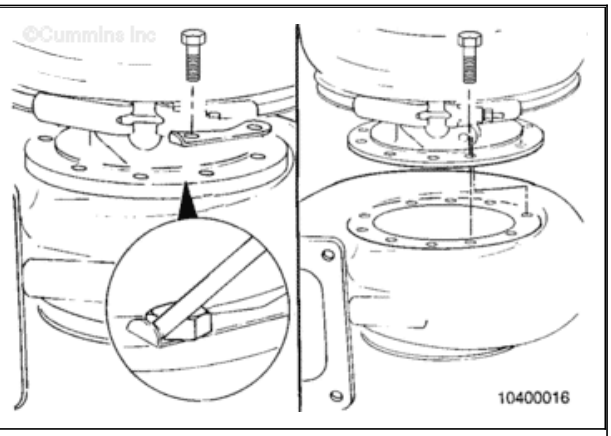
Adjust

Marine Applications

To adjust the bearing housing, bend the lockplate off the capscrew heads.

Remove the capscrews.

Rotate the bearing housing. Align the drain tube and the capscrew holes.

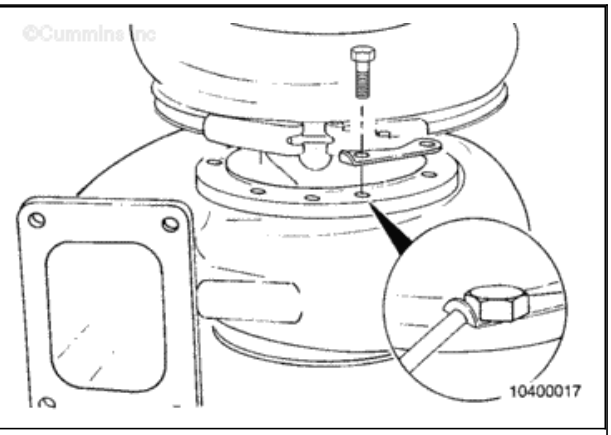


Install the lockplates and capscrews.

Tighten the capscrews.

Torque Value: 20 n.m [180 in-lb]

Bend the lockplate tabs over the capscrews.



To adjust the turbocharger compressor housing alignment:

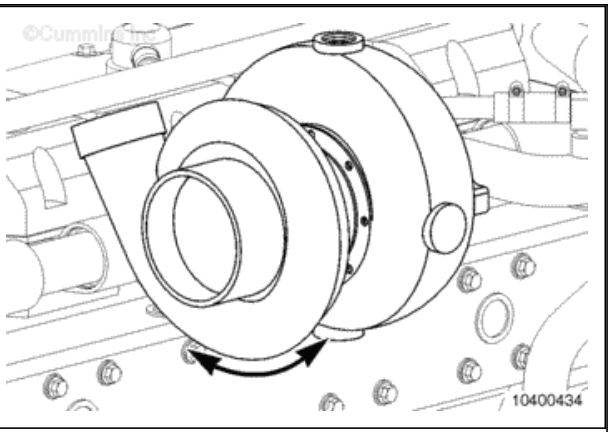
Loosen the v-band clamp.

Turn the compressor housing to the correct alignment.

Tighten the clamp.

Torque Value: 8 n.m [71 in-lb]

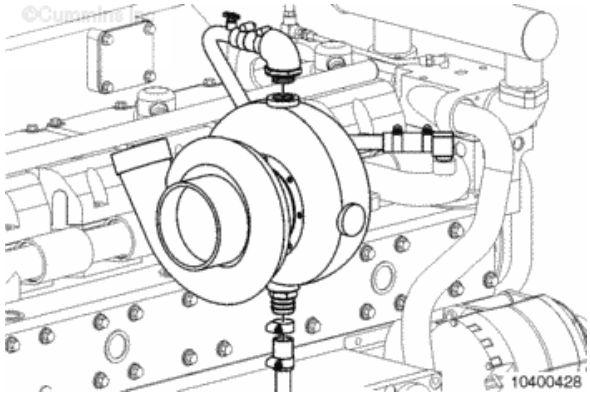
Tap the clamp with a mallet and tighten the clamp again.



Connect the coolant supply hose and the coolant return hose to the turbocharger.

Install the elbow and tighten the v-clamps.

Torque Value: 8 n.m [71 in-lb]



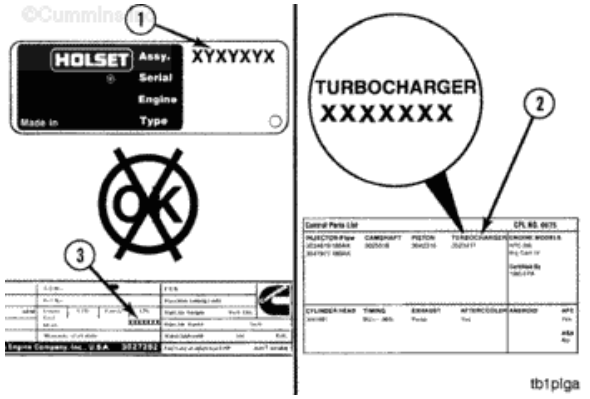
Check for Correct Component

Marine Applications

Compare the assembly number (1) on the turbocharger dataplate with the turbocharger specified in the engine Control Parts List (CPL) Manual (2).

The CPL number for each engine is listed on the engine dataplate (3).

If an incorrect turbocharger was installed, remove it and install the correct turbocharger.



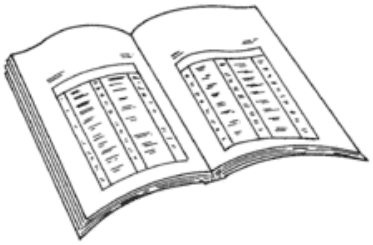
Finishing Steps

Marine Applications

- Add engine oil to the turbocharger bearing housing. Connect the oil supply hose. Refer to Refer to Procedure 010-046 in Section 10.
- Connect the oil drain hose.

Refer to Procedure 010-045 in Section 10.

- Install the air crossover. Refer to Procedure 010-019 in Section 10.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine until the coolant temperature is 71°C [160°F] and check for leaks.



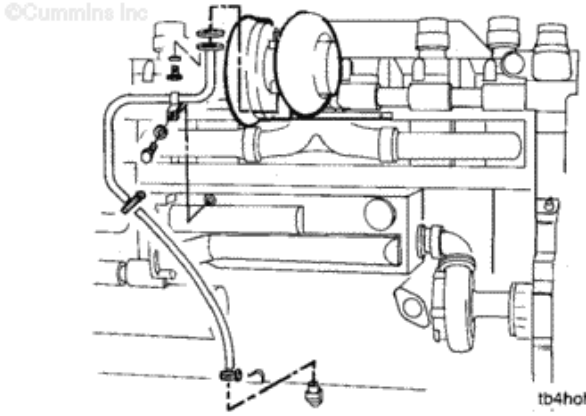
ck800wa

Last Modified: 07-Sep-2011

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010-045 Turbocharger Oil Drain Line

Remove

Remove the capscrews and disconnect the oil drain line from the turbocharger. Remove and discard the gasket. Disconnect the oil drain tube from the union and remove the oil drain line. Remove the adapter elbow from the cylinder block.		

Clean and Inspect for Reuse

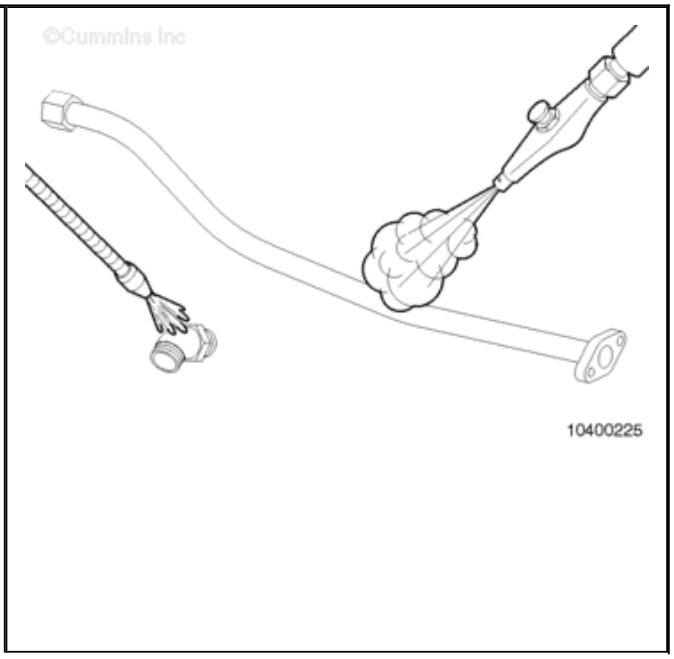
WARNING

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.

WARNING

Wear appropriate eye and face protection when using





compressed air. Flying debris and dirt can cause personal injury.

Clean the turbocharger oil drain tube and the adapter elbow with solvent.

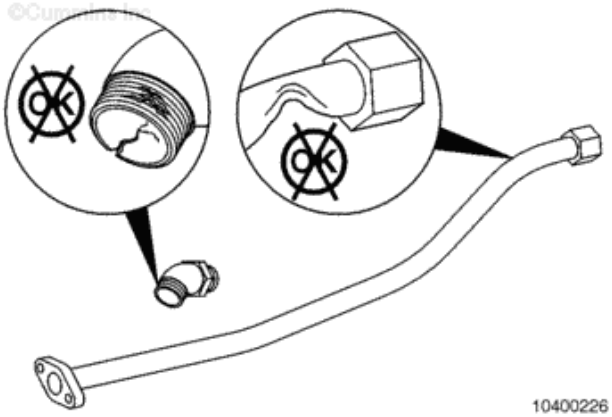
Dry with compressed air.

Inspect the oil drain tube for any restrictions that prevent the flow of oil.

Replace the turbocharger oil drain tube if kinks, damage or leakage is found.

Inspect the union adapter elbow for damage.

Replace the union adapter elbow if damaged, cracked, or stripped threads.



Install

CAUTION

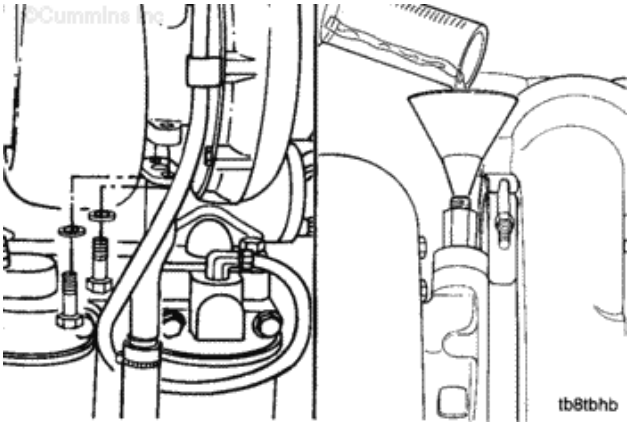
These parts are safety related, make sure the parts are clamped correctly to prevent fretting.

Install the adapter elbow to the cylinder block.

Connect the oil drain tube to the adapter.

Connect the oil drain tube to the turbocharger.

Tighten the capscrews.



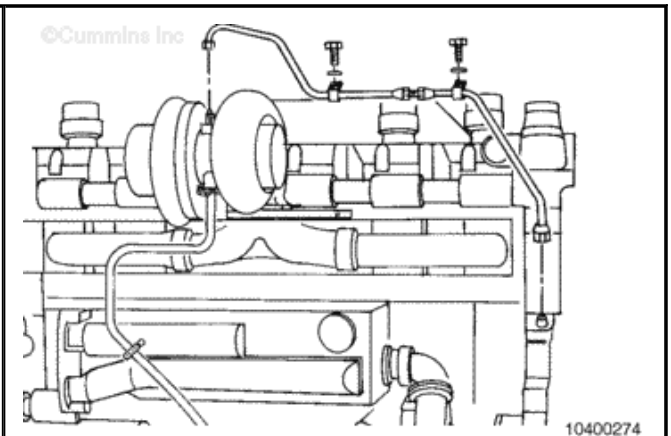
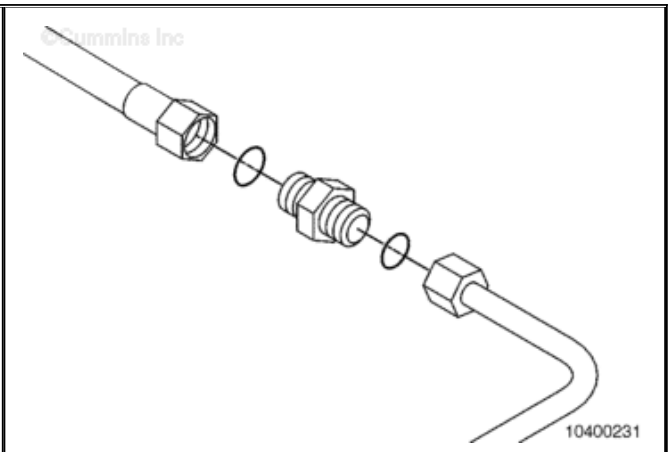
Torque **Value:** 45 n.m [33 ft-lb] Pour 50 to 60 cc [2.0 to 3.0 oz] of clean engine oil into the oil supply fitting.		

Last Modified: 29-Nov-2004

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010-046 Turbocharger Oil Supply Line

Remove

Remove the turbocharger oil supply line.		
Disconnect the turbocharger oil supply hose from the turbocharger supply tube at the male union. Discard the o-rings from the male union.		

Clean and Inspect for Reuse

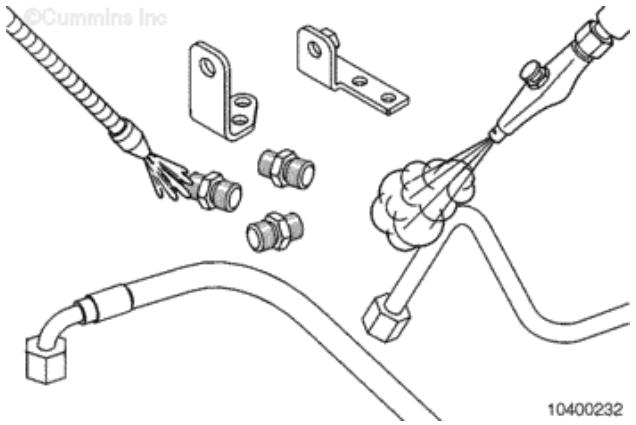
WARNING

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 all of the components with solvent and dry with compressed air.



Inspect the turbocharger oil supply hose for cracks, damage or restrictions.

Replace the hose if damaged.

Inspect the turbocharger oil supply tube for damage, kinks or restrictions.

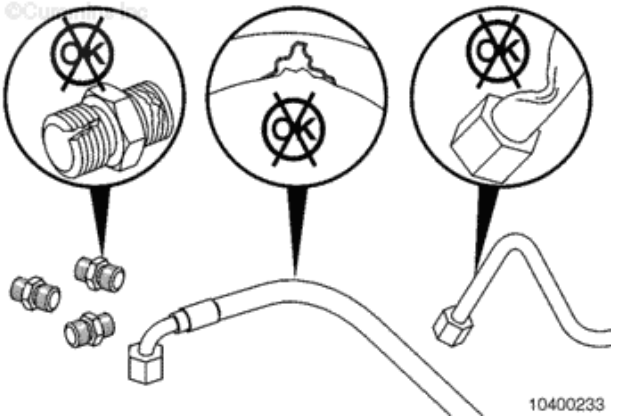
Replace the tube if damaged.

Inspect the male unions for damage, cracks, or stripped threads.

Replace male union if damaged.

Inspect the clips for damage.

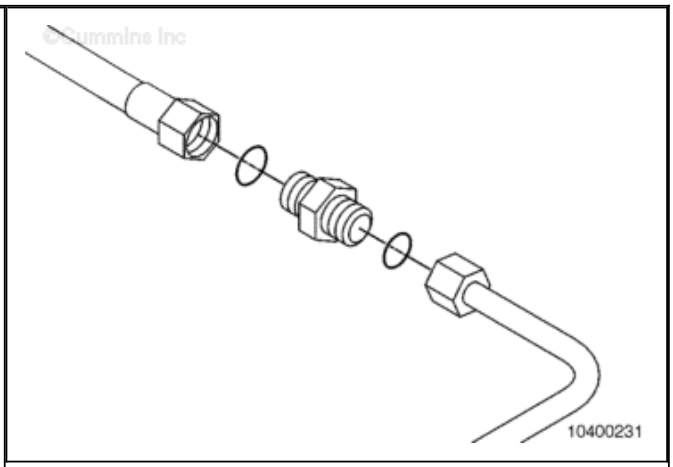
Replace the clips if damaged.



Install

Lubricate the o-rings with vegetable oil.

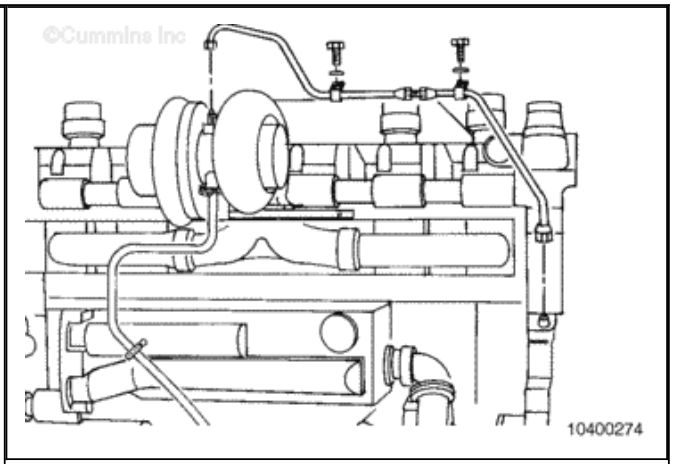
Install o-rings. Connect the turbocharger oil supply hose to the oil supply tube.



Make sure the turbocharger bearing housing has been filled with clean engine oil.

Install the turbocharger oil supply hose.

AiReasearch	45 n.m	[33 ft-lb]
Holset	20 n.m	[15 ft-lb]



Last Modified: 29-Nov-2004

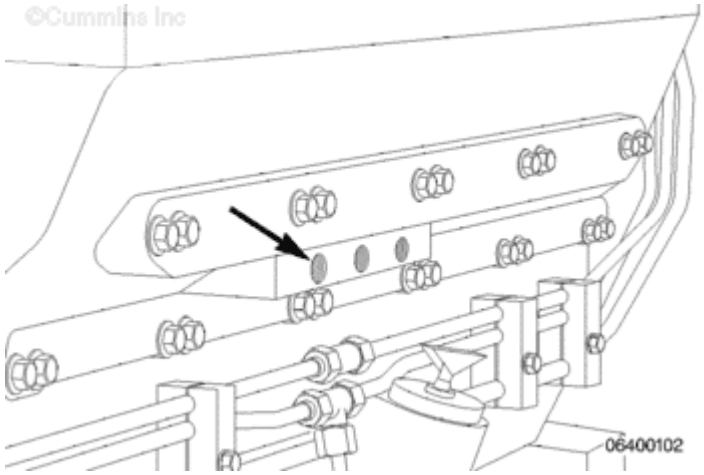
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010-057 Intake Manifold Pressure

Measure

Install a 0 - 2030 mm-Hg [0 - 80 in Hg] manometer (or gauge) in the straight threaded plug hole in the aftercooler housing.

Do **not** drill and tap a hole in the aftercooler cover. A faulty reading can result if the aftercooler core is leaking.

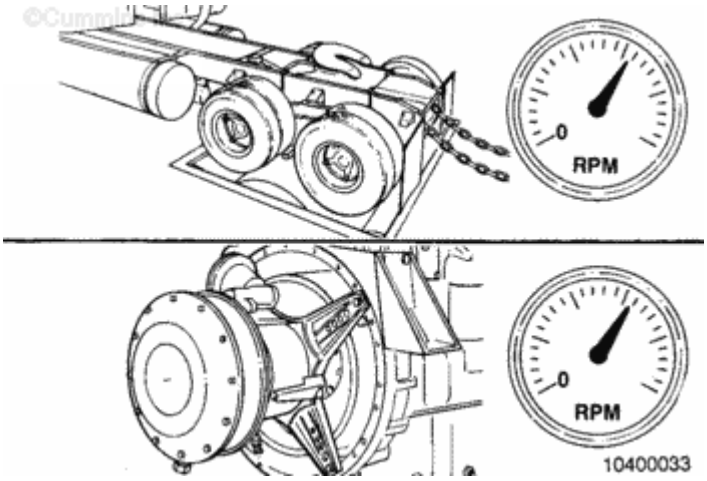


Obtain the CPL number from the engine dataplate and the fuel pump code from the fuel pump dataplate.

Engine performance specifications and fuel system calibration values are listed for specific engine CPL and fuel pump codes in the current publications of the following:



1. Fuel Pump Calibration Values 2. Injector Parts Flow and Cross Reference 3. Engine Data Sheets.		

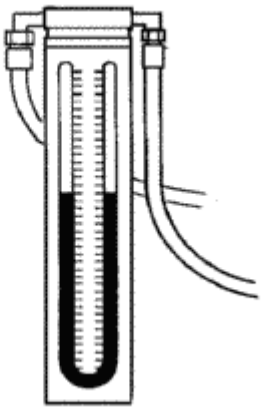
Stall speed is **not** full power. Operate the engine at rated rpm and full load. Compare the value to specifications.		

Last Modified: 29-Nov-2004

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022-001 Service Tools

Exhaust System

Tool Number		
ST-1111-3	**Manometer (Mercury Filled Slack Tube)** Used to measure exhaust restriction.	©Cummins Inc 

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011-007 Exhaust Manifold, Dry

Preparatory Steps

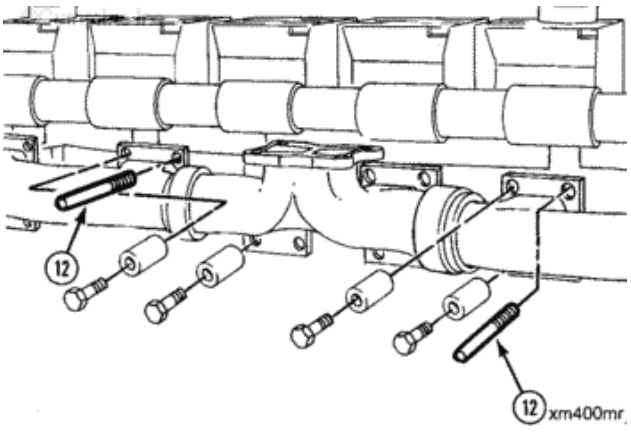
- Remove the turbocharger(s). Refer to Procedure 010-033.
- Remove the water bypass tube. Refer to Procedure 008-062.



Remove

Remove two capscrews.

Install two 7/16-14 x 5 inch guide studs (12) as shown.



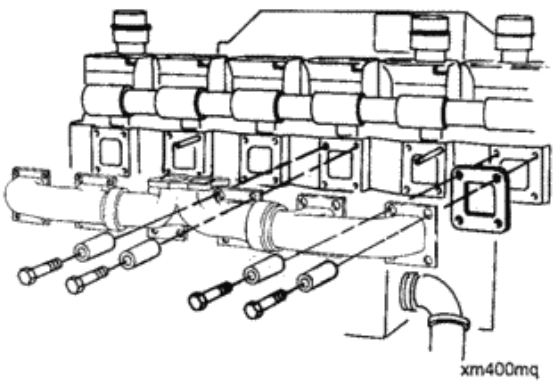
WARNING

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

Remove the remaining capscrews.

Remove the exhaust manifold and the gaskets.

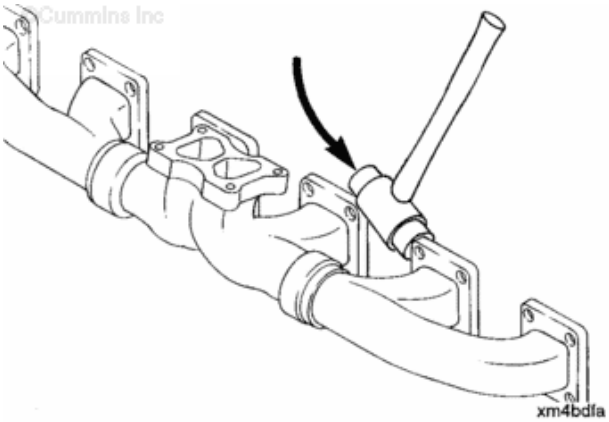
Discard the gaskets.



Disassemble

NOTE: Disassemble the manifold only if the one of the sections need to be replaced.

Use a mallet to remove the end sections from the exhaust manifold center section.



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.

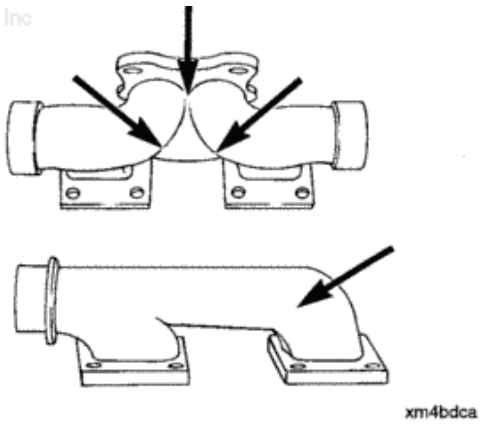
WARNING

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

Use solvent or steam to clean the exhaust manifold.

Use a wire brush to remove any scale on the exhaust manifold sealing joint inside and outside diameters.

Inspect the exhaust manifold for cracks.

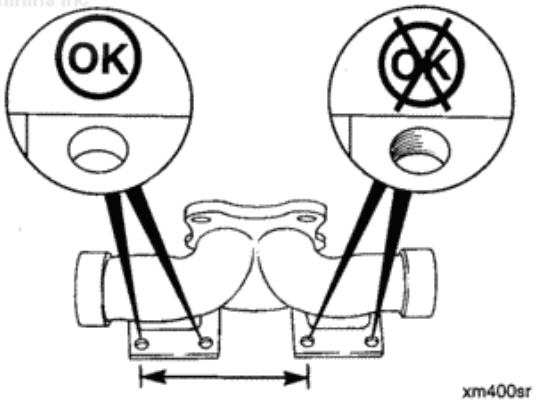


Inspect the capscrew holes in the center section for damage.

The exhaust manifold is subjected to high temperatures and cause the manifold to shrink. Capscrew threads visible on the side of the capscrew holes is an indication the exhaust manifold has shrunk.

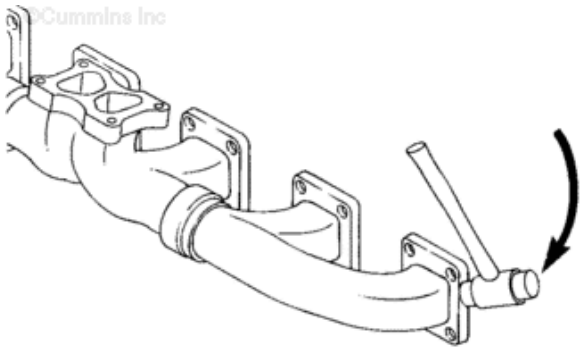
Measure the center-to-center distance between the same position capscrew holes of the two flanges on the center section and both end sections to determine if the manifold is too short.

Exhaust Manifold Capscrew Holes	
mm	in

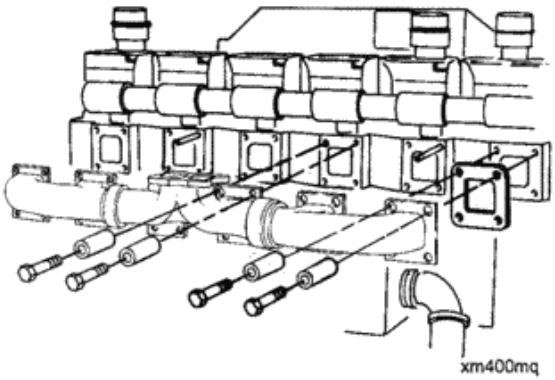


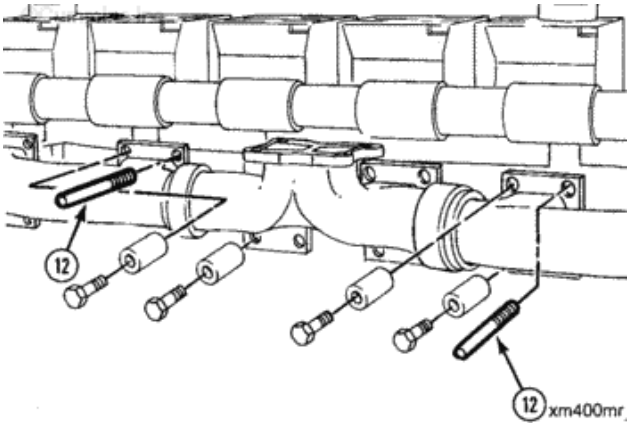
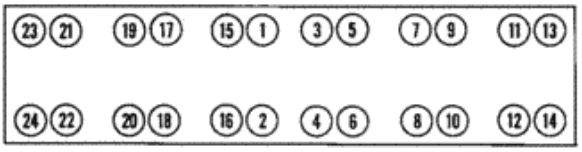
191.5	MIN	7.54
193.5	MAX	7.62

Assemble

Use a mallet and drive the end section into the center section.		 xm4bdha

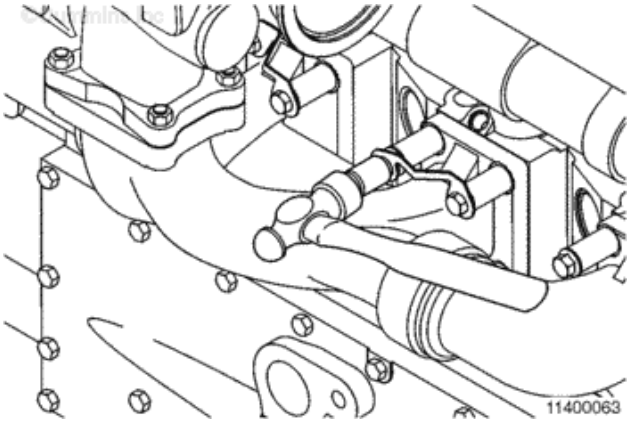
Install

WARNING This component weighs more than 23 kg [50 lb]. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component. **CAUTION** Do not use gasket cement when installing the exhaust manifold gasket. Use of gasket cement will cause the		 xm400mq

gasket to fail. Install the guide studs used during removal. Use contact adhesive and 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 (12) and install the remaining capscrews.		
Tighten the capscrews in the sequence illustrated in the graphic. **Torque Value:** 61 n.m [45 ft-lb]		©Cummins Inc  xm400oa
Align the lock plate with the top of both capscrews. Place the socket that was used to install the capscrew onto one of the capscrews and drive the lock plate down until it reaches the		

capscrew flange.

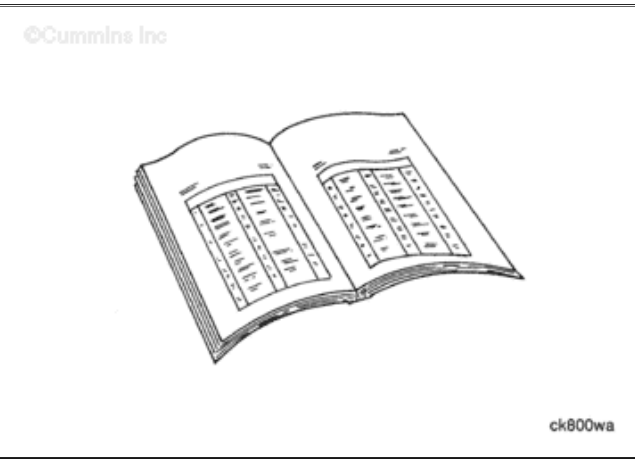
Repeat the process on the remaining capscrews and lock plates.



Finishing Steps

- Install the water bypass tube. Refer to Procedure 008-062.
- Install the turbocharger Refer to Procedure 010-033.





Last Modified: 19-Oct-2004

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011-008 Exhaust Manifold, Wet

Preparatory Steps

WARNING

Do not remove the pressure cap or coolant hoses from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing cooling system components. 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.

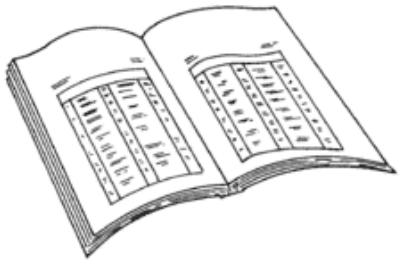
WARNING

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 or assembly weighs greater than 23 kg

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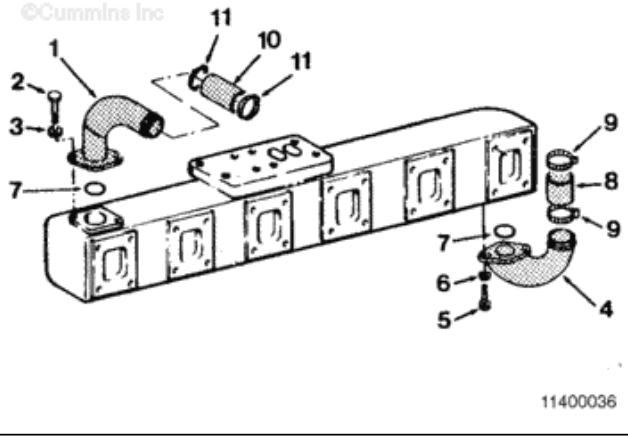


ck800wa

[50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly. • Disconnect the batteries.Refer to Procedure 013-009 in Section 13. • Drain the cooling system.Refer to Procedure 008-018 in Section 8. • Remove the air crossover. Refer to Procedure 010-019 in Section 10. • Remove the turbocharger oil supply line. Refer to Procedure 010-046 in Section 10. • Remove the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10. • Remove the turbocharger.Refer to Procedure 010-033 in Section 10. If turbocharger is watercooled, use the following procedure. Refer to Procedure 010-037 in Section 10. • Remove the water bypass tube. Refer to Procedure 008-062 in Section 8.		

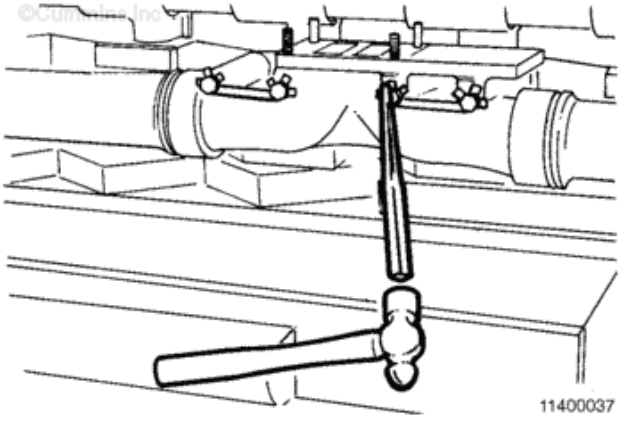
Remove

Remove the water transfer connections (1) and (4) from the exhaust manifold. Remove and discard the 2 o-ring seals (7) and the hoses (8) and (10).		



Use a drift and hammer to bend the lockplate tabs away from the capscrew heads.

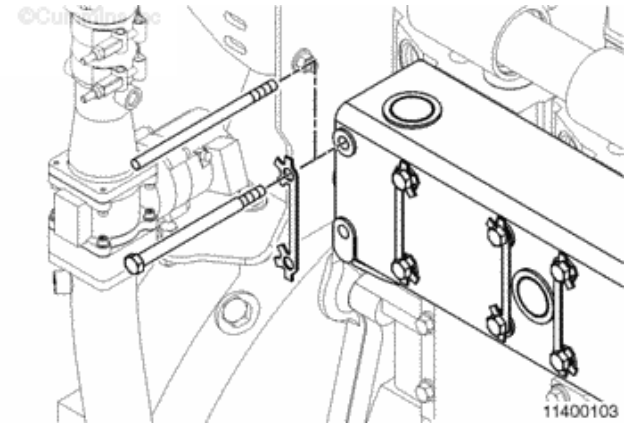
Some engines are equipped with different style lockplates or use locking capscrews instead of lockplates.



Remove the two exhaust manifold capscrews and lockplates.

Use two 7/16-14 x 15 inch guide studs to support the manifold during removal.

Install the guide studs.



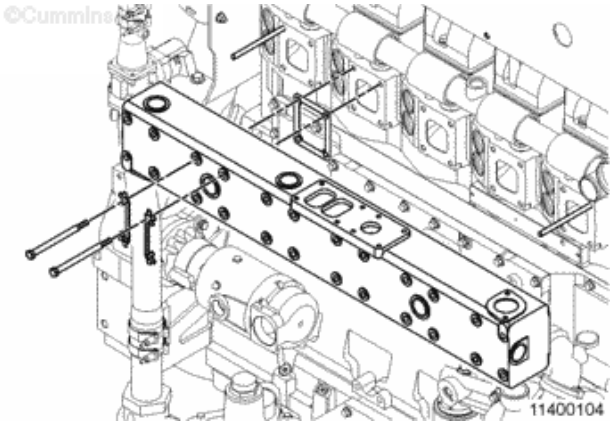
WARNING

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 remaining capscrews and lockplates.

Remove the exhaust manifold and gaskets.

Discard the gaskets.



Clean and Inspect for Reuse

WARNING

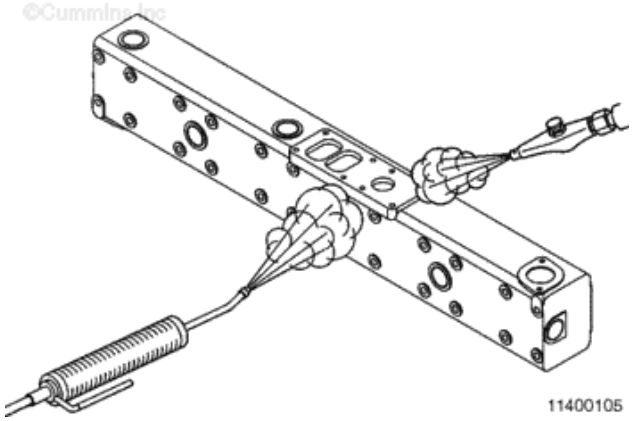
Wear safety glasses or a face shield, as well as protective clothing, to prevent personal injury when using a steam cleaner or high-pressure water.

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 steam to clean the exhaust manifold sections.

Use a wire brush to remove any scale from the outside and inside diameters of the section sealing joints.

Inspect the manifold sections for cracks in the areas shown.

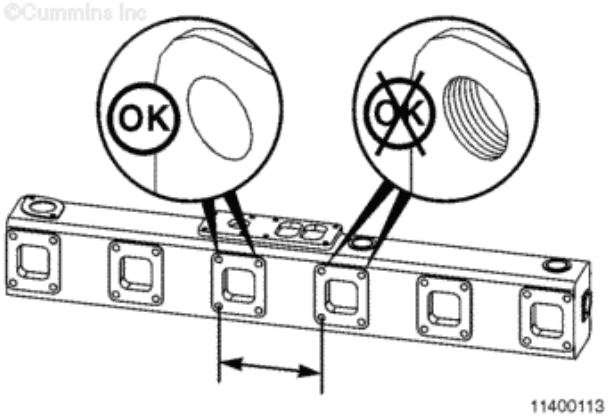
Inspect the capscrew holes in the center section for damage.

High temperature can cause the manifold to deform. If capscrew thread marks are visible on the sides of the capscrew holes, the manifold has been subjected to high temperature.

Measure the center-to-center distance between the same position capscrew holes of the two flanges on the center section and both end sections.

Exhaust Manifold Capscrew Holes

mm		in
191.5	MIN	7.54
193.5	MAX	7.62



Install

CAUTION

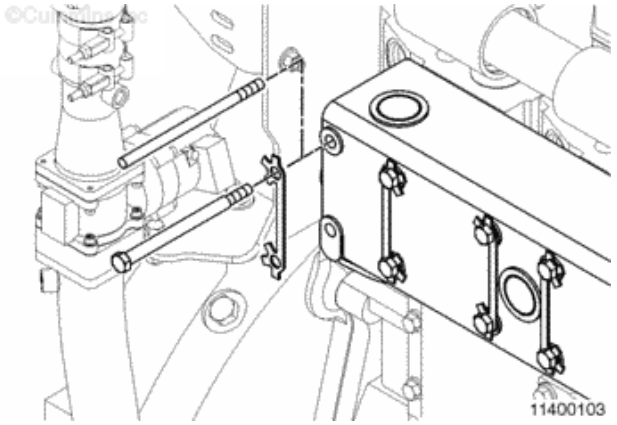
Do not use gasket cement to hold the exhaust

manifold gaskets in place during installation. The use of gasket cement lead to an exhaust gas leak.

Use two 7/16-14 x 5 inch guide studs to support the manifold during installation.

Install the exhaust manifold gaskets onto the cylinder head. Use a contact adhesive to hold the gaskets in place during installation.

Install the exhaust manifold onto the guide studs.



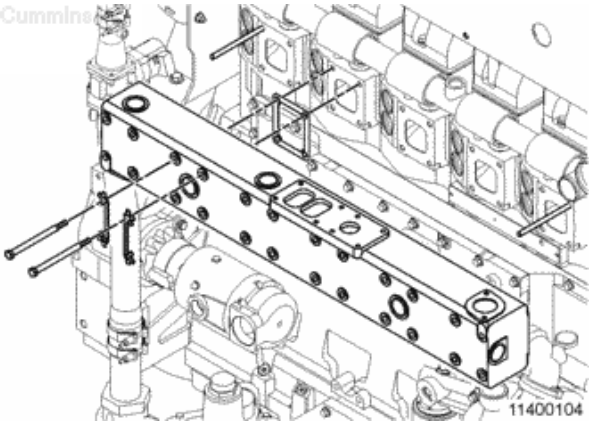
WARNING

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.

Apply anti-seize compound to the capscrew threads.

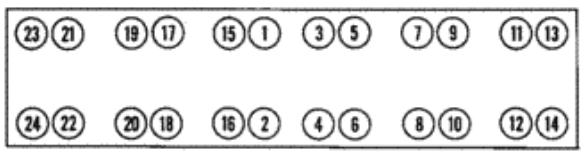
Install the lockplates and capscrews.

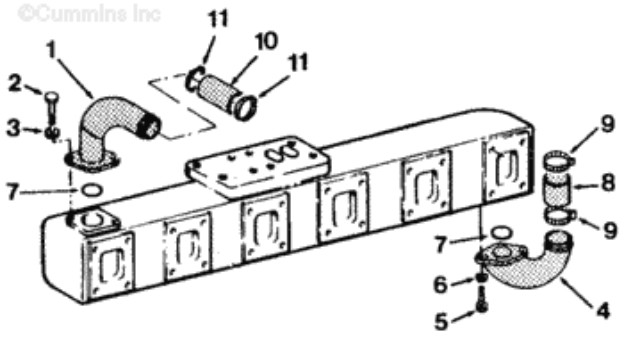
Remove the guide studs (12) and install the remaining capscrews.



Tighten the capscrews in the sequence shown.

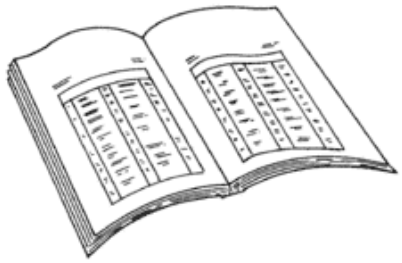
Torque
Value: 45 n.m [33 ft-lb]



Install the wet manifold water transfer connections. Slide the hose (10) and hose clamps (11) onto the front water connection (1). Install the seal ring (7) into the flange of the front water connection (1). Install the front water connection, washers (3), and capscrews (2) onto the exhaust manifold. Tighten the capscrews. **Torque** **Value:** 45 n.m [35 ft-lb] Connect the front water connection hose (10) to the transfer tube between cylinder number 1 and cylinder number 2. Tighten the clamps (11). **Torque** **Value:** 5.6 n.m [50 in-lb] Slide the hose (8) and hose clamps (9) onto the rear water connection (4). Install the seal ring (7) into the flange of the rear water connection (4). Install the rear water connection, washers (6), and capscrews (5) onto the exhaust manifold. Tighten the capscrews. **Torque** **Value:** 45 n.m [35 ft-lb] Connect the rear water connection hose (4) to the transfer tube between cylinder number 5 and cylinder number 6.	 	 11400036

Tighten the clamps (9). **Torque** **Value:** 5.6 n.m [50 in-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 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. • Install the water bypass tube.Refer to Procedure 008-062 in Section 8. • Install the turbocharger. Refer to Procedure 010-037 in Section 10. If the turbocharger is watercooled, use the following procedure. Refer to Procedure 010-037 in Section 11. • Install the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.		©Cummins Inc  ck800wa

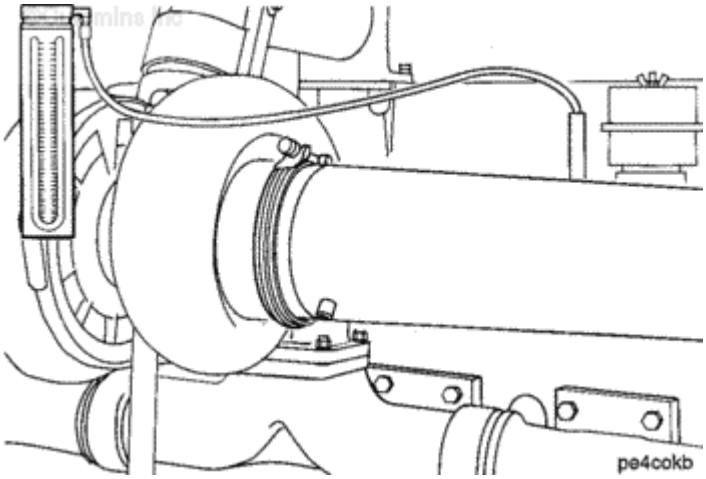
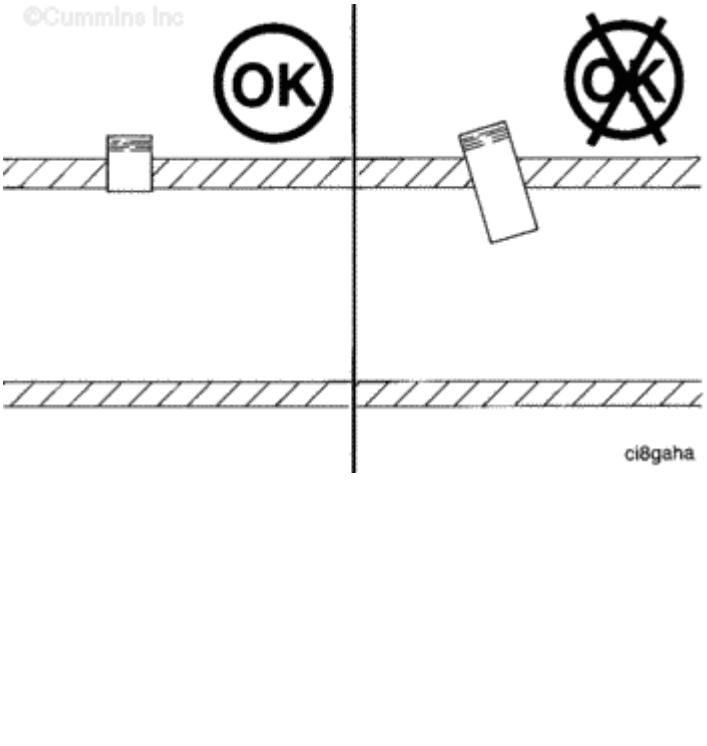
• Install the turbocharger oil supply line. Refer to Procedure 010-046 in Section 10. • Install the turbocharger inlet connection. Refer to Procedure 010-044 in Section 10. • Install the air crossover. Refer to Procedure 010-019 in Section 10. • Fill the cooling system.Refer to Procedure 008-018 in Section 8. • Connect the batteries. Refer to Procedure 013-009 in Section 13. • Start the engine and check for normal operation.		

Last Modified: 09-Jun-2009

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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 inch-Hg] or 1676 mm - $H_2 0$ [66 inch-$H_2 0$].		
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 inch] after the turbocharger. The adapter **must not** extend through the wall of the exhaust tubing.		

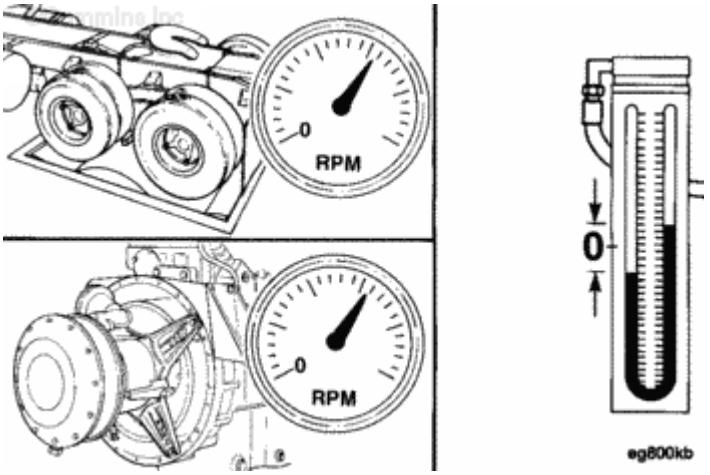
If the adapter **must** be located in a curved section of tubing, locate it on the flat side of the curve, **not** in the radius, or the measured value will **not** be accurate.

Connect a 13 mm [1/2-inch] piece of metal tubing between the gauge adapter and the gauge hose. This will prevent damage to the hose from extreme heat.

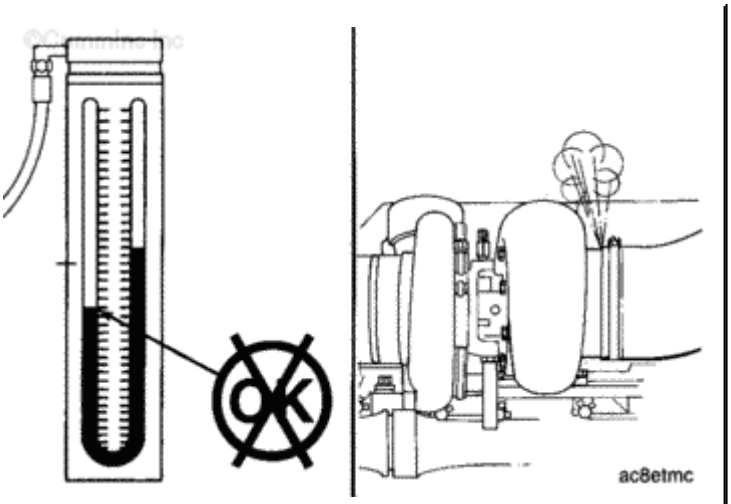
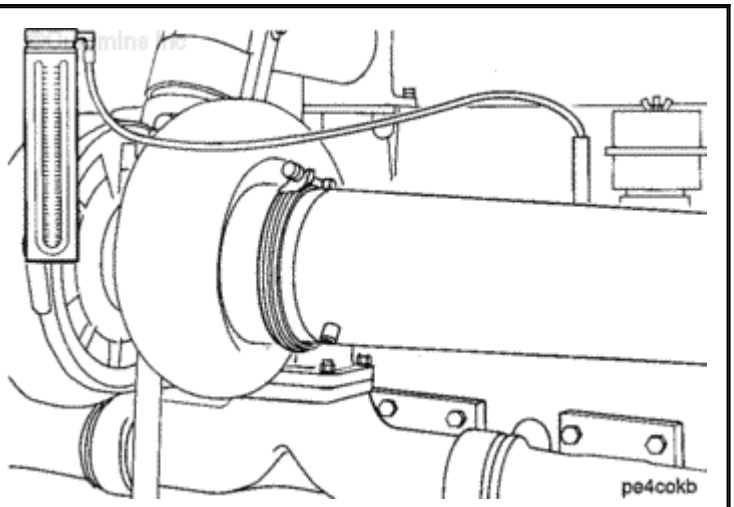
Stall speed is **not** full power.

Operate the engine at rated rpm and load, and record the manometer reading.

The exhaust pressure **must not** exceed 75 mm [3.0 inch-Hg].



If the exhaust pressure exceeds the specification, inspect the exhaust piping for damage. Refer to the equipment

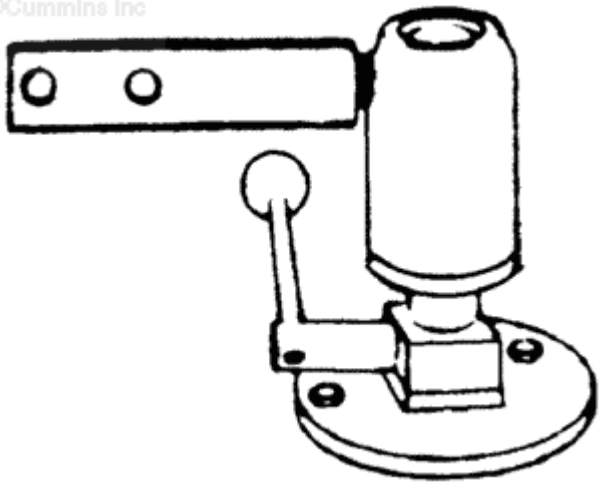
manufacturer's instructions. If damage is **not** visible, check the size and routing of the exhaust piping. Refer to the Installation Recommendation Bulletin.		
Remove the test equipment.		

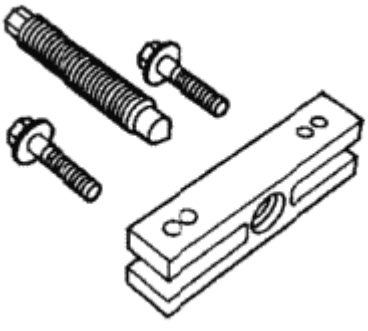
Last Modified: 22-Nov-2004

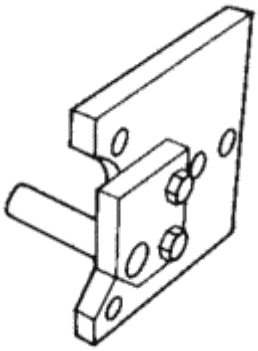
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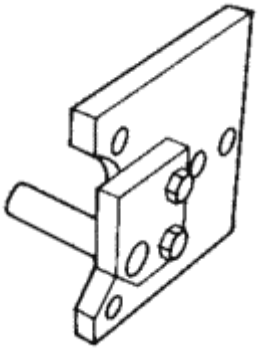
022-001 Service Tools

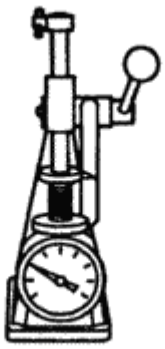
Compressed Air System

Tool Number ST-302	**Ball Joint Vise** Use to hold the air compressor for disassembly or assembly.	

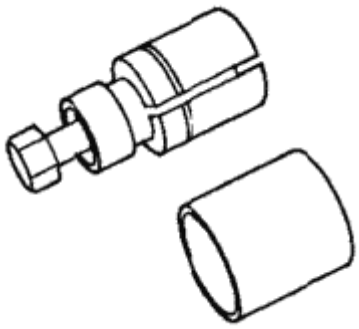
Tool Number ST-647	**Standard Puller** Use to pull the drive gear. Use with puller capscrews that have M8 x 1.25-6H thread.	

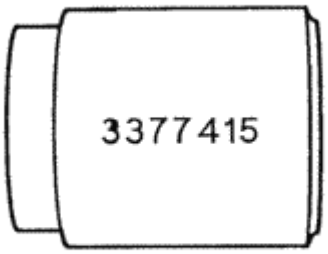
Tool Number ST-749	**Mounting Plate** Use to mount the air compressor to the vise.	©Cummins Inc  st-749

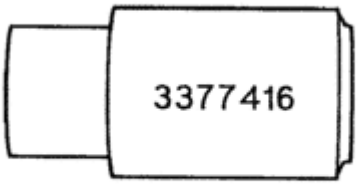
Tool Number 3823596	**Mounting Plate** Use to mount the air compressor to the vise.	©Cummins Inc  st-749

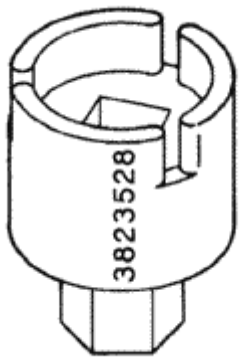
Tool Number 3375182	**Valve Spring Tester** Use to check the exhaust valve, intake valve, and unloader valve cap springs.	©Cummins Inc  kn8togs

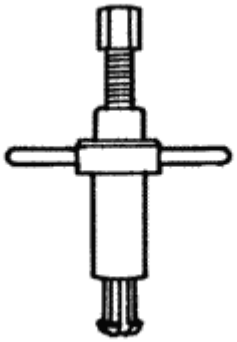
Tool Number	**Coupling Puller**	

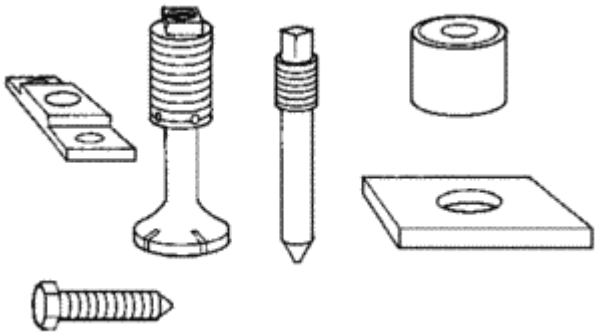
3376663	Use to remove the spline coupling hub.	 bp8togg

Tool Number 3377415	**Air Compressor Seat Installation Tool** Use to install the exhaust valve seats.	 3377415

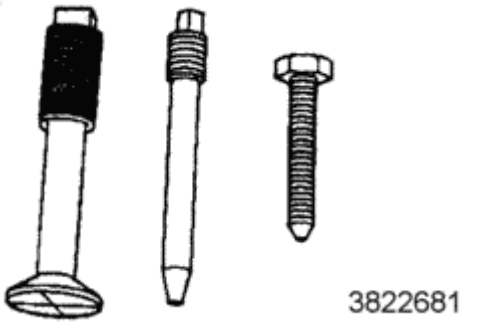
Tool Number 3377416	**Air Compressor Seat Removal Tool** Use to remove the exhaust valve seats.	 3377416

Tool Number		
3823528	**Air Compressor Seat Socket** Use to remove and install the exhaust valve seat and the inlet valve cage.	 3823528

Tool Number		
ST-544	**Valve Seat Puller** Used to remove the exhaust valve seat on older compressors, when the head is mounted on the air compressor.	 st-544

Tool Number		
3822674	**Compressor Exhaust Valve Seat Kit** Tools used to pull and install the press fit nine hole exhaust seat in single cylinder Cummins air compressors.	 3822674

Tool Number		
	Compressor Exhaust Valve Seat Kit Kit that converts	

3822681	Compressor Exhaust Valve Seat Kit, Part Number 3822674, into a two cylinder air compressor kit.	©Cummins Inc 

Last Modified: 25-Oct-2004

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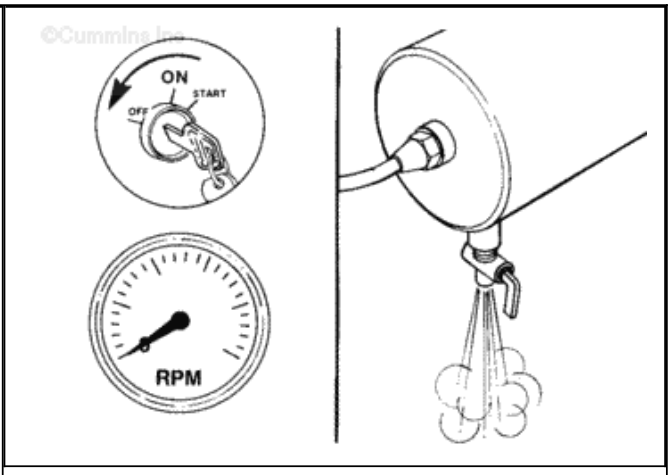
012-003 Air Compressor Carbon Buildup

Initial Check

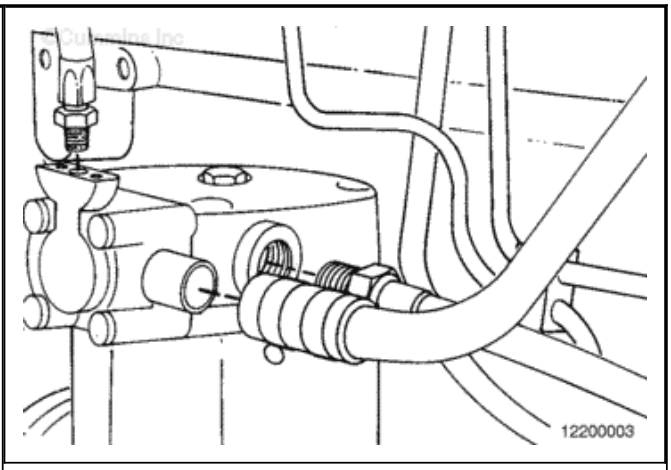
NOTE: The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for other models of Cummins air compressors will be shown where necessary.

Shut off the engine.

Open the drain cock on the wet tank to release compressed air from the system.



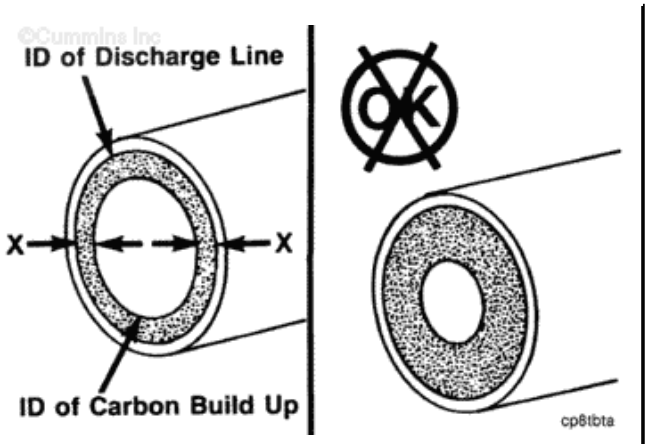
Remove the inlet and outlet connections from the air compressor.



Measure the total carbon deposit thickness inside the air discharge line as shown.

Air Compressor Inlet and Outlet Line Carbon Deposit

mm		in
1.6	MAX	0.06

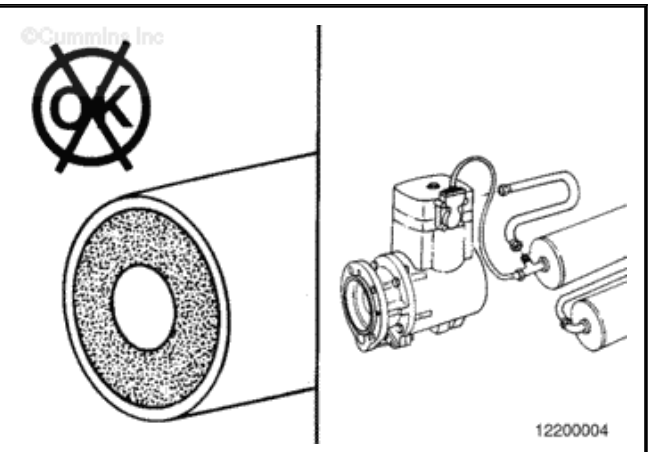


WARNING

The air discharge line must be capable of withstanding extreme heat and pressure to reduce the possibility of personal injury and property damage. Refer to the manufacturer's specifications.

If the total carbon deposit thickness exceeds the maximum specification, remove and clean, or replace the air discharge line.

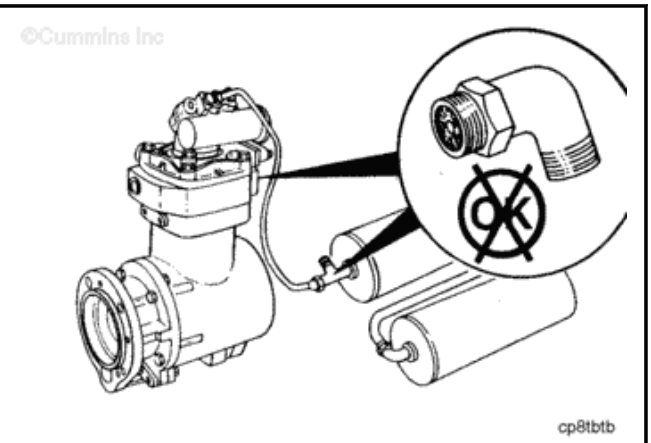
Refer to the manufacturer's specifications.



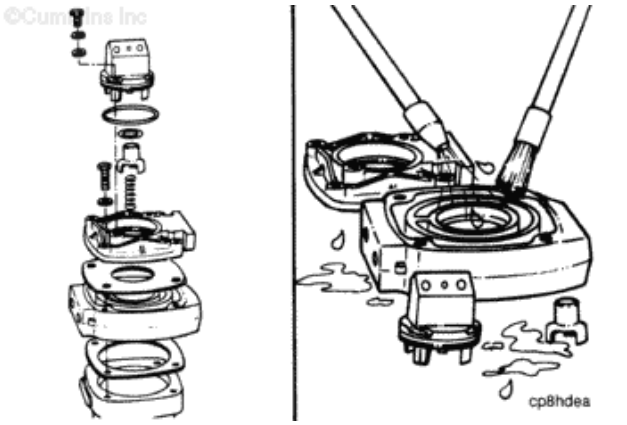
WARNING

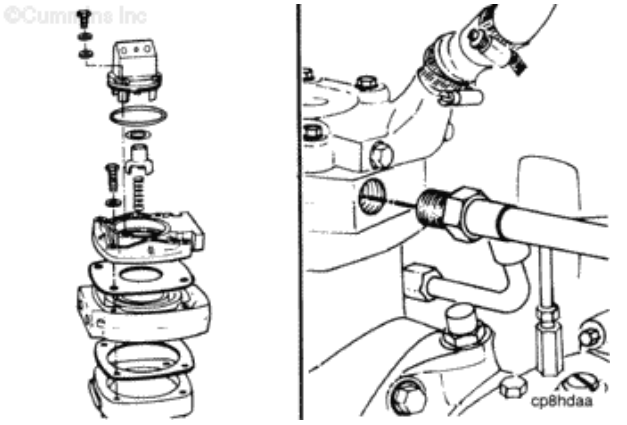
The air discharge line must be capable of withstanding extreme heat and pressure to reduce the possibility of personal injury and property damage. Refer to the manufacturer's specifications.

Continue to check for carbon buildup in the air discharge line connections up to the first

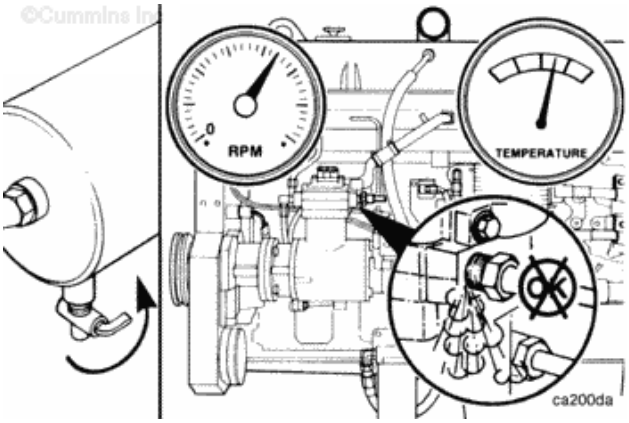


connection, or wet tank. If the total carbon deposit thickness exceeds the maximum specification, remove and clean, or replace the air discharge line. Refer to the manufacturer's specifications.		

CAUTION Do not use a sharp object to remove carbon. The sealing surfaces can be damaged. Remove, clean and inspect the compressor cylinder head and valve assembly. Refer to Procedure 012-103, 012-104, or 012-106.		

Assemble the air compressor using new gaskets and o-rings. Refer to Procedure 012-103, 012-104, or 012-106. Install and tighten the air inlet and outlet connections.		

Close the wet tank drain cock. Operate the engine and check for air leaks.		



Last Modified: 01-Dec-2004

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012-010 Air Compressor Pin Bore Wear

Initial Check

WARNING

The unloader valve body is installed with spring tension. Use care when removing to reduce the possibility of personal injury. Always wear protective eye wear.

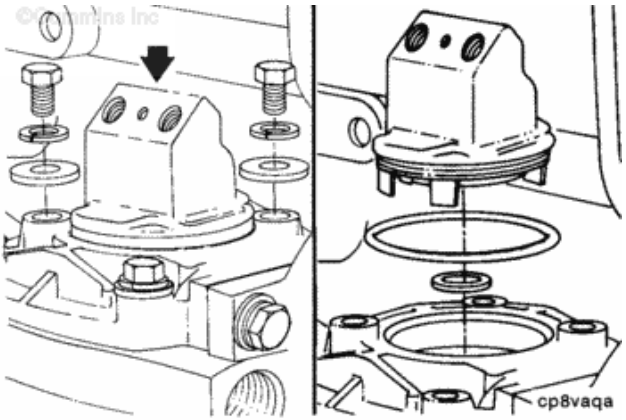
NOTE: This procedure applies to SS and ST models only.

Hold the unloader valve body down and remove the two captive washer capscrews and the two plain washers.

Remove the unloader valve body.

Remove the o-ring seal.

Remove the rectangular ring seal.

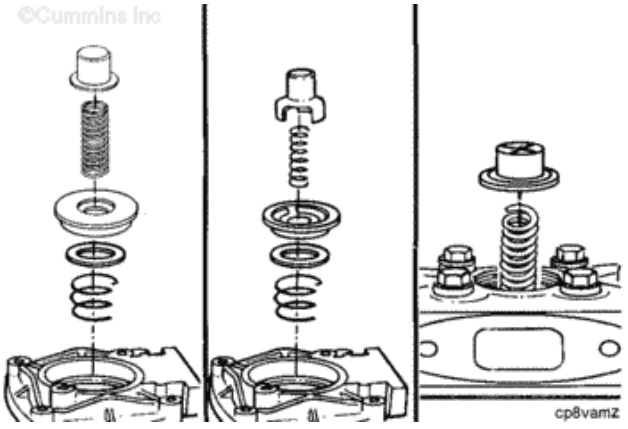


NOTE: Disassembly of the center unloader valve on Holset® two cylinder air compressors is similar to the single cylinder unloader valve.

Remove the unloader valve cap and the unloader valve spring.

Remove the intake valve seat and valve.

Remove the intake valve



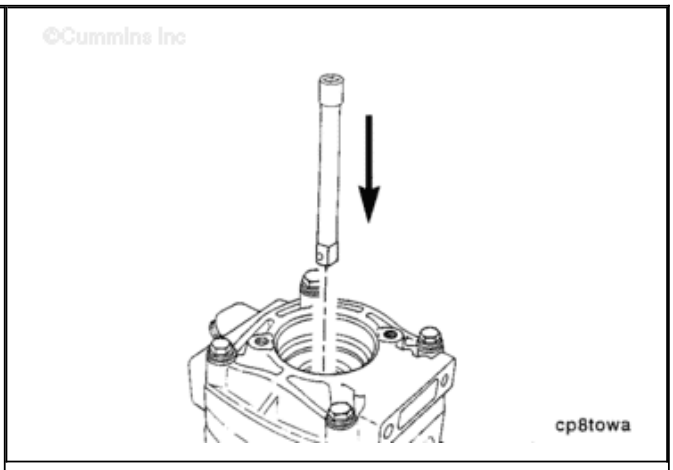
spring.

To avoid damage to the air compressor, do **not** allow any debris to fall into the air compressor cylinder.

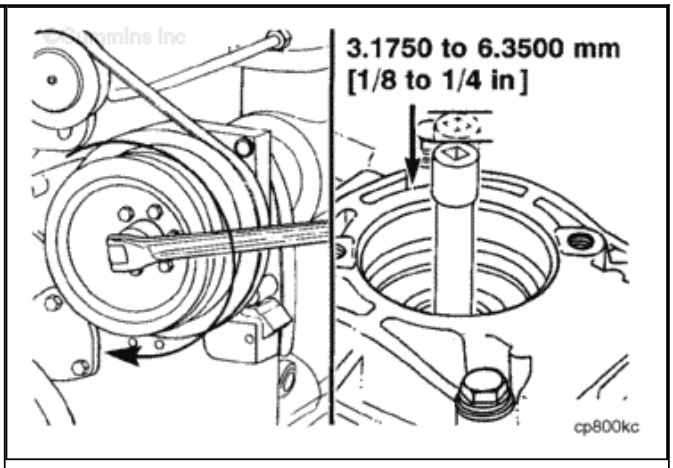
CAUTION

Do not use a screwdriver. A screwdriver can gouge the top of the piston.

Insert the small end of a 3/8 inch drive socket extension (6 to 10 inches long) through the exhaust valve seat onto the top of the piston.



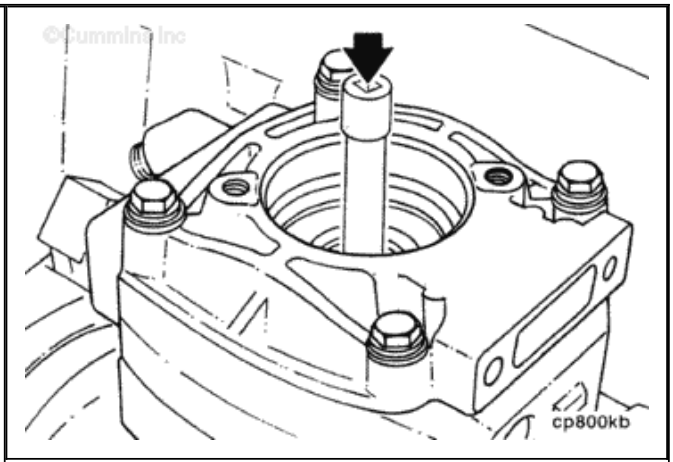
Bar the crankshaft over until the compressor piston reaches top dead center and the extension starts to move downward approximately 3 to 6 mm [1/8 to ¼ in].

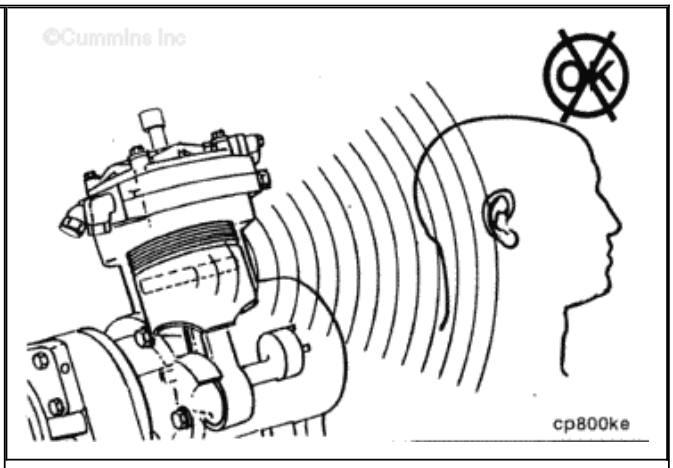


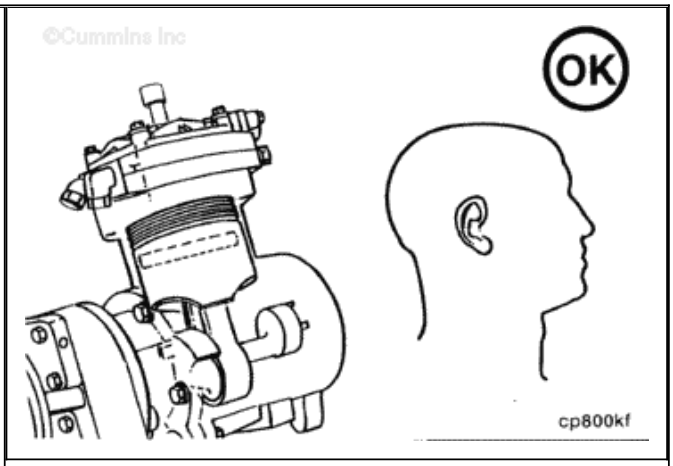
CAUTION

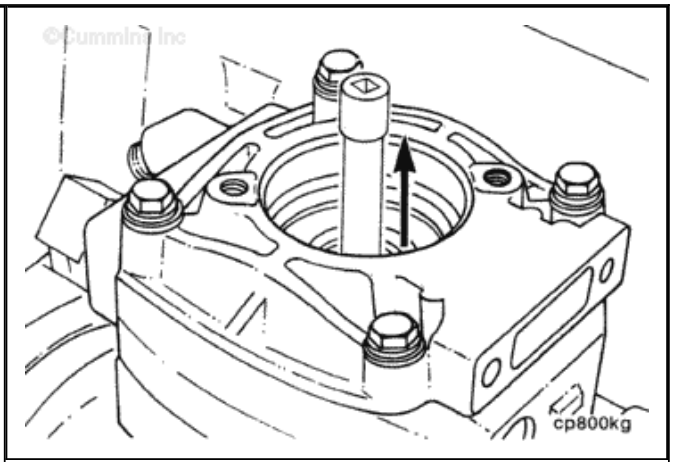
To reduce the possibility of damage to the top of the piston, do not use a hammer.

Give a quick, hard push downward on the extension and listen for a metallic click as wear clearance is taken up.



If significant piston motion is felt or a metallic click is heard, the pin bores can be worn, and the compressor **must** be examined further.		

If no motion or sound is heard, the compressor is in satisfactory condition and does **not** need to be replaced. All air compressors will **not** exhibit pin bore wear.		

Remove the extension.		

Install the intake valve spring		

with the tang down.

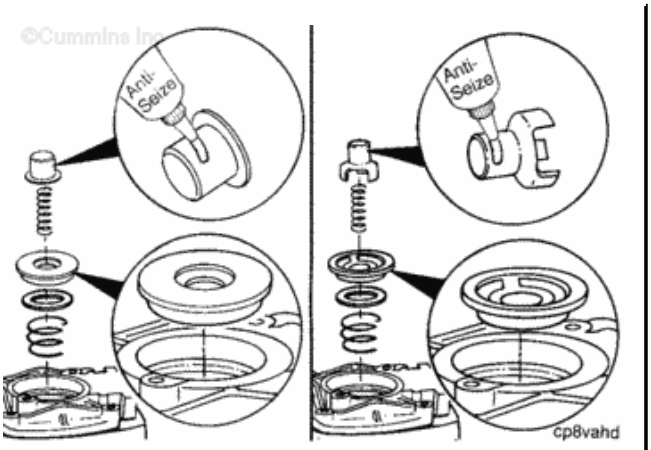
Install the intake valve.

Install the intake valve seat with the flange side up.

Install the unloader valve cap spring.

Install the unloader valve cap.

Use high temperature grease (Accrolube Lubrication Teflon Grease or equivalent) to lubricate the outside diameter of the cap.



The rectangular ring seal **must** be installed with the grooved side up.

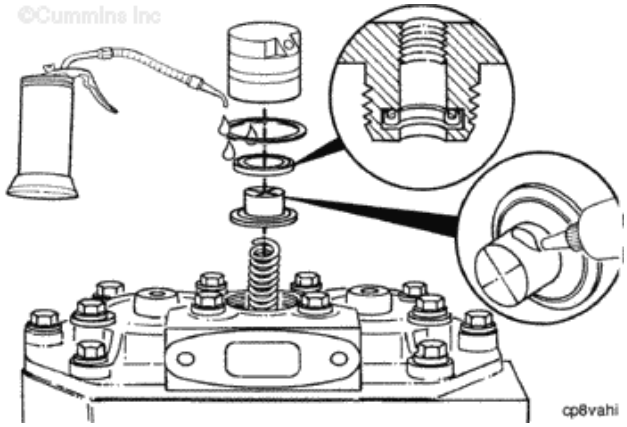
Install the rectangular ring seal.

Install the o-ring seal.

Use clean 15W-40 engine oil to lubricate the o-ring seal.

Install the unloader valve body.

Press the unloader valve body down to be sure the tangs of the unloader valve cap are in the three slots of the intake valve seat.

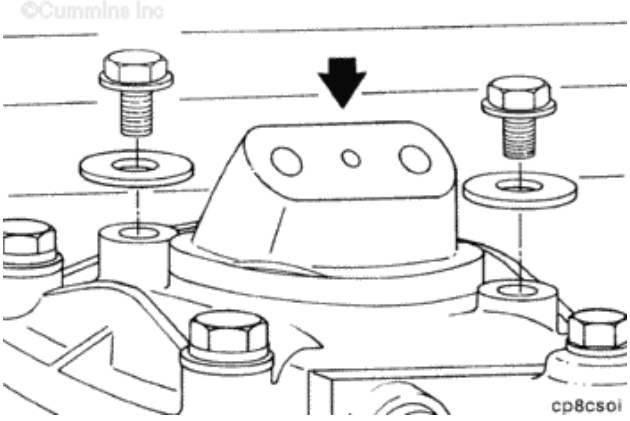


CAUTION

Do not over tighten the capscrews. Compressor damage will result.

Hold the unloader body down and install the two plain washers and captive washer capscrews.

Tighten the capscrews.



Torque **Value:** 14 n.m [120 in-lb]		

Last Modified: 01-Dec-2004

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012-013 Air Compressor Unloader and Valve Assembly

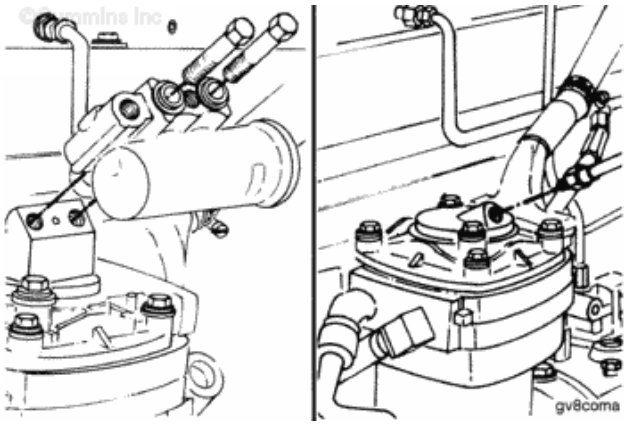
Initial Check

WARNING

Air pressure must be released from system before removing the air governor to prevent personal injury.

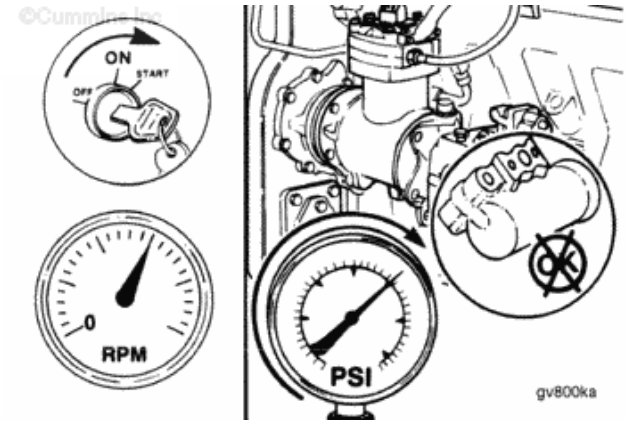
The following procedures are for Holset® air compressors **only**. The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for SS, QE and ST model Holset® air compressors will be shown where necessary.

Remove the air governor or air governor hose from the air compressor unloader body.



Operate the engine to activate the air compressor.

If the air compressor is **not** pumping, the unloader valve is malfunctioning and **must** be repaired or replaced.



Remove

Holset® SS296, SS296E, and SS338E A/C Model

WARNING

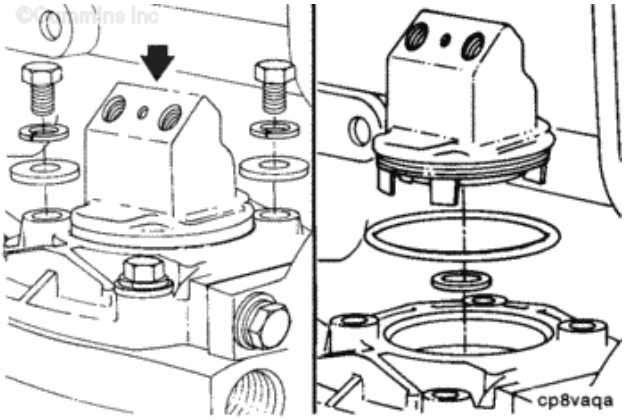
The unloader valve body is installed with spring tension. Use care when removing to prevent personal injury. Always wear protective eye wear.

Hold the unloader valve body down and remove the two captive washer capscrews and the two plain washers.

Remove the unloader valve body.

Remove the o-ring seal.

Remove the rectangular ring seal.

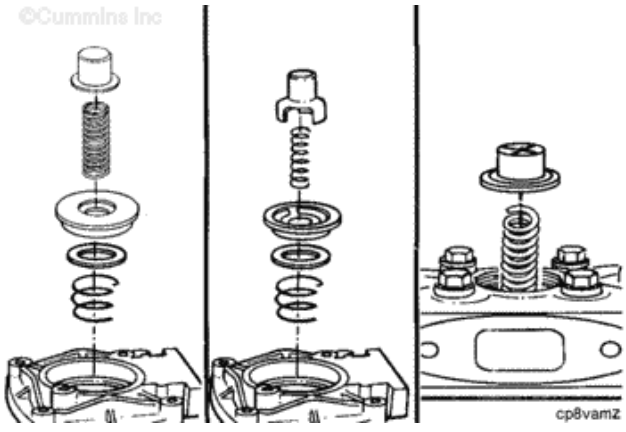


NOTE: Disassembly of the center unloader valve on Holset® two cylinder air compressors is similar to the single cylinder unloader valve.

Remove the unloader valve cap and the unloader valve spring.

Remove the intake valve seat and valve.

Remove the intake valve spring.



Holset® QE230, QE296, and QE338 A/C Model

WARNING

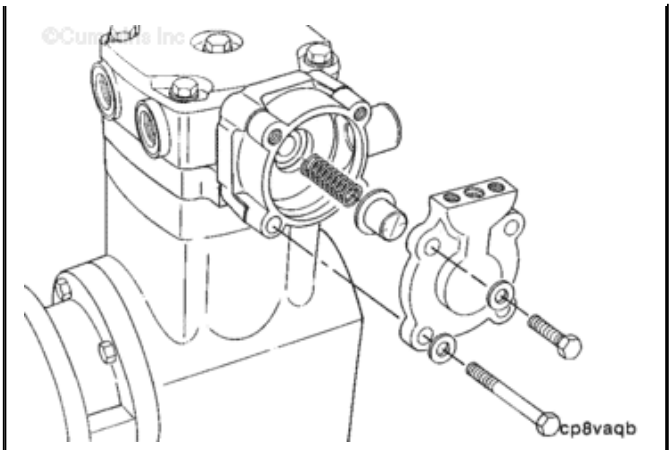
The unloader body is installed with spring tension.

Use care when removing to prevent personal injury. Always wear protective eye wear.

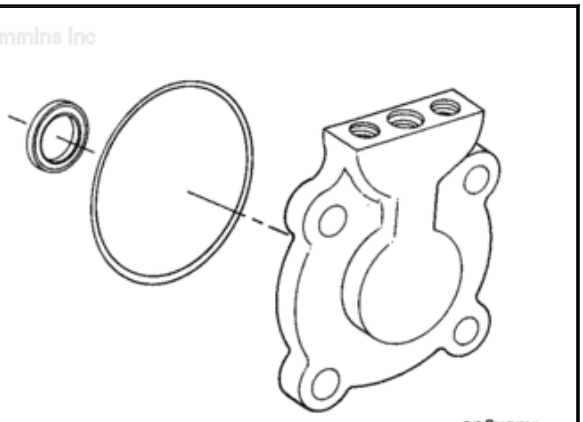
Hold the unloader valve body down and remove the four capscrews.

Remove the unloader valve spring.

Remove the unloader valve cap.



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

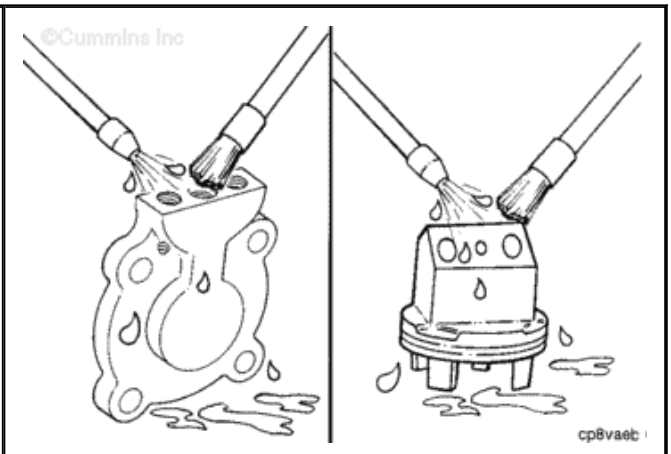


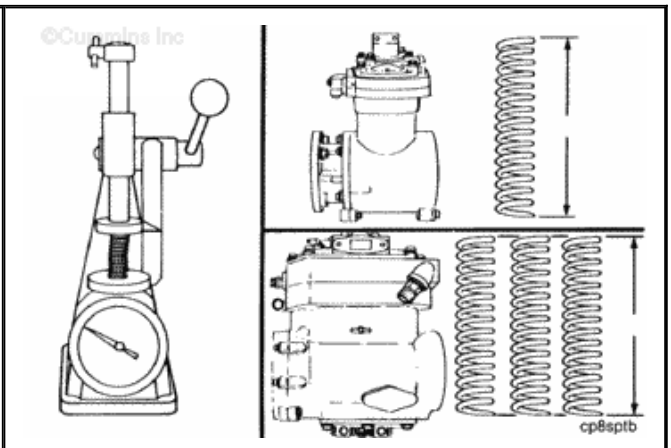
Clean and Inspect for Reuse

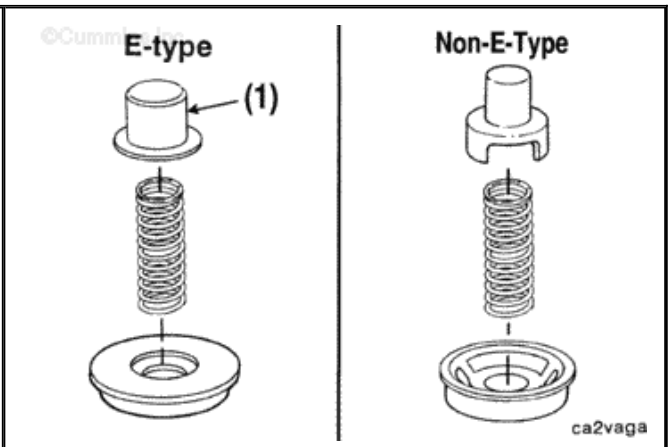
CAUTION

Do not use caustic cleaners. Caustic cleaners may can damage to component parts.

Remove all carbon and varnish from the unloader valve cap body.



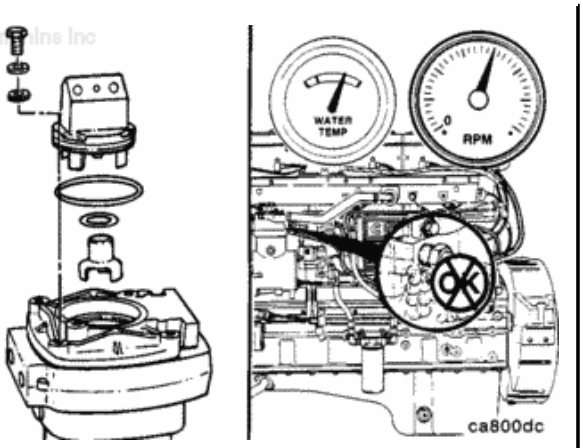
For Holset® two cylinder air compressors, check both cylinder and center unloader springs. Holset Engineering Co., Inc., recommends that new springs be installed during rebuild.		

If the compressor has a flat hat type unloader cap (1), it **must** use an unloader spring and valve seat different than that used with the three prong unloader.		

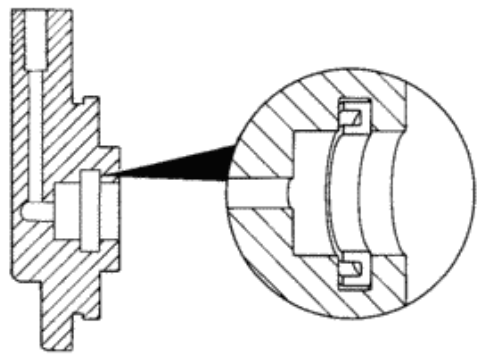
Install

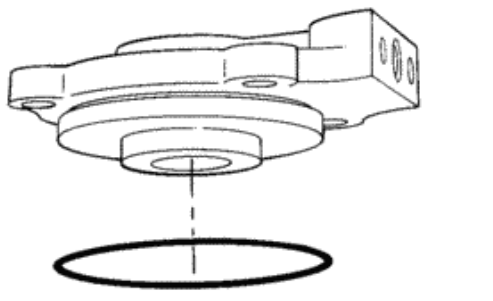
Holset® SS296, SS296E, and SS338E Air Compressor Model

Assemble the air compressor. Lubricate the rectangular ring seal, unloader cap and unloader body bore with high temperature grease (Accrolube Lubrication Teflon Grease or		

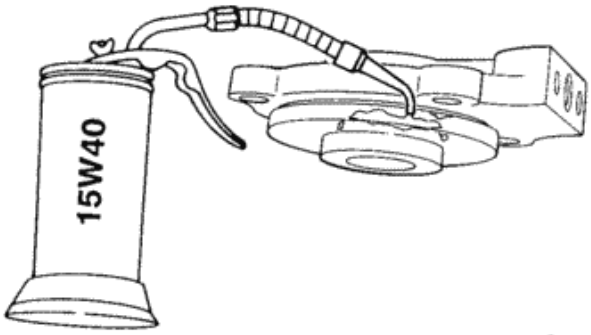
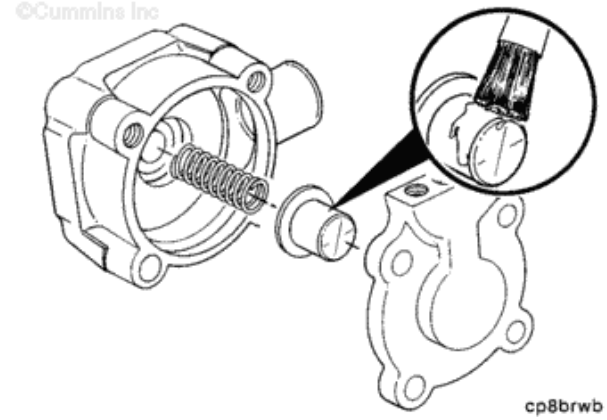
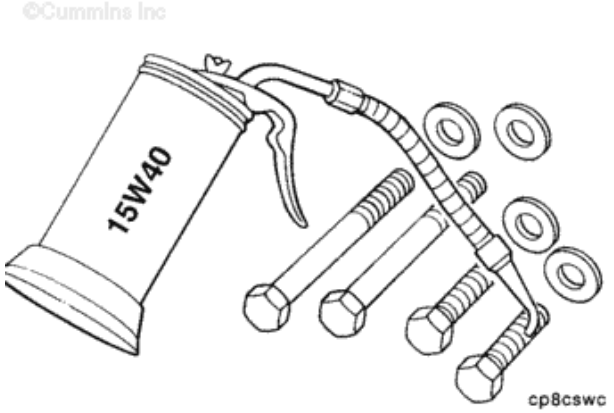
equivalent). **Torque** **Value:** 14 n.m [10 ft-lb] Operate the engine and check the compressor for air leaks.		

Holset® QE230, QE296, and QE338 A/C Model

Install the new rectangular V-seal, with the grooved side up, into the unloader body. Liberally lubricate the unloader valve bore above and below the rectangular ring seal with high temperature grease (Accrolube Lubrication Teflon Grease or equivalent).		

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

Use clean 15W40 engine oil,		

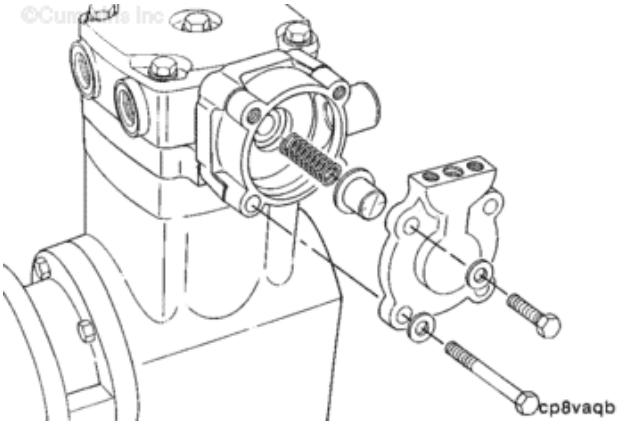
Accrolube Lubrication Teflon Grease, or equivalent to lubricate the seal.		 cp8sewa
Liberally lubricate the unloader valve body bore and unloader cap with high temperature grease (Accrolube Lubrication Teflon Grease or equivalent). Install the unloader cap. Install the unloader spring.		 cp8brwb
Lubricate the unloader screw threads and underhead with clean engine oil (SAE 15W40), before installation. The two unloader body screws **must not** be used to attach any brackets.		 cp8cswc
Assemble the unloader components and attach the unloader assembly to the valve plate with the four		

capscrews and washers.

The longer capscrews are used to mount the manifold to the air compressor.

Torque
Value: 27 n.m [20 ft-lb]

Operate the engine and check the air compressor for air leaks.



Last Modified: 31-Jul-2006

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012-014 Air Compressor

Preparatory Steps

WARNING

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

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

WARNING

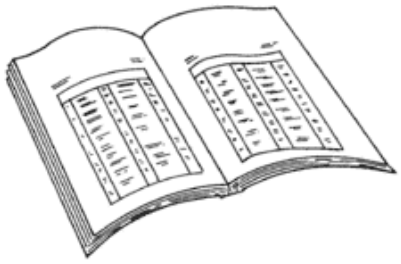
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

NOTE: The illustrations shown will be the SS model





ck800wa

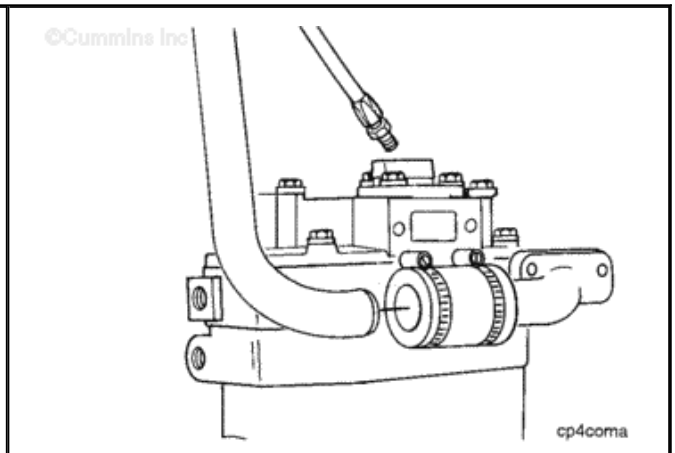
single cylinder air compressor. Differences in procedures for SS, QE, and ST Cummins® air compressors will be shown where necessary.

- Use steam to clean the air compressor. Dry with compressed air.
- Remove the fuel pump. Refer to Procedure 005-016 in Section 5.
- Drain the engine coolant. Refer to Procedure 008-018 in Section 8.
- Remove the coolant lines from the air compressor.

Remove

Single Cylinder

Remove the air inlet and outlet connections from the air compressor.



WARNING

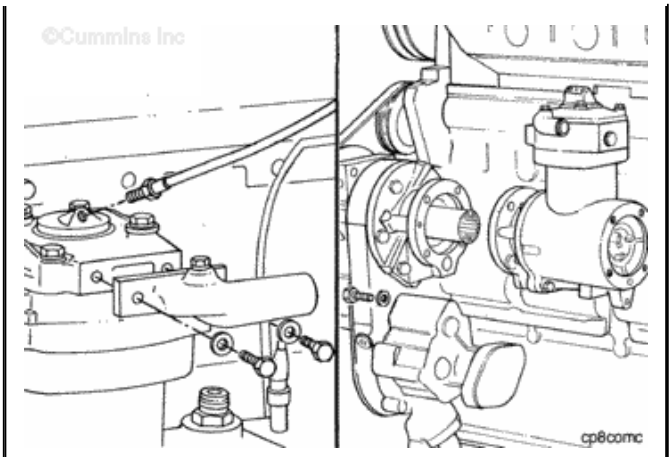
This component or assembly weighs greater than 23 kg [50 lbs]. To prevent serious personal injury, be sure to have assistance or use

appropriate lifting equipment to lift this component or assembly.

Remove the air connections from the air compressor.

Remove the air compressor support bracket and capscrews.

Remove the four capscrews, the air compressor, and splined coupling.



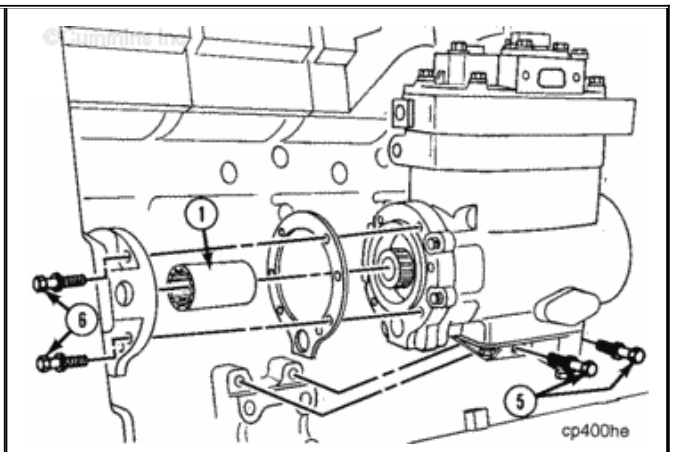
Twin Cylinder

Remove the air compressor support mounting capscrews (5).

Remove the four capscrews (6). Remove the air compressor. Remove the splined coupling (1). Remove and discard the gasket.

It a two-piece bracket is used, remove the bolts and nuts securing the brackets together. Remove the bracket from the compressor and the bracket from the block.





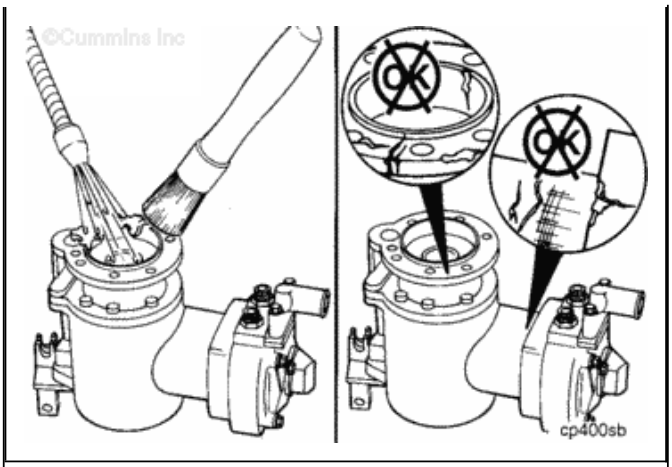
Clean and Inspect for Reuse

Single Cylinder

Clean air compressor and inspect housing for cracks or damage.

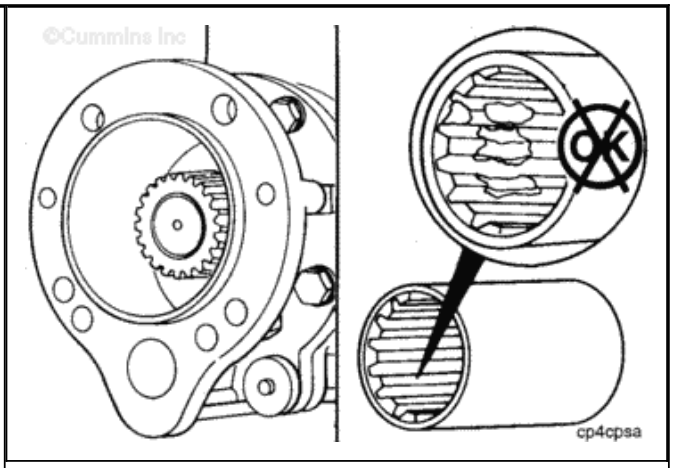






Inspect the splined coupling for cracks or damage.





Check crankshaft end clearance on the single cylinder air compressor.

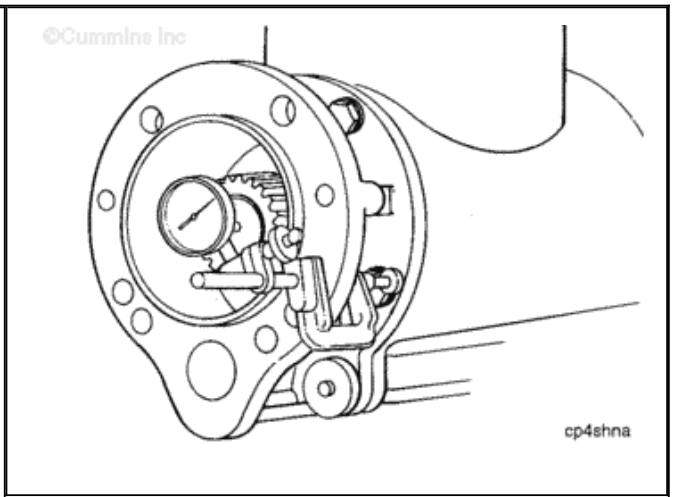




End Clearance (Aluminum Support, Part Number 3005153)

mm		in
.05	MIN	.002
.69	MAX	.027

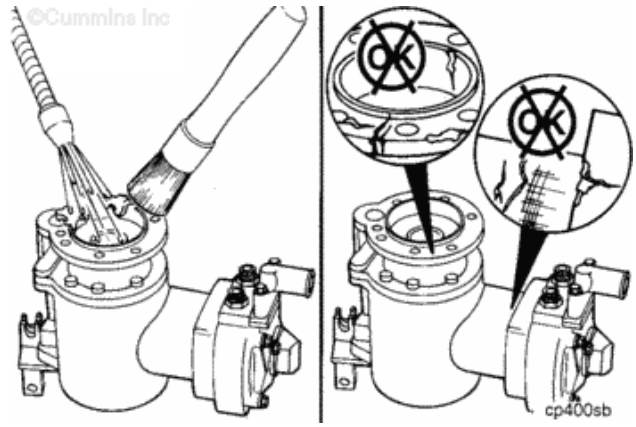
If end clearance is **not** within specifications, go to the Master Repair Manual, Holset® Air Compressors, Bulletin 3666121.



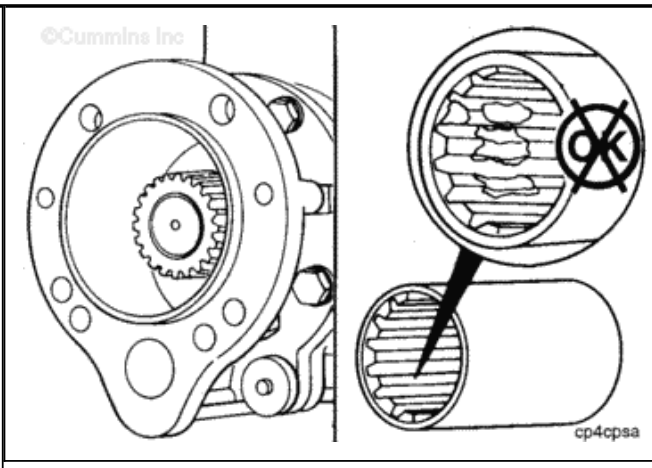
Twin Cylinder

Use solvent, Part Number 3824421, or equivalent, and clean the exterior of the air compressor.

Inspect the compressor housing for cracks or damage.



Inspect the splined coupling for cracks or damage.

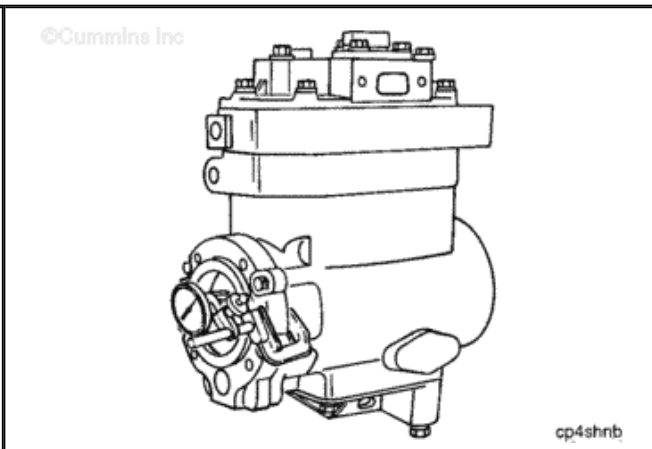


Check the crankshaft end clearance on the two cylinder air compressor.

Crankshaft End Clearance

mm		in
0.038	MIN	0.0015
0.200	MAX	0.0080

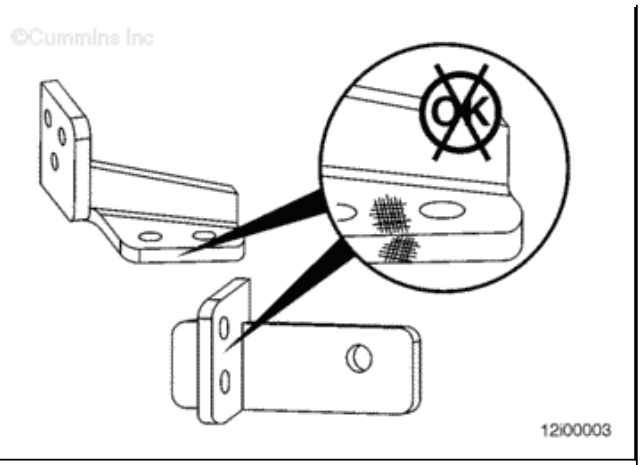
If end clearance is **not** within specifications, go to ST676 Two Cylinder Air Compressor Shop Manual, Bulletin 3666221, for rebuild instructions.



Inspect the brackets and capscrews for fretting or

other damage. If damage is found, the brackets **must** be replaced to prevent damage to the air compressor housing.

NOTE: Surface wear that only removes the paint on the brackets is acceptable.



Install

Single Cylinder

WARNING

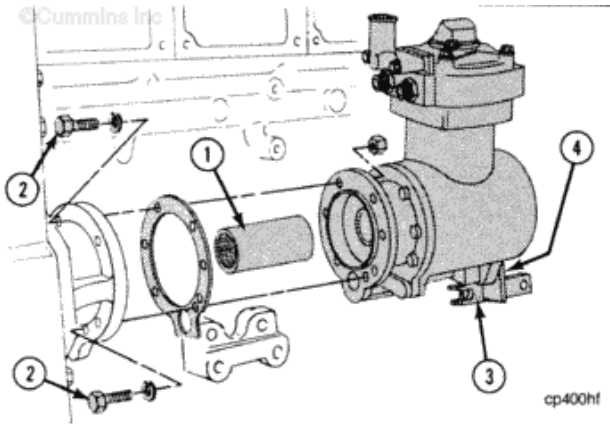
This component or assembly weighs greater than 23 kg [50 lbs]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Install the splined coupling (1) on the accessory drive shaft.

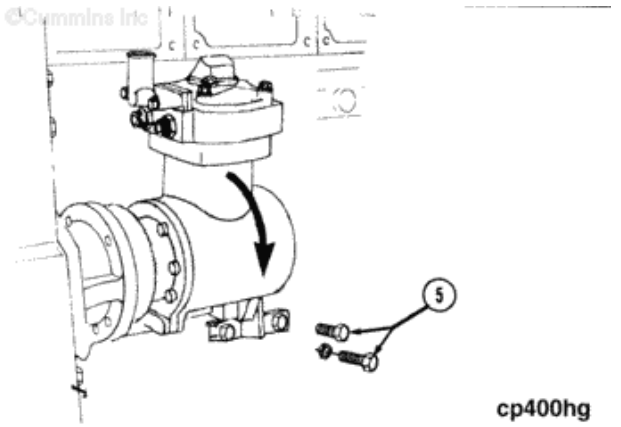
Be sure the gasket surfaces of the accessory drive and air compressor are clean and **not** damaged.

Use a new gasket to install the air compressor.

Install and **only** hand-tighten the four capscrews and nuts (2).



Install the two capscrews (5) for the bracket. The support bracket **must** be flat against the block. Turn the compressor until the bracket is flat against the block.



CAUTION

The bracket must be flat against the compressor. Failure to have the bracket flat can cause premature component failure.

Tighten the compressor to the accessory drive capscrews (2).

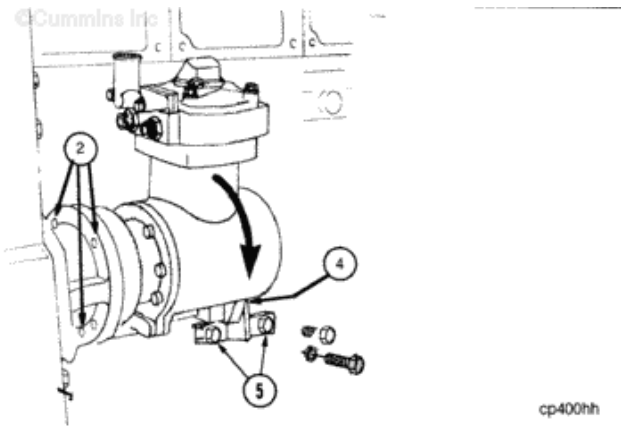
Torque
Value: 60 n.m [44 ft-lb]

Tighten the bracket to the block capscrews (5).

Torque
Value: 45 n.m [33 ft-lb]

Tighten the bracket to the compressor capscrew (4).

Torque
Value: 45 n.m [33 ft-lb]

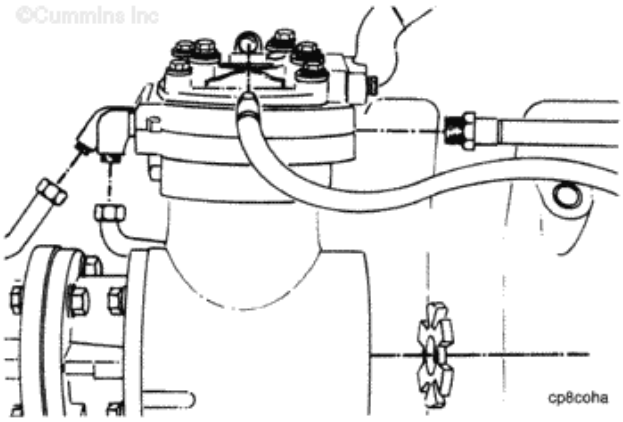


NOTE: If rubber grommets are used on the coolant lines, be sure they are installed carefully to prevent cuts or tears to the grommets which cause coolant leaks. When flexible tubing is used, make sure that it does not

rub any other surface.

Install the coolant and air lines to the air compressor and tighten.

Install the fuel pump drive coupling on the air compressor.



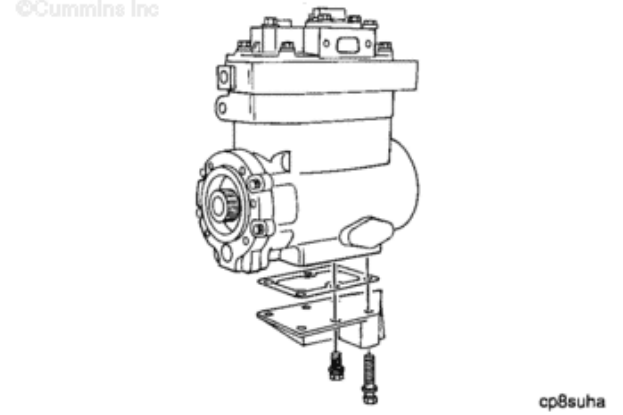
Twin Cylinder

WARNING

This component or assembly weighs greater than 23 kg [50 lbs]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

On twin cylinder compressors with a one piece bracket, install the gasket and the cover plate (support bracket) on the compressor.

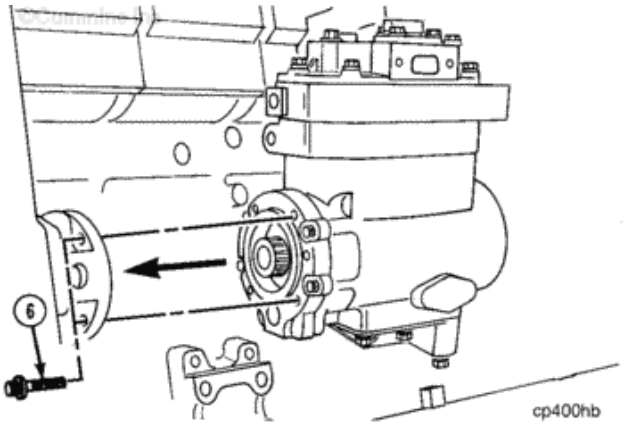
Do **not** tighten the six capscrews. The support **must** be adjusted.



NOTE: Do not install the splined coupling or the mounting gasket.

Install the compressor on the accessory drive.

Install the four capscrews (6). **Only** tighten the capscrews enough to pull the compressor to the accessory drive. The compressor **must** be turned



to align the support bracket.

CAUTION

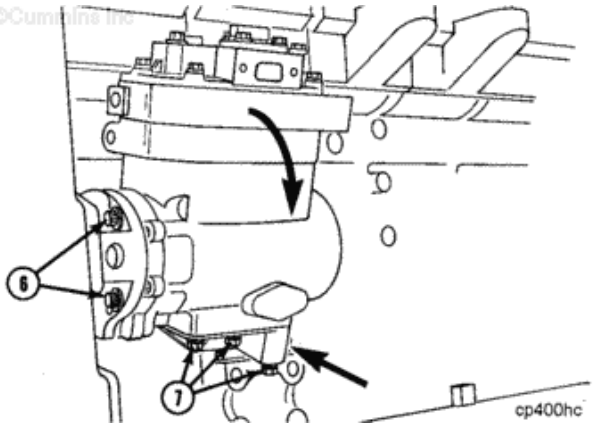
The support must be flat against the block. Rotate the compressor until the support is aligned properly against the block. If the support is not flat, the compressor and/or accessory drive will fail.

Tighten the four capscrews (6).

Torque
Value: 60 n.m [44 ft-lb]

The bracket **must** remain flat against the block. Tighten the support capscrews (7) that are accessible.

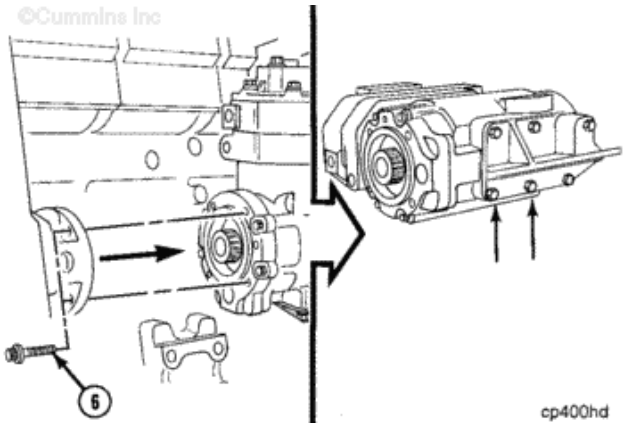
Torque
Value: 45 n.m [33 ft-lb]



Remove the four capscrews (6). Remove the compressor.

Tighten the two remaining supports to the compressor capscrews.

Torque
Value: 45 n.m [33 ft-lb]



CAUTION

The support must be flat against the block. Rotate the compressor until the support is aligned properly

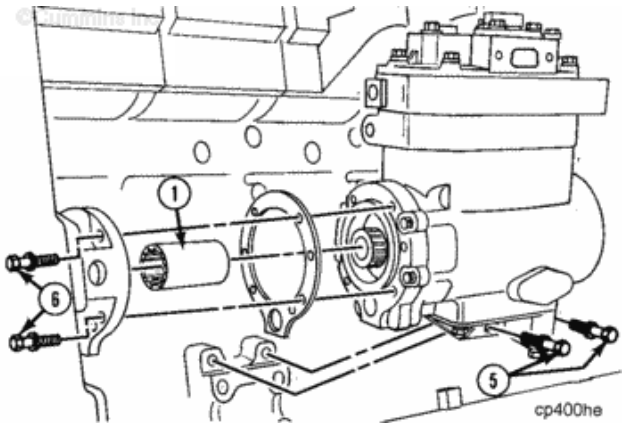
against the block. If the support is not flat, the compressor and/or accessory drive will fail.

Install the splined coupling (1), gasket, and compressor.

Install the four capscrews (6) and two capscrews (5).

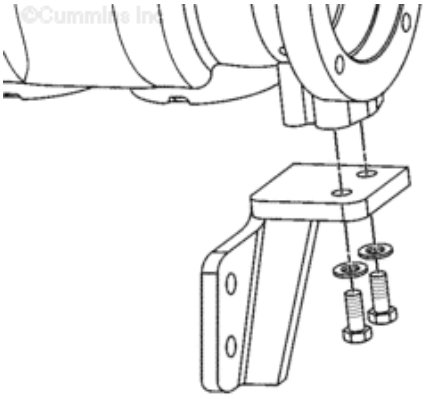
Torque Value:
Capscrew (6) 60 n.m [44 ft-lb]

Torque Value:
Capscrew (5) 45 n.m [33 ft-lb]



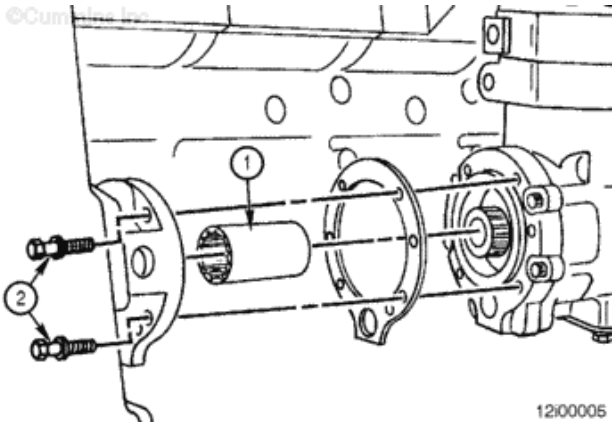
On air compressors with the two-piece bracket, install the top bracket, washers, and capscrews onto the bottom face of the air compressor.

Hand tighten the capscrews.



Install the splined coupling (1), gasket, and compressor.

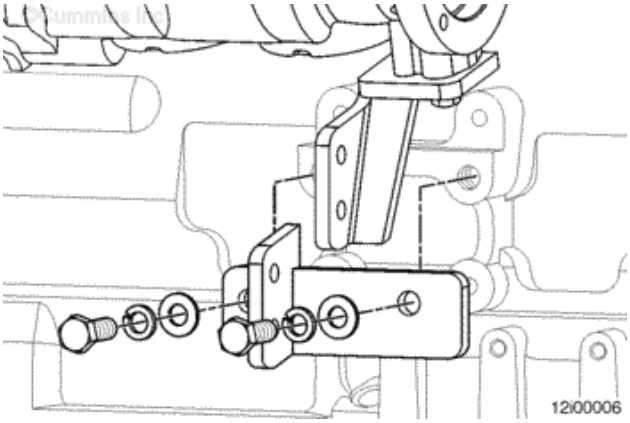
Install the four capscrews (2), but do **not** tighten to allow movement of the compressor for support bracket installation.



Position the bottom bracket

behind the top bracket and install the capscrews, lock washers, and plain washers.

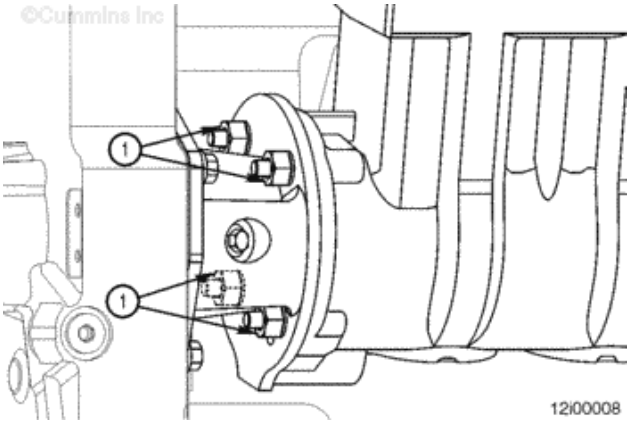
Hand tighten the capscrews.



Tighten the four air compressor mounting capscrews (1).

Torque Value:
Mounting
Capscrews 47 n.m [35 ft-lb]

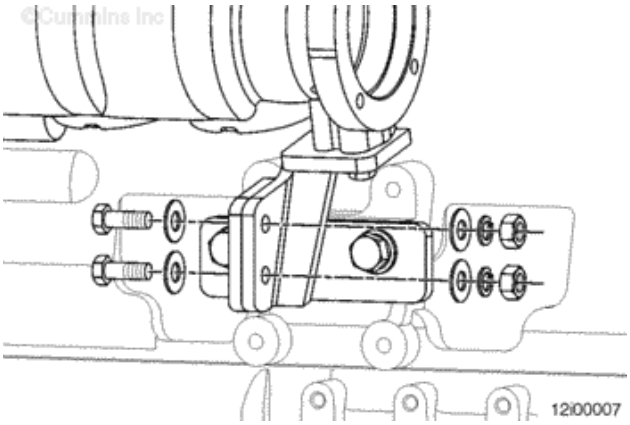
NOTE: The air compressor mounting brackets have slotted holes to allow for proper alignment when the air compressor is tightened.



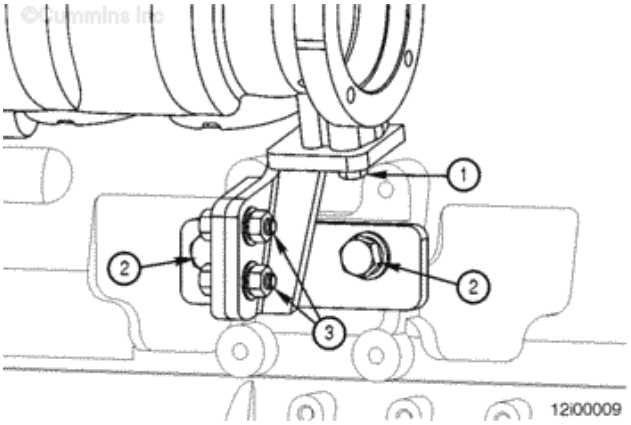
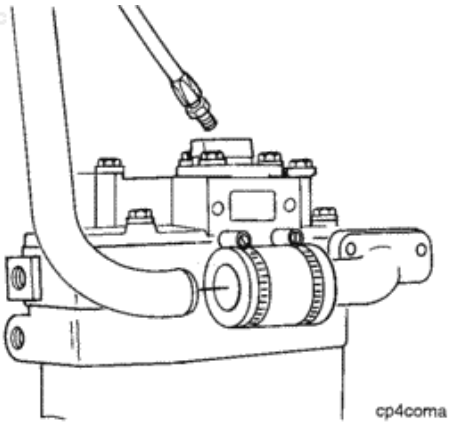
Install the two capscrews through both brackets using two plain washers, one lock washer, and one nut on each capscrew.

Hand tighten the capscrews and nuts.

NOTE: Be sure the bracket mating surfaces are flush before tightening capscrews.



NOTE: Be sure brackets are flush against the compressor, block, and each other.

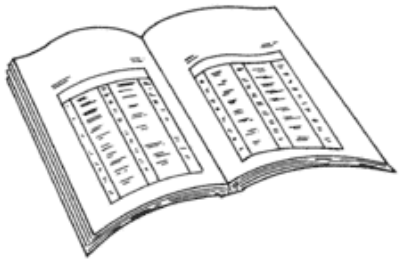
Tighten the capscrews to the compressor (1). **Torque Value:** Compressor Capscrews 47 n.m [35 ft-lb] Tighten the capscrews to the block (2). **Torque Value:** Capscrews to Block 135 n.m [100 ft-lb] Tighten the capscrews and nuts (3). **Torque Value:** Capscrews and Nuts 47 n.m [35 ft-lb]		
On the one-piece and two-piece brackets, install the air inlet and outlet connections to the air compressor. Tighten the clamps. **Torque Value:** 6 n.m [53 in-lb]		

Finishing Steps

• Install the fuel pump. Refer to Procedure 005-016 in Section 5. • Install the coolant lines to the air compressor. • Fill the cooling system. Refer to Procedure 008-018 in Section 8. • Operate the engine to		

operating temperature and check for leaks.

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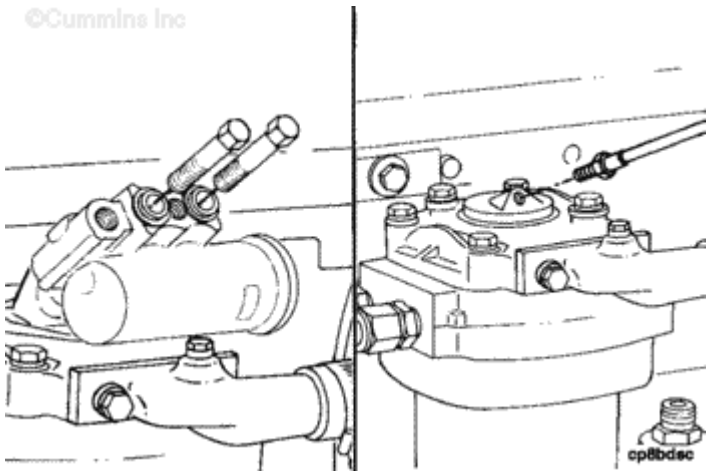
ck800wa

Last Modified: 11-Nov-2010

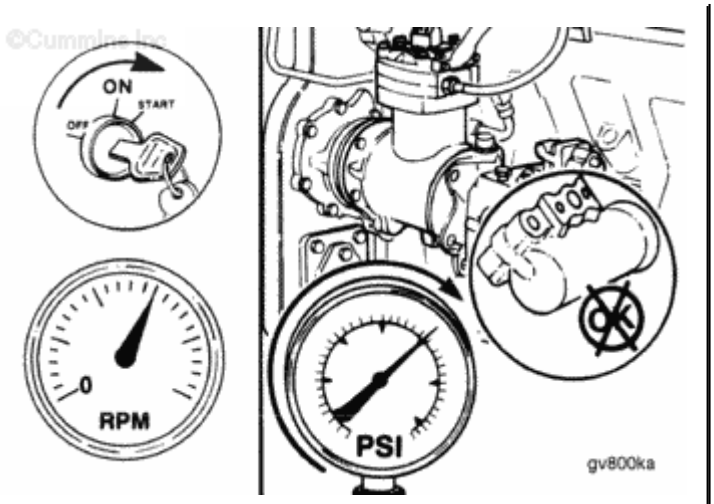
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012-017 Air Governor (Air Compressor Will Not Pump)

Initial Check

NOTE: The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for Holset® models SS, QE, ST, and Cummins air compressors will be shown where necessary. Remove the air governor or air governor line from the air compressor unloader body.		
Operate the engine to activate the air compressor. If the air compressor is pumping, the air governor is malfunctioning and **must** be repaired or		

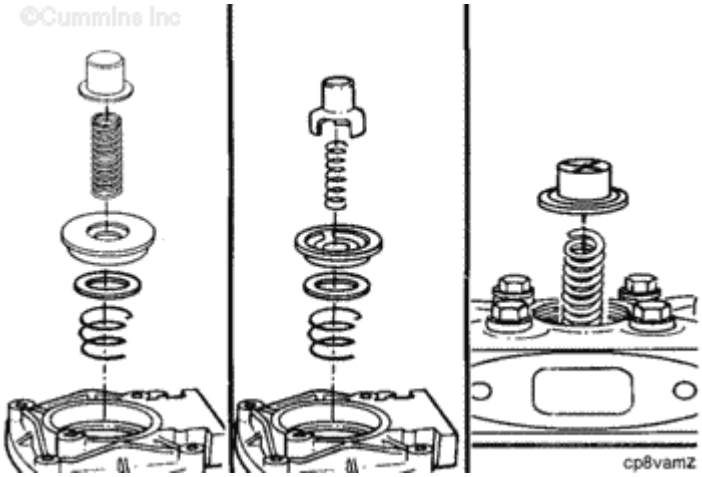
replaced. Refer to the manufacturer's instructions.



If the air compressor does **not** pump, remove, clean, and inspect the air compressor unloader valve assembly. Refer to Air Compressor Unloader Valve. Refer to the Holset® Air Compressor Master Repair Manual, Bulletin 3666121.

If the unloader valve assembly is okay, clean and inspect the exhaust valve assembly. Refer to the Holset® Master Repair Manual, Bulletin 3666121.

NOTE: Not all air compressors referenced can be used on



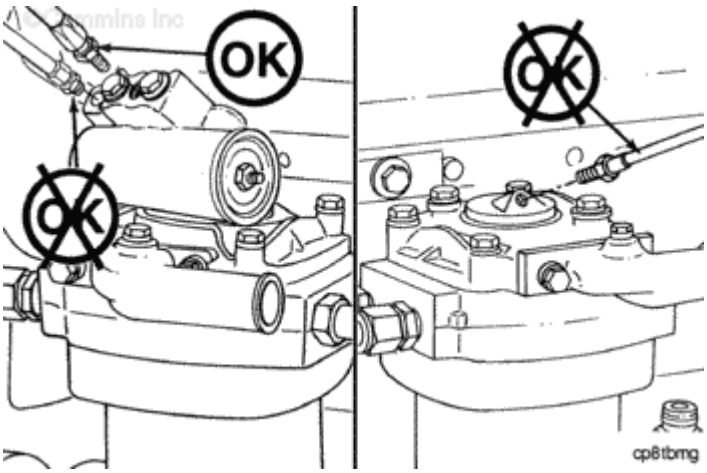
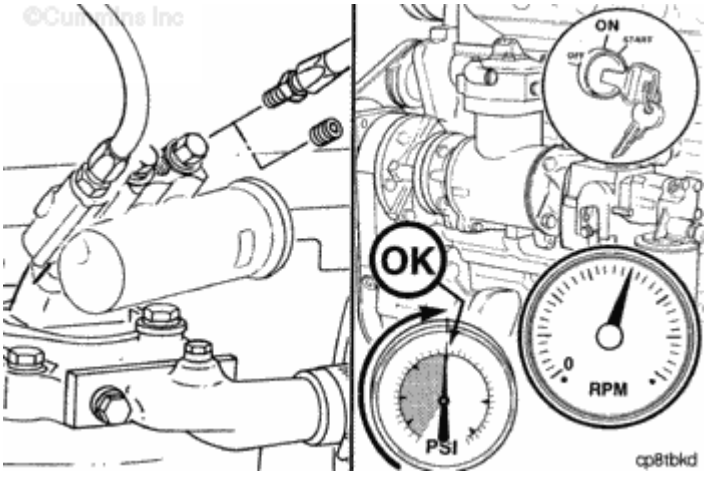
every engine or application.		

Last Modified: 01-Dec-2004

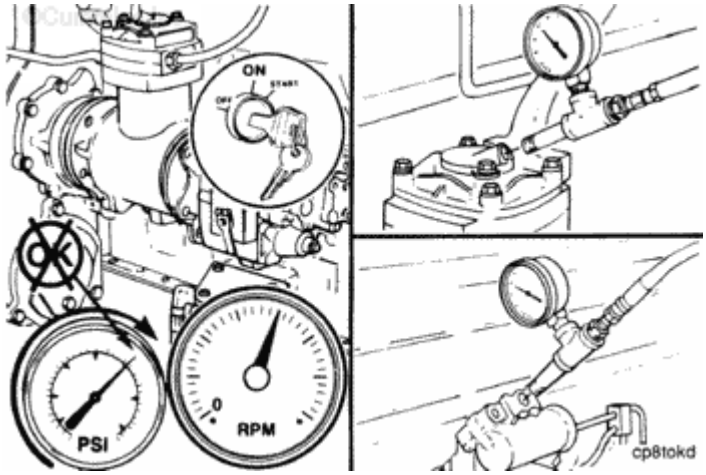
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012-018 Air Governor (Air Compressor Pumps Continuously)

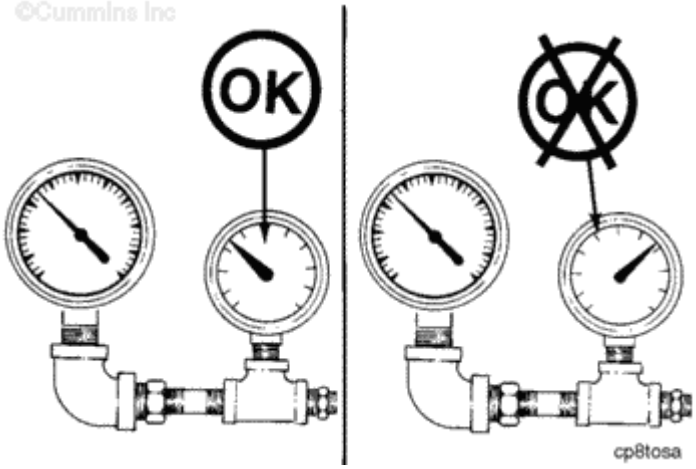
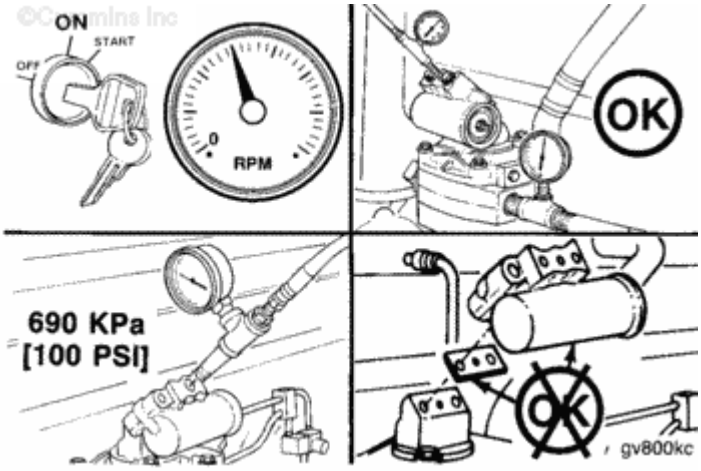
Initial Check

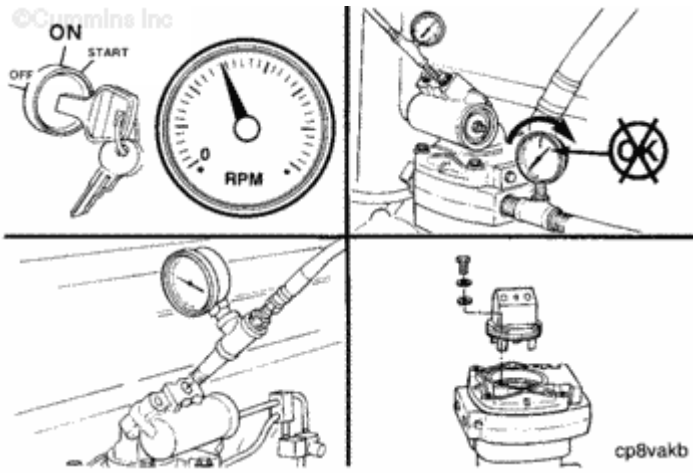
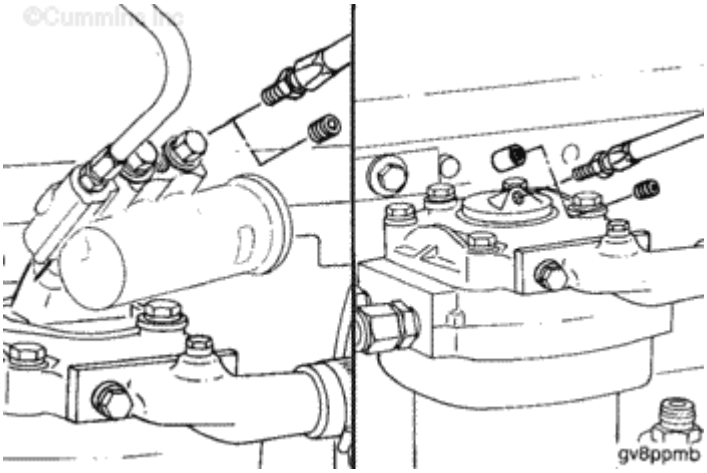
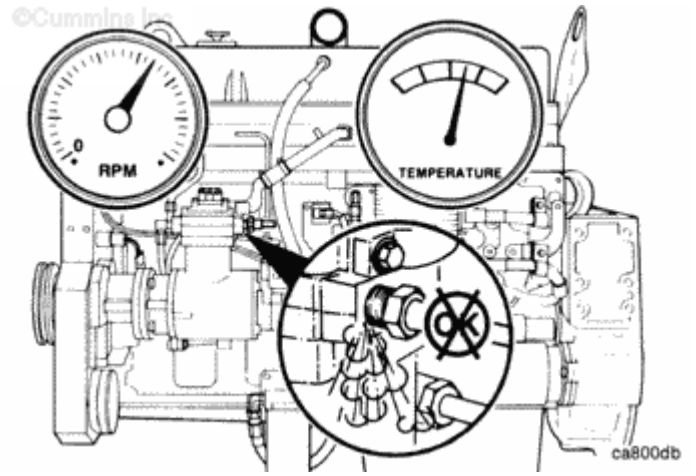
NOTE: The illustrations shown will be of the SS model single cylinder air compressor. Differences in procedures for Holset® models SS, QE, ST, and Cummins air compressors will be shown where necessary. Remove the air accessory air lines from the air compressor governor.		
Install pipe plugs in the air governor unloader ports where accessory air lines were removed. Operate the engine to activate the air compressor.		

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

If the air compressor does **not** stop pumping (air pressure continues to rise) at the governed air pressure, connect a regulated shop air pressure line to one of the following: The air compressor unloader valve port One of the air governor unloader valve ports.		

Be sure the air pressure gauge is accurate, and the supply lines and fittings are in good condition before performing any air pressure checks. Use a master gauge		

of known accuracy to check the air pressure gauge.		
Apply 690 kPa [100 psi] air pressure to the unloader port. If the air compressor stops pumping (air pressure stops rising), the air governor is malfunctioning and **must** be repaired or replaced, or the air governor mounting gasket is leaking. Refer to the manufacturer's instructions.		
If the air compressor continues to pump (air pressure continues to rise), the unloader valve is malfunctioning and **must** be		

repaired or replaced. Refer to Procedure 012-013.		
Remove the pipe plugs from the unloader ports used for accessory air lines. Install and tighten the accessory air lines. Connect the line to the unloader valve.		
Operate the engine and check for air leaks.		

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012-019 Air Leaks, Compressed Air System

Initial Check

WARNING

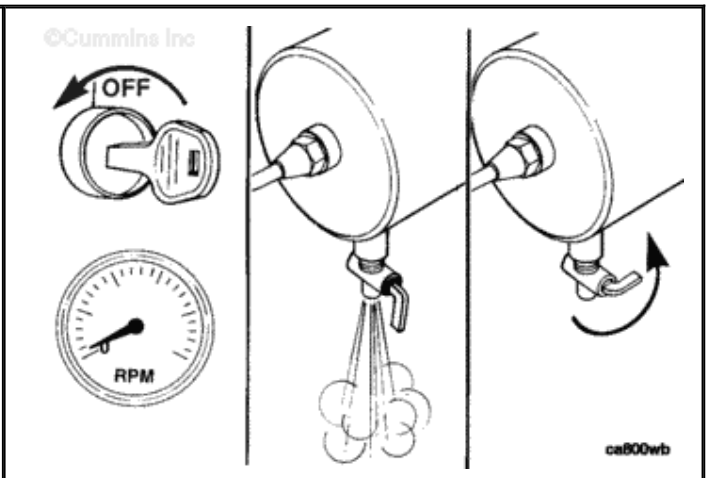
Compressed air can propel debris into eyes and ears. Keep head away and wear protective eye wear.

NOTE: The illustrations shown will be of the single cylinder air compressor. Differences in procedures for Holset® models SS, QE, ST, and Cummins air compressors will be shown where necessary.

Shut off the engine.

Open the drain cock on the wet tank to release air from the system.

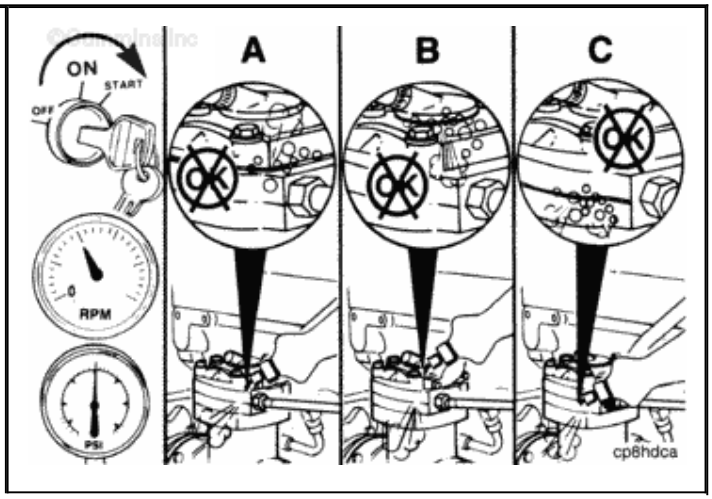
Close the drain cock after the pressure is released.



Operate the engine to activate the air compressor.

With the air compressor pumping between 550 to 690 kPa [80 to 100 psi], use a solution of soapy water to check for air leaks in the following areas:





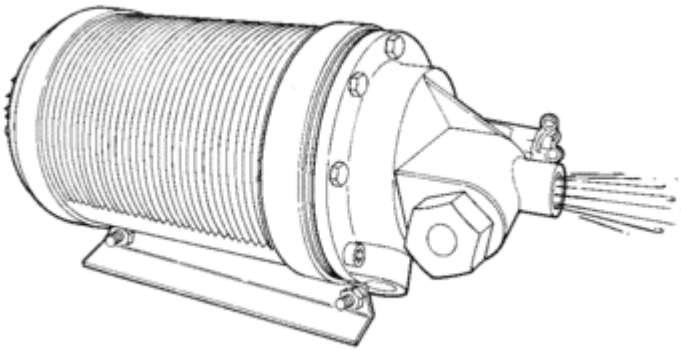
• Air compressor cover gasket • Unloader body o-ring (Holset® **only**) • Air compressor head gasket • Air compressor valve plate gasket (Holset® QE models **only**) • Hose and fitting leaks If air leaks are found, replace the leaking gasket or o-ring. Refer to the Holset® Air Compressor Master Repair Manual, Bulletin 3666121. **NOTE: Not all air compressors referenced can be used on every engine or application.**		

Last Modified: 01-Dec-2004

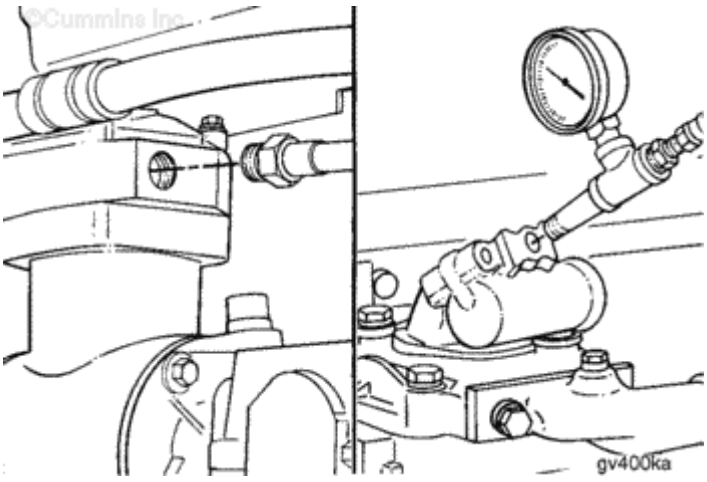
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012-020 Air Compressor (Oil Carryover)

Test

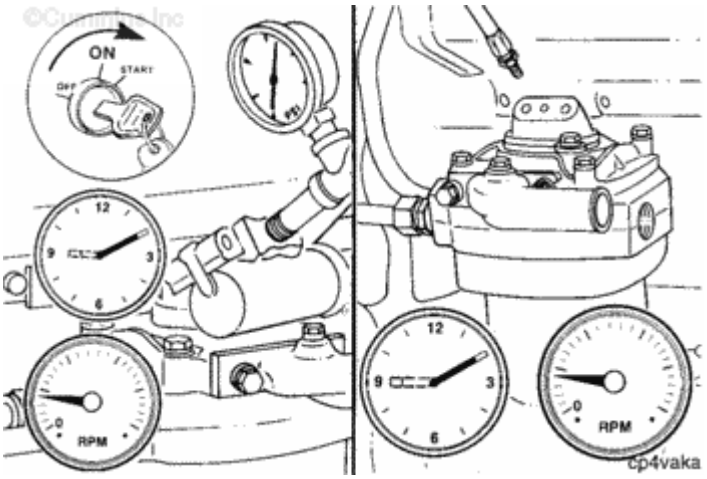
NOTE: The illustrations shown will be of the single cylinder air compressor. Differences in procedure for one or two cylinder Cummins air compressors will be shown where necessary. Cycle the air compressor five times while viewing the discharge from the air dryer. If the discharge appears excessively oily, perform the following check.		
Remove the air compressor line from the air compressor. Apply regulated air pressure to the air governor unloader port.		

Measurements		
	kpa	psi
Air Pressure	690	100



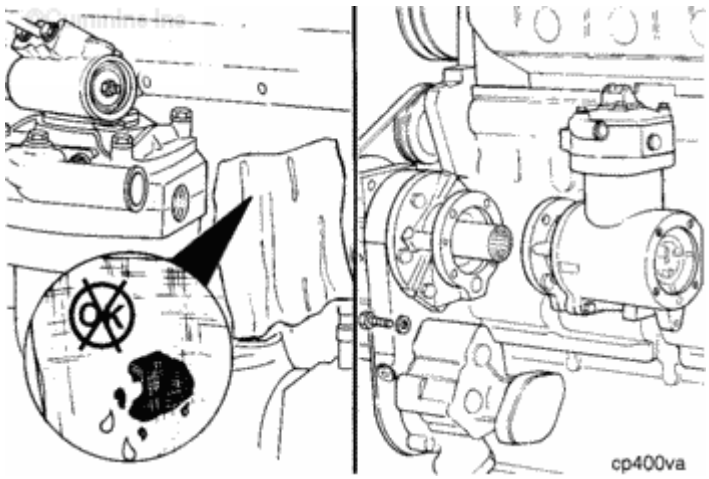
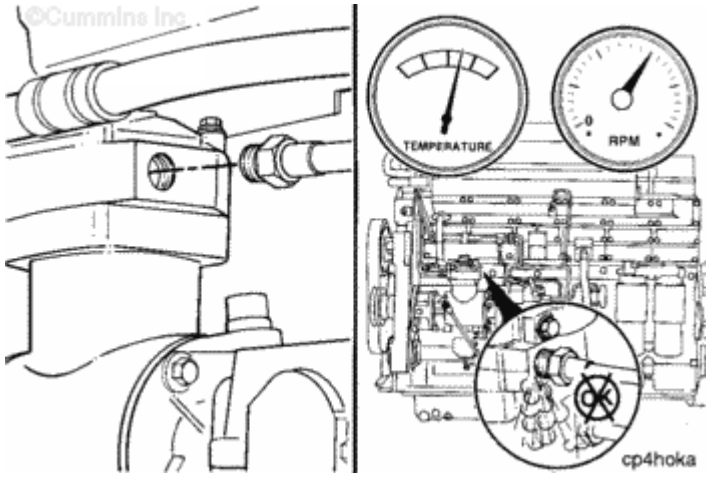
Operate the engine at low idle for 10 minutes with the air compressor unloaded (shop air applied to the unloader port).

Remove the shop air pressure from the unloader port. Operate the engine at low idle for 10 minutes with a white cloth over the air compressor discharge port.



Remove the white cloth and check the cloth for contamination.

If the cloth indicates more than a trace of gray, the air compressor is using an

excessive amount of oil and **must** be replaced. Refer to Procedure 012-014.		
Install and tighten the air discharge line. Operate the engine and check for air leaks.	 	

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012-103 Air Compressor Cylinder Head (Holset® SS and E-Type Models)

Disassemble

WARNING

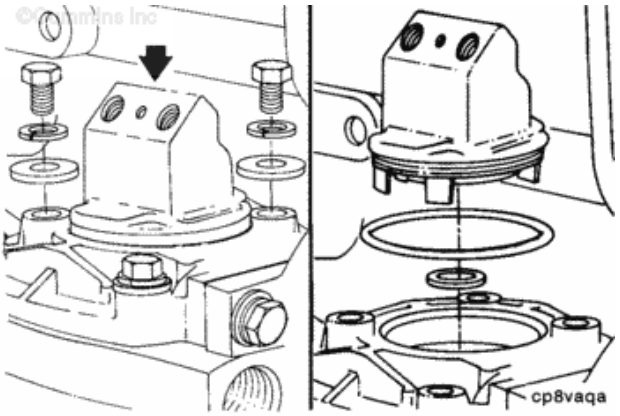
The unloader valve body is installed with spring tension. To reduce the possibility of personal injury, use care when removing. Always wear protective eye wear.

Hold the unloader valve body down and remove the two captive washer capscrews and the two plain washers.

Remove the unloader valve body.

Remove the o-ring seal.

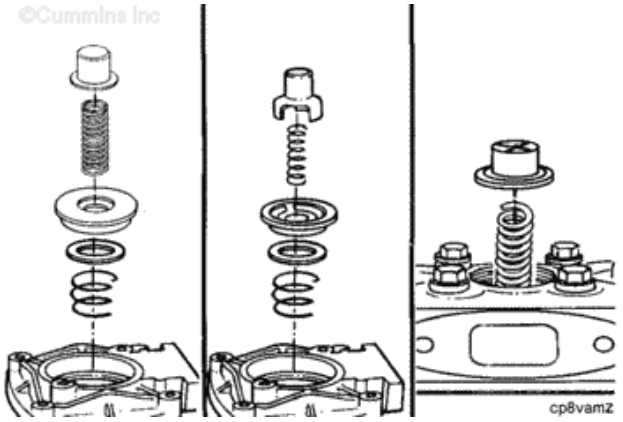
Remove the rectangular ring seal.

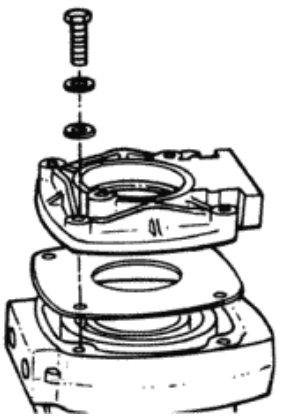


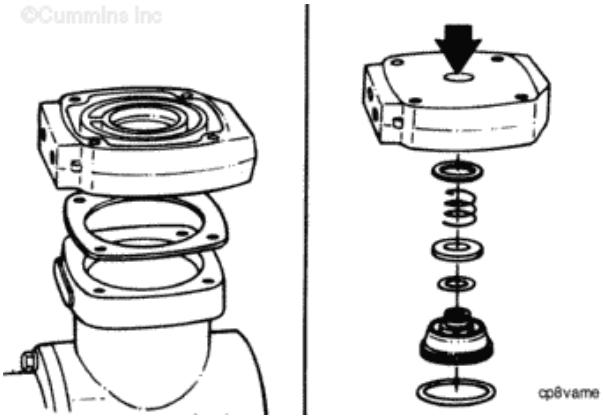
Remove the unloader valve cap and the unloader valve spring.

Remove the intake valve seat and valve.

Remove the intake valve spring.



Remove the capscrews, lock washers and plain washers that hold the cover and head to the crankcase. Remove the cover and discard the gasket.		

Remove the head and discard the gasket. Hold the head bottom side up, and use thumb pressure to remove the exhaust valve seat assembly. If the exhaust valve seat assembly can **not** be removed by thumb pressure, use valve seat puller, Part Number 3822674. A press and air compressor seat removal tool, Part Number 3377416, can be used to remove the exhaust valve seat. Remove the o-ring seal from the exhaust valve seat or head. Remove the exhaust valve. Remove the compression spring and wear plate from the head.		

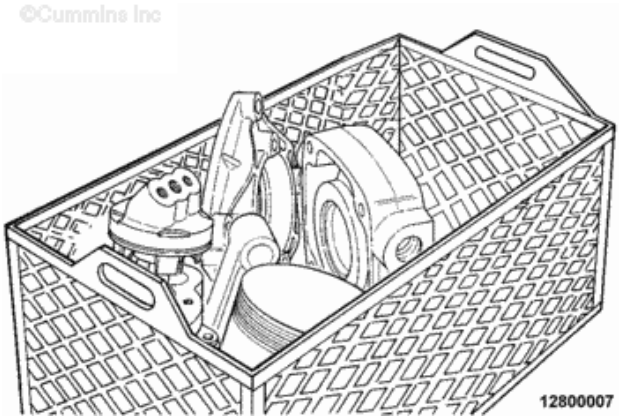
Clean and Inspect for Reuse

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.

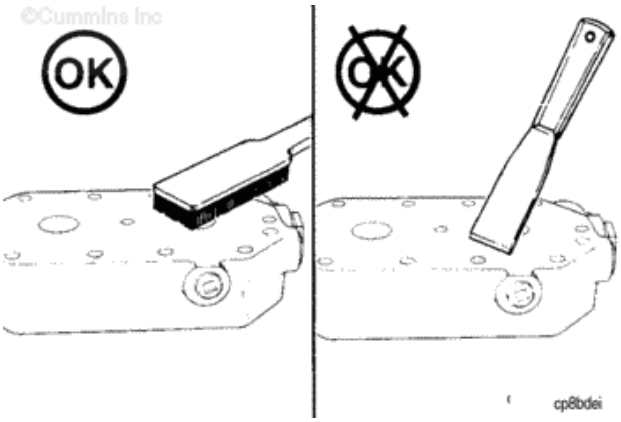
Soak the parts in a kerosene emulsion-based cleaner designed to remove carbon.

The cleaner **must** have a pH of 9.5 or less to avoid turning aluminum parts black. The cleaner manufacturer or supplier **must** be contacted about solution concentration, temperature and soak time.



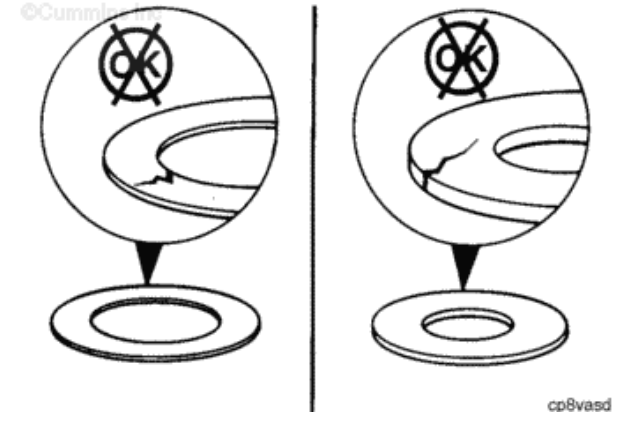
Do **not** use a scraper to remove carbon and scale, the sealing surfaces can be damaged.

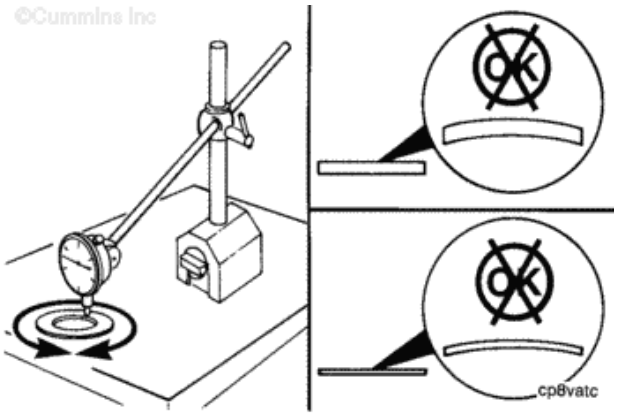
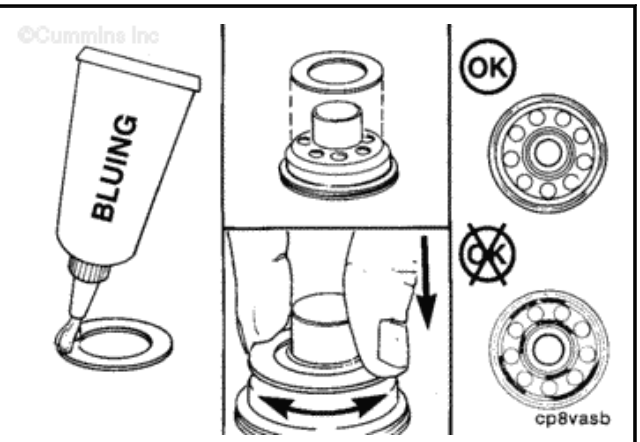
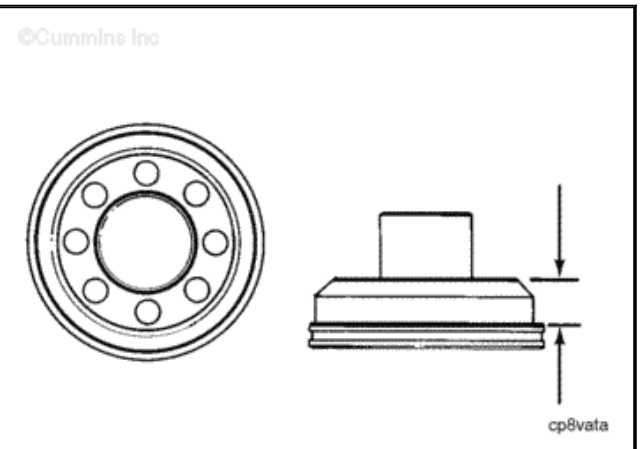
The parts can be scrubbed with a stiff nonmetallic bristle brush.



Inspect the intake and the exhaust valves for cracks or damage.

If the exhaust valve is cracked or damaged, it **must** be replaced.



NOTE: Holset Engineering Co., Inc. recommends that new valves be installed. Measure the flatness of the intake and exhaust valves. Both valves **must** be flat within 0.03 mm [0.001 in].		
Apply a bluing compound to the exhaust valve seating surface. Install the exhaust valve on the valve seating surface and check the seating area. Replace the seat if the contact area is **not** 100 percent.		
Measure the exhaust valve seat height. If the seat height is less than 12.32 mm [0.485 in], replace the seat.		
Apply a bluing compound to the intake valve seating		

surfaces.

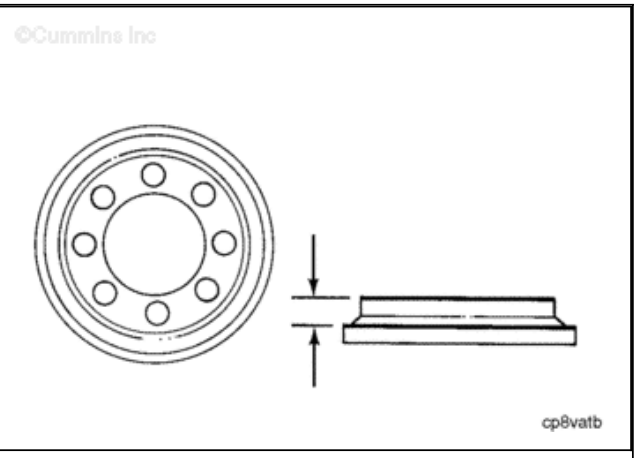
Install the intake valve on the valve seating surface and check the seating area.

Replace the seat if the contact area is **not** 100 percent.

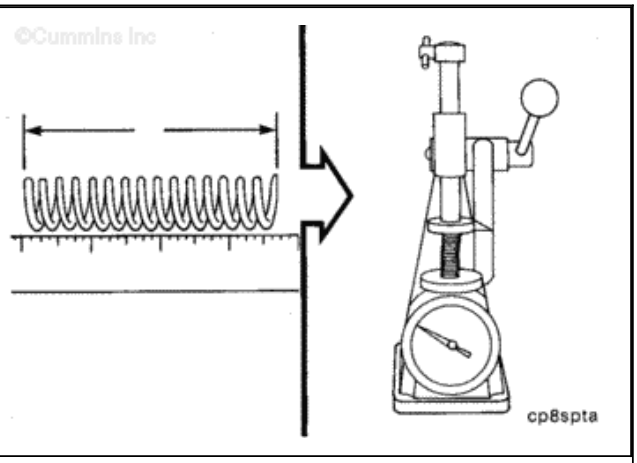


Measure the intake valve seat height.

If the seat height is less than 6.86 mm [0.270 in], replace the seat.



Holset Engineering Co., Inc. recommends that new springs be installed.



Assemble

Install the wear plate and compression spring in the head as shown.

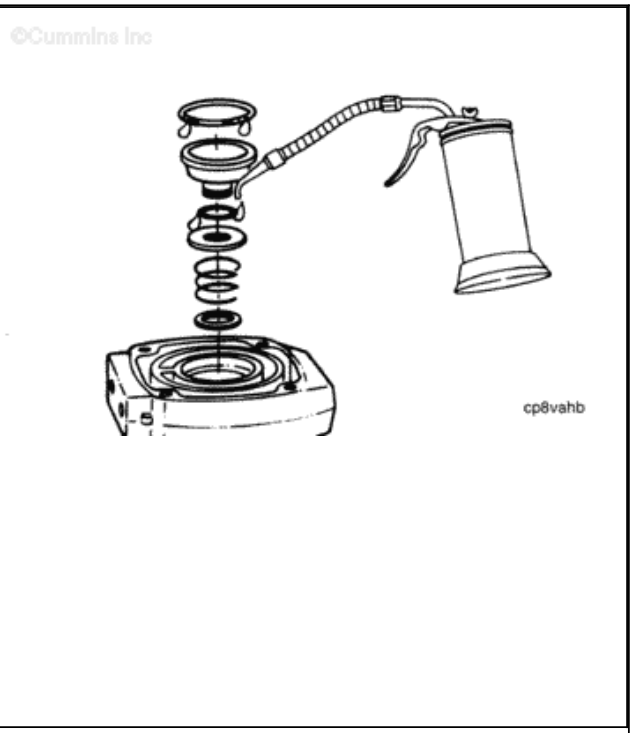
Install the exhaust valve on the exhaust valve seat.

Install the o-ring seal on the seat.

Use clean 15W-40 oil to lubricate the o-ring seals.

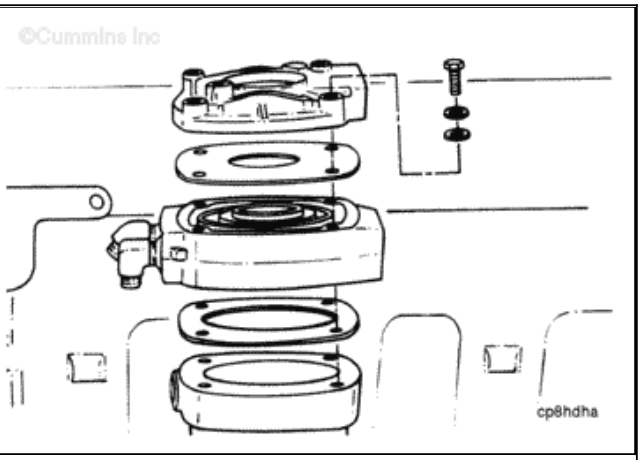
Use hand pressure to install the exhaust valve assembly in the head.

NOTE: For SS-296 and ST-676 air compressor models, a press and air compressor seat installation tool, Part Number 3377415, can be used. Exhaust valve seat puller, Part Number 3822674, can also be used to install the valve seat.



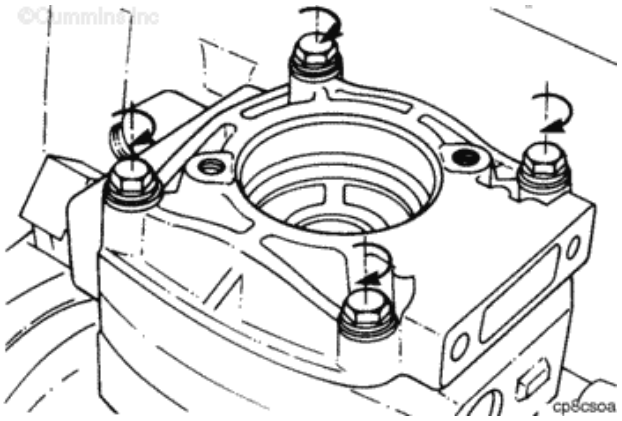
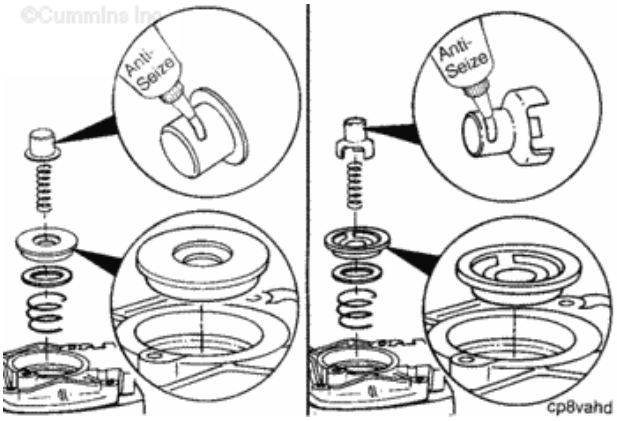
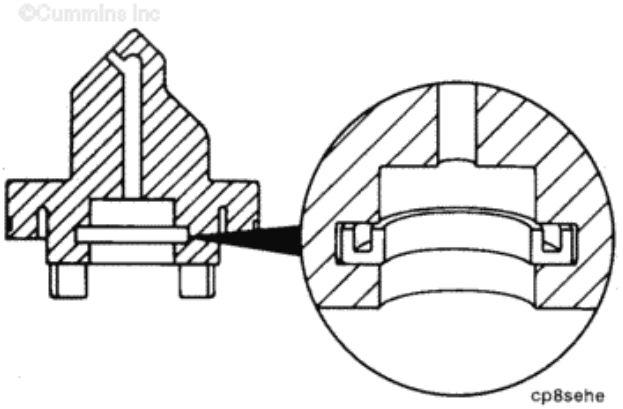
Use new gaskets to install the cylinder head and cover.

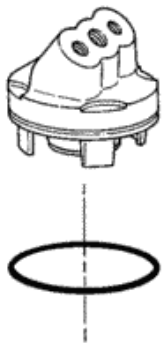
Install the flat washers, lock washers and capscrews.



Tighten the cylinder head capscrews of the single cylinder compressor in an alternating sequence.

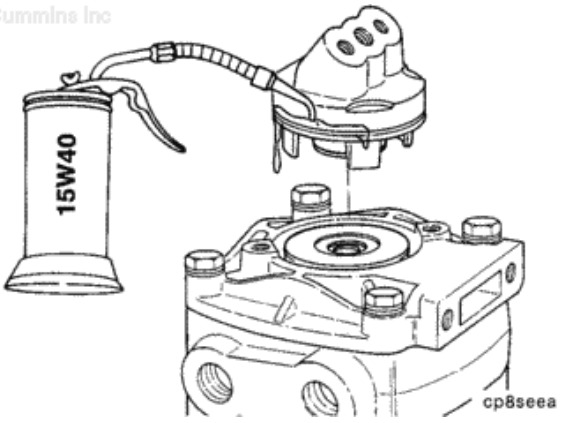
Torque Value: Step 1 7 n.m [60 in-lb]

Step 2 14 n.m [120 in-lb] Step 3 20 n.m [180 in-lb] Step 4 27 n.m [20 ft-lb]		
Install the intake valve spring with the tang down. Install the intake valve. Install the intake valve seat with the flange side up. Install the unloader valve cap spring. Install the unloader valve cap. Use high temperature grease (Accrolube Lubrication Teflon Grease or equivalent) to lubricate the outside diameter of the cap.		
Install the new rectangular ring seal, with the grooved side up, into the unloader body.		
Install a new o-ring seal on the unloading valve body.		



cp8semd

Use clean 15W-40 oil to lubricate the seal.

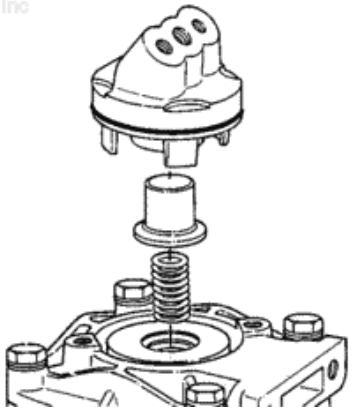


cp8seea

Install the compression spring.

Use Accrolube Lubrication Teflon Grease to lubricate the outside diameter of the unloader cap and install it into the unloading valve body.

Install the unloading valve body.



cp8hdme

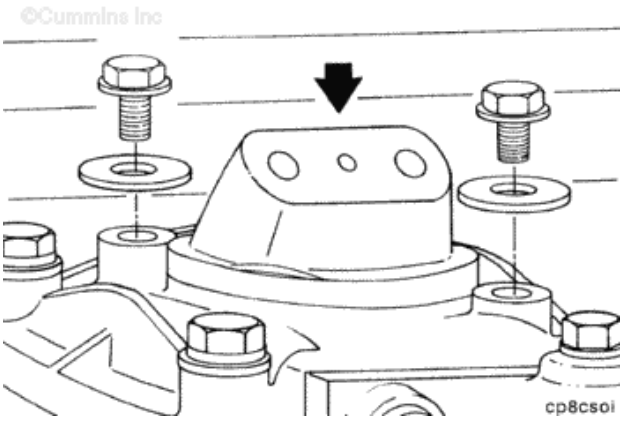
CAUTION

Do **not** over tighten capscrews. Compressor damage will result.

Hold the unloader body down and install the two plain washers and captive washer capscrews.

Tighten the capscrews.

Torque
Value: 14 n.m [120 in-lb]



Last Modified: 02-Dec-2004

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012-104 Air Compressor Cylinder Head (Holset® QE Models)

Preparatory Steps

Holset® Models

WARNING

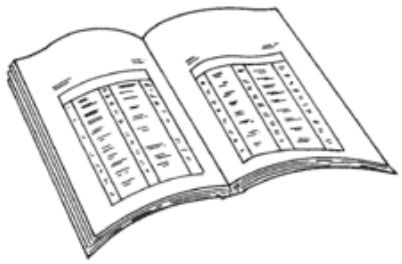
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

WARNING

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

- If the cylinder head is removed while the air compressor is on the engine, drain the coolant. Refer to Procedure 008-018.



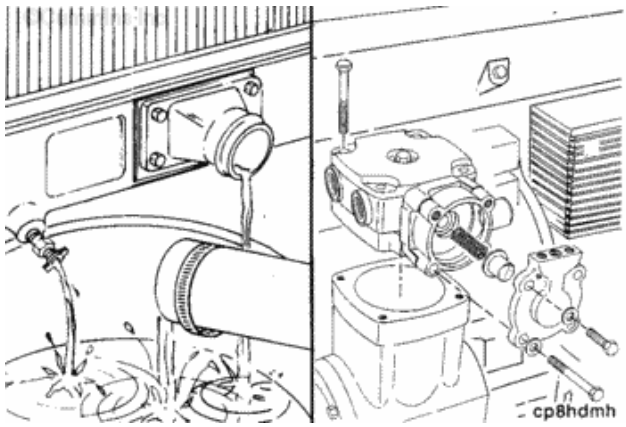


Disassemble

Holset® Models

The valve plate, head and unloader body are indexible.

Mark the parts to make sure they are reassembled in the proper orientation.



WARNING

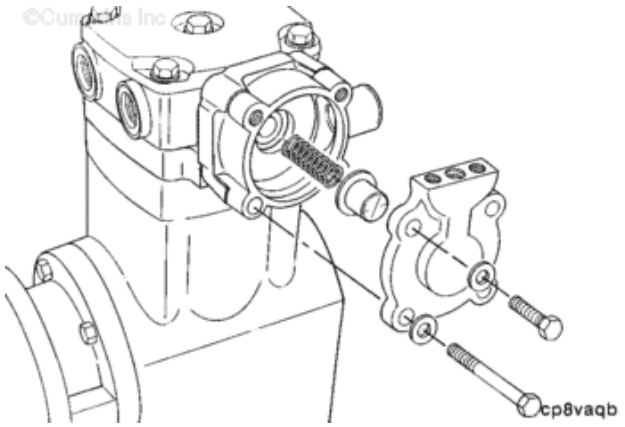
The unloader body is installed with spring tension. Use care when removing to prevent personal injury. Always wear protective eye wear.

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

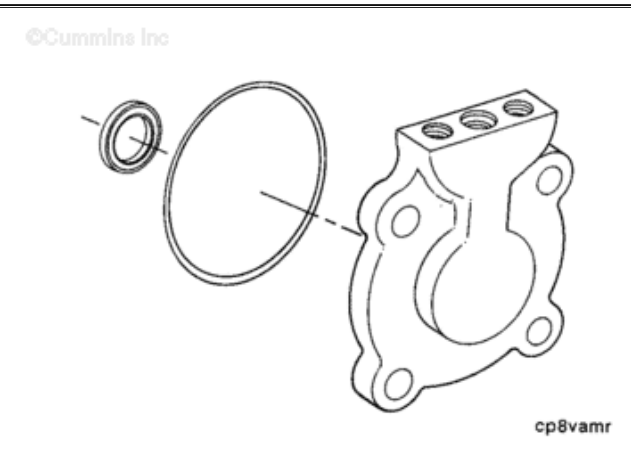
Remove the unloader valve body.

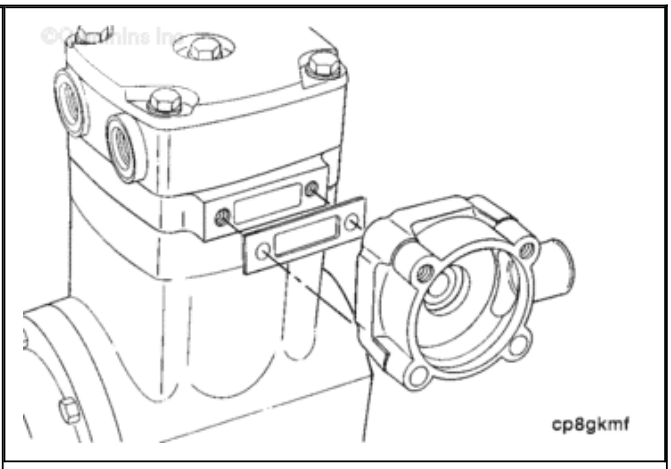
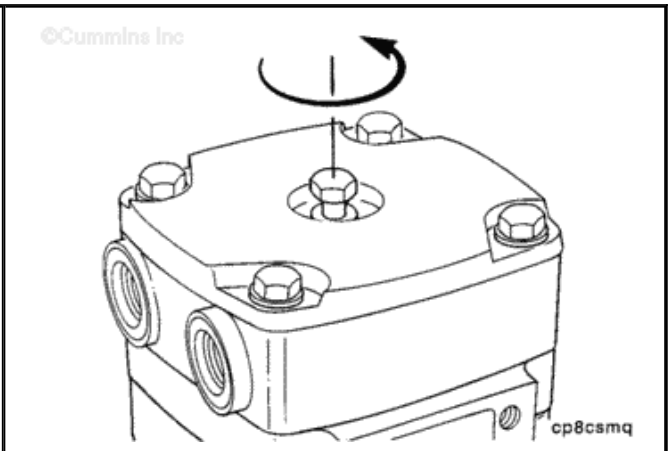
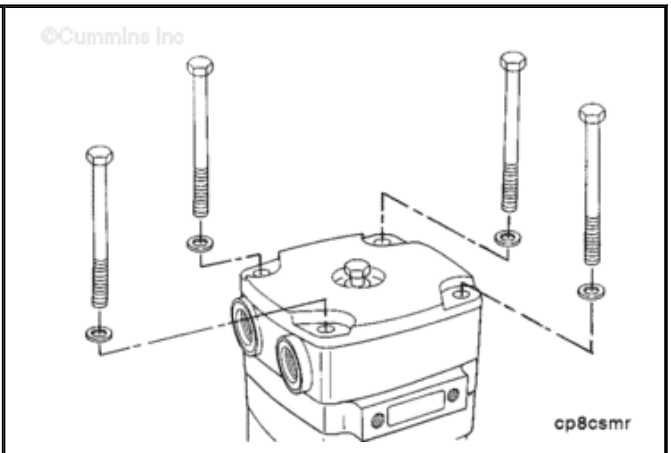
Remove the unloader valve spring.

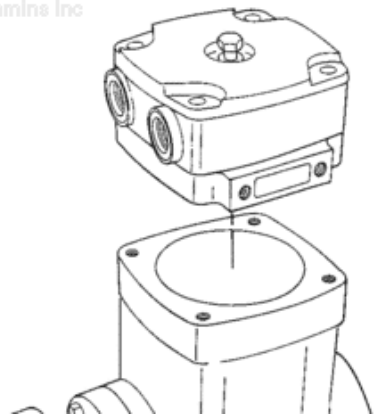
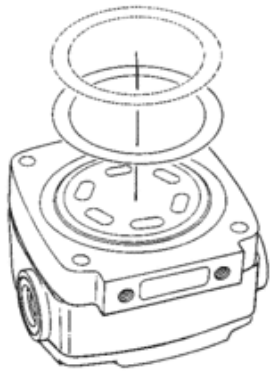
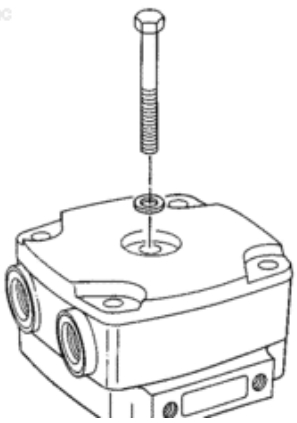
Remove the unloader valve cap.

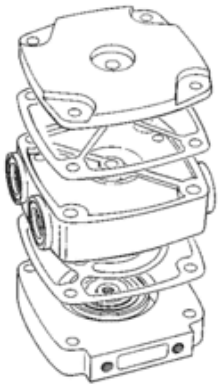


Remove the unloader body gasket and unloader valve cap rectangular ring seal.



Remove the intake manifold and gasket.		
Loosen, but do **not** remove, the center head capscrew. Mark the head for orientation during assembly.		
Loosen and remove the four corner head capscrews. Save the capscrews for reuse.		
Remove the head, cover, and valve plate assembly		

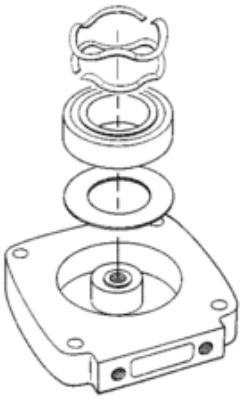
and place it on a clean work surface with the intake valve facing upward. If continuing with disassembly of the head, valve plate, and cover, be sure the work surface is clean. Grit pushed into the valve sealing surfaces by setting components on a dirty surface will cause a malfunction after reassembly.		
Some units have a press-fit intake valve retainer. If present, carefully remove it to prevent part damage. Remove the intake valve.		
Turn the head assembly over and set it on a clean surface. Remove the center capscrew. This capscrew can be reused. The center capscrew is shorter than the four corner capscrews.		
Remove the cover, cover gasket, head, and head gasket.		



cp8cvmg

Remove the two wave washers, exhaust valve retainer and exhaust valve.

The wave washers **must** be replaced.



cp8wama

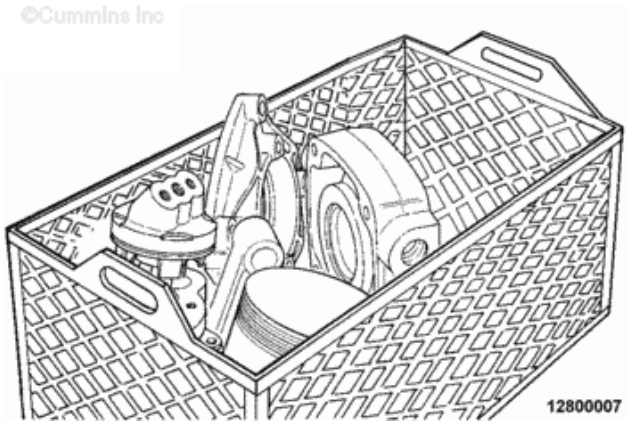
Clean and Inspect for Reuse

Holset® Models

WARNING

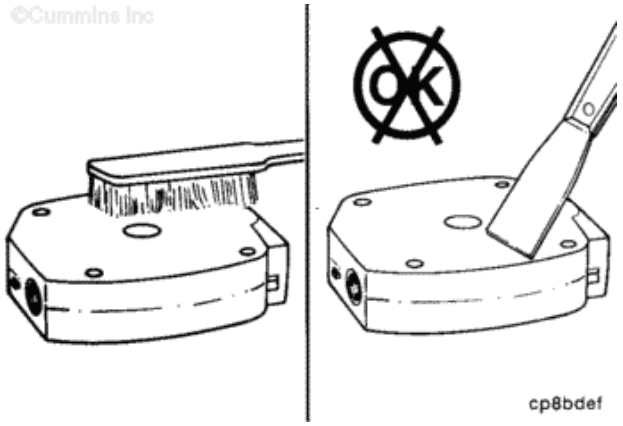
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Soak the parts in a kerosene emulsion-based cleaner designed to remove carbon. The cleaner **must** have a pH of 9.5 or less to avoid turning aluminum parts black. The cleaner manufacturer or supplier can be contacted about solution concentration, temperature and soak time.



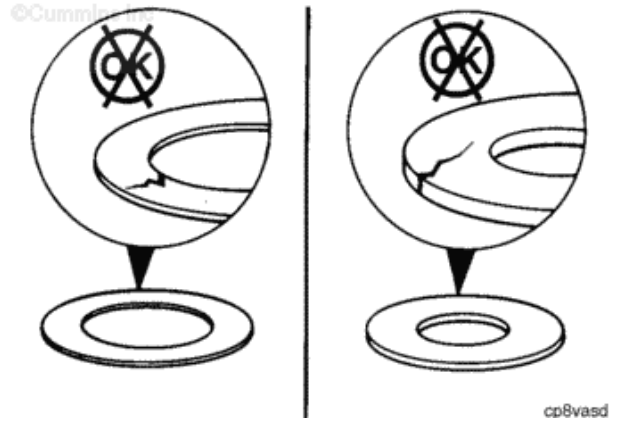
Do **not** use a scraper to remove carbon and scale, the sealing surfaces can be damaged.

The parts can be scrubbed with a stiff nonmetallic bristle brush.

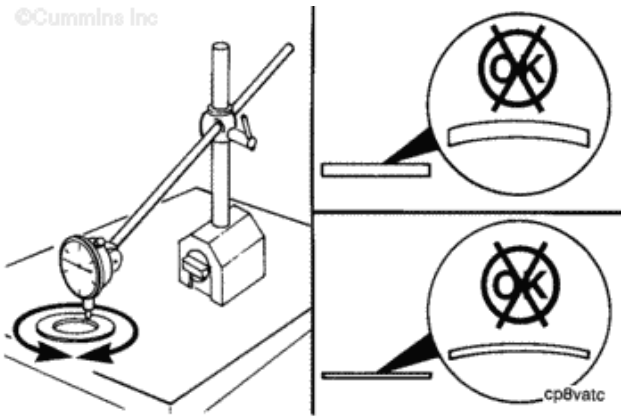
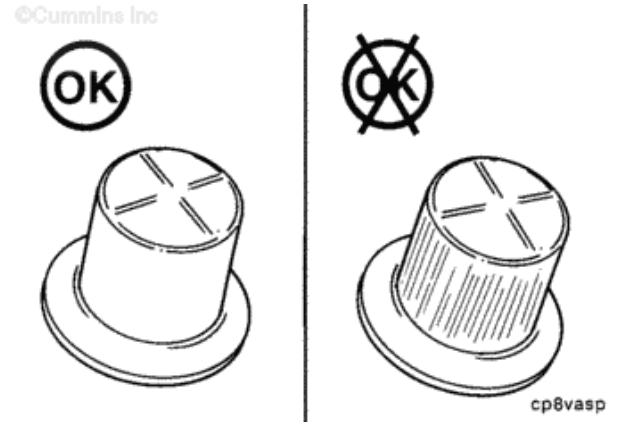
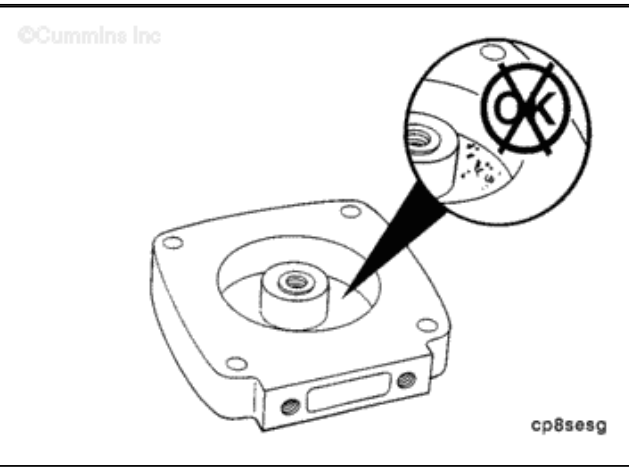


Inspect the intake and exhaust valves for cracks or damage.

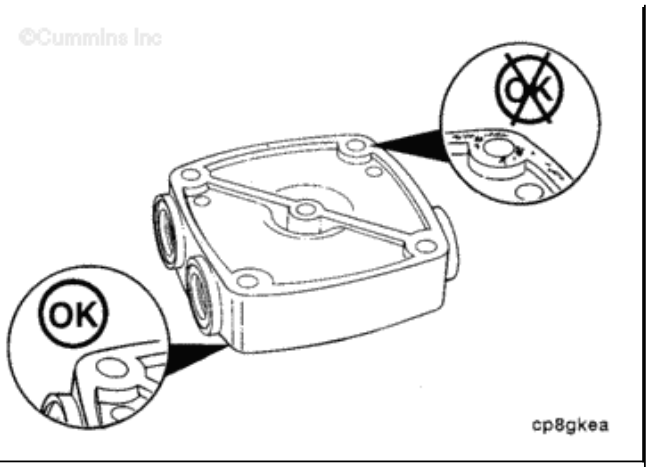
If a valve is cracked or damaged, it **must** be replaced.



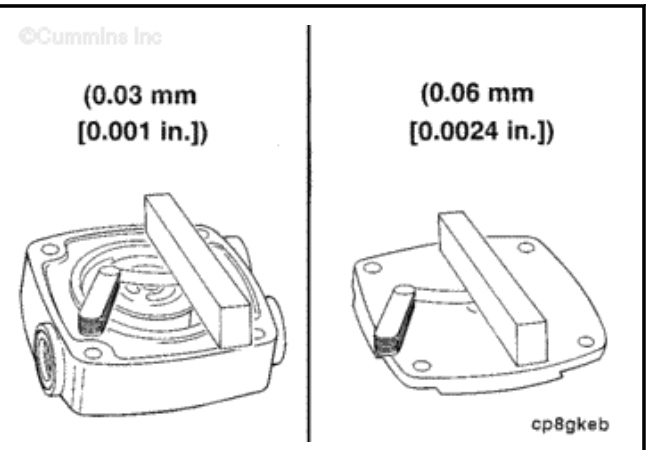
Holset Engineering Co., Inc., recommends new valves be installed.

Measure the flatness of the intake and exhaust valves. Both valves **must** be flat within 0.03 mm [0.001 in]. Replace valves if cracked, damaged, or **not** flat.		
Inspect the upper part of the unloader valve cap where the rectangular V-seal operates. Check for scoring. If the unloader valve cap is scored, it **must** be replaced.		
NOTE: Inspection of the valve seats in the valve plate requires specialized equipment and is beyond the scope of field service. Inspect the valve seat surfaces. If the valve seat is visibly damaged, or can **not** be cleaned, a new valve plate is available in a service kit. Otherwise, a QE valve plate service assembly can be used.		
Gasket sealing surfaces **must** be clean and free of all old gasket material, carbon, rust, and other buildup. Surfaces		

must be free of scratches, gouges, burrs, and other deformities.

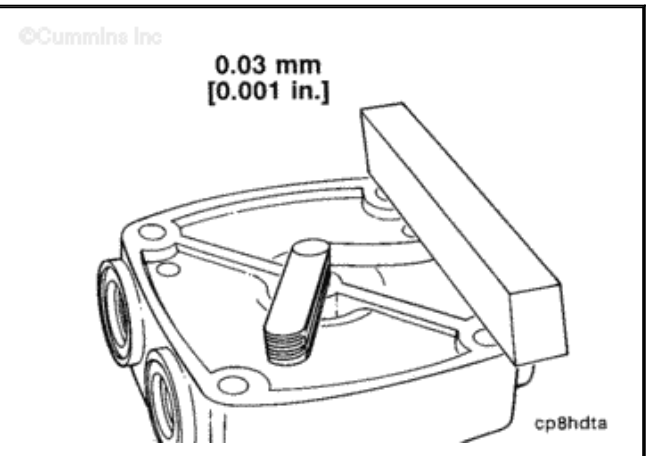


After making sure all gasket surfaces are clean and free of the above, inspect the head and cover for flatness. Use the flat plate and the feeler gauges.

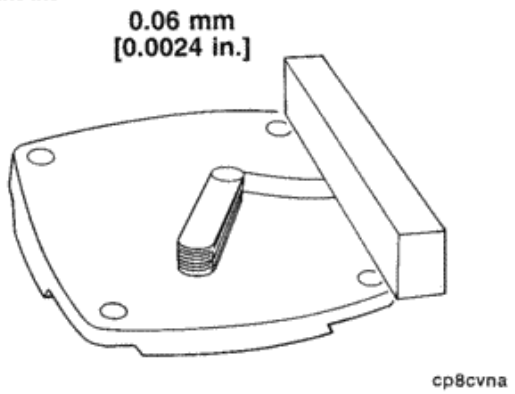
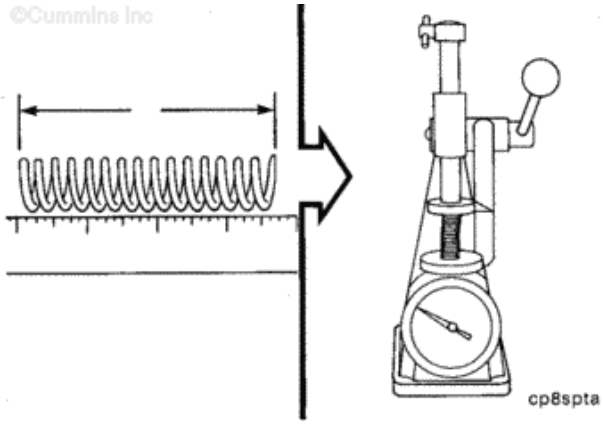


Single cylinder heads **must** be flat within 0.03 mm [0.001 in] between any two adjacent capscrew holes.

If the cylinder head is **not** within specifications, it **must** be replaced.



Single cylinder top cover **must** be flat within 0.06 mm [0.0024 in] between any two adjacent capscrew holes

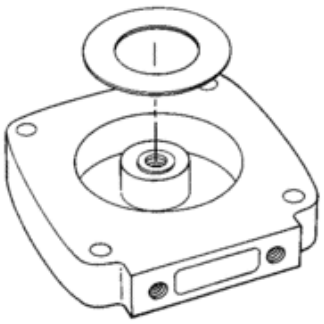
and 0.10 mm [0.004 in] total. If the cylinder top cover is **not** within specifications, it **must** be replaced.		©Cummins Inc 
Holset Engineering Co., Inc., recommends that new springs be installed.		©Cummins Inc 

Assemble

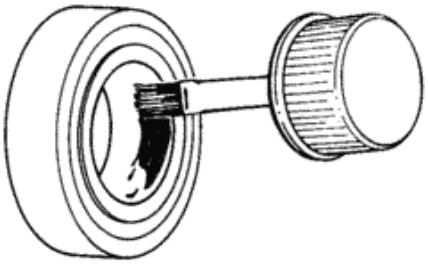
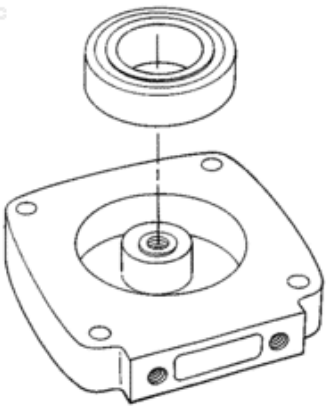
Holset® Non-European A/C Model

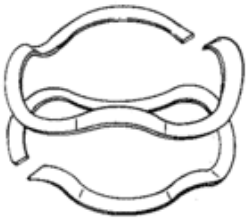
Install the exhaust valve over the post in the valve plate.		

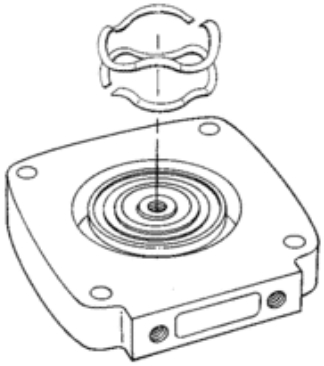
©Cummins Inc

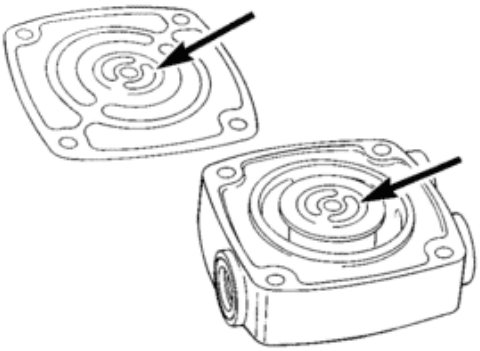


cp8vahk

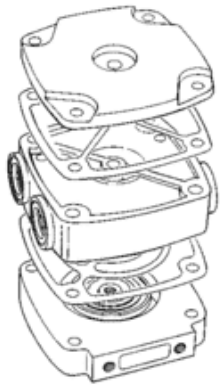
Apply a thin coating of antiseize to the inside diameter of the exhaust valve retainer.		 cp8rtwa
Slide the exhaust valve retainer over the valve plate. Make sure that the end of the retainer with the groove faces upward.		 cp8rtha
Align the wave spring gaps 180 degrees from each other so they do **not** overlap.		

		 cp8sphe

Place the wave springs in the retainer groove.		 cp8sphf

Determine the final orientation of the valve plate (air intake location) and the head (coolant ports with respect to air inlet or manifold location). Align the kidney-shaped slots in the head with the kidney shaped slots in the gasket. Use orientation marks that were made before disassembly.		 cp8plaa

Assemble the cover, cover gasket, head, head gasket, and valve plate.		



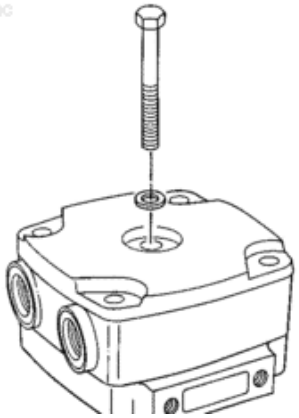
cp8cvmg

Make sure corner capscrew holes are aligned.

Lubricate the threads under the head.

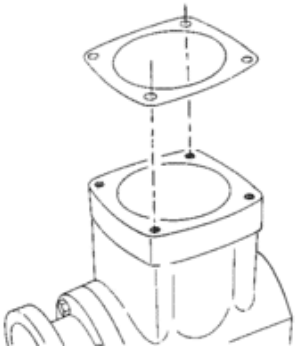
Install the shorter capscrew with washer through the center hole.

Torque
Value: 14 n.m [120 in-lb]



cp8hdec

Install the valve plate gasket.

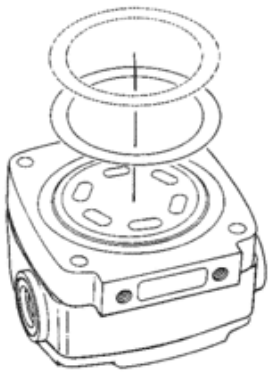


cp8pihe

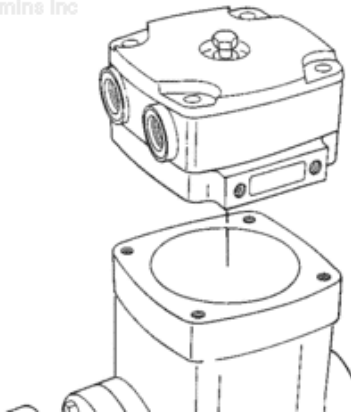
Carefully place the intake valve in the valve plate.

Install the intake valve

retainer.

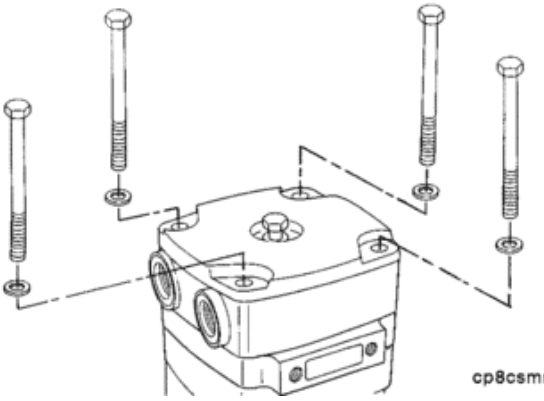


Install the valve plate assembly.



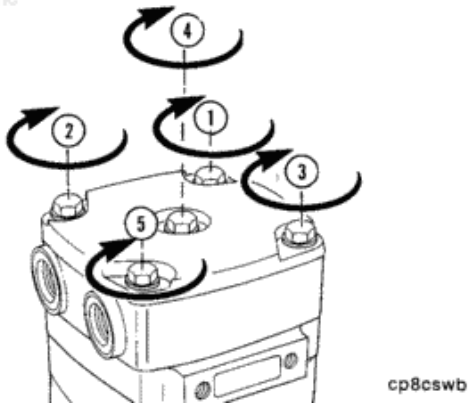
Lubricate the threads under the head and washer of the capscrews if initially installed.

Install the four head capscrews and washers.



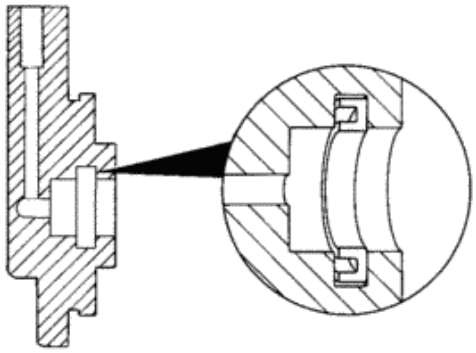
Tighten all five capscrews.

Torque
Value: 28 n.m [250 in-lb]

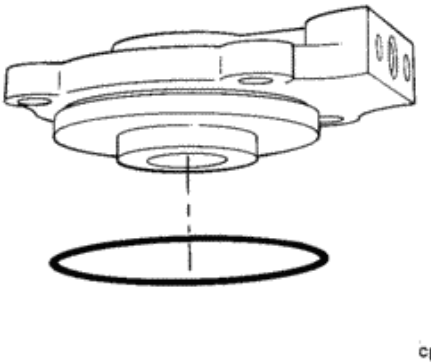


Install the new rectangular V-seal, with the grooved side up, into the unloader body.

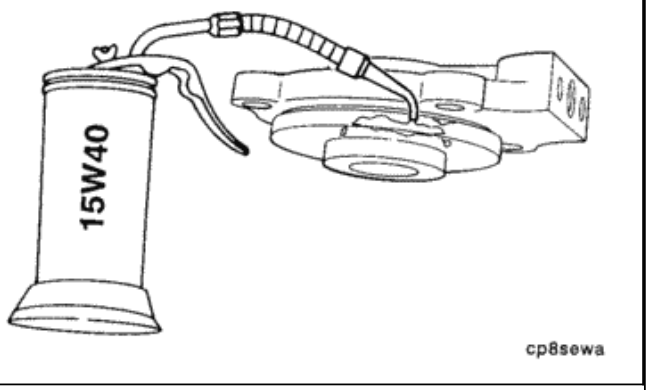
Liberally lubricate the unloader valve bore above and below the rectangular ring seal with high temperature grease (Accrolube Lubrication Teflon Grease or equivalent).



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



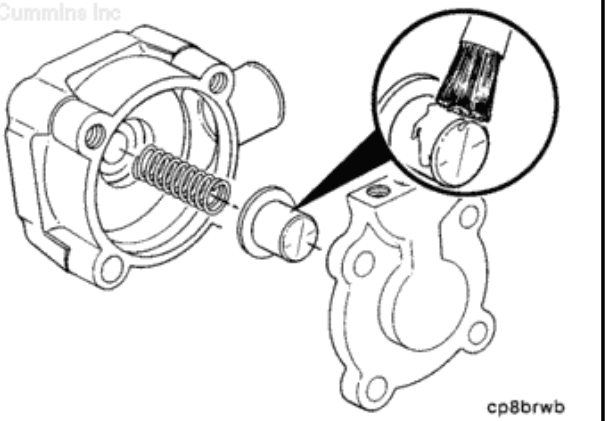
Use clean 15W-40 oil or Accrolube Lubrication Teflon Grease (or equivalent) to lubricate the seal.



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

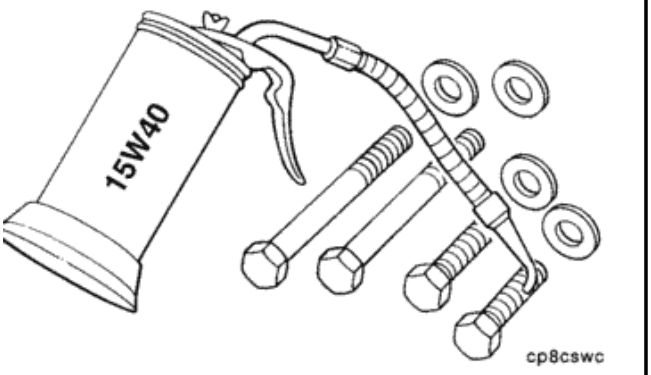
Install the unloader cap.

Install the unloader spring.

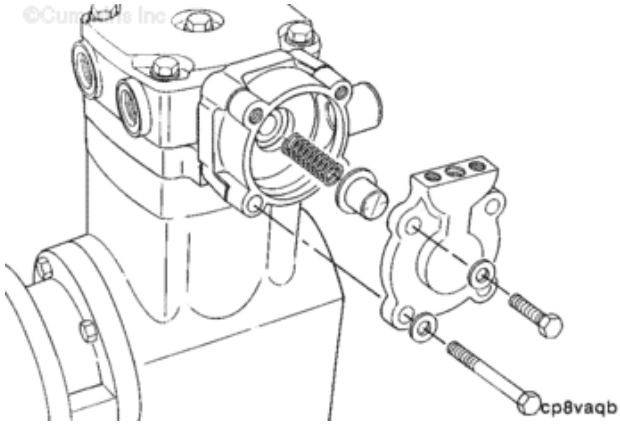


Lubricate the unloader screw threads and underhead with clean engine oil (SAE 15W-40), before installation.

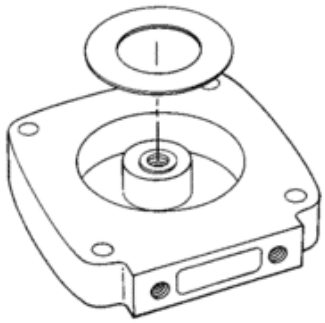
The two unloader body screws **must not** be used to attach any brackets.

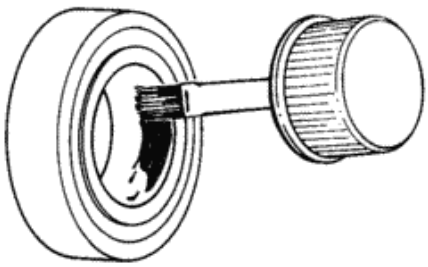


Assemble the unloader components and attach the unloader assembly to the valve plate with the four

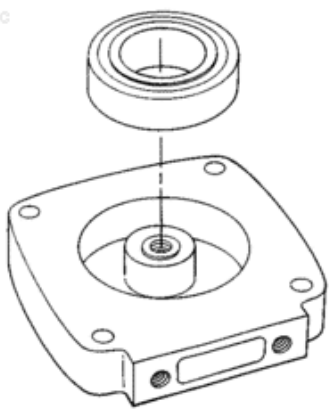
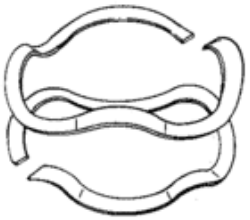
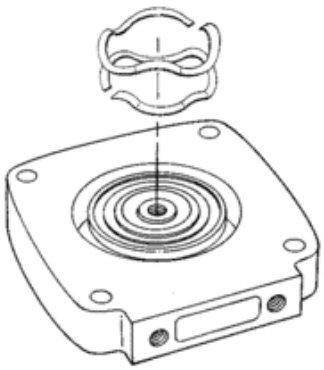
capscrews and washers. The longer capscrews are used to mount the manifold to the air compressor. Tighten the capscrews. **Torque** **Value:** 27 n.m [20 ft-lb]		

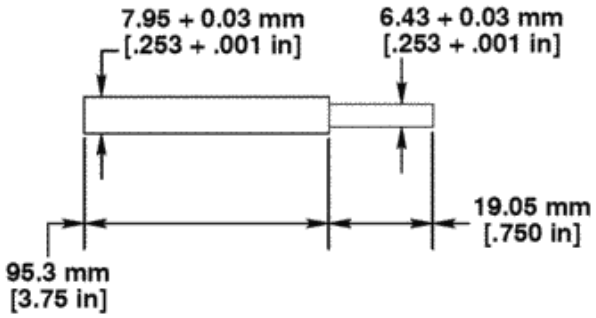
Holset® European A/C Model

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

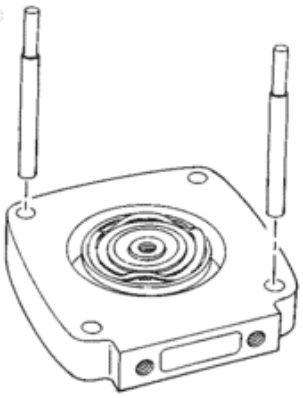
Apply a thin coating of anti-seize to the inside diameter of the exhaust valve retainer.		

Slide the exhaust valve retainer over the valve plate.		

Make sure that the end of the retainer with the groove faces upward.		 cp8rtha
Align the wave spring gaps 180 degrees from each other so they do **not** overlap.		 cp8sphe
Place the wave springs in the retainer groove.		 cp8sphf
Fabricate or reuse the four guide pin tools.		

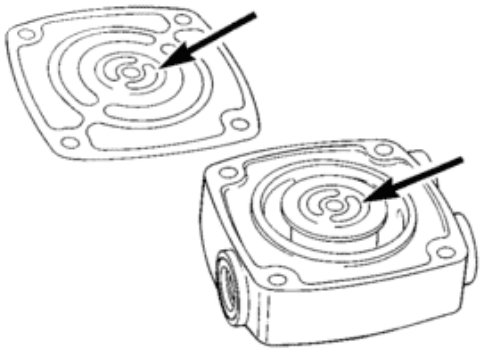


Insert the larger end of two guide pins in opposite corner holes of the valve plate.

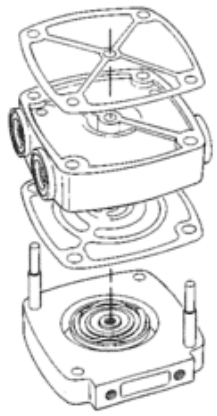
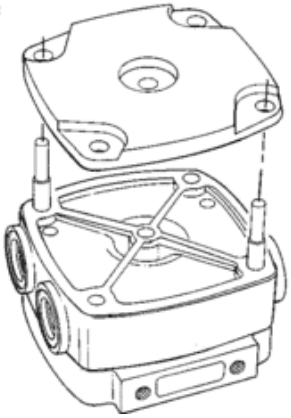
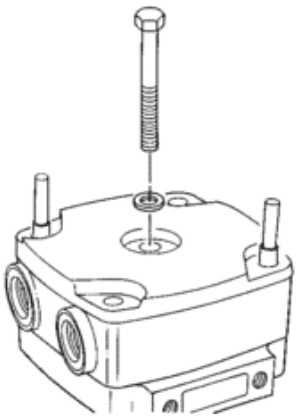


Determine the final orientation of the valve plate (air intake location) and the head (coolant ports with respect to air inlet or manifold location). Align the kidney-shaped slots in the head with the kidney shaped slots in the gasket.

Use the orientation marks that were made before disassembly.

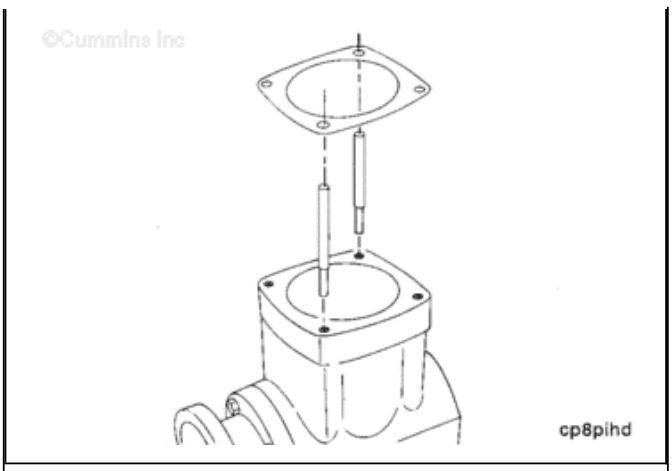


Install the head gasket onto the guide pins (either side up, but with correct slot orientation).

Install the head onto the guide pins with the kidney-shaped slots aligned and toward the valve plate. Install the cover gasket over the guide pins.		©Cummins Inc  cp8gkhf
Assemble the cover.		©Cummins Inc  cp8cvhb
Install the shorter capscrew with washer, if initially installed, through the center hole. **Torque** **Value:** 14 n.m [120 in-lb]		©Cummins Inc  cp8cshh
Place the remaining two guide pins in the crankcase head capscrew holes (that will **not** interfere with the		

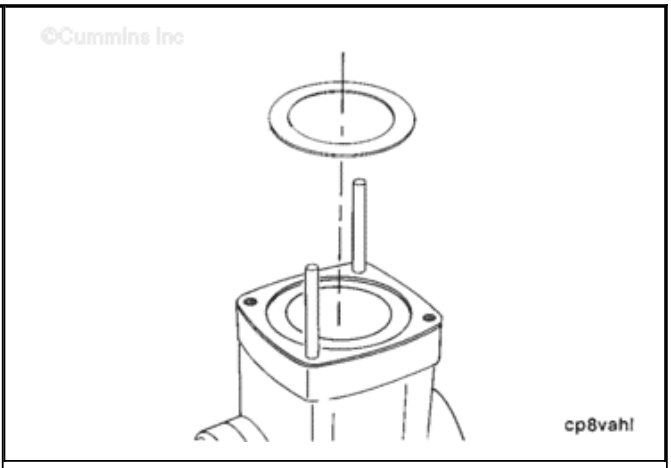
guide pins already in the head assembly).

Install the valve plate gasket.



Carefully place the intake valve on the crankcase, located by the valve plate gasket.

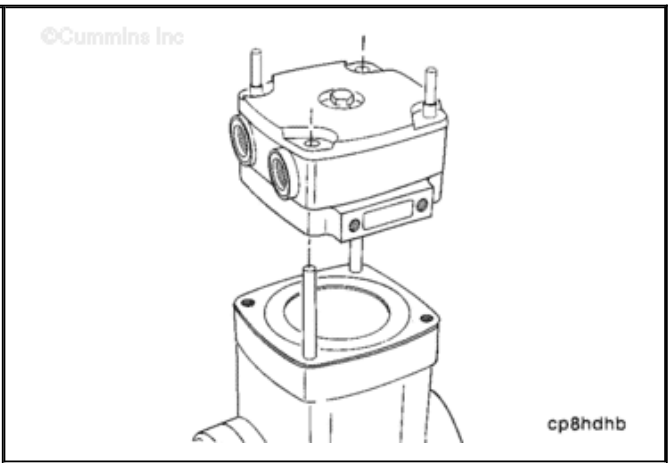
Do **not** allow the valve to overlap the gasket.



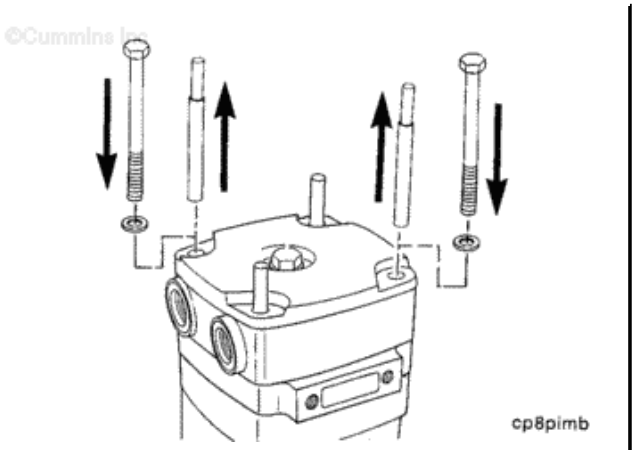
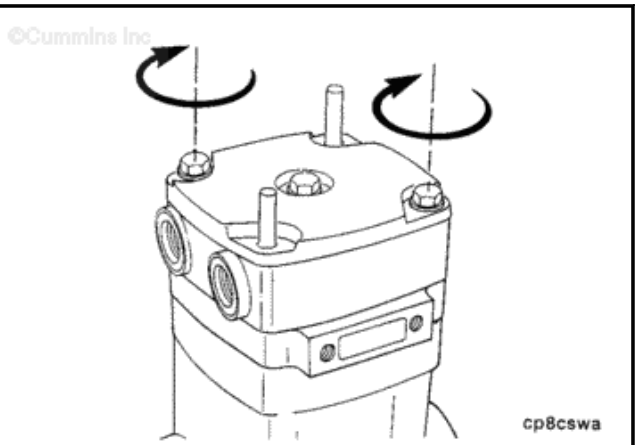
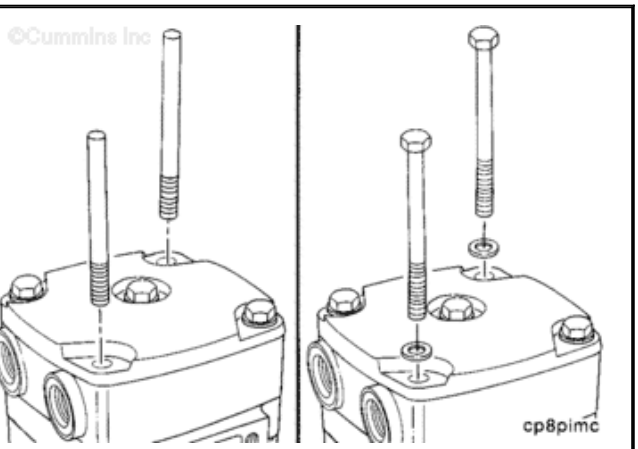
Install the head assembly over the guide pins.

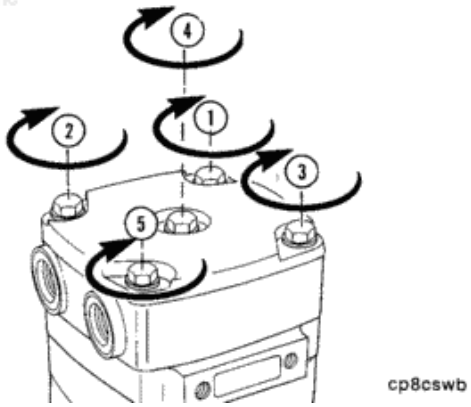
Be careful **not** to disturb the location of the intake valve.

The compressor will **not** work if the valve overlaps the gasket and is pinched.



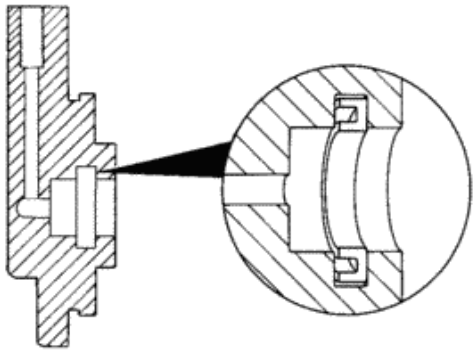
Carefully remove two of the guide pins and replace with two head capscrews and washers, if initially installed.

		
Tighten the two head capscrews. **Torque** **Value:** 14 n.m [120 in-lb]		
Remove the remaining two pins and replace with two head capscrews and washers if initially installed.		
Tighten all five capscrews. **Torque** **Value:** 28 n.m [250 in-lb]		

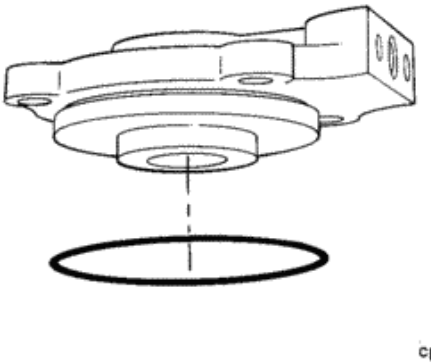


Install the new rectangular V-seal, with the grooved side up, into the unloader body.

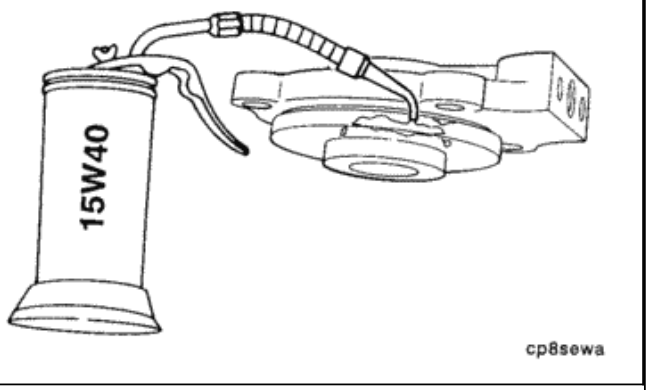
Liberally lubricate the unloader valve bore above and below the rectangular ring seal with high temperature grease (Accrolube Lubrication Teflon Grease or equivalent).



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



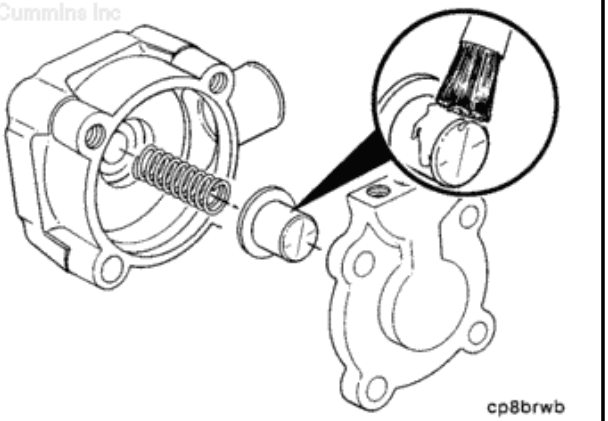
Use clean 15W-40 oil or Accrolube Lubrication Teflon Grease (or equivalent) to lubricate the seal.



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

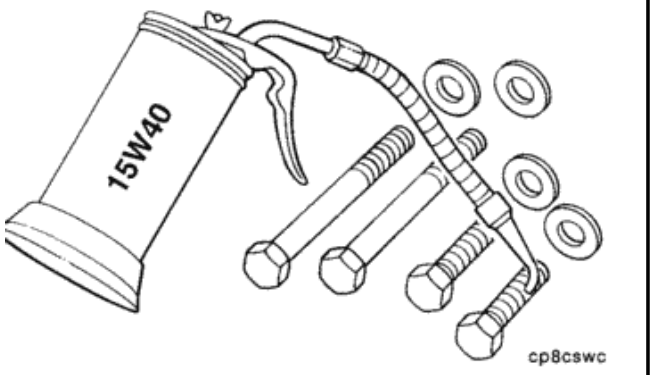
Install the unloader cap.

Install the unloader spring.



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

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



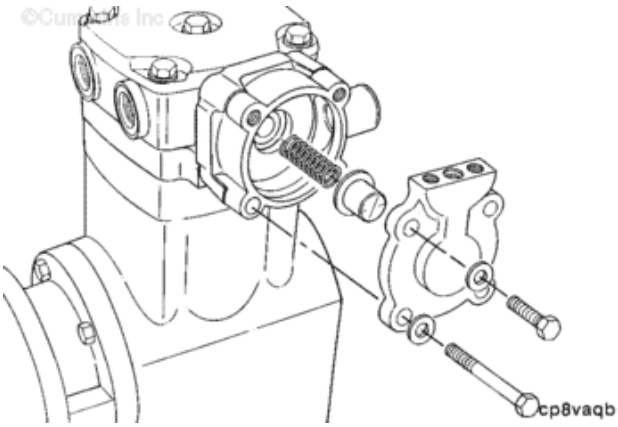
Assemble the unloader components and attach the unloader assembly to the valve plate with the four

capscrews and washers.

The longer capscrews are used to mount the manifold to the air compressor.

Tighten the capscrews.

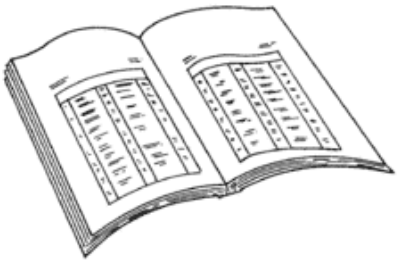
Torque
Value: 27 n.m [20 ft-lb]



Finishing Steps

Holset® Models

- Fill cooling system, if drained. Refer to Procedure 008-018.



Last Modified: 02-Dec-2004

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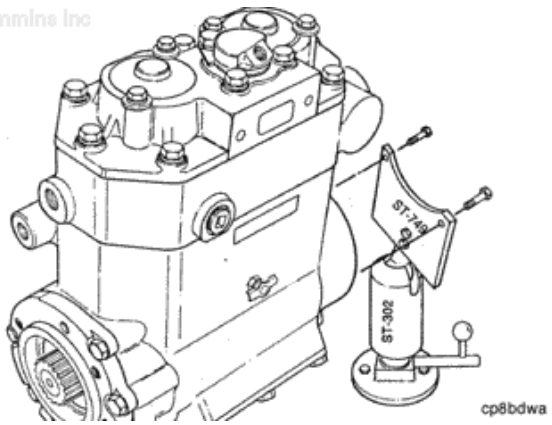
012-106 Air Compressor Cylinder Head (Holset® ST Models)

Disassemble

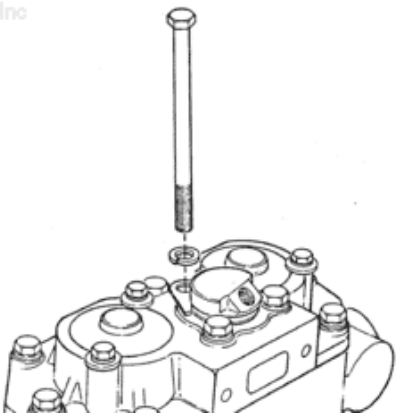
WARNING

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

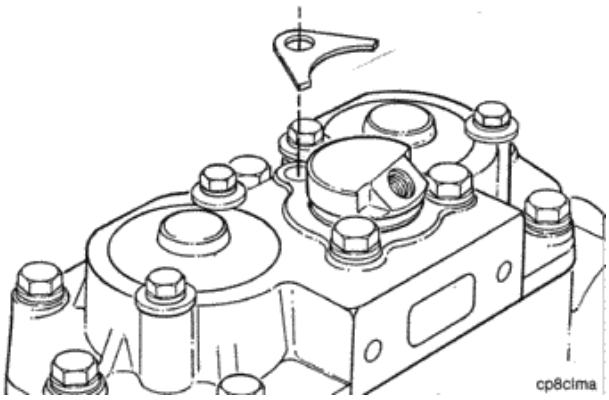
Use two 5/16 - 18 x 1 ¼ inch capscrews to mount the air compressor on the mounting plate, Part Number ST-749 which is used with the ball joint vise, Part Number ST-302.



Remove the center unloader body hexagon head capscrew and lock washer.



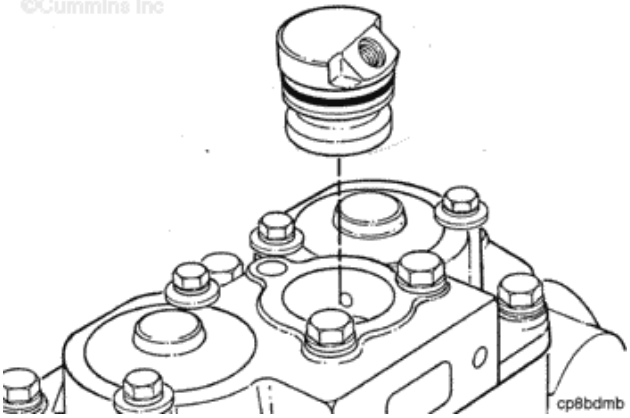
Remove the retaining clamp.



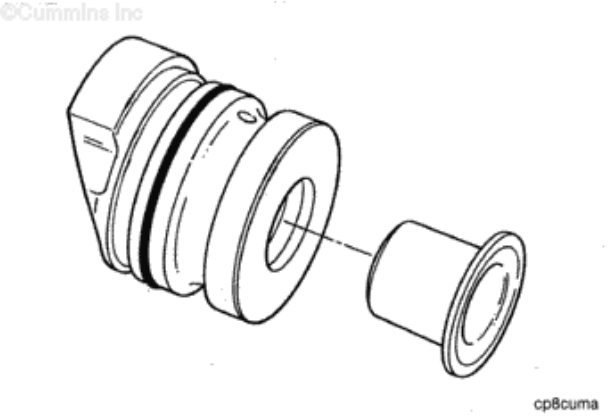
WARNING

The unloader body is installed with spring tension, it must be removed carefully to reduce the possibility of personal injury. Always wear protective eye wear.

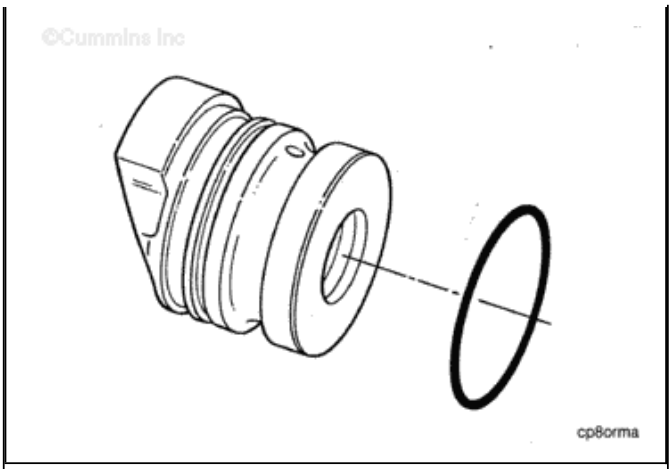
Remove the unloading valve body.



Remove the unloader valve cap, if installed.

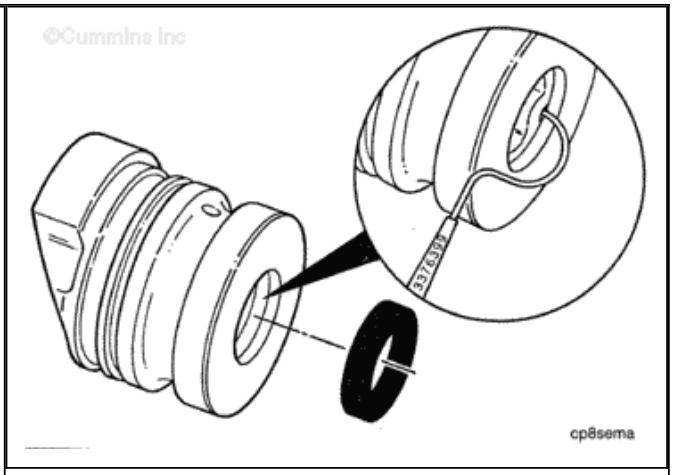


Remove and discard the o-ring seal.

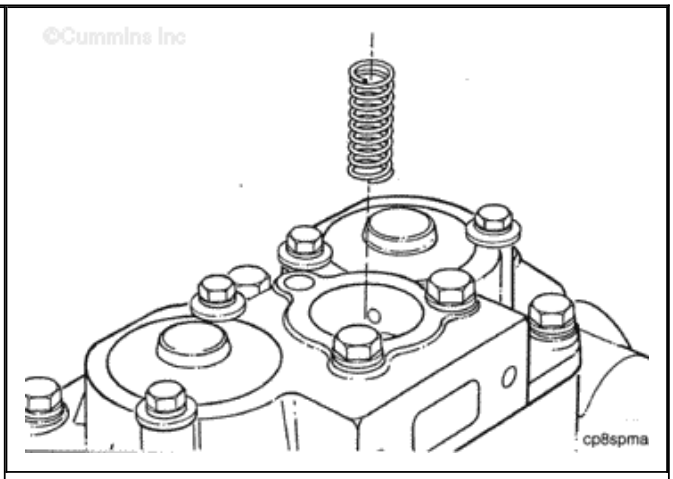


Use an o-ring pick, Part Number 3376399, to remove the rectangular ring seal, if installed.

Discard the seal.

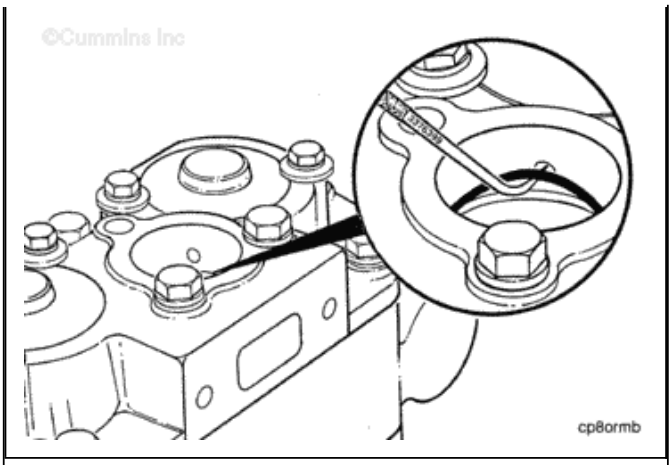


Remove the unloader valve cap spring.

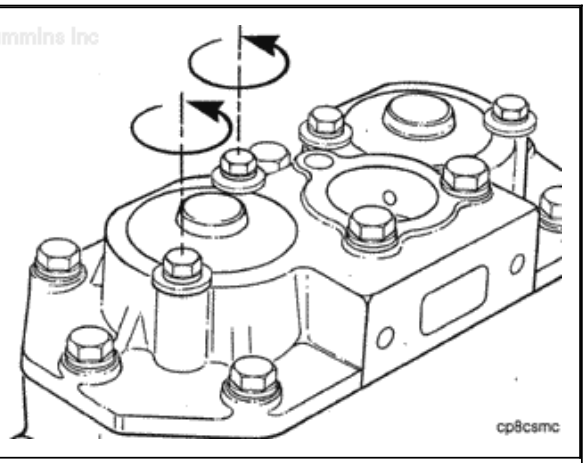


Use a o-ring pick, Part Number 3376399, to remove the o-ring seal.

Discard the seal.



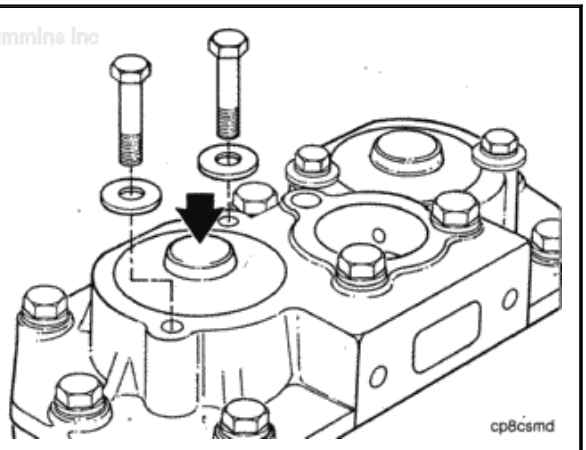
Loosen the two unloader body hexagon head capscrews.



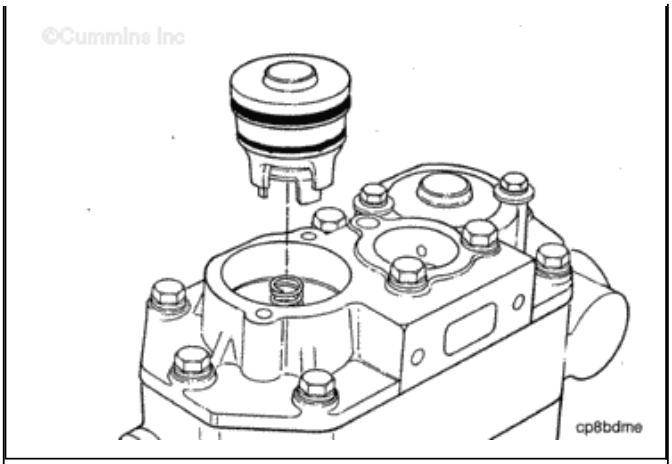
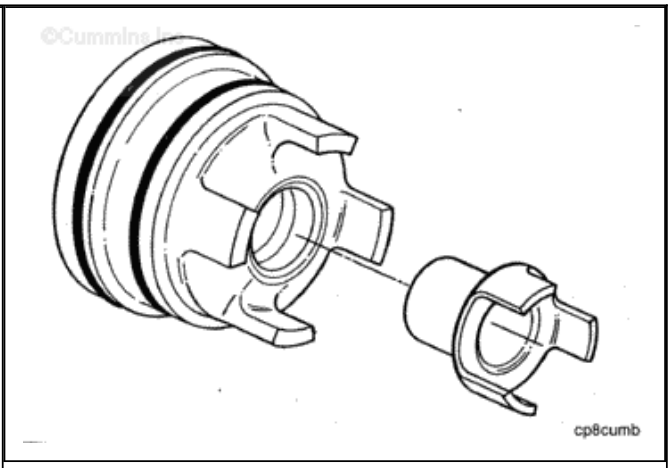
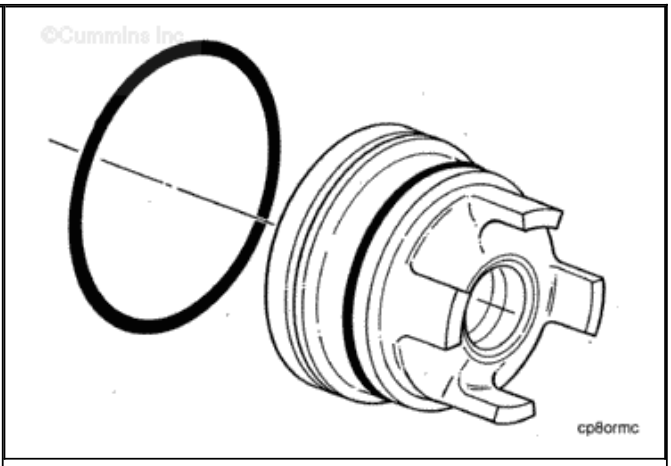
WARNING

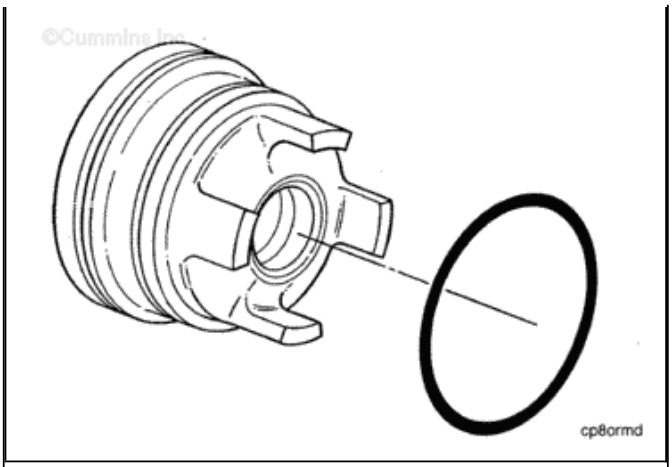
The unloader body is installed with spring tension, it must be removed carefully to reduce the possibility of personal injury. Always wear protective eye wear.

Hold down on the unloader body and slowly remove the two unloader body capscrews and the two plain washers so as to prevent the unloader body from being thrown free and causing personal injury.



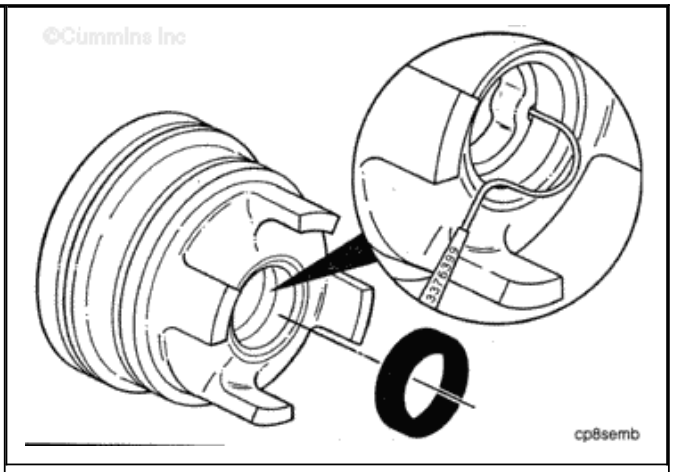
Remove the unloader valve body.

		
Remove the unloader cap.		
Remove and discard the top o-ring seal.		
Remove and discard the bottom o-ring seal.		



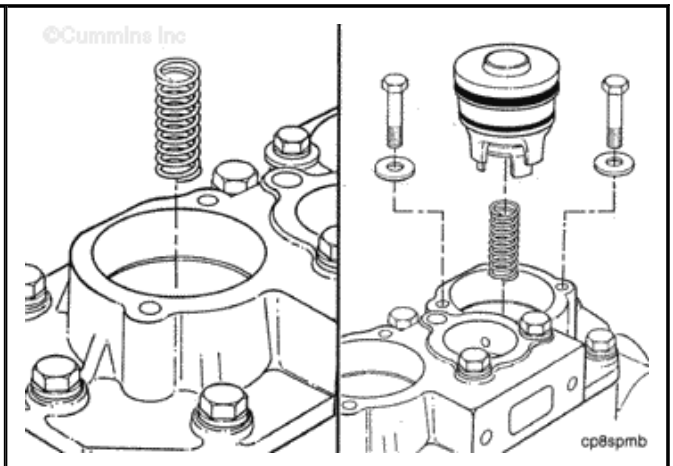
Use an o-ring pick, Part Number 3376399, to remove the rectangular ring seal.

Discard the seal.

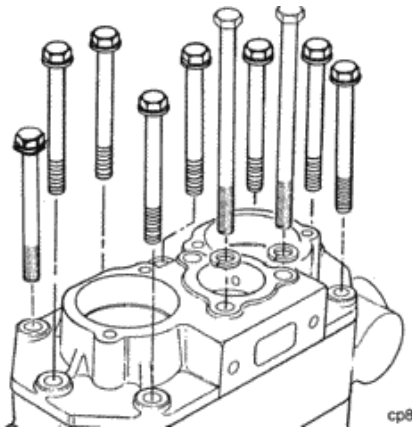
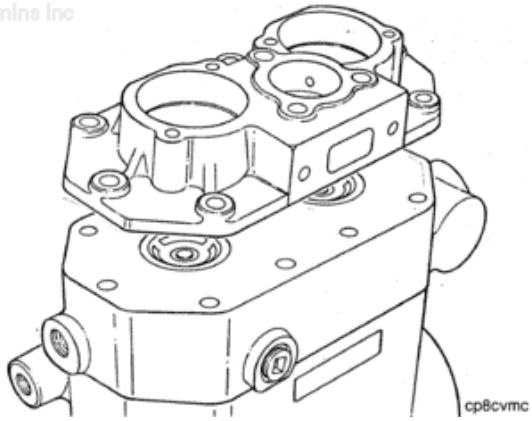
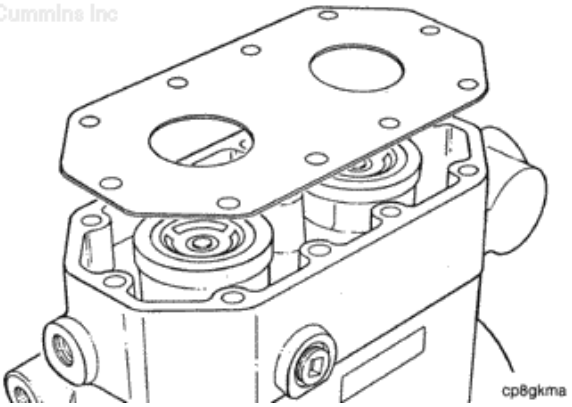


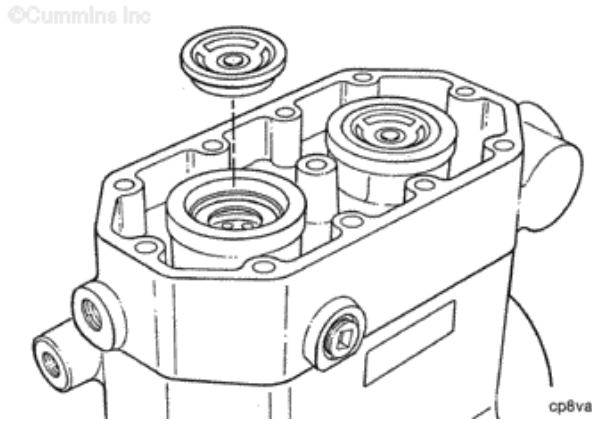
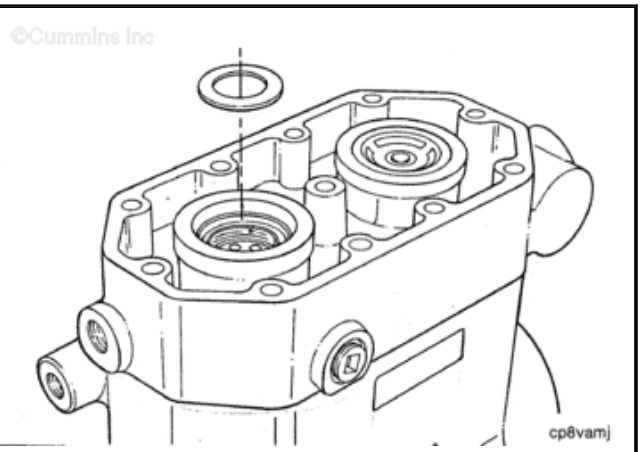
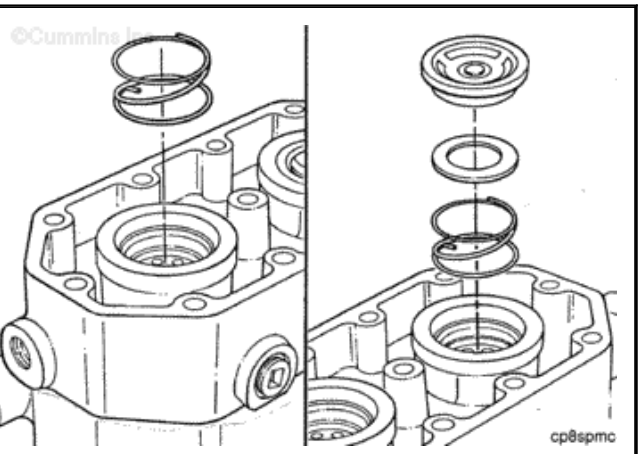
Remove the unloader cap spring.

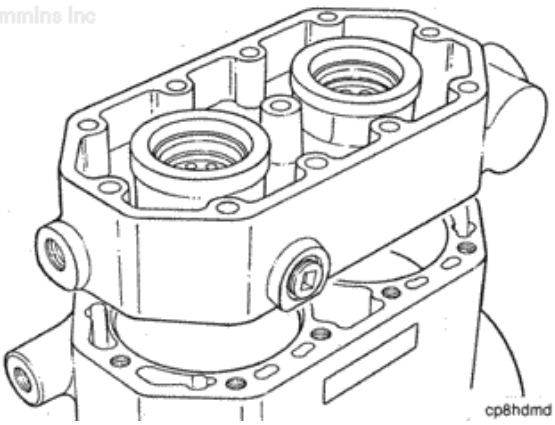
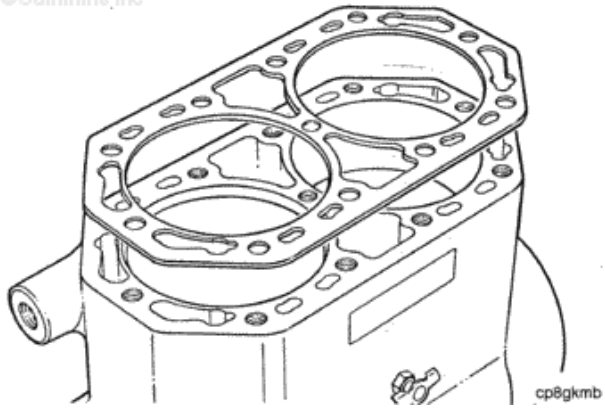
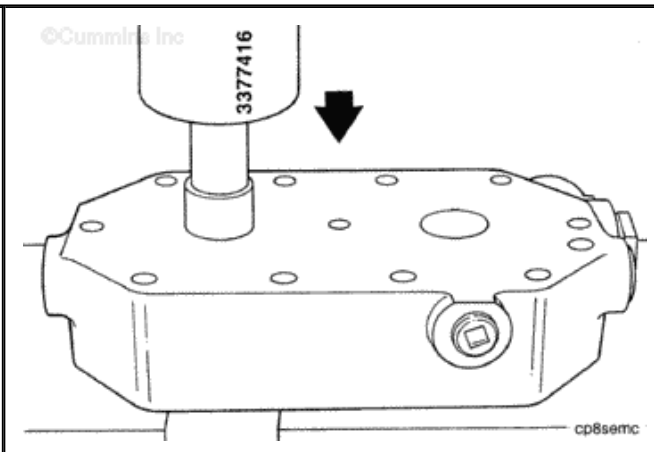
Repeat the last eight steps to remove the other unloader body assembly.

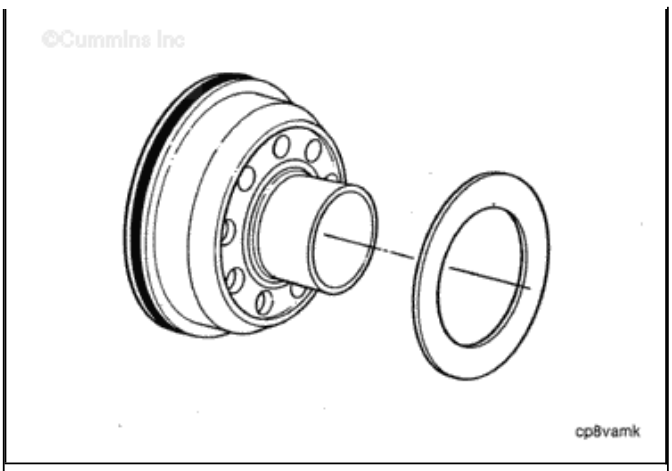
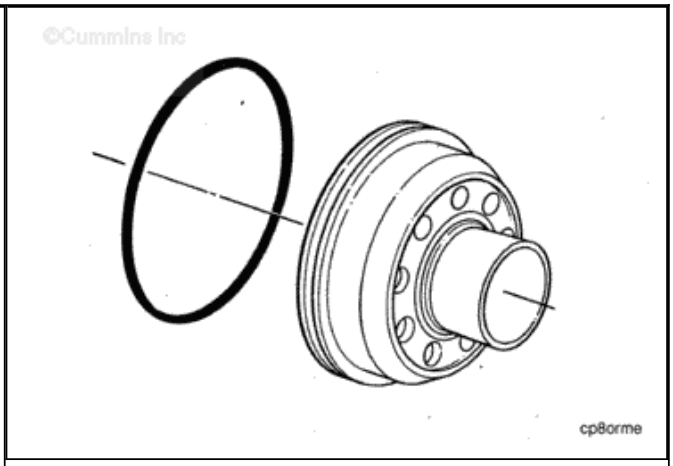
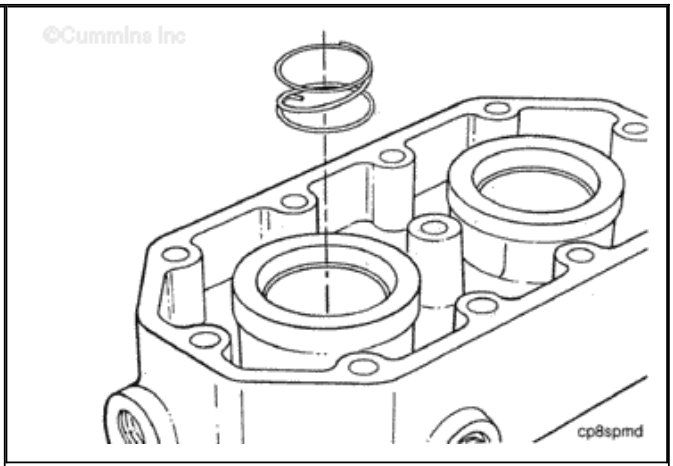


For the ST676, remove the ten remaining hexagon head capscrews and two lock

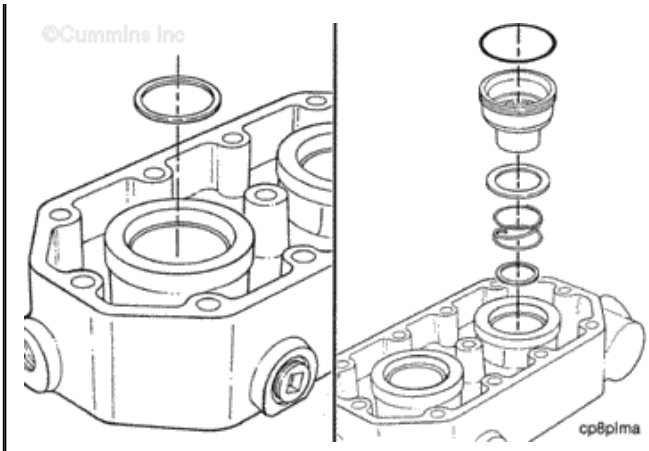
washers. For the ST773, remove the eight captive washer capscrews and the two hexagon head capscrews and lock washers.		
Remove the cover.		
Remove and discard the cover gasket.		
Remove the intake valve seat.		

		
Remove the intake valve.		
Remove the intake valve spring. Repeat the last three steps to remove the other intake valve assembly.		
Remove the head.		

		
Remove and discard the head gasket.		
Use a press and an air compressor seat removal tool, Part Number 3377416, to remove the exhaust valve seat assembly from the head.		
Remove the exhaust valve.		

		
Remove and discard the o-ring seal.		
Remove the exhaust valve spring.		
Remove the wear plate. Repeat the last five steps to disassemble the other		

exhaust valve seat assembly.

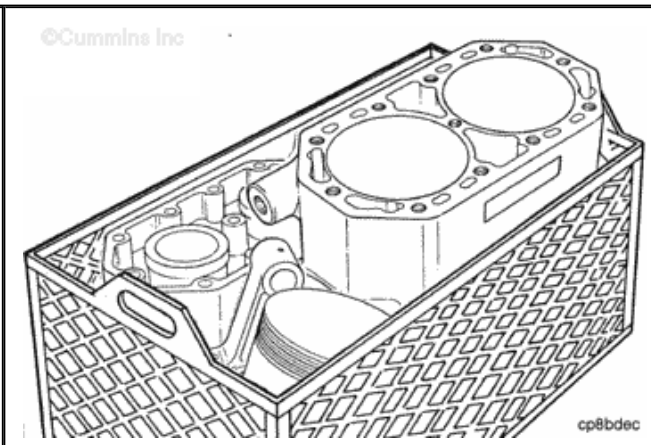


Clean and Inspect for Reuse

WARNING

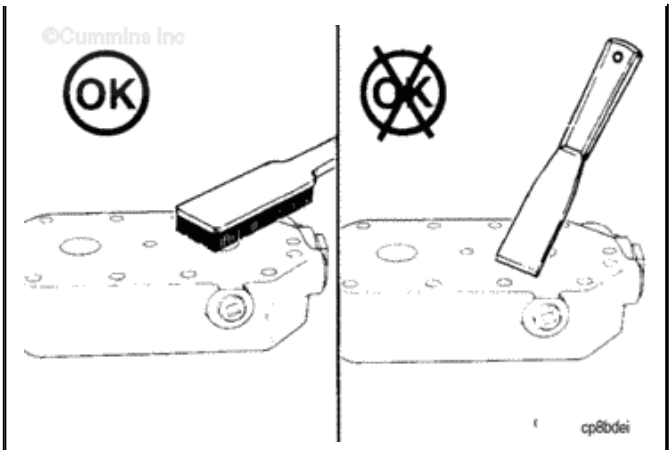
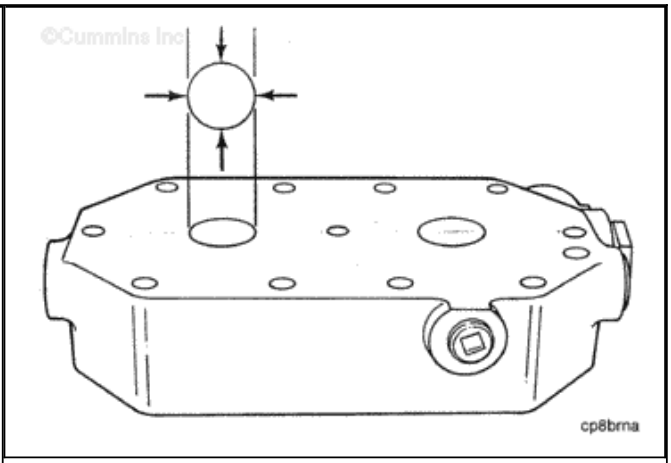
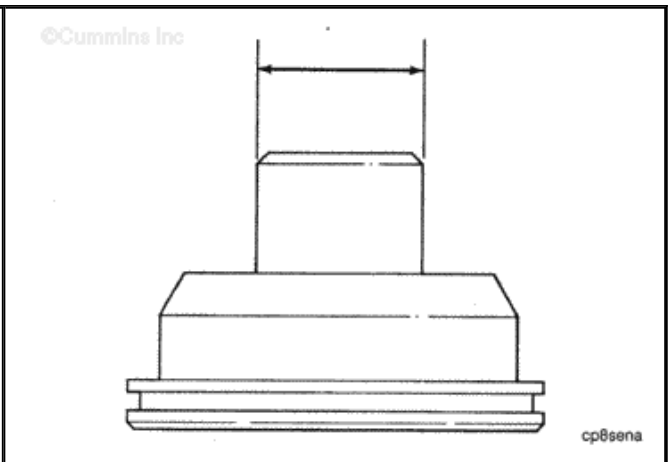
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing.

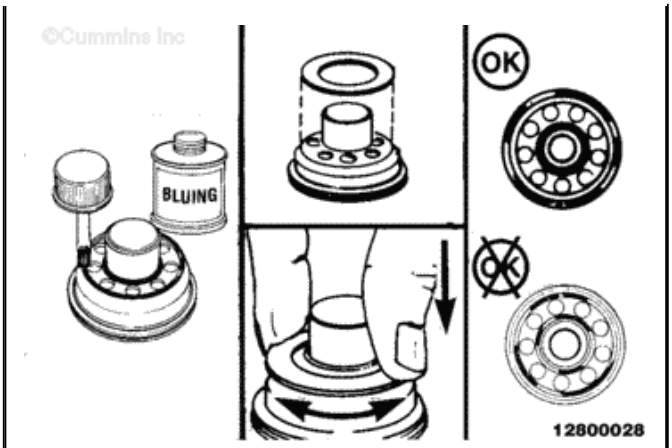
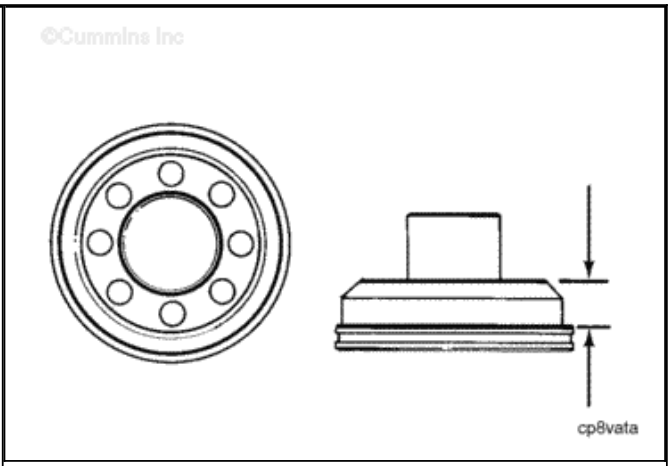
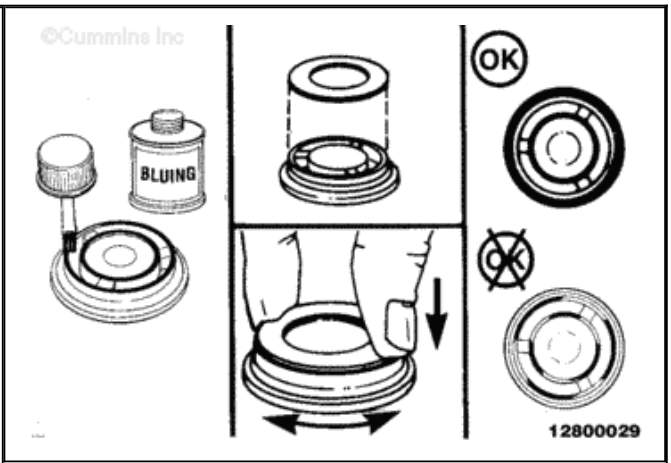
Soak the parts in a kerosene emulsion based cleaner designed to remove carbon. The cleaner **must** have a pH of 9.5 or less to avoid turning aluminum parts black. The cleaner manufacturer or supplier **must** be contacted about solution concentration, temperature and soak time.



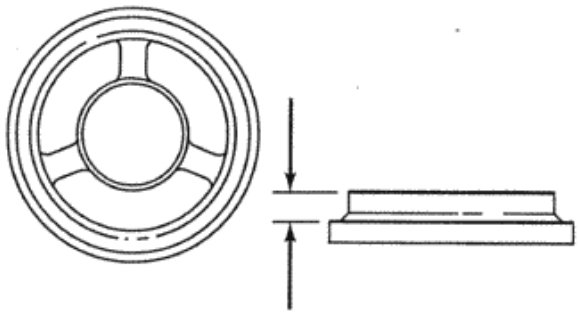
Do **not** use a scraper to remove carbon and scale, the sealing surfaces can be damaged.

The parts can be scrubbed with a stiff nonmetallic bristle

brush.		
Measure the exhaust valve seat press fit diameter in the cylinder head. Replace if worn larger than 20.688 mm [0.8145 in].		
Measure the exhaust valve seat press fit diameter. Replace if worn smaller than 20.714 mm [0.8155 in].		
Apply "bluing" to the exhaust seating surface to check the seat.		

If the seating surface is **not** 100 percent true discard and replace the valve seat.		
Measure the exhaust valve seat height. If the height is less than 12.32 mm [0.485 in] replace the exhaust valve seat.		
Apply "bluing" to the intake valve seating surface. If the seating surface is **not** 100 percent true replace the intake valve seat.		
Measure the intake valve seat height. If the height is less than 6.86		

mm [0.270 in] replace the intake valve seat.

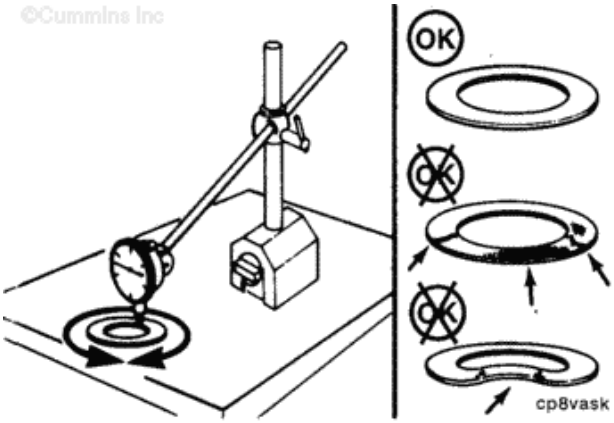


Inspect the exhaust and intake valves for cracks and damage.

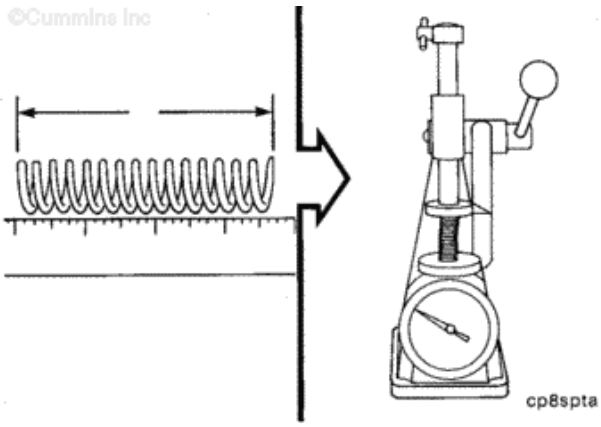
Measure valves for flatness. The valves **must** be flat within 0.03 mm [0.001 in].

Replace the valves if cracked, damaged, or **not** flat.

Holset® Engineering Co., Inc. recommends that new valves be installed during rebuild.



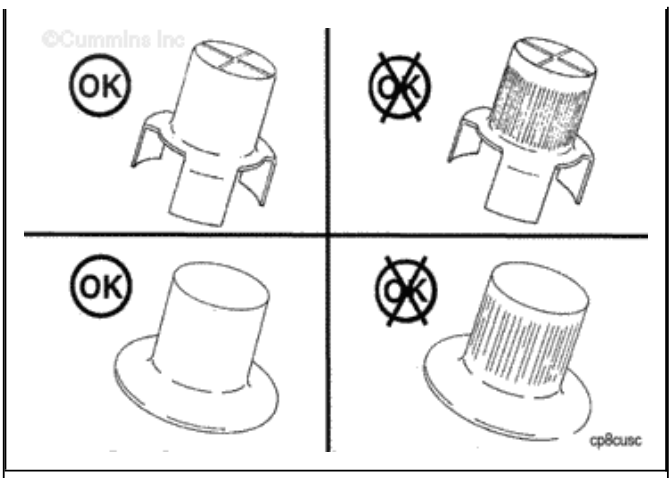
Holset Engineering Co., Inc. recommends that new springs be installed during rebuild.



Inspect the upper part of the unloader cap where the rectangular ring seal seats

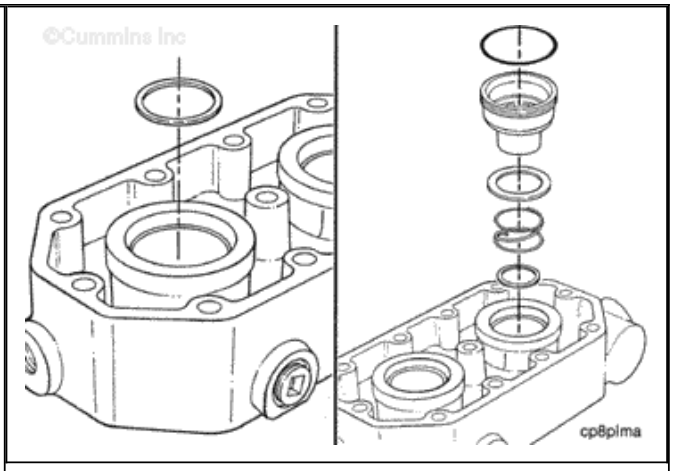
for scoring.

Replace if scored.



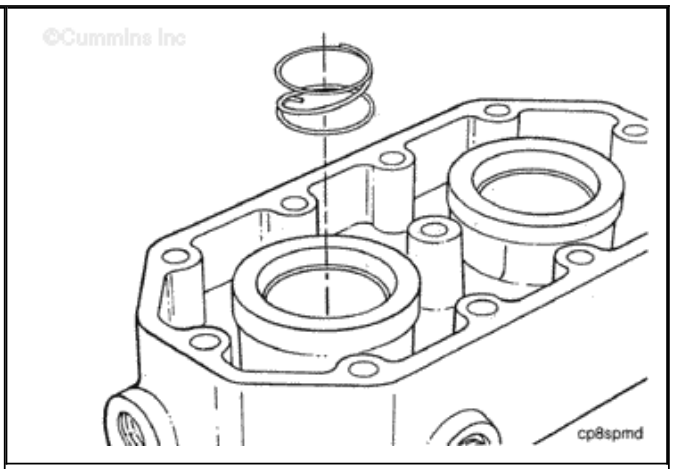
Assemble

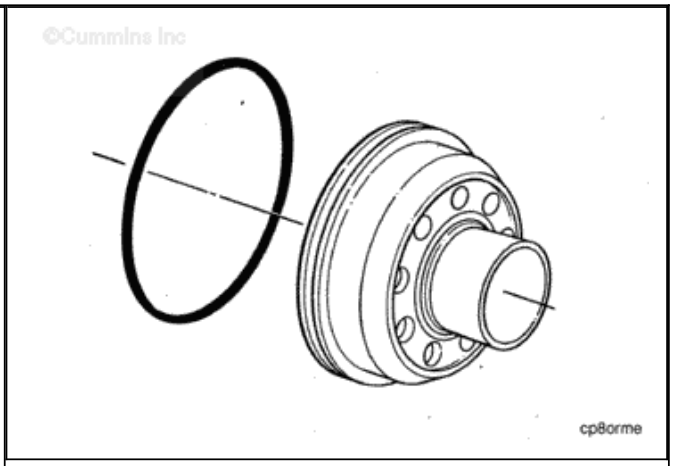
Install the wear plate.

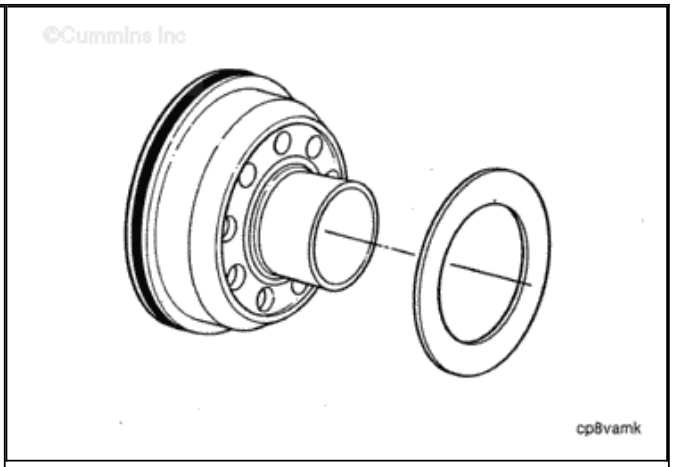


Holset Engineering Co., Inc. recommends that new springs be installed during rebuild.

Install the exhaust valve spring with the tang end down.

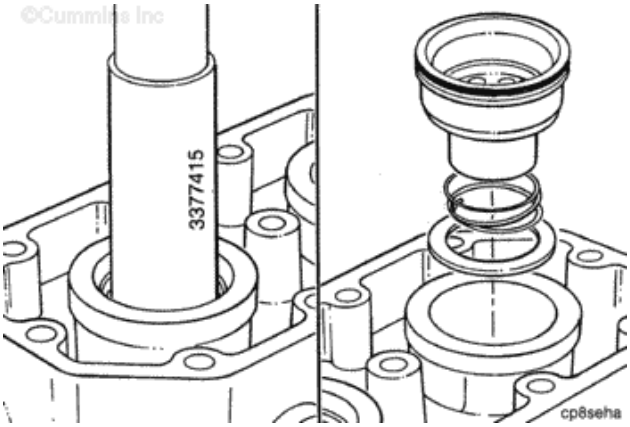
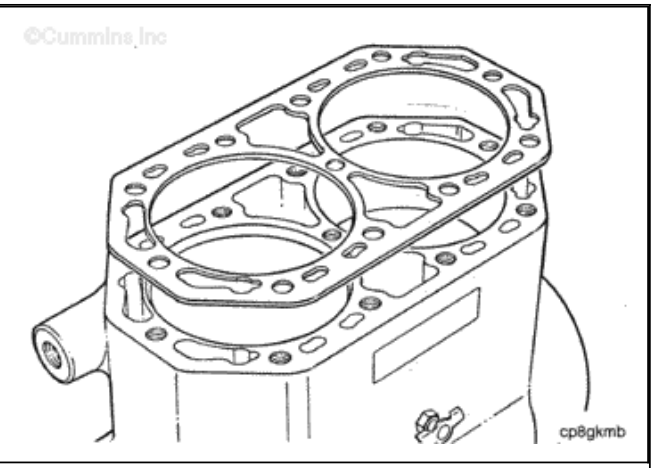
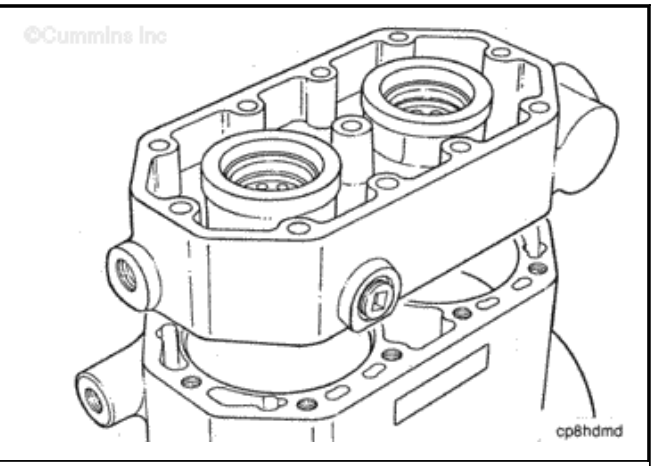


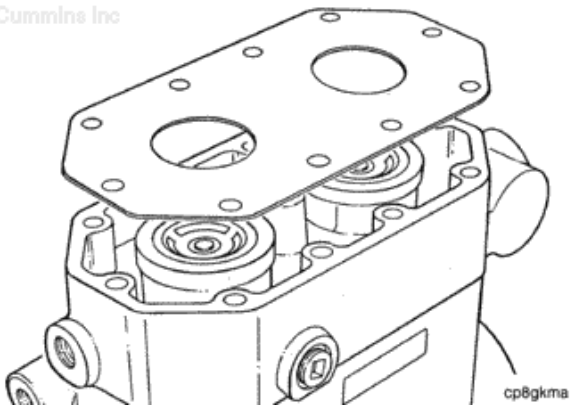
Install a new o-ring seal.		

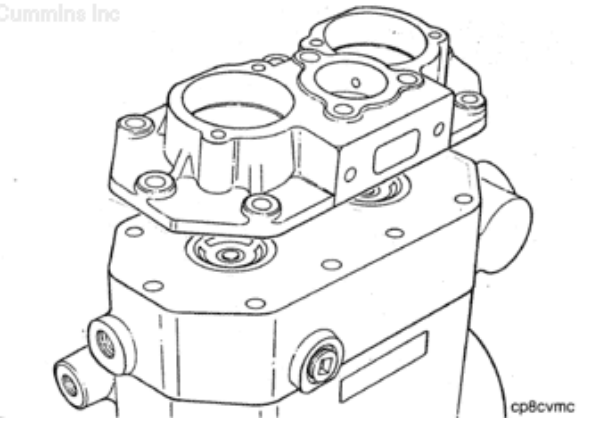
Holset Engineering Co., Inc. recommends that new exhaust valves be installed during rebuild. Install the exhaust valve.		

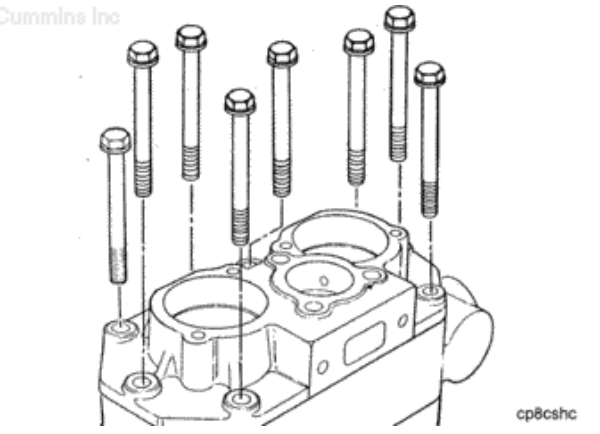
Use clean 15W-40 oil to lubricate the seal.		

Do **not** use excessive		

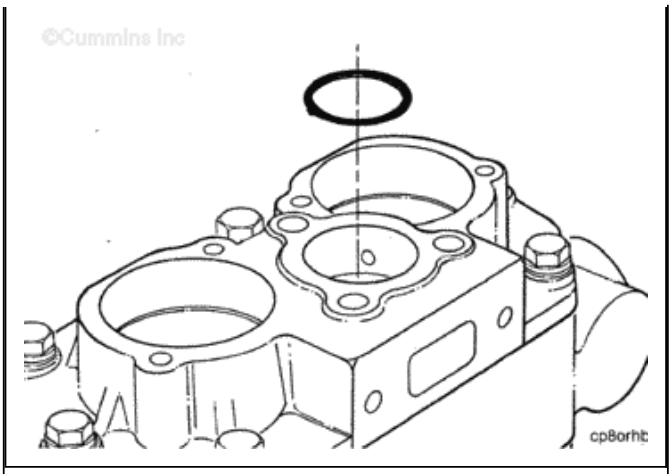
pressure on the exhaust valve seats, to do so can distort the valve. Use a hand press and an air compressor seat installation tool, Part Number 3377415, to press the exhaust valve seat into the head. Repeat the last six steps to install the other exhaust valve assembly.		
Install a new cylinder head gasket.		
Install the head.		
Install a new cover gasket.		

Install the cover.		

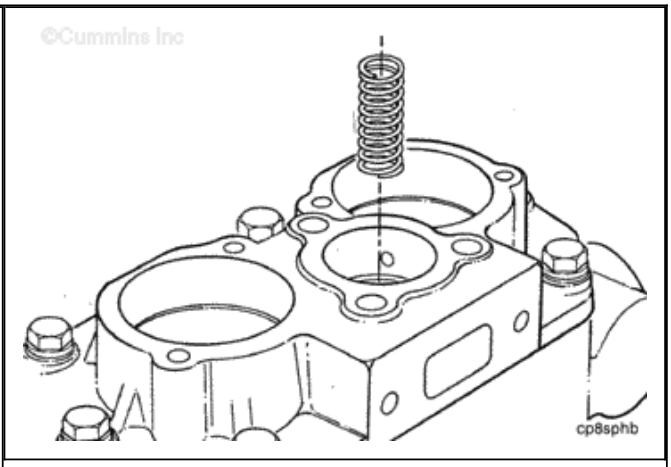
For the ST676, install the eight hexagon head capscrews and finger tighten. For the ST773, install the eight captive washer capscrews.		

Use an o-ring pick, Part Number 3376399, to correctly install the new o-ring seal.		



Holset Engineering Co., Inc. recommends that new springs be installed during rebuild.

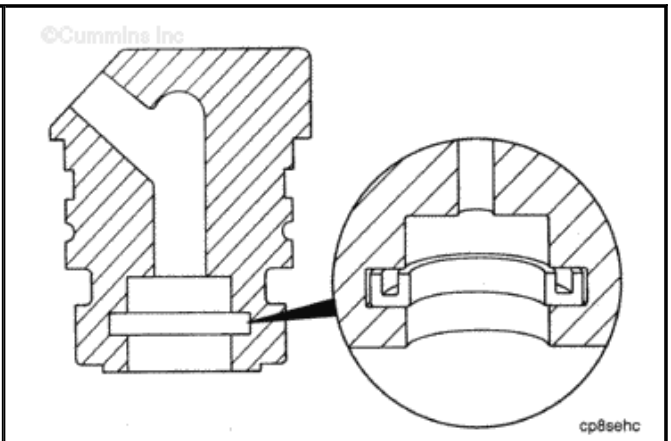
Install the unloading spring.



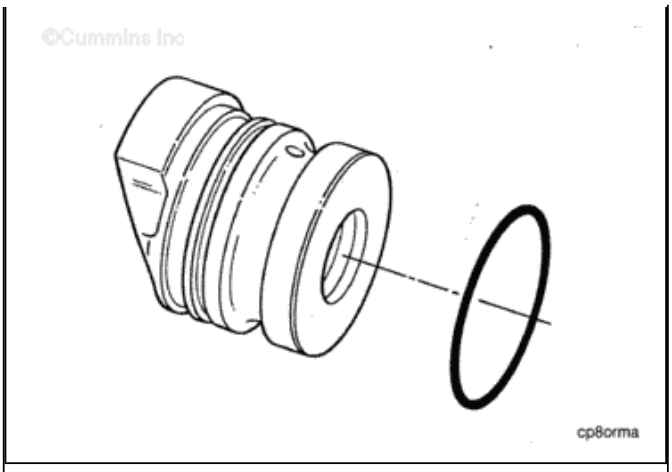
CAUTION

The rectangular ring seal must be installed with the grooved side up; failure to do so will result in air system damage and brake failure.

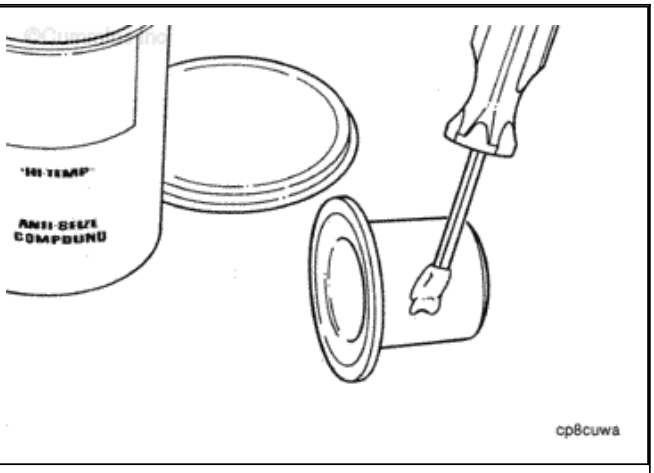
Use an o-ring pick, Part Number 3376399, to correctly install the new rectangular ring seal, if the unloader body has a cavity for this o-ring.



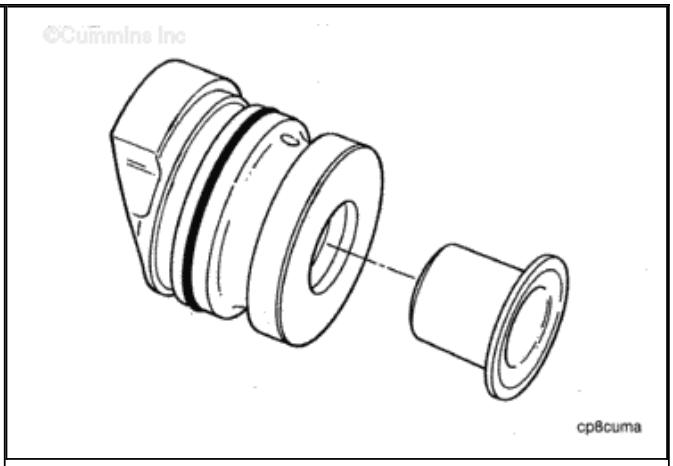
Install a new o-ring seal.



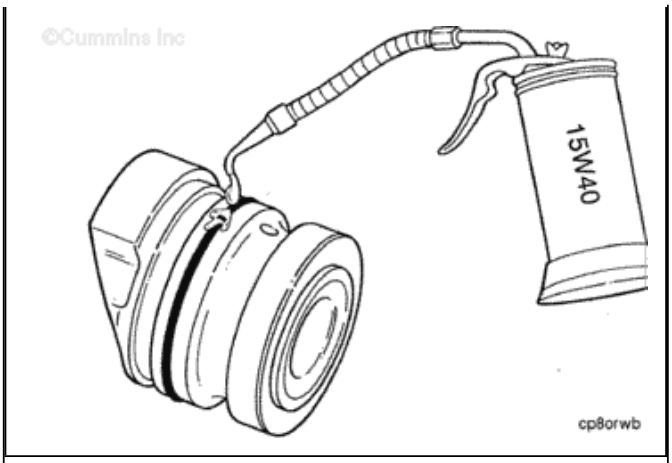
Use antiseize compound to lubricate the outside diameter of the unloader valve cap.



Install the cap into the unloading valve body.



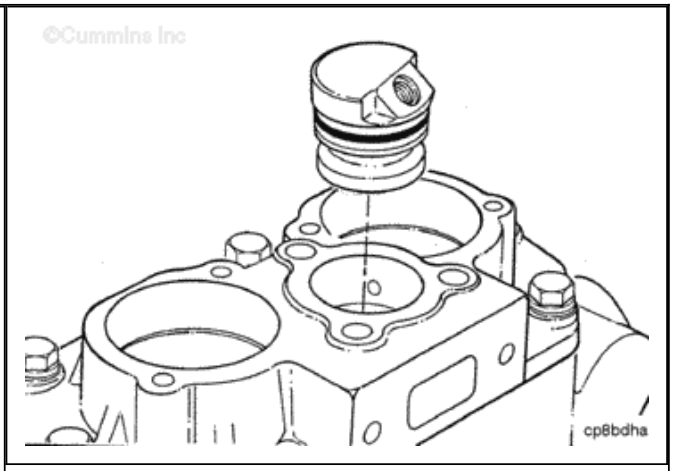
Use clean 15W-40 oil to lubricate the seal.



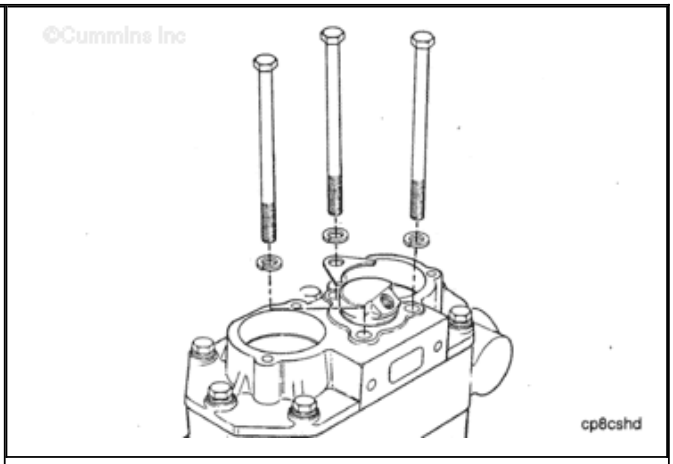
WARNING

The unloader body is installed with spring tension, it must be removed carefully to reduce the possibility of personal injury. Always wear protective eye wear.

Install the body into the cover.



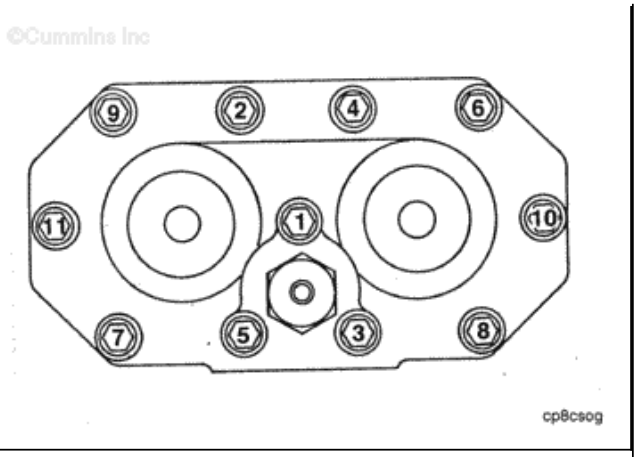
Install the retaining clamp and the three lock washers and the three hexagon head capscrews.



Tighten the capscrews in the sequence shown.

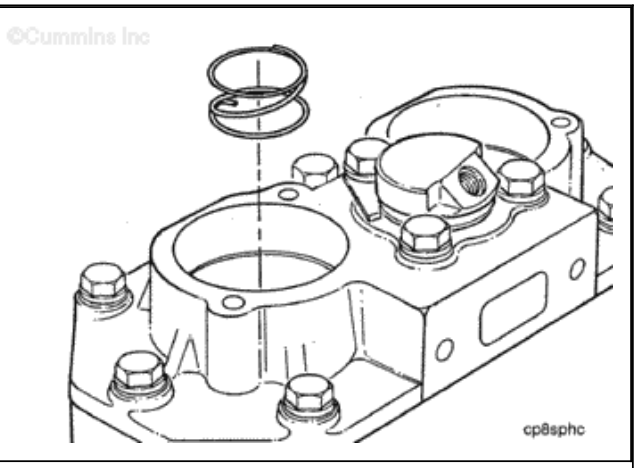
Torque

Value: 41 n.m [30 ft-lb]



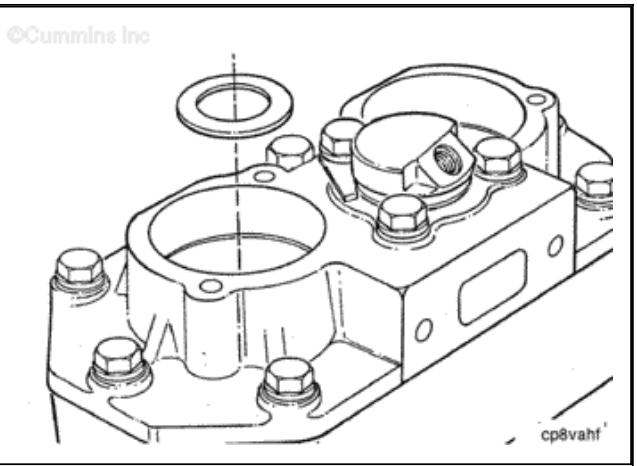
Holset Engineering Co., Inc. recommends that new springs be installed during rebuild.

Install the intake valve spring with the tang end down.

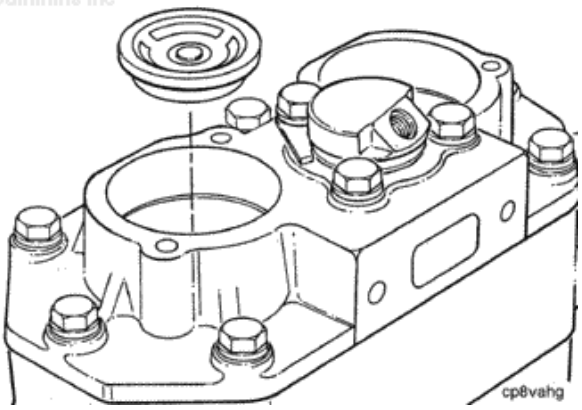


Holset Engineering Co., Inc. recommends that new intake valves be installed during rebuild.

Install the intake valve.

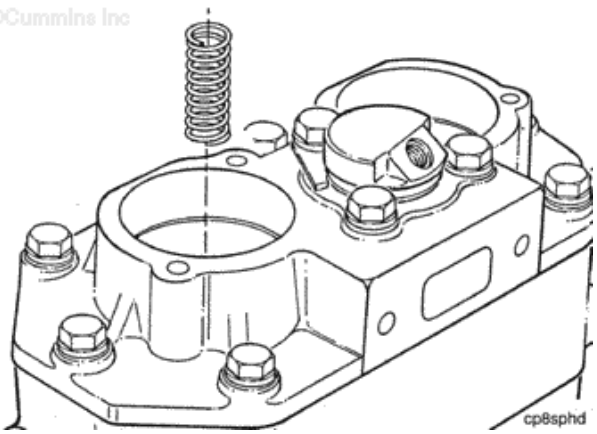


Install the intake valve seat with the flange end up.

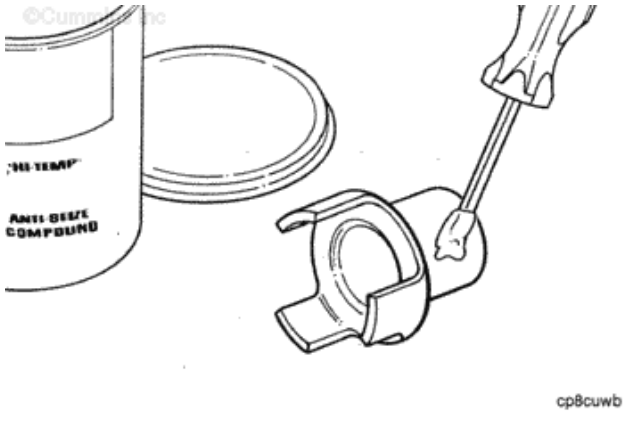


Holset Engineering Co., Inc. recommends that new springs be installed during rebuild.

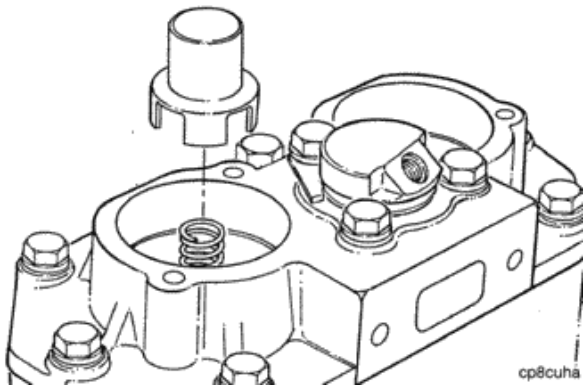
Install the unloader cap spring.



Use anti-seize compound to lubricate the outside diameter of the unloader valve cap.



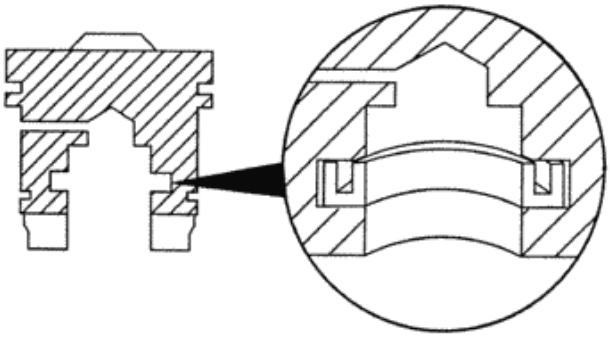
Install the cap into the cover and make sure the three tangs are in the three slots of the intake valve seat.



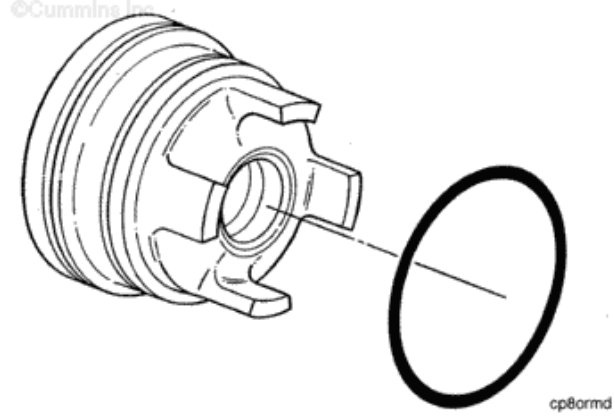
CAUTION

The rectangular ring seal must be installed with the grooved side up; failure to do so will result in air system damage and brake failure.

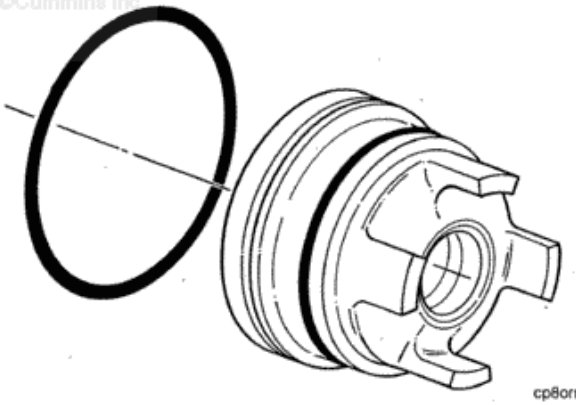
Use an o-ring pick, Part Number 3376399, to correctly install the new rectangular ring seal.



Install a new bottom o-ring seal.



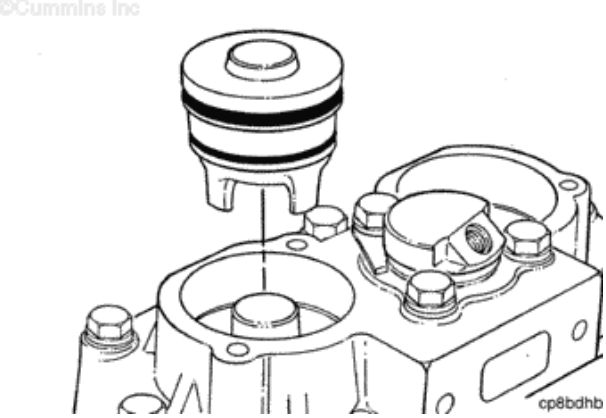
Install a new top o-ring seal.



Use clean 15W-40 oil to lubricate the seals.



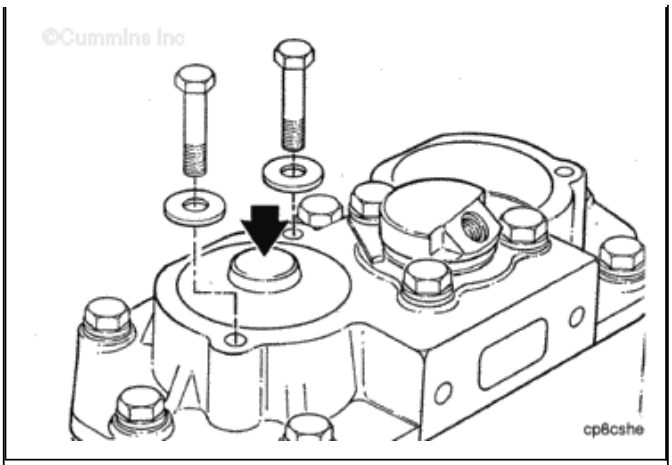
Install the unloading body into the cover.



WARNING

The unloader body is installed with spring tension, it must be removed carefully to reduce the possibility of personal injury. Always wear protective eye wear.

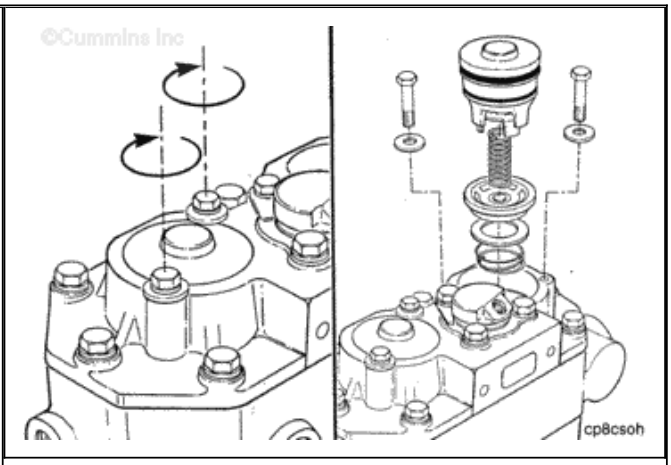
Hold down on the unloading body firmly and install the capscrews and plain washers so as to prevent the unloader body from being thrown free and causing personal injury.



Tighten the capscrews.

Torque
Value: 14 n.m [120 in-lb]

Repeat the last thirteen steps to install the other unloading body assembly.

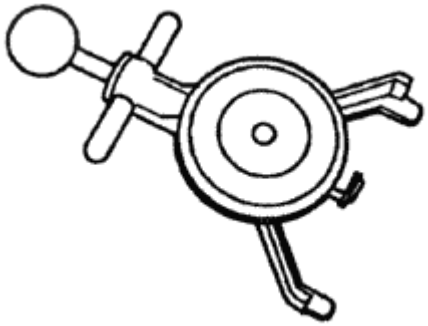


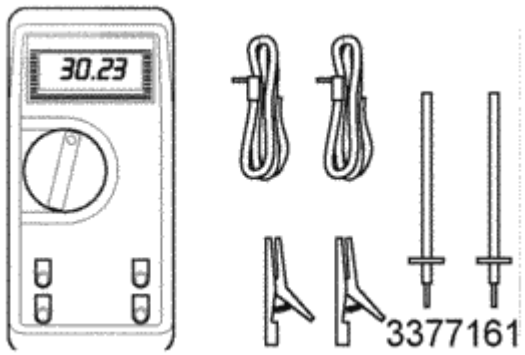
Last Modified: 02-Dec-2004

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022-001 Service Tools

Electrical Equipment

Tool Number		
ST-1138	**Belt Tensioner Gauge** Used to measure alternator belt tension.	 fa8togc

Tool Number		
3377161	**Digital Multimeter** Measure voltage (volts) and resistance (ohms) in a circuit.	

Last Modified: 22-Nov-2004

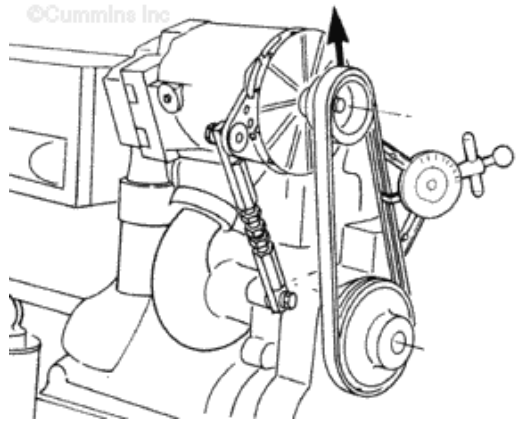
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013-001 Alternator

Initial Check

The following instructions are for use with the inductive charging and cranking system analyzer, Part Number 3377193, or equivalent.

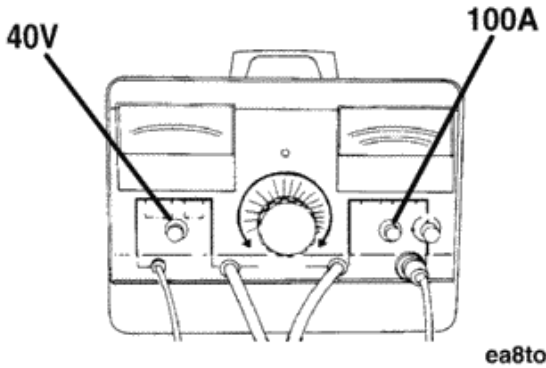
Before performing the following test, be sure the alternator belt is tightened to the correct specifications. Refer to Procedure 013-005.



Set the voltage selector knob to the appropriate scale.

For a 24 VDC system, choose the 40 volt scale.

Set the amp selector knob to 100 amps.



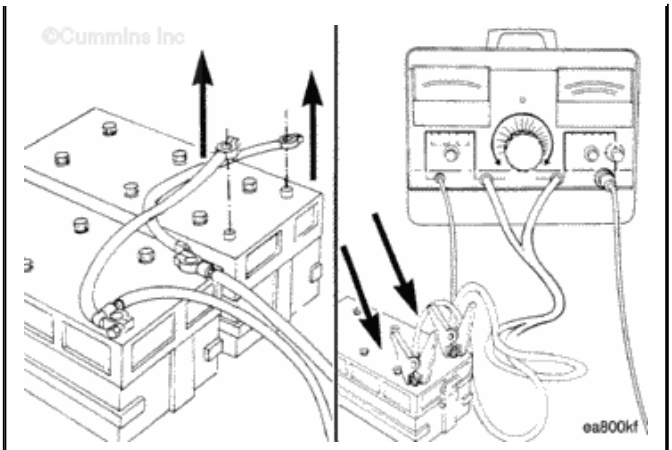
WARNING

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.

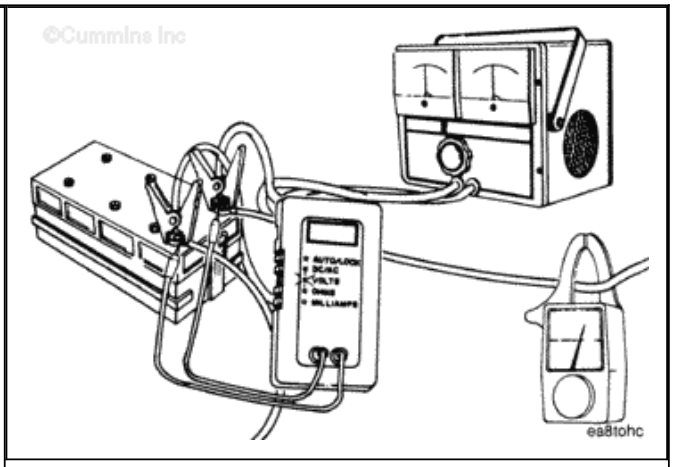
Remove the cables to any other battery in the circuit.

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.



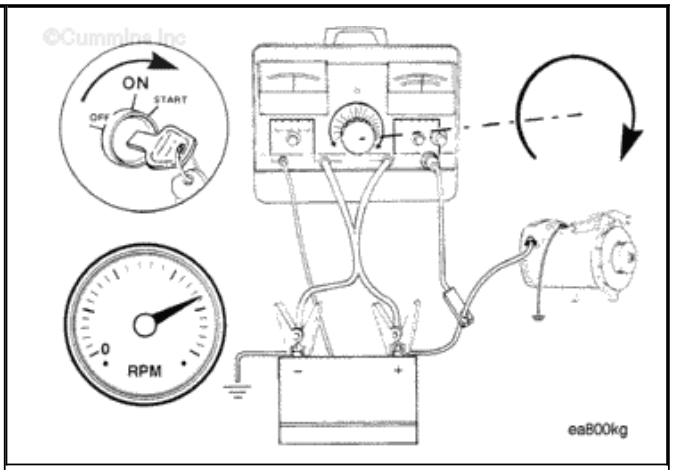


Operate the engine at high idle and turn the analyzer load control knob **clockwise** until a maximum amperage reading is obtained.

Do **not** let the load voltage drop below 26 VDC for a 24 volt system.

The maximum amp reading is the alternator output, and **must** meet the alternator manufacturer's specifications.





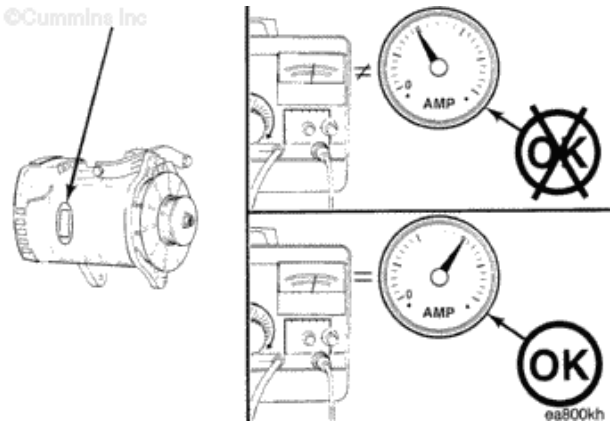
The alternator maximum rated output is normally



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 **must** 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.

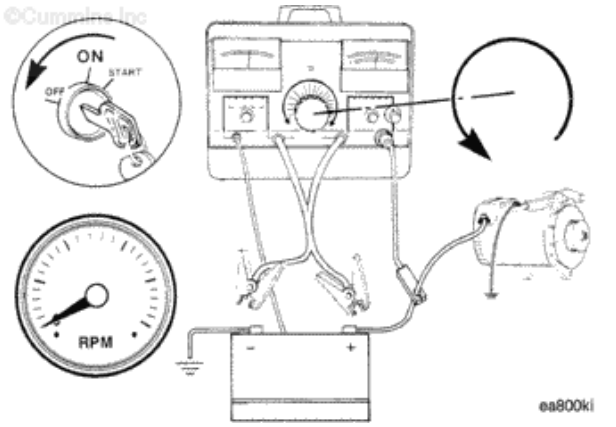


WARNING

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.



Preparatory Steps

WARNING

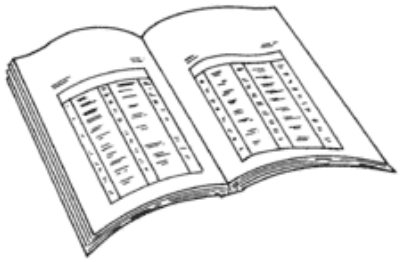
Batteries can emit explosive

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.

Remove the alternator belt. Refer to Procedure 013-005.

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ck800wa

Remove

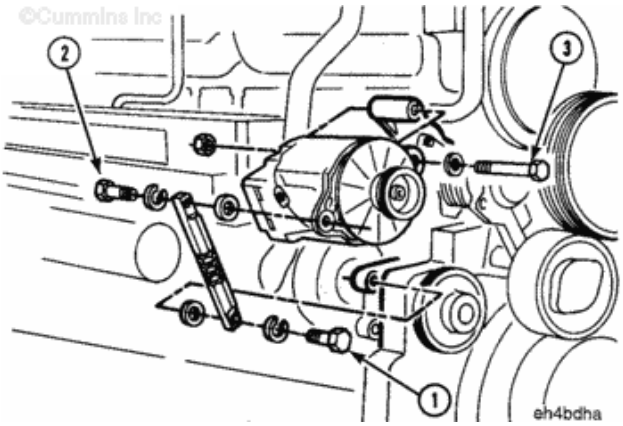
Disconnect the wiring and ground strap from the alternator.

Remove capscrews (1) and (2) and the adjusting link.

Remove capscrew (3) and nut.

Remove the alternator.

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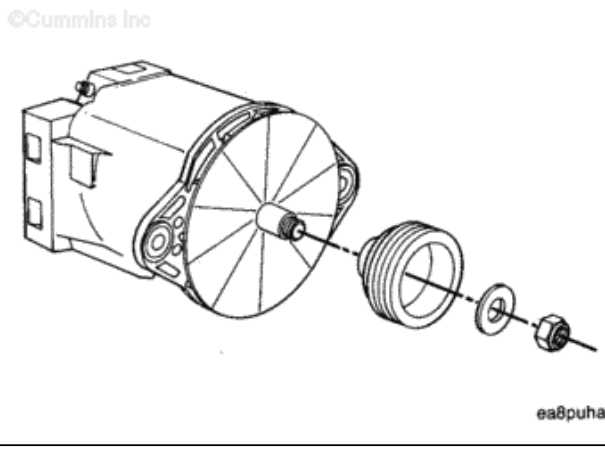
eh4bdha

Clean and Inspect for Reuse

Remove the nut and the pulley from the alternator.

Clean and check the pulley for reuse.





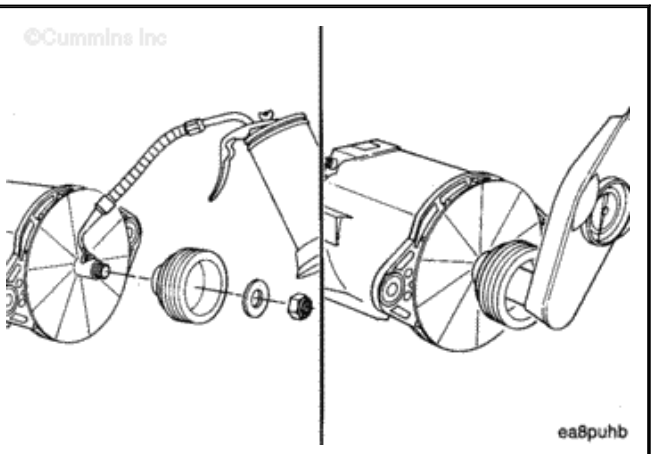
Install

Lubricate the shaft with engine oil. Install the pulley and nut on the alternator shaft.

Tighten the nut.

Torque
Value: 100 n.m [75 ft-lb]





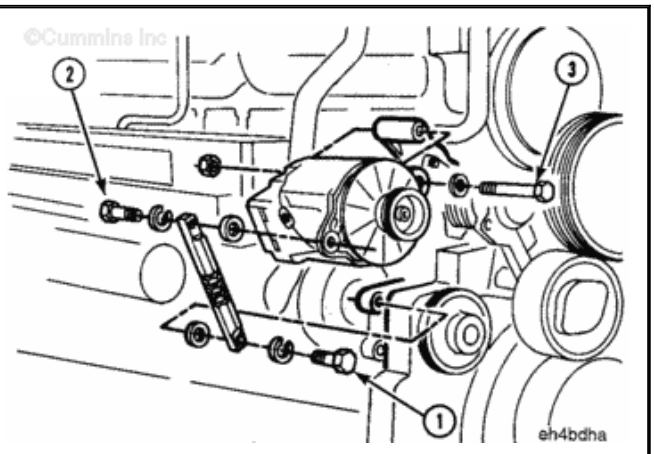
The belt **must** be adjusted before the capscrews are tightened.

The end of the adjusting link with the largest area at the capscrew hole **must** be nearest to the alternator.

Install the alternator and the adjusting link as shown.

Connect the wiring to the alternator.



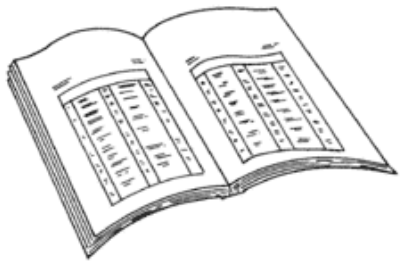


Finishing Steps

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 alternator belt. Refer to Procedure 013-005.
- Connect the batteries.



ck800wa

Last Modified: 22-Nov-2004

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013-003 Alternator Bracket

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 solvents to clean parts.

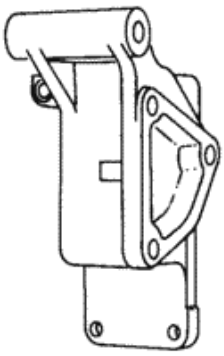
Dry with compressed air.

Check the threads for damage.

Check for cracks.

Check the bores for wear.

If the bracket has damaged or excessively worn it **must** be repaired or replaced.



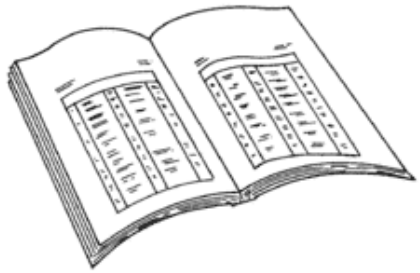
13400103

Last Modified: 29-Nov-2004

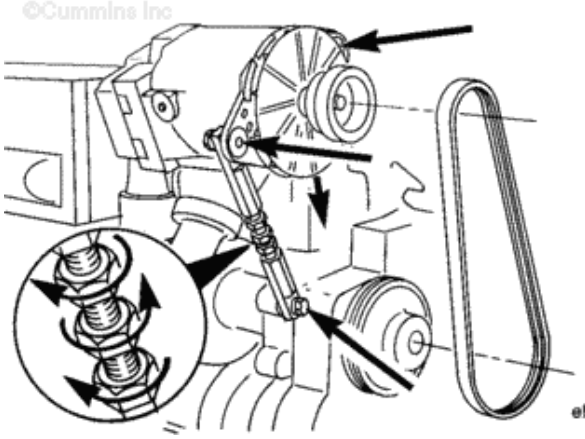
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013-005 Drive Belt, Alternator

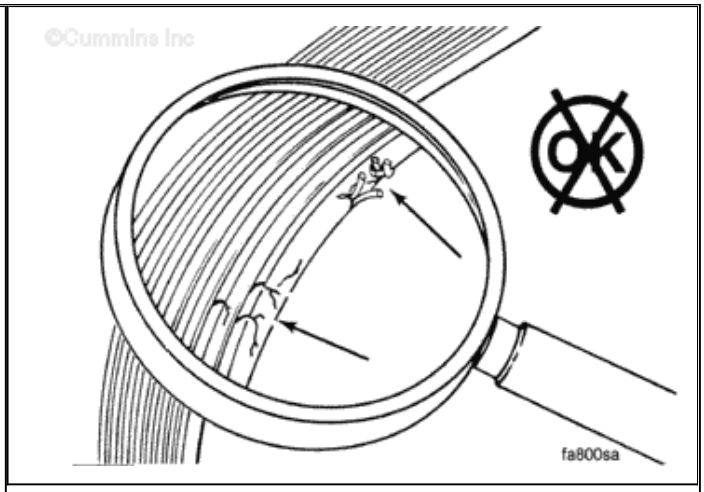
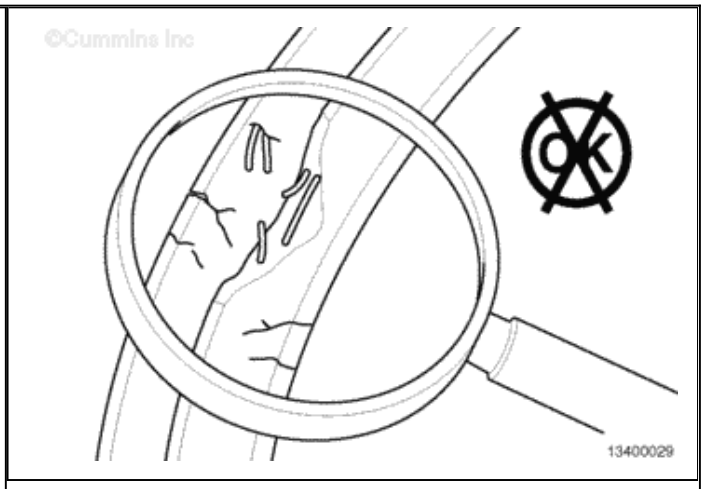
Preparatory Steps

• Disconnect the batteries. Refer to the OEM service manual. • Remove the alternator drive belt guard. Refer to Procedure 008-001 in Section 8.		

Remove

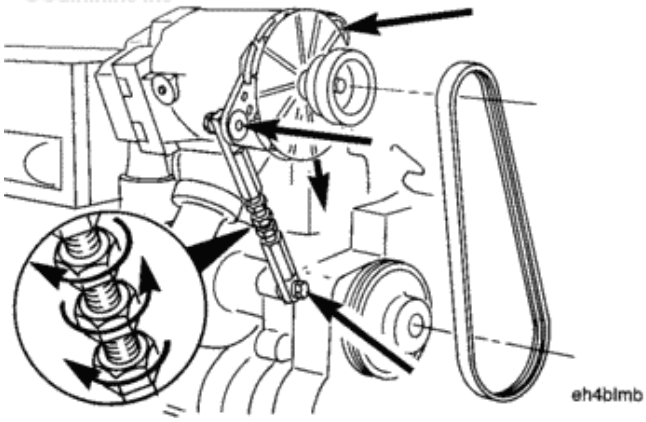
Loosen the adjusting link and the alternator mounting capscrews. **NOTE: The lower jam nut has left-hand threads.** Loosen both of the jam nuts. Turn the adjusting screw to relieve the belt tension. Remove the belt.		

Inspect for Reuse

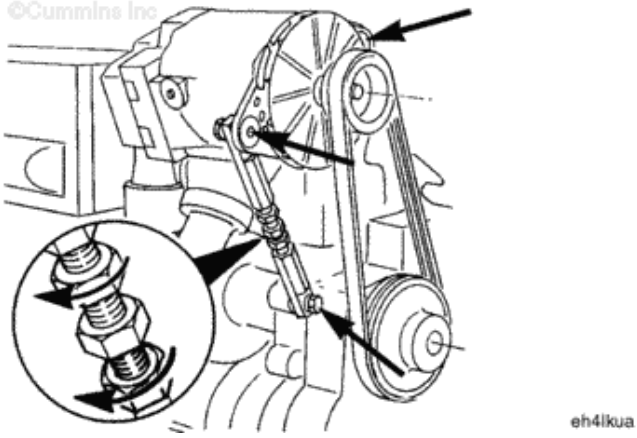
Check the belt for wear. If the belt indicates any wear, it **must** be replaced.		
Inspect the belt for cracks, glazing, tears, or cuts. The belt **must** be replaced if damaged.		

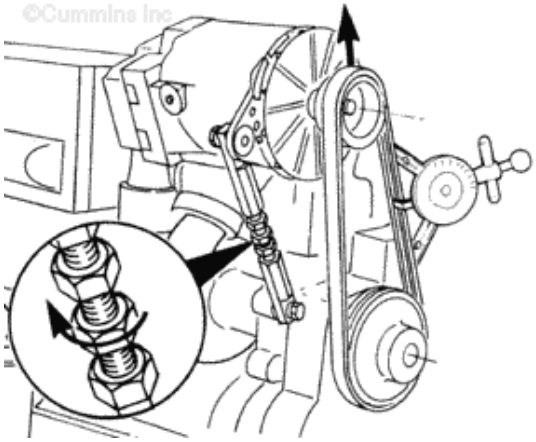
Install

Do **not** attempt to pry the belt on the pulley.		

Turn the adjusting screw **counterclockwise** to shorten the link if necessary. Install the alternator belt.		

Adjust

NOTE: The lower jam nut has left-hand threads. Loosen the alternator and adjusting link mounting capscrews. Loosen the jam nuts on the adjusting screw.		
Turn the adjusting screw **clockwise** to tighten the belt tension.		



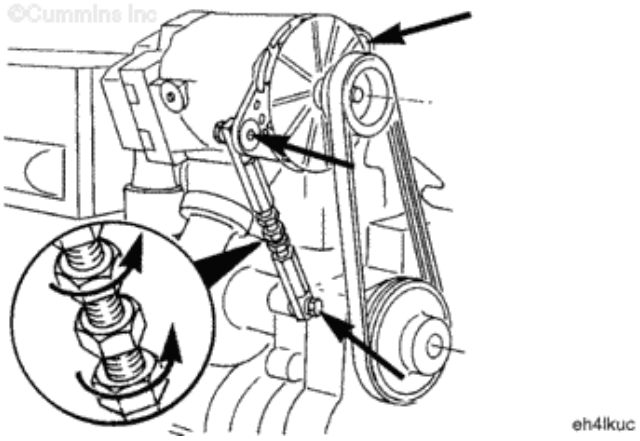
NOTE: The lower jam nut has left-hand threads.

Tighten the jam nuts on the adjusting screw.

Tighten the adjusting link and alternator mounting capscrews.

Torque Value:
Jam Nuts 55 n.m [41 ft-lb]

Torque Value:
Alternator Mounting Capscrews 55 n.m [41 ft-lb]

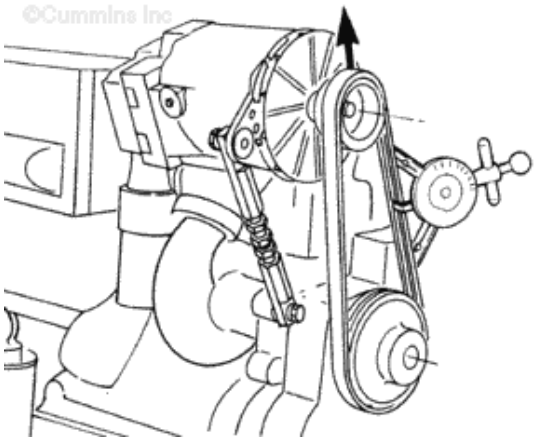


Check the belt tension again to be sure it is correct.

The belt tension **must** be:

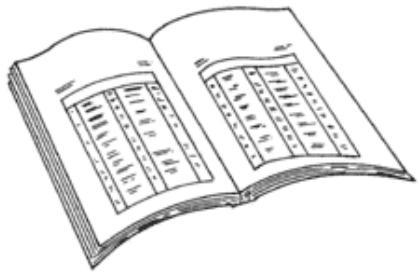
Measurements	n	lbf
Belt Tension:	670	150

If the belt tension is **not** within specification, repeat the Adjust section of this



procedure.		

Finishing Steps

• Install the alternator drive belt guard. Refer to Procedure 008-001 in Section 8. • Connect the batteries. Refer to the OEM service manual. • Start the engine and check for proper operation.		

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013-006 Alternator Pulley

Inspect for Reuse

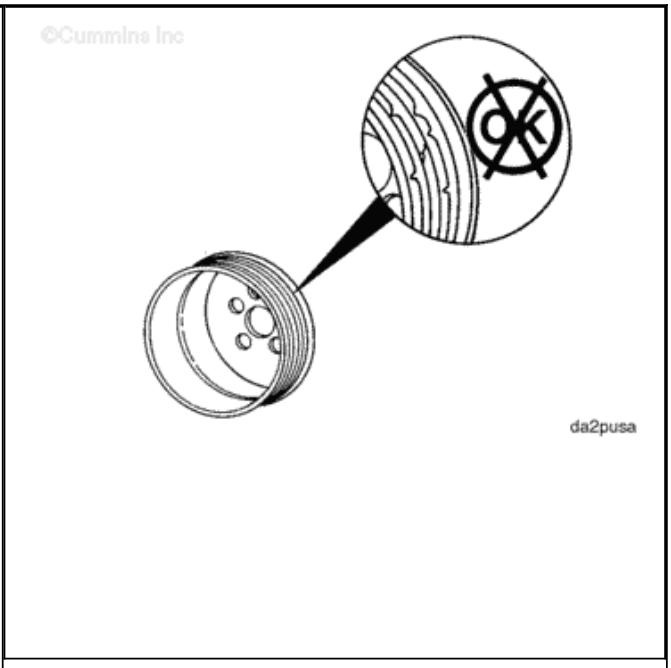
WARNING

When using sovents, 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 drive and accessory drive pulley with steam or solvent.

Check the grooves of the pulley for wear. Check the wear sleeve on the accessory drive pulley. If the part **must** be replaced, Refer to Procedure 009-004.





Last Modified: 22-Nov-2004

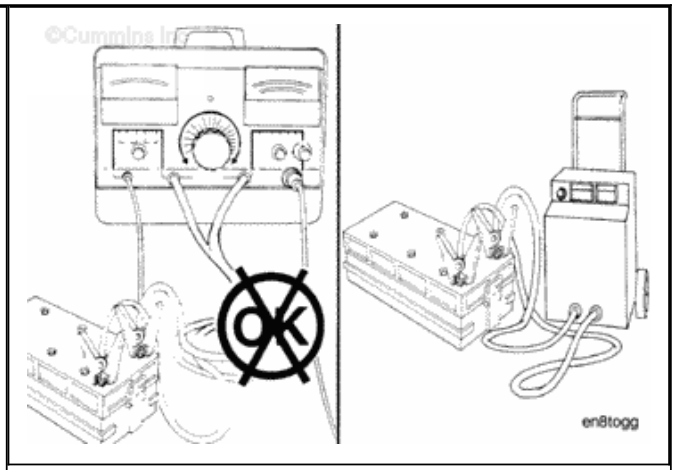
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013-007 Batteries

Inspect

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.

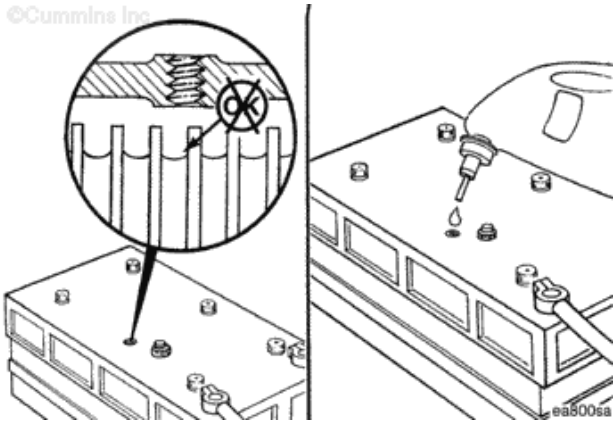


WARNING

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.

WARNING

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the



batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

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

If conventional batteries are used, remove the cell caps or covers and check the electrolyte (water and sulfuric acid solution) level.

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.

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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

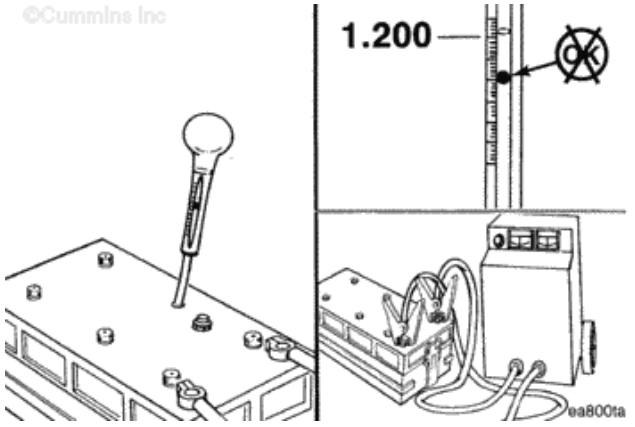
ea800ka

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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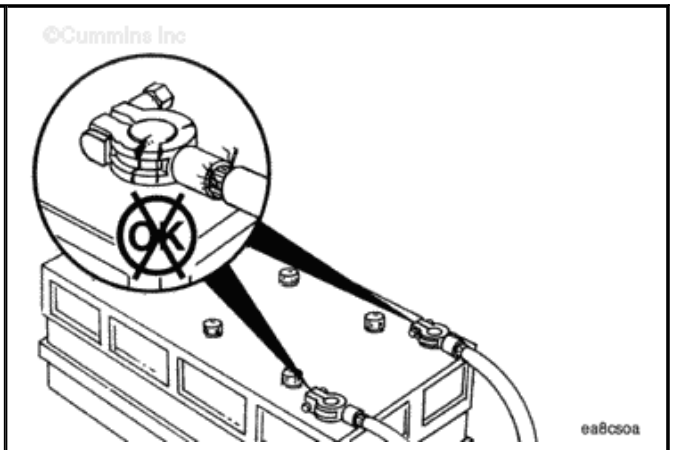
Last Modified: 22-Nov-2004

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013-009 Battery Cables and Connections

Inspect for Reuse

Inspect the battery terminals for loose, broken, or corroded connections.

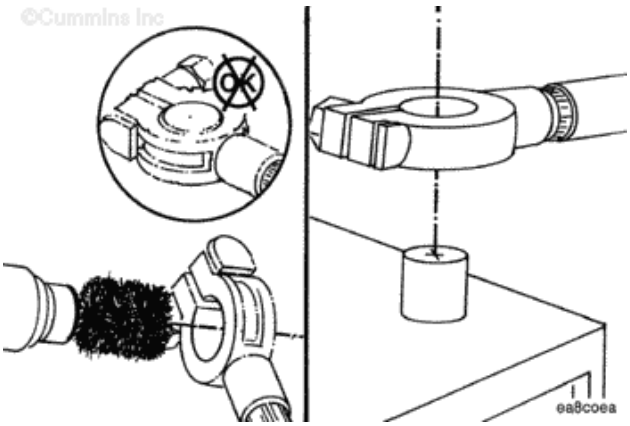


WARNING

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 the connections are corroded, remove the cables and use a battery brush to clean the cable and battery terminals.

Connect and tighten the battery cables. Use grease to coat the battery terminals to prevent corrosion.



Last Modified: 22-Nov-2004

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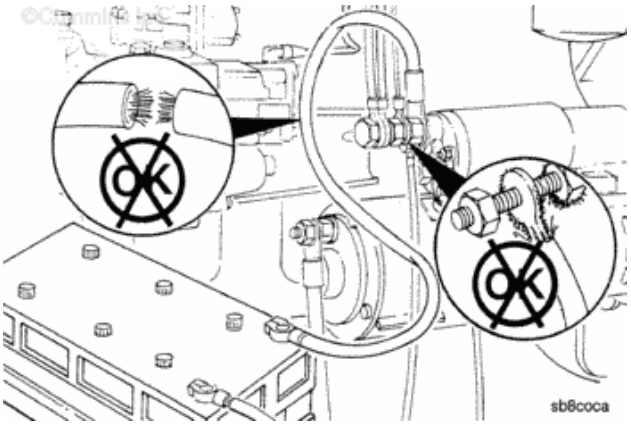
013-017 Starter Magnetic Switch

Inspect for Reuse

Before inspecting specific starting system components with the multimeter:

- Inspect terminals for loose, broken, or corroded connections.
- Replace or repair wiring and components as necessary.





WARNING

Be sure the starter switch is in the OFF position to reduce the possibility electrical shock and personal injury.

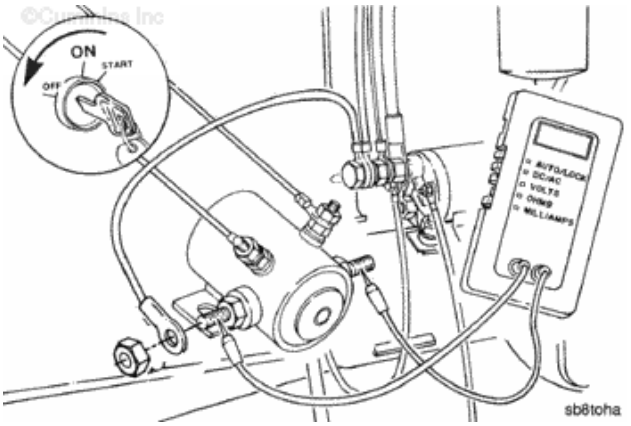


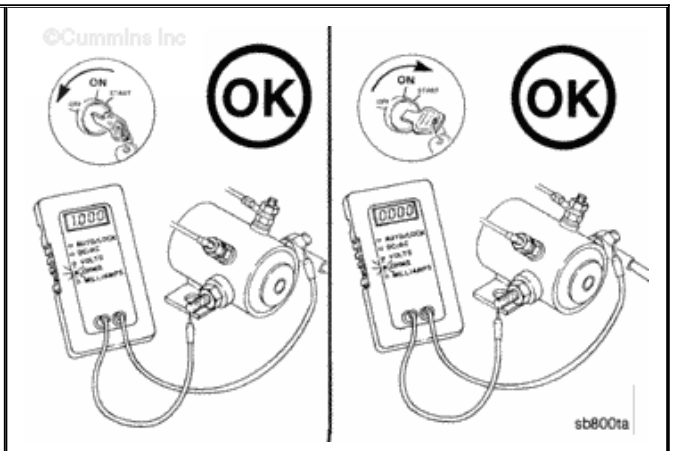
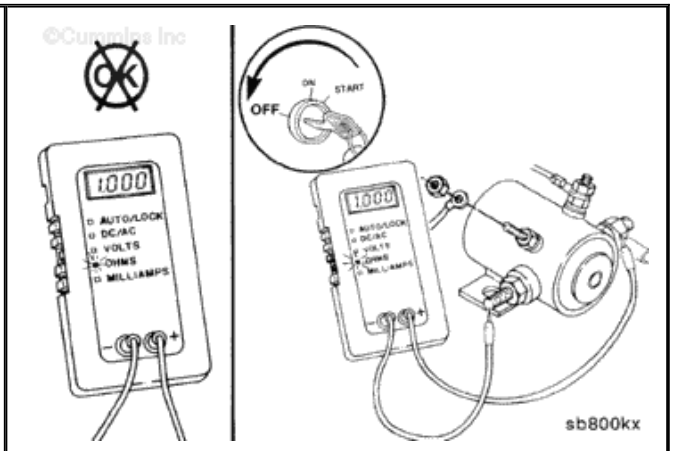
Remove the cable connecting the magnetic switch to the starter solenoid from the magnetic switch terminal.

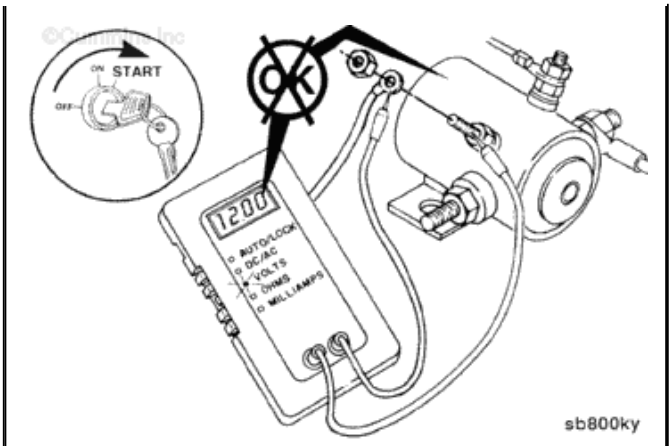
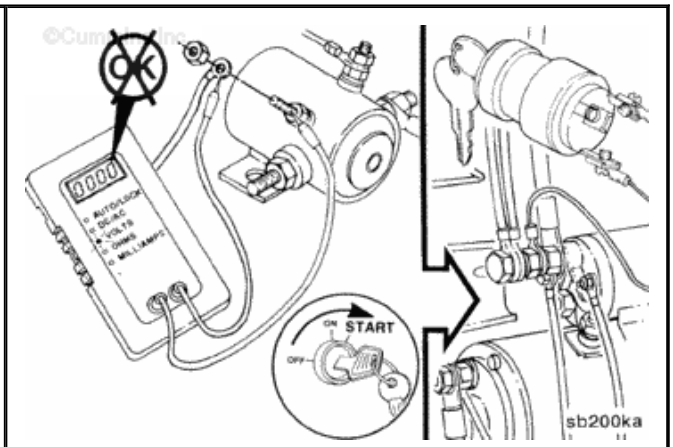
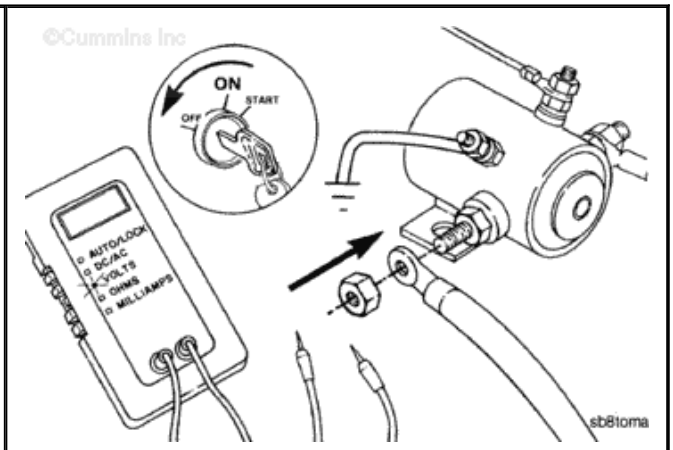
Connect the leads of the digital multimeter, Part Number 3377161, to the two, large switch terminals.

Set the multimeter to measure resistance (OHMS).

With the starter switch in the OFF position, the multimeter **must** indicate resistance at



infinity. • If the multimeter indicates ZERO ("0") or very little resistance, replace the magnetic switch. • If the multimeter indicates resistance at infinity, proceed with the following instructions.		
Turn the starter switch to the START position. The multimeter **must** indicate ZERO ("0") or very little resistance. An audible click will be heard when the starting switch is turned to the START position.		
If the multimeter indicates resistance at infinity with the starter switch in the START position and an audible click is **not** heard: • Turn the starter switch to the OFF position. • Set the multimeter scale to indicate DC voltage.		
Connect the positive lead of the one multimeter to the magnetic switch ground wire terminal and the other lead to the small magnetic switch terminal. Turn the starter switch to the START position.		

The multimeter will indicate some voltage across the magnetic switch terminals. If the multimeter indicates full system voltage, the magnetic switch is malfunctioning and **must** be replaced.		
If the multimeter indicates no voltage, the magnetic switch is **not** the cause of the complaint. Refer Procedure013-018.		
Turn the starter switch to the OFF position. Remove the multimeter leads and connect the magnetic switch to starter solenoid wire.		

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013-018 Starter Switch

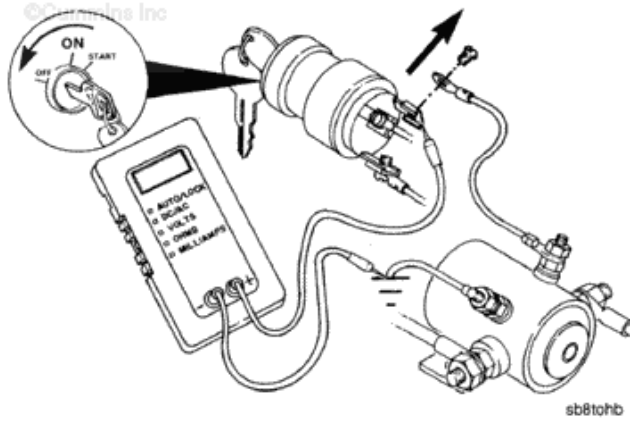
Inspect for Reuse

WARNING

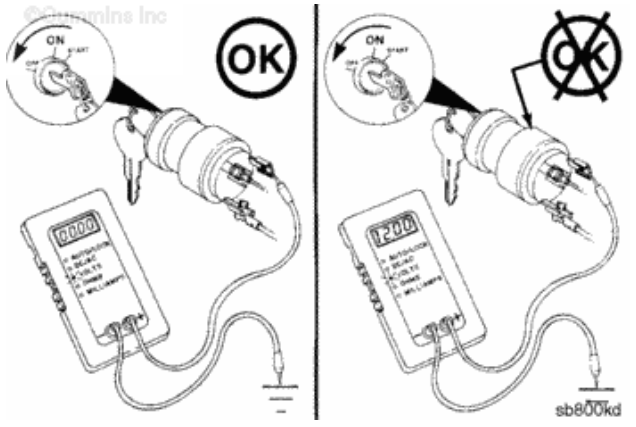
Be sure the starter switch is in the OFF position to prevent electrical shock and personal injury.

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, to the starter switch terminal and the negative lead to a chassis or engine ground location.



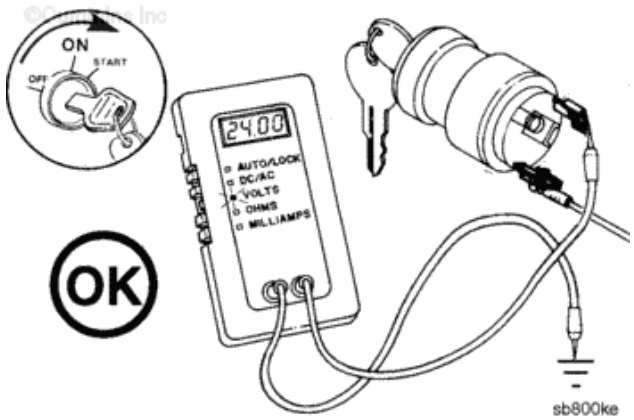
With the starter switch in the OFF position, there **must not** be voltage at the starter switch terminal. If the multimeter indicates voltage, the starter switch is malfunctioning and **must** be replaced.



Turn the starter switch to the START position.

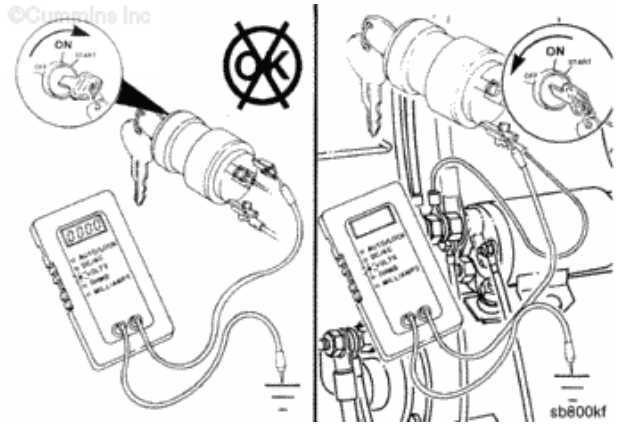
The multimeter **must**

indicate system voltage.

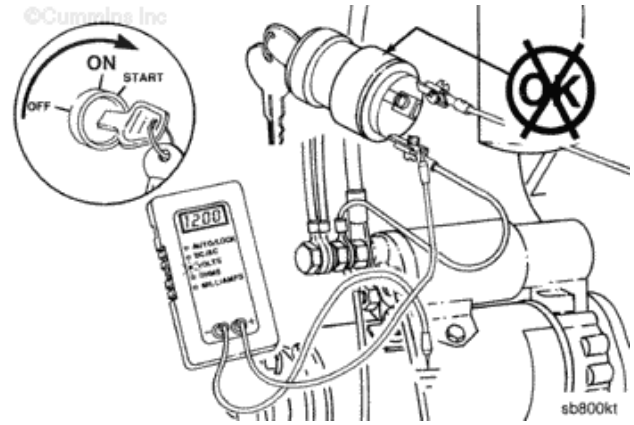


If there is **no** voltage:

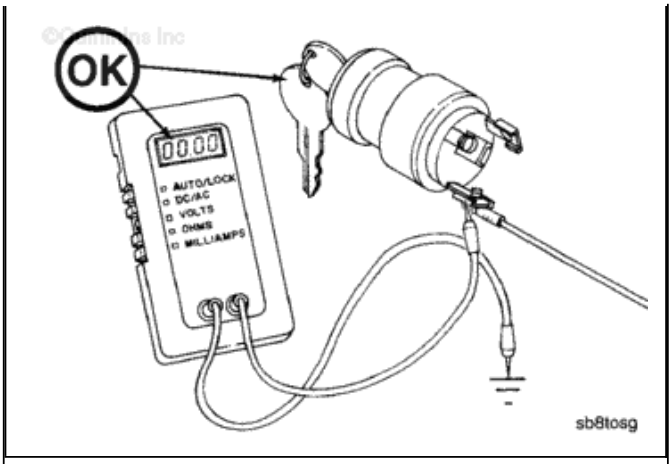
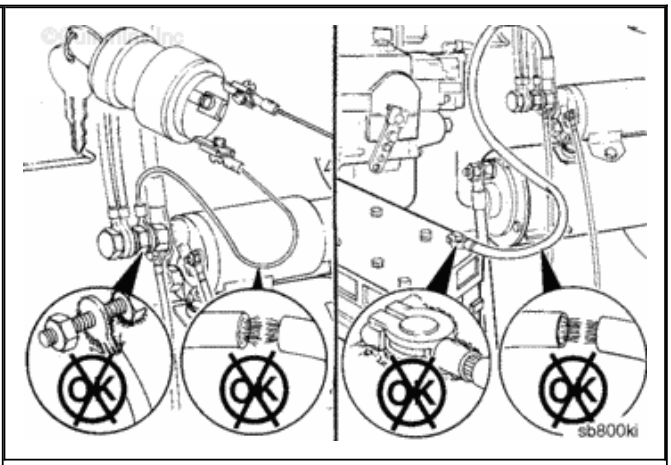
- Turn the starter switch to the OFF position.
- Connect the multimeter positive lead to the starter switch terminal having a wire connecting the starter switch to the starter solenoid.



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 complaint.

		
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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013-020 Starting Motor

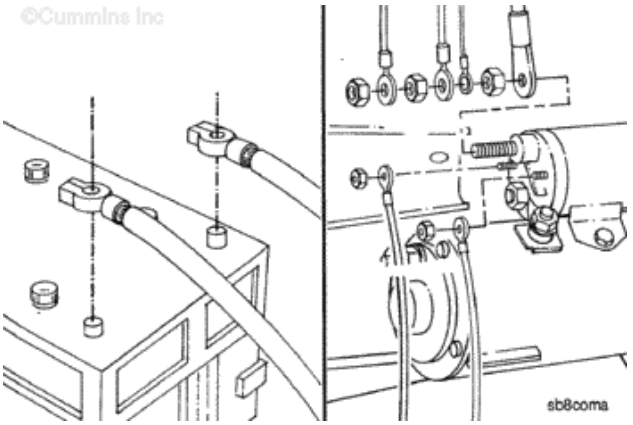
Remove

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing 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 electrical connections from the starting motor.



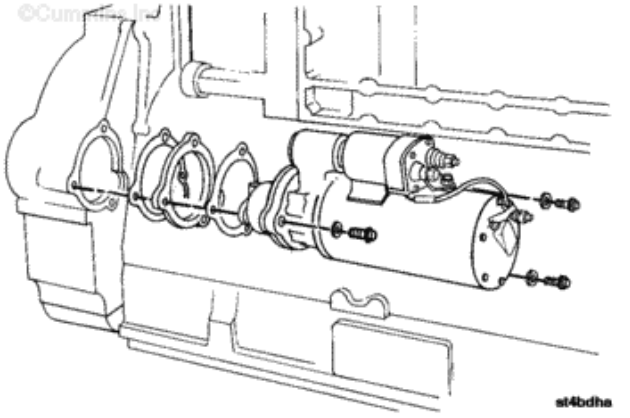
WARNING

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

NOTE: All engines do notcontain spacers and gaskets.

Remove the starting motor capscrews, the starter, spacers, and the gaskets.

Discard the gaskets.



Clean and Inspect for Reuse

WARNING

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

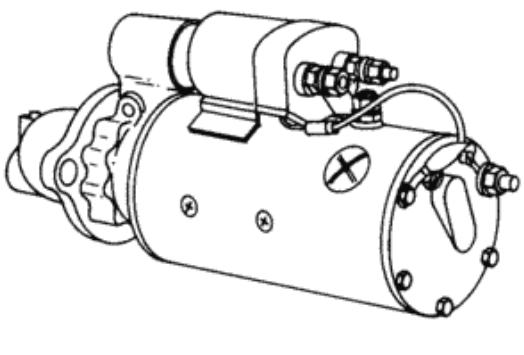
Clean the exterior of the motor with steam.

NOTE: A pipe plug must be removed to lubricate the bushing on some starter motors.

Inspect the gear, shaft, and the bushing for wear or damage.

Replace part if damaged or excessively worn.





Install

WARNING

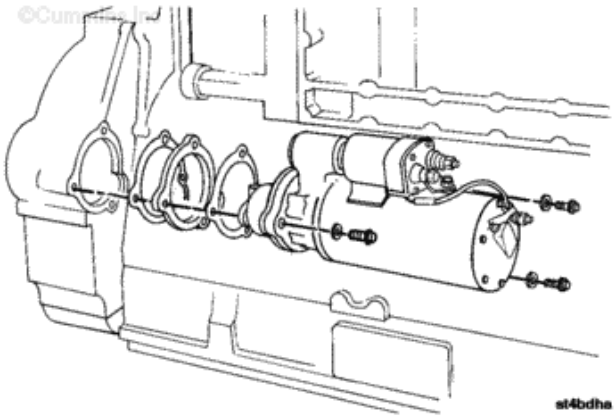
This component weighs more than 23 kg [50 lb]. To reduce the possibility of personal injury, use a hoist or get personal assistance to lift this component.

NOTE: Not all engines use spacers.

NOTE: The wet type flywheel







housing requires gaskets for the starting motor.

Lubricate the bushing with engine oil.

Install any spacer or gaskets.

Install the starting motor and capscrews.

Use the following to tighten the capscrews.

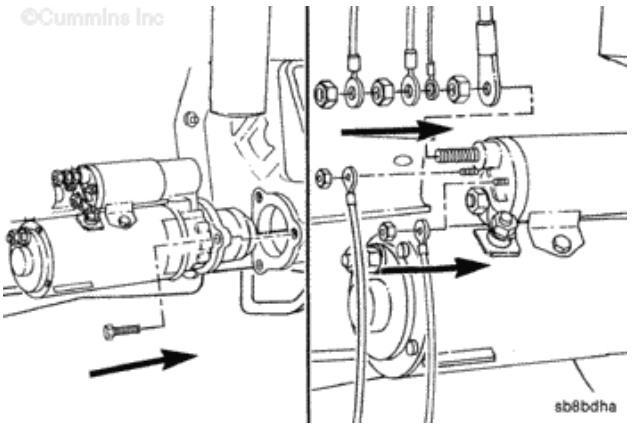
With Cast Iron Flywheel Housing	215 n.m	[160 ft-lb]
Without Aluminum Flywheel Housing	195 n.m	[145 ft-lb]

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing 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.



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013-022 Alternator Adjusting Link

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.

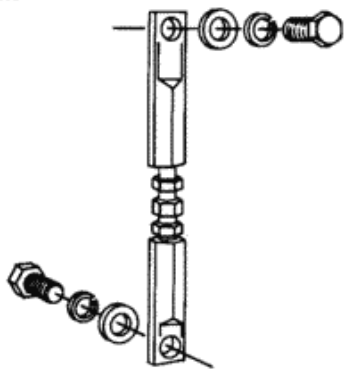
WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use solvents to clean the alternator adjusting link.

Dry with compressed air.

Check the threads for damage.



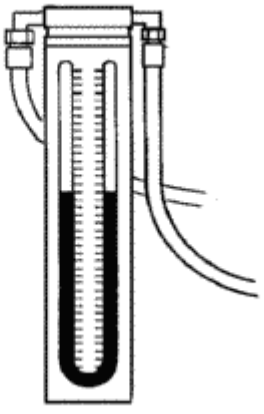
Last Modified: 29-Nov-2004

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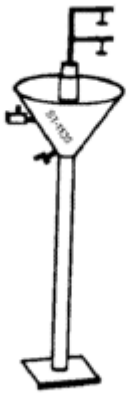
022-001 Service Tools

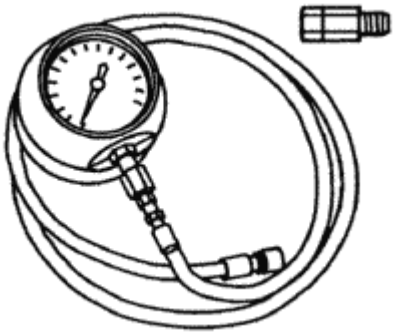
Engine Testing

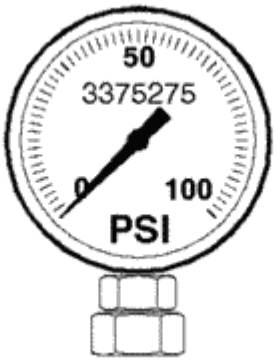
Tool Number ST-434	**Vacuum Gauge** Used to check fuel filter or intake air restriction.	©Cummins Inc  eg8togc

Tool Number ST-1111-3	**Manometer** Used with blowby checking tool.	©Cummins Inc  eg100ja

Tool Number	**Lubricating Oil**	

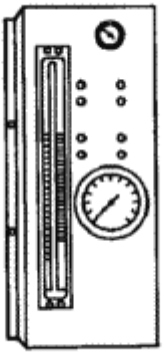
ST-1135	**Sampling Filter** Used to monitor oil contamination.	 st-1135

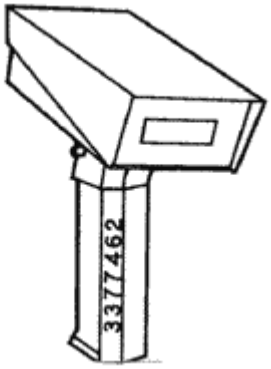
Tool Number ST-1273	**Pressure Gauge [0-75 In-Hg]** Used to measure intake manifold pressure and fuel drain line restriction.	 eg8togi

Tool Number 3375275	**Pressure Gauge [0-160 psi]** Used to measure lubricating oil pressure.	 3375275

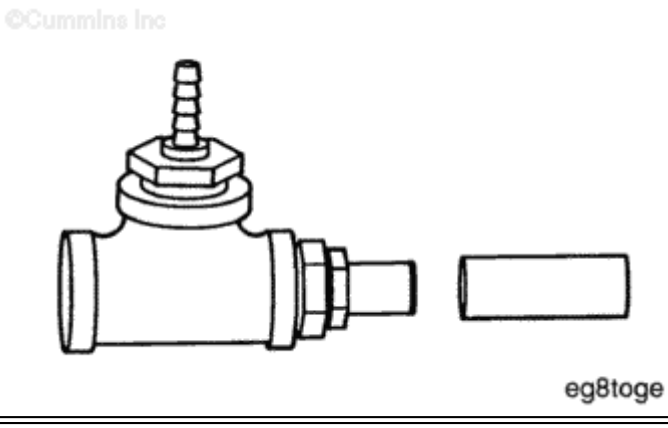
Tool Number	**Pressure Gauge [0-300 psi]** Used to measure fuel pressure. Includes necessary hoses and	

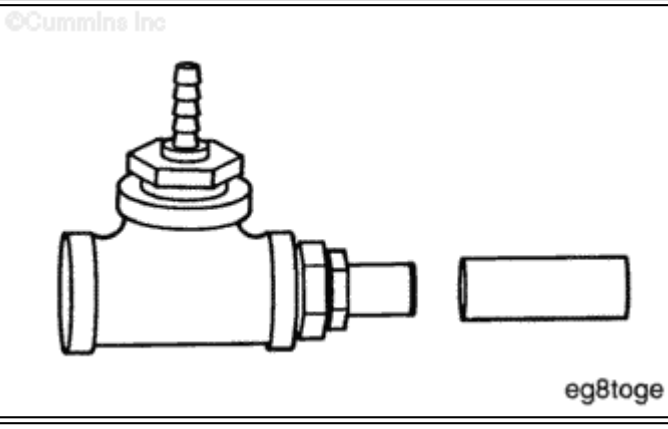
3375932	hardware to attach to a fuel pump. Part Number ST-435-6 is the pressure gauge.	 eg8togh

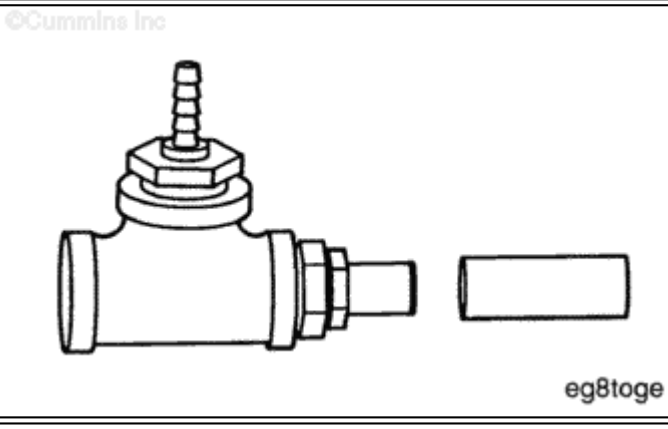
Tool Number 3376375	**Fuel Measuring Device** Measure the rate of fuel consumption of a Cummins diesel engine.	 eg8togf

Tool Number 3377462	**Digital Optical Tachometer** Used to measure engine speed (RPM). Use with reflective tape, Part Number 3377464.	 3377462

Tool Number	**Blowby Check Tool (0.302 inch orifice)** Used with manometer, Part Number ST-1111-	

3822566	3, to measure the engine crankcase pressure.	

Tool Number 3823567	**Blowby Check Tool (0.354 inch orifice)** Used with manometer, Part Number ST-1111-3, to measure the engine crankcase pressure.	

Tool Number 3822568	**Blowby Check Tool (0.406 inch orifice)** Used with manometer, Part Number ST-1111-3, to measure the engine crankcase pressure.	

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014-001 Dynamometer Worksheet

Worksheet

Date:	Repair Order Number	Operator:
ESN:	CPL:	Fuel Pump Code:
Complaint:		SC Code:

Parameter	Code Specifications	Actual Reading
Fuel Pressure (psi @ rpm)	150 to 180 psi at Idle	
Fuel Pressure (psi @ rpm)	225 to 250 psi at 1800 rpm	
Fuel Pressure (psi @ rpm)	250 to 300 psi at 2100 rpm	
Fuel Rate (lb/hr)		
Intake Manifold. Pressure (in.Hg)	See Fuel Pump Code	
Intake Manifold. Temperature		
*Intake Air Restriction	25 in. H_2O, Maximum	
*Exhaust Air Restriction	3 in. Hg, Maximum	
*Fuel Inlet Restriction	8 in. Hg (Dirty Filter), Maximum	
*Fuel Drain Line Restriction	3 psi, Maximum	
Engine Blowby	See Tables	
* Recorded at maximum horsepower speed and full load		

Road Speed Limit	Engine High Speed Limit					
Check Oil Level	Low	High	OK	Fuel Quality	OK	**Not** OK

Engine Speed	Fuel *Rate/Pressure		Fuel Temperate	Turbocharger Inlet Air Temperature	Intake Manifold Temperature/Pressure	Coolant Temperature/Pressure	Engine Blowby	Lubricating Oil Press	HP or Torque	
* Be sure that the fuel rate is corrected for temperature.										

Fuel Temperature	Correction for Flow Rate
Less than 7°C [45°F]	Flow meter **not** accurate
7 to 13°C [45 to 55°F]	Subtract 2% from flow rate reading
13.0 to 20.0°C [55 to 68°F]	Subtract 1% from flow rate reading
20.0 to 29°C [68 to 85°F]	No Correction
29 to 42°C [85 to 108°F]	Add 1% to flow rate reading
42 to 56°C [108 to 132°F]	Add 2% to flow rate reading
56°C above [132°F]	Flow meter **not** accurate

Pressure Conversions
1 in. H_2 0 = 0.074 in. Hg = 0.036 psi
1 in. Hg = 13.514 in. H_2 0 = 0.491 psi

1 psi = 2.036 in. Hg = 27.7 in. $H_2 0$

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014-002 Engine Testing (Chassis Dynamometer)

Setup

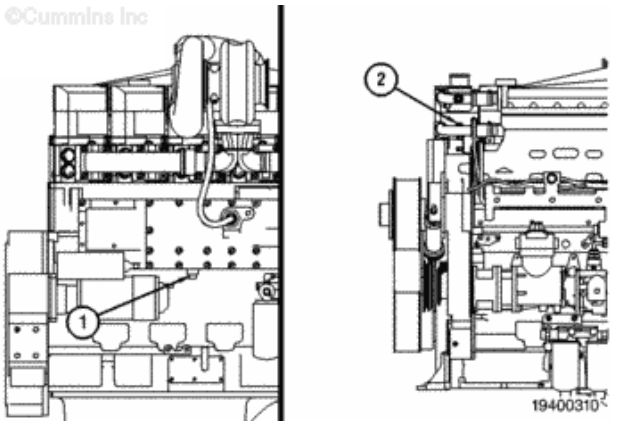
The performance of an engine installed in on-highway vehicles can be tested on a chassis dynamometer.

Because of driveline inefficiencies and engine-driven accessories, the rated horsepower will be reduced by approximately:

- 20 percent for single axle vehicles
- 25 percent for tandem axle vehicles.

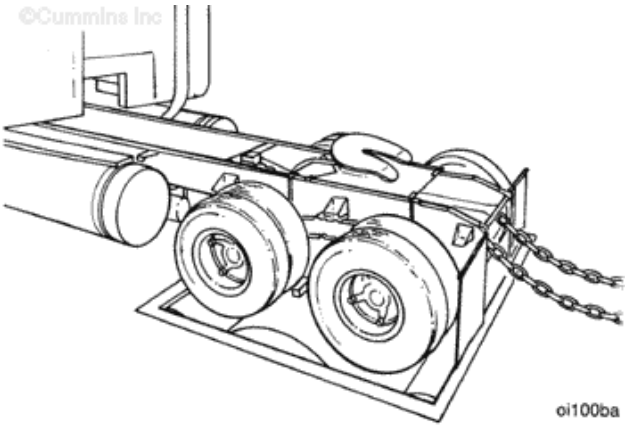
The net horsepower available is called wheel horsepower.

Operate the vehicle in a gear that produces a road speed of 90 to 95 Km/H [55 to 60 MPH].



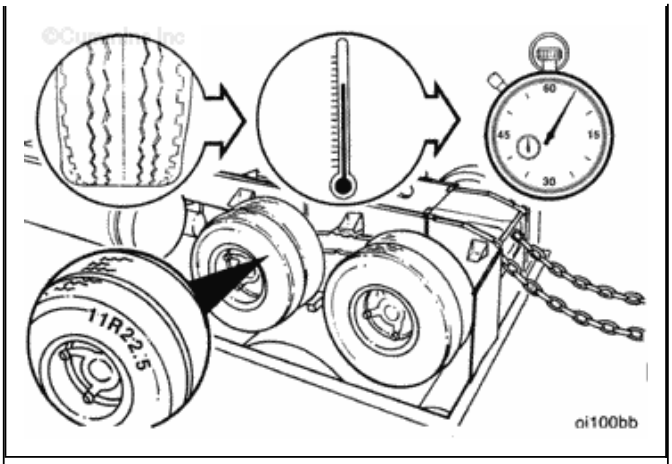
WARNING

Before installing or operating a vehicle on a chassis dynamometer, follow all the vehicle manufacturer's safety precautions.



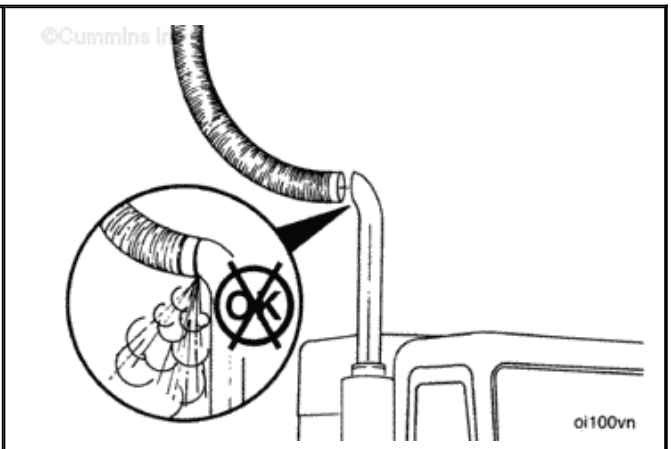
CAUTION

Low profile radial tires are more sensitive to heat than bias ply tires. Excessive operating time at full load can damage tires due to overheating. Check the tire manufacturer's recommendations for the maximum allowable chassis dynamometer operating time.

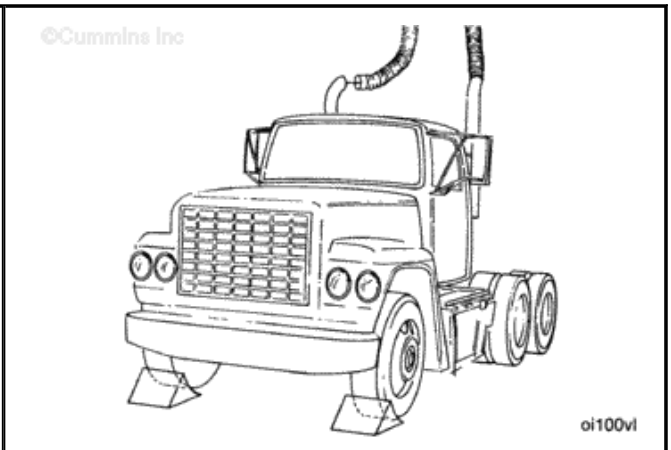


Adjust the vehicle and dynamometer room exhaust system to be sure that all exhaust gases are removed from the room.

Refer to the chassis dynamometer and vehicle manufacturer's recommendations and specifications for testing procedures.



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

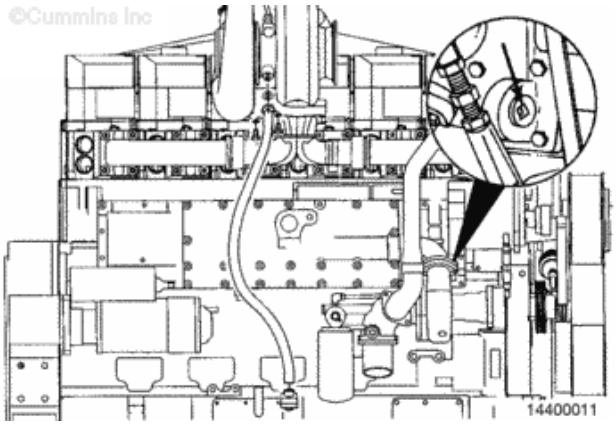


Engine Testing

CAUTION

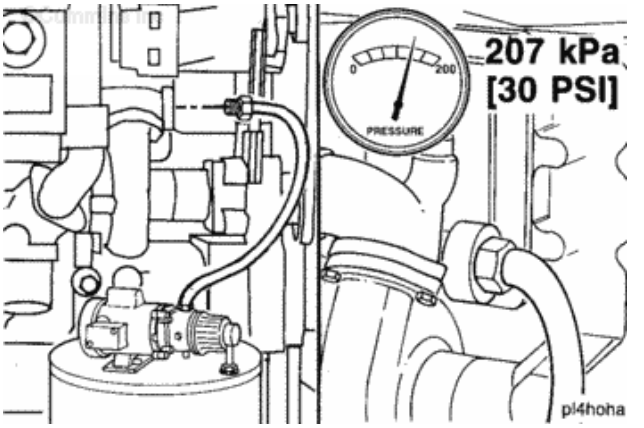
The lubricating oil system must be primed before operating the engine after rebuild, bearing replacement, or power cylinder replacement to avoid internal component damage. Do not prime the system from the bypass filter as the filter will be damaged.

Remove the large plug from the oil cooler housing.

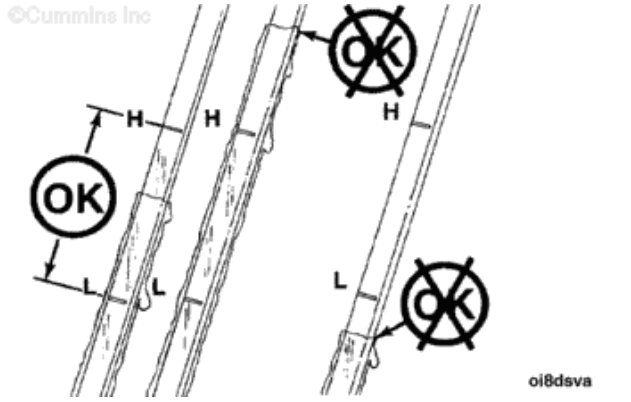


Use a pump capable of supplying 205 kPa [30 psi] continuous pressure. Connect the pump to the front of the engine oil cooler as shown.

Use a supply of clean 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.

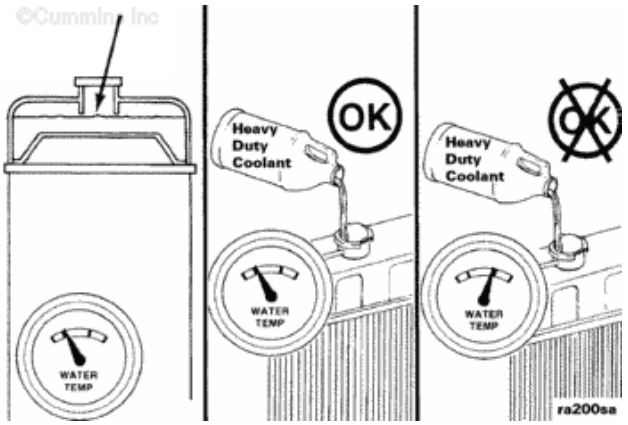
CAUTION

Do not add cold coolant to a hot engine. This can cause engine casting damage. Allow the engine to cool to below 50°C [120°F] before adding coolant.

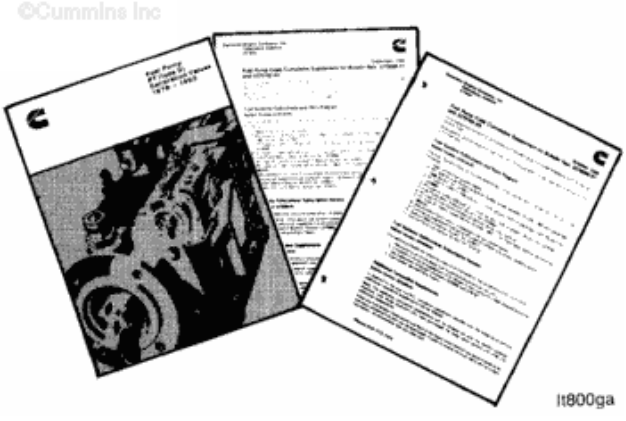
Check the engine coolant level to be sure it is filled to the proper level. Refer to Procedure 008-018.

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 fuel. The lighter the fuel, the lower the energy content (BTU) per gallon (liter, etc.).



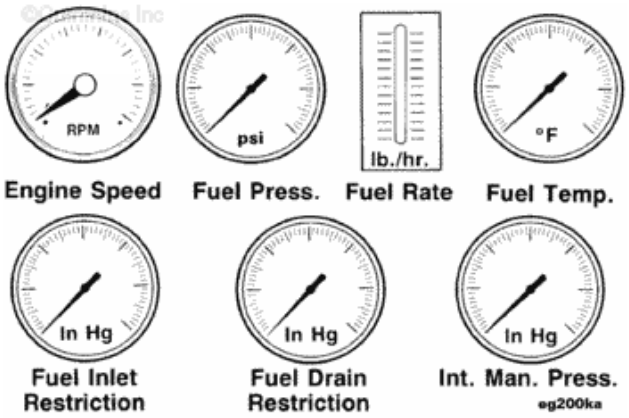
Engine operating specifications can be found in publications available from the local Cummins Authorized Repair location.



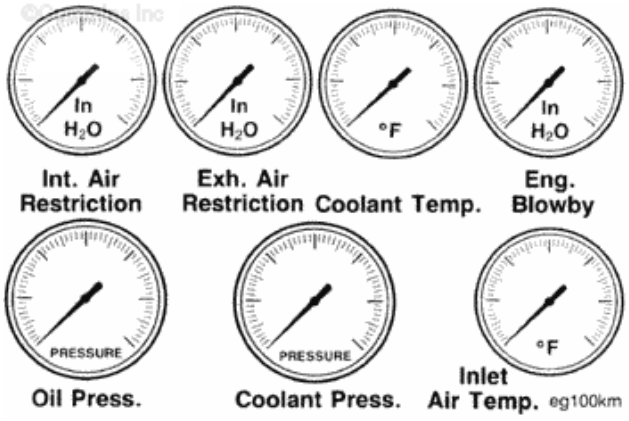
Test

To properly monitor engine performance, record the following parameters. To limit dynamometer operating time, instrument the engine to perform as many checks as possible.

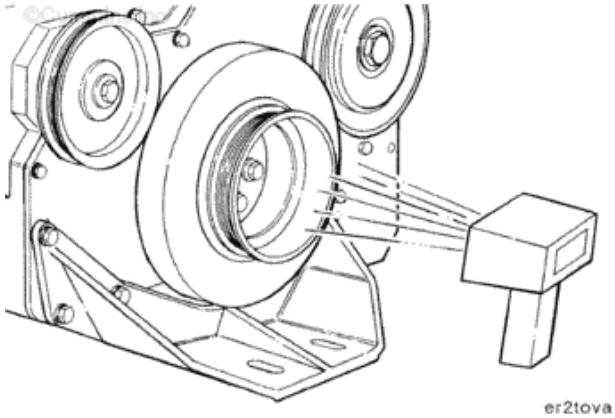
- Engine speed rpm with a verified tachometer
- Fuel pressure
- Fuel rate (Use Service Tool, Part Number 3376375)
- Fuel inlet restriction
- Fuel drain line restriction
- Intake manifold pressure



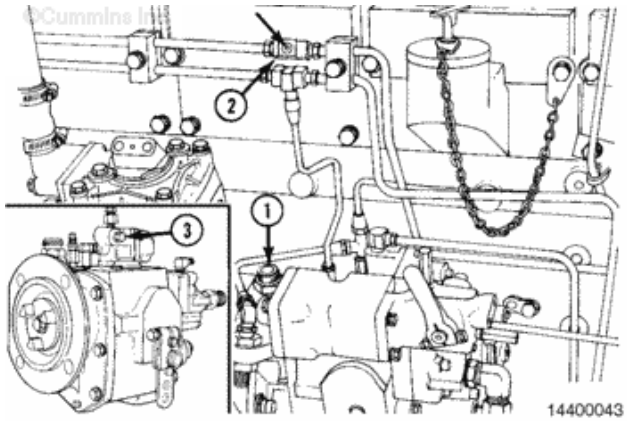
- Intake air restriction
- Exhaust air restriction
- Coolant temperature
- Engine blowby
- Lubricating oil pressure
- Coolant pressure.

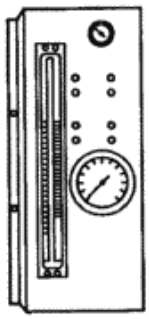


Verify the engine speed with a digital optical tachometer, Part Number 3377462, or equivalent, in conjunction with reflective tape, Part Number 3377464, or equivalent.

Fuel Rate

Measure the fuel supply pressure at the junction block on the fuel tube (2). If the engine does **not** have a fuel junction block, measure the fuel pressure at the fuel pump shutoff valve (3). The minimum gauge capacity is 2070 kPa [300 psi]. Refer to Procedure 005-016.		

Measure the rate of fuel consumption with fuel measuring device, Part Number 3376375.		

Fuel Inlet Restriction

NOTE: Do not measure		

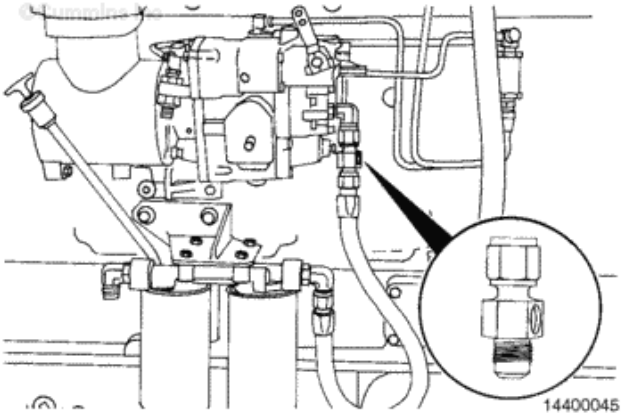
fuel inlet restriction with the fuel rate measuring device installed. This will not measure the inlet restriction of the vehicle's supply plumbing.

Install the Number 10 hose adapter, Part Number ST-434-2, as close to the fuel pump inlet as possible.

Minimum gauge capacity is 760 mm-Hg [30 in-Hg].

Install a vacuum gauge, Part Number ST-434, between the fuel filter and the gear pump inlet.

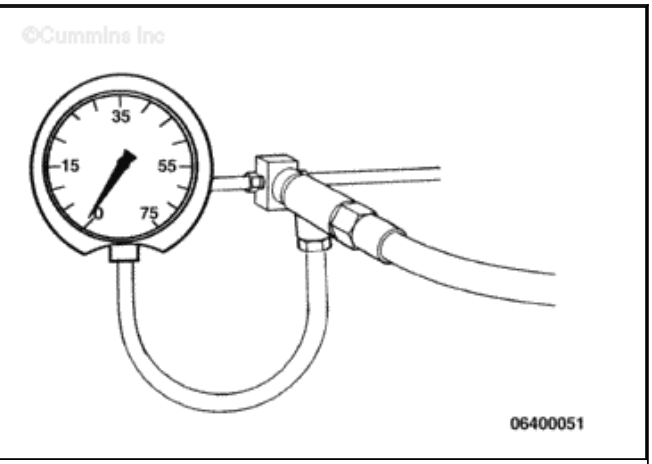
Refer to Procedure 006-020.



Fuel Drain Line Restriction

NOTE: Do not measure fuel drain line restriction with the fuel rate measuring device installed. This will not measure the drain line restriction of the vehicle's return plumbing.

Measure the fuel drain line restriction with pressure gauge, Part Number ST-1273. Refer to Procedure 006-015

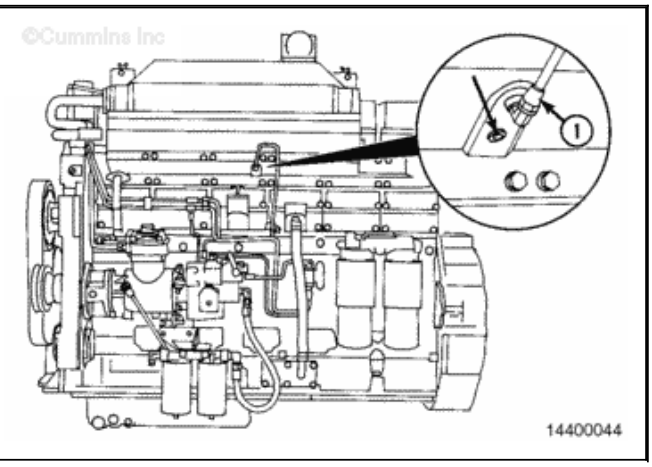


Intake Manifold Pressure

Minimum gauge capacity is 1525 mm-Hg [60 in-Hg].

Install pressure gauge, Part Number ST-1273, in the intake manifold as shown.

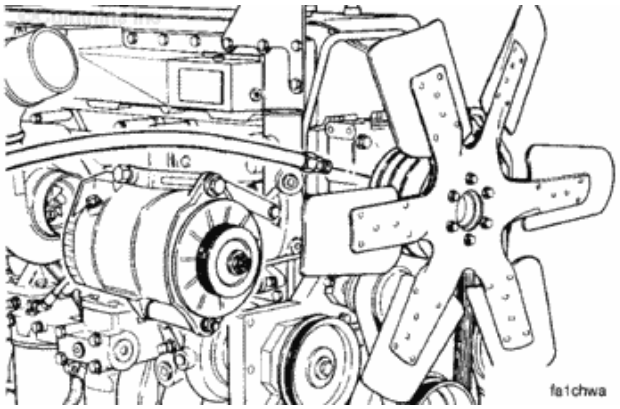
Observe the reading on the pressure gauge.



Intake Manifold Air Temperature Control - Chassis Dynamometer test

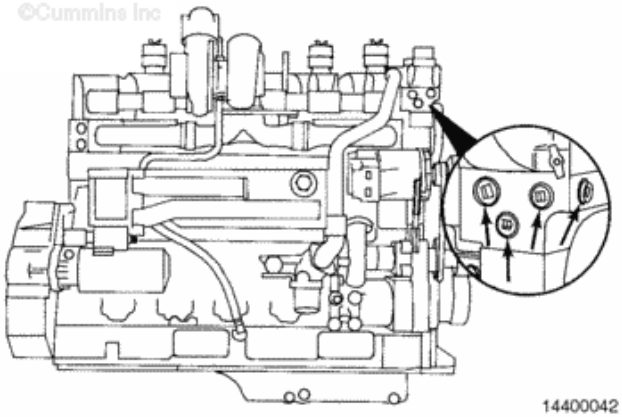
When operating an engine on a chassis dynamometer, follow these steps for best results and safe operation.

If the engine is equipped with automatic fan, lock the cooling fan in the ON mode. This can be done by installing a jumper across the temperature switch, or by supplying shop air to the control valve. Refer to the fan drive manufacturer for the recommended procedure.



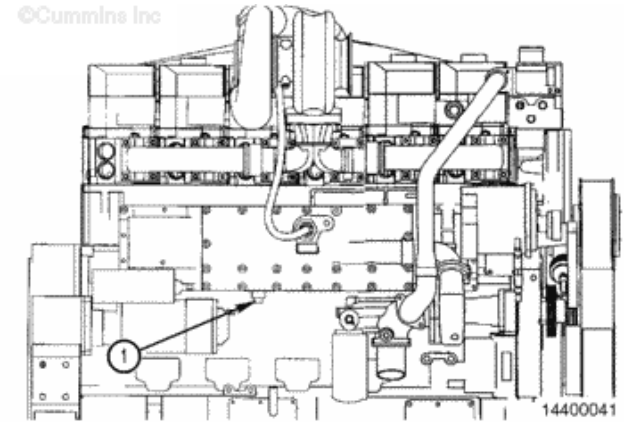
Measure the coolant temperature at the thermostat housing support.

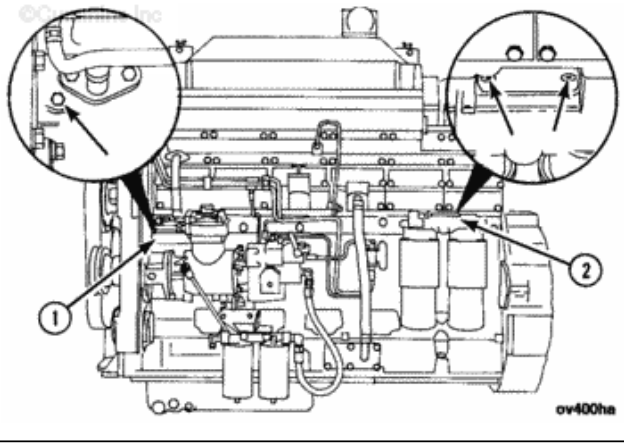
Minimum gauge capacity 107°C [225°F].



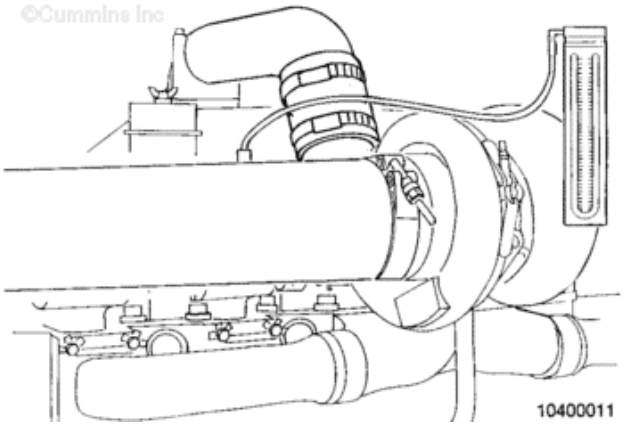
Measure the coolant pressure at one of the drain ports on the bottom of the oil cooler housing.

Minimum gauge capacity 345 kPa [50 psi].

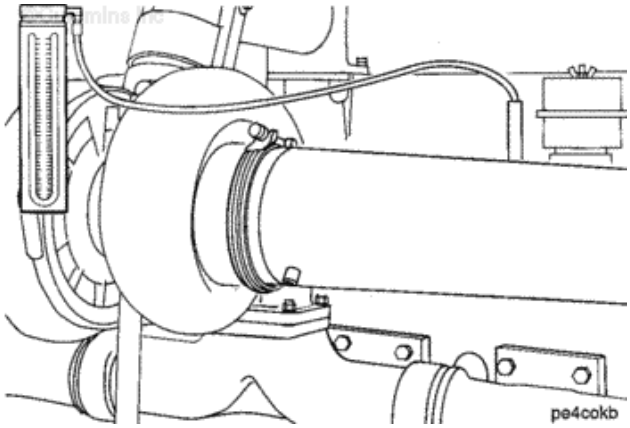


Measure the oil pressure at location (1) which is the front of the main oil rifle. If location (1) is **not** accessible, remove one of the pipe plugs from the oil filter head (2) and measure the oil pressure. Minimum gauge capacity 830 kPa [120 psi].		

Intake Air Restriction

The gauge adapter **must** be installed at a 90 degree angle to the air flow in a straight section of pipe at a minimum of one pipe diameter before the turbocharger. Install the vacuum gauge, Part Number ST-434, manometer, Part Number ST-1111-3, or digital manometer, Part Number 3164875, in the intake air piping. Measure the inlet air restriction. Refer to Procedure 010-031.		

Exhaust Air Restriction

The gauge adapter **must** be installed near the turbocharger in a straight section of pipe at the turbine outlet. Install the pressure gauge, Part Number ST-1273, manometer, Part Number ST-111-3 or equivalent, or digital manometer, Part Number 3164875, or equivalent in the exhaust air		

piping.

Measure the exhaust air restriction. Refer to Procedure 011-009.

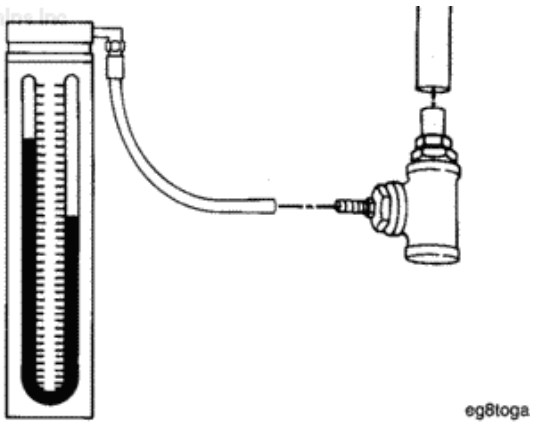
Engine Blowby

Excessive blowby indicates an air compressor, a turbocharger, or an engine malfunction, allowing combustion gases or air to enter the crankcase and build a pressure higher than normal.

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, or equivalent, or digital manometer, Part Number 3164875, or equivalent.

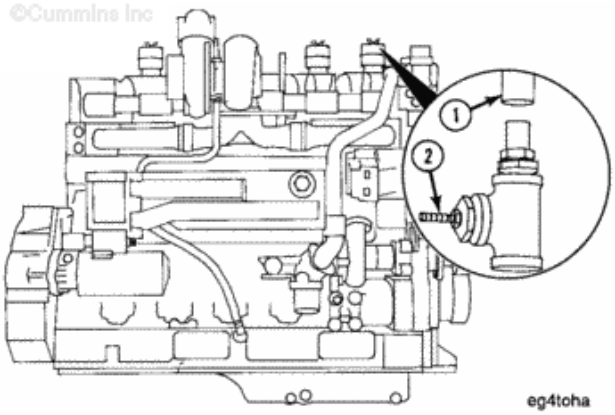
Blowby Tool Sizes	
Blowby Tool Part Number	**Orifice Size**
3822566	7.67 mm [0.302 in]
3822567	9.00 mm [0.354 in]
3822568	10.30 mm [0.406 in]



Use a length of hose (1) to attach the blowby tool to one of the crankcase breathers.

Plug all of the other breathers.

Attach a manometer to the location shown (2).

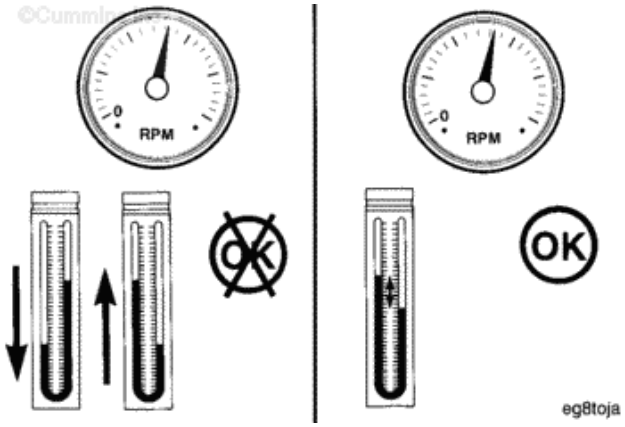


Operate the engine at rated rpm and full load (wide open throttle) until a steady reading is obtained.

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 (because of wear of internal engine components).

Engine Blowby 7.67 mm [0.302 in]		
RPM	**New/Rebuilt**	**Used**
KTTA All Ratings	508 mm $H_2 0$ [20 in $H_2 0$]	1270 mm $H_2 0$ [50 in $H_2 0$]
KTA 2000 and above	355 mm $H_2 0$ [14 in $H_2 0$]	889 mm $H_2 0$ [35 in $H_2 0$]
KTA 1500 to 1900	305 mm $H_2 0$ [12 in $H_2 0$]	762 mm $H_2 0$ [30 in $H_2 0$]
KT 2000 and above	254 mm $H_2 0$ [10 in $H_2 0$]	635 mm $H_2 0$ [25 in $H_2 0$]
KT		508 mm



1500 to 1900	203 mm $H_2 0$ [8 in $H_2 0$]	$H_2 0$ [20 in $H_2 0$]

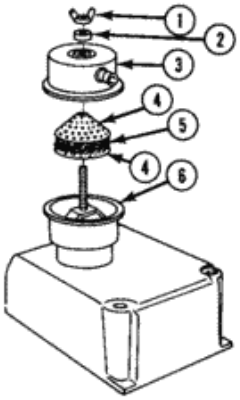
Engine Blowby 9.0 mm [0.354 in]		
RPM	**New/Rebuilt**	**Used**
KTTA All Ratings	229 mm $H_2 0$ [9 in $H_2 0$]	584 mm $H_2 0$ [23 in $H_2 0$]
KTA 2000 and above	203 mm $H_2 0$ [8 in $H_2 0$]	508 mm $H_2 0$ [20 in $H_2 0$]
KTA 1500 to 1900	178 mm $H_2 0$ [7 in $H_2 0$]	457 mm $H_2 0$ [18 in $H_2 0$]
KT 2000 and above	152 $H_2 0$ [6 in $H_2 0$]	380 mm $H_2 0$ [15 in $H_2 0$]
KT 1500 to 1900	127 mm $H_2 0$ [5 in $H_2 0$]	318 mm $H_2 0$ [13 in $H_2 0$]

Engine Blowby 10.3 mm [0.406 in]		
RPM	**New/Rebuilt**	**Used**
KTTA All Ratings	127 mm $H_2 0$ [5 in $H_2 0$]	330 mm $H_2 0$ [13 in H_2

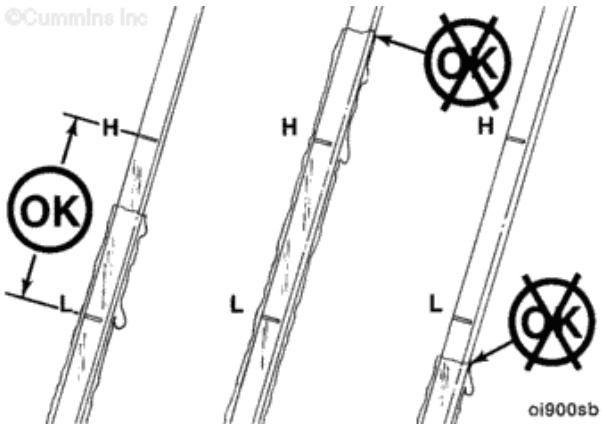
0]

If the blowby is higher than normal, check the crankcase breathers and breather tubes to see if they are plugged.

(1) Wing nut
(2) Washer
(3) Breather cap
(4) Screen mesh
(5) Breather element
(6) Breather base.



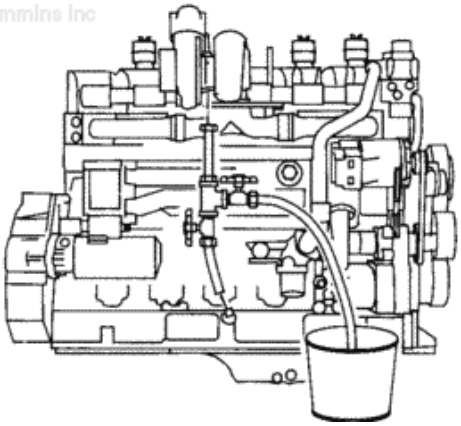
Check the engine oil level. If the level is too high, it can cause a higher than normal crankcase pressure.



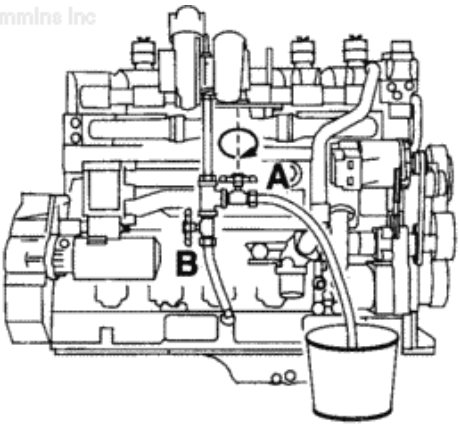
WARNING

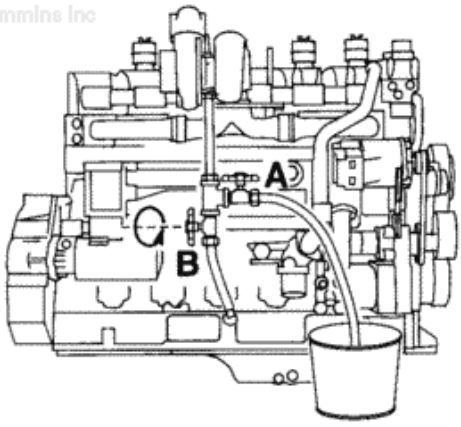
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Isolate the turbocharger to



determine if the high crankcase pressure is because of seal leakage in the turbocharger. Disconnect the turbocharger drain line from the oil pan adaptor. 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 to the bucket.		

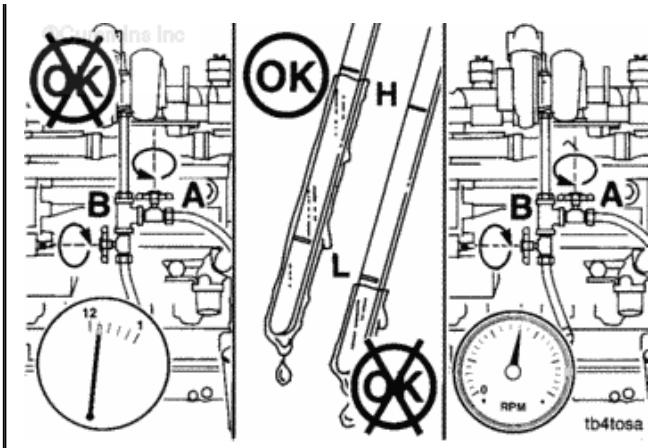
Open the valve (B) that allows the oil to drain into the engine.		

CAUTION

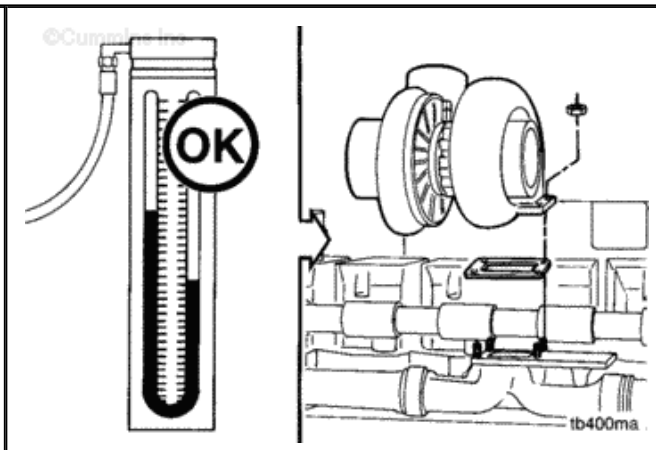
Do not operate the engine with valve (A) open and valve (B) closed for more than 1 minute. Operation for more than 1 minute can result in severe engine damage.

Operate the engine at rated speed. Record the blowby value.

Continue operating at rated speed and load. Open valve (A) and close valve (B). Record the blowby reading.



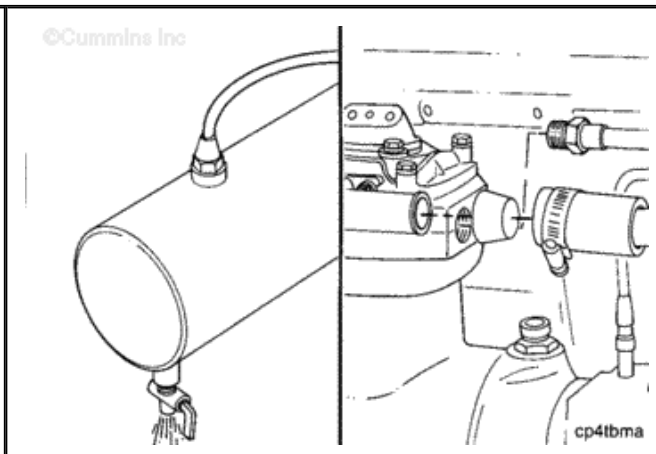
Compare the value to the original reading. If the blowby is now acceptable, replace the turbocharger.

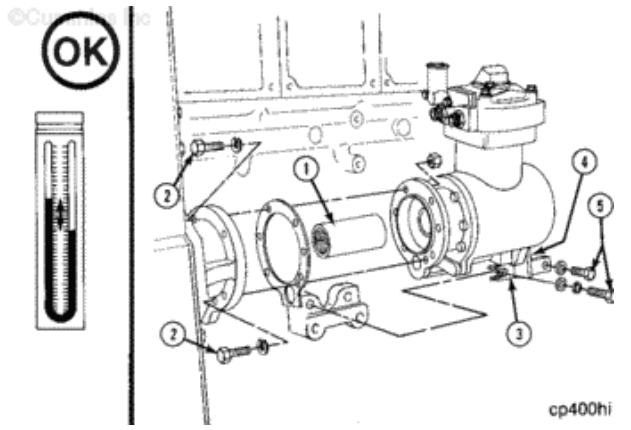
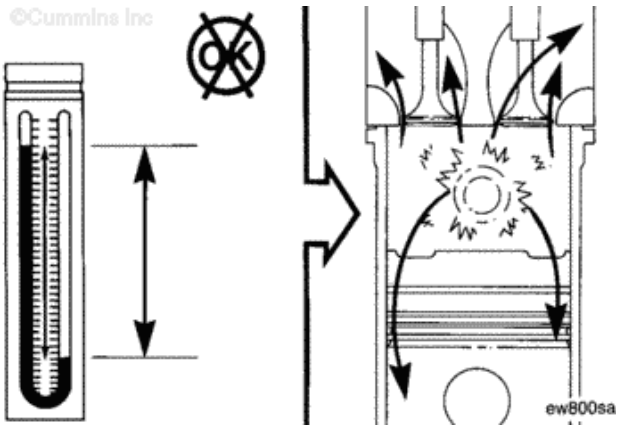


Isolate the air compressor to determine if it is malfunctioning and causing the high blowby pressure.

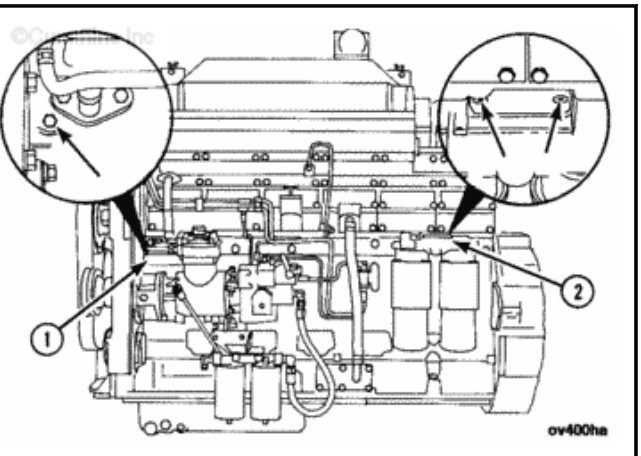
Relieve the air pressure on the first air tank in the system after the air compressor (wet tank).

Disconnect the air inlet and outlet connections. Plug the intake manifold or air piping where the inlet connection was removed.



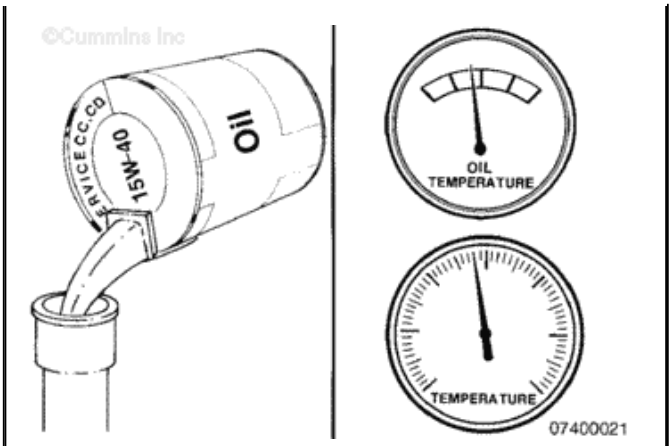
Operate the engine at rated speed and full load (wide open throttle) until a steady blowby reading is obtained. Compare the blowby readings to the previous value. If the blowby is **now** acceptable, replace the air compressor.		
A sudden increase in blowby or a high reading that is **not** steady indicates that there is internal damage in the engine. To determine which cylinder is at fault see the Troubleshooting Symptom Trees.		

Lubricating Oil Pressure

Install the pressure gauge, Part Number 3375275, to the main oil rifle (1) or oil filter head (2). Check the lubricating oil pressure. • Low Idle (minimum allowable) 138 kPa [20 psi] • At 1200 rpm (minimum allowable) 207 kPa [30 psi]		
Check the lubricating oil		

temperature.

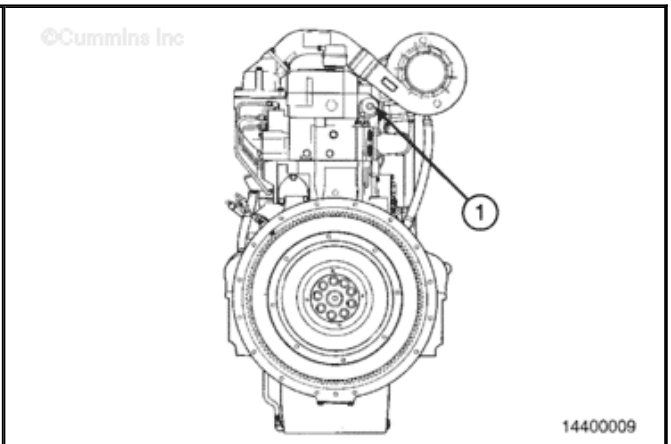
Refer to Procedure 007-038.



Engine Coolant Pressure

Measure the coolant pressure at the water manifold (1).

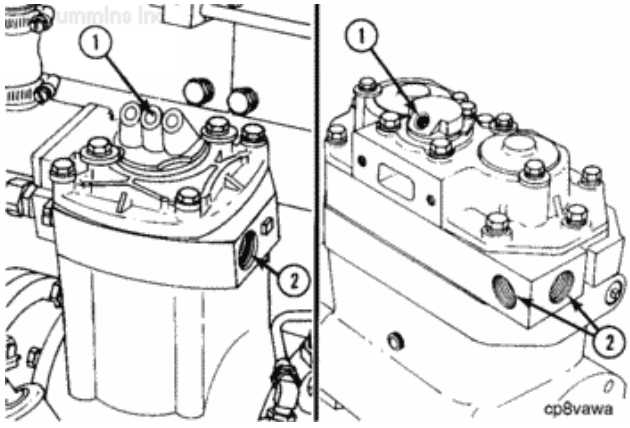
Measurements		
	kpa	psi
Maximum Coolant Pressure with Closed Thermostat and No Pressure Cap	241	35



Air Compressor

All air compressors manufactured by Cummins Inc. **must** be operating during the engine run-in. During the performance check, all air compressors **must** be in the unload or non-operating mode.

Connect a source of compressed air capable of producing 665 kPa [95 psi] to the air compressor unloader (1). This air line **must** contain a valve between the source and the unloader.



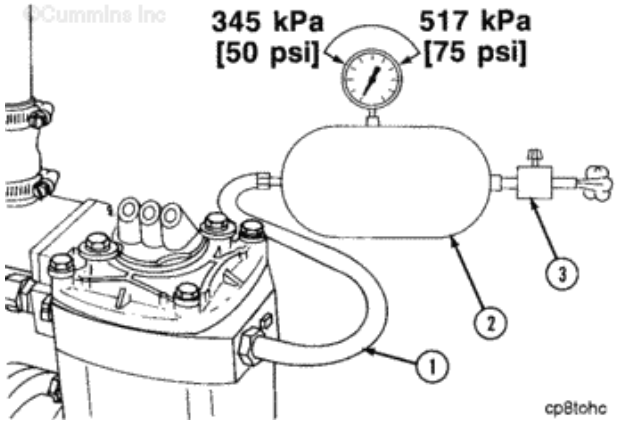
The compressed air load **must** be attached to the air compressor outlet (2).

Use an air tank (2). Install an air regulator (3) capable of maintaining 345 to 517 kPa [50 to 75 psi] air pressure at both minimum and maximum engine rpm.

Install a steel tube or high temperature hose (1).

Measurements		
	celsius	fahrenheit
Hose Temperature (Minimum)	260	500

Connect the tube or hose (1) to the air compressor outlet.

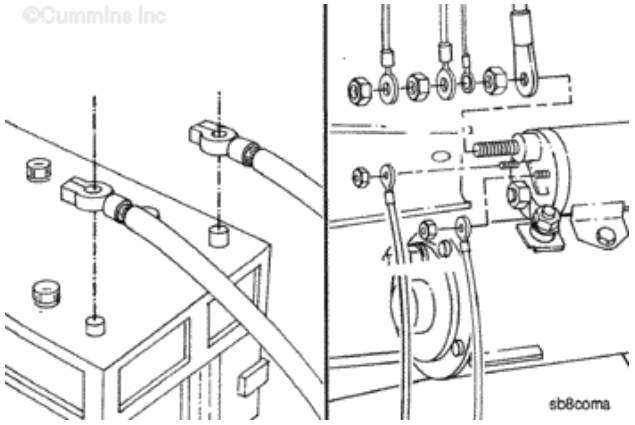


Starting Motor

Inspect the voltage rating on the starting motor before installing the electrical wiring.

Install the electrical wiring to the starting motor and batteries, if used.

NOTE: If another method of starting the engine is used, follow the manufacturer's instructions to make the necessary connections.



Last Modified: 10-Dec-2004

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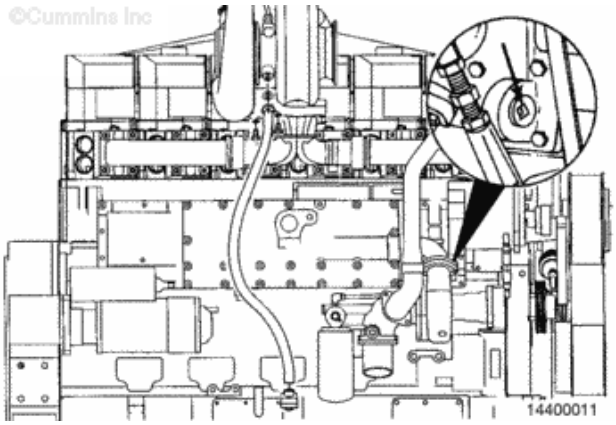
014-003 Engine Run-in (Chassis Dynamometer)

General Information

CAUTION

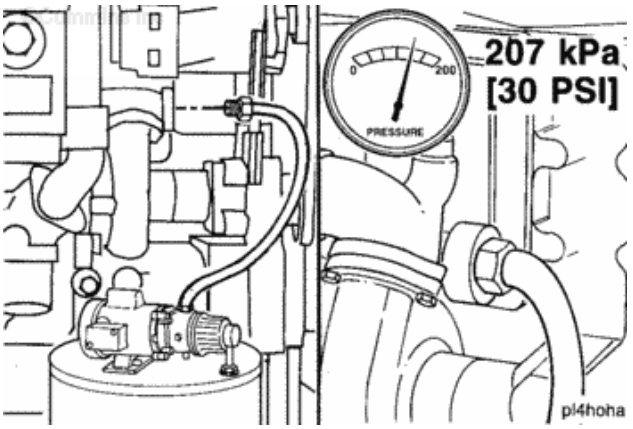
The lubricating oil system must be primed before operating the engine after rebuild, bearing replacement, or power cylinder replacement to avoid internal component damage. Do not prime the system from the bypass filter as the filter will be damaged.

Remove the large plug from the oil cooler housing.

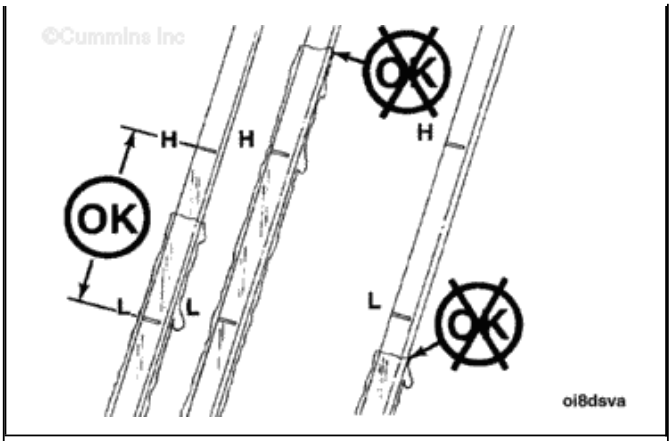


Use a pump capable of supplying 205 kPa [30 psi] continuous pressure. Connect the pump to the front of the engine oil cooler as shown.

Use a supply of clean 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 system steam can cause personal injury.

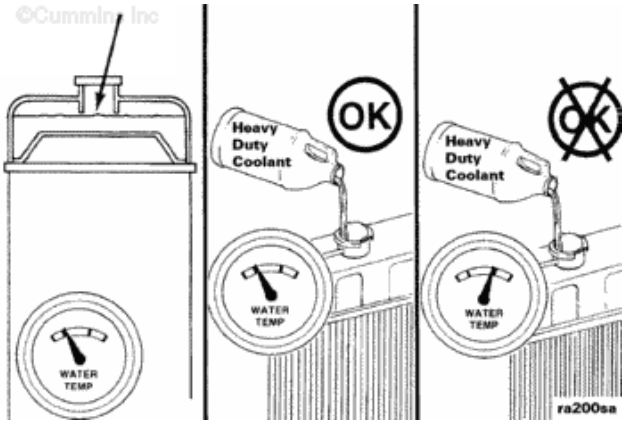
CAUTION

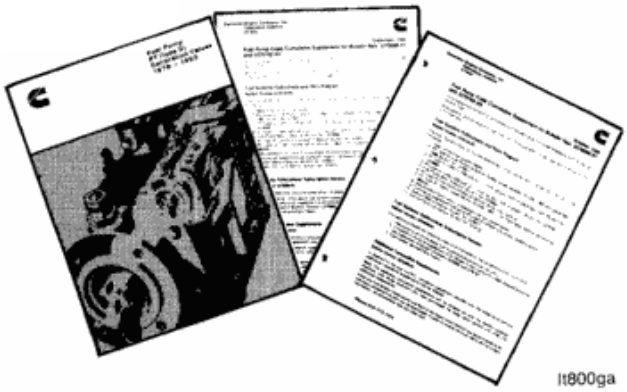
Do not add cold coolant to a hot engine. This can cause engine casting damage. Allow the engine to cool to below 50°C [120°F] before adding coolant.

Check the engine coolant level to make sure it is filled to the proper level. Refer to Procedure 008-018.

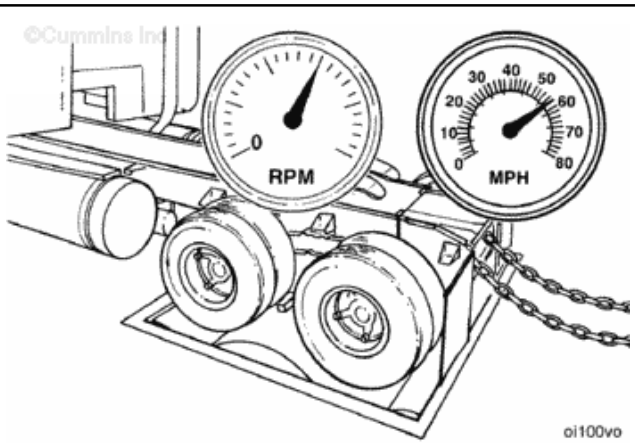
Use a known source of good quality Number 2 diesel fuel.

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 fuel. The lighter the fuel, the lower the energy content (BTU) per gallon (liter, etc.).



Engine operating specifications can be found in publications available from the local Cummins Authorized Repair location.		

Run-In Instructions

Refer to Chassis Dynamometer - Operation, Procedure 014-002, for general operating procedures and safety precautions.		

Use this chart to determine the test load.

Example: The test load for a 475 HP engine rated at 2000 rpm with a 15 percent torque rise is 225 ft-lb.

This chart assumes the dynamometer constant is 5252. If the dynamometer constant is **not** 5252, use the following formula to determine the correct test load:

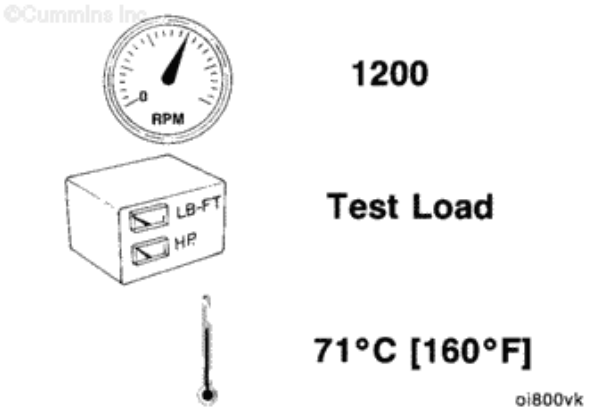
Correct test load = (Dynamometer constant) x (Test load) /d 5252.

Example: The dynamometer constant for testing the engine in the above example is 4000.

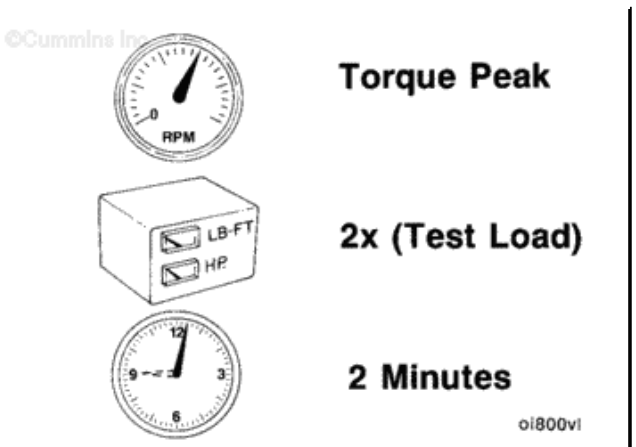
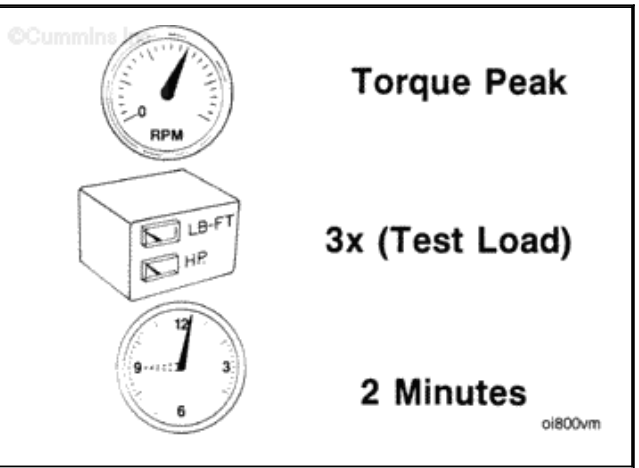
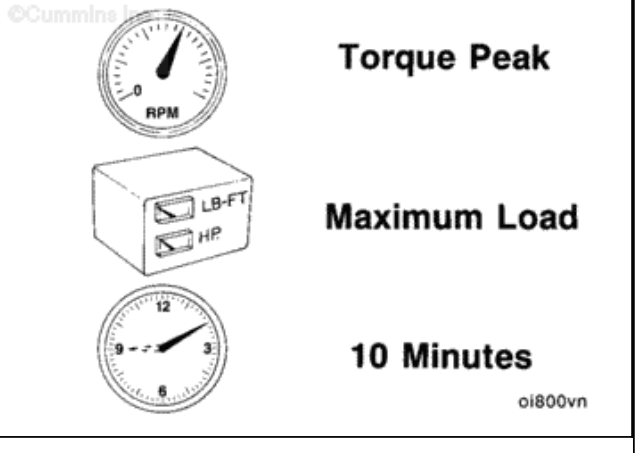
Correct test load = (4000 x 225) /d 5252 = 171 ft-lb.

This chart assumes vehicle run-in on a chassis dynamometer.

Rated RPM	Rated Horsepower	Torque Rise	Test Load
1200	All	All	305 N•m [225 ft-lb]
1500	All	All	305 N•m [225 ft-lb]
1800	0 to 499	All	305 N•m [225 ft-lb]
1800	500 and above	All	380 N•m [280 ft-lb]
1900	0 to 474	All	305 N•m [225 ft-lb]
1900	475 and above	All	380 N•m [280 ft-lb]
2000	0 to 499	0 to 24 percent	305 N•m [225 ft-lb]
2000	0 to 499	25 percent and above	380 N•m [280 ft-lb]
2000	500 and above	All	380 N•m [280 ft-lb]
2100	0 to 474	0 to 32 percent	305 N•m [225 ft-lb]
2100	0 to 474	33 percent plus	305 N•m [225 ft-lb]
2100	475 to 530	0 to 15 percent	305 N•m [225 ft-lb]
2100	475 to 530	16 percent and above	380 N•m [280 ft-lb]
2100	531 to 649	All	380 N•m [280 ft-lb]
2100	650 and above	All	405 N•m [300 ft-lb]

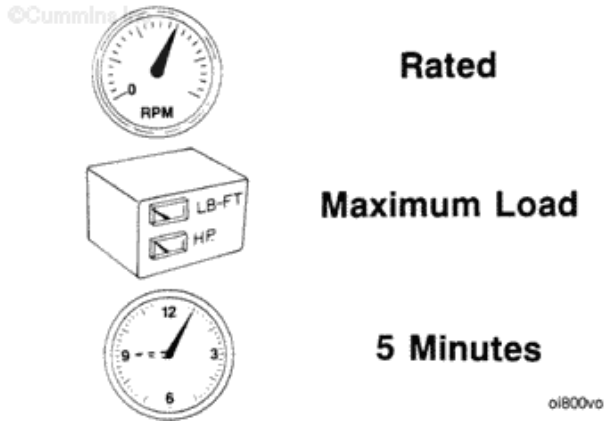
Adjust the engine rpm to 1200 rpm. Adjust the dynamometer load to the test load as previously determined. Operate the engine at this setting until the coolant temperature indicates 70°C [160°F]. Check for leaks. Fix all leaks. Check all of the gauges and record the readings. Do **not** proceed to the 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 the 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 the 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 the 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 the gauges and record the readings.



CAUTION

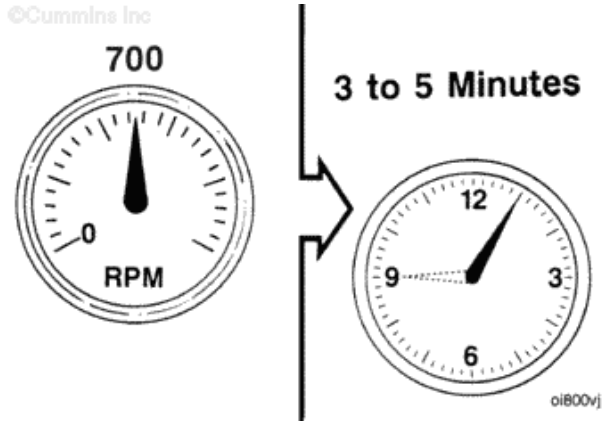
Do not turn the engine OFF immediately. The engine must be allowed to cool or damage to the turbocharger may result.

CAUTION

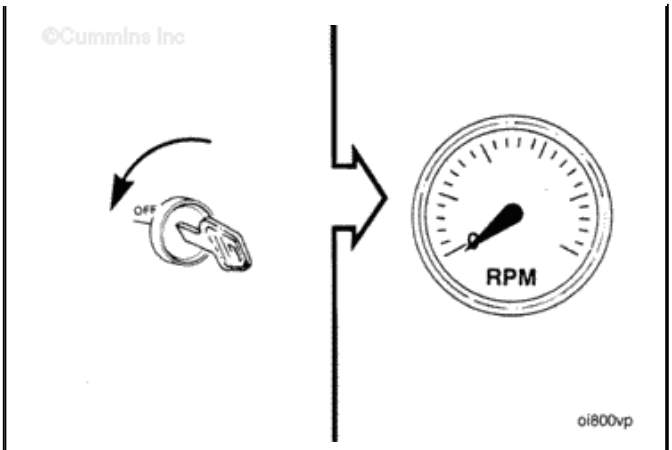
Do not operate the engine at IDLE longer than specified. Excessive carbon formation can cause engine damage.

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.



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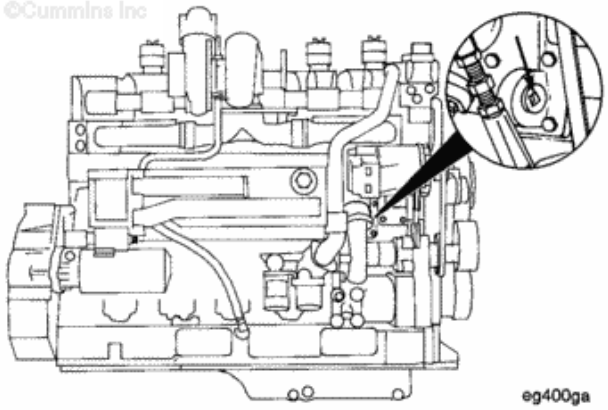
014-004 Engine Run-in (Without Dynamometer)

Engine Testing

CAUTION

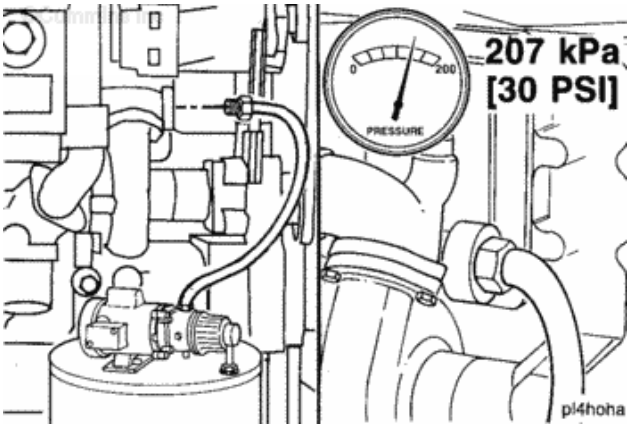
The lubricating oil system must be primed before operating the engine after rebuild, bearing replacement, or power cylinder replacement to avoid internal component damage. Do not prime the system from the bypass filter as the filter will be damaged.

Remove the large plug from the oil cooler housing.

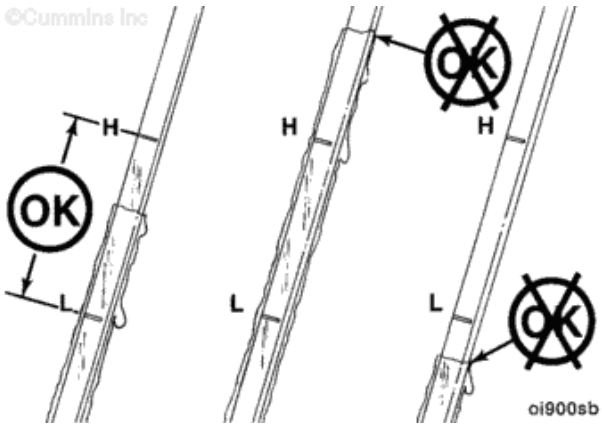


Use a pump capable of supplying 205 kPa [30 psi] continuous pressure. Connect the pump to the front of the engine oil cooler as shown.

Use a supply of clean 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.

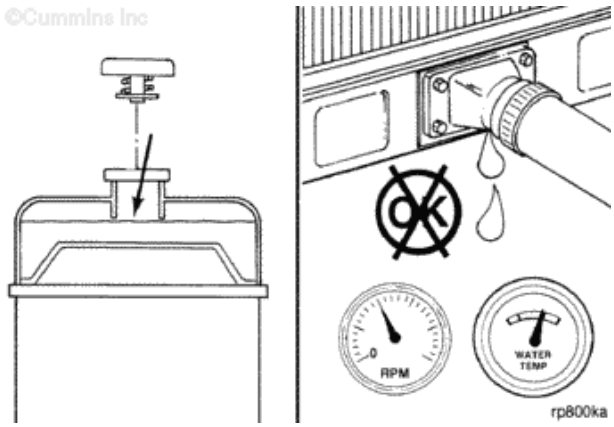


WARNING

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 system steam can cause personal injury.

CAUTION

Do not add cold coolant to a hot engine. This can cause engine casting damage. Allow the engine to cool to below 50°C [120°F] before adding coolant.

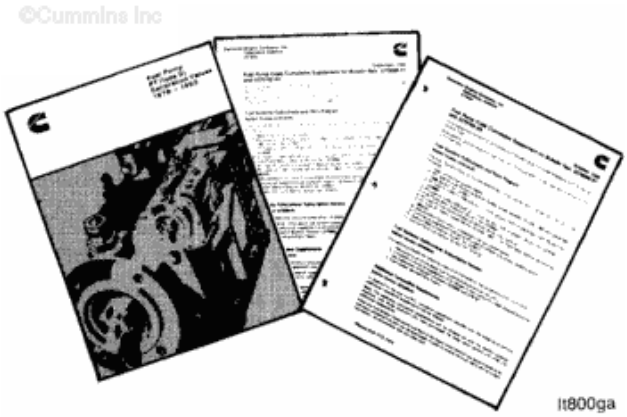


Check the engine coolant level to make sure it is filled to the proper level. Refer to Procedure 008-018.

Use a known source of good quality Number 2 diesel fuel.

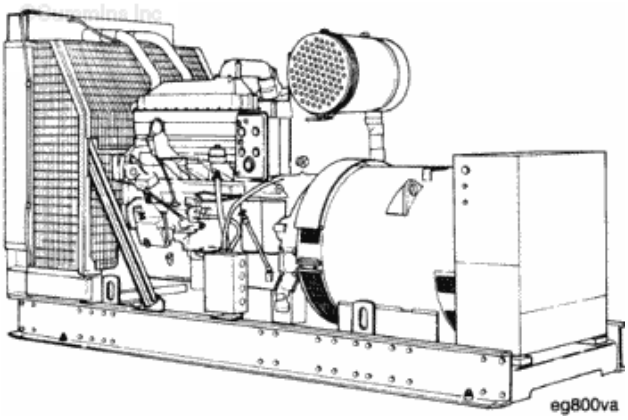
This is very important since Number 1 diesel fuels, along with most other alternate fuels, are lighter (lower specific gravity, higher API gravity) than Number 2 diesel fuel. The lighter the fuel, the lower the energy content (BTU) per

gallon (liter, etc.).		

Engine operating specifications can be found in publications available from your local Cummins Authorized Repair Location.		

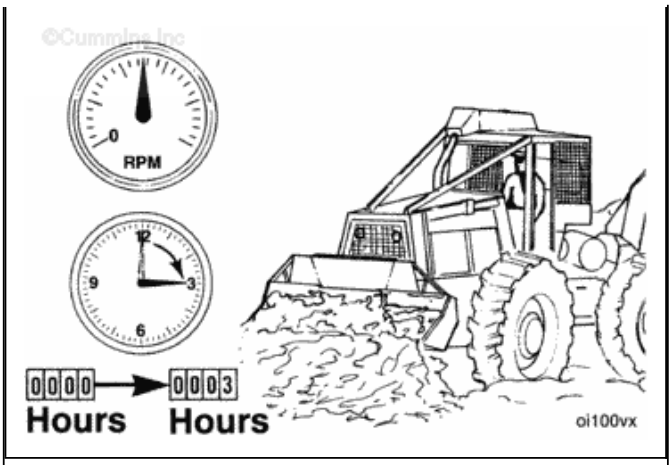
Run-In Instructions

Generator Set Applications

Operate the engine in steps, varying the load from 25 to 100 percent, until blowby remains constant.		

Off-Highway Applications

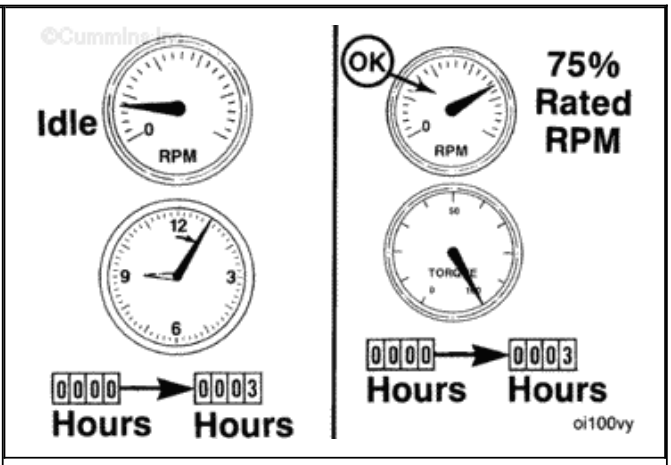
Operate the equipment in the normal duty cycle at part load during the first three hours after rebuild.		



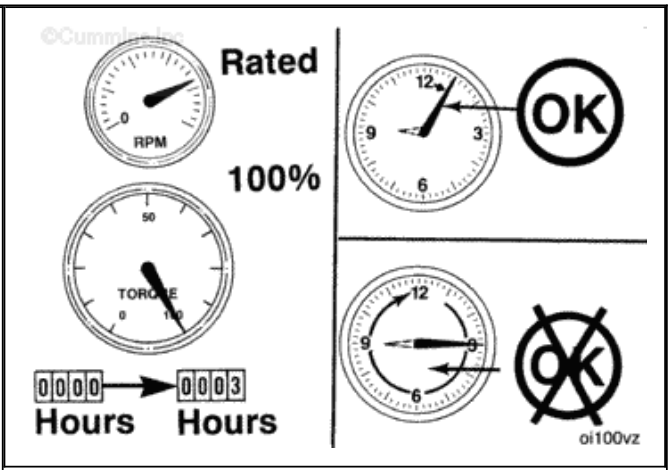
Do **not** idle the engine for more than 5 minutes at any one time.

Do **not** operate the engine at rated rpm. Operate at 75 percent of rated rpm or lower.

Rated RPM	Maximum RPM for First Three Hours
2100	1575
2000	1500
1900	1425
1800	1350



Do **not** operate the engine at full load for more than 5 minutes at any one time.

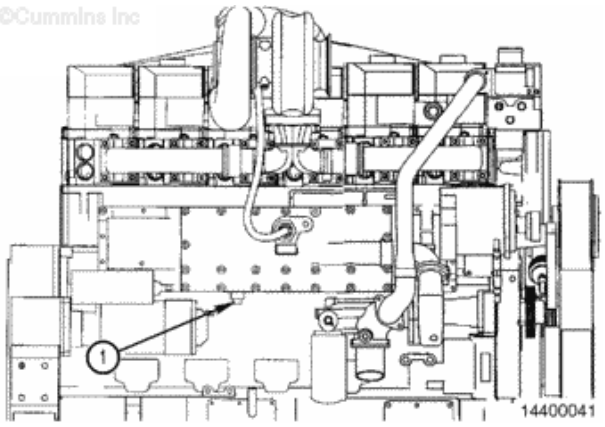
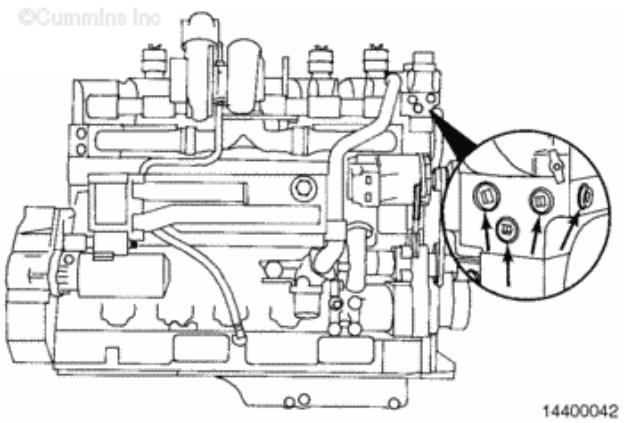


Last Modified: 27-Oct-2004

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014-005 Engine Testing (Engine Dynamometer)

Install

Be sure 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 3162871, to install the engine to the test stand. Align and connect the dynamometer. Refer to the manufacturer's instructions for aligning and testing the engine. Obtain Service Bulletin Number 3666005, Dynamometer and Road Engine Testing, for detailed instructions on auxiliary aftercooling system attachment. Install the coolant pressure sensor (1).		
Install a coolant pressure gauge with a minimum capacity of 345 kPa [50 psi]. Installl a coolant temperature gauge with a minimum capacity of 107°C [225°F]. Measure the coolant temperature at the thermostat housing support.		

Coolant Plumbing

CAUTION

Connect a deaeration hose to the fitting on the top of the thermostat housing or open the petcock during the filling process. All air must be eliminated to allow a complete fill of coolant. Fill the engine with coolant. Check for leaks. Repair any leaks immediately.

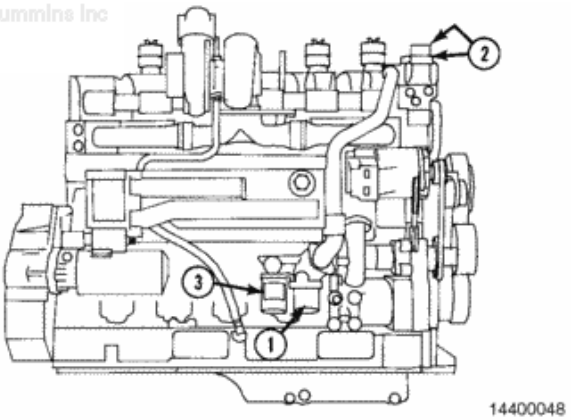
Connect the coolant supply to the water inlet connection (1).

Connect the coolant return to the water outlet connections (2).

Install the drain plugs and close all of the water drain cocks.

NOTE: LTA engines require connecting the LTA water lines to a remote heat exchanger.

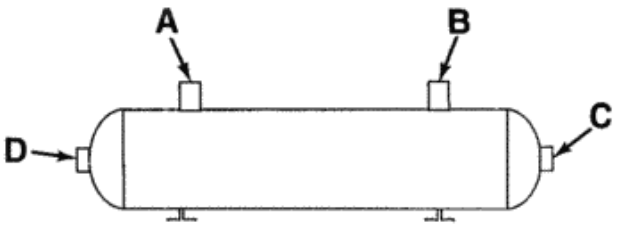
Install a precharge coolant filter (3). Make sure the coolant filter valve is in the “ON” position.



Intake Air Temperature Control

The use of a remote heat exchanger is mandatory whenever a Cummins LTA 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 LTA engine without any means of controlling the intake manifold air temperature.

A = Aftercooler water OUT



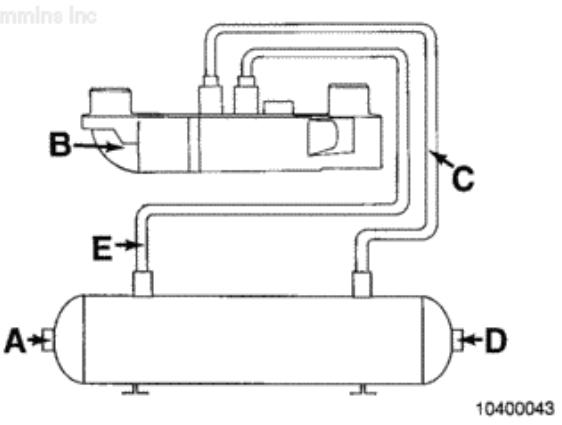
B = Aftercooler water IN
C = Water OUT to drain
D = Cool water IN.

LTA

Some marine ratings require Low Temperature Aftercooling (LTA) and, therefore, have unique radiator requirements. The LTA is a one-pump, two-loop cooling system.

The heat exchanger **must** be sized to maintain 70°C [160°F] maximum intake air temperature at full power.

A. Water IN
B. Thermostat housing
C. LTA OUT
D. Water OUT
E. LTA return.

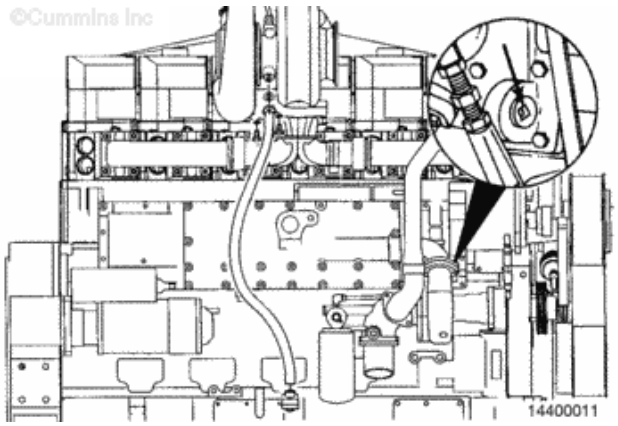


Test

CAUTION

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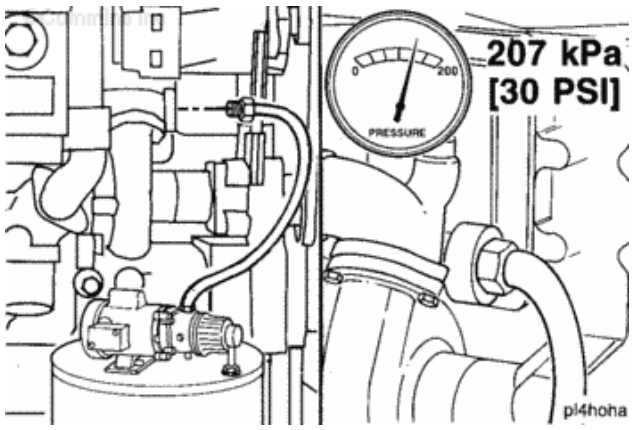
Remove the large plug from the oil cooler housing.



Use a pump capable of supplying 205 kPa [30 psi] continuous pressure. Connect the pump to the front of the engine oil cooler as shown.

Use a supply of clean 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

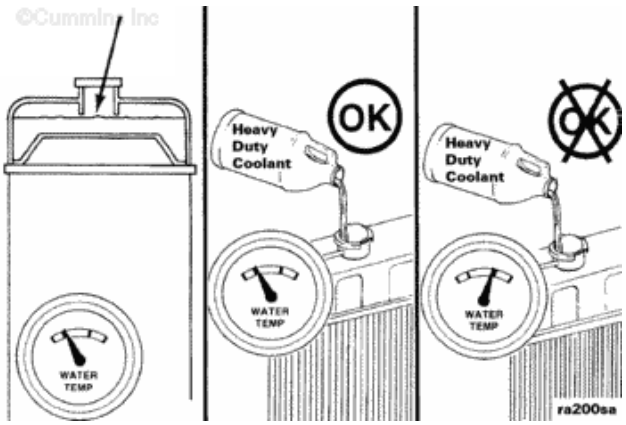
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Check the engine coolant level to be sure it is filled to the proper level.

Refer to Procedure 008-018.

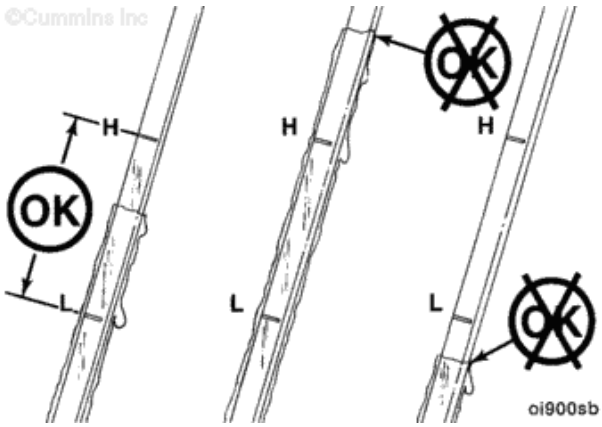


Check the engine lubricating oil level to be sure it is filled to the proper level.

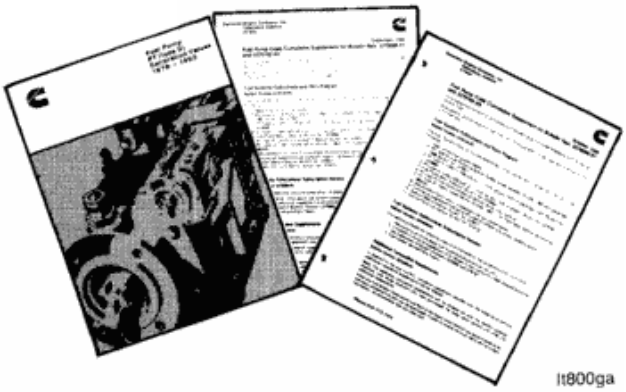
Use a known source of good quality Number 2 diesel fuel.

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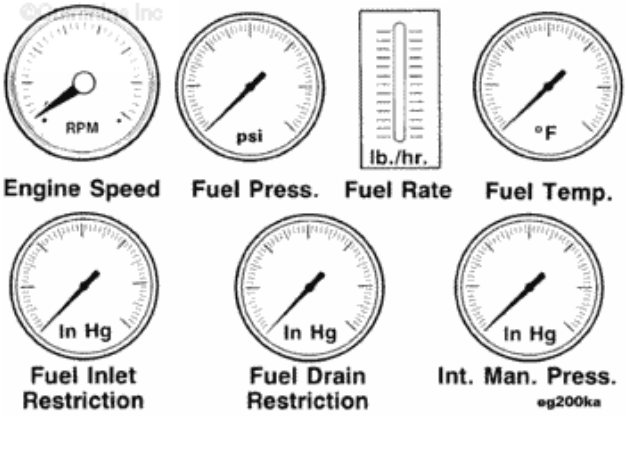
Engine operating specifications are available from the local Cummins Authorized Repair location.



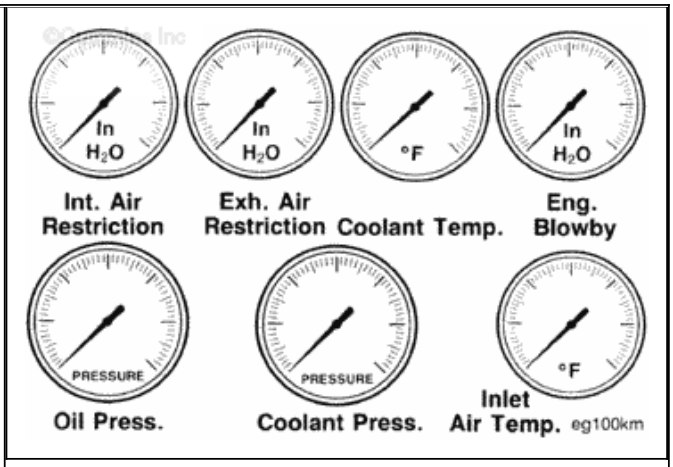
Test

To properly monitor engine performance, record the following parameters. To limit dynamometer operating time, instrument the engine to make as many checks as possible.

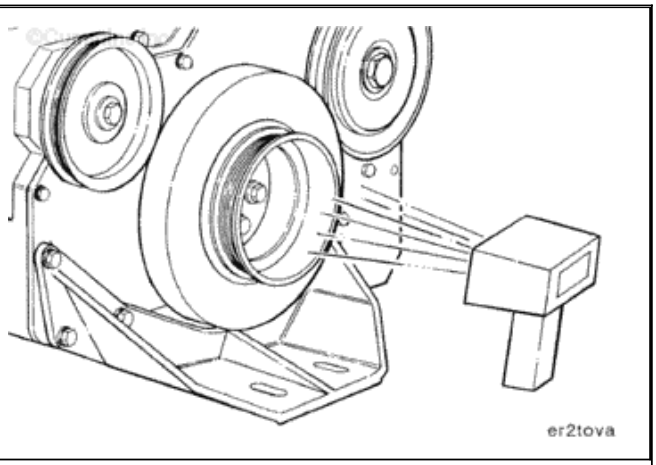
- Engine speed rpm with a verified tachometer
- Fuel pressure
- Fuel rate (Use Service Tool, Part Number 3376375)



• Fuel inlet restriction • Fuel drain line restriction • Intake manifold pressure		

• Intake air restriction • Exhaust air restriction • Coolant temperature • Engine blowby • Lubricating oil pressure • Coolant pressure.		

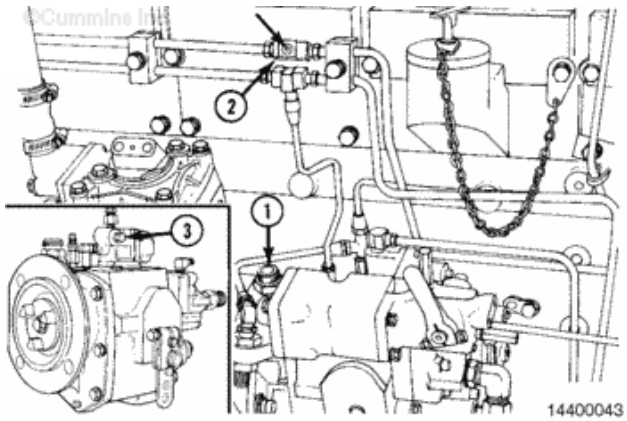
Engine Speed (rpm)

Check engine speed with digital optical tachometer, Part Number 3377462, or equivalent, along with reflective tape, Part Number 3377464, or equivalent.		

Fuel Pressure

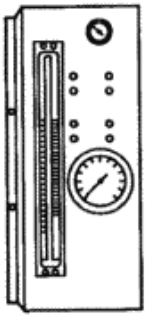
Measure the fuel supply pressure at the junction block on the fuel tube (2). If the engine does **not** have a fuel junction block, measure the fuel pressure at the fuel pump shutoff valve (3). Minimum gauge capacity 2070		

kPa [300 psi].



Fuel Rate

Use fuel measuring device, Part Number 3376375, to measure the rate of fuel consumption.

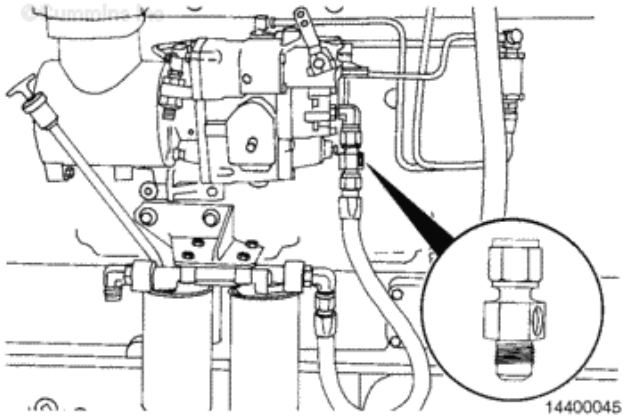


Fuel Inlet Restriction

Measure the fuel inlet restriction. Install a vacuum gauge, Part Number ST-434, between the fuel filter and the gear pump inlet.

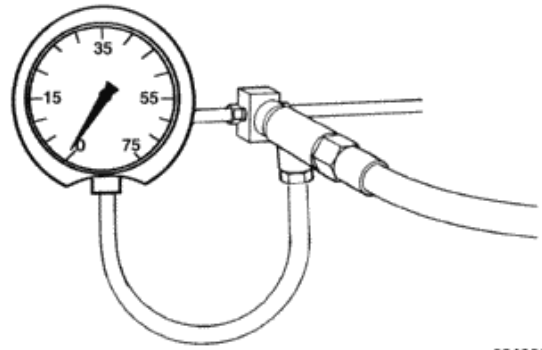
NOTE: Do not measure fuel inlet restriction with the fuel rate measuring device installed. This will not measure the inlet restriction of the vehicle's supply plumbing.

Install a Number 10 hose adapter, Part Number ST-434-2, as close to the fuel pump inlet as possible.

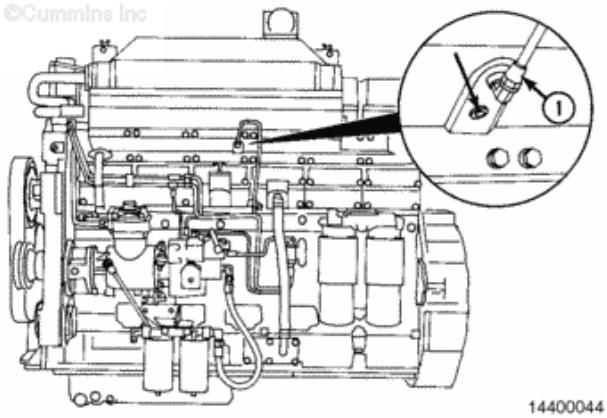


Install a gauge into the adapter. Minimum gauge capacity 760 mm-Hg [30 in-Hg].		

Fuel Drain Line Restriction

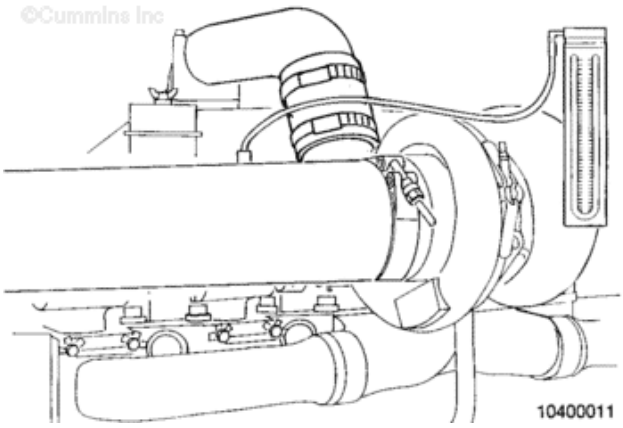
Measure the fuel drain line restriction with pressure gauge, Part Number ST-1273. **NOTE: Do not measure fuel drain line restriction with the fuel rate measuring device installed. This will not measure the drain line restriction of the vehicle's return plumbing.** Refer to Procedure 006-015.		

Intake Manifold Pressure

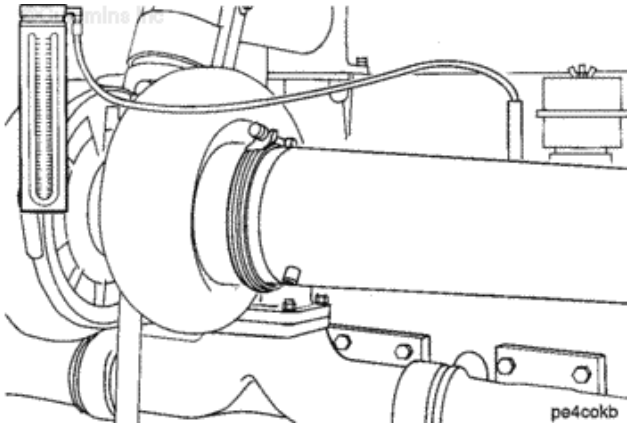
Measure the intake manifold pressure (turbocharger boost). Install pressure gauge, Part Number ST-1273, in the intake manifold as shown. Refer to Procedure 010-057. Observe the reading on the pressure gauge.		

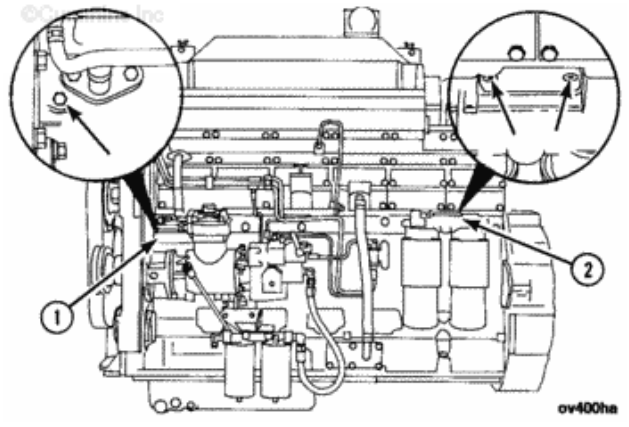
Intake Air Restriction

Measure the inlet air restriction. Install the vacuum gauge, Part Number ST-434, or a manometer in the intake air piping. The gauge adapter **must** be installed at a 90 degree angle		

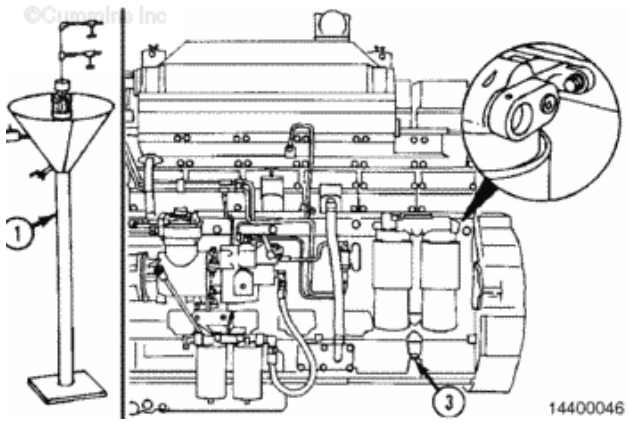
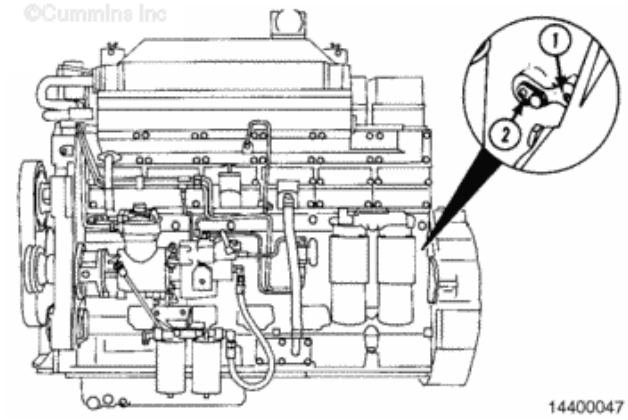
to the air flow in a straight section of pipe at a minimum of one pipe diameter before the turbocharger. Refer to Procedure 010-031.		

Exhaust Air Restriction

Measure the exhaust air restriction. Install the pressure gauge, Part Number ST-1273, a manometer, Part Number ST-1111-3, or equivalent, or digital manometer, Part Number 3164875, or equivalent in the exhaust air piping. The gauge adapter **must** be installed near the turbocharger in a straight section of pipe at the turbine outlet.		

Measure the oil pressure. Measure the oil pressure at location (1), which is the front of the main oil rifle. If location (1) is **not** accessible, remove on of the pipe plugs from the oil filter head (2). Minimum gauge capacity 830 kPa [120 psi].		

Monitor the oil		

contamination. Connect lubricating oil sampling filter, Part Number ST-1135 (1) or equivalent, to the oil filter inlet hose location on the lubricating oil filter head (2). The oil is **not** filtered at this location. Connect the sampling filter oil outlet hose to the engine above the oil level (3). Refer to the manufacturer's instructions to perform this test. If the sampling filter is **not** available, cut both of the oil filters open and inspect the filters after the test is complete.		
Measure the piston cooling pressure. Measure the piston cooling oil rifle pressure at plug (1) in the piston cooling rifle near the rear of the cylinder block. If plug (1) is **not** accessible, measure the pressure at the smallest plug on the bottom of the lubricating oil filter head. Minimum gauge capacity. 830 kPa [120 psi]. When the main oil rifle pressure exceeds 130 kPa [19 psi], the oil will begin to flow to the piston cooling rifle. When the main oil rifle pressure indicates 200 kPa [29 psi], and greater, the pressure in the piston cooling rifle **must** be within 35 kPa [5 psi] of the main oil rifle pressure.		

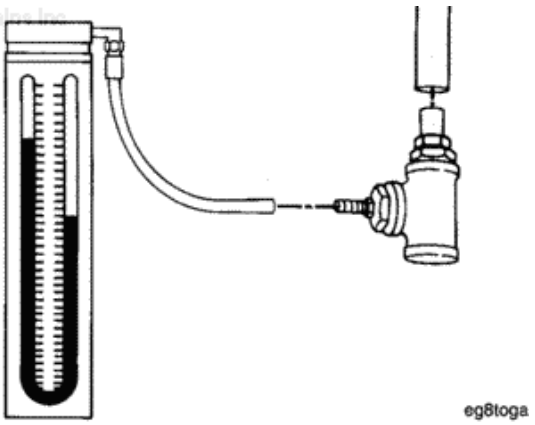
Engine Blowby

Excessive blowby indicates an air compressor, a turbocharger, or an engine malfunction, allowing combustion gases or air to enter the crankcase and build a pressure higher than normal.

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, or equivalent, or digital manometer, Part Number 3164875, or equivalent. The engine blowby tools are similar in design. The difference between the tools is in the size of the orifice.

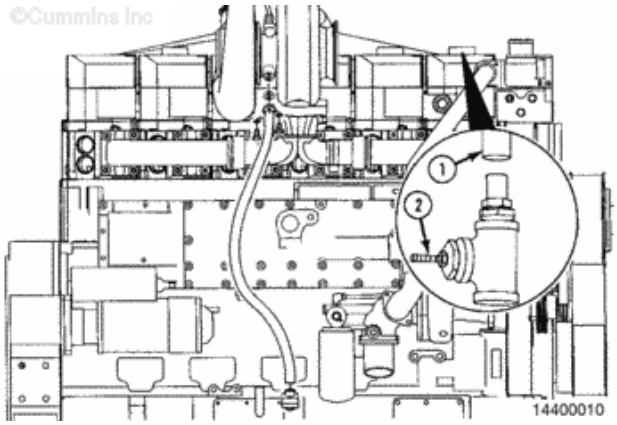
Blowby Tool Sizes	
Blowby Tool Part Number	**Orifice Size**
3822566	7.67 mm [0.302 in]
3822567	9.00 mm [0.354 in]
3822568	10.30 mm [0.406 in]



Use a length of hose (1) to attach the blowby tool to one of the crankcase breathers.

Plug all of the other breathers.

Attach a manometer to the location shown (2).

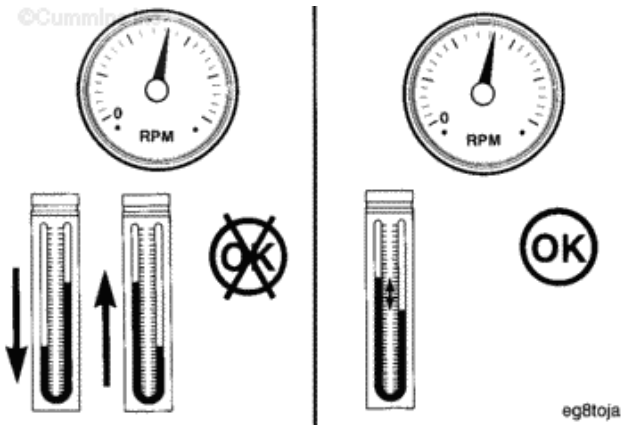


Operate the engine at rated rpm and full load (wide open throttle) until a steady reading is obtained.

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.

NOTE: 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).

Engine Blowby 7.67 mm [0.302 in]		
RPM	**New/Rebuilt**	**Used**
KTTA All Ratings	508 mm H_2 0 [20 in H_2 0]	1270 mm H_2 0 [50 in H_2 0]
KTA 2000 and above	355 mm H_2 0 [14 in H_2 0]	889 mm H_2 0 [35 in H_2 0]
KTA 1500 to 1900	305 mm H_2 0 [12 in H_2 0]	762 mm H_2 0 [30 in H_2 0]
KT 2000 and above	254 mm H_2 0 [10 in H_2 0]	635 mm H_2 0 [25 in H_2 0]
KT 1500 to	203 mm H_2	508 mm H_2 0 [20 in



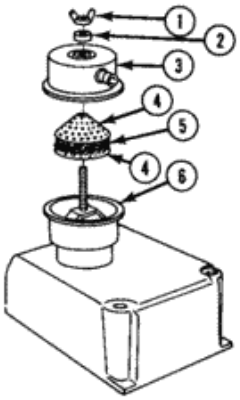
1900	0 [8 in H_2 0]	H_2 0]

Engine Blowby 9.0 mm [0.354 in]		
RPM	**New/Rebuilt**	**Used**
KTTA All Ratings	229 mm H_2 0 [9 in H_2 0]	584 mm H_2 0 [23 in H_2 0]
KTA 2000 and above	203 mm H_2 0 [8 in H_2 0]	508 mm H_2 0 [20 in H_2 0]
KTA 1500 to 1900	178 mm H_2 0 [7 in H_2 0]	457 mm H_2 0 [18 in H_2 0]
KT 2000 and above	152 H_2 0 [6 in H_2 0]	380 mm H_2 0 [15 in H_2 0]
KT 1500 to 1900	127 mm H_2 0 [5 in H_2 0]	318 mm H_2 0 [13 in H_2 0]

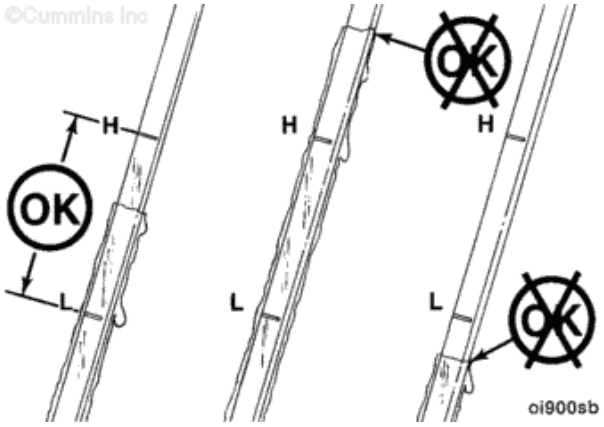
Engine Blowby 10.3 mm [0.406 in]		
RPM	**New/Rebuilt**	**Used**
KTTA All Ratings	127 mm H_2 0 [5 in H_2 0]	330 mm H_2 0 [13 in H_2 0]

If the blowby is higher than normal, check the crankcase breathers and breather tubes to see if they are plugged.

(1) Wing nut
(2) Washer
(3) Breather
(4) Screen mesh
(5) Breather element
(6) Breather base.



Check the engine oil level. If the level is too high it can cause a higher than normal crankcase pressure.

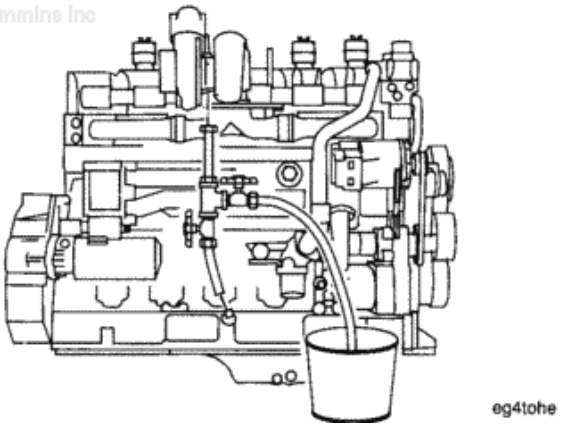


Isolate the turbocharger to determine if the high crankcase pressure is due to seal leakage in the turbocharger.

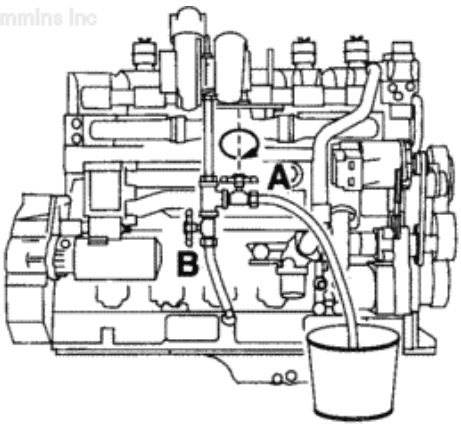
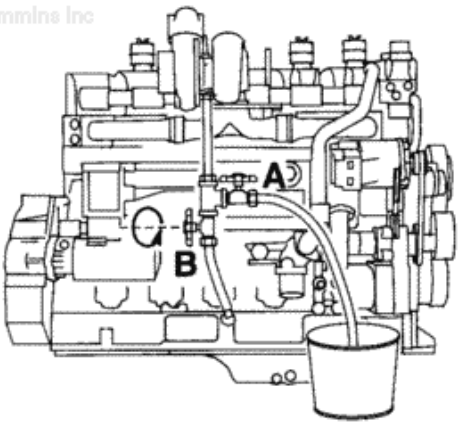
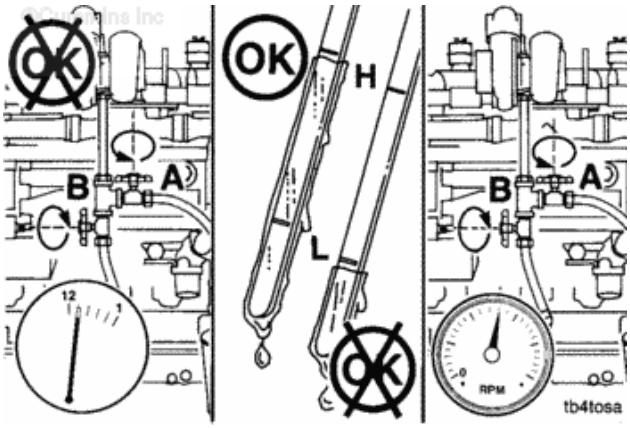
Disconnect the turbocharger drain line from the oil pan adaptor.

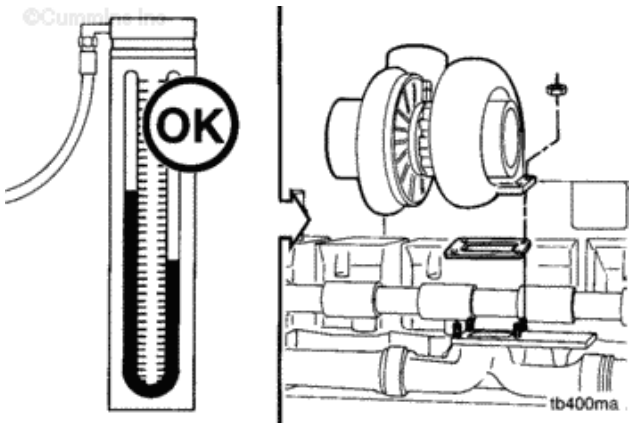
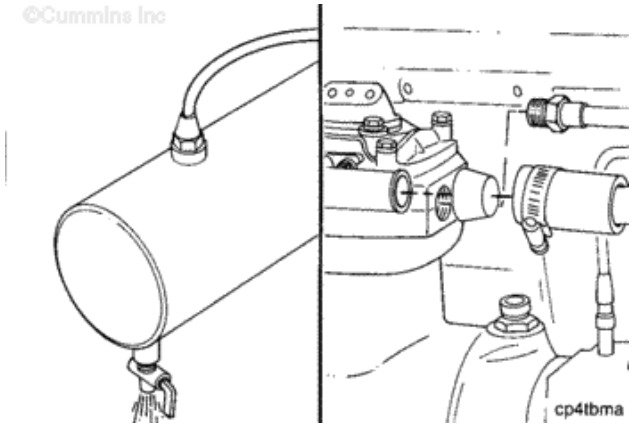
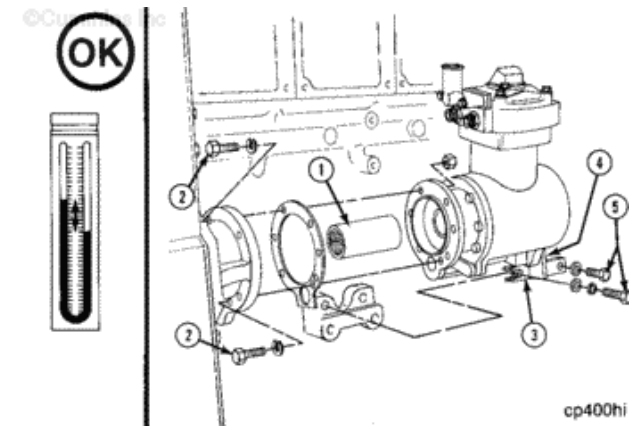
Install a hose assembly with the two shutoff valves arranged as shown. Place the other hose in an 8 to 19 liter [2 to 5 gallon] bucket.

The valves **must** have a minimum inside diameter of 19 mm [0.75 inch].

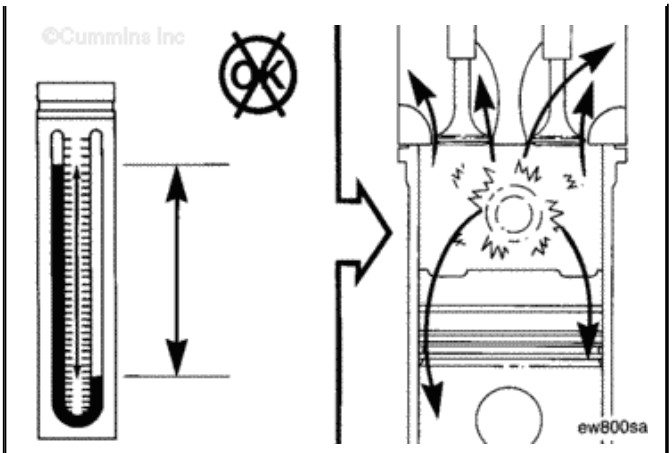


Close the valve (A) that allows

the oil to drain to 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 010-033.		
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.		
Operate the engine at rated speed and full load (wide open throttle) until a steady blowby reading is obtained. Compare the blowby readings to the previous value. If the blowby is now acceptable, replace the air compressor. Refer to Procedure 012-014.		
A sudden increase in blowby or a high reading that is **not** steady indicates that there is internal damage in the		

engine.

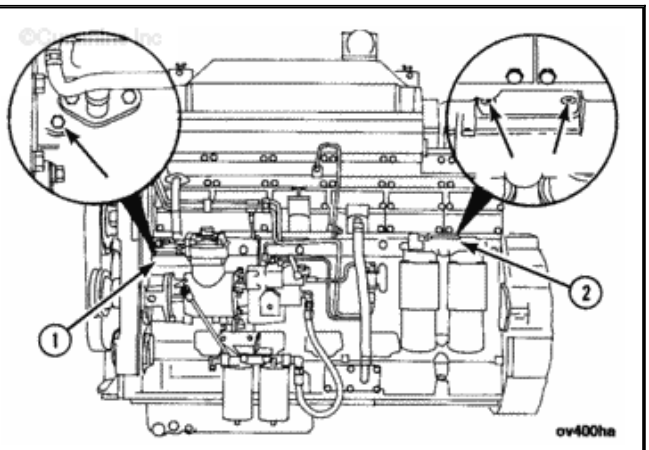


Lubricating Oil Pressure

Use Pressure Gauge, Part Number 3375275, to measure lubricating oil pressure.

Install the pressure gauge to the main oil rifle (1) or air filter head (2).

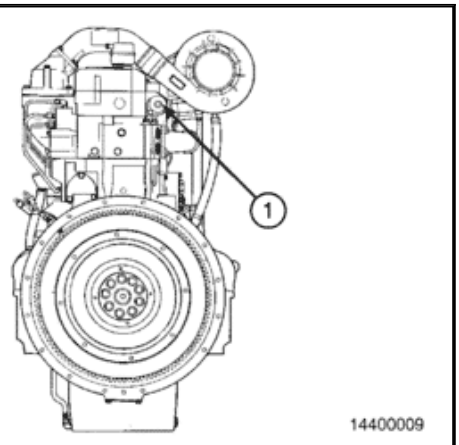
Lubricating Oil Pressure (15W40 oil at 107°C [225°F])			
	kpa		psi
At Low Idle	138	MIN	20
AT 1200 RPM	207	MIN	30



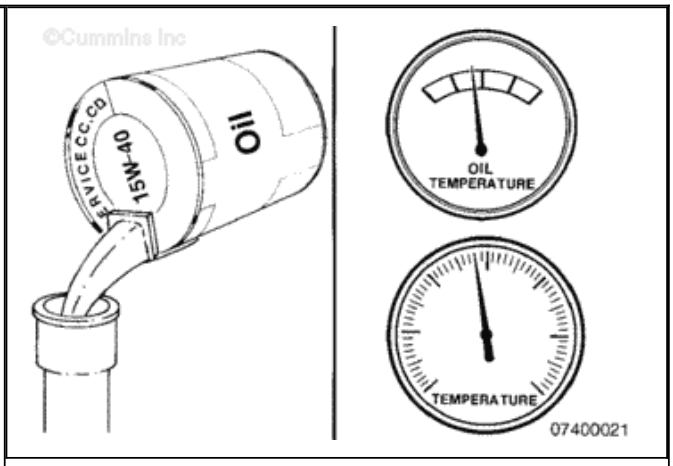
Engine Coolant Pressure

Measure the coolant pressure at the water manifold (1).

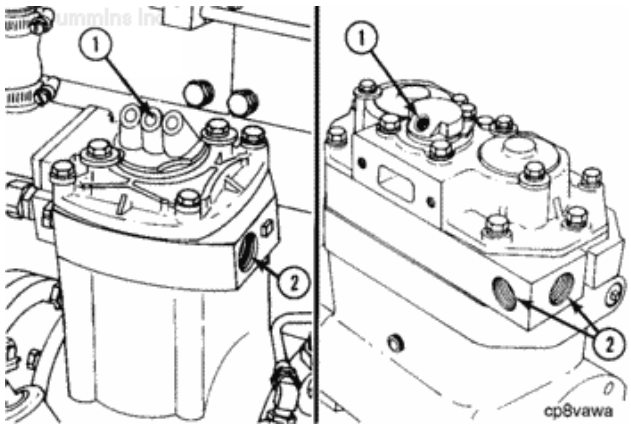
Coolant Pressure			
	kpa		psi
Closed Thermostat, No Pressure Cap	241	MAX	35

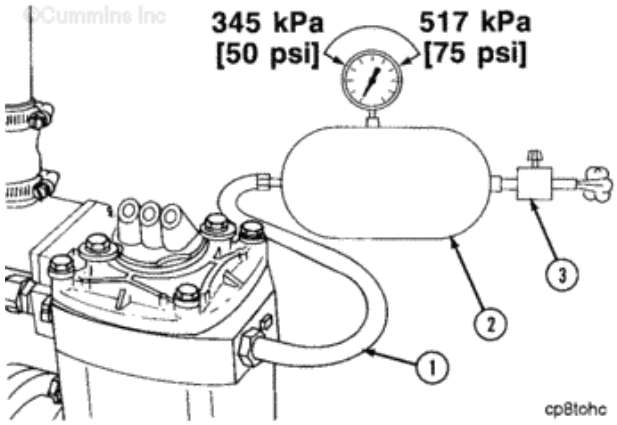


High Engine Oil Temperature

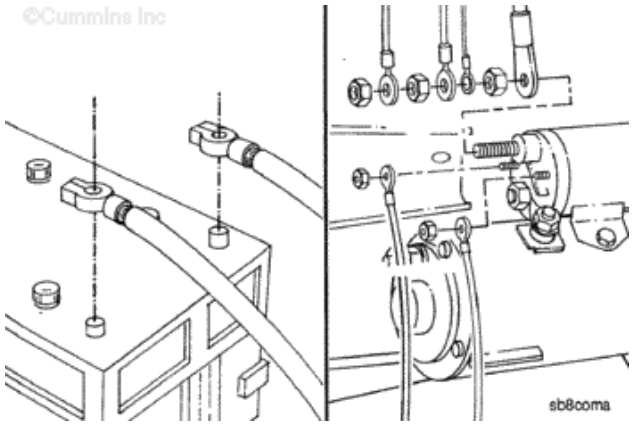
Check the lubricating oil temperature. Refer to Procedure 007-038.		

Air Compressor

All air compressors manufactured by Cummins Inc. **must** be operating during the engine run-in. During the performance check, all air compressors **must** be in the unload or non-operating mode. Connect a source of compressed air capable of producing 665 kPa [95 psi] to the air compressor unloader (1). This air line **must** contain a valve between the source and the unloader. The compressed air load in the accompanying illustration **must** be attached to the air compressor outlet (2).		
Use an air tank (2). Install an air regulator (3) capable of maintaining 345 to 517 kPa [50 to 75 psi] air pressure at both minimum and maximum engine rpm. Install a steel tube or high temperature hose (1).		

The hose **must** be rated at 260°C [500°F]. Connect the tube or hose (1) to the air compressor outlet.		

Starting Motor

Inspect the voltage rating on the starting motor before installing the electrical wiring. Install the electrical wiring to the starting motor and batteries, if used. **NOTE: If another method of starting the engine is used, follow the manufacturer's instructions to make the necessary connections.**		

Last Modified: 10-Dec-2004

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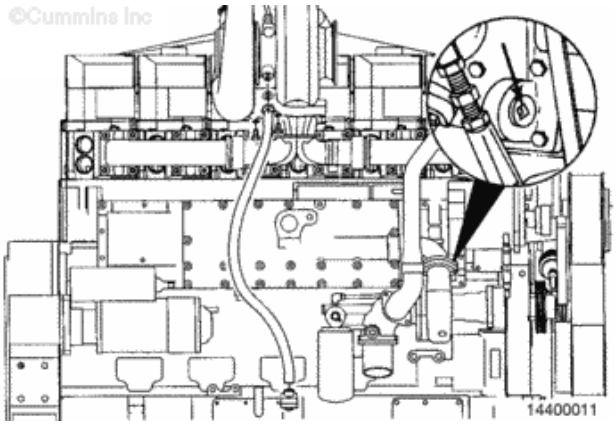
014-006 Engine Run-in (Engine Dynamometer)

Install

CAUTION

The lubricating oil system must be primed before operating the engine after rebuild, bearing replacement, or power cylinder replacement to avoid internal component damage. Do not prime the system from the bypass filter as the filter will be damaged.

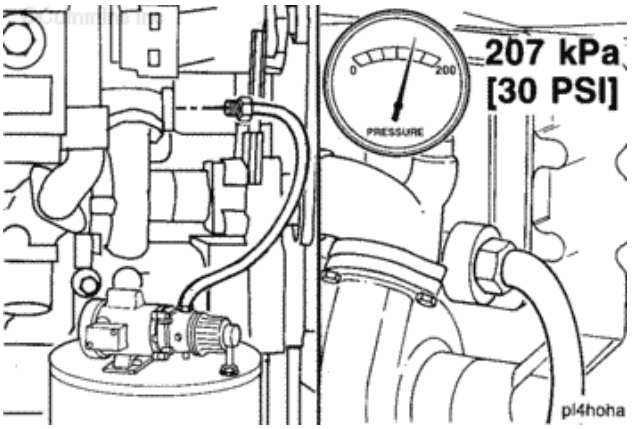
Remove the large plug from the oil cooler housing.



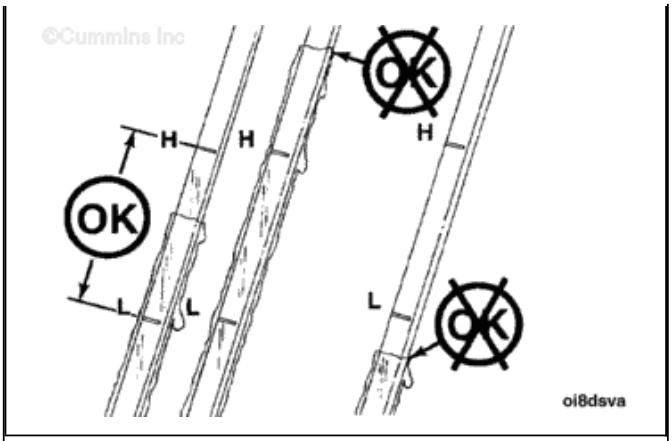
Use a pump capable of supplying 205 kPa [30 psi] continuous pressure.

Connect the pump to the front of the engine oil cooler as shown.

Use a supply of clean 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.

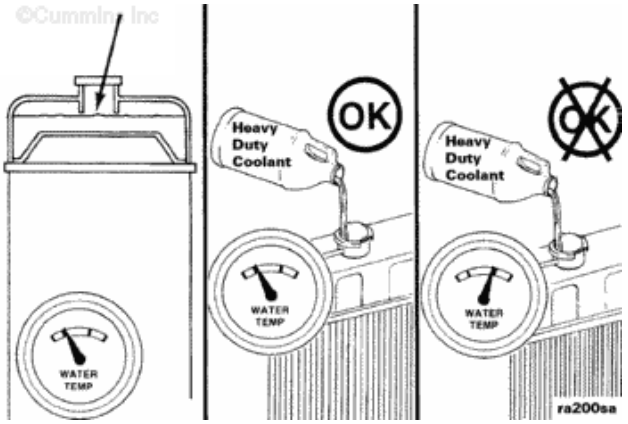
CAUTION

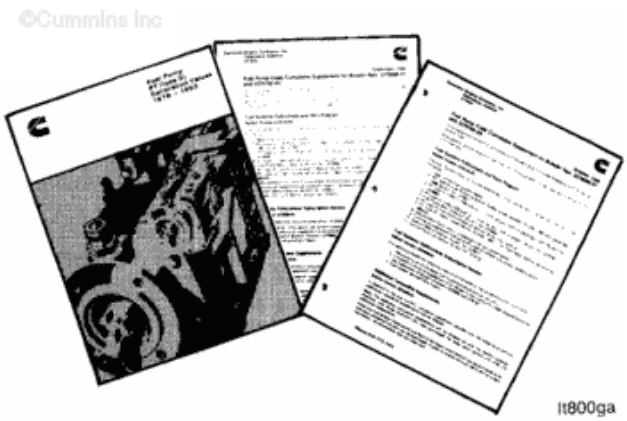
Do not add cold coolant to a hot engine. This can cause engine casting damage. All ow the engine to cool to below 50°C [120°F] before adding coolant.

Check the engine coolant level to make sure it is filled to the proper level. Refer to Procedure 008-018.

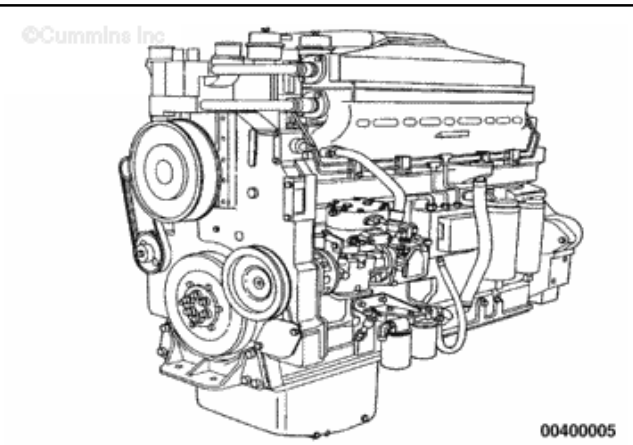
Use a known source of good quality Number 2 diesel fuel.

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 fuel. The lighter the fuel, the lower the energy content (BTU) per gall (liter, etc.).



Engine operating specifications can be found in publications available from the local Cummins Authorized Repair location.		

Run-In Instructions

Refer to Engine Testing-Dynamometer, Procedure 014-005, for general operating procedures and safety precautions.		

Use this chart to determine the test load.

The run-in test **must** be performed with the engine operating at torque peak rpm. Operate a generator set engine at rated rpm.

Example: The test load for a 475 horsepower engine rated at 2000 rpm with a 15 percent torque rise is 300 ft-lb.

This chart assumes the dynamometer constant is 5252. IF the dynamometer constant is **not** 5252, use the following formula to determine the correct test load:

Correct test load = (Dynamometer constant) x (Test load) / d 5252.

Example: The dynamometer constant for testing the engine in the above formula is 4000.

Correct test load = (4000 x 300) / d 5252 = 228 ft-lb.

This chart assumes vehicle run-in on a chassis dynamometer.

Rated RPM	Rated Horsepower	Torque Files	Test Load
1200	All	All	405 N•m [300 ft-lb]
1500	All	All	405 N•m [300 ft-lb]
1800	0 to 499	All	405 N•m [300 ft-lb]
1800	500 and above	All	510 N•m [375 ft-lb]
1900	0 to 474	All	405 N•m [300 ft-lb]
1900	475 and above	All	510 N•m [375 ft-lb]
2000	0 to 499	0 to 24 percent	405 N•m [300 ft-lb]
2000	0 to 499	25 percent and above	510 N•m [375 ft-lb]
2000	500 and above	All	510 N•m [375 ft-lb]
2100	0 to 474	0 to 32 percent	405 N•m [300 ft-lb]
2100	0 to 474	33 percent plus	405 N•m [300 ft-lb]
2100	475 to 530	0 to 15 percent	405 N•m [300 ft-lb]
2100	475 to 530	16 percent and above	510 N•m [375 ft-lb]
2100	531 to 649	All	510 N•m [375 ft-lb]
2100	650 and above	All	540 N•m [400 ft-lb]

CAUTION

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

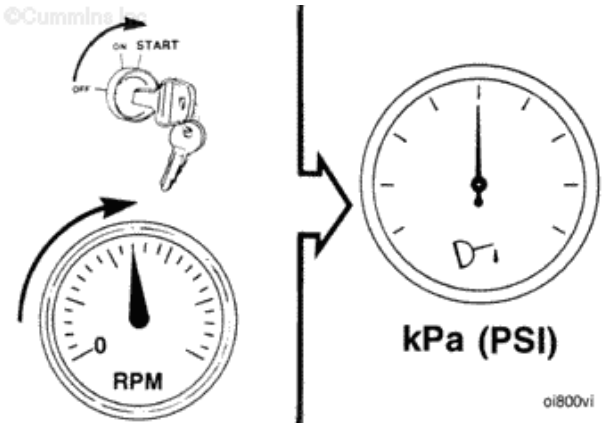
CAUTION

If the oil pressure is not within specifications, stop the engine immediately. Both low and high oil pressure will cause engine damage.

If the engine does **not** start after 30 seconds, allow two minutes for the starting motor to cool.

Start the engine.

Check the engine oil pressure at the main oil rifle when the 15W40 engine oil is 107°C [225°F].

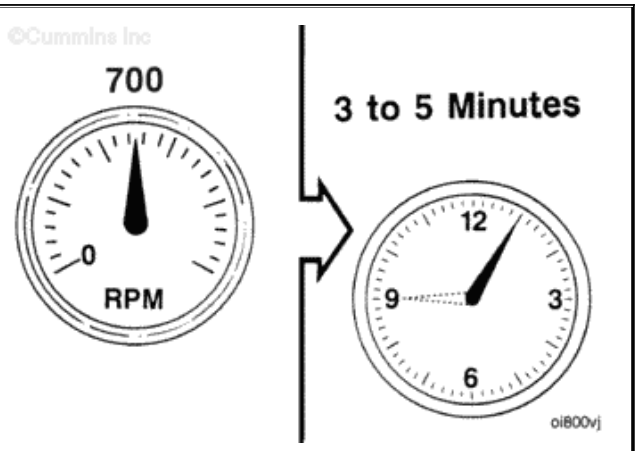


Main Oil Rifle Pressure (At Idle)		
kpa		psi
138	MIN	20

CAUTION

Do not operate the engine at idle longer than specified. Excessive carbon formation will cause engine damage.

Operate the engine at idle position and check for leaks.



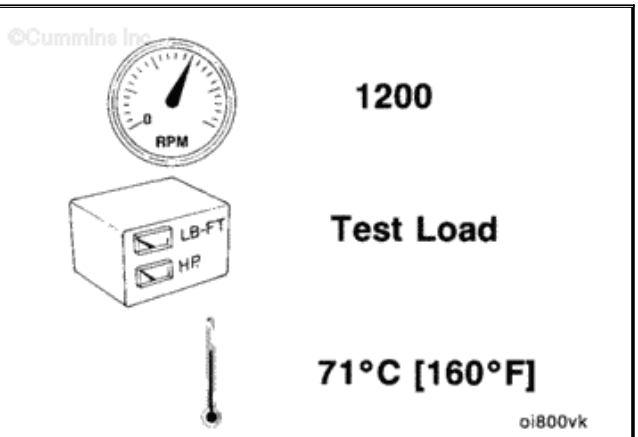
Adjust the engine rpm to 1200 rpm. Adjust the dynamometer load to the test load as previously determined. Operate the engine at this setting until the coolant temperature indicates 70°C [160°F].

Check for leaks.

Fix all leaks.

Check all gauges and record all readings.

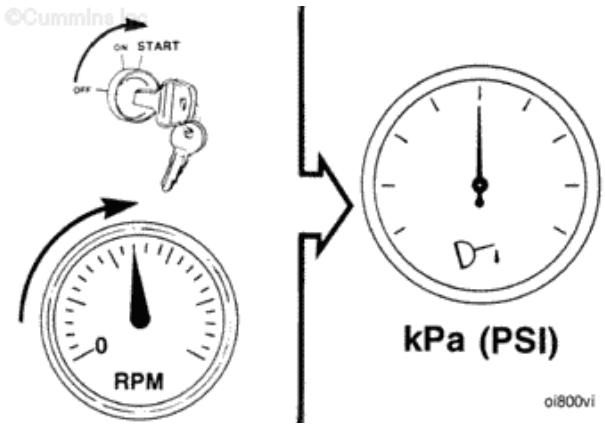
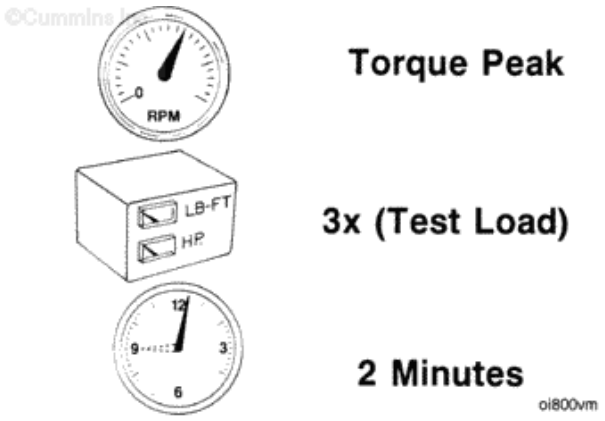
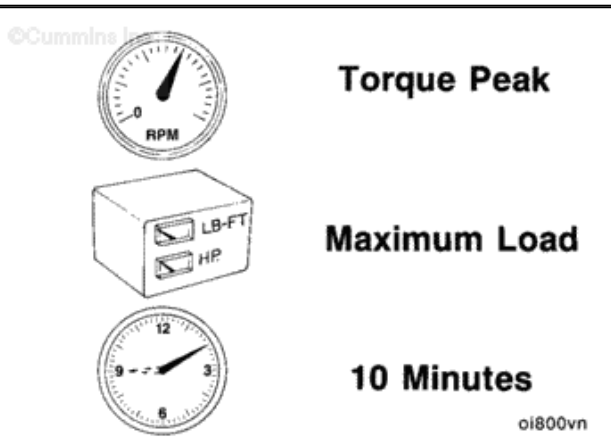
Do **not** proceed to the next step until the blowby becomes stable within specifications.



Adjust the engine rpm to the torque peak rpm.

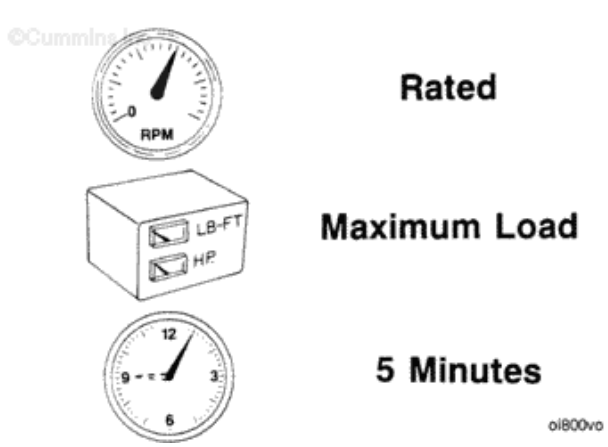
Adjust the dynamometer load to equal two times the test load.

Operate the engine for two minutes.

Check and record all 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 load to equal three times the test load. Operate the engine at this load for two minutes. Check all the 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 the gauges and record the readings.		
Decrease the dynamometer load until the engine rpm increases to 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.

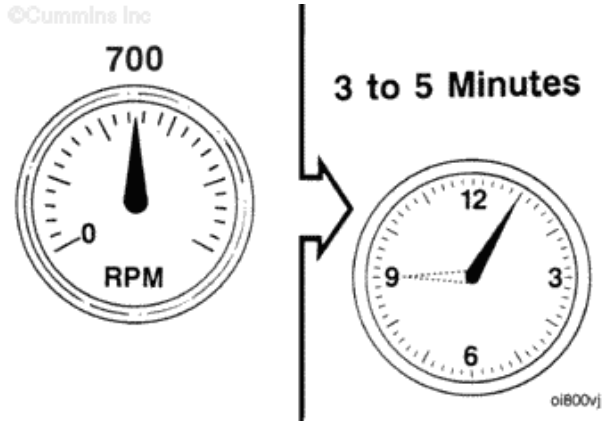
CAUTION

Do not operate the engine at idle longer than specified. Excessive carbon formation can cause engine damage.

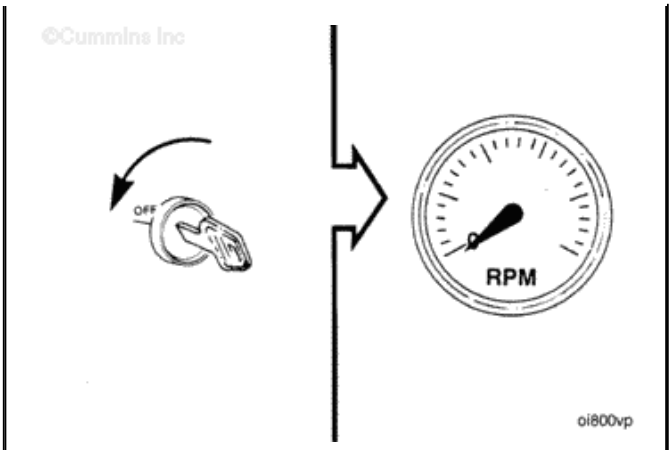
Decrease the dynamometer load completely.

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 other engine components to cool.



Turn the engine off.



Last Modified: 27-Oct-2004

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014-008 Engine Testing (In Chassis)

Stall Speed Check

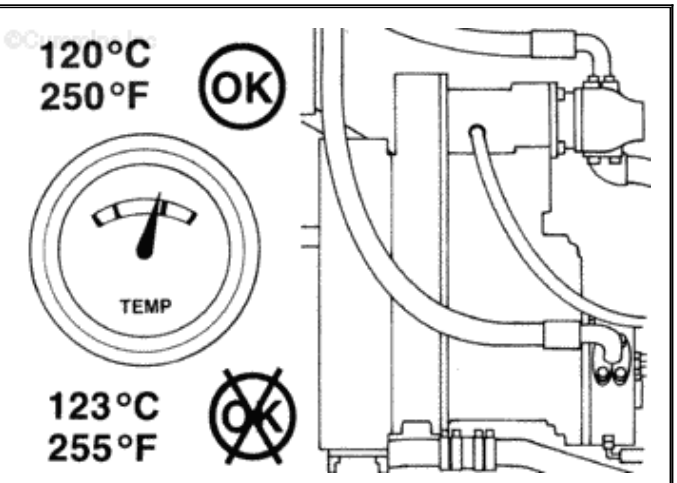
The stall speed is the engine speed (rpm) obtained at full throttle when the converter output shaft is locked.

The vehicle brakes do **not** always hold an electronically controlled transmission.



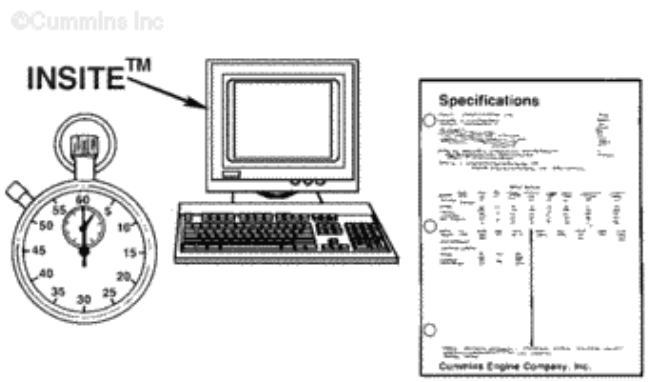
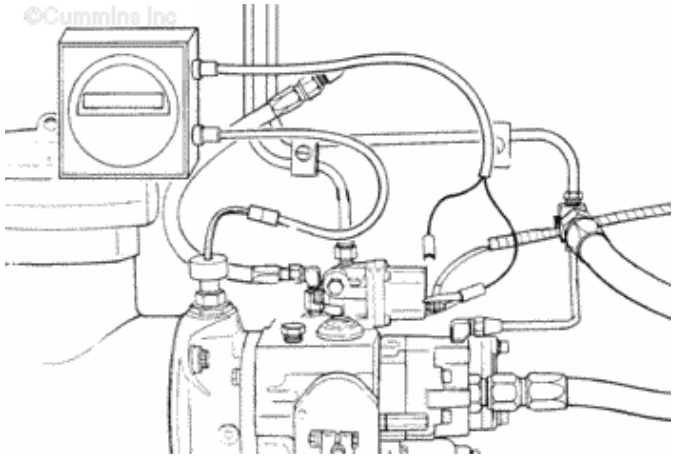
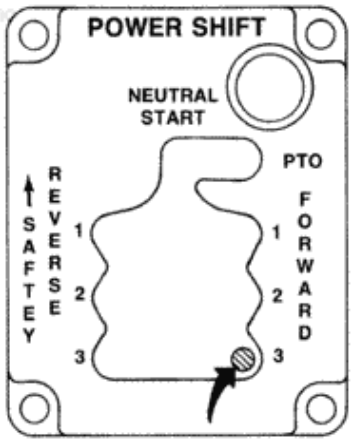
CAUTION

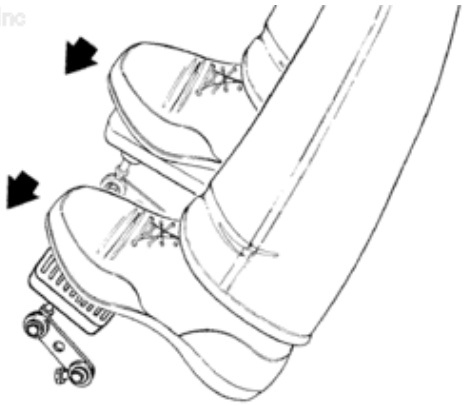
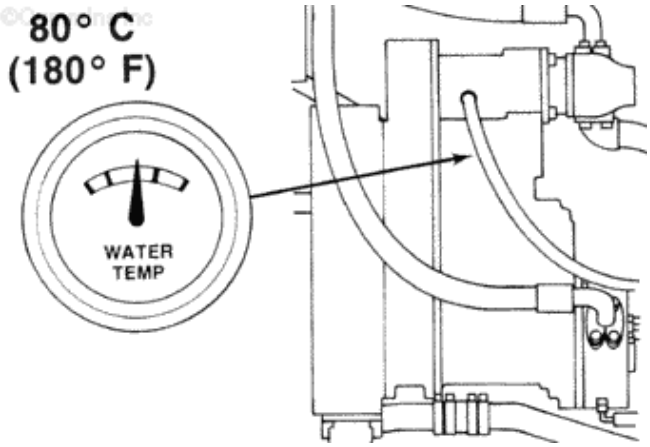
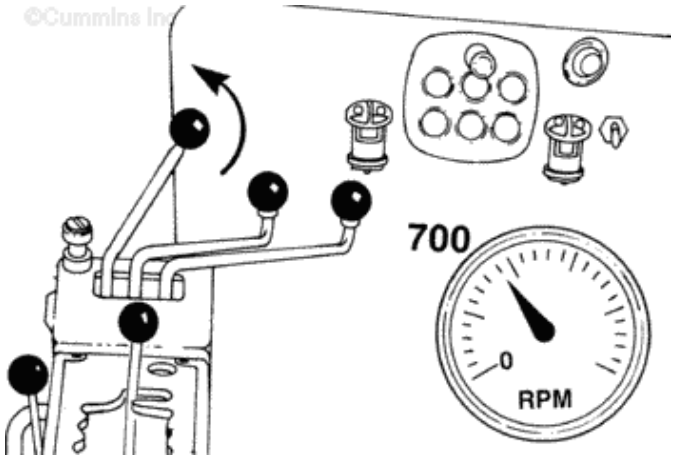
Do not exceed 120°C [250° F] converter oil temperature. If the oil temperature exceeds 120° C [250°F], put the transmission in neutral and operate the engine until the oil temperature is below 120°C [250°F]. Check the converter oil level.



The following equipment is needed for this check:

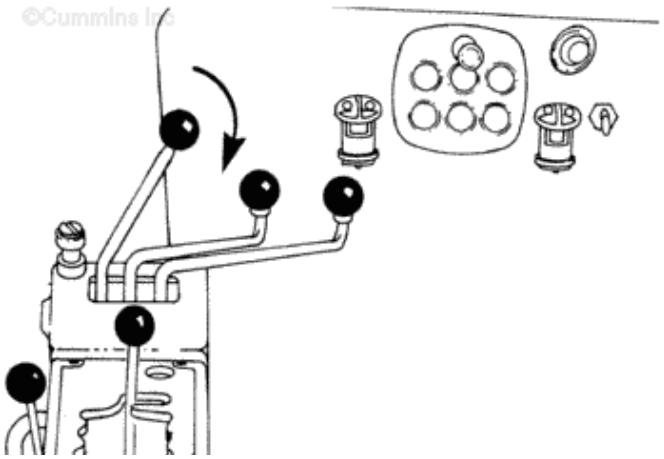
- Stop watch

• Digital tachometer, Part Number 3375631, or a hand held optical tachometer, Part Number 3377462. • Equipment manufacturer's stall speed and time to stall specifications.		
Install the tachometer on the fuel pump.		
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.		

Do **not** exceed 120°C [250°F] converter oil temperature.

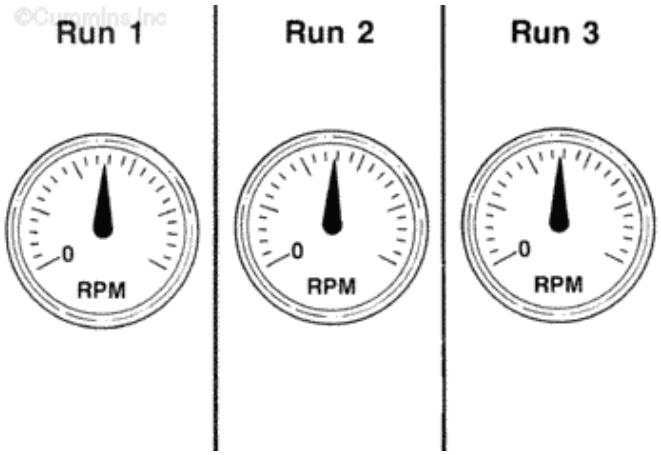
Move the throttle to the full open position. Do **not** perform this test for more than 15 seconds. If the engine speed continues to slowly increase, the torque converter fluid is being overheated.



Check the engine speed (rpm) at the point of stall.

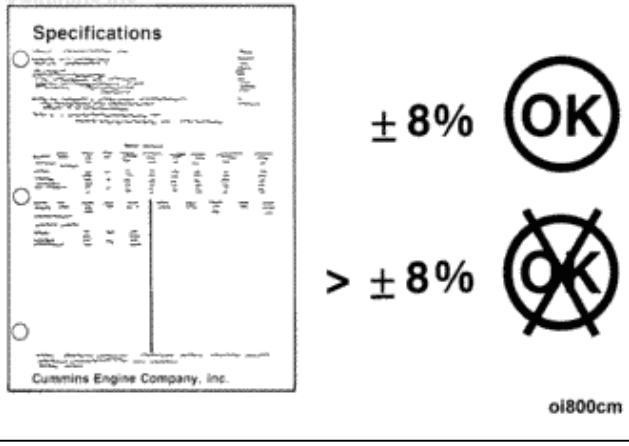
Always hold the speed until it is stable.

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.

The stall speed for the engine and converter/transmission can vary plus/minus 8 percent (±8%) from the manufacturer's specifications.



If the stall speed is **not** within the specifications, use the Stall Speed Check List .

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



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STALL SPEED CHECK LIST

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

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

If the cause for the stall speed being too low is low engine power output, check the Engine Power Output Low Troubleshooting Symptom . Make the correct repair based on the fuel rate, fuel pressure, and intake manifold pressure readings.

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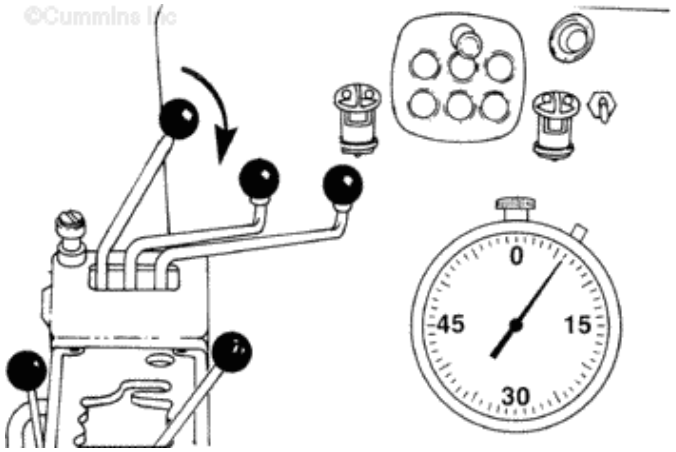
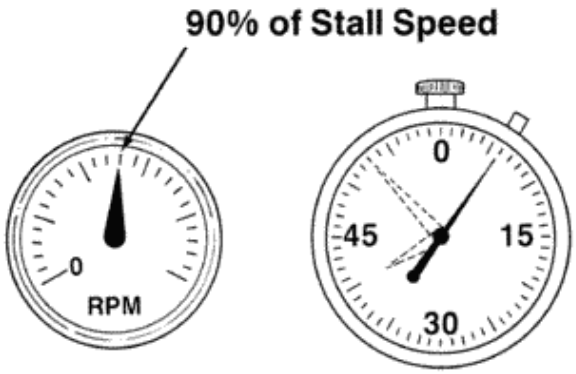
SYMPTOM: LOW POWER

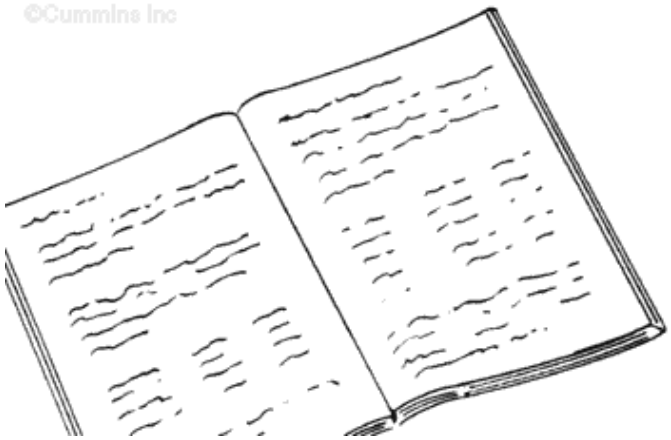
Cause	Correction
Vehicle Overloaded	Reduce vehicle load or use lower gear.
OK	
Low Power Due to Altitude	Derate engine above 3600 meters [12,000 feet]. Refer to page 5-3.
OK	
Fuel Suction Line or Fuel Filter Restricted	Check fuel inlet restriction. Refer to page 5-65.
OK	
Lubricating Oil Level Too High	Check dipstick calibration and oil pan capacity. Refer to pages 2-24 and 2-3.

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 .90 = 1880 rpm).

		©Cummins Inc Stall Speed X 90% =Stall Speed Reference Point Example: 2089RPM X .90 = 1880RPM
Quickly move the throttle to the full open position and start the stop watch at the same time.		©Cummins Inc 
When the engine speed is 90 percent (90%) of the stall speed rpm, stop the stop watch. 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.		©Cummins Inc 

Check the equipment manufacturer's specifications for the time to stall or the acceleration time. If the time is excessive, check the Engine Acceleration/Response Poor Troubleshooting Symptoms Tree.		

If the stall speed Is too low, check the following:

Stall Speed Check List (Stall Speed Too Low)			
Check Number	**Yes**	**No**	**Check Performed**
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 over-fueled engine that will also negatively affect durability. Do **not** increase the fuel rate as a cure-all.

If the stall speed is too high, check the following:

Stall Speed Check List (Stall Speed Too High)			
Check Number	**Yes**	**No**	**Check Performed**
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. (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.

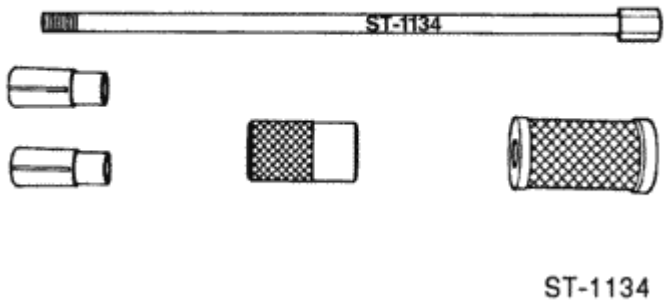
The reasons for abnormal stall speeds listed above are some which have been encountered by Cummins representatives and probably do **not** include all possible causes. The correction of the problem is either covered in the vehicle service manual, the converter service manual, or is self-explanatory.

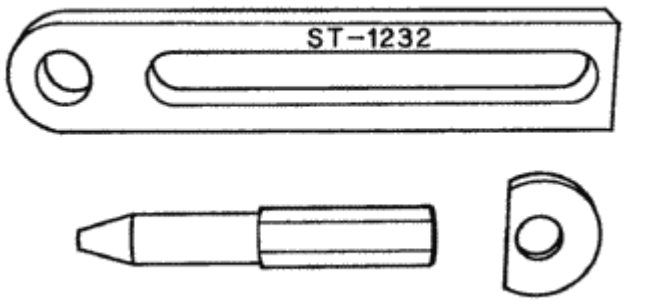
Last Modified: 29-Nov-2004

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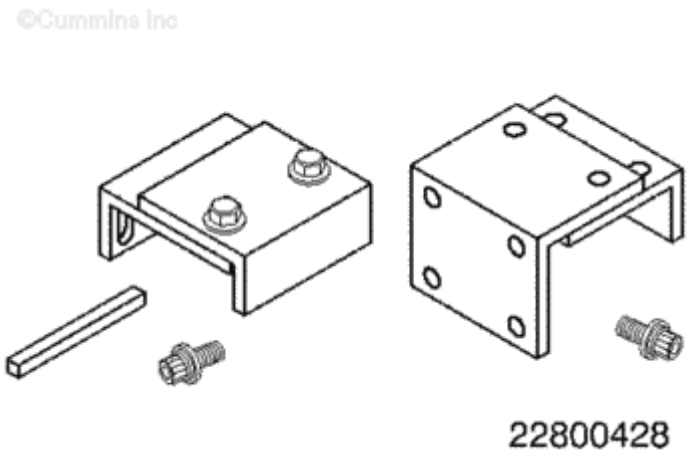
022-001 Service Tools

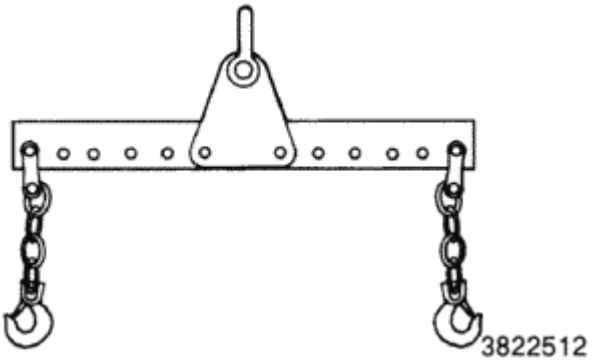
Mounting Adaptations

Tool Number		
ST-1134	**Dowel Pin Extractor** Use to remove dowel pins.	 ST-1134

Tool Number		
ST-1232	**Drill Ream Fixture** Machine dowel hole 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	Engine Support Bracket	

3375272	Attaches to the each side of the cylinder block and supports the front of the engine.	

Tool Number	**Engine Lifting Fixture**	
3822512	Use to remove and install the engine. Designed to lift 1816 kg [4000 lb].	

Last Modified: 29-Nov-2004

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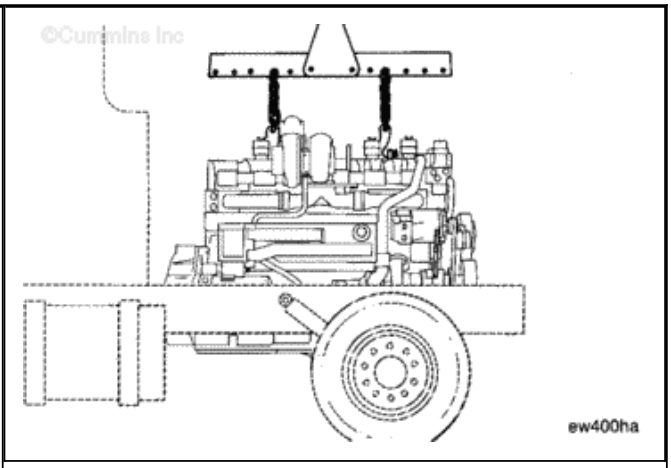
016-002 Engine Support Bracket, Front

Remove

WARNING

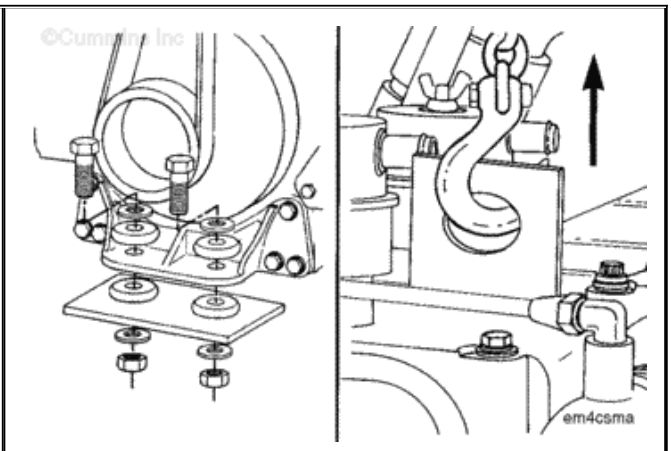
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component.

Install engine lifting fixture, Part Number 3822512.



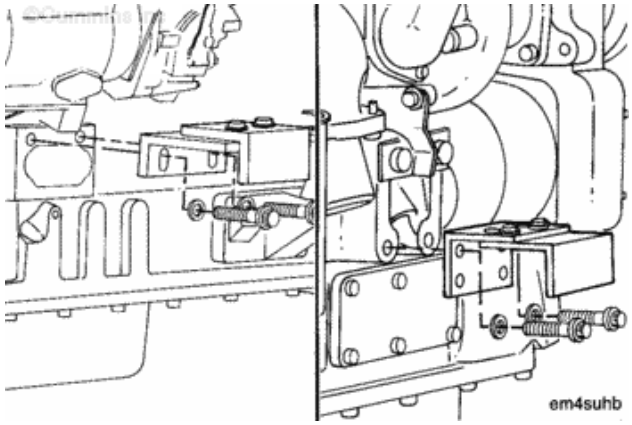
Remove the two capscrews that attach the support to the equipment frame.

Use a hoist to lift the weight of the engine off the front support.

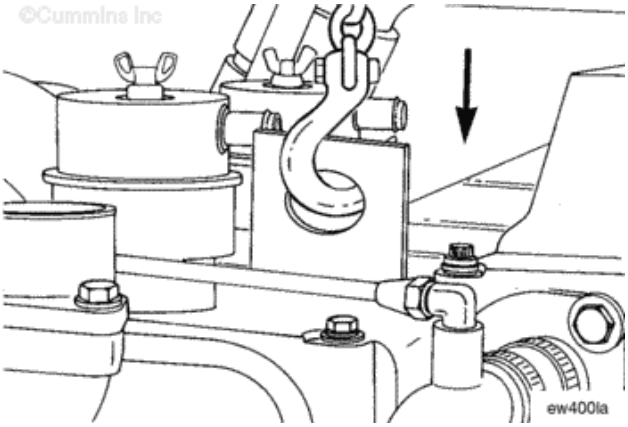


Use the engine support bracket kit, Part Number 3375272.

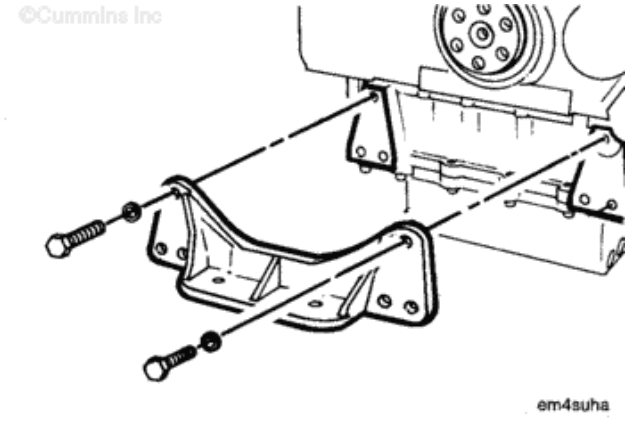
Install one bracket on each side of the engine.



Lower the engine until the brackets are supporting the weight.



Remove the front engine support.



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

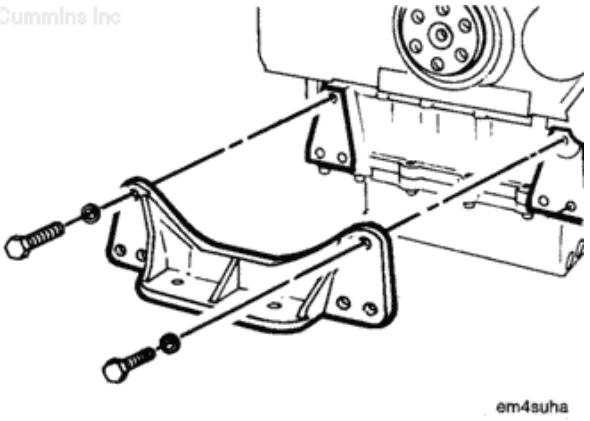
When using solvents, acids, or alkaline material for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause bodily injury.

Clean the engine support bracket with solvent or steam.

Dry with compressed air.

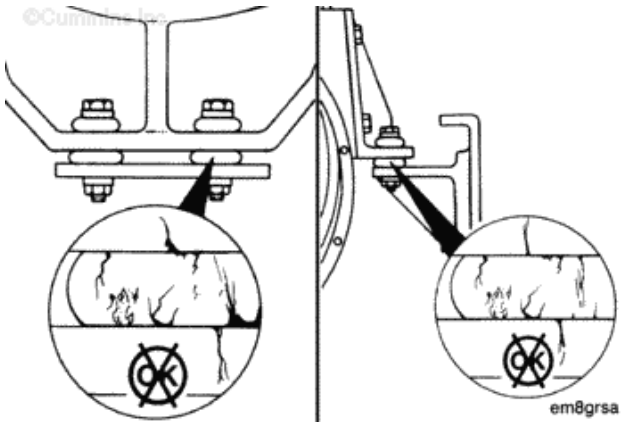


WARNING

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

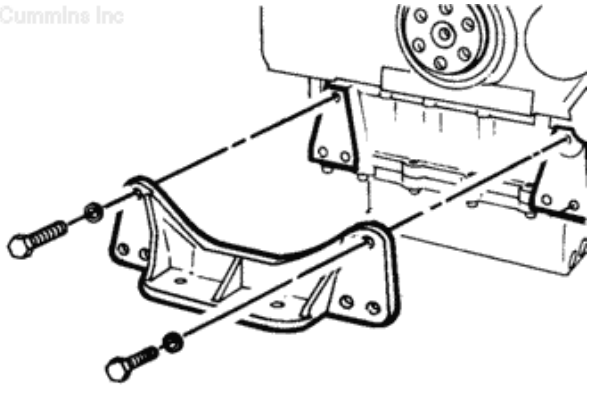
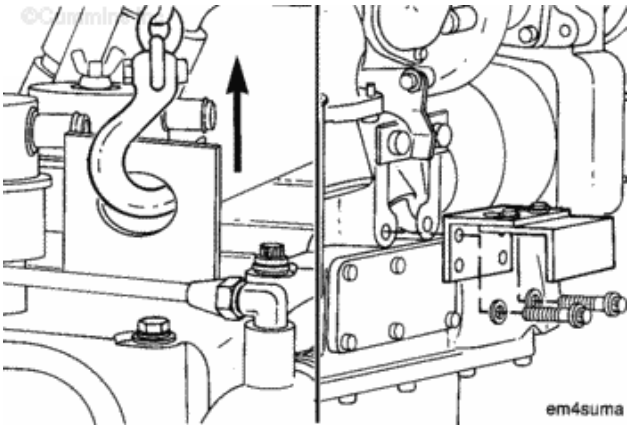
Clean the engine mounts.

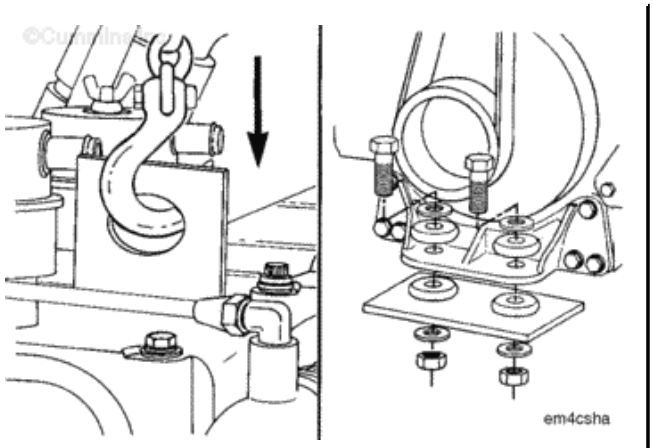
Check all rubber-cushioned mounts for cracks or damage.



Inspect all mounting brackets for cracks or damaged bolt holes. Damaged engine mounts and brackets can cause the engine to move out of alignment, damage the driveline components in the equipment, and result in vibration complaints.		

Install

WARNING This component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component. Install the support, washers, and capscrews. Tighten the capscrews. **Torque** **Value:** 195 n.m [145 ft-lb]		 em4suha
Raise the engine to remove the weight from the support brackets. Remove the support brackets.		 em4suma

Lower the engine until the front engine support is in position. Install and tighten the capscrews. Refer to the equipment manufacturer's instructions.		

Last Modified: 28-Jul-2006

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016-005 Flywheel

Preparatory Steps

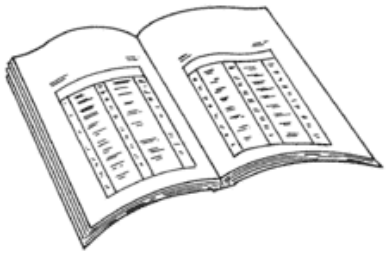
WARNING

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 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 or air starter to prevent accidental engine starting.
- Remove the transmission, clutch, and all related components. Refer to the equipment manufacturer's instructions.



ck800wa

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.

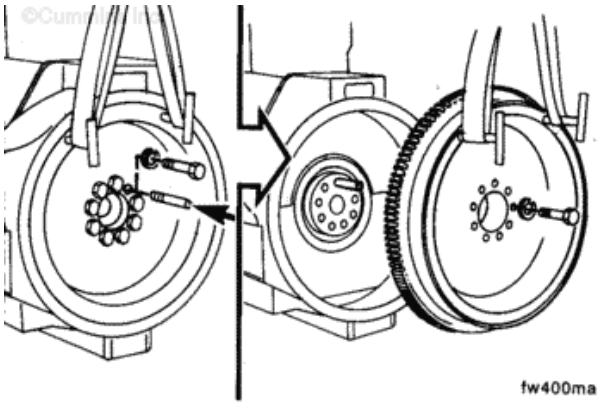
Use two [5/8-18 inch] guide studs to prevent the flywheel from rotating. Remove two capscrews and install the guide studs.

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

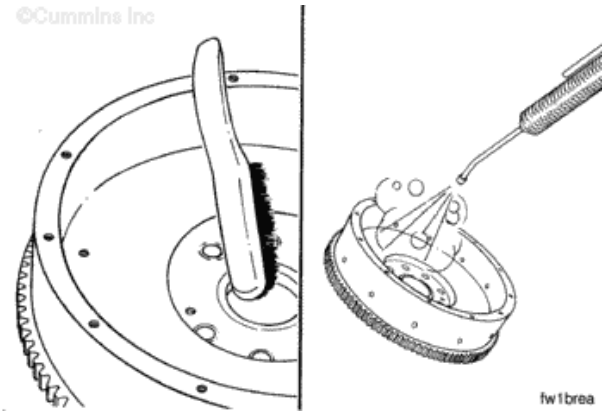
WARNING

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



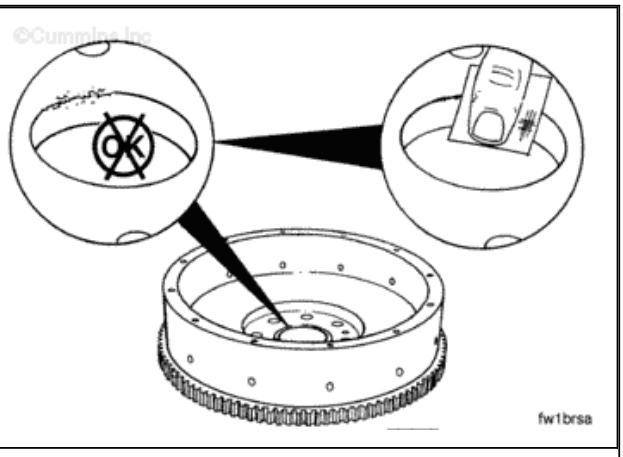
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use a wire brush to clean the crankshaft pilot bore. Use steam or solvent to clean the flywheel.

Dry with compressed air.

Inspect for nicks or burrs.

Use a crocus cloth to remove small nicks and burrs.

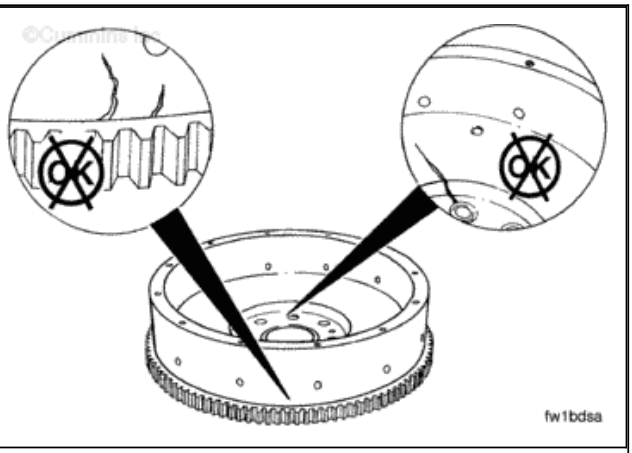


WARNING

Do not use a cracked flywheel. A cracked flywheel can break or cause serious personal injury.

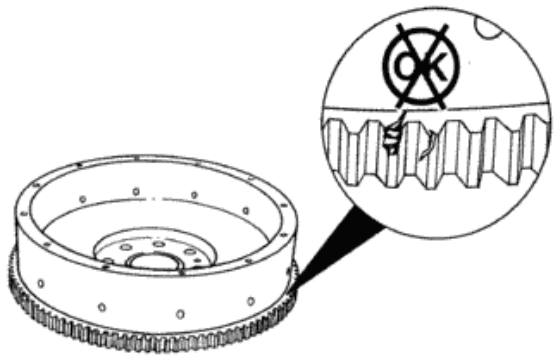
Inspect the flywheel for cracks.

If the flywheel is cracked, it **must** be replaced.



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.



Install

WARNING

The flywheel mounting capscrews must be a minimum of SAE Grade 8 with rolled threads. The flywheel mounting washers are special hardened plain washers. Use identical replacements to avoid possible flywheel failure resulting in personal injury or property damage.

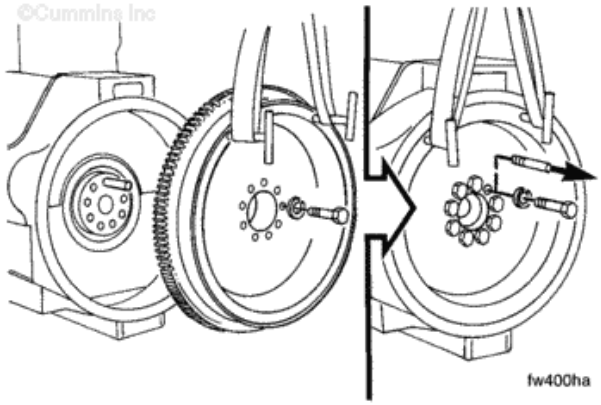
WARNING

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

Lubricate the capscrews and washers with engine oil. Allow the excess oil to drip off the parts.

Do **not** lubricate the threads of the crankshaft.

A guide stud will help during



assembly.

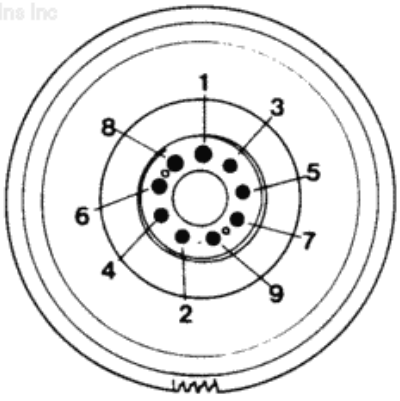
Install the flywheel, washers, and capscrews.

The flywheel **must** be firmly against the crankshaft.

Tighten the capscrews in sequence.

Torque Value: Step 1 150 n.m [110 ft-lb]

Step 2 285 n.m [210 ft-lb]



Measure

The crankshaft end clearance **must** be pushed or pulled in the same direction each time a point is measured.

Attach an indicator as shown.

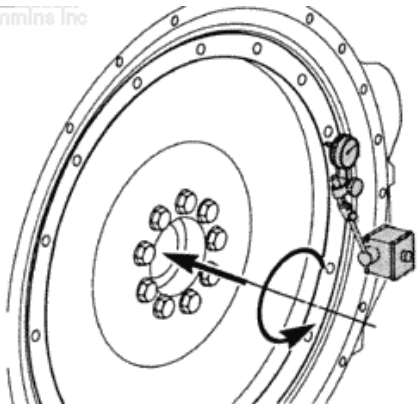
Measure the flywheel alignment at 4 equally spaced points.

Measure the distance from the center of the crankshaft to the indicator tip. Multiply the distance to obtain the maximum runout.

The alignment specification is 0.025 mm [0.001 inch] per 25.4 mm [1.0 inch] distance from the center of the crankshaft.

Center of Crankshaft-To-Indicator Tip:

Multiply by 0.025 mm [0.001



inch] to obtain the center of crankshaft-to-indicator tip.

If the flywheel alignment is **not** within specifications, check for interference between the flywheel and the crankshaft.

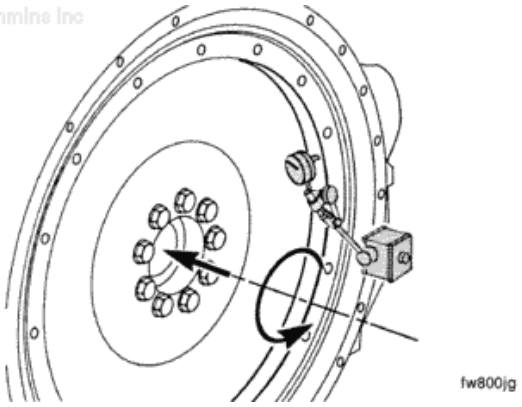
Attach an indicator as shown.

Observe the indicator while rotating the engine.

Measurements		
	mm	in
Maximum Radial Runout	0.13	0.005

If the 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.



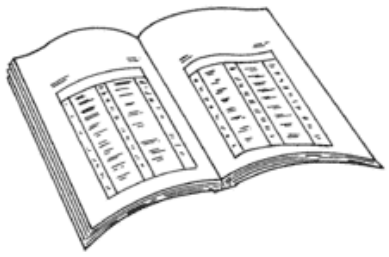
Finishing Steps

WARNING

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

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 clutch, transmission and all related components. Refer to the equipment manufacturer's instructions. • Connect the batteries or air starter. • Start the engine. Check the operation of the equipment.		

Last Modified: 29-Nov-2004

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016-006 Flywheel Housing

Preparatory Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, away 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 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

WARNING

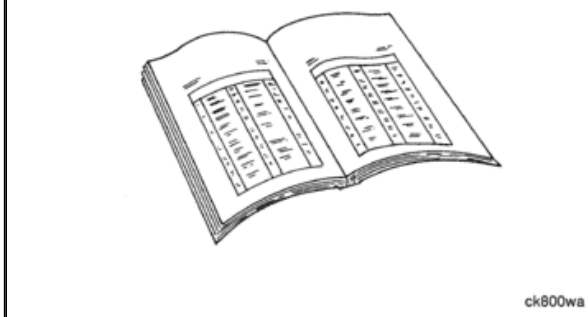
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

WARNING

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, or prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

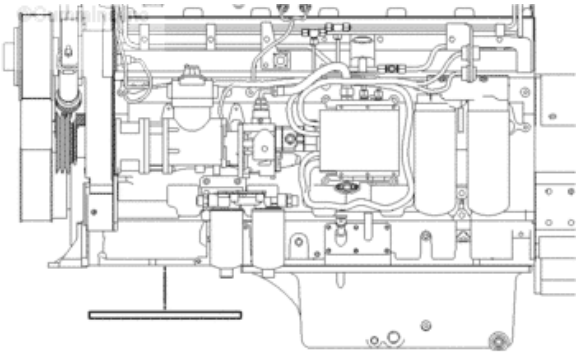
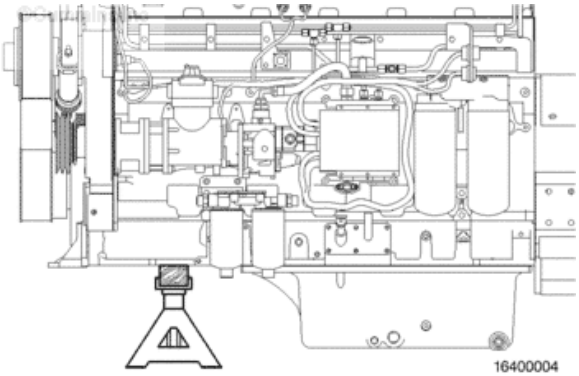
- Disconnect the batteries and air starter to prevent accidental engine starting.
- Remove the transmission, clutch, and all related components. Refer to the

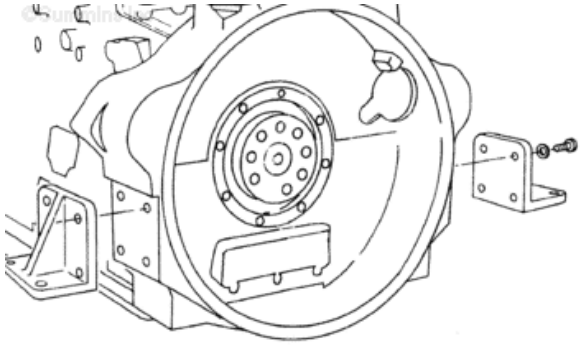




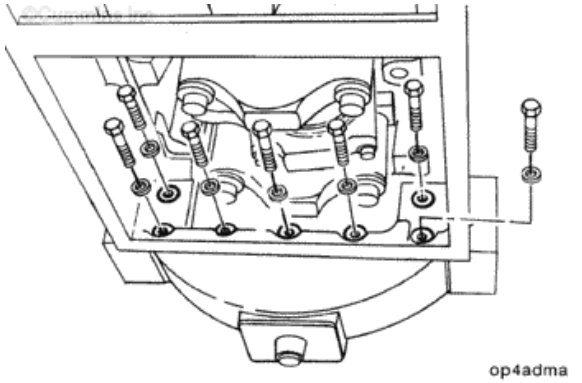
equipment manufacturer's instructions. • Remove the flywheel. Refer to Procedure 016-005. • Drain the oil. Refer to Procedure 007-037. • Remove the oil filters. Refer to Procedure 007-013. • Remove the rear crankshaft seal. Refer to Procedure 001-024. • Remove the starter motor. Refer to Procedure 013-020.		

Remove

Remove the adapter cover plate or oil sump (whichever is in the front position).		
Place a wooden block the width of the oil pan adapter between the floor jack and the oil pan adapter to prevent damage to the engine. Use a floor jack or a suitable lifting fixture to support the front of the engine. Put the support in position to allow access to the capscrews in the oil pan adapter that attach to the flywheel housing.		
Remove the rear engine mounts from the flywheel housing.		



Remove the two [7/16-14 inch] capscrews, and the five [3/8-16 inch] capscrews from the flywheel housing.



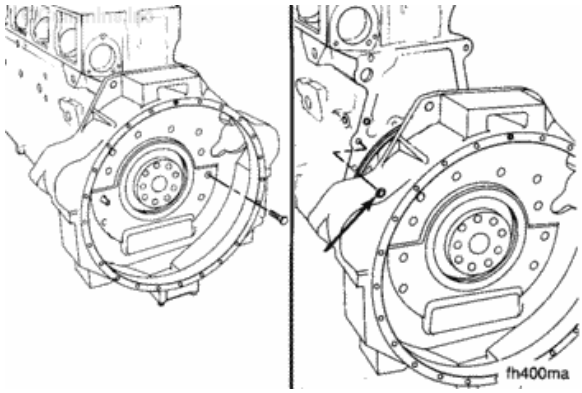
WARNING

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.

Use two guide studs to prevent the flywheel housing from rotating during disassembly.

Remove the two capscrews.

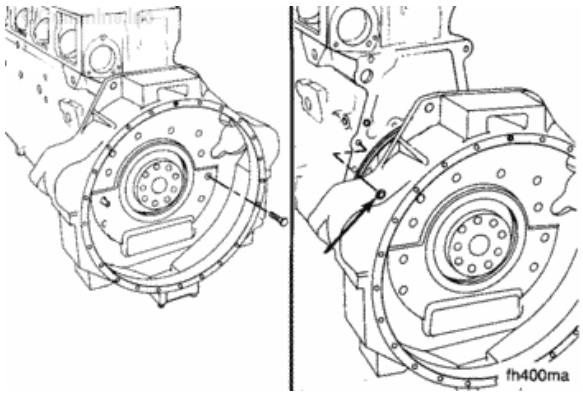
Install the guide studs.



Use a hoist, a tee handle, and a lifting sling. Install the tee handle.

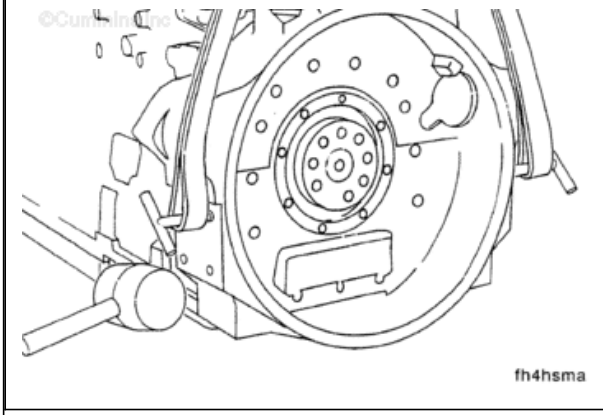
Adjust the hoist until there is tension in the lifting sling.

Remove the remaining capscrews.



Use a mallet and tap the flywheel housing off the two locating dowels.

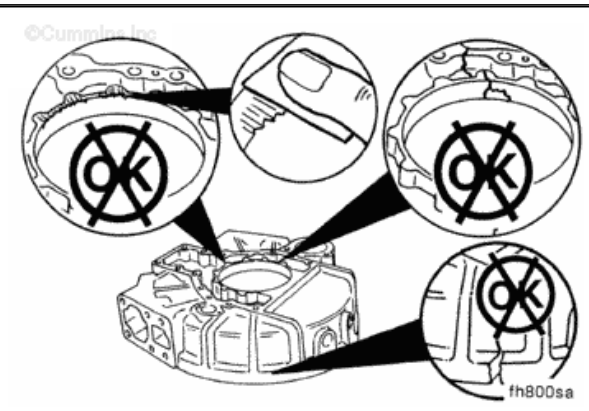
Remove and discard the rectangular seal and the bolt seals.



Inspect for Reuse

Inspect all surfaces for nicks, burrs, or cracks.

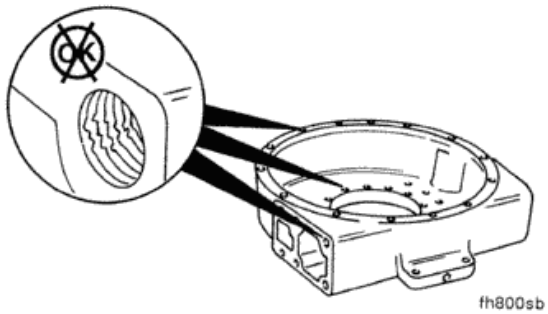
Use a fine crocus cloth to remove small nicks and burrs.



Inspect all threaded capscrew holes

for damage.

Repair or replace the housing if the capscrew holes are damaged.

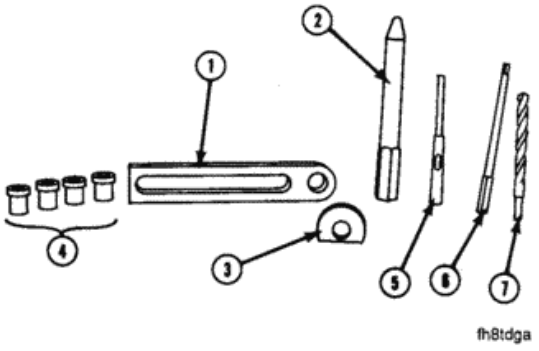


Redowel

The tools needed to perform this procedure are:

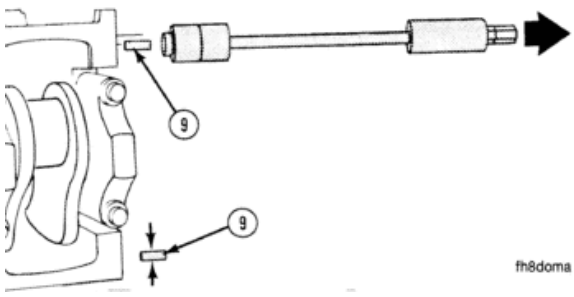
The kit needed to perform this procedure is the drill ream fixture, Part Number ST-1232, and it contains:

(1) Plate, Part Number ST-1232-1
(2) Locator Pin, Part Number 3375052
(3) Spacer washer, Part Number ST-1232-2
(4) Drill/Ream bushing set (actual sizes depend on the dowel size as listed)
(5) Drill adapter (locally obtained; use to adapt open (1) shank reamers to drill-chuck)
(6) Reamer (locally obtained)
(7) Drill bit (locally obtained).



Remove the two dowels (9) from the block with dowel pin extractor, Part Number ST-1134, or equivalent.

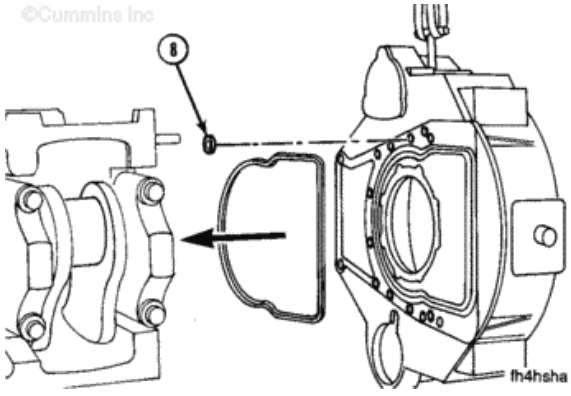
Measure a dowel pin that is removed so that an oversize dowel pin can be determined.



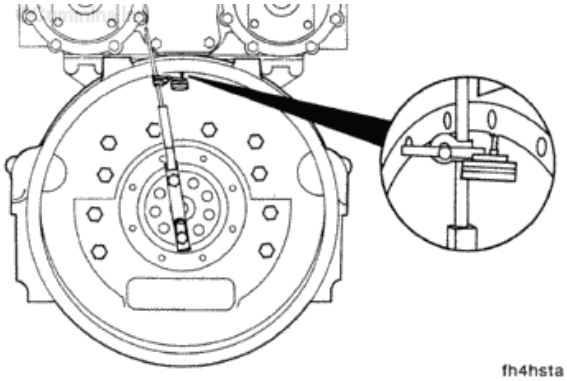
WARNING

This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance when lifting this component.

Install the new rectangular seals (8) in the flywheel housing.



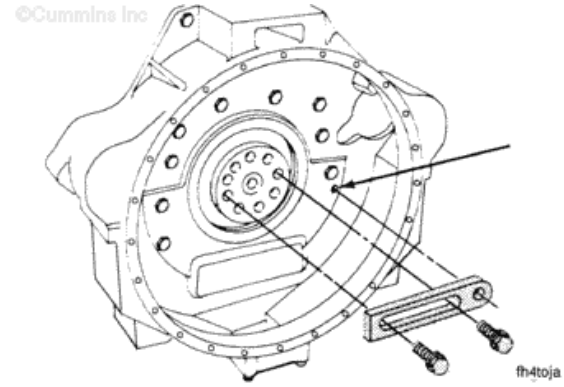
Install and align the flywheel housing.



Use the appropriate size capscrews.

Attach the plate, Part Number ST-1232-1, that is contained in drill ream fixture, Part Number ST-1232.

Hand-tighten the capscrews so the plate can be moved.



CAUTION

Be sure the crankshaft is in the locked position during reaming to prevent damage.

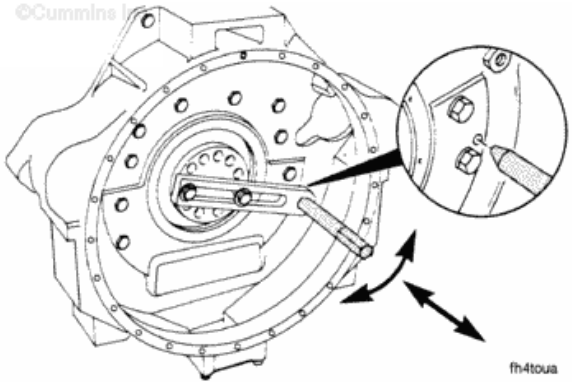
Use the locator pin to align the plate with

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.

Lock the crankshaft in position. Check to be sure the locator pin is still in alignment and that the locator pin can be rotated easily.



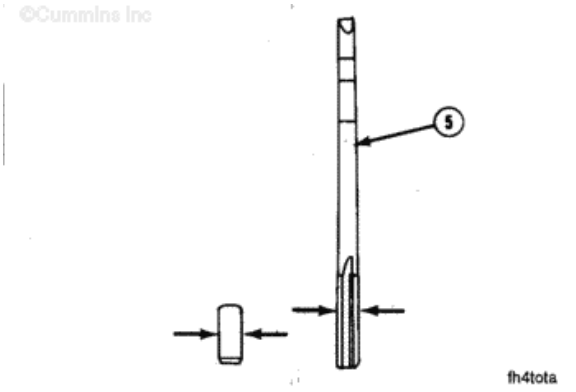
Measure the dowel pins to be installed.

Obtain a reamer (5) that is 0.13 mm to 0.02 mm [0.005 in to 0.001 in] smaller than the dowel.

The dowel **must** be long enough to protrude from the block one-half of the flywheel housing wall thickness.

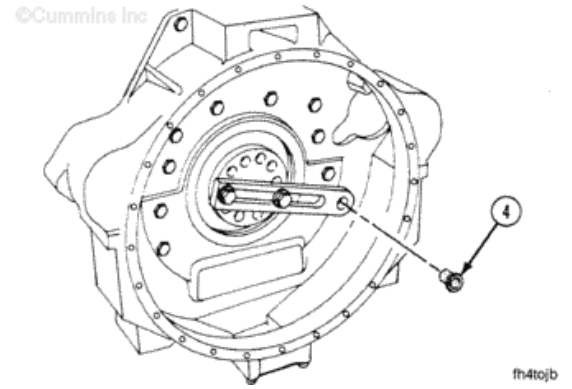
There are three oversize dowel pins available from Cummins Inc.

Oversize Dowel Pin Outside Diameter	
Overall Dimension	**Oversize**
13.08 mm [0.515 in]	0.38 mm [0.015 in]
13.46 mm [0.530 in]	0.76 mm [0.030 in]
13.84 mm [0.545 in]	1.14 mm [0.045 in]



Install the appropriate drill bushings (4). The table shows the bushings available from Cummins Inc.

Drill/Ream Bushing Sets - 25.4 mm [1 Inch] Outside Diameter		
Tool Number	**Oversize**	**Bushing Size**
	Special	12.304 mm [0.4844 in]
	Standard	12.700 mm [0.500 in]
	0.38 mm	13.096 mm



	[0.015 in]	[0.5156 in]
3376495	0.76 mm [0.30 in]	13.494 mm [0.5312 in]
	1.14 mm [0.045 in]	13.879 mm [0.5464 in]
ST-1234	Standard	14.288 mm [0.5625 in]
	0.38 mm [0.015 in]	14.684 mm [0.5781 in]
	0.76 mm [0.030 in]	15.081 mm [0.5937 in]
	1.14 mm [0.045 in]	15.478 mm [0.6094 in]
ST-1235	Standard	15.875 mm [0.6250 in]
	0.38 mm [0.015 in]	16.272 mm [0.6406 in]
	0.76 mm [0.030 in]	16.669 mm [0.6562 in]
	1.14 mm [0.045 in]	17.066 mm [0.6719 in]
ST-1236	Standard	17.463 mm [0.6875 in]
	0.38 mm [0.015 in]	17.859 mm [0.7031 in]
	0.76 mm [0.030 in]	18.256 mm [0.7187 in]
	1.14 mm [0.045 in]	18.653 mm [0.7344 in]
ST-1237	Standard	19.050 mm [0.7500 in]
	0.38 mm [0.015 in]	19.447 mm [0.7656 in]
	0.76 mm [0.030 in]	19.844 mm [0.7812 in]
ST-1238		22.621 mm [0.8906 in]
		23.813 mm [0.9375 in]

The drill bushing that is used **must** be the same size as the reamer (or the drill) that is used.

CAUTION

Do not allow metal chips to enter the engine. Damage to the engine will result.

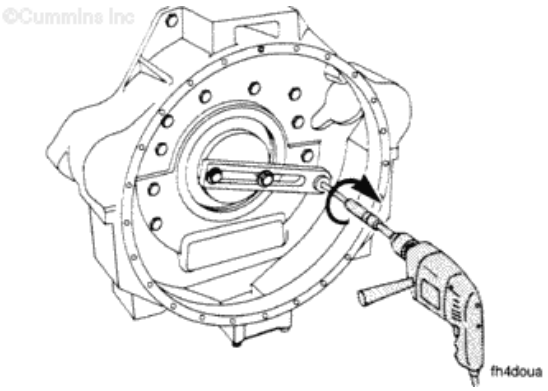
If the new dowel pins are more than 0.38 mm [0.015 in] larger than the old dowels, drill the hole to a size that is slightly smaller than the reamer. Then the reamer will **not** have to remove an excess amount of material.

Ream the hole until the reamer touches the bottom of the hole in the block.

Remove the reamer.

Clean the hole and run the reamer through the hold 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 second dowel hole. Repeat the procedure in the second hole.

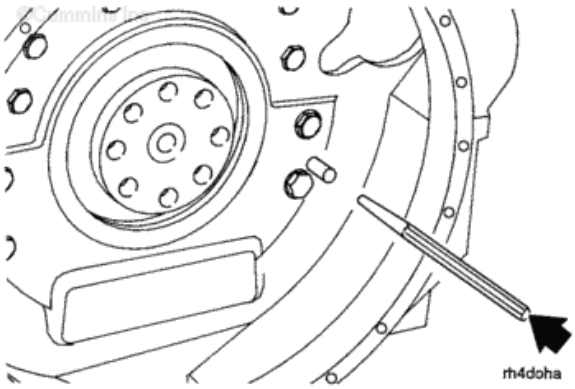


CAUTION

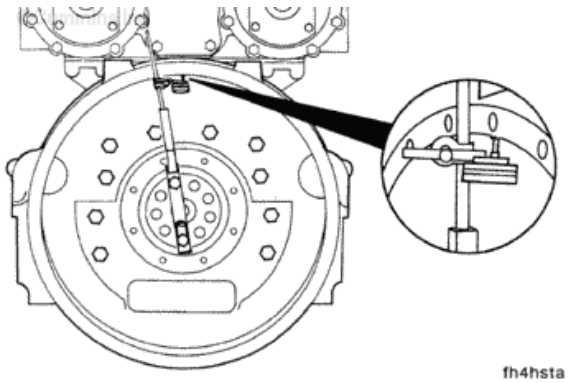
Be sure the dowel hole does not contain any metal chips. Engine damage will result.

Remove the plate from the crankshaft.

Use a square nose drift. Drive each dowel in until it touches the bottom of the hole in the block.



After the dowels are installed, measure the bore and the face alignment again.



Install

WARNING

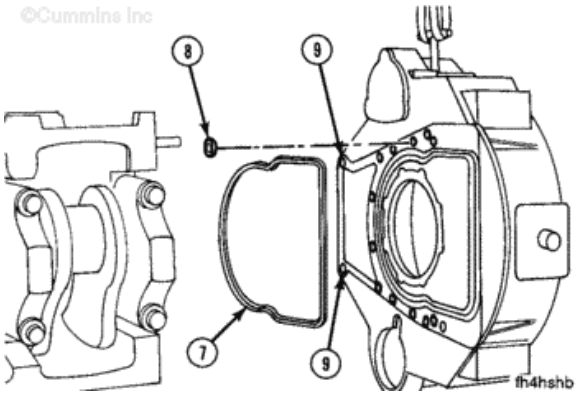
This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance when lifting this component.

Make sure the flywheel housing dowels are installed in the block.

Install the sealing ring (7) in the groove on the housing. If a wet type is used, install the seals (8) in the counterbores as shown. The holes (9) do **not** require seals.

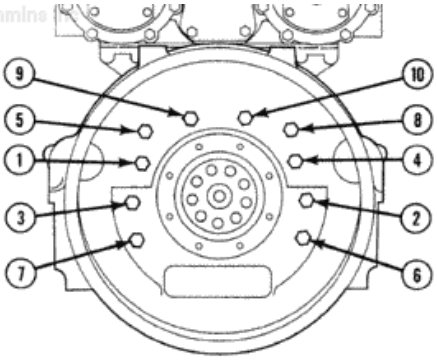
Use guide bolts to help during alignment.

Install the housing and the capscrews.



Tighten the flywheel housing capscrews using the sequence shown.

Torque Value:	Step 1	100 n.m [75 ft-lb]
	Step 2	205 n.m [150 ft-lb]

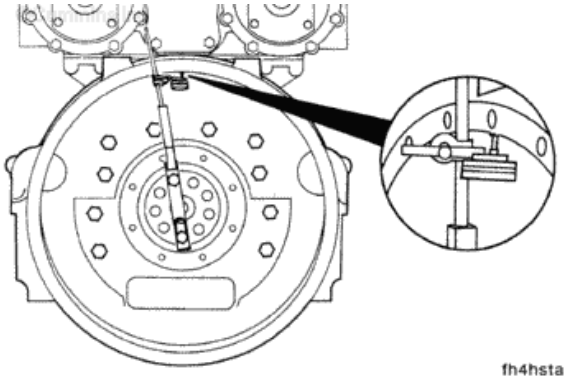


Measure the flywheel housing alignment.

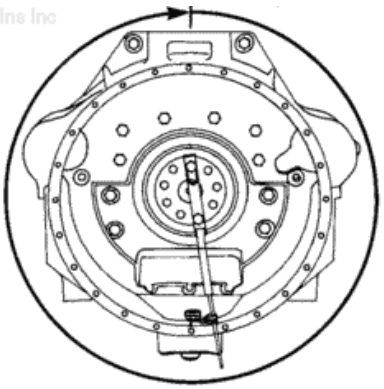
The bore and the face of the housing **must** be in alignment with the crankshaft.

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.

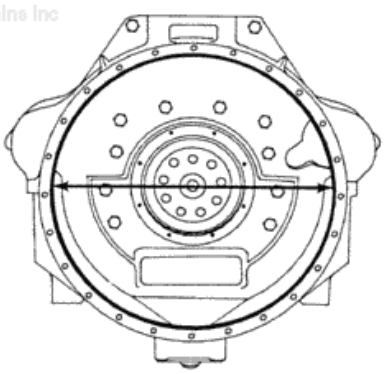


The maximum allowable total indicator runout depends on the diameter of the bore.

Bore Diameter Maximum Total Indicator Runout		
SAE Number	**Size**	**Minimum/Maximum**
00	0.30 mm [0.012 in]	787.4 to 810.5 mm [31.00 to 31.91 in]
0	0.25 mm [0.010 in]	647.7 to 648.0 mm [25.50 to 25.51 in]
½	0.25 mm [0.010 in]	584.2 to 584.4 mm [23.00 to 23.008 in]
1	0.20 mm [0.008 in]	511.2 to 511.3 mm [20.125 to 20.13 in]

If the alignment is **not** within specifications and the bore is round, the housing can be shifted.

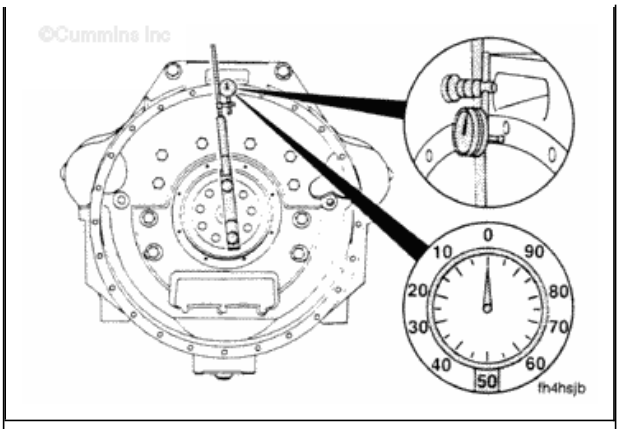
If the alignment is **not** within specifications and the bore is **not** round, the housing **must** be replaced.



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.

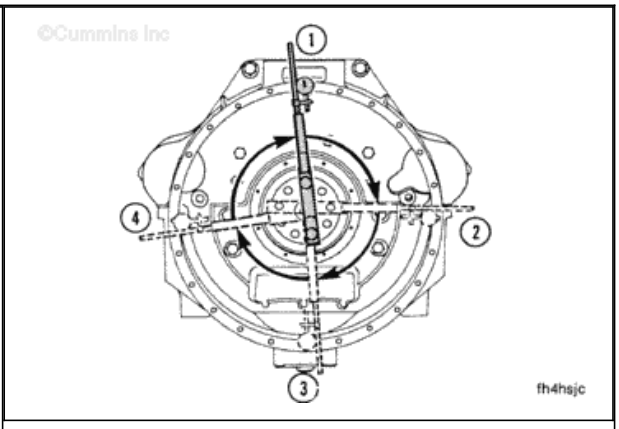


Record the indicator reading at three different points; 3 o'clock, 6 o'clock, and 9 o'clock.

Turn backward to the original position. Be sure the needle still points to zero. Determine the total indicator runout.

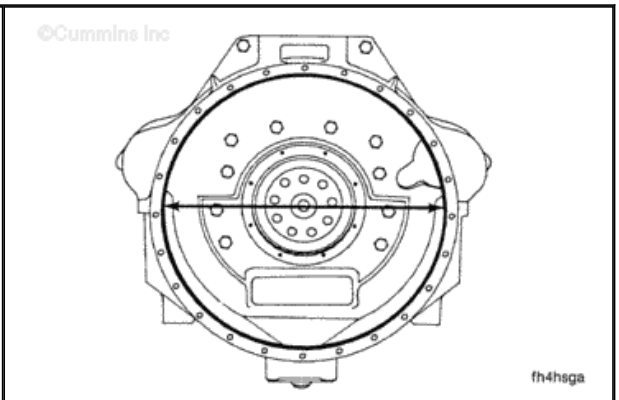
Example:

3 o'clock 0.00 mm [0.00 in] + 6 o'clock +0.08 mm [+0.003 in] + 9 o'clock -0.05 mm [-0.002 in] = 0.13 mm [0.005 in] total indicator runout.



The maximum allowable total indicator runout depends on the diameter of the bore.

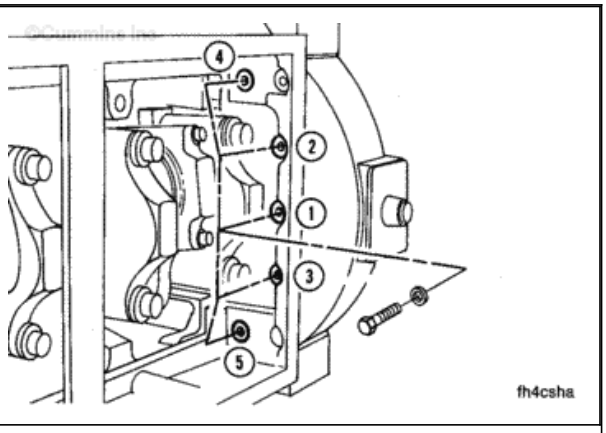
Bore Diameter Maximum Total Indicator Runout		
SAE Number	**Size**	**Minimum/Maximum**
00	0.30 mm [0.012 in]	787.4 to 810.5 mm [31.00 to 31.91 in]
0	0.25 mm [0.010 in]	647.7 to 648.0 mm [25.50 to 25.51 in]
½	0.25 mm [0.010 in]	584.2 to 584.4 mm [23.00 to 23.008 in]
1	0.20 mm [0.008 in]	511.2 to 511.3 mm [20.125 to 20.13 in]



If the alignment is **not** within specifications, remove the housing. Check for nicks, burrs, or foreign material between the block and the housing. Check the alignment again. If the alignment is **not** within specifications, the block or the housing is **not** machined correctly.

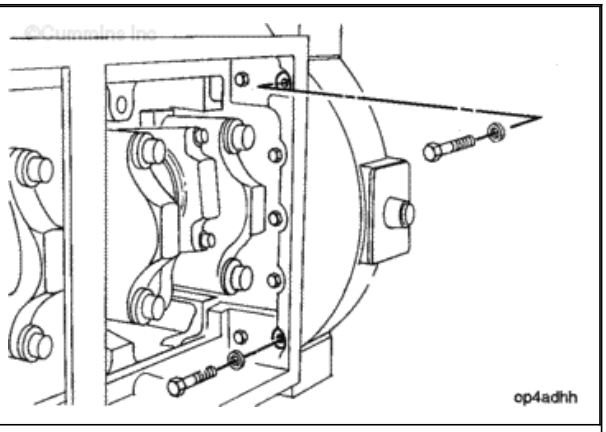
Tighten the five [3/8-inch] washers and capscrews in the sequence shown.

Torque Value:	Step 1	25 n.m [20 ft-lb]
	Step 2	40 n.m [30 ft-lb]
	Step 3	45 n.m [35 ft-lb]



Install the two [7/16-inch] washers and capscrews as shown. Tighten the capscrews.

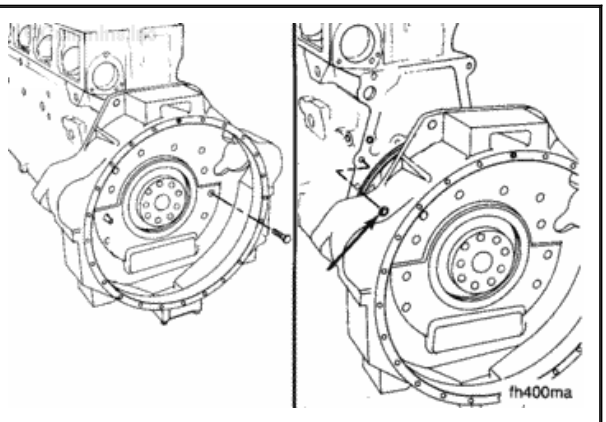
Torque Value: 65 n.m [50 ft-lb]



Install the flywheel housing mounting capscrews.

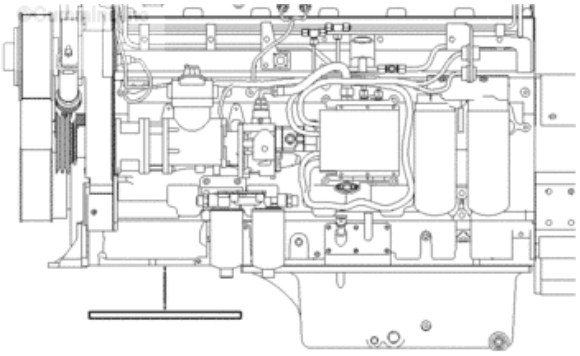
Tighten the capscrews.

Torque Value: 205 n.m [150 ft-lb]



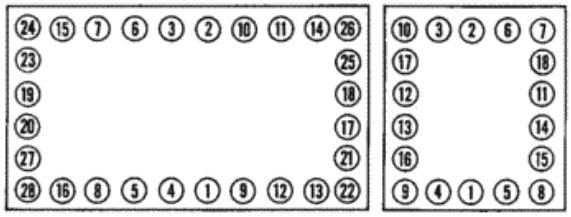
Gasket cement will prevent the gasket from sealing properly. Use a contact adhesive, such as 3M Spray 77 or 3M 1463, to hold the gasket in position.

Install the gasket, oil plate (or sump), washers, and capscrews.



Tighten the capscrews in the sequence shown.

Torque Value: 45 n.m [35 ft-lb]



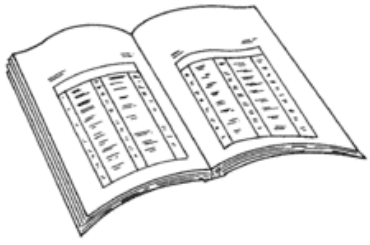
Finishing Steps

WARNING

This component weighs 23 kg [50 lb] or more. To reduce the possibility of personal injury, use a hoist or get assistance when lifting this component.

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, away 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 rear crankshaft seal. Refer to Procedure 001-024. • Install the starter motor. Refer to Procedure 013-020. • Install the oil filters. Refer to Procedure 007-013 • Fill engine with oil. Refer to Procedure 007-037. • Install the flywheel. Refer to Procedure 016-005. • Install the clutch, transmission and all related components. Refer to the manufacturer's instructions. • Connect batteries or air supply to air starter. • Operate the engine and check for leaks.		

Last Modified: 29-Nov-2004

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016-008 Flywheel Ring Gear

Disassemble

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

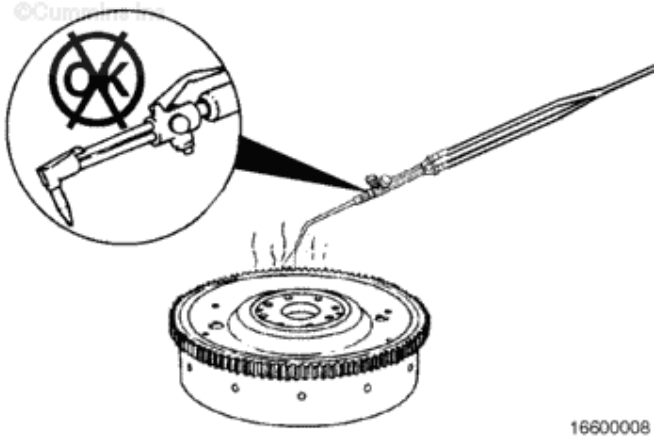
To reduce the possibility of personal injury or equipment damage, this procedure must only be performed by suitably qualified service technicians.

WARNING

To reduce the possibility of personal injury, wear goggles and protective clothing.

CAUTION

Adjust the torch to a good heating flame. Do not use a cutting flame (a blue flame) to heat the ring gear. Damage to the flywheel can result.



CAUTION

Do **not** use a steel drift.

Heat the ring gear with a torch

Use a brass drift and a hammer to remove the hot ring gear.

WARNING

To reduce the possibility of personal injury or equipment damage, this procedure must only be performed by suitably qualified service technicians.

WARNING

To reduce the possibility of personal injury, wear goggles and protective clothing.

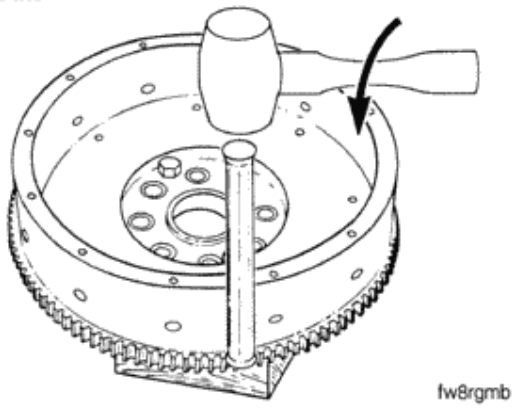
CAUTION

Do **not** use a steel drift.

If a heating torch is **not** available, the ring gear can be removed with a brass drift and hammer.

If this method is used to remove the ring gear from a flexplate assembly, make sure a wooden block is used to support the ring gear adapter.

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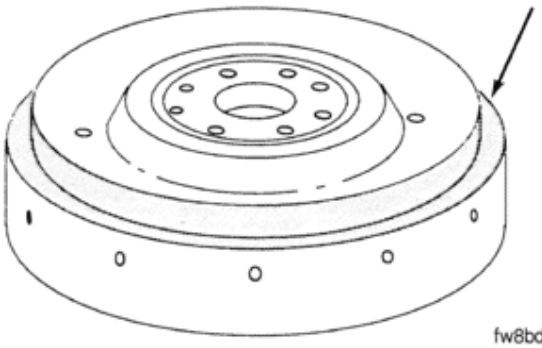
fw8rgmb

Clean and Inspect for Reuse

Check the flywheel outside diameter for damage at the ring gear location.

If the flywheel is damaged, it **must** be replaced.





Assemble

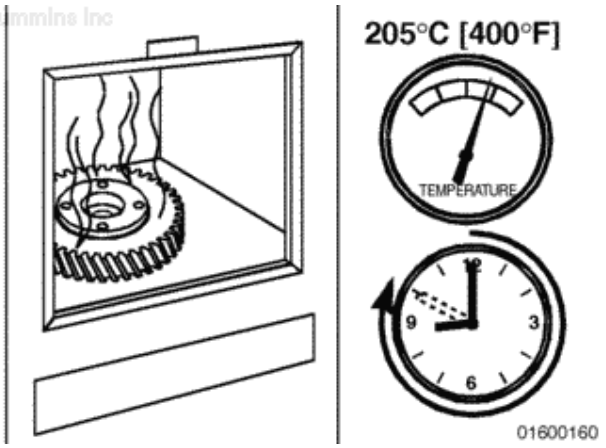
WARNING

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

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

CAUTION



Do not exceed the specified time or temperature. Damage to the ring gear and ring gear teeth can result.

CAUTION

Do not attempt to install the ring gear without heating it. The ring gear will be damaged or broken.

Preheat the oven to an adjusted temperature of 205°C [400°F].

Heat the ring gear in the oven for a **minimum** of 40 minutes but **not** more than a maximum of one hour.

The inner diameter of the ring gear will become larger and simplify the installation of the ring gear on the flywheel.

WARNING

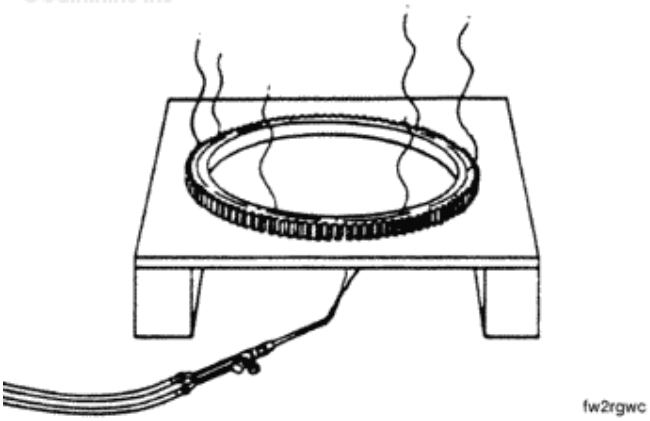
To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

Use a heating flame to heat the gear if an oven is not available.

Use a temperature indicator marker (Templistik®), Part Number 3165163, or equivalent, to check the temperature of the gear.

Heat the gear to 232°C [450°F].

A more even temperature is obtained by placing the ring gear on a metal plate and then

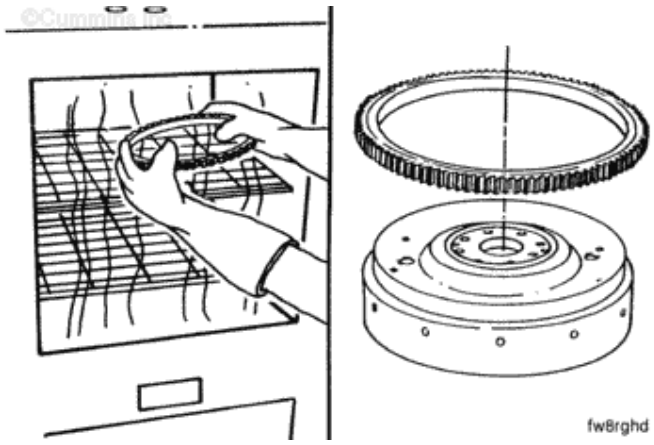


heating the bottom side of the plate with the torch. Do **not** exceed the specified temperature.

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

Remove the ring gear from the oven.



WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

CAUTION

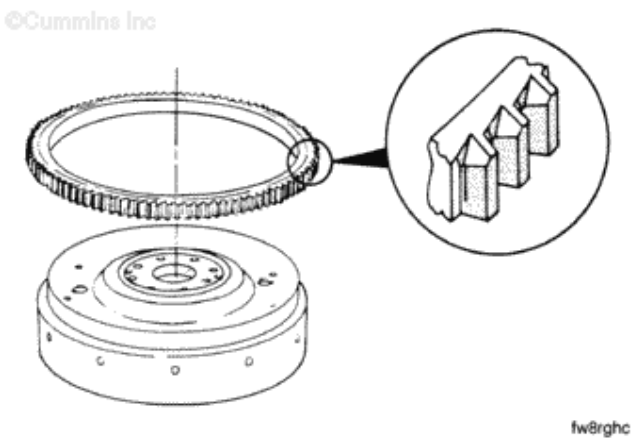
Allow the ring gear to air cool. Do not use water or oil to reduce the cooling time. Damage to the ring gear can result.

The part number is on the same side as the bevel.

Position the ring gear so that the bevel is positioned toward the crankshaft edge of the flywheel as shown.

Install the ring gear.

When installed correctly, the



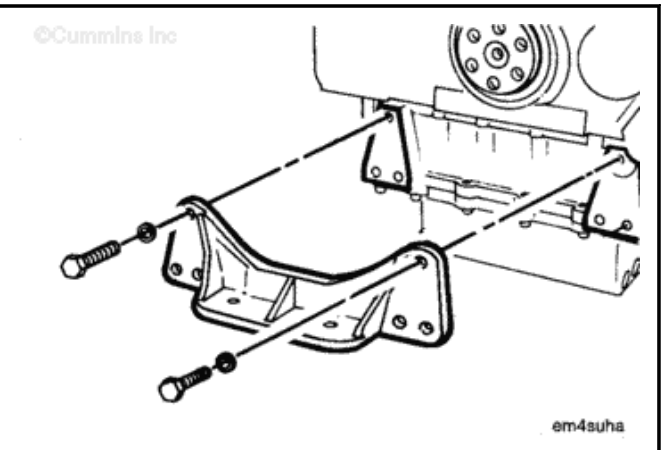
bevel machined at the root of each gear tooth will be toward the starting motor when the flywheel is installed.		

Last Modified: 06-Nov-2013

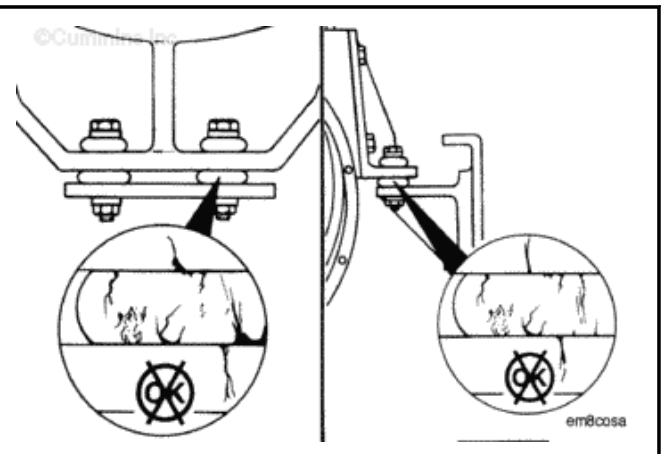
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016-010 Engine Mounts

Remove

Remove the front engine support capscrews. Remove the front engine support.		

Clean and Inspect for Reuse

Inspect all rubber-cushioned mounts for cracks or damage. Inspect all mounting brackets for cracks or damaged bolt holes. Damaged engine mounts and brackets can cause the engine to move out of alignment, can damage the drive line components in the equipment, and can result in vibration complaints.		

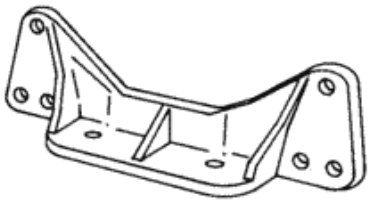
WARNING

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, Part Number 3824421 or equivalent to clean the support.

Inspect the support for cracks or damage.

If the support is cracked or damaged, it **must** be repaired or replaced.



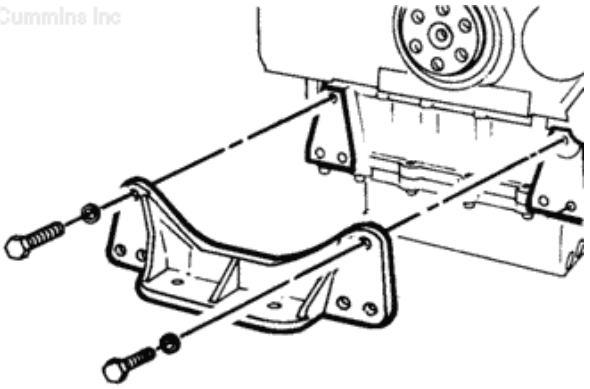
01400415

Install

Install the front engine support and capscrews.

Tighten the capscrews.

Torque
Value: 195 n.m [145 ft-lb]



em4suha

Last Modified: 27-Oct-2004

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020-999 Vehicle Braking - Overview

General Information

For the installation and adjustment of the Jacobs® Engine Brake Model K-1200 refer the equipment manufacturer's instructions.

The Model K-1200 replaces Jacobs® K-200 and K-1150 engine brakes.

When installing a Jacobs® engine brake, the Cummins KT-450 and KTC-450 engine models **must** include a spacer group option.

Last Modified: 20-Dec-2004

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021-009 Generator, Main

General Information

Alternator

The alternator is a Newage Stamford, four pole, three phase, 50 and 60 Hz design. It is a brushless rotating field design and is built to meet BS5000 Part 3 and international standards. The alternator is self-excited with excitation power from a permanent magnet generator (PMG) powered excitation system. The service alternate will be Part Number 4930067. It will be re-connectable for varying voltage outputs. The procedure for reconnecting is included on the manuals which ship with the alternator.

The manufacturer's installation service and maintenance manual is available on the manufacturer's website at:

- http://www.newage-avkseg.com/engish/content/download/newage/manuals/hc/HC4-7English.pdf

For service parts and contacts, information can be viewed at the following address:

- http://www.newage-avkseg.com/select_language.html

NOTE: To access this document, copy the URL above and paste it into your web browser address bar.

Generator Control Panels

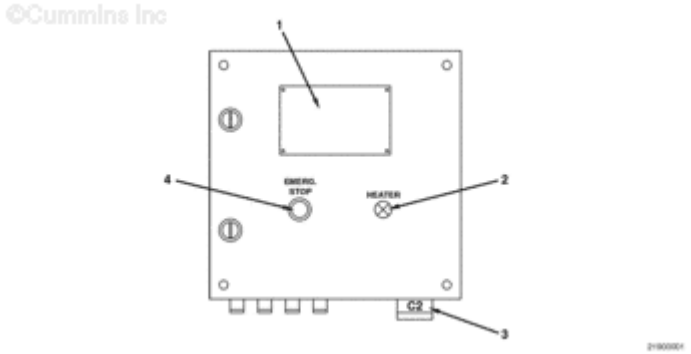
There are three different generator control panel options consisting of two types of panels.

The following is a breakdown of the generator control panel options.

Control Panel Options			
Option Number	**Panels Used**	**Quantity**	**Description**
GP 4001	None	0	No controls
GP 4002	3978367	1	Base panel
GP 4003	3978367	1	Base panel
	3972970	1	Remote panel

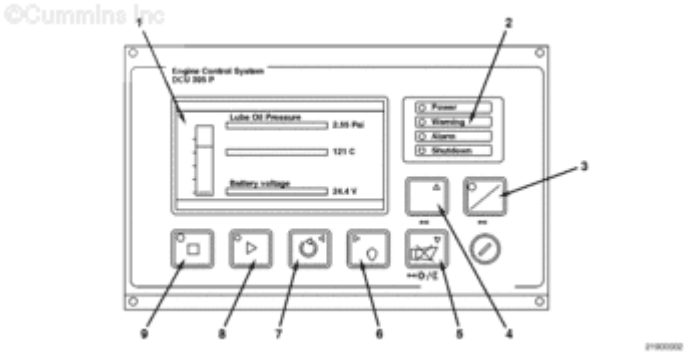
GP 4004	3978367	1	Base panel
	3972970	2	Remote panel

Panel Descriptions



Base Panel Cabinet into which the base panel mounts.

1. Control panel
2. Block heater indicator button
3. Cable connection
4. Emergency stop button



Base Control Panel

1. Digital display
2. LED indicator lights
3. Button A: toggles between instrument view and alarm list view
4. Button B: toggles between two instrument views
5. Alarm silence
6. Backlight on/off
7. Alarm acknowledge
8. Start button
9. Stop button.

The base panel is an electronic control unit for controlling and monitoring diesel engines used as propulsion engines or generator sets. The base panel monitors the following data:

- oil pressure
- oil temperature
- turbocharger pressure
- coolant temperature
- battery voltage
- engine speed
- exhaust temperature
- total engine hours
- trip engine hours
- number of starts.

The panel is also equipped with an event log which records a history of the last 500 events such as alarms, start ups, and shut downs.

The base panel has several built in alarms as shown in the table below.

Base Panel Built-in Alarms	
Alarm	**Description**
Low battery voltage	Low voltage at the start battery
Secondary battery low voltage	Low voltage at the secondary battery source
Overspeed	Engine running faster than the overspeed setpoint
Engine Stopped	Engine stopped for unknown reason
Engine failed to stop	60 seconds after issuing the stop command, the engine has still **not** stopped
Start failure	Engine failed to start after the last start attempt
Pickup failure	Unable to read the pickup signal while engine is running
Output circuit overload	Short circuit in one of the +24 VDC terminals
Analog sensor failure	Detailed information on which analog channel has failed
Broken wire	Detailed information on which terminal experiences the broken wire

Operation of the Base Panel - The base panel has several different screens or views. These views include: two instrument views, alarm list view, information view, and event log view.

To toggle between instrument view and alarm list view press button A. (See Figure 2)

To toggle between the two instrument views press button B. (See Figure 2)

To go to information view press and hold button A for approximately 1 second.

To go to event log view press and hold button B for approximately 1 second.

When connected to the remote panel, both the remote panel and the base panel can control the engine. However it is possible to lock out the remote panel and allow

control **only** from the base panel.

To lock out the remote panel:

1. Go to INFO view
2. Press and hold BUZZER OFF for 2 seconds until a beep is heard. The screen will change to toggle Local Mode ON/OFF. When the red LED in the stop button is lit this indicates that the control unit is pulling the stop solenoid.

Stop Button - To stop the unit, press and hold the red button labeled STOP until the unit has stopped. If the STOP button is held for less than .5 seconds the engine will **not** stop. The control unit stops the generator set by pulling the stop solenoid. When the red LED in the stop button is lit this indicates that the control unit is pulling the stop solenoid.

Start Button - Manual start is done with the green button labeled Start. Press and hold the button until the engine has started.

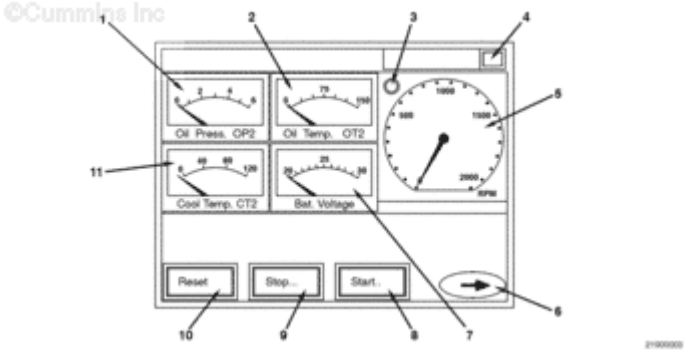
A running engine indicated by the green LED in the Start button and the text Running in the left most status field on the digital display. The rpm meter will indicate the engine speed.

Standby and Manual Mode Button - The standby button is a toggle button, meaning that for every other keypress, the unit is set to Standby or Manual. A green LED in the Standby button indicates that the unit is set to Standby. The right most status field also indicates the chosen mode by displaying either Standby or Manual.

Acknowledge (Reset) Button - In case of alarms, a press on the acknowledge button, labeled ACKN will reset the alarm(s). At the same time, the buzzer will be silenced. In the Alarm List view ACKN will reset all alarms, whereas, in the instrument view, ACKN will reset the alarm in the top of the screen **only**.

Buzzer Off Button - Press the buzzer OFF button to silence the built in buzzer signal that is activated when an alarm occurs. The alarm that activated the buzzer remains active until acknowledged.

Remote Panel Digital Display



Remote Panel Digital Display

The remote panel is a touch screen display that shows most of the data available

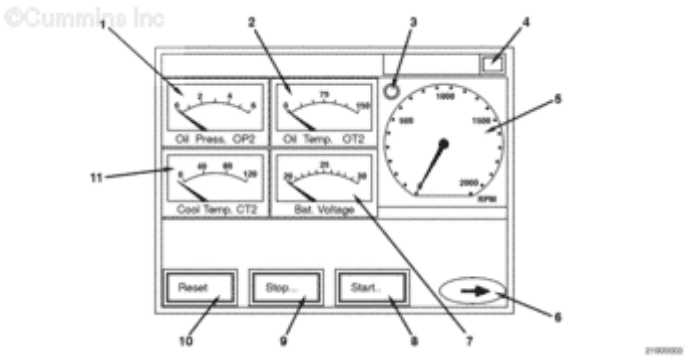
from the base control panel. It can also execute many of the same commands as the base panel. It connects to the supplied terminals on the engine cabinet with six wires. Four wires are for communication and two are for power supply.

1. Oil pressure gauge
2. Coolant temperature gauge
3. Oil temperature gauge
4. Indicator light
5. Grey - ready to start
6. Green - Starting/running
7. Red - stopping/stopped
8. Button to access the alarm list
9. Engine rpm
10. Navigate between pages
11. Start button
12. Battery voltage gauge
13. Stop button
14. Reset button.

Analog Values Available From the Remote Panel	
Value Description	**Range and Units**
Oil pressure	0.0 to 6.0 bar [0 to 87 psi]
Oil temperature	0 to 150°C [32 to 302°F]
Coolant temperature	0 to 130°C [32 to 266°F]
Battery voltage	20 to 30 VDC
Engine speed	0 to 2000 rpm
Exhaust stack temperature	0 to 600°C [32 to 1112°F]
Total engine hours	0 to 99999 hours
Trip engine hours	0 to 999 hours
Start counter	0 to 99999 starts

Screen Overviews

NOTE: The alarm list is not displayed. It can be accessed from all the pages.



Start up screen and the applications main view.

Main View

This is the Start-up screen and the applications main view.

1. Oil pressure

2. Oil temperature

3. Indicator light

Grey - ready to start

Green - starting/running

Red - stopping/stopped

4. Button to access the alarms list

5. rpm

6. Navigate between pages

7. Battery voltage

8. Start button

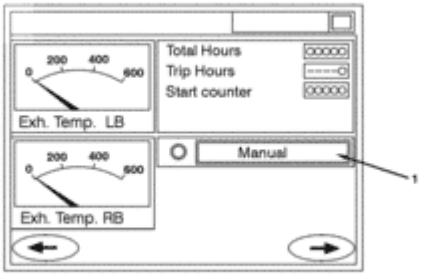
9. Stop button

10. Reset button

11. Coolant temperature.

Exhaust Temperatures

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Each press on this button toggles between Standby and Manual setting

This screen displays the exhaust temperatures and the counters. The

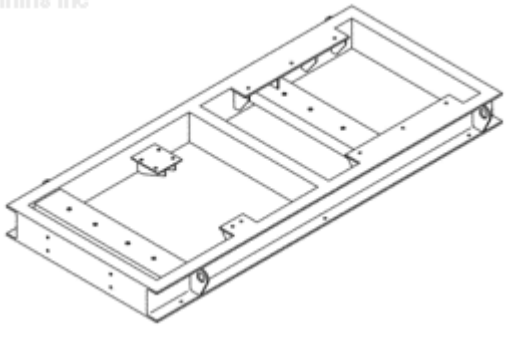
Standby/Manual setting is changed through this screen as well.

The following table lists the commands that can be executed with the remote panel.

Remote Panel Commands	
Command	**Description**
Engine Start	Brings up a dialog to confirm engine start
Engine Stop	Brings up a dialog to confirm engine stop. An ongoing start attempt can be cancelled by pressing stop.
Acknowledge Alarms	Will acknowledge all pending alarms in the Base Panel
Set to Standby	The base panel will do automatic start attempts.
Set to Manual	The base panel will **not** do automatic start attempts.

Remote Panel Alarm Descriptions	
Alarm Description	**Comment**
Low oil pressure	1.7 bar [25 psi]
High coolant temperature	106°C [223°F]
Emergency stop/start disabled	Manual emergency stop is operated. Start is disabled.
Low coolant pressure	0.7 bar [10 psi]
Power failure	Either the primary or the secondary (backup) voltage supply to the DCU 305 R2 is too low.
Overspeed	50 Hz overspeed = 1725 rpm
	60 Hz overspeed = 2070 rpm
Oil pressure	2.4 bar [35 psi]
Oil temperature	120°C [248°F]
Coolant temperature	104°C [219°F]
Start failure	When set to standby **only**.

Subbase



Because the engine and alternator are being offered as a complete set, another new option is the subbase. The subbase option includes all the vibration damping and fastening hardware necessary to mount the engine and alternator onto the base rail.

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205-001 Additional Service Literature

General Information

The following publications can be purchased by contacting a Cummins Inc. Distributor:

Bulletin	Title of Publication
3379001	Fuel for Cummins Engines
3810340	Cummins® Engine Oil Recommendations
3666132	Cummins® Coolant Requirements and Maintenance
3379000	Air For Your Engine
3387266	Cold Weather Operation
3666121	Holset® Air Compressor Master Repair Manual
3666013	Operation and Maintenance Manual K19 Series Engines
3666069	CENTRY™ System Operation and Maintenance Manual
3666078	CENTRY™ Wiring Diagram
3666867	CENTRY™ Operation and Maintenance Manual (Spanish)
3666870	CENTRY™ Operation and Maintenance Manual (French)
3396712	INSITE™ CENTRY™ Users Manual
4095418	CENTRY™ Troubleshooting and Repair Manual (Russian)
4021499	CENTRY™ Troubleshooting and Repair Kit
3810259	K19 Specifications Manual
3379084	Fuel Pump Rebuild Manual
3379664	Injector Specifications Manual
3379071	Injector Rebuild Manual
3379091	Turbochargers Rebuild Manual (T18A)
3810243	HC-5A Turbocharger Shop Manual
3379068	Fuel Pump PT (type G) Calibration Values 1970-1975
3379182	Fuel Pump PT (type G) Calibration Values 1976-1980
3379352	Fuel Pump PT (type G) Calibration Values 1981-1989

3666011	Fuel Pump PT (type G) Calibration Values 1990-2003
3810349	Industrial Electric Fuel Control
3379231	Electric Fuel Control Governor

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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

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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018-015 General Engine

Specifications

NOTE: 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	19 liters [1150 cu in]
Bore and Stroke	158.75 mm x 158.75 mm [6.25 in x 6.25 in]

Engine Weight:

Dry	1720 kg [3800 lb]
Wet	1800 kg [3965 lb]

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

Valve Settings:

Intake Valve Adjustment	0.36 mm [0.014 in]
Intake Valve Limits	0.28 to 0.43 mm [0.011 to 0.017 in]
Exhaust Valve Adjustment	0.69 mm [0.027 in]
Exhaust Valve Limits	0.61 to 0.76 mm [0.024 to 0.030 in]

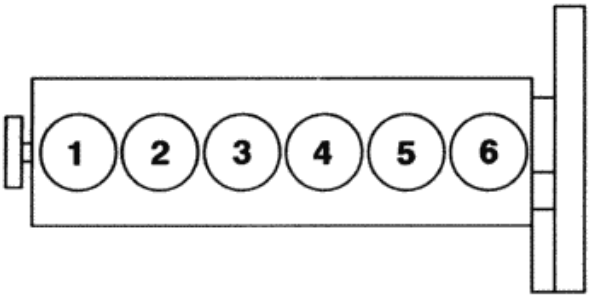
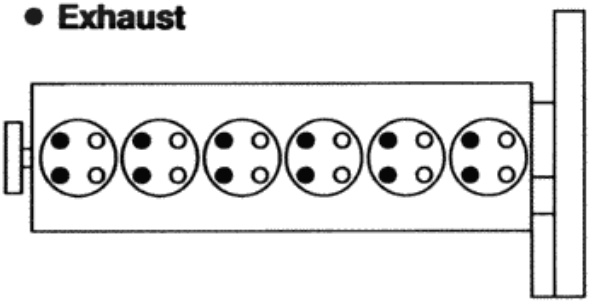
Injector Settings:

Fixed Time, Indicator (nominal)	7.72 mm [0.304 in] travel
Fixed Time, Indicator (reset Limits)	7.67 to 7.77 mm [0.302 to 0.306] travel
STC and HVT, OBC (nominal)	10 N•m [90 in-lb]
STC and HVT, OBC (reset limits)	10 N•m [90 in-lb]
Crosshead Lash (nominal)	0 mm [0 in]
Crosshead Lash (reset limits)	0 mm [0 in]

NOTE: Crosshead lash is only for crossheads with stems.

Compression Ratio	13.8:1 to 15.5:1
Crankshaft Rotation (viewed from the front of the engine)	Clockwise

Refer to the graphic for the cylinder locations. The cylinder firing order is: 1-5-3-6-2-4.		

		QSK19 Cylinder Location  00400001
Refer to the graphic for the intake and exhaust valve locations.		○ Intake ● Exhaust  ew400gd

Last Modified: 16-May-2007

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018-016 Fuel System

Specifications

NOTE: 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	600 to 1400 rpm

Minimum Low Idle

KTTA	800 rpm
KTA and KT	625 rpm

Maximum No Load Governed Speed	150 rpm above rated speed
Maximum Overspeed Capability	2656 rpm

Fuel Inlet Maximum Restriction at Fuel Pump Inlet:

Clean Fuel Filter	100 mm Hg [4.0 in Hg]
Dirty Fuel Filter	203 mm Hg [8.0 in Hg]

Maximum Allowable Return Line Restriction without check valves	63 mm Hg [2.5 in Hg]
Maximum Allowable return Line restriction with Check Valves and/or Overhead Tanks	165 mm Hg [6.5 in Hg]
Engine Minimum Cranking Speed	150 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	See engine data sheet
Derate Engine Fuel Rate for Hot Weather	See engine data sheet
Shutoff Valve Solenoid Coil Resistance in ohms 24 VDC	28 to 32 ohms

Fuel Filter Specifications for Engines with Electronic Fuel Control Valve (Cummins Inc. Standard Number 14,223):

Efficiency:

at 10 microns	98.7 percent
at 8 microns	96 percent
at 5 microns	86 percent

Fuel Filter Specifications for Engines with Electronic Fuel Control Valve (Cummins Inc. Standard Number 14,223):

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)	138 kPa [20 psi]
At No-Load Governed Speed	345 to 483 kPa [50 to 70 psi]

Oil Temperature:

Maximum	120°C [250°F]

Oil Filter Capacity:

Bypass Filter (spin-on)	2.3 liters [0.6 gal]
Full-Flow Filter (spin-on)	2.7 liters [0.7 gal]
Combination Filter	2.3 liters [0.6 gal]

Bypass Filter, Canister Type	11.3 liters [3.0 gal]

Piston Cooling Regulator:

Start to Open Pressure (nominal)	131 kPa [19 psi]
Fully Open Pressure (nominal)	200 kpa [29 psi]

Maximum Difference in Main Oil Rifle Pressure and Piston Cooling Rifle Pressure

Rated Speed, Hot Oil	34 kPa [5 psi]

Maximum Pressure Drop Across Oil Filters	55 kPa [8 psi]

Lubricating Oil Pan Capacities				
Part Number	**Low (Liter)**	**High (Liter)**	**Low [Gallon]**	**High [Gallon]**
205774	32	38	8.5	10
205881	57	64	15	17
207304	40	47	10.5	12.5
207305	32	38	8.5	10
3006484	40	47	10.5	12.5
3008538	32	38	8.5	10
3009643	40	47	10.5	12.5
3024391	66	72	17.4	19
3032521	40	47	10.5	12.5
3032541	61	68	16	18
3046856	32	38	8.5	10

3088256	40	47	10.5	12.5
3166244	32	38	8.5	10
3200709	40	47	10.5	12.5
3201960	40	47	10.5	12.5
3202152	32	38	8.5	10
3227451	32	38	8.5	10
3234794	55	61	14.5	16
3627067	53	61	14	16
3630061	55	61	14.5	16

NOTE: If the engine contains a rear gear train, add 7.6 liters [2 gal] to the oil pan capacity.

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018-018 Cooling System

Specifications

Coolant Capacity (engine **only)**	32.2 liters [34 qt]
Standard Modulating Thermostat Range	82° to 94°C [180° to 202°F]

Maximum Coolant Pressure (exclusive of pressure cap):

Block Pressure with Thermostats Open	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 Draw Down or 20 Percent of System Capacity (whichever is greater)	11 liters [12 qt]
Minimum Allowable Pressure Cap	50 kPa [7 psi]
Low Temperature Aftercooling Thermostat (Marine Engines) Range	68 to 78°C [154 to 172°F]

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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]

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018-020 Exhaust System

Specifications

Maximum Exhaust Restriction	75 mm Hg [3 in Hg]

Exhaust Pipe Size (normally acceptable inside diameter):

For Engines with One Turbocharger	127 mm [5 in]
For Engines with Two Turbochargers	152 mm [6 in]

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018-021 Electrical System

Specifications

Minimum Battery Capacity at -18° to 0°C [0° to 32°F] Ambient Temperature:

12-VDC Starter 400 Ampere Hour	1800 Cold Cranking Amps at -18°C [0°F]
24-VDC Starter 200 Ampere Hour	900 Cold Cranking Amps at -18°C [0°F]

Minimum Battery Capacity above 0°C [32°F] Ambient Temperature:

12-VDC Starter 300 Ampere Hour	1280 Cold Cranking Amps at -18°C [0°F]
24-VDC Starter 150 Ampere Hour	640 Cold Cranking Amps at -18°C [0°F]

Maximum Starting Circuit Resistance:

12-VDC Starter	0.00075 ohms
24-VDC Starter	0.00200 ohms

Battery Cable Sizes - American Wire Gauge (maximum length in cranking motor circuit) 12-VDC:

Number 00	3.7 m [12 ft]
Number 000	4.9 m [16 ft]
Number 0000 or two Number 0*	6.1 m [10 ft]
Two Number 00	7.6 m [25 ft]

Battery Cable Sizes - American Wire Gauge (maximum length in cranking motor circuit) 12-VDC High Output:

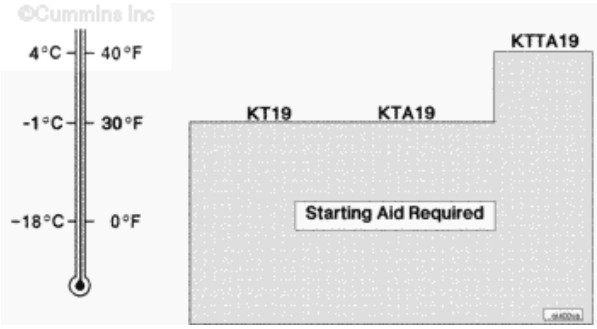
Number 00	2.1 m [7 ft]
Number 000	2.7 m [9 ft]
Number 0000 or two Number 0*	3.7 m [12 ft]
Two Number 00	4.3 m [14 ft]

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]

* Two strands of Number 0 cable can be used instead of one strand of Number 0000 cable, provided that all connections are carefully made to provide equal current flow in each parallel cable.

Minimum Cranking Speed without Starting Aid	150 rpm
Minimum Ambient Temperature Without Starting Aid	Refer to the starting aid chart.



NOTE: Starting aids, such as block heaters, lubricating oil pan heaters, and so forth, are available to aid in cold weather starting.

Battery State of Charge	Specific Gravity at 27°C [80°F]
100 percent	1.260 to 1.280
75 percent	1.230 to 1.250
50 percent	1.200 to 1.220
25 percent	1.170 to 1.190
Discharged	1.110 to 1.130

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018-022 Compressed Air System

Specifications

Holset® ST676 A/C Model

The following specifications are for a upright two-cylinder air compressor (Holset® ST676 Air Compressor Model)

Cylinders	2
Compressor Capacity (at 1250 rpm)	14.2 liter [30.00 cfm] per second
Piston Displacement	676 cc [41.3 C.I.D.]
Bore	92.08 mm [3.625 in]
Stroke	50.8 mm [2 in]
Speed	Engine speed
Cooling	Engine coolant
Lubrication	Engine lubricating oil

Plumbing Line Sizes:

Coolant Inlet and Outlet (pipe fitting)	12.7 mm NPTF [0.50 in NPTF]
Air Inlet (inside diameter)	22.22 mm [0.875 in]
Air Outlet (minimum inside diameter)	15.88 mm [0.625 in]

Height, Overall (approximate)	34.3 cm [13.5 in]
Width, Overall (approximate)	17.8 cm [7 in]
Length, Overall (approximate)	28.7 cm [11.30 in]
Weight (approximate)	33.5 kg [74.5 lb]

NOTE: In applications where duty cycles average 10 percent or more or air pressures are above 862 kPa [125 psi], use a discharge line with a minimum inside diameter of 15.9 mm [0.625 in] for single-cylinder compressors and 25.4 mm [1 in] for twin-cylinder compressors to prevent carbon buildup. Examples of these applications are as follows:

- **Refuse trucks**
- **Pickup and delivery trucks**
- **Transit buses**
- **Equipment with high accessory air usage.**

Holset® SS296, SS296E, and SS338E A/C Model

The following specifications are for a upright single-cylinder air compressor (Holset® SS338/QE338 Air Compressor Models)

Cylinders	1
Compressor Capacity (at 1250 rpm)	7.1 liter [15.00 cfm] per second
Piston Displacement	338 cc [20.63 C.I.D.]

Bore	98.4 mm [3.875 in]
Stroke	44.5 mm [1.75 in]
Speed	Engine speed
Cooling	Engine coolant
Lubrication	Engine lubricating oil

Plumbing Line Sizes:

Coolant Inlet and Outlet (pipe fitting)	9.53 mm NPTF [0.375 in NPTF]
Air Inlet (inside diameter)	22.22 mm [0.875 in]
Air Outlet (minimum inside diameter	12.7 mm [0.5 in]

Height, Overall (approximate)	31.1 cm [12.25 in]
Width, Overall (approximate)	14.6 cm [5.75 in]
Length, Overall (approximate)	22.9 cm [9 in]
Weight (approximate)	18 kg [40 lb]

Holset® SS296/SS296E/QE296 A/C Models

The following specifications are for a upright single-cylinder air compressor (Holset® SS296/SS296E/QE296 Air Compressor Models)

Cylinders	1
Compressor Capacity (at 1250 rpm)	6.2 liter [13.20 cfm] per second
Piston Displacement	296 cc [18.06 C.I.D.]
Bore	92.08 mm [3.625 in]
Stroke	44.5 mm [1.75 in]
Speed	Engine speed
Cooling	Engine coolant
Lubrication	Engine lubricating oil

Plumbing Line Sizes:

Coolant Inlet and Outlet (pipe fitting)	9.53 mm NPTF [0.375 in NPTF]
Air Inlet (inside diameter)	22.22 mm [0.875 in]
Air Outlet (minimum inside diameter)	12.7 mm [0.5 in]

Height, Overall (approximate)	31.1 cm [12.25 in]
Width, Overall (approximate)	14.6 cm [5.75 in]
Length, Overall (approximate	22.9 cm [9 in]
Weight (approximate)	18 kg [40 lb]

Compressor Spring Force Specifications						
Spring Use	**Approximate Free Length**	**Number of Coils**	**Wire Diameter**	**Measurement Length**	**Minimum**	**Maximum**
Exhaust Valve	17.02 mm [0.670 in]	3.0	2.03 mm [0.080 in]	7.11 mm [0.280 in]	3.63 N [8.00 lb]	4.72 N [10.40 lb]
Intake Valve	12.70 mm [0.500 in]	2.8	1.58 mm [0.062 in]	7.11 mm [0.280 in]	0.25 N [0.50 lb]	0.50 N [1.10 lb]
Unloading Valve						

(Naturally Aspirated)	41.91 mm [1.650 in]	11.5	2.03 mm [0.080 in]	24.89 mm [0.980 in]	13.6 N [30.00 lb]	17.23 N [38.00 lb]
Unloading Valve (Turbocharged up to 1270 mm Hg [50 in Hg]	41.91 mm [1.650 in]	12.0	1.83 mm [0.072 in]	24.89 mm [0.980 in]	7.72 N [17.00 lb]	9.98 N [22.00 lb]
Unloading Valve (all Turbocharged Engines)	41.91 mm [1.650 in]	10.8	2.89 mm [0.065 in]	24.89 mm [0.980 in]	5.4 N [12.00 lb]	7.72 N [17.00 lb]

Last Modified: 16-May-2007

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018-005 Drive Belt Tension

Tension Chart

SAE Belt Size	Belt Tension Gauge Part No.		Belt Tension New		Belt Tension Range Used*	
	Click-type	Burroughs	N	lbf	N	lbf
0.380 in	3822524		620	140	270 to 490	60 to 110
0.440 in	3822524		620	140	270 to 490	60 to 110
1/2 in	3822524	ST-1138	620	140	270 to 490	60 to 110
11/16 in	3822524	ST-1138	620	140	270 to 490	60 to 110
3/4 in	3822524	ST-1138	620	140	270 to 490	60 to 110
7/8 in	3822524	ST-1138	620	140	270 to 490	60 to 110
4 rib	3822524	ST-1138	620	140	270 to 490	60 to 110
5 rib	3822524	ST-1138	670	150	270 to 530	60 to 120
6 rib	3822525	ST-1293	710	160	290 to 580	65 to 130
8 rib	3822525	ST-1293	890	200	360 to 710	80 to 160
10 rib	3822525	3823138	1110	250	440 to 890	100 to 200
12 rib	3822525	3823138	1330	300	530 to 1070	120 to 240
12 rib K section	3822525	3823138	1330	300	890 to 1070	200 to 240
31 rib	–	3164750	1668	375	1330 to 1560	300 to 350

NOTE: This chart does not apply to automatic belt tensioners.

* A belt is considered used if it has been in service for ten minutes or longer.

* If used belt tension is less than the minimum value, tighten the belt to the maximum used belt value.

Last Modified: 25-Jan-2010

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018-009 Capscrew Markings and Torque Values

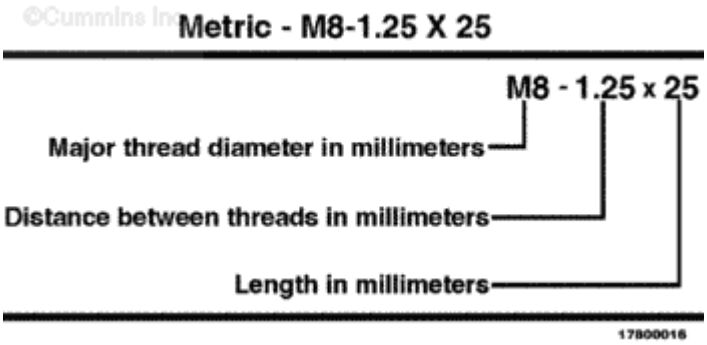
General Information

CAUTION

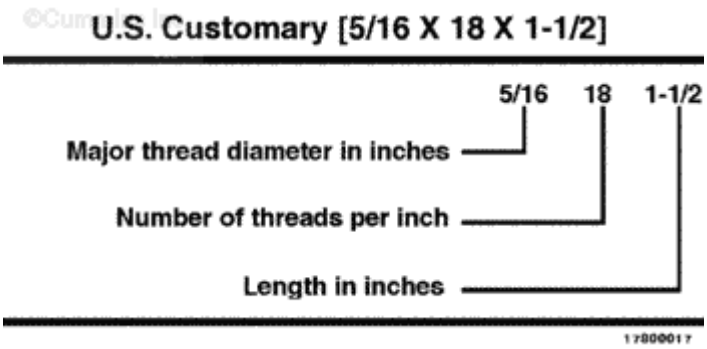
When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

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:

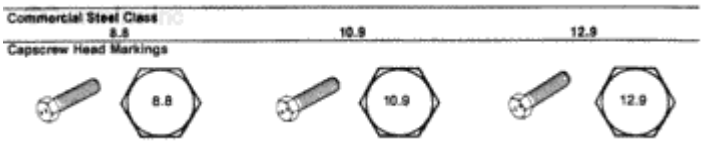


- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the 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.



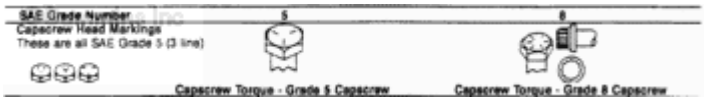
- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the 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
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

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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

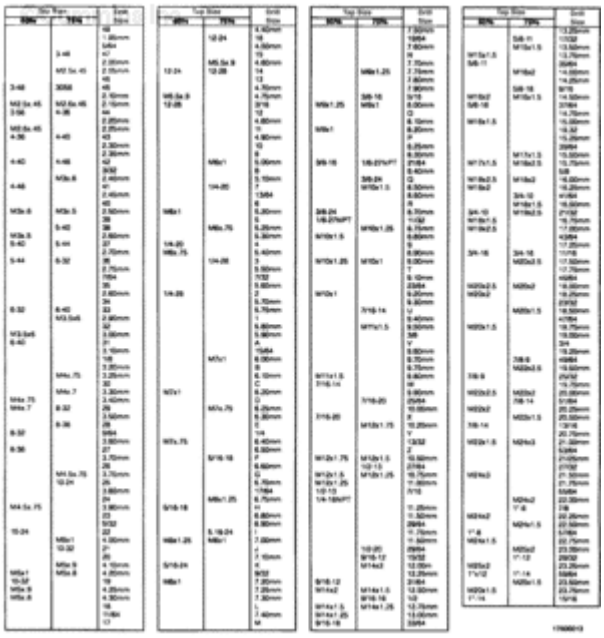
Last Modified: 03-Mar-2004

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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.



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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

Last Modified: 03-Mar-2004

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Manual Change History

(4021499) K19 Service Manual				
Date	**Section**	**Procedure Number**	**Procedure Title**	**Update Reason**
Not Available	front	4021499-toc	Table of Contents	
12-Mar-2002	Section i - Introduction	99-204-004	Symbols	
12-Mar-2002	Section i - Introduction	99-204-005	Illustrations	
03-Apr-2002	Section TS - Troubleshooting System	99-t00-002	Troubleshooting Symptom Charts	
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	Weight and Measures - Conversion Factors	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t006-tr	Air Compressor Noise is Excessive	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t007-tr	Air Compressor Pumping Excess Lubricating Oil into the Air System	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t008-tr	Air Compressor will Not Maintain Adequate Air Pressure (Not Pumping Continuously	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t009-tr	Air Compressor Will Not Pump Air	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t010-tr	Air Compressor Will Not Stop Pumping	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t013-tr	Alternator Not Charging or Insufficient Charging	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t014-tr	Alternator Overcharging	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t048-tr	Engine Noise Excessive - Combustion Knocks	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t051-tr	Engine Noise Excessive - Piston	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t052-tr	Engine Noise Excessive - Turbocharger	
07-Jul-2004	Section TS - Troubleshooting System	4021499-t091-tr	Fuel in Coolant	
	Section TS -	4021499-		

07-Jul-2004	Troubleshooting System	t092-tr	Fuel in Lubricating Oil
07-Jul-2004	Section TS - Troubleshooting System	4021499-t106-tr	Lubricating Oil Sludge in Crankcase Excessive
09-Jul-2004	Section TS - Troubleshooting System	4021499-t004-tr	Air Compressor Air Pressure Rises Slowly
23-Jul-2004	Section DS - Engine Disassembly - Group 00	18-007-037-shopds	Lubricating Oil System
23-Jul-2004	Section DS - Engine Disassembly - Group 00	18-007-018-shopds	Lubricating Oil Filter Head Adapter
23-Jul-2004	Section DS - Engine Disassembly - Group 00	18-001-052-shopds	Vibration Damper
23-Jul-2004	Section AS - Engine Assembly - Group 00	18-001-052-shopas	Vibration Damper
23-Jul-2004	Section AS - Engine Assembly - Group 00	18-007-018-shopas	Lubricating Oil Filter Head Adapter
23-Jul-2004	Section AS - Engine Assembly - Group 00	18-007-037-shopas	Lubricating Oil System
23-Jul-2004	Section 1 - Cylinder Block - Group 01	18-001-017	Crankshaft Adapter
23-Jul-2004	Section 1 - Cylinder Block - Group 01	18-001-052-tr	Vibration Damper
23-Jul-2004	Section 1 - Cylinder Block - Group 01	18-001-064-tr	Cylinder Liner Protrusion
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-018-tr	Lubricating Oil Filter Head Adapter
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-028	Lubricating Oil Pressure Gauge
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-029	Lubricating Oil Pressure Regulator (Main Rifle)
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-037-tr	Lubricating Oil System
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-044	Lubricating Oil Contamination
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-050	Cylinder Smokes (Blue Smoke)
23-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-061	Oil Transfer Connection
23-Jul-2004	Section 8 - Cooling System - Group 08	18-008-004	Coolant Temperature Gauge
27-Jul-2004	Section 7 - Lubricating Oil System - Group 07	18-007-083	Lubricating Oil and Filter Analysis
05-Aug-2004	Section 0 - Complete Engine - Group 00	18-000-002	Engine Install

16-Aug-2004	Section TS - Troubleshooting System	4021499-t044-tr	Engine Difficult to Start or Will Not Start (No Exhaust Smoke)
16-Aug-2004	Section TS - Troubleshooting System	4021499-t064-tr	Engine Shuts Off Unexpectedly or Dies During Deceleration
16-Aug-2004	Section TS - Troubleshooting System	4021499-t075-tr	Engine Vibration Excessive
16-Aug-2004	Section TS - Troubleshooting System	4021499-t087-tr	Fuel Consumption Excessive
16-Aug-2004	Section TS - Troubleshooting System	4021499-t097-tr	Intake Manifold Pressure (Boost) is Below Normal
16-Aug-2004	Section TS - Troubleshooting System	4021499-t104-tr	Lubricating Oil Pressure High
16-Aug-2004	Section TS - Troubleshooting System	4021499-t105-tr	Lubricating Oil Pressure Low
16-Aug-2004	Section TS - Troubleshooting System	4021499-t107-tr	Lubricatign Oil Temperature Above Specifications
16-Aug-2004	Section DS - Engine Disassembly - Group 00	18-008-041-shopds	Marine Gear Oil Cooler
16-Aug-2004	Section AS - Engine Assembly - Group 00	18-008-041-shopas	Marine Gear Oil Cooler
16-Aug-2004	Section 8 - Cooling System - Group 08	18-008-038	Fan Shroud Assembly
16-Aug-2004	Section 8 - Cooling System - Group 08	18-008-041-tr	Marine Gear Oil Cooler
16-Aug-2004	Section 8 - Cooling System - Group 08	18-008-047	Radiator Pressure Cap
16-Aug-2004	Section 8 - Cooling System - Group 08	18-008-049	Radiator Shutter Assembly
16-Aug-2004	Section 8 - Cooling System - Group 08	18-008-051	Radiator Top Tank
25-Aug-2004	Section DS - Engine Disassembly - Group 00	18-001-036-shopds	Idler Gear, Camshaft
25-Aug-2004	Section DS - Engine Disassembly - Group 00	18-001-040-shopds	Idler Gear, Water Pump
25-Aug-2004	Section AS - Engine Assembly - Group 00	18-001-040-shopas	Idler Gear, Water Pump
25-Aug-2004	Section AS - Engine Assembly - Group 00	18-001-036-shopas	Idler Gear, Camshaft
25-Aug-2004	Section 1 - Cylinder Block - Group 01	18-001-036-tr	Idler Gear, Camshaft
25-Aug-2004	Section 1 - Cylinder Block - Group 01	18-001-040-tr	Idler Gear, Water Pump
22-Sep-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-002	AFC Anti-Drain Back Valve
22-Sep-2004	Section 6 - Injectors and Fuel Lines -	18-006-003	Air In Fuel

	Group 06		
23-Sep-2004	Section DS - Engine Disassembly - Group 00	18-004-014-shopds	Push Rods or Tubes
23-Sep-2004	Section DS - Engine Disassembly - Group 00	18-003-013-shopds	Rocker Lever Housing
23-Sep-2004	Section AS - Engine Assembly - Group 00	18-003-013-shopas	Rocker Lever Housing
23-Sep-2004	Section AS - Engine Assembly - Group 00	18-004-014-shopas	Push Rods or Tubes
23-Sep-2004	Section 3 - Rocker Levers - Group 03	18-003-013-tr	Rocker Lever Housing
23-Sep-2004	Section 4 - Cam Follower - Group 04	18-004-014-tr	Push Rods or Tubes
24-Sep-2004	Section DS - Engine Disassembly - Group 00	18-001-067-shopds	Crankshaft Wear Sleeve, Rear
24-Sep-2004	Section DS - Engine Disassembly - Group 00	18-001-023-shopds	Crankshaft Seal, Front
24-Sep-2004	Section AS - Engine Assembly - Group 00	18-001-067-shopas	Crankshaft Wear Sleeve, Rear
24-Sep-2004	Section AS - Engine Assembly - Group 00	18-001-023-shopas	Crankshaft Seal, Front
24-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-012	Camshaft Gear (Camshaft Installed)
24-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-013	Camshaft Gear (Camshaft Removed)
24-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-018	Crankshaft Gear, Front (Crankshaft Installed)
24-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-023-tr	Crankshaft Seal, Front
24-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-056	Camshaft Thrust Bearing
24-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-067-tr	Crankshaft Wear Sleeve, Rear
29-Sep-2004	Section DS - Engine Disassembly - Group 00	18-001-024-shopds	Crankshaft Seal, Rear
29-Sep-2004	Section AS - Engine Assembly - Group 00	18-001-024-shopas	Crankshaft Seal, Rear
29-Sep-2004	Section 1 - Cylinder Block - Group 01	18-001-024-tr	Crankshaft Seal, Rear
06-Oct-2004	Section E - Engine and System Identification	18-100-001	Engine Identification
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-011-007-shopds	Exhaust Manifold, Dry
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-007-045-shopds	Lubricarting Oil Cooler Cover
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-008-065-shopds	Torque Converter Cooler

19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-007-046-shopds	Lubricating Oil Cooler Housing
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-006-024-shopds	Fuel Supply Lines
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-006-013-shopds	Fuel Drain Lines
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-010-002-shopds	Aftercooler Assembly
19-Oct-2004	Section DS - Engine Disassembly - Group 00	18-008-015-shopds	Thermostat Support
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-008-015-shopas	Thermostat Support
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-010-002-shopas	Aftercooler Assembly
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-006-013-shopas	Fuel Drain Lines
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-006-024-shopas	Fuel Supply Lines
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-007-046-shopas	Lubricating Oil Cooler Housing
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-008-065-shopas	Torque Converter Cooler
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-007-045-shopas	Lubricating Oil Cooler Cover
19-Oct-2004	Section AS - Engine Assembly - Group 00	18-011-007-shopas	Exhaust Manifold, Dry
19-Oct-2004	Section 2 - Cylinder Head - Group 02	18-002-001	Crosshead
19-Oct-2004	Section 3 - Rocker Levers - Group 03	18-003-001	Crankcase Breather, External
19-Oct-2004	Section 3 - Rocker Levers - Group 03	18-003-010	Rocker Lever Bushings
19-Oct-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-024-tr	Fuel Supply Lines
19-Oct-2004	Section 7 - Lubricating Oil System - Group 07	18-007-017	Lubricating Oil Filter Head (Remote Mounted)
19-Oct-2004	Section 7 - Lubricating Oil System - Group 07	18-007-045-tr	Lubricating Oil Cooler Cover
19-Oct-2004	Section 7 - Lubricating Oil System - Group 07	18-007-046-tr	Lubricating Oil Cooler Housing
19-Oct-2004	Section 8 - Cooling System - Group 08	18-008-008	Coolant Filter Head (Remote Mounted)
19-Oct-2004	Section 8 - Cooling System - Group 08	18-008-015-tr	Thermostat Support

19-Oct-2004	Section 8 - Cooling System - Group 08	18-008-042	Radiator
19-Oct-2004	Section 8 - Cooling System - Group 08	18-008-065-tr	Torque Converter Cooler
19-Oct-2004	Section 9 - Drive Units - Group 09	18-009-013	Fuel Pump Drive Gear and Shaft
19-Oct-2004	Sectionj 10 - Air Intake - Group 10	18-010-002-tr	Aftercooler Assembly
19-Oct-2004	Section 11 - Exhaust System - Group 11	18-011-007-tr	Exhaust Manifold, Dry
25-Oct-2004	Section 1 - Cylinder Block - Group 01	18-022-001_01	Service Tools
25-Oct-2004	Section 1 - Cylinder Block - Group 01	18-001-026	Cylinder Block
25-Oct-2004	Section 8 - Cooling System - Group 08	18-022-001_08	Service Tools
25-Oct-2004	Section 12 - Compressed AIr System - Group 12	18-022-001_12	Service Tools
25-Oct-2004	Section 14 - Engine Testing - Group 14	18-022-001_14	Service Tools
27-Oct-2004	Section F - Familiarization	18-007-999	Lubricating Oil System - Overview
27-Oct-2004	Section F - Familiarization	18-013-999	Electrical Equipment - Overview
27-Oct-2004	Section DS - Engine Disassembly - Group 00	18-006-022-shopds	Fuel Manifold
27-Oct-2004	Section DS - Engine Disassembly - Group 00	18-006-042-shopds	STC Wiring Control Harness
27-Oct-2004	Section AS - Engine Assembly - Group 00	18-006-042-shopas	STC Wiring Control Harness
27-Oct-2004	Section AS - Engine Assembly - Group 00	18-006-022-shopas	Fuel Manifold
27-Oct-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-022-tr	Fuel Manifold (Supply)
27-Oct-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-025	Static Injection Timing
27-Oct-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-033	STC Fuel Pressure Switch
27-Oct-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-036	STC Oil Control Valve (Electronic)
27-Oct-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-042-tr	STC Wiring Harness
27-Oct-2004	Section 14 - Engine Testing - Group 14	18-014-003	Engine Run In (Chassis Dynamometer)
27-Oct-2004	Section 14 - Engine Testing - Group 14	18-014-004	Engine Run In (Without Dynamometer)
27-Oct-2004	Section 14 - Engine Testing - Group 14	18-014-006	Engine Run In (Engine Dynamometer)
27-Oct-2004	Section 16 - Mounting Adaptations - Group	18-016-010	Engine Mounts

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27-Oct-2004	Section L - Service Literature	18-205-001	Additional Service Literature
29-Oct-2004	Section F - Familiarization	18-009-999	Drive Units - Overview
29-Oct-2004	Section DS - Engine Disassembly - Group 00	18-004-002-shopds	Cam Follower Cover
29-Oct-2004	Section DS - Engine Disassembly - Group 00	18-001-046-shopds	Piston Cooling Nozzle
29-Oct-2004	Section AS - Engine Assembly - Group 00	18-001-046-shopas	Piston Cooling Nozzle
29-Oct-2004	Section AS - Engine Assembly - Group 00	18-004-002-shopas	Cam Follower Cover
29-Oct-2004	Section 1 - Cylinder Block - Group 01	18-001-046-tr	Piston Cooling Nozzle
29-Oct-2004	Section 4 - Cam Follower - Group 04	18-004-002-tr	Cam Follower Cover
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-010	Fuel Consumption
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-024	Fuel Pump Fuel Rate with Throttle Shaft Plunger
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-026	Fuel Pump Gear Pump Check Valve
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-029	Fuel Pump Idle Speed
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-031	Fuel Pulsation Damper
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-035	Fuel Pump Throttle Lever
29-Oct-2004	Section 5 - Fuel System - Group 05	18-005-054	Stall Speed Test
04-Nov-2004	Section TS - Troubleshooting System	18-t00-004	Troubleshooting Overview
04-Nov-2004	Section 0 - Complete Engine - Group 00	18-000-001	Engine Remove
04-Nov-2004	Section DS - Engine Disassembly - Group 00	18-006-011-shopds	Fuel Filter (Remote Mounted)
04-Nov-2004	Section DS - Engine Disassembly - Group 00	18-008-053-shopds	Heat Exchanger
04-Nov-2004	Section DS - Engine Disassembly - Group 00	18-006-017-shopds	Fuel Filter Head
04-Nov-2004	Section DS - Engine Disassembly - Group 00	18-009-004-shopds	Accessory Drive Pulley
04-Nov-2004	Section DS - Engine Disassembly - Group 00	18-001-039-shopds	Idler Gear, Hydraulic Pump
04-Nov-2004	Section AS - Engine Assembly - Group 00	18-001-039-shopas	Idler Gear, Hydraulic Pump
04-Nov-2004	Section AS - Engine Assembly - Group	18-009-004-	Accessory Drive Pulley

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04-Nov-2004	Section AS - Engine Assembly - Group 00	18-006-017-shopas	Fuel Filter Head
04-Nov-2004	Section AS - Engine Assembly - Group 00	18-008-053-shopas	Heat Exchanger
04-Nov-2004	Section AS - Engine Assembly - Group 00	18-006-011-shopas	Fuel Filter (Remote Mounted)
04-Nov-2004	Section 1 - Cylinder Block - Group 01	18-001-039-tr	Idler Gear, Hydraulic Pump
04-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-011-tr	Fuel Filter (Remote Mounted)
04-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-012	Fuel Drain Line Restriction
04-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-013	Fuel Drain Lines
04-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-017-tr	Fuel Filter Head
04-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-059	Fuel Line, Low Pressure
04-Nov-2004	Section 8 - Cooling System - Group 08	18-008-020	Cooling System Diagnostics
04-Nov-2004	Section 8 - Cooling System - Group 08	18-008-053-tr	Heat Exchanger
04-Nov-2004	Section 9 - Drive Units - Group 09	18-009-004-tr	Accessory Drive Pulley
11-Nov-2004	Section F - Familiarization	18-000-999	Complete Engine - Overview
11-Nov-2004	Section F - Familiarization	18-001-999	Engine Block - Overview
11-Nov-2004	Section F - Familiarization	18-002-999	Cylinder Head - Overview
11-Nov-2004	Section DS - Engine Disassembly - Group 00	18-009-035-shopds	Engine Barring Device
11-Nov-2004	Section DS - Engine Disassembly - Group 00	18-009-036-shopds	Outer Hydraulic Pump Support Drive
11-Nov-2004	Section AS - Engine Assembly - Group 00	18-009-036-shopas	Outer Hydraulic Pump Support Drive
11-Nov-2004	Section AS - Engine Assembly - Group 00	18-009-035-shopas	Engine Barring Device
11-Nov-2004	Section 9 - Drive Units - Group 09	18-009-005	Accessory Drive Pulley Wear Sleeve
11-Nov-2004	Section 9 - Drive Units - Group 09	18-009-019	Hydraulic Pump Drive Gear and Shaft
11-Nov-2004	Section 9 - Drive Units - Group 09	18-009-032	Water Pump Drive Pulley
11-Nov-2004	Section 9 - Drive Units - Group 09	18-009-035-tr	Engine Barring Device
11-Nov-2004	Section 9 - Drive Units - Group 09	18-009-036-tr	Outer Hydraulic Pump Support Drive

15-Nov-2004	Section 3 - Rocker Levers - Group 03	18-022-001_03	Service Tools
15-Nov-2004	Section 5 - Fuel System - Group 05	18-022-001_05	Service Tools
15-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-022-001_06	Service Tools
15-Nov-2004	Section 7 - Lubricating Oil System - Group 07	18-022-001_07	Service Tools
15-Nov-2004	Section 9 - Drive Units - Group 09	18-022-001_09	Service Tools
15-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-022-001_10	Service Tools
15-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-006	Aftercooler Coolant Tube
15-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-008	Aftercooler Element
22-Nov-2004	Section DS - Engine Disassembly - Group 00	18-013-001-shopds	Alternator
22-Nov-2004	Section AS - Engine Assembly - Group 00	18-013-001-shopas	Alternator
22-Nov-2004	Section 11 - Exhaust System - Group 11	18-011-009	Exhaust Restriction
22-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-022-001_13	Service Tools
22-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-001-tr	Alternator
22-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-006	Alternator Pulley
22-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-007	Batteries
22-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-009	Battery Cables and Connections
29-Nov-2004	Section F - Familiarization	18-004-999	Cam Followers/Tappets - Overview
29-Nov-2004	Section F - Familiarization	18-006-999	Injectors and Fuel Lines - Overview
29-Nov-2004	Section F - Familiarization	18-010-999	Air Intake System - Overview
29-Nov-2004	Section F - Familiarization	18-012-999	Compressed Air System - Overview
29-Nov-2004	Section F - Familiarization	18-014-999	Engine Testing - Overview
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-010-046-shopds	Turbochager, Oil Supply Hose
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-010-045-shopds	Turbocharger, Oil Drain Tube
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-010-018-shopds	Air Connection Pipe (Turbocharger to Turbocharger)
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29-Nov-2004	Disassembly - Group 00	18-010-019-shopds	Air Crossover
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-013-020-shopds	Starter Motor
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-006-051-shopds	Injector Supply Lines (High Pressure)
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-007-011-shopds	Lubricating Oil Dipstick Tube
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-016-005-shopds	Flywheel
29-Nov-2004	Section DS - Engine Disassembly - Group 00	18-016-006-shopds	Flywheel Housing
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-016-006-shopas	Flywheel Housing
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-016-005-shopas	Flywheel
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-007-011-shopas	Lubricating Oil Dipstick Tube
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-006-051-shopas	Injector Supply Lines (High Pressure)
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-013-020-shopas	Starter Motor
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-010-019-shopas	Air Crossover
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-010-018-shopas	Turbocharger, Air Connection
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-010-045-shopas	Turbocharger, Oil Drain Tube
29-Nov-2004	Section AS - Engine Assembly - Group 00	18-010-046-shopas	Turbocharger, Oil Supply Hose
29-Nov-2004	Section 1 - Cylinder Block - Group 01	18-001-043	Piston
29-Nov-2004	Section 1 - Cylinder Block - Group 01	18-001-055	Gear Train Backlash (Front)
29-Nov-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-051-tr	Injector Supply Lines
29-Nov-2004	Section 7 - Lubricating Oil System - Group 07	18-007-011-tr	Lubricating Oil Dipstcik Tube
29-Nov-2004	Section 8 - Cooling System - Group 08	18-008-016	Coolant Thermostat Seal
29-Nov-2004	Section 8 - Cooling System - Group 08	18-008-017	Coolant Vent Lines
29-Nov-2004	Section 8 - Cooling System - Group 08	18-008-045	Radiator Hoses
29-Nov-2004	Section 8 - Cooling	18-008-052-	Expansion Tank

	System - Group 08	tr	
29-Nov-2004	Section 9 - Drive Units - Group 09	18-009-037	Hydraulic Pump Support Bushing
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-018-tr	Air Connection Pipe (Turbocharger to Turbocharger)
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-019-tr	Air Crossover
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-024	Air Leaks, Air Intake and Exhaust Systems
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-031	Air Intake Restriction
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-045-tr	Turbocharger Oil Drain Line
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-046-tr	Turbocharger Oil Supply Line
29-Nov-2004	Sectionj 10 - Air Intake - Group 10	18-010-057	Intake Manifold Pressure
29-Nov-2004	Section 11 - Exhaust System - Group 11	18-022-001_11	Service Tools
29-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-003	Alternator, Bracket
29-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-017	Started Magnetic Switch
29-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-018	Starter Switch
29-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-020-tr	Starter Motor
29-Nov-2004	Section 13 - Electrical Equipment - Group 13	18-013-022	Alternator Adjusting Link
29-Nov-2004	Section 14 - Engine Testing - Group 14	18-014-001	Dynamometer Worksheet
29-Nov-2004	Section 14 - Engine Testing - Group 14	18-014-008	Engine Testing (In Chassis)
29-Nov-2004	Section 16 - Mounting Adaptations - Group 16	18-022-001_16	Service Tools
29-Nov-2004	Section 16 - Mounting Adaptations - Group 16	18-016-005-tr	Flywheel
29-Nov-2004	Section 16 - Mounting Adaptations - Group 16	18-016-006-tr	Flywheel Housing
29-Nov-2004	Section 16 - Mounting Adaptations - Group 16	18-016-008	Flywheel Ring Gear
01-Dec-2004	Section DS - Engine Disassembly - Group 00	18-009-016-shopds	Hydraulic Pump Drive
01-Dec-2004	Section DS - Engine Disassembly - Group 00	18-007-031-shopds	Lubricating Oil Pump

01-Dec-2004	Section AS - Engine Assembly - Group 00	18-007-031-shopas	Lubricating Oil Pump
01-Dec-2004	Section AS - Engine Assembly - Group 00	18-009-016-shopas	Hydraulic Pump Drive
01-Dec-2004	Section 5 - Fuel System - Group 05	18-005-007	EFC Actuator Valve
01-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-031-tr	Lubricating Oil Pump
01-Dec-2004	Section 9 - Drive Units - Group 09	18-009-016-tr	Hydraulic Pump Drive
01-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-003	Air Compressor Carbon Buildup
01-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-010	Air Compressor Pin Bore Wear
01-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-017	Air Governor (Air Compressor Will Not Pump)
01-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-018	Air Governor (Air Compressor Pumps Continuously)
01-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-019	Air Leaks, Compressed Air System
02-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-020	Air Compressor (Oil Carryover)
02-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-103	Air Compressor Cylinder Head , Holset SS and E type Models
02-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-104	Air Compressor Cylinder Head, Holset QE Models
02-Dec-2004	Section 12 - Compressed AIr System - Group 12	18-012-106	Air Compressor Cylinder Head, Holset ST Models
07-Dec-2004	Section F - Familiarization	18-016-999	Mounting Adaptations - Overview
07-Dec-2004	Section DS - Engine Disassembly - Group 00	18-001-031-shopds	Gear Cover
07-Dec-2004	Section DS - Engine Disassembly - Group 00	18-001-008-shopds	Idler Gear, Camshaft
07-Dec-2004	Section DS - Engine Disassembly - Group 00	18-001-025-shopds	Crankshaft Wear Sleeve, Front
07-Dec-2004	Section AS - Engine Assembly - Group 00	18-001-025-shopas	Crankshaft Wear Sleeve, Front
07-Dec-2004	Section AS - Engine Assembly - Group 00	18-001-008-shopas	Camshaft
07-Dec-2004	Section AS - Engine Assembly - Group 00	18-001-031-shopas	Gear Cover
07-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-007	Bearings, Thrust

07-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-008-tr	Camshaft
07-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-025-tr	Crankshaft Wear Sleeve, Front
07-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-029-tr	Gear Cover, Spacer Plate
07-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-031-tr	Gear Cover, Front
08-Dec-2004	Section DS - Engine Disassembly - Group 00	18-001-033-shopds	Gear Housing, Front
08-Dec-2004	Section DS - Engine Disassembly - Group 00	18-007-025-shopds	Lubricating Oil Pan
08-Dec-2004	Section AS - Engine Assembly - Group 00	18-007-025-shopas	Lubricating Oil Pan
08-Dec-2004	Section AS - Engine Assembly - Group 00	18-001-033-shopas	Gear Housing, Front
08-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-033-tr	Gear Cover Housing, Front
08-Dec-2004	Section 5 - Fuel System - Group 05	18-005-043	Fuel Shutoff Valve
08-Dec-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-020	Fuel Inlet Restriction
08-Dec-2004	Section 6 - Injectors and Fuel Lines - Group 06	18-006-047	AFC No Air Check
08-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-003	Lubricating Oil Cooler
08-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-025-tr	Lubricating Oil Pan
10-Dec-2004	Section TS - Troubleshooting System	4021499-t020-tr	Coolant Loss - External
10-Dec-2004	Section TS - Troubleshooting System	4021499-t021-tr	Coolant Loss - Internal
10-Dec-2004	Section TS - Troubleshooting System	4021499-t022-tr	Coolant Temperature Above Normal - Gradual Overheat
10-Dec-2004	Section TS - Troubleshooting System	4021499-t023-tr	Coolant Temperature Above Normal - Sudden Overheat
10-Dec-2004	Section TS - Troubleshooting System	4021499-t024-tr	Coolant Temperature is Below Normal
10-Dec-2004	Section TS - Troubleshooting System	4021499-t033-tr	Engine Acceleration or Response Poor
10-Dec-2004	Section TS - Troubleshooting System	4021499-t041-tr	Engine Decelerates Slowly
10-Dec-2004	Section TS - Troubleshooting System	4021499-t043-tr	Engine Difficult to Start or Will Not Start (Exhaust Smoke)
	Section TS -	4021499-	

10-Dec-2004	Troubleshooting System	t047-tr	Engine Noise Excessive
10-Dec-2004	Section TS - Troubleshooting System	4021499-t049-tr	Engine Noise Excessive - Connecting Rod
10-Dec-2004	Section DS - Engine Disassembly - Group 00	18-009-029-shopds	Water Pump Drive
10-Dec-2004	Section DS - Engine Disassembly - Group 00	18-009-011-shopds	Fuel Pump Drive
10-Dec-2004	Section DS - Engine Disassembly - Group 00	18-009-024-shopds	Rear Gear Drive (Upper Assembly)
10-Dec-2004	Section DS - Engine Disassembly - Group 00	18-009-023-shopds	Rear Gear Drive (Lower Assembly)
10-Dec-2004	Section DS - Engine Disassembly - Group 00	18-001-006-shopds	Bearings, Main
10-Dec-2004	Section AS - Engine Assembly - Group 00	18-001-006-shopas	Bearings, Main
10-Dec-2004	Section AS - Engine Assembly - Group 00	18-009-023-shopas	Rear Gear Drive (Lower Assembly)
10-Dec-2004	Section AS - Engine Assembly - Group 00	18-009-024-shopas	Rear Gear Drive (Upper Assembly)
10-Dec-2004	Section AS - Engine Assembly - Group 00	18-009-011-shopas	Fuel Pump Drive
10-Dec-2004	Section AS - Engine Assembly - Group 00	18-009-029-shopas	Water Pump Drive
10-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-006-tr	Bearings, Main
10-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-038	Lubricating Oil Temperature Gauge
10-Dec-2004	Section 8 - Cooling System - Group 08	18-008-025	Fan Clutch, Air Engaged
10-Dec-2004	Section 9 - Drive Units - Group 09	18-009-011-tr	Fuel Pump Drive
10-Dec-2004	Section 9 - Drive Units - Group 09	18-009-023-tr	Rear Gear Drive (Lower Assembly)
10-Dec-2004	Section 9 - Drive Units - Group 09	18-009-024-tr	Rear Gear Drive (Upper Assembly)
10-Dec-2004	Section 9 - Drive Units - Group 09	18-009-029-tr	Water Pump Drive
10-Dec-2004	Sectionj 10 - Air Intake - Group 10	18-010-037	Turbocharger, Water Cooled
10-Dec-2004	Section 14 - Engine Testing - Group 14	18-014-002	Engine Testing (Chassis Dynamometer)
10-Dec-2004	Section 14 - Engine Testing - Group 14	18-014-005	Engine Testing (Engine Dynamometer)
16-Dec-2004	Section 5 - Fuel System - Group 05	18-005-001	AFC Assembly
20-Dec-2004	Section F - Familiarization	18-003-999	Rocker Levers - Overview
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20-Dec-2004	Familiarization	18-011-999	Exhaust System - Overview
20-Dec-2004	Section TS - Troubleshooting System	4021499-t050-tr	Engine Noise Excessive - Main Bearing
20-Dec-2004	Section TS - Troubleshooting System	4021499-t057-tr	Engine Power Output Low
20-Dec-2004	Section TS - Troubleshooting System	4021499-t061-tr	Engine Runs Rough at Idle
20-Dec-2004	Section TS - Troubleshooting System	4021499-t062-tr	Engine Runs Rough or Misfires
20-Dec-2004	Section TS - Troubleshooting System	4021499-t066-tr	Engine SpeedSurges at Low or High Idle
20-Dec-2004	Section TS - Troubleshooting System	4021499-t077-tr	Engine Will Not Crank or Cranks Slowly (Air Starter)
20-Dec-2004	Section TS - Troubleshooting System	4021499-t078-tr	Engine Will Not Crank or Cranks Slowly (Electric Starter)
20-Dec-2004	Section TS - Troubleshooting System	4021499-t080-tr	Engine Will Not Reach Rated Speed (RPM)
20-Dec-2004	Section TS - Troubleshooting System	4021499-t081-tr	Engine Will Not Shut Off
20-Dec-2004	Section TS - Troubleshooting System	4021499-t083-tr	Fault Code Warning Lamps Stay On (No Apparant Reason)
20-Dec-2004	Section TS - Troubleshooting System	4021499-t108-tr	Lubricating Oil in the Coolant
20-Dec-2004	Section TS - Troubleshooting System	4021499-t116-tr	Smoke, Black, Excessive
20-Dec-2004	Section TS - Troubleshooting System	4021499-t118-tr	Smoke, White, Excessive
20-Dec-2004	Section TS - Troubleshooting System	4021499-t122-tr	Turbocharger Leaks Engine Oil or Fuel
20-Dec-2004	Section 0 - Complete Engine - Group 00	18-022-001_00	Service Tools
20-Dec-2004	Section DS - Engine Disassembly - Group 00	18-008-040-shopds	Cooling Fan
20-Dec-2004	Section DS - Engine Disassembly - Group 00	18-007-015-shopds	Lubricating Oil Filter Head
20-Dec-2004	Section DS - Engine Disassembly - Group 00	18-004-001-shopds	Cam Follower Lever
20-Dec-2004	Section DS - Engine Disassembly - Group 00	18-007-026-shopds	Lubricating Oil Pan Adapter Cover
20-Dec-2004	Section AS - Engine Assembly - Group 00	18-007-026-shopas	Lubricating Oil Pan Adapter Cover
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20-Dec-2004	Assembly - Group 00	18-004-001-shopas	Cam Follower Lever
20-Dec-2004	Section AS - Engine Assembly - Group 00	18-007-015-shopas	Lubricating Oil Filter Head
20-Dec-2004	Section AS - Engine Assembly - Group 00	18-008-040-shopas	Cooling Fan
20-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-003	Accessory Drive Seal
20-Dec-2004	Section 1 - Cylinder Block - Group 01	18-001-021	Crankshaft Gear, Rear (Crankshaft Removed)
20-Dec-2004	Section 4 - Cam Follower - Group 04	18-004-001-tr	Cam Follower Assembly
20-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-007	Lubricating Oil Cooler Element
20-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-015-tr	Lubricating Oil Filter Head
20-Dec-2004	Section 7 - Lubricating Oil System - Group 07	18-007-026-tr	Lubricating Oil Pan Adapter Cover
20-Dec-2004	Section 8 - Cooling System - Group 08	18-008-013	Coolant Thermostat
20-Dec-2004	Section 8 - Cooling System - Group 08	18-008-022	Cooling System Service Requirements
20-Dec-2004	Section 8 - Cooling System - Group 08	18-008-030	Fan Drive Idler Pulley Assembly
20-Dec-2004	Section 8 - Cooling System - Group 08	18-008-040-tr	Fan, Cooling
20-Dec-2004	Section 20 - Vehicle Braking - Group 20	18-020-999	Vehicle Braking - Overview
12-Jan-2005	Section TS - Troubleshooting System	4021499-t072-tr	Engine Starts but Will Not Keep Running
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11-Jul-2008	Section 1 - Cylinder Block - Group 01	18-001-028-tr	Cylinder Liner
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20-Jan-2009	Section DS - Engine Disassembly - Group 00	18-006-038-shopds	STC Oil Manifold
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20-Jan-2009	Section 6 - Injectors and Fuel Lines - Group 06	18-006-038-tr	STC Oil Control Manifold
23-Jan-2009	Section DS - Engine Disassembly - Group 00	18-001-054-shopds	Piston and Connecting Rod
23-Jan-2009	Section AS - Engine Assembly - Group 00	18-001-054-shopas	Piston and Connecting Rod
23-Jan-2009	Section 1 - Cylinder Block - Group 01	18-001-014	Connecting Rod
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01-Apr-2009	Section DS - Engine Disassembly - Group 00	18-008-057-shopds	Sea Water Pump
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07-May-2009	Section DS - Engine Disassembly - Group 00	18-002-004-shopds	Cylinder Head
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09-Jun-2009	Section 11 - Exhaust System - Group 11	18-011-008-tr	Exhaust Manifold, Wet	
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09-Oct-2009	Section 0 - Complete Engine - Group 00	99-000-005-tr	Engine Storage - Long Term	
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21-Jan-2010	Section DS - Engine Disassembly - Group 00	18-001-016-shopds	Crankshaft	
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25-Jan-2010	Section i - Introduction	99-204-006-tr	General Safety Instructions	
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11-May-2010	Section 1 - Cylinder Block - Group 01	18-001-005	Bearings, Connecting Rod	
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20-May-2010	Section 1 - Cylinder Block - Group 01	18-001-016-tr	Crankshaft	
19-Oct-2004	Section 2 - Cylinder Head - Group 02	18-002-004-tr	Cylinder Head	Updated Vacuum Test section.
11-Nov-2010	Section 12 - Compressed AIr System - Group 12	18-012-014-tr	Air Compressor	Updated procedure to include new mounting bracket.
10-Dec-2010	Section 1 - Cylinder	18-001-054-	Piston and Connecting Rod	Updated procedure to include

	Block - Group 01	tr	Assembly	steps for offset pin pistons.
07-Jan-2011	Section 13 - Electrical Equipment - Group 13	18-013-005-tr	Drive Belt, Alternator	Added information for captive fasteners on alternator belt guard.
07-Jan-2011	Section 8 - Cooling System - Group 08	18-008-001-tr	Belt Guard	Added to Section 8.
04-Apr-2011	Section 1 - Cylinder Block - Group 01	18-001-043	Piston	Updated requirements for inspect for reuse.
28-Sep-2011	Section 8 - Cooling System - Group 08	18-008-087-tr	Cooling Fan Belt Tensioner	Addition of procedure to outline and manual.
19-Dec-2011	Section 3 - Rocker Levers	18-003-006-tr	Overhead Set (OBC)	Added: Use service Part Number 3163171 (Intake) or Part Number 3163172 (exhaust).
19-Dec-2011	Section 3 - Rocker Levers	18-003-007-tr	Overhead Set (Dial Indicator)	Added: Use service Part Number 3163171 (Intake) or Part Number 3163172 (exhaust).
02-May-2012	Section 2 - Cylinder Head - Group 02	18-002-004-tr	Cylinder Head	Added new valve spring technical information.
30-Apr-2012	Section 1 - Cylinder Block - Group 01	18-001-046-tr	Piston Cooling Nozzle	Added instructions for two piece nozzle design.
27-Jun-2012	Section 6 - Injectors and Fuel Lines	18-006-025	Static Injection Timing	
27-Jun-2012	Section 6 - Injectors and Fuel Lines	50-006-025	Static Injection Timing	Changed Control Part List (CPL) Manual, Bulletin to 4021328, and added refer to Procedure 99-850-013.
25-Jun-2012	Section 1 - Cylinder Block - Group 01	18-001-028-tr	Cylinder Liner	Updated the Remove step to add instruction that liner seals must be discarded if removed from the liner.
20-Aug-2012	Section TS - Troubleshooting System	4021499-t102-tr	Lubricating Oil Consumption Excessive	Changed first step to include inspection of OEM components for external oil leaks.
28-June-2013	Section 3 - Rocker Levers	18-003-013-tr	Rocker Lever Housing	Install Step: Added statement, checking for capscrews for damage. Change capscrew torque to 122 N.m [90 ft-lb]. Change graphic.

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