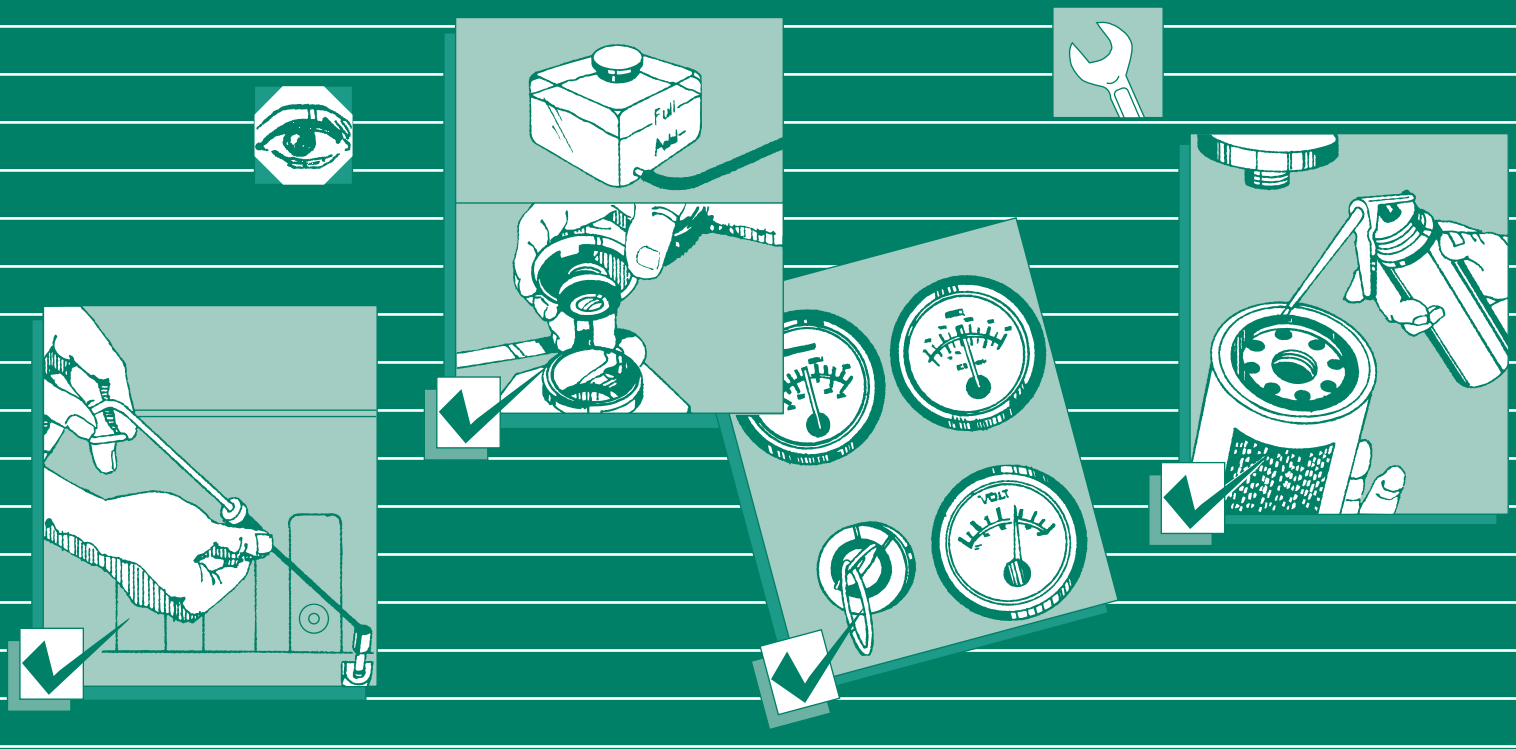
Operation and Maintenance Manual
Industrial B3.9, B4.5, and B5.9 Series Engines



Cummins Customer Assistance Center
1-800-DIESELS™ (1-800-343-7357)
APPLICABLE ONLY IN U.S.A. AND CANADA

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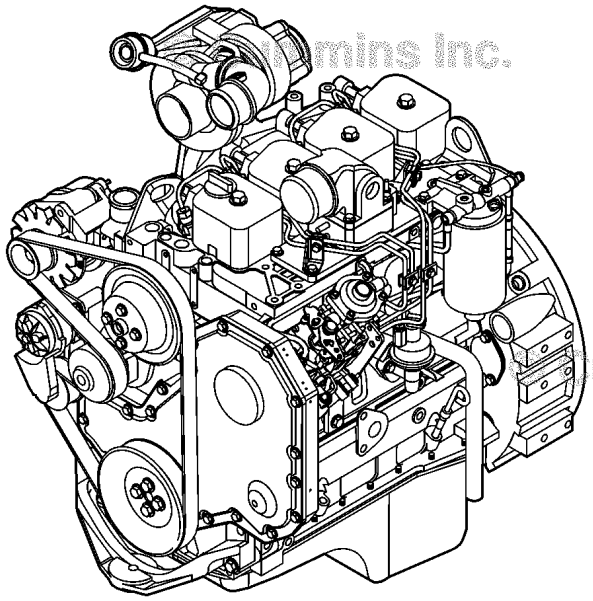
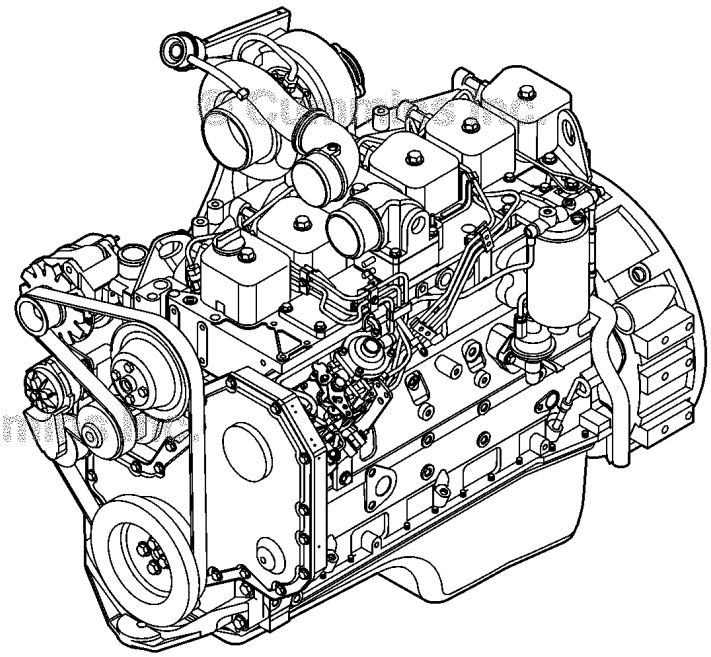


B3.9 and B4.5



B5.9

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Foreword

This manual contains information for the correct operation and maintenance of your Cummins engine. It also includes important safety information, engine and systems specifications, troubleshooting guidelines, and listings of Cummins Authorized Repair Locations and component manufacturers.

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

Keep this manual with the equipment. If the equipment is traded or sold, give the manual to the new owner.

The information, specifications, and recommended maintenance guidelines in this manual are based on information in effect at the time of printing. Cummins Inc. reserves the right to make changes at any time without obligation. If you find differences between your engine and the information in this manual, contact your local 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 were used to produce this engine. When replacement parts are needed, we recommend using only genuine Cummins or ReCon® exchange parts.

NOTE: Note: Warranty information is located in Section W. Make sure you are familiar with the warranty or warranties applicable to your engine.

Table of Contents

Important Reference Numbers

Fill in the part name and number in the blank spaces provided below. This will give you a reference whenever service or maintenance is required.

Name	Number	Number
Engine Model		
Engine Serial Number (ESN)		
Control Parts List (CPL)		
Fuel Pump Part Number		
Electronic Control Module (ECM)		
Electronic Control Module Serial Numbers (ECM)		
Filter Part Numbers:		
• Air Cleaner Element		
• Lubricating Oil		
• Fuel		
• Fuel-Water Separator		
• Coolant		
• Crankcase Ventilation		
• Cummins Particulate Filter		
Governor Control Module (GCM) (if applicable)		
Belt Part Numbers:		
•		
•		
•		
Clutch or Marine Gear (if applicable):		
• Model		
• Serial Number		
• Part Number		
• Oil Type		
• Sea Water Pump		
- Model		
- Part Number		

Section i - Introduction

Section Contents

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To the Owner and Operator

General Information

Preventive maintenance is the easiest and least expensive type of maintenance. Follow the maintenance schedule recommendations outlined in Maintenance Guidelines (Section 2).

Keep records of regularly scheduled maintenance.

Use the correct fuel, lubricating oil, and coolant in your engine as specified in Maintenance Specifications (Section V). Blending engine oil with fuel is prohibited for engines with an aftertreatment system.

Cummins Inc. uses the latest technology and the highest quality components to produce its engines. Cummins Inc. recommends using genuine Cummins new parts and ReCon® exchange parts.

Personnel at Cummins Authorized Repair Locations have been trained to provide expert service and parts support. If you have a problem that can **not** be resolved by a Cummins Authorized Repair Location, follow the steps outlined in the Service Assistance (Section S).

Product coverage, warranty limitations and owner responsibilities are available in Warranty (Section W).

⚠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 cable of the welder to the ECM cooling plate or ECM. Welding on the engine or engine mounted components is not recommended.

About the Manual

General Information

This manual contains information needed to correctly operate and maintain your engine as recommended by Cummins Inc. For additional service literature and ordering locations, refer to Service Literature (Section L).

This manual does **not** cover vehicle, vessel, or equipment maintenance procedures. Consult the original vehicle, vessel, or equipment manufacturer for specific maintenance recommendations.

Both metric and U.S. customary values are listed in this manual. The metric value is listed first, followed by the U.S. customary in brackets.

Numerous illustrations and symbols are used to aid in understanding the meaning of the text. Refer to Symbols in this section for a complete listing of symbols and their definitions.

Each section of the manual is preceded by a Section Contents to aid in locating information.

How to Use the Manual

General Information

This manual is organized according to intervals at which maintenance on your engine is to be performed. A maintenance schedule, that states the required intervals and maintenance checks, is located in Maintenance Guidelines (Section 2). Locate the interval at which you are performing maintenance; then follow the steps given in that section for all the procedures to be performed.

Keep a record of all the checks and inspections made. A maintenance record form is located in Maintenance Guidelines (Section 2).

Engine troubleshooting procedures for your engine are located in Troubleshooting Symptoms (Section TS).

Specifications for your engine are located in Maintenance Specifications (Section V).

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:

WARNING - Serious personal injury or extensive property damage can result if the warning instructions are **not** followed.

CAUTION - Minor personal injury can result or a part, an assembly, or the engine can be damaged if the caution instructions are **not** followed.

Indicates a **REMOVAL or DISASSEMBLY** step.

Indicates an **INSTALLATION or ASSEMBLY** step.

INSPECTION is required.

CLEAN the part or assembly.

PERFORM a mechanical or time **MEASUREMENT**.

LUBRICATE the part or assembly.

Indicates that a **WRENCH or TOOL SIZE** will be given.

TIGHTEN to a specific torque.

PERFORM an electrical **MEASUREMENT**.

Refer to another location in this manual or another publication for additional information.

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

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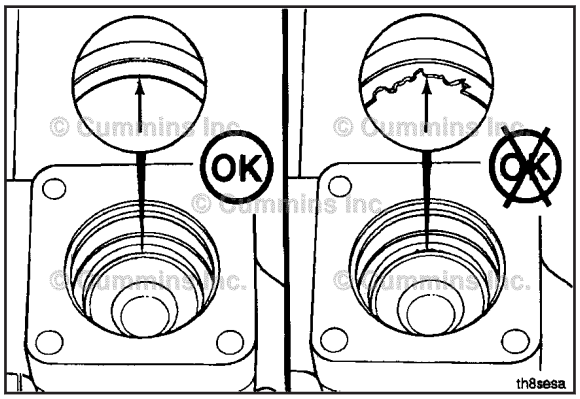
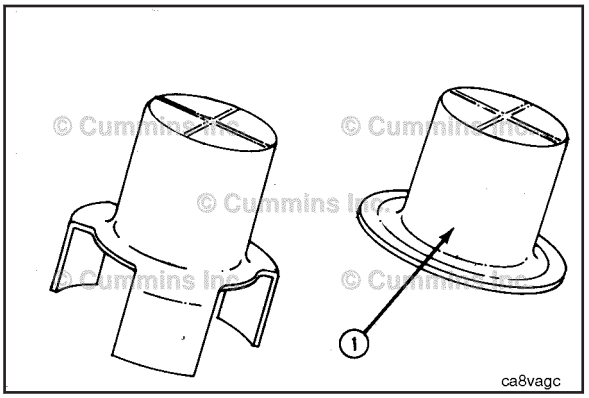
Illustrations

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.



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.

General Repair Instructions

General Information

This engine or 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
- The engine or system and its components **must** be kept clean during any repair. Contamination of the engine, system or components will cause premature wear.
- 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

Complete rebuild instructions are available in the service manual which can be ordered or purchased from a Cummins Authorized Repair Location. Refer to Section L — Service Literature for ordering instructions.

Welding on a Vehicle with an Electronic Controlled Fuel System

⚠CAUTION⚠

Disconnect both the positive (+) and negative (-) battery cables from the low voltage 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

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.

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
ATDC	After Top Dead Center
BTU	British Thermal Unit
BTDC	Before Top Dead Center
°C	Celsius
CAN	Controller Area Network
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
MCRS	Modular Common Rail System
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
TDC	Top Dead Center
VDC	Volts of Direct Current
VGT	Variable Geometry Turbocharger
VS	Variable Speed
VSS	Vehicle Speed Sensor

Section E - Engine and System Identification

Section Contents

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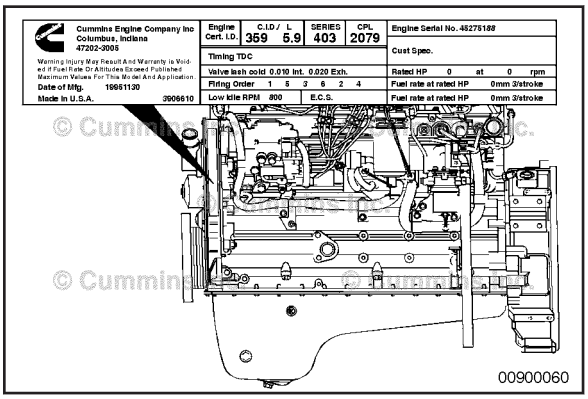
Engine Identification

Engine Dataplate

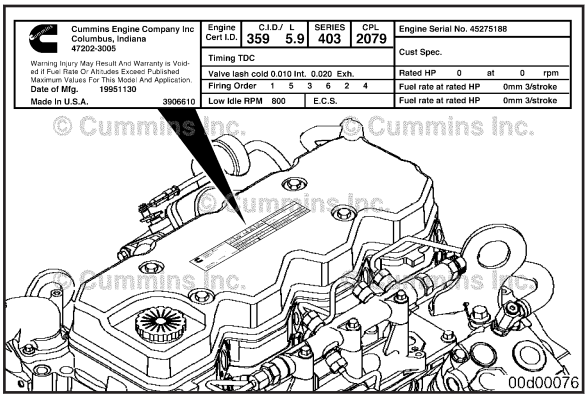
B3.9, B5.9, and B4.5 Engines

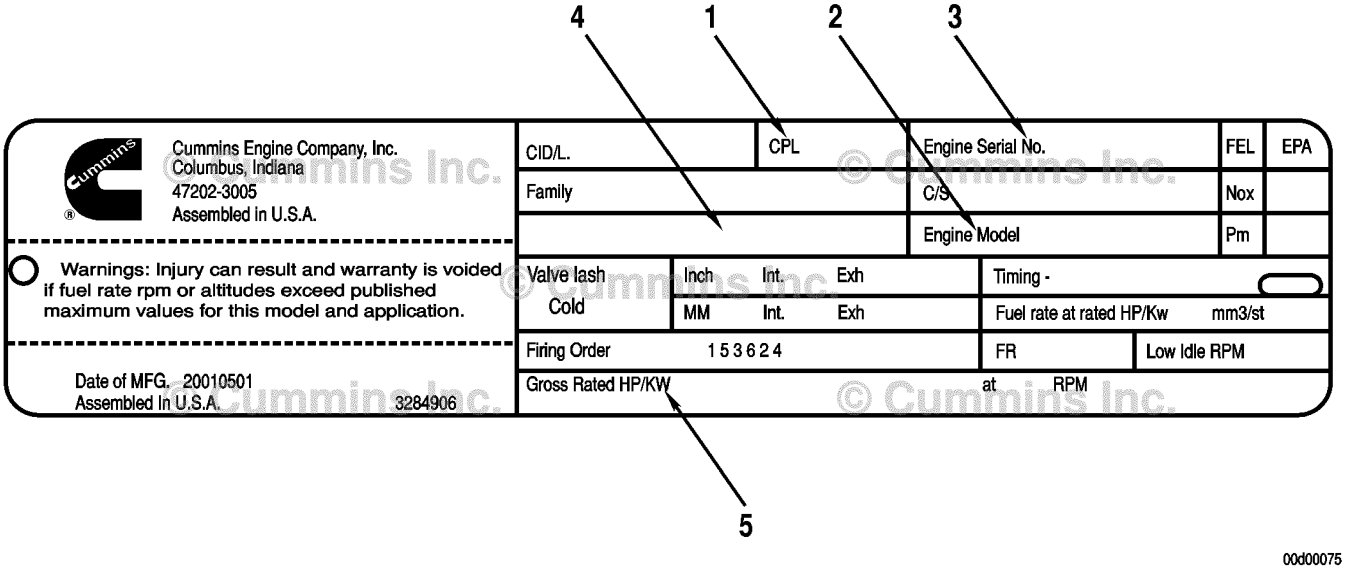
The engine dataplate shows specific facts about your engine. The engine serial number and Control Parts List provide information for ordering parts and for service. The engine dataplate **must not** be changed unless approved by Cummins Inc.



B4.5 RGT Engines

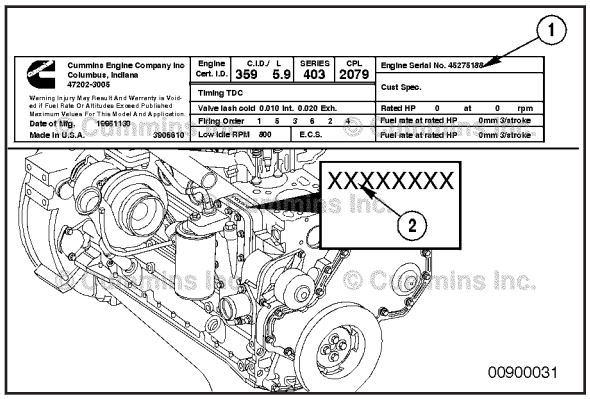
The engine dataplate shows specific facts about your engine. The engine serial number and Control Parts List provide information for ordering parts and for service. The engine dataplate **must not** be changed unless approved by Cummins Inc.



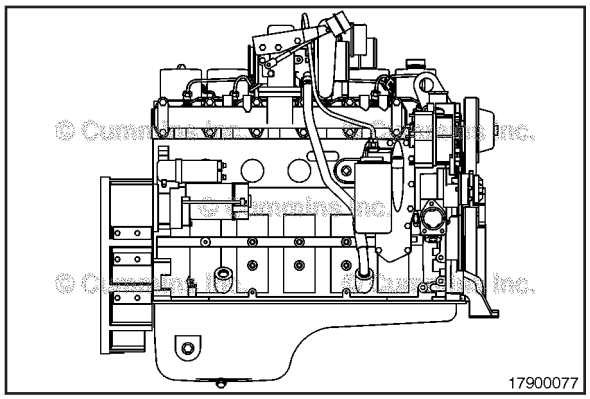


Have the following engine data available when communicating with a Cummins Authorized Repair Location. The information on the dataplate is **mandatory** when sourcing service parts.

1. Control parts list (CPL)
2. Model
3. Engine serial number
4. Emissions certification
5. Horsepower and rpm rating.



NOTE: If the engine dataplate (1) is **not** readable, the engine serial number (2) can be identified on the engine block above the oil cooler.

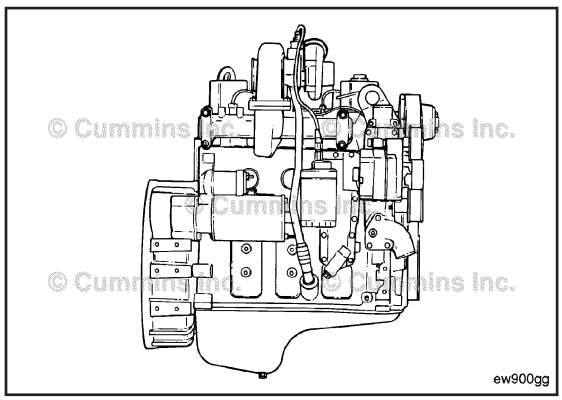


Cummins® Engine Nomenclature

B5.9

The model name provides the following engine data:

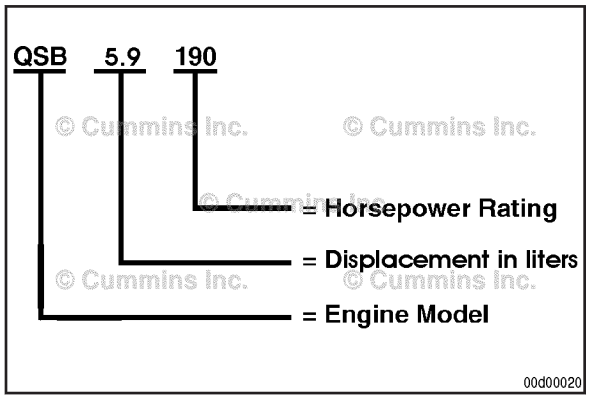
B = Engine series
5.9 = Displacement in liters.



B3.9

The model name provides the following engine data:

B = Engine series
3.9 = Displacement in liters.



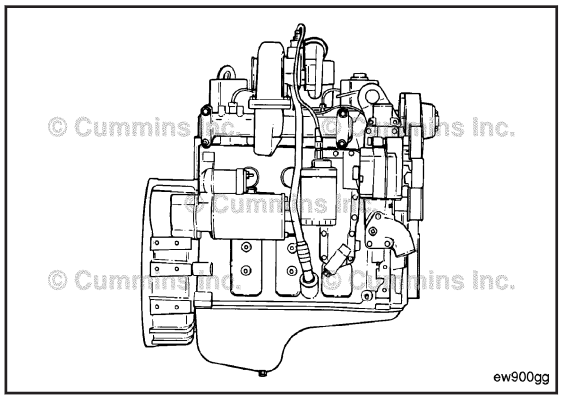
The Cummins engine nomenclature provides the data as illustrated in the graphic.

The model name for engines in industrial applications provides the data shown below For example:

4BTAA-3.9

4 = Number of cylinders
B = Engine series
T = Turbocharged
AA = Charge air cooled
3.9 = Displacement in liters.

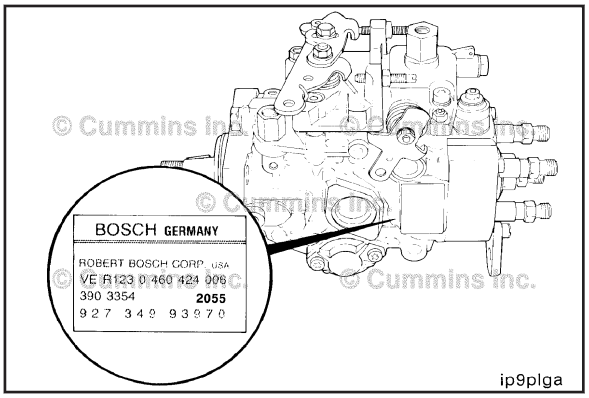
NOTE: The suffix RGT refers to “Rear Gear Train” engines.



Fuel Injection Pump Dataplate

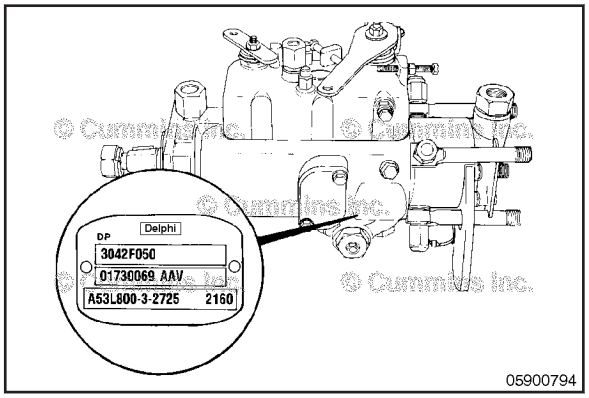
Bosch® Rotary

The injection pump dataplate for the Bosch® VE pump is located on the side of the injection pump. The dataplate provides information for fuel pump calibration.



Delphi Rotary

The injection pump dataplate for the Delphi DP pump is located on the side of the injection pump. The dataplate provides information for fuel pump calibration.



Engine Diagrams

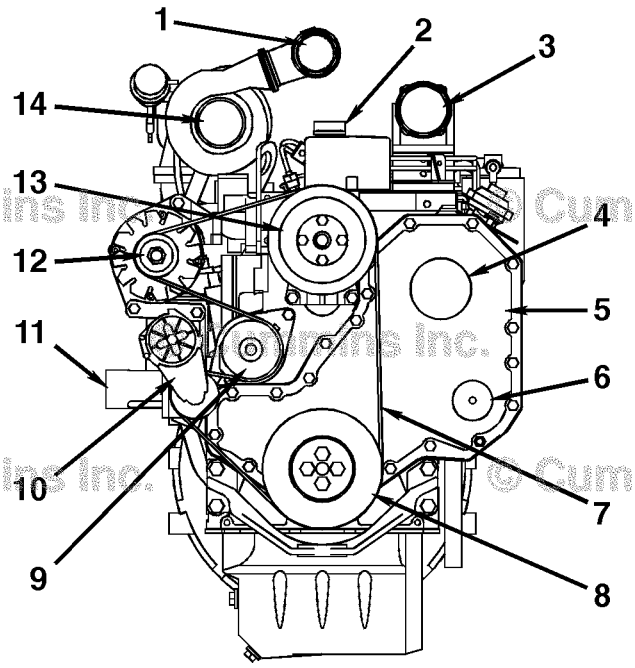
Engine Views

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

NOTE: The illustrations are **only** a reference to show a typical engine.

Engine Diagrams

Engine Views



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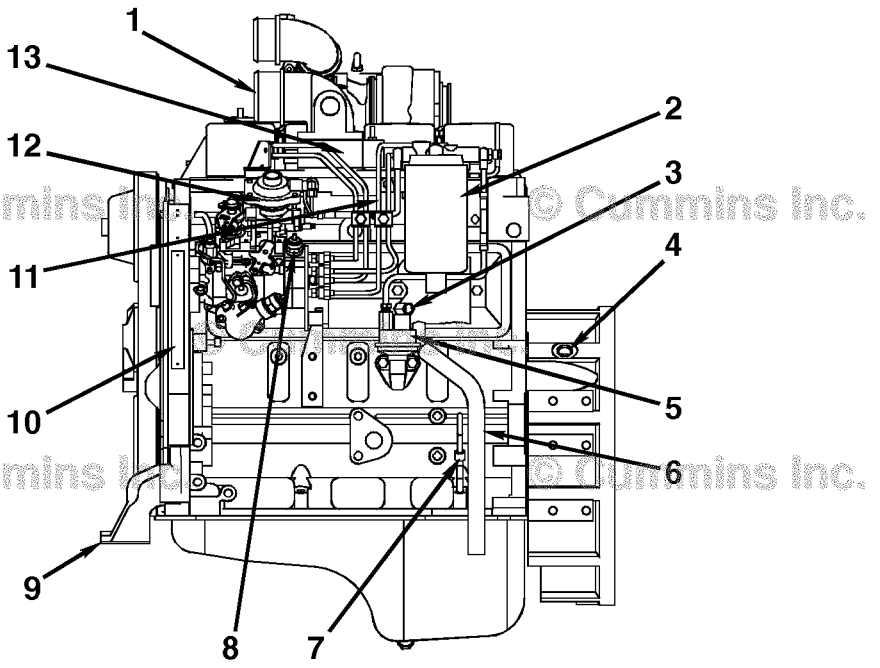
Front View - B3.9 Industrial

1. Turbocharger air outlet
2. Lubricating oil fill
3. Engine air inlet
4. Fuel pump drive cover
5. Front gear cover
6. Accessory drive cover (optional)
7. Fan drive belt
8. Front Pulley
9. Water pump
10. Automatic belt tensioner
11. Water inlet
12. Alternator
13. Fan pulley
14. Turbocharger air inlet.

Engine Diagrams

Engine Views

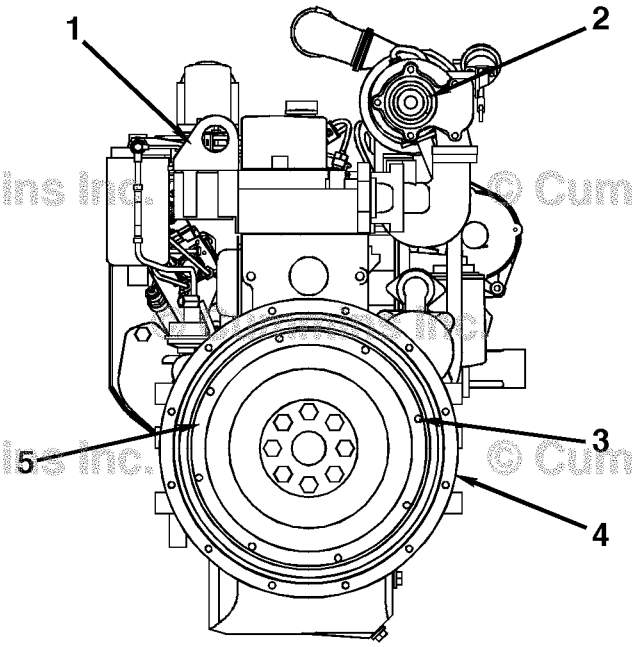


Left Side View - B3.9 Industrial

1. Engine air inlet
2. Fuel filter/water separator
3. Fuel inlet connection
4. Magnetic pickup location (3/4-16 UNF)
5. Fuel lift pump
6. Crankcase breather tube
7. Lubricating oil dipstick
8. Fuel drain connection
9. Front engine mounting bracket
10. Engine dataplate
11. High pressure fuel lines
12. Fuel injection pump
13. Intake air preheater (optional).

Engine Diagrams

Engine Views



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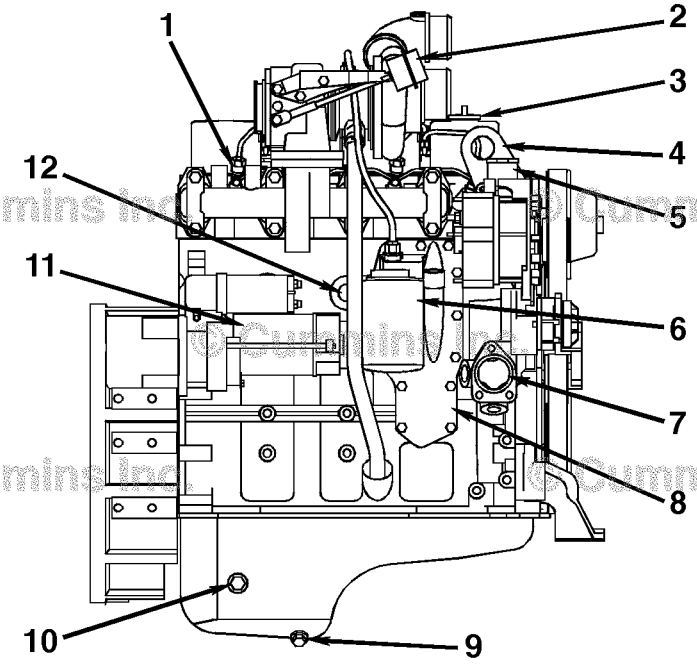
Rear View - B3.9 Industrial

1. Rear engine lifting bracket
2. Turbocharger exhaust outlet
3. Flexplate mounting holes
4. Flywheel housing
5. Flywheel/flexplate.

Engine Diagrams

Engine Views



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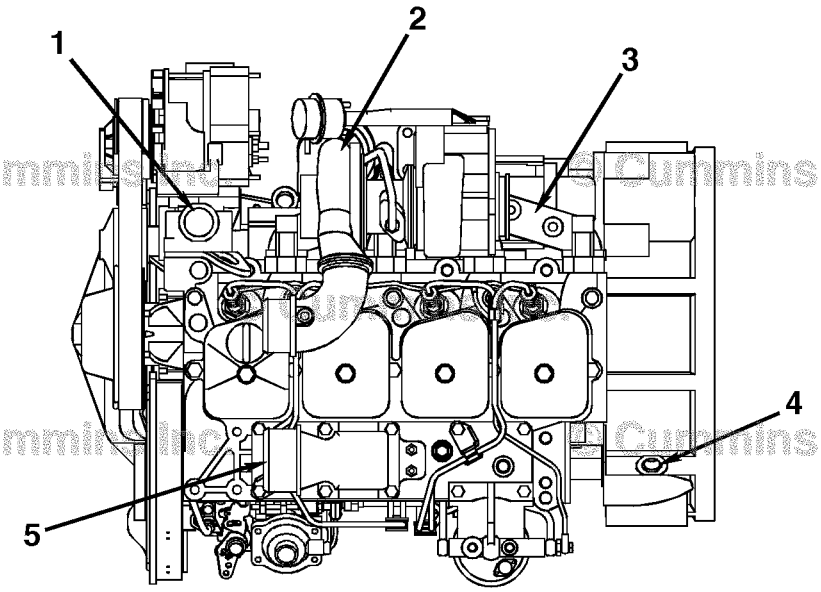
Right Side View - B3.9 Industrial

1. Fuel injection nozzles
2. Turbocharger wastegate actuator
3. Lubricating oil fill
4. Front engine lifting bracket
5. Water outlet
6. Lubricating oil filter
7. Water inlet
8. Lubricating oil cooler
9. Lubricating oil drain
10. Provision for lubricating oil immersion heater
11. Starter motor and solenoid
12. Provision for coolant heater.

Engine Diagrams

Engine Views



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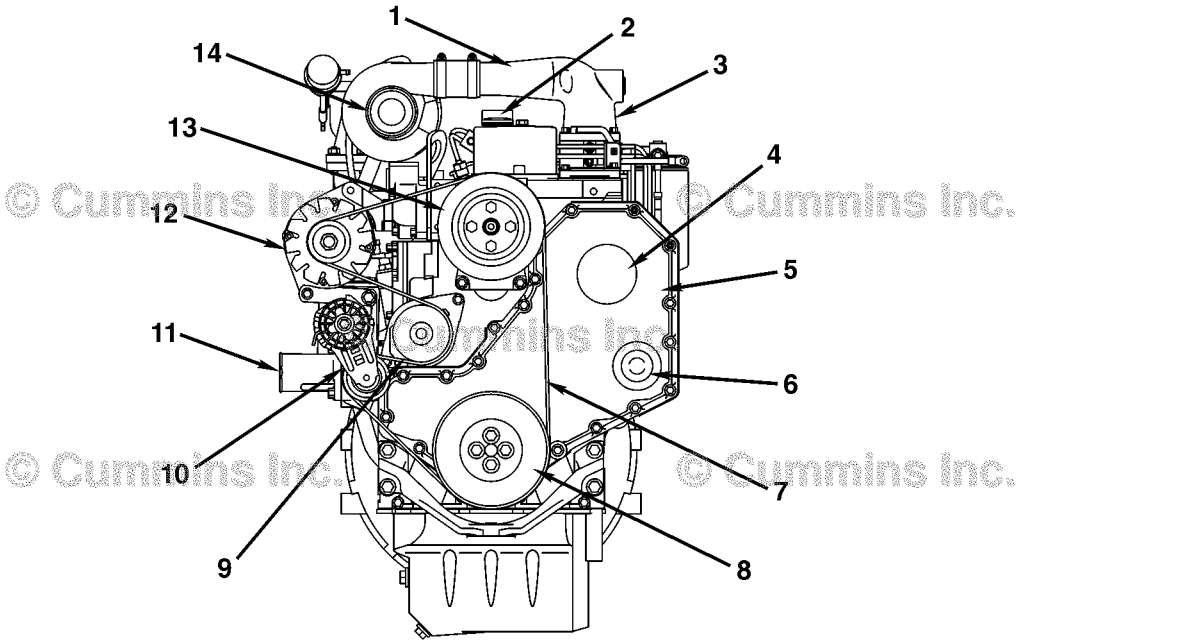
Top View - B3.9 Industrial

1. Water outlet
2. Turbocharger
3. Exhaust manifold
4. Magnetic pickup location (3/4-16 UNF)
5. Engine air inlet.

Engine Diagrams

Engine Views

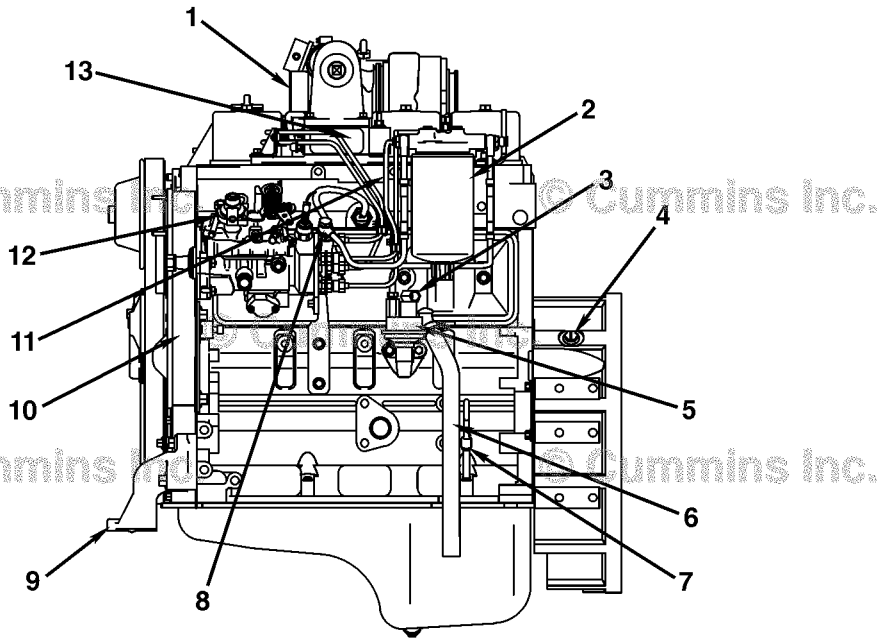


Front View - B4.5 Industrial

1. Turbocharger air outlet
2. Lubricating oil fill
3. Engine air inlet
4. Fuel pump drive cover
5. Front gear cover
6. Accessory drive cover (optional)
7. Fan drive belt
8. Front Pulley
9. Water pump
10. Automatic belt tensioner
11. Water inlet
12. Alternator
13. Fan pulley
14. Turbocharger air inlet.

Engine Diagrams

Engine Views



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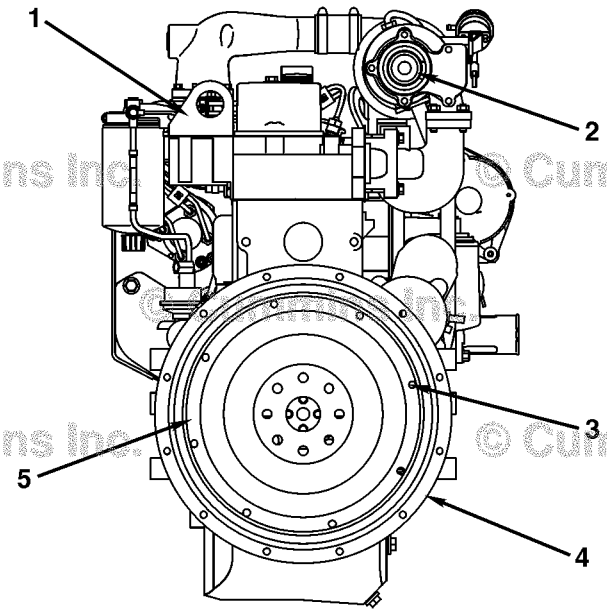
Left Side View - B4.5 Industrial

1. Engine air inlet
2. Fuel filter/water separator
3. Fuel inlet connection
4. Magnetic pickup location (3/4-16 UNF)
5. Fuel lift pump
6. Crankcase breather tube
7. Lubricating oil dipstick
8. Fuel drain connection
9. Front engine mounting bracket
10. Engine dataplate
11. High pressure fuel lines
12. Fuel injection pump
13. Intake air preheater (optional).

Engine Diagrams

Engine Views



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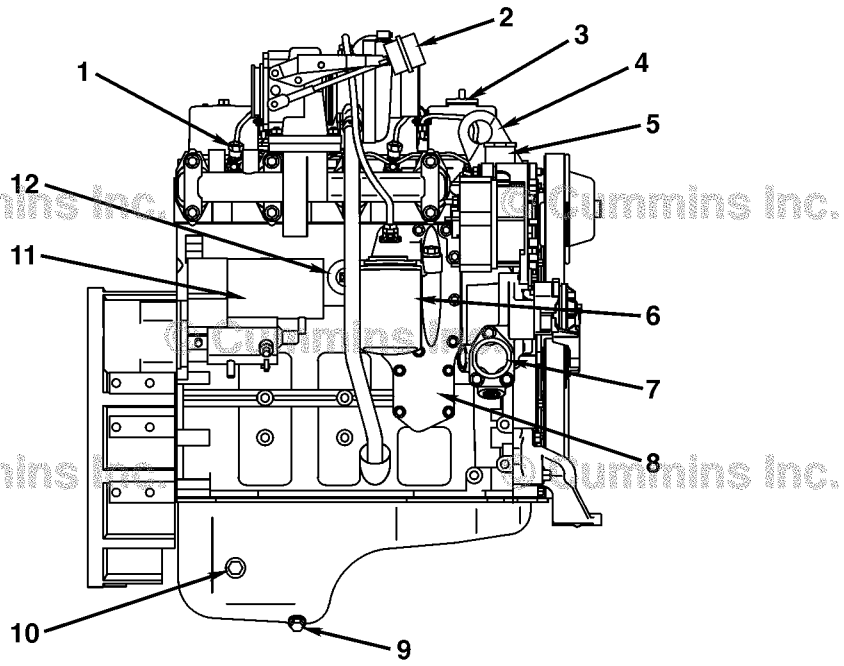
Rear View - B4.5 Industrial

1. Rear engine lifting bracket
2. Turbocharger exhaust outlet
3. Flexplate mounting holes
4. Flywheel housing
5. Flywheel/flexplate.

Engine Diagrams

Engine Views



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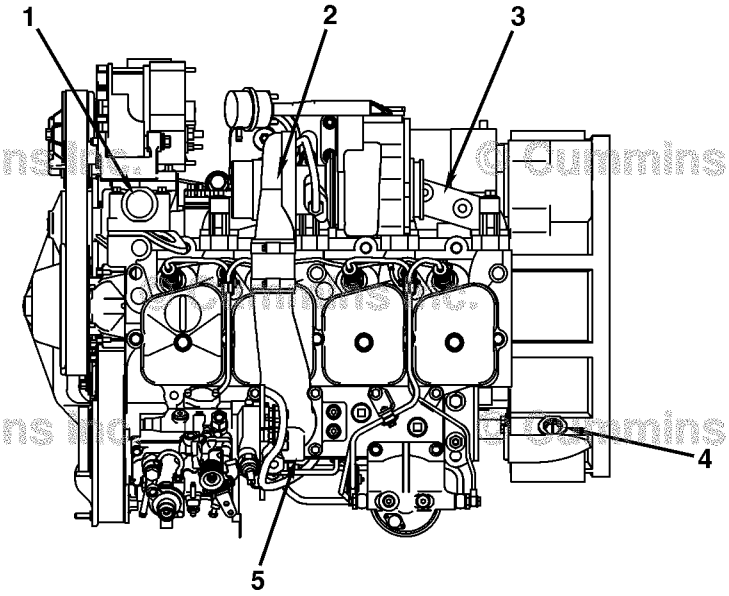
Right Side View - B4.5 Industrial

1. Fuel injection nozzles
2. Turbocharger wastegate actuator
3. Lubricating oil fill
4. Front engine lifting bracket
5. Water outlet
6. Lubricating oil filter
7. Water inlet
8. Lubricating oil cooler
9. Lubricating oil drain
10. Provision for lubricating oil immersion heater
11. Starter motor and solenoid
12. Provision for coolant heater.

Engine Diagrams

Engine Views



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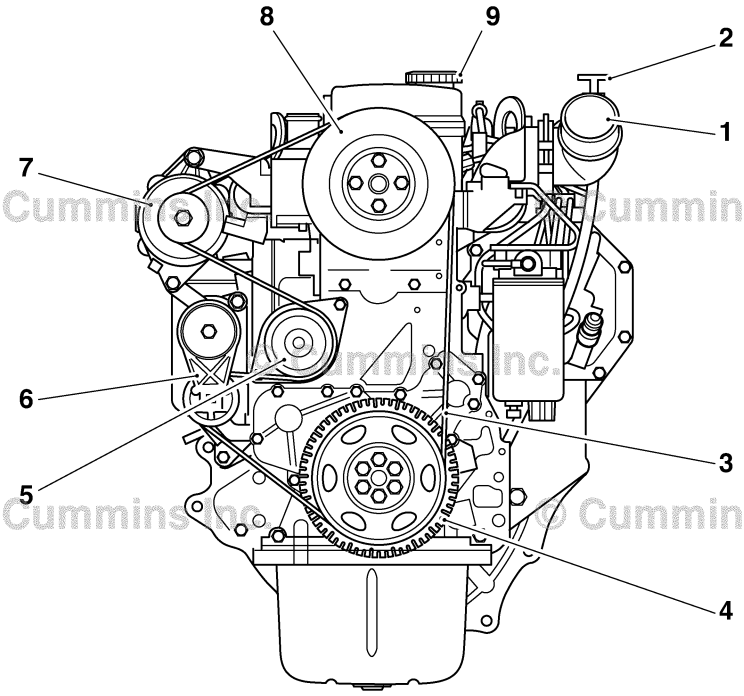
Top View - B4.5 Industrial

1. Water outlet
2. Turbocharger
3. Exhaust manifold
4. Magnetic pickup location (3/4-16 UNF)
5. Engine air inlet.

Engine Diagrams

Engine Views



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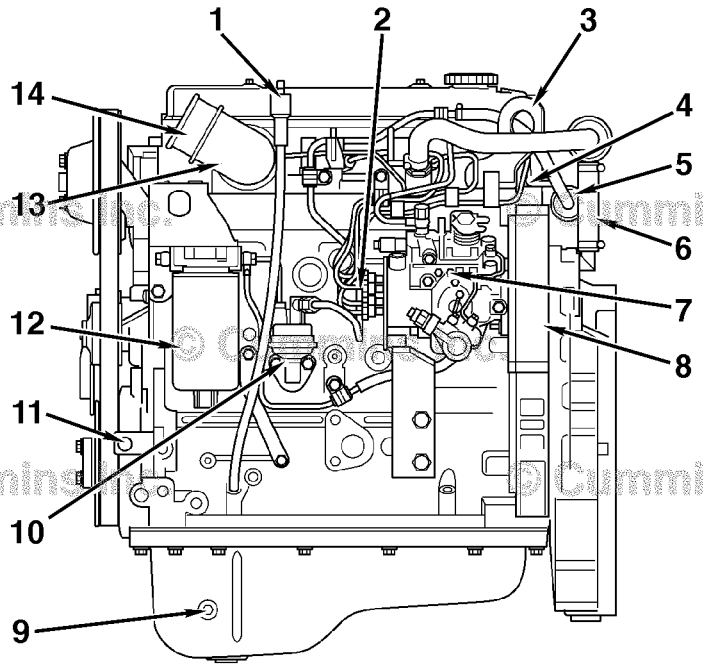
Front View - B4.5 RGT

1. Engine air inlet
2. Lubricating oil dipstick
3. Fan drive belt
4. Front pulley
5. Water pump
6. Automatic belt tensioner
7. Alternator
8. Fan pulley
9. Lubricating oil fill.

Engine Diagrams

Engine Views



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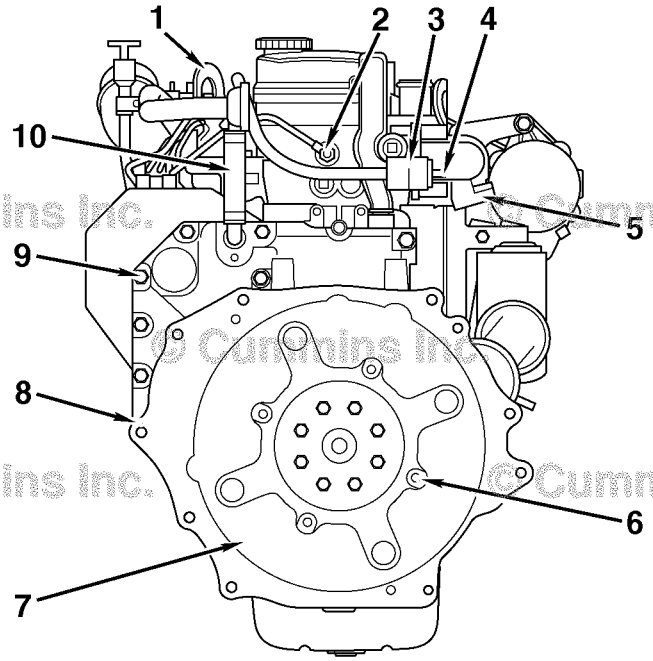
Left Side View - B4.5 RGT

1. Lubricating oil dipstick
2. High pressure fuel lines
3. Rear engine mounting bracket
4. Fuel return line and fuel drain connection
5. Inlet fuel filter
6. Crankcase breather tube
7. Fuel injection pump
8. Engine dataplate
9. Provision for lubricating oil immersion heater
10. Fuel lift pump
11. Magnetic pickup location (3/4-16 UNF)
12. Fuel filter/water separator
13. Intake air preheater (optional)
14. Engine air inlet.

Engine Diagrams

Engine Views



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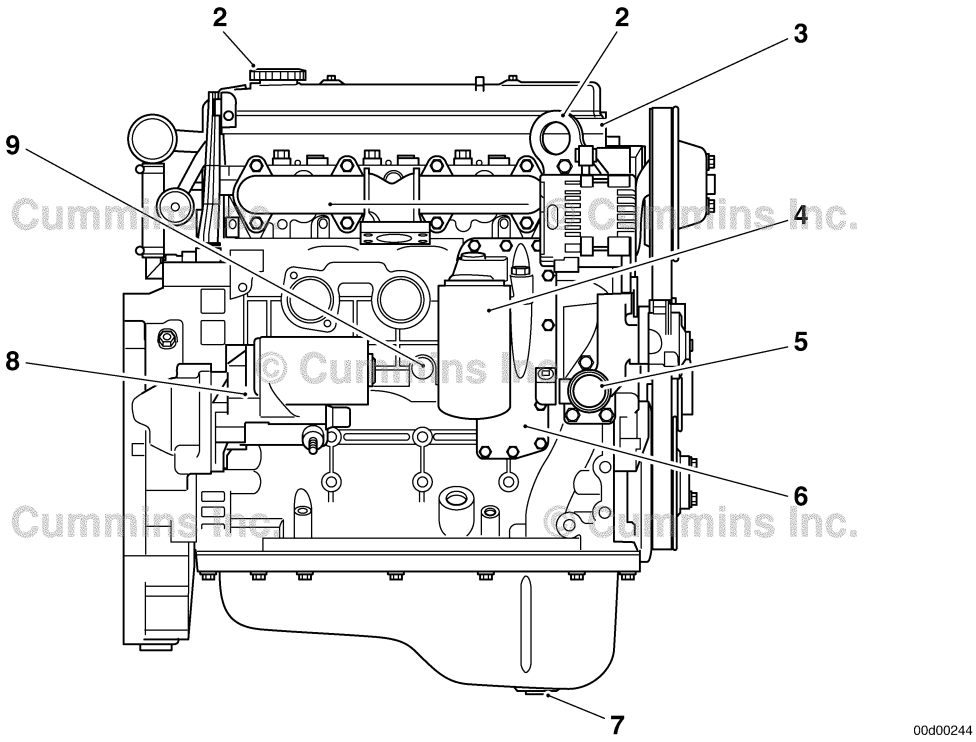
Rear View - B4.5 RGT

1. Rear engine lifting bracket
2. Fuel return and fuel drain connection
3. Inline fuel filter
4. Fuel Inlet connection
5. Exhaust outlet
6. Flexplate mounting holes
7. Flywheel/flexplate
8. Flywheel housing
9. Rear gear train housing
10. Crankcase breather tube.

Engine Diagrams

Engine Views

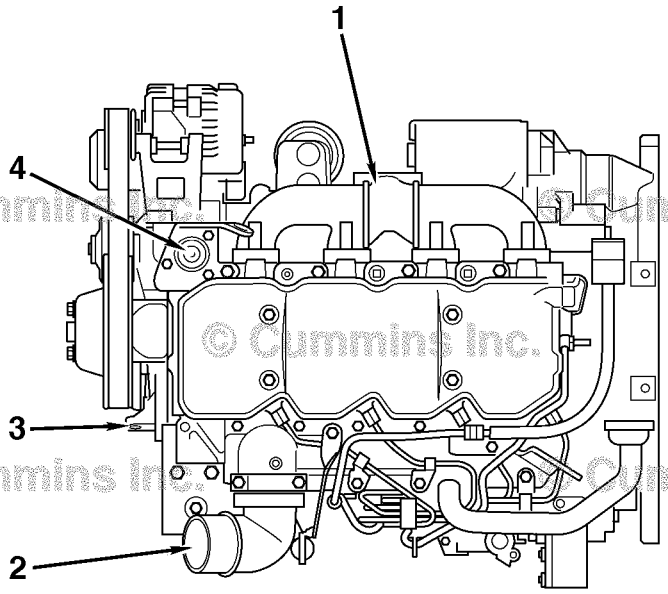


Right Side View - B4.5 RGT

1. Lubricating oil fill
2. Front engine lifting bracket
3. Water outlet
4. Lubricating oil filter
5. Water inlet
6. Lubricating oil cooler
7. Lubricating oil drain
8. Starter motor and solenoid
9. Provision for coolant heater.

Engine Diagrams

Engine Views



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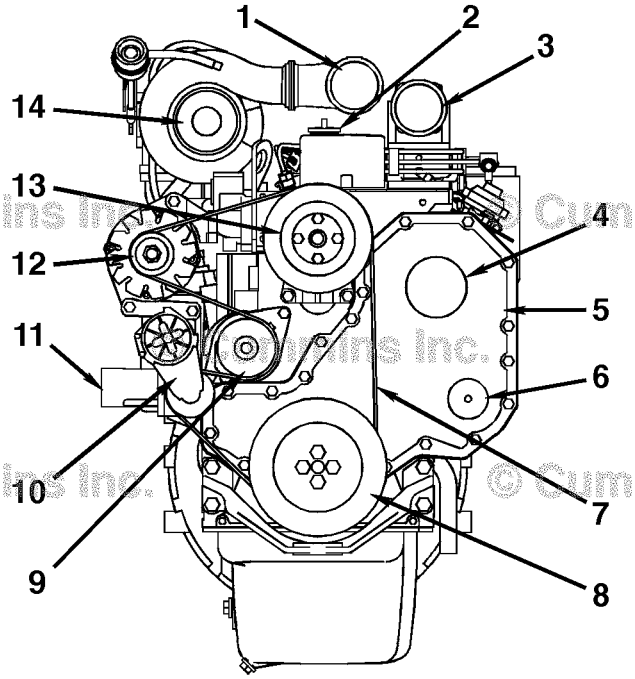
Top View - B4.5 RGT

1. Exhaust manifold
2. Engine air inlet
3. Magnetic pickup location (3/4-16 UNF).
4. Water outlet

Engine Diagrams

Engine Views



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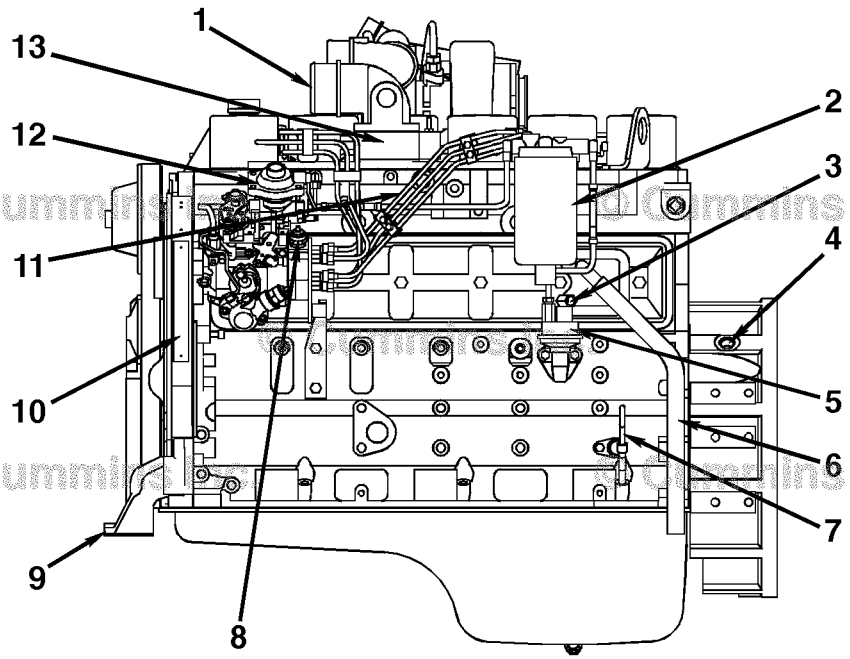
Front View - B5.9 Industrial

1. Turbocharger air outlet
2. Lubricating oil fill
3. Engine air inlet
4. Fuel pump drive cover
5. Front gear cover
6. Accessory drive cover (optional)
7. Fan drive belt
8. Vibration damper
9. Water pump
10. Automatic belt tensioner
11. Water inlet
12. Alternator
13. Fan pulley
14. Turbocharger air inlet.

Engine Diagrams

Engine Views



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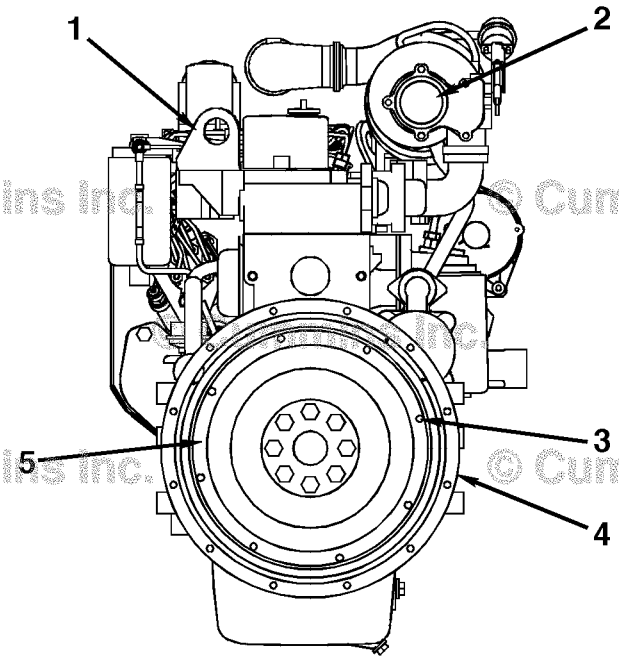
Left Side View - B5.9 Industrial

1. Engine air inlet
2. Fuel filter/water separator
3. Fuel inlet connection
4. Magnetic pickup location (3/4-16 UNF)
5. Fuel lift pump
6. Crankcase breather tube
7. Lubricating oil dipstick
8. Fuel drain connection
9. Front engine mounting bracket
10. Engine dataplate
11. High pressure fuel lines
12. Fuel injection pump
13. Intake air preheater (optional).

Engine Diagrams

Engine Views



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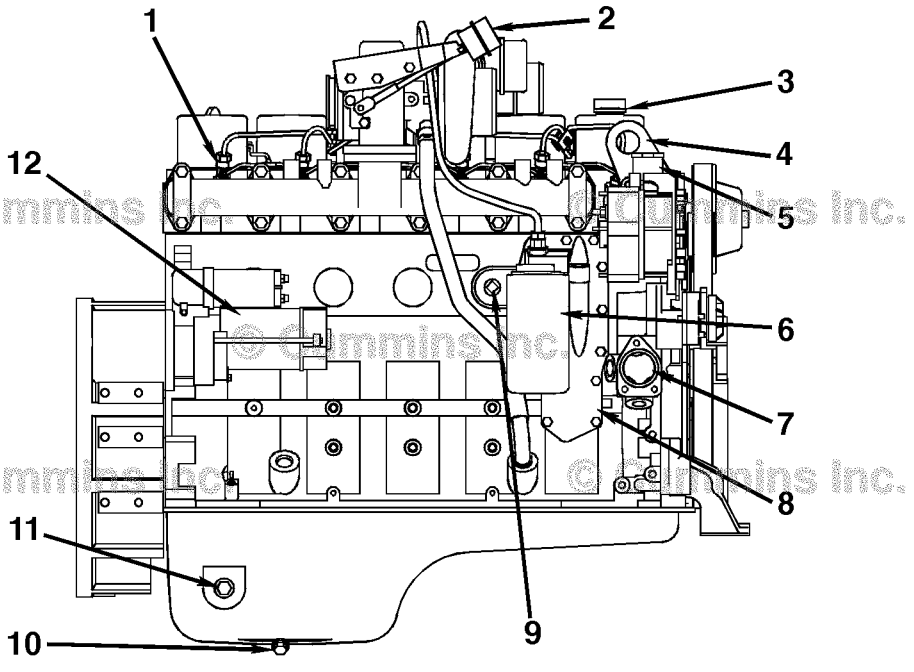
Rear View - B5.9 Industrial

1. Rear engine lifting bracket
2. Turbocharger exhaust outlet
3. Flexplate mounting holes
4. Flywheel housing
5. Flywheel/flexplate.

Engine Diagrams

Engine Views

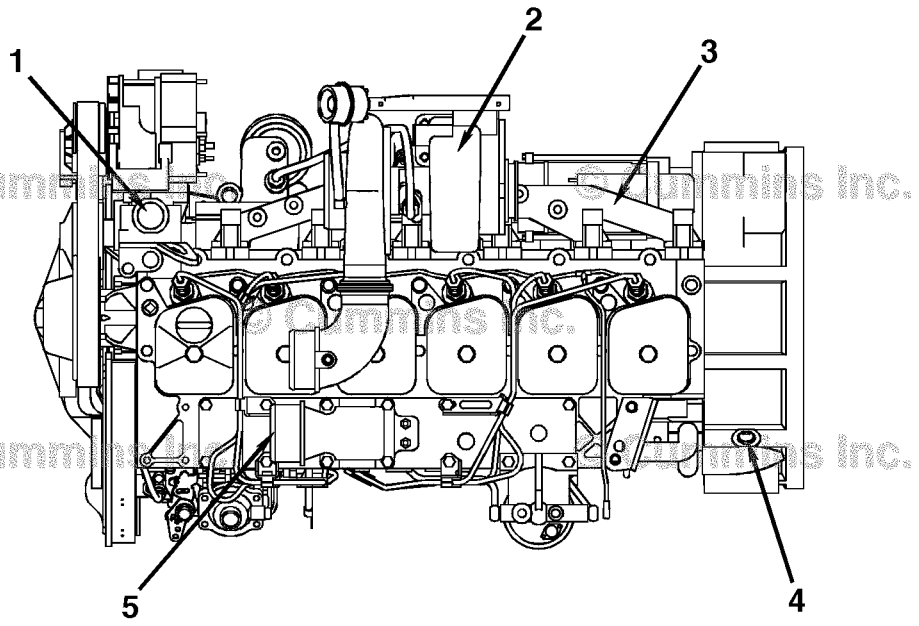


Right Side View - B5.9 Industrial

1. Fuel injection nozzles
2. Turbocharger wastegate actuator
3. Lubricating oil fill
4. Front engine lifting bracket
5. Water outlet
6. Lubricating oil filter
7. Water inlet
8. Lubricating oil cooler
9. Provision for coolant heater
10. Lubricating oil drain
11. Provision for lubricating oil immersion heater
12. Starter motor and solenoid.

Engine Diagrams

Engine Views



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00900352

Top View - B5.9 Industrial

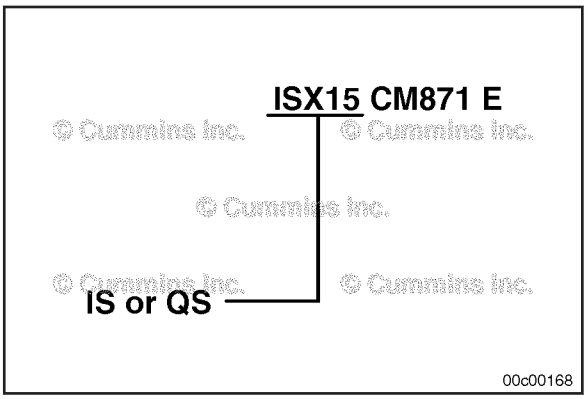
1. Water outlet
2. Turbocharger
3. Exhaust manifold
4. Magnetic pickup location (3/4-16 UNF)
5. Engine air inlet.

Cummins® Service Engine Model Product Identification

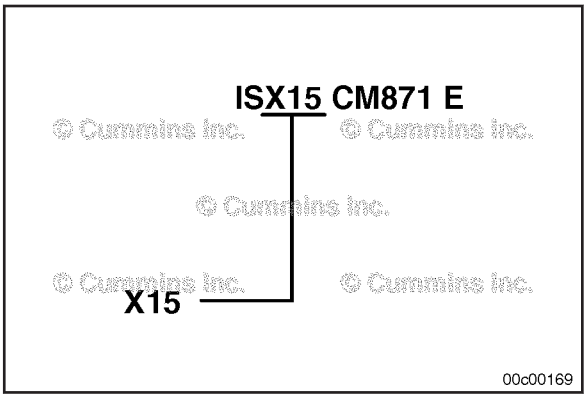
General Information

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.

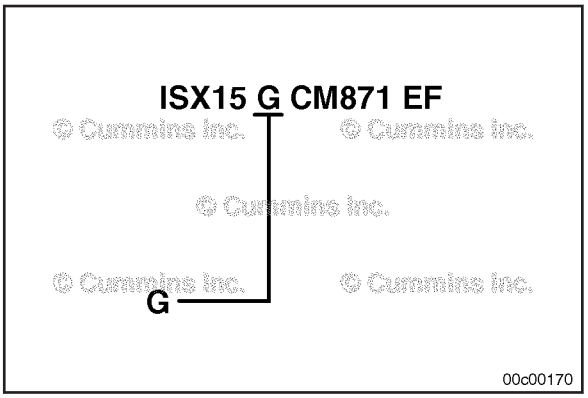
Electronic engines are identified by the first two letters, either an "IS" for On-Highway automotive or "QS" for Off-Highway industrial market applications.

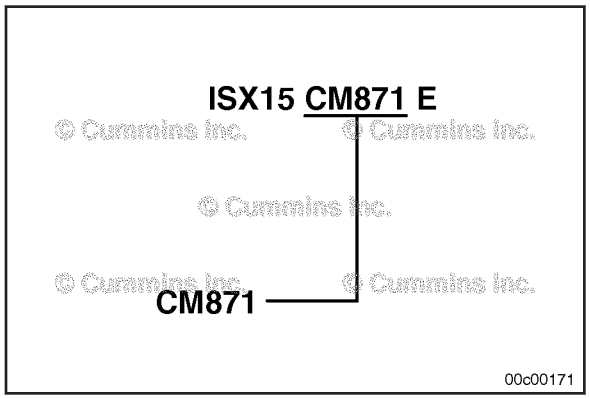


The third letter is the engine platform designation followed by the engine liter size.

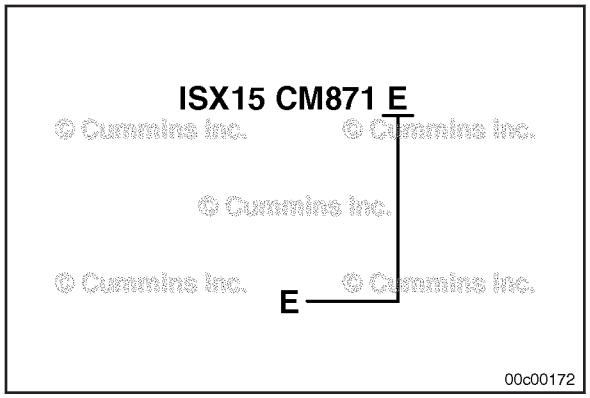


If the engine operates on a fuel type other than diesel, the type will be identified after the liter size.

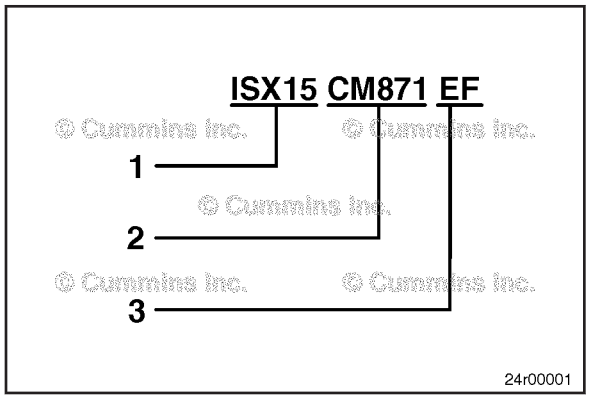




The control system is identified with the letters "CM" followed by the control system model number.



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

Notes

Section 1 - Operating Instructions

Section Contents

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Operating Instructions - Overview

General Information

Correct care of your engine will result in longer life, better performance, and more economical operation.

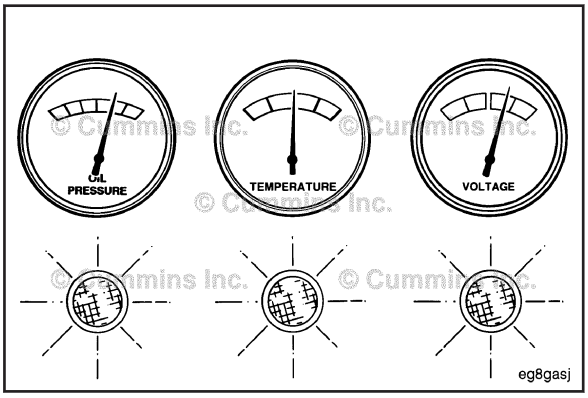
Follow the daily maintenance checks listed in Maintenance Guidelines (Section 2).

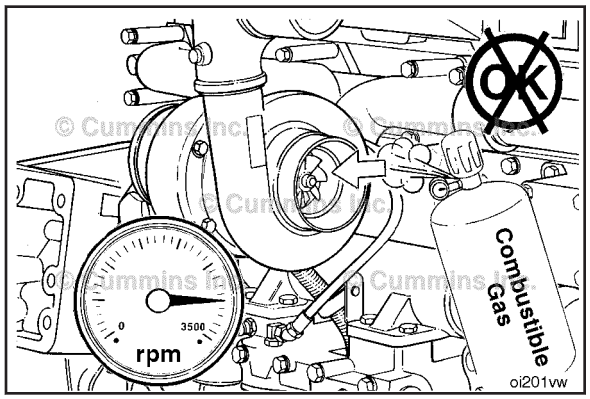
The new Cummins® engine associated with this manual does **not** require a "break-in" procedure. This section of the manual provides all of the necessary information required for proper engine operation.

U.S. legislation requires that stationary compression ignition internal combustion engines designated for emergency use are limited to emergency operations and required maintenance and testing.

Check the oil pressure indicators, temperature indicators, warning lights, and other gauges daily to make sure they are operational.

Check the oil pressure, coolant temperatures DEF level, and other engine parameters daily via the OEM front panel to make sure they are operational. Check the panel regularly for any alarm messages. Take appropriate action to rectify the alarm condition or contact your nearest Authorized Cummins® Distributor.

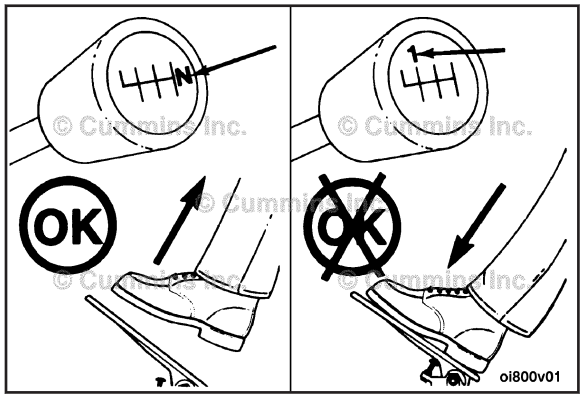




⚠WARNING⚠
Do not operate a diesel engine where there are or can BE COMBUSTIBLE vapors. These vapors can be sucked through the air intake system and cause engine acceleration and over speeding that can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of over speeding where an engine, due to its application, is operating in a combustible environment, such as due to a fuel spill or gas leak. Remember, Cummins Inc. has no way of knowing the use you have for your engine. The equipment owner and operator ARE responsible for safe operation in a hostile environment. Consult A Cummins® Authorized Repair Location for further information.

△CAUTION△
Do not expose the engine to corrosive chemicals. Corrosive chemicals can damage the engine.

Cummins recommends the installation of an air intake shutoff device or a similar safety device to minimize the risk of overspeeding when an engine is operating in a combustible environment, such as due to a fuel spill or gas leak.



Normal Starting Procedure

General Information

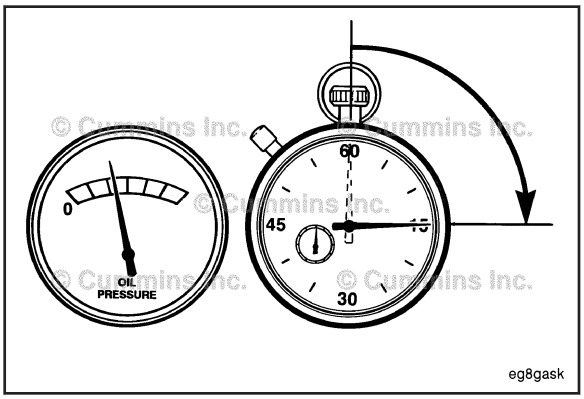
⚠WARNING⚠
Do not depress the accelerator pedal or move the accelerator lever from the idle position while cranking the engine. This can result in engine overspeed and severe damage to the engine.

△CAUTION△
To prevent damage to the starting motor, do not engage the starting motor for more than 30 seconds. Wait 2 minutes between each attempt to start (electrical starting motors only).

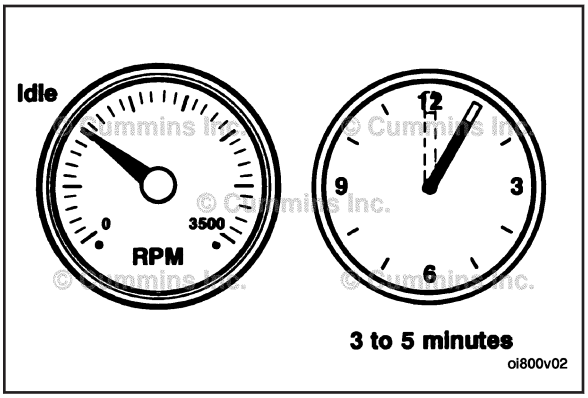
NOTE: Engines equipped with air starting motors require a minimum of 480 kPa [70 psi].

- Disengage the driven unit, or if equipped, put the transmission in neutral.
- With the accelerator pedal or lever in the idle position, turn the key switch to the ON position, and wait for the WAIT-TO-START lamp to go out; then, turn the key to the START position.
- If the engine does **not** start after three attempts, check the fuel supply system. Absence of blue or white exhaust smoke during cranking indicates no fuel is being delivered.

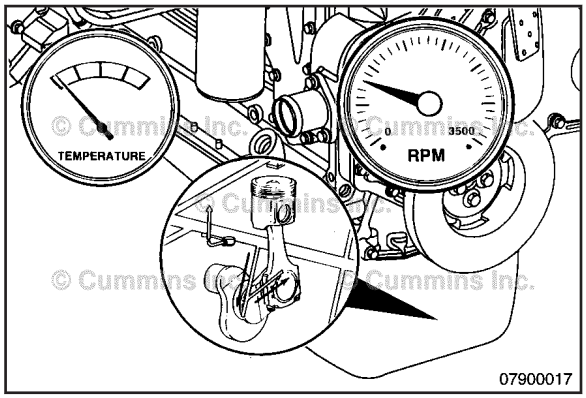
⚠CAUTION⚠
The engine must have adequate oil pressure within 15 seconds after starting. If the WARNING lamp indicating low oil pressure has not gone out or there is no oil pressure indicated on a gauge within 15 seconds, shut off the engine immediately to avoid engine damage. The low oil pressure troubleshooting procedure is located in Troubleshooting Symptoms(Section TS).



Idle the engine 3 to 5 minutes before operating with a load.

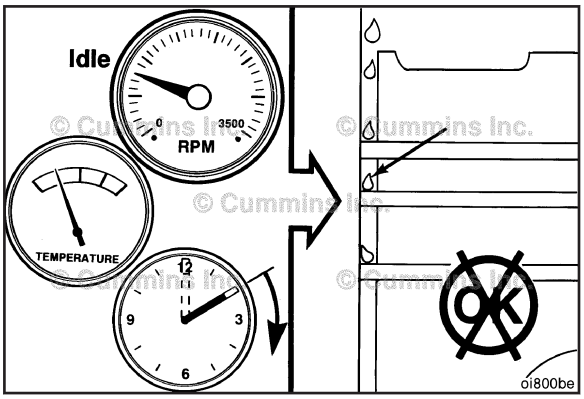


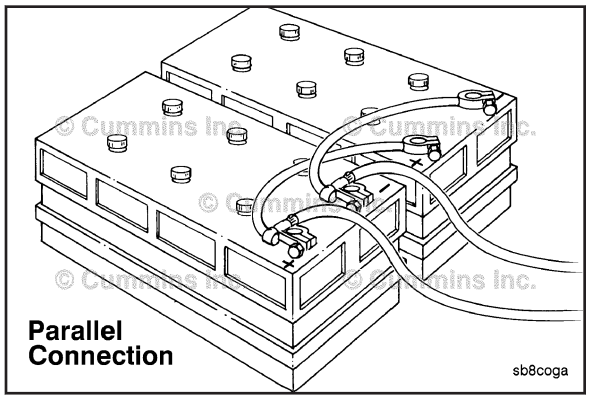
After starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.



⚠CAUTION⚠
Do not operate engine at low idle for long periods with engine coolant temperature below the minimum specification in Maintenance Specifications (Section V). This can result in the following:

- Fuel Dilution of the lubricating oil
- Carbon build up in the cylinder
- Cylinder head valve sticking
- Reduced performance.





Jump Starting

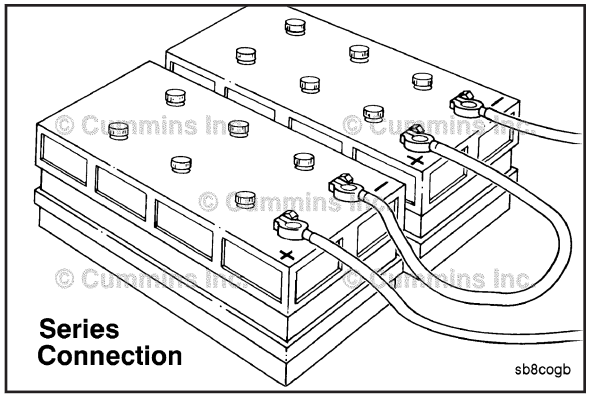
⚠WARNING⚠
Batteries can emit explosive gases. To avoid personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative(-) battery cable last.

△CAUTION△
When using jumper cables to start the engine, make sure to connect the cables in parallel: Positive (+) to positive (+) and negative(-) to negative (-). When using an external electrical source to start the engine, turn the disconnect switch to the OFF position. Remove the key before attaching the jumper cables.

△CAUTION△
To avoid damage to engine parts, do not connect jumper starting or battery charging cable to any fuel system or electronic component.

This illustration shows a typical parallel battery connection. This arrangement doubles the cranking amperage.

NOTE: Always reference the relevant OEM literature for jump starting procedures. Failure to follow correct procedures can result in damage to the ECM and other electrical equipment.

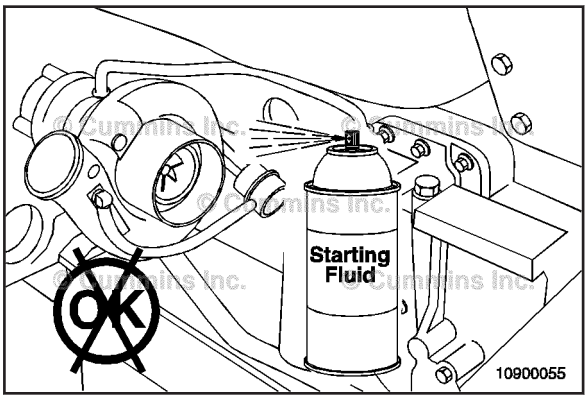


This illustration shows a typical series battery connection. This arrangement, positive (+) to negative (-), doubles the voltage.

NOTE: Always reference the relevant OEM literature for jump starting procedures. Failure to follow correct procedures can result in damage to the ECM and other electrical equipment.

Cold Weather Starting

With Flame Start System



⚠WARNING⚠
Do not use starting fluids with this engine. This engine is equipped with a flame start system; use of starting fluid can cause an explosion, fire, personal injury, severe damage to the engine and property damage.

The **only** recommended cold weather starting aids for industrial applications with grid a flame start system, are engine coolant preheaters and oil pan immersion heaters. Contact a Cummins® Authorized Repair Location for more information

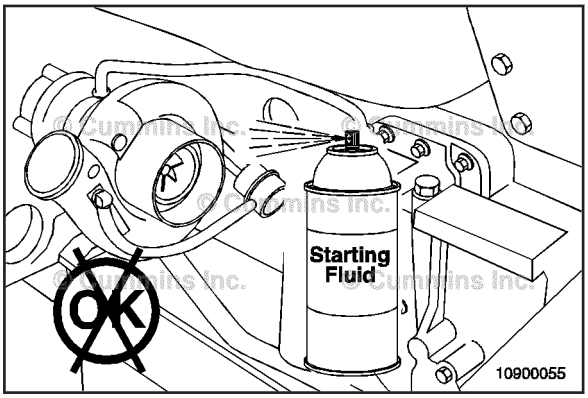
Cold weather starting aids are available for your engine. Contact a Cummins® Authorized Repair Location for more information.

In cold weather, the WAIT-TO-START lamp will stay on longer.

If ambient temperature is below 16° C [60° F], fully depress the throttle after engaging the stater. Full throttle on the VE pump makes sure there is sufficient start fuel delivery and helps keep the engine operating once started. The in-line pumps with RQV and RQV-K governors require full throttle position and hold the rack in the start fuel position. The throttle **must** be depressed after engaging the starter to allow the shutoff lever to move to the run position before moving the throttle.

Grid Heater

Industrial Applications



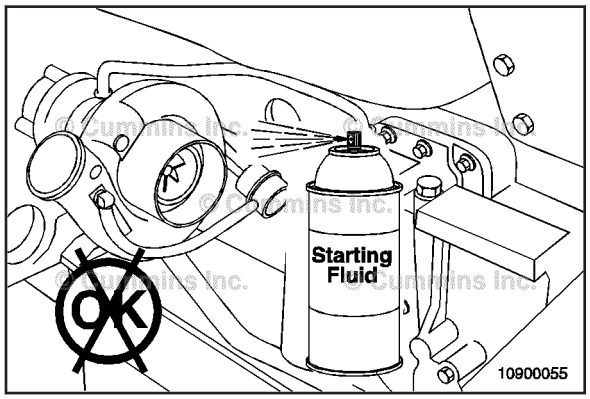
⚠WARNING⚠
Do not use starting fluids with this engine. This engine is equipped with an intake air heater; use of starting fluid can cause an explosion, fire, personal injury, severe damage to the engine and property damage.

The **only** recommended cold weather starting aids for marine or industrial applications with grid a heater or air intake heater, are engine coolant preheaters and oil pan immersion heaters. Contact a Cummins® Authorized Repair Location for more information

Cold weather starting aids are available for your engine. Contact a Cummins® Authorized Repair Location for more information.

In cold weather, the WAIT-TO-START lamp will stay on longer.

If ambient temperature is below 16° C [60° F], fully depress the throttle after engaging the stater. Full throttle on the VE pump makes sure there is sufficient start fuel delivery and helps keep the engine operating once started. The in-line pumps with RQV and RQV-K governors require full throttle position and hold the rack in the start fuel position. The throttle **must** be depressed after engaging the starter to allow the shutoff lever to move to the run position before moving the throttle.



Ether Starting Aids

Industrial Applications

⚠WARNING⚠
Because of the potential for an explosion, do not use volatile cold starting aids in underground mine or tunnel operations. Ask the local U.S. Bureau of Mines inspector for instructions.

⚠WARNING⚠
Starting fluid is highly flammable and explosive. Keep flames, sparks, and arcing switches away from starting fluid.

⚠WARNING⚠
To reduce the possibility of personal injury, avoid inhalation of starting fluid vapors.

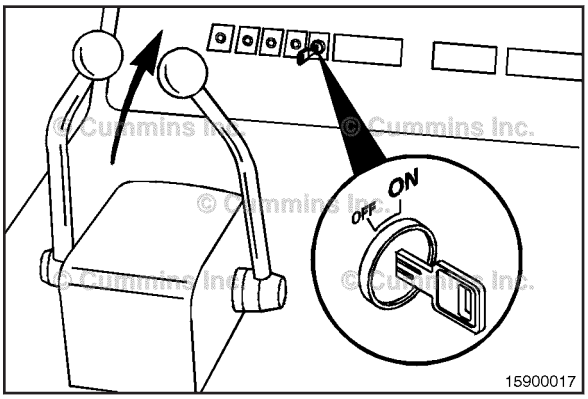
△CAUTION△
Do not use excessive amounts of starting fluid when starting an engine. The use of too much starting fluid will cause damage to the engine.

If ambient temperature is below 16° C [60° F], fully depress the throttle after engaging the stater. Full throttle on the VE pump makes sure there is sufficient start fuel delivery and helps keep the engine operating once started. The in-line pumps with RQV and RQV-K governors require full throttle position and hold the rack in the start fuel position. The throttle **must** be depressed after engaging the starter to allow the shutoff lever to move to the run position before moving the throttle.

Spray starting fluid into the air cleaner intake while another person cranks the engine.

Starting Procedure After Extended Shutdown or Oil Change

General Information

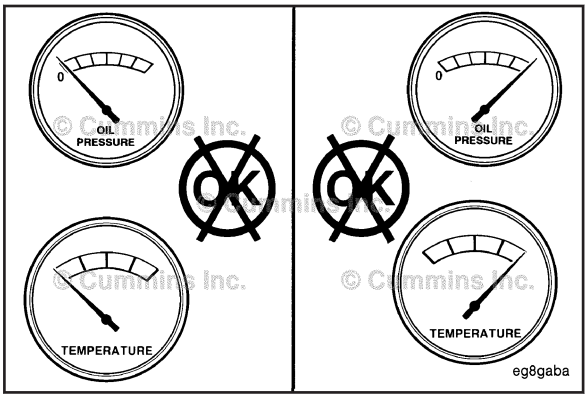


Complete the following steps after each oil change, or after the engine has been shut down for more than 30 days to make sure the engine receives the correct oil flow through the lubricating oil system.

1. Disconnect the electrical wire from the fuel pump solenoid.
2. Rotate the crankshaft, using the starting motor, until oil pressure appears on the gauge or the warning lamp goes out.
3. Connect the electrical wire to the fuel pump solenoid valve.
4. Start the engine. Refer to 101-014 (Normal Starting Procedure).

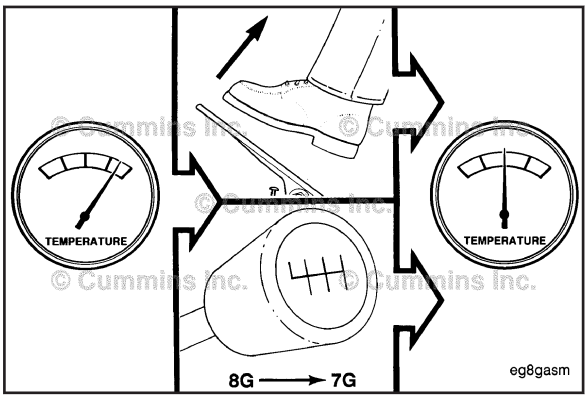
Operating the Engine

Normal



If equipped, monitor the oil pressure and coolant temperature gauges frequently. Refer to Lubricating Oil System specifications and Cooling System specifications, in Maintenance Specifications (Section V) for recommended operating pressures and temperatures. Shut off the engine if any pressure or temperature does **not** meet the specifications.

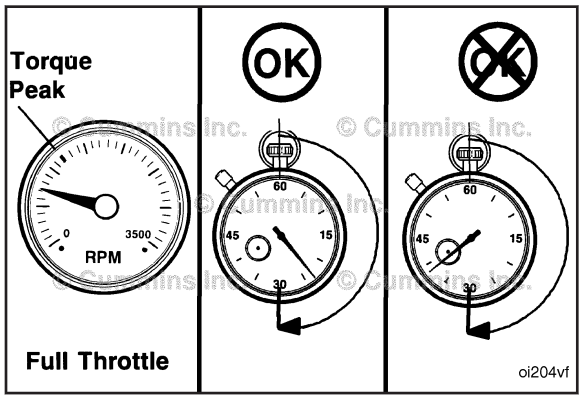
Continuous operation with engine coolant temperature above or below the engine coolant temperature specifications listed in Maintenance Specifications (Section V) can damage the engine.



If an overheating condition starts to occur, reduce the power output of the engine by releasing the accelerator pedal or lever or shifting the transmission to a lower gear, or both, until the temperature returns to the normal operating range. If the engine temperature does **not** return to normal, shut off the engine, and refer to Troubleshooting Symptoms (Section TS), or contact a Cummins® Authorized Repair Location.

Winterfronts and Shutters

Winterfronts and shutters can be used on a vehicle or equipment to reduce air flow through the radiator core into the engine compartment. This can reduce the time required to warm the engine and help maintain the engine coolant temperature. The engine coolant temperature specifications are in the Maintenance Specification (Section V).



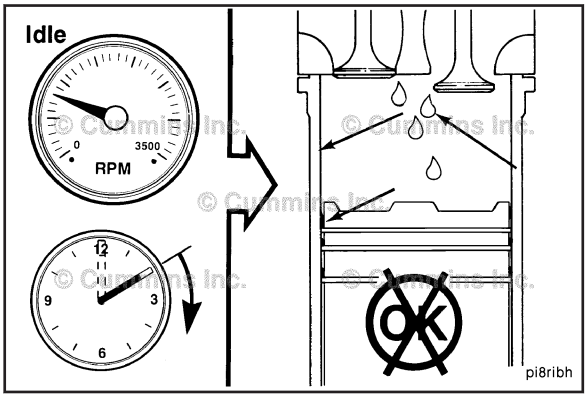
Engine Operating Range

General Information

⚠CAUTION⚠
Do not operate the engine at full throttle below peak torque rpm (refer to engine dataplate for peak torque rpm) for more than 30 seconds. Operating the engine at full throttle below peak torque will shorten engine life to overhaul, can cause serious engine damage, and is considered engine abuse.

Cummins® engines are designed to operate successfully at full throttle under transient conditions down to peak torque engine speed. This is consistent with recommended operating practices.

⚠CAUTION⚠
Do not operate the engine beyond the maximum engine speed. Operating the engine beyond the maximum engine speed can cause severe engine damage. Use proper operating techniques for the vehicle, vessel, or equipment to prevent engine overspeed. The maximum engine speed specification is listed in Maintenance Specifications (Section V).



⚠CAUTION⚠
Do not idle the engine for excessively long periods. Long periods of idling, more than 10 minutes, can cause poor engine performance.

Engine Shutdown

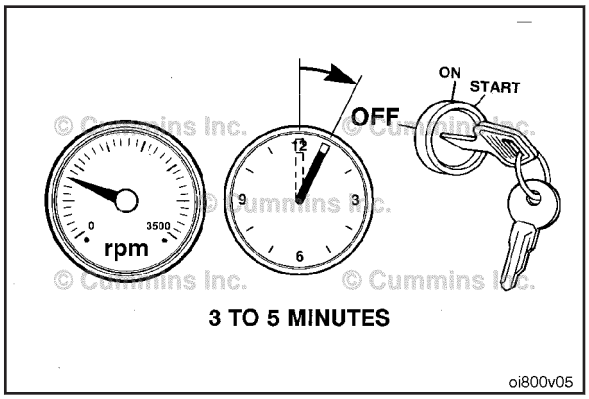
General Information

Allow the engine to idle 3 to 5 minutes before shutting it off after a full-load operation. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

NOTE: For engines equipped with an electronic control module (ECM) ensure the keyswitch is turned off for a minimum of 70 seconds prior to disconnecting the continuous (unswitched) battery power supply. If the unswitched battery power supply is disconnected in less than 70 seconds after the keyswitch is turned off active fault codes and incorrect ECM information can occur.

Turn the ignition switch to the OFF position. If the engine does **not** shut down, refer to Troubleshooting Symptom (Section TS) in appropriate Operation and Maintenance manual.

⚠CAUTION⚠
Failure to follow the correct shutdown procedure may result in damage to the turbocharger and shorten the turbocharger life.



Electromagnetic Interference (EMI)

General Information

Some applications utilize accessories such as (CB radios, mobile transmitters, etc.) if not installed and used correctly the radio frequency energy generated by these accessories can cause electromagnetic interference (EMI) conditions to exist between the accessory and the Cummins electronically controlled systems. Cummins is **not** liable for any performance problems with either the electronically controlled systems or the accessory due to EMI. EMI is **not** considered by Cummins to be a system failure and therefore is **not** warrantable.

System EMI Susceptibility

Your Cummins product has been designed and tested for minimum sensitivity to incoming electromagnetic energy. Testing has shown that there is no performance degradation at relatively high energy levels; however, if very high energy levels are encountered, then some noncritical diagnostic fault code logging can occur. The electronically controlled systems EMI susceptibility level will protect your systems from most, if **not** all, electromagnetic energy-emitting devices that meet the legal requirements.

System EMI Radiation Levels

Your Cummins product has been designed to emit minimum electromagnetic energy. Electronic components are required to pass various Cummins and industry EMI specifications. Testing has shown that when the systems are properly installed, they will not interfere with onboard communication equipment or with the vehicle's, equipment's, or vessel's ability to meet any applicable EMI standards and regulated specifications.

If an interference condition is observed, follow the suggestions below to reduce the amount of interference:

1 Locate the transmitting antenna as far away from the electronically controlled systems and as high as possible.

2 Locate the transmitting antenna as far away as possible from all metal obstructions (e.g., exhaust stacks)

3 Consult a representative of the accessory supplier in your area to:

- Accurately calibrate the device for proper frequency, power output, and sensitivity (both base and remote site devices **must** be properly calibrated)
- Obtain antenna reflective energy data measurements to determine the optimum antenna location
- Obtain optimum antenna type and mounting arrangement for your application
- Make sure your accessory equipment model is built for maximum filtering to reject incoming electromagnetic noise.

Notes

Section 2 - Maintenance Guidelines

Section Contents

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Maintenance Guidelines - Overview

General Information

Cummins Inc. recommends that the system be maintained according to the Maintenance Schedule in this section.

If the system is operating in ambient temperatures below -18°C [0°F] or above 38°C [100°F], perform maintenance at shorter intervals. Shorter maintenance intervals are also required if the system is operated in a dusty environment or if frequent stops are made. For gas fueled generator sets, shorter maintenance intervals are also required, if operating at loads below 70% for prolonged periods. Contact your local Cummins® Authorized Repair Location for recommended maintenance intervals.

Some of these maintenance procedures require special tools or must be completed by qualified personnel. Contact your local Cummins® Authorized Repair Location for detailed information.

If your system is equipped with a component or accessory not manufactured or supplied by Cummins Inc., refer to the component manufacturer's maintenance recommendations.

OEM supplied equipment and components can impact on the performance and reliability of the engine if they are not correctly maintained.

Use the chart provided in this section as a convenient way to record maintenance performed.

Tool Requirements

General Information

Most of the maintenance operations described in this manual can be performed with common hand tools (metric and S.A.E. wrenches, sockets, and screwdrivers).

The following is a list of special service tools required for some maintenance operations:

Tool Part Number	Description
ST-1273	Pressure gauge
3375045	Torque wrench (0 to 175 ft-lb)
3375049	Oil filter wrench
3376807	Engine coolant and fuel filter wrench
3824556	Charge air cooler (CAC) pressure kit
3824591	Engine barring gear
3824783	Torque wrench (0 to 300 in-lb)
CC-2800	Refractometer
CC-2802	Coolant test kit
3824842	M10 Compucheck® fitting
3377161	Digital multimeter
3164488	Digital multimeter

Contact your nearest Cummins® Authorized Repair Location for the required service tools.

Maintenance Schedule

General Information

For your convenience, listed below are the section numbers that contain specific instructions for performing the maintenance checks.

Perform maintenance at whichever interval occurs first. At each scheduled maintenance interval, perform all previous maintenance checks that are due for scheduled maintenance.

Maintenance Procedures at Daily Interval(4) .....Section 3

- Air Intake Piping - Inspect
- Air Tank and Reservoirs - Drain
- Cooling Fan - Check
- Crankcase Breather Tube - Inspect
- Drive Belts - Check
- Engine Coolant Level - Check
- Engine Lubricating Oil Level - Check
- Fuel-Water Separator - Drain

Maintenance Procedures at 250 Hours or 3 Months(1, 4) .....Section 4

- Air Cleaner Restriction - Check
- Air Compressor Mounting Hardware - Check
- Charge Air Cooler - Check
- Charge Air Piping - Check
- Fuel Injection Pump Mounting Hardware - Check
- Lubricating Oil and Filters - Change
- Radiator Hoses - Check
- Radiator Pressure Cap - Check

Maintenance Procedures at 500 Hours or 6 Months(2, 3, 4) .....Section 5

- Engine Coolant - Check
- Fuel Filter, Canister Type - Change
- Fuel Filter, Spin-On Type - Change
- Lubricating Oil and Filters - Change

Maintenance Procedures at 1000 Hours or 1 Year(4) .....Section 6

- Cooling Fan Belt Tensioner - Check
- Fan Hub, Belt-Driven - Check
- Overhead Set - Adjust

Maintenance Procedures at 2000 Hours or 2 Years(3, 4) .....Section 7

- Air Compressor Discharge Line - Check
- Cooling System - Flush5
- Vibration Damper, Rubber - Check
- Vibration Damper, Viscous - Check

1 The lubricating oil and lubricating oil filter interval can be adjusted based on application, fuel consumption, gross vehicle weight, and idle time. For engines whose aspiration is jacket water-cooled, turbocharged **only**, or natural, refer to Table 1 in the Oil Drain Intervals section.

2 The lubricating oil and lubricating oil filter interval can be adjusted based on application, fuel consumption, gross vehicle weight, and idle time. For engines whose aspiration is charge air cooled, refer to Table 2 in the Oil Drain Intervals section.

3 Antifreeze check interval is every oil change or 500 hours or 6 months, whichever occurs first. The operator **must** use a heavy-duty year-round antifreeze that meets the chemical composition of ASTM D6210. The antifreeze change interval is 2 years, 2000 hours, or whichever occurs first. Antifreeze is essential for freeze, overheat, and corrosion protection.

4 Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical components, charge air cooler, radiator, air compressor, air cleaner, refrigerant compressor, and fan clutch.

5 The cooling system requirement to Flush at this scheduled maintenance includes: Drain, Flush. and Fill.

Oil Drain Intervals

Refer to Table 1 or Table 2 to determine the maximum recommended oil change and filter change intervals engine operating in hours or months, whichever comes first.

Table 1: Jacket Water Cooled, Turbocharged Only, or Naturally Aspirated Engines

Cummins® Engine Standard Classification	American Petroleum Institute Classification	International Classifications	All Engine Ratings
(CES)	(API)		
CES-20078, CES-20077, CES-20076, CES-20072, CES-20071	API CI-4/SK, API CI-4, API CH-4, API CH-4/SJ	ACEA E-5, Global DHD-1	250 Hours or 3 Months
CES-20075	API CF-4/SG	ACEA E-3, ACEA E-2, JAMA DH-1	150 Hours or 6 Weeks
	API CG-4/SH, API CD, API CE	ACEA E-1	Obsolete. Do **not** use.

Table 2: Charge Air Cooled Engines

Cummins® Engine Standard Classification	American Petroleum Institute Classification	International Classifications	All Engine Ratings
(CES)	(API)		
CES-20078, CES-20077, CES-20076, CES-20072, CES-20071	API CI-4/SK, API CI-4, API CH-4, API CH-4/SJ	ACEA E-5, Global DHD-1	500 Hours or 6 Months
CES-20075	API CF-4/SG	ACEA E-3, ACEA E-2, JAMA DH-1	250 Hours or 3 Months
Months	API CG-4/SH, API CD, API CE	ACEA E-1	Obsolete. Do **not** use.

Maintenance Record Form

Maintenance Data

Maintenance Record	
Engine Serial No.:	Engine Model:
Owner's Name:	Equipment Name/Number:

Key to table headings:
A = Date
B = km [Miles], Hours or Time Interval
C = Actual km [Miles] or Hours
D = Maintenance Check Performed
E = Check Performed By
F = Comments

A	B	C	D	E	F

Notes

Section 3 - Maintenance Procedures at Daily Interval

Section Contents

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Daily Maintenance Procedures - Overview

General Information

Preventative maintenance begins with day-to-day awareness of the system. Before starting the system, check the appropriate fluid levels. Look for:

- Leaks
- Loose or damaged parts
- Worn or damaged belts
- Worn or damage low and high voltage harnesses
- Any change in system appearance.
- Odor of fuel
- Odor of electronic devices

System Operation Report

The system **must** be maintained in top mechanical and electronic condition if the operator is to get optimum satisfaction from its use. The maintenance department needs daily running reports from the operator to make necessary adjustments in the time allocated. The daily running report also helps to make provisions for more extensive maintenance work as the reports indicate the necessity.

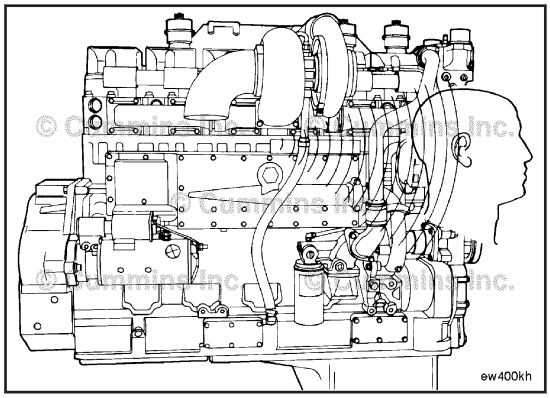
Comparison and intelligent interpretation of the daily report, along with a practical follow-up action, will eliminate most failures and emergency repairs.

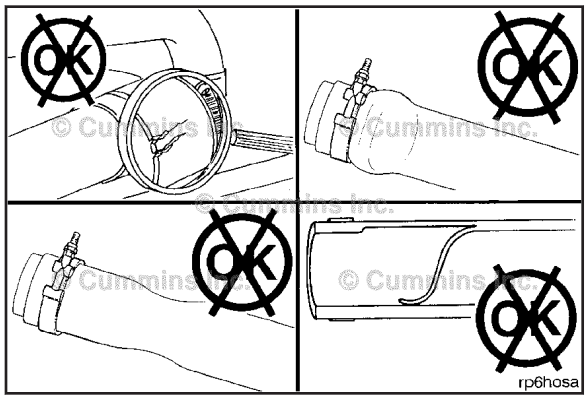
Report to the maintenance department any of the following conditions that may apply:

- Low lubricating oil pressure
- Low power
- Power increases or engine surge
- Erratic or no accelerator control or response
- Any warning lights flashing or staying on
- Abnormal water or oil temperature
- Unusual system noise
- Excessive smoke
- Excessive use of coolant, fuel, or lubricating oil
- Any fuel, coolant, or lubricating oil leaks
- Loose or damaged parts
- Worn or damaged belts
- Worn or damaged low or high voltage harnesses

Unusual System Noise

During daily maintenance checks, listen for any unusual system noise(s) that can indicate that service is required.





Air Intake Piping

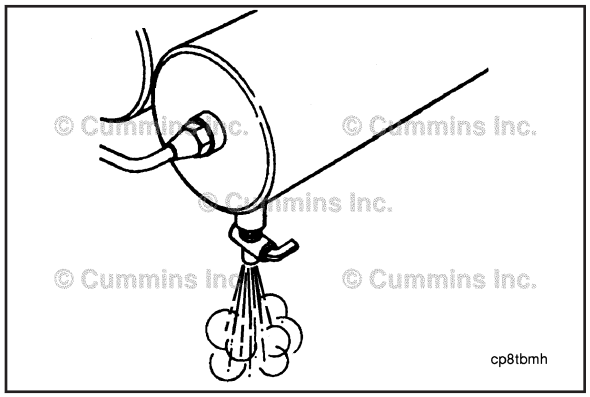
Maintenance Check

Inspect the intake piping daily for wear points and damage to piping, loose clamps, and punctures that can damage the engine.

Replace damaged pipes and tighten loose clamps, as necessary, to prevent the air system from leaking.

Torque Value: 8 N•m [71 in-lb]

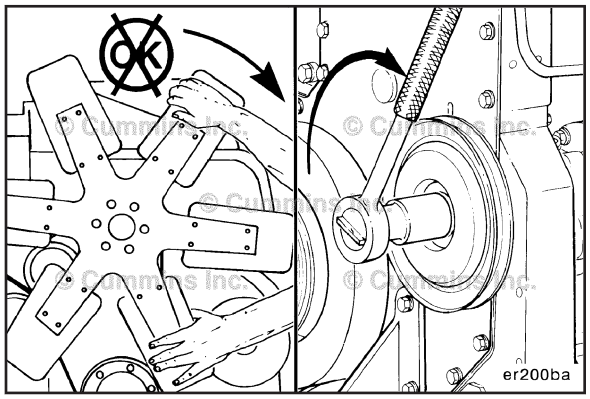
Check for corrosion under the clamps and hoses of the intake system piping. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean, as required.



Air Tanks and Reservoirs

Drain

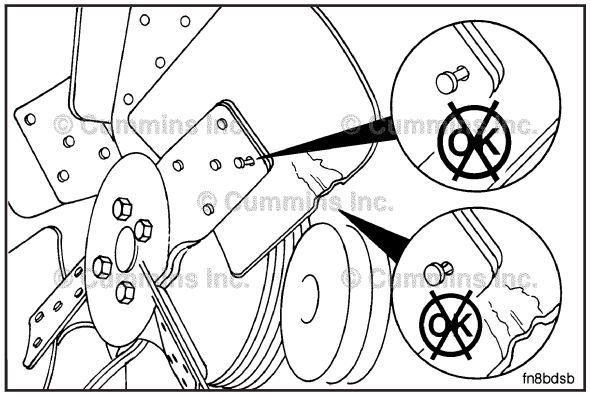
If automatic purging or spitter valves are used, confirm the valves are operating correctly. If a manual drain valve is used on the wet tank, open the draincock on the wet tank to drain any moisture accumulated in the air system. If oil is present, the air compressor system **must** be checked. Contact your Cummins Authorized Repair Location.



Fan, Cooling

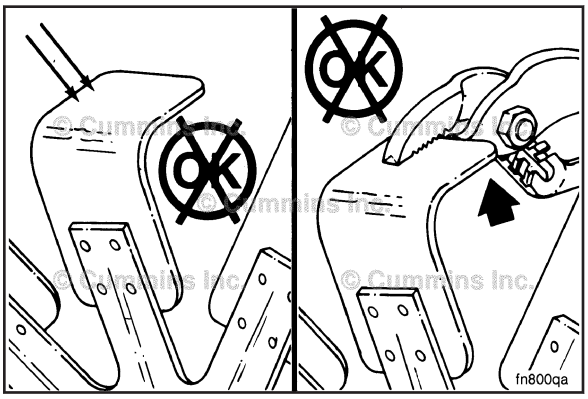
Inspect for Reuse

⚠WARNING⚠
Do not rotate the engine by pulling or prying on the fan. The fan blade(s) can be damaged and cause the fan to fail and cause personal injury or property damage. Use the accessory drive shaft or the crankshaft barring tool to rotate the crankshaft.



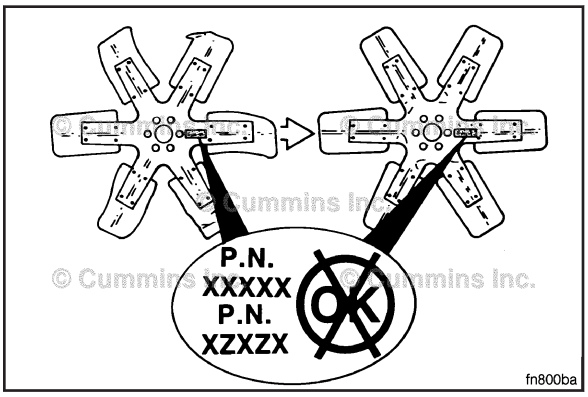
A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, and bent or loose blades. Check the fan to make sure it is securely mounted. Tighten the capscrews, if necessary.

⚠WARNING⚠
Do not straighten a bent fan blade or continue to use a damaged fan. A bent or damaged fan blade can fail during operation and cause personal injury or property damage.



Replace original equipment fan that is damaged with a fan of the identical part number. Cummins Inc. **must** approve any other fan changes to be covered under warranty.

Refer to the vehicle or equipment manufacturer's specifications for capscrew torque.

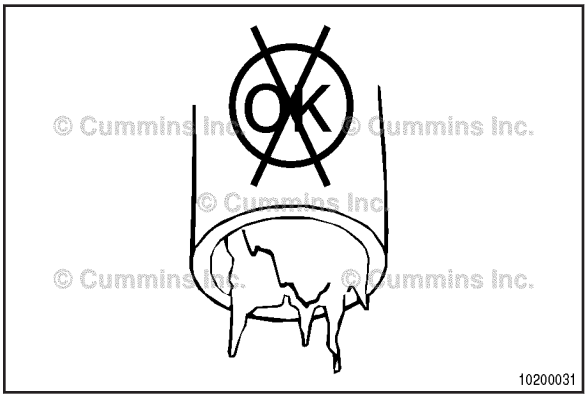


Crankcase Breather Tube

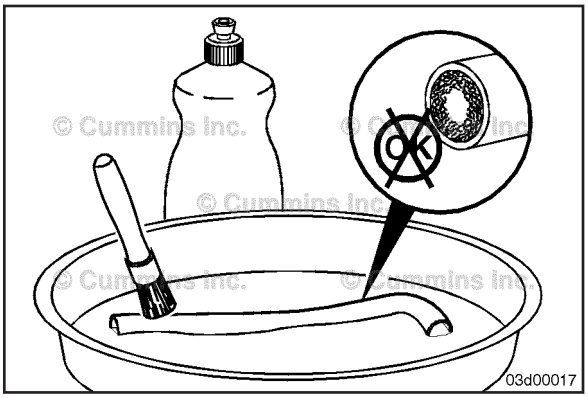
Maintenance Check

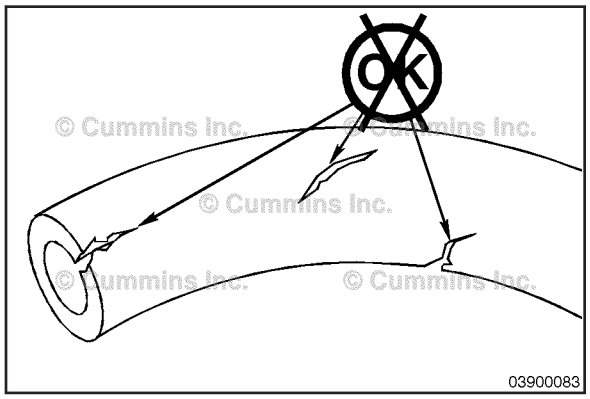
Inspect the breather tube for sludge, debris, or ice in the tube.

Inspect the tube more frequently in icy conditions.

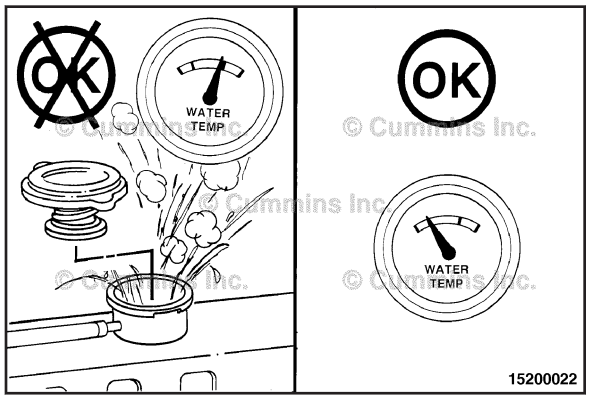


If sludge, debris, or ice is found clean the tube with detergent and warm water or a solvent. Dry the tube with compressed air.





Visually inspect the tube for cracks or damage. If damage is found, replace the crankcase breather tube. Contact your Cummins Authorized Repair Location.



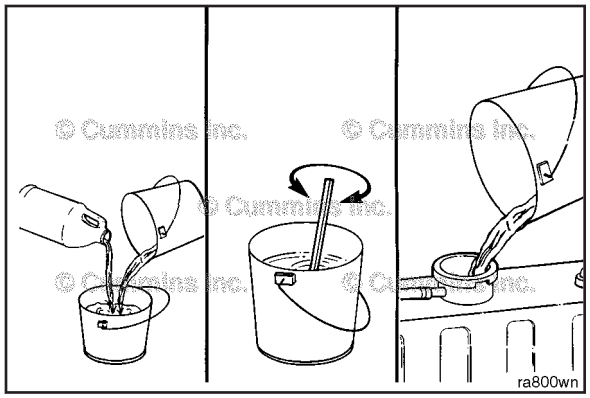
Coolant Level

Maintenance Check

⚠WARNING⚠
Do not remove a 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△
Never use a sealing additive to stop leaks in the cooling system. This can result in cooling system plugging and inadequate coolant flow, causing the engine to overheat.

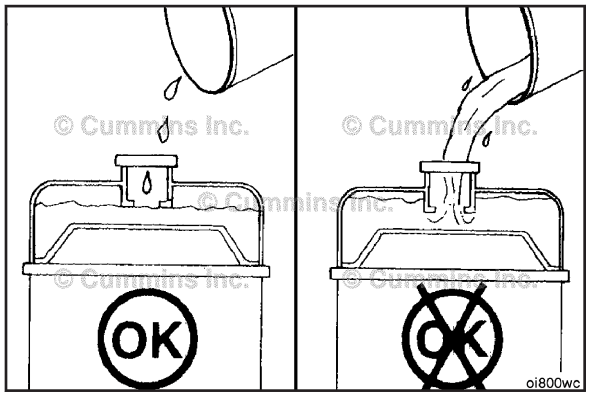
The coolant level **must** be checked daily.



△CAUTION△
Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool to below 50°C [120°F] before adding coolant.

Coolant added to the engine **must** be mixed with the correct proportions of antifreeze, supplemental coolant additive, and water to avoid engine damage.

Coolant recommendations and specification details on correct mixing of coolant can be found in Maintenance Specifications (Section V).



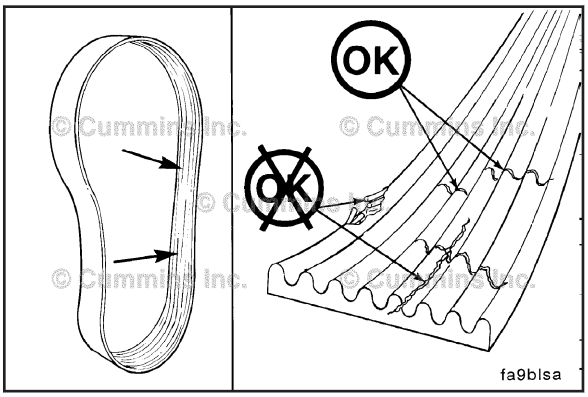
Fill the cooling system with coolant. Refer to the markings on the radiator or expansion tank for coolant levels or refer to the OEM manual.

NOTE: Some radiators have two fill necks, both of which **must** be filled when the cooling system is drained.

Drive Belts

Maintenance Check

Poly-Vee Belt



⚠CAUTION⚠

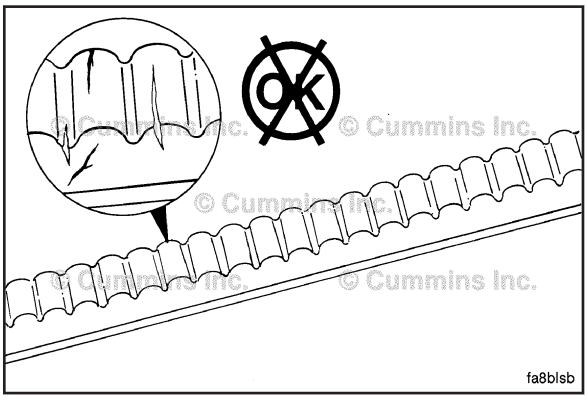
Make sure that the engine is switched off and any starting mechanisms are isolated before any inspections are made. Daily belt inspections can be carried out through an appropriate aperture. Do not remove any guards.

Inspect the belts daily. Check the belt for intersecting cracks. Traverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks that intersect with transverse cracks are **not** acceptable. Replace the belt if it is frayed or has pieces of material missing. Refer to Section A for belt adjustment and replacement procedures.

Belt damage can be caused by:

- Incorrect tension
- Incorrect size or length
- Pulley misalignment
- Incorrect installation
- Severe operating environment
- Oil or grease on the side of belts.

Cogged Belt

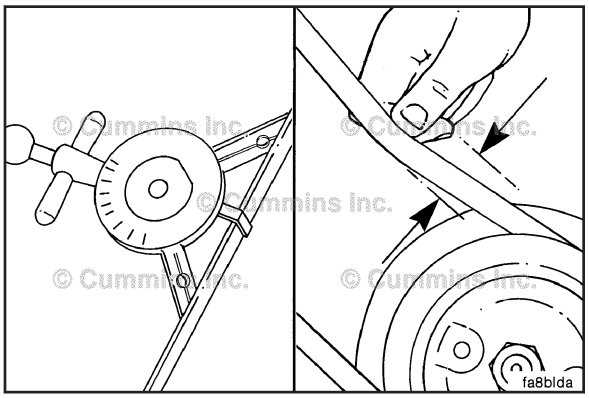


Inspect the belts daily. Replace the belts if they are cracked, frayed, or have chunks of material missing. Small cracks are acceptable.

Adjust the belts that have a glazed or shiny surface, which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear. Refer to Section A for belt adjustment and replacement procedures.

Belt damage can be caused by:

- Incorrect tension
- Incorrect size or length
- Pulley misalignment
- Incorrect installation
- Severe operating environment
- Oil or grease on the belts

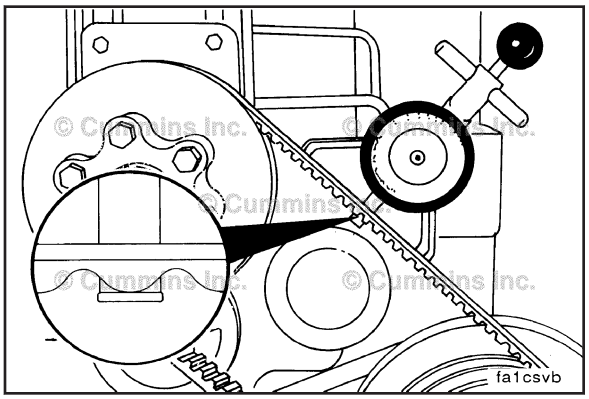


Measure the belt tension in the center span of the pulleys.

Refer to the Belt Tension Chart in Section V for the correct gauge and tension value for the belt width used.

An alternate method (deflection method) can be used to check belt tension by applying 110 N [25 lbf] force between the pulleys on v-belts. If the deflection is more than one belt thickness per foot of pulley center distance, the belt tension **must** be adjusted.

Refer to Section A for adjustment procedures.



For cogged belts, **make sure** that the belt tension gauge is positioned so that the center tensioning leg is placed directly over the high point (hump) of a cog. Other positioning will result in incorrect measurement.

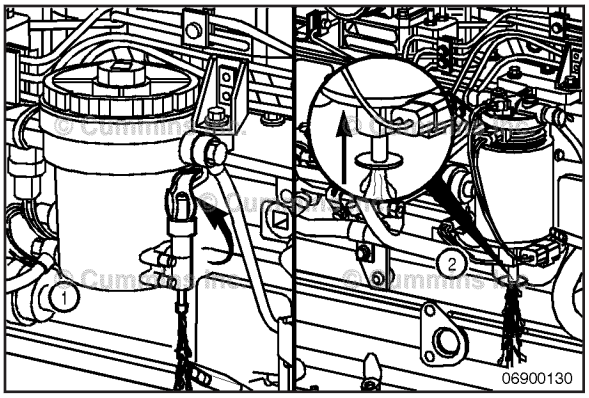
Fuel-Water Separator

Drain

⚠WARNING⚠
Drain the water-fuel separator into a container and dispose of in accordance with local environmental regulations.

Cummins Inc. requires a fuel-water separator or fuel filter be installed in the fuel supply system.

Drain the water and sediment from the separator daily.



Canister Type

Shut off the engine.

Pull up on the drain valve lever until fluid drains out of the drain tube. Drain the filter sump until clear fuel is visible.

Push up on the drain valve until fluid drains out of the drain tube.

Spin-on Type

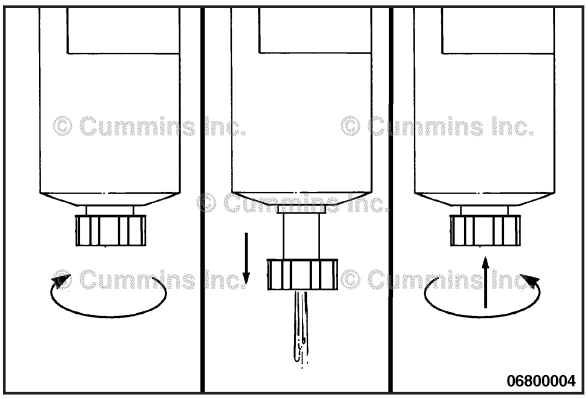
Shut off the engine.

Use your hand to open the drain valve. Turn the valve **counterclockwise** approximately 3½ turns until the valve drops down 25.4mm [1 in] and draining occurs.

Drain the filter sump until clear fuel is visible.

⚠CAUTION⚠
When closing the drain valve, do not overtighten the valve. Overtightening can damage the threads.

To close the valve, lift the valve and turn **clockwise** until it is hand-tight.



Lubricating Oil Level

Maintenance Check

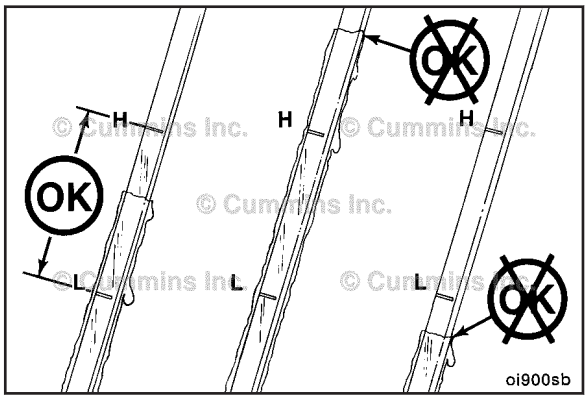
⚠CAUTION⚠
Never operate the engine with oil level below the L (low) mark or above the H (high) mark. Poor engine performance or engine damage can occur.

The engine **must** be level when checking the oil level to make sure the measurement is correct.

Shut off the engine for an accurate reading.

Wait at least 15 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain into the oil pan.

For additional lubricating oil recommendations and oil pan capacity information, refer to Maintenance Specifications (Section V).



Notes

Section 4 - Maintenance Procedures at 250 Hours or 3 Months

Section Contents

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Maintenance Procedures - Overview

General Information

All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

Air Cleaner Restriction

Maintenance Check

Mechanical Indicator

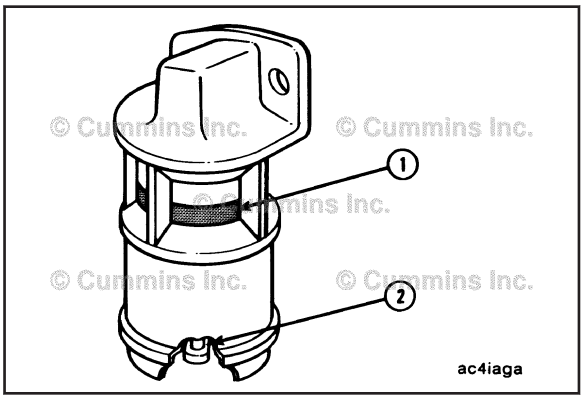
⚠CAUTION⚠

Never operate the engine without an air cleaner. Intake air must be filtered to prevent dirt and debris from entering the engine and causing premature wear.

NOTE: Do **not** remove the felt washer from the indicator. The felt washer absorbs moisture.

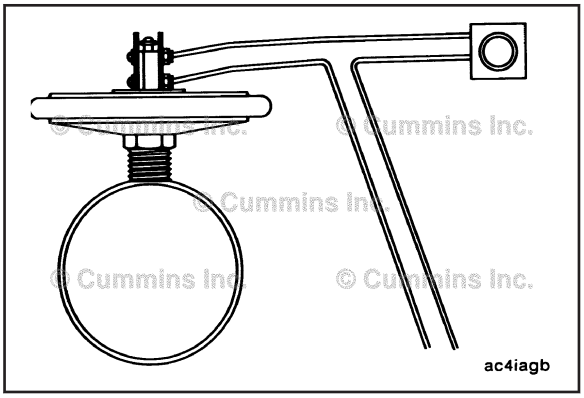
A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in the air cleaner outlet or on the instrument panel. The red flag (1) in the window gradually rises as the cartridge loads with dirt. After changing or replacing the cartridge, reset the indicator by pushing the reset button (2).

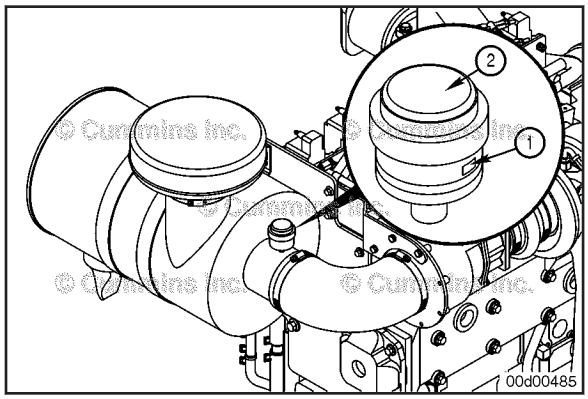
Restriction or vacuum indicators need to be installed as close as possible to the turbocharger air inlet in order to obtain a true indication of restrictions.



Vacuum Indicator

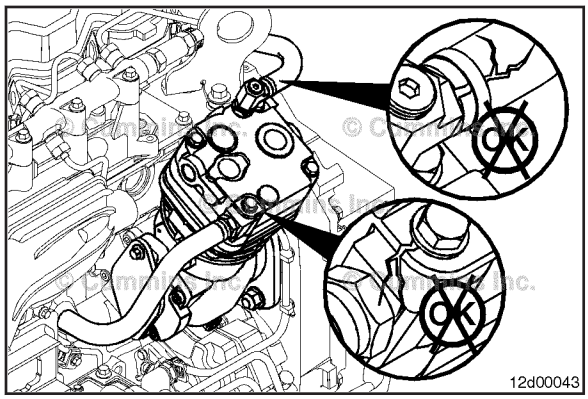
Vacuum switches actuate a warning light on the instrument panel when the air restriction becomes excessive.





Industrial Gas Mechanical Indicator

A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument is mounted in the air cleaner outlet. The red flag (1) in the window gradually rises as the cartridge loads with dirt. When air restriction is indicated the air filter **must** be replaced. After changing or replacing the cartridge, reset the indicator by pushing the reset button (2)



Air Compressor

Maintenance Check

NOTE: Depending on the application, it is possible engines will **not** be equipped with an air compressor.

Inspect the compressor housing for cracks and damage.

Inspect the hydraulic pump couplings for cracks, wear, or other damage, if equipped.

Inspect the air plumbing for splits or cracks.

Inspect the air compressor mounting nuts, including support bracket, for loose or damaged hardware.

Operate the engine and check for correct compressor operation.

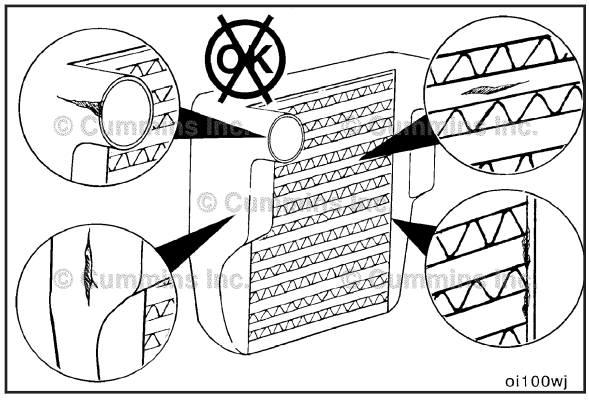
Check for air, oil, and coolant leaks.

Torque Value:
Mounting 18 mm

Step 1	77 N•m	[57 ft-lb]

Torque Value:
Bracket 10 mm

Step 1	45 N•m	[33 ft-lb]



Charge-Air Cooler

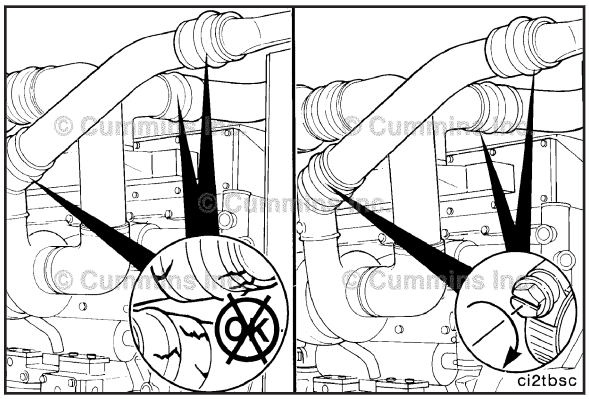
Maintenance Check

Inspect the charge-air cooler (CAC) for dirt and debris blocking the fins. Check for cracks, holes, or other damage. If damage is found, refer to the vehicle, vessel, or equipment manufacturer.

Charge-Air Piping

Maintenance Check

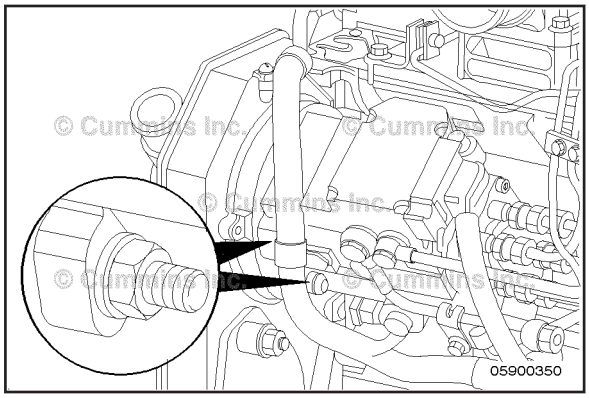
Inspect the charge-air piping and hoses for leaks, holes, cracks, or loose connections. Tighten the hose clamps if necessary. Refer to the vehicle or equipment manufacturer's specifications for the correct torque value.



Fuel Pump

Maintenance Check

Inspect the fuel injection pump mounting nuts, including the tail support bracket, for loose or damaged hardware.



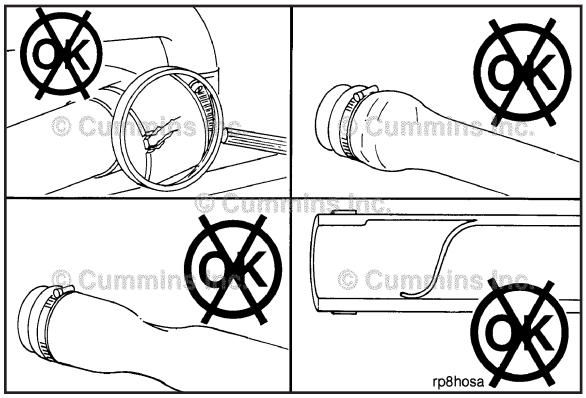
Radiator Hoses

Maintenance Check

Check all hoses for cracks, cuts, or collapsing.

NOTE: The silicone engine coolant hose will exhibit swelling due to the elasticity of the hose.

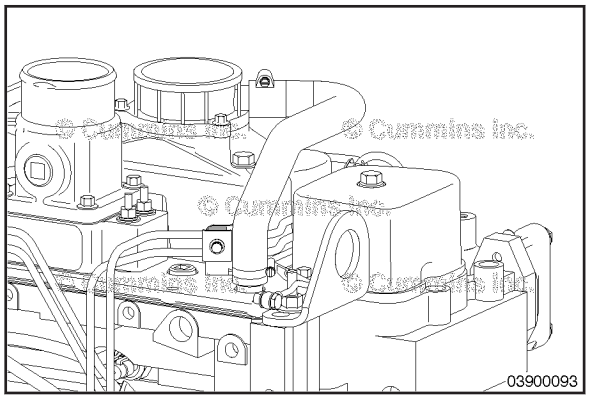
If damage is found, replace damaged hoses. Contact your local Cummins Authorized Repair Location.

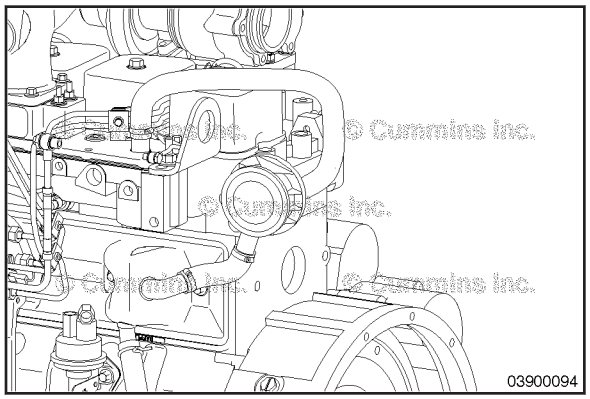


Closed Crankcase Ventilation Hoses

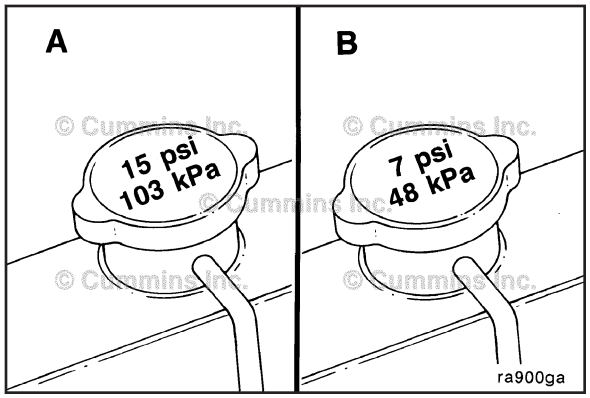
Maintenance Check

Inspect the closed-crankcase ventilation piping and hoses for leaks, holes, cracks, or loose connections. Tighten the hose clamps, if necessary to proper torque. Refer to Section V for torque specification. The illustration shown is one of two options available for the closed-crankcase ventilation system.





The illustration shown is the second of two options available for the closed-crankcase ventilation system.



Radiator Pressure Cap

General Information

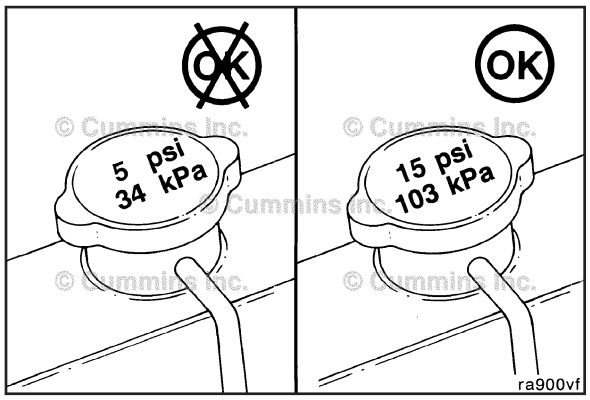
Pressure Caps

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

Different caps are specified for the two recommended systems:

Radiator Cap Pressure Test		
	System	**Cap**
A (Normal-Duty)	104°C [219°F]	103 KPa [15 psi]
B (Light-Duty)	99°C [210°F]	48 KPa [7 psi]

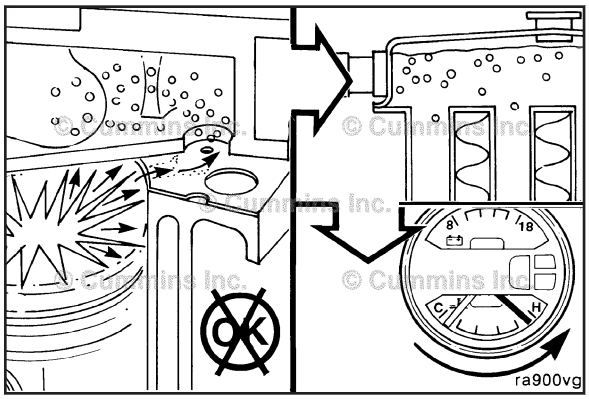
NOTE: An incorrect or malfunctioning cap can result in the loss of coolant and the engine running hot.



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

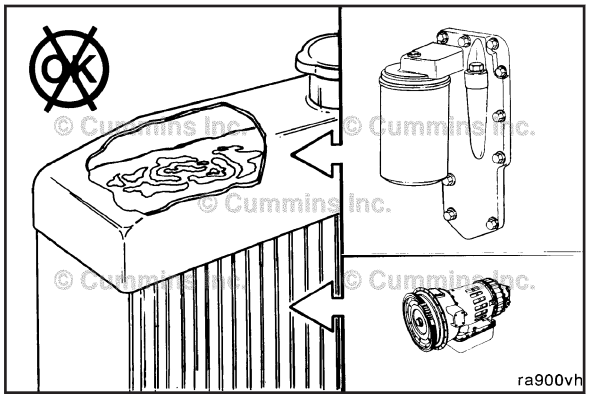
Air in the coolant can result in loss of coolant from the overflow when the aerated coolant is hot. The heated air expands, increasing the pressure in the system, causing the cap to open.

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



The operating pressure of the coolant system and the lubricating system can result in the mixing of the fluids if there is a leak between the systems, such as the head gasket or oil cooler (refer to Procedure 007-037 Lubricating Oil System in Section 7).

NOTE: Transmission fluid can also leak into the coolant through radiator bottom tank transmission oil coolers. Refer to the OEM service manual.



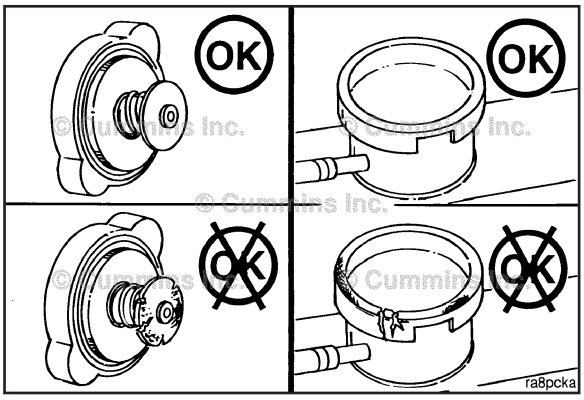
Inspect for Reuse

Be sure the correct radiator cap is being used. Refer to (Cooling System) in Section V - Specifications.

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 for instructions if the fill neck is damaged.

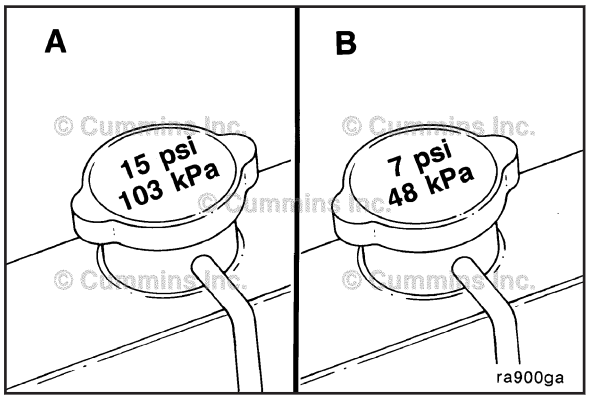


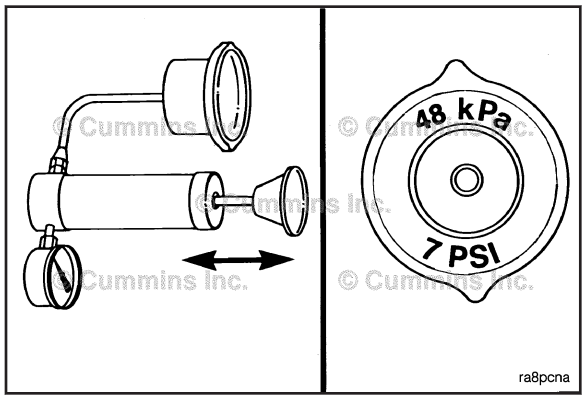
Pressure Test

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

Different caps are specified for the two recommended systems:

System	Cap
A-Normal-Duty 104°C [219°F]	103 kPa [15 psi]
B-Light-Duty 99°C [210°F]	48 kPa [7 psi]





Pressure-test the radiator cap.

The pressure cap **must** seal within the value stated on the cap, or it **must** be replaced.

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

Section 5 - Maintenance Procedures at 500 Hours or 6 Months

Section Contents

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Maintenance Procedures - Overview

General Information

All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

Engine Coolant Antifreeze

Maintenance Check

⚠CAUTION⚠
Overconcentration of antifreeze or use of high silicate antifreeze can cause damage to the engine.

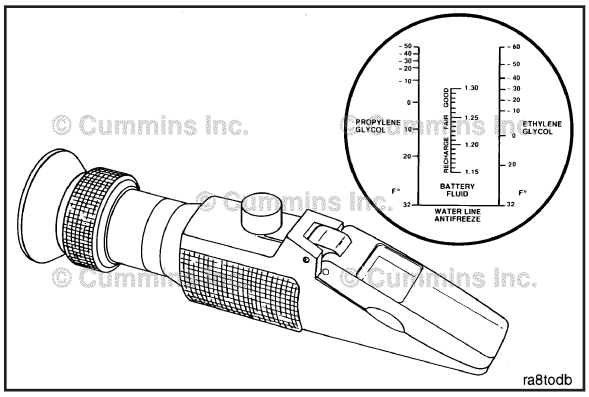
Check the antifreeze concentration. Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol-base antifreeze to protect the engine to -32°C [-25°F] year-around.

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.

It broadens the operating temperature by lowering the coolant freezing point and by raising its boiling point.

The corrosion inhibitors also protect the cooling system components from corrosion and provides longer component life.

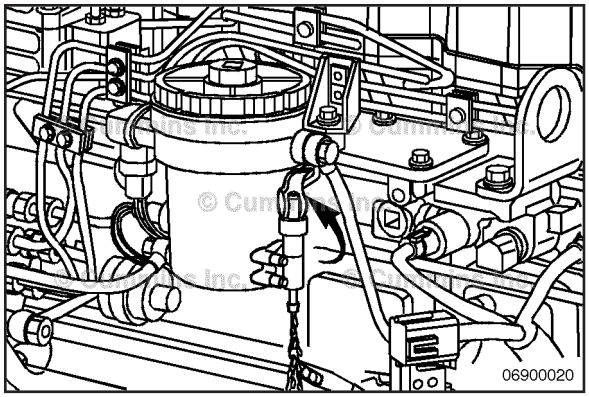


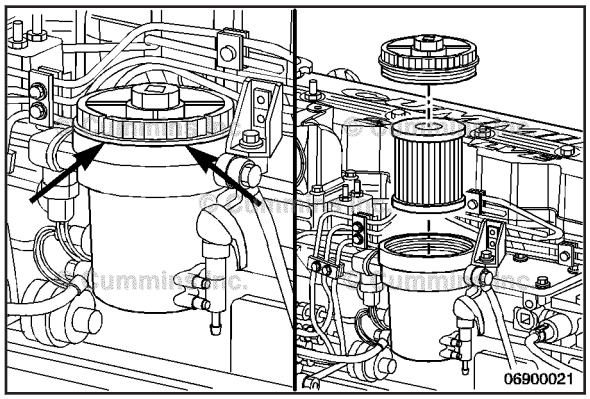
Fuel Filter (Canister Type)

Preparatory Steps

⚠WARNING⚠
Drain the fuel-water separator into a container, and dispose of contents in accordance with local environmental regulations.

Lift up on the filter drain lever to drain fuel out of the filter for approximately 5 seconds. This will eliminate fuel from running over the top of the filter upon removal.



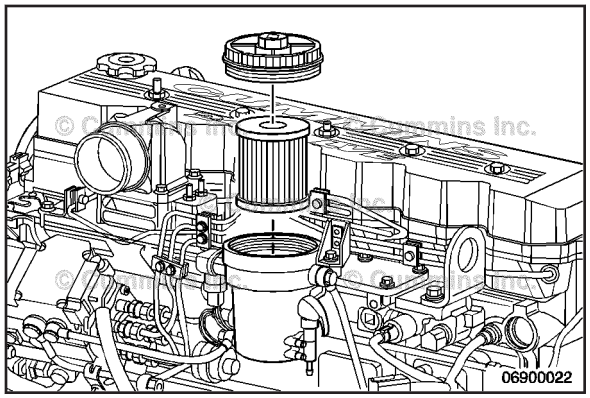


Remove

Clean all debris from around the canister lid.

Remove the filter lid and filter element. A crescent wrench can be used if the lid can **not** be removed by hand.

NOTE: Remove the filter element by twisting the element sideways from the filter lid.



Install

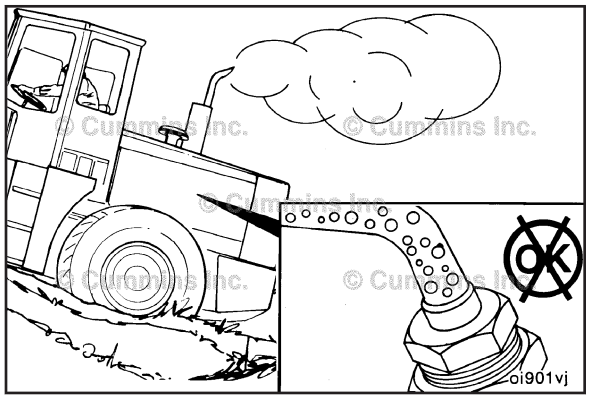
Install the new element in the canister lid, and place back in the canister by twisting **clockwise**.

Refer to Procedure 018-024 (Cummins/Fleetguard® Filter Specifications) in Section V.

NOTE: The replacement filter element comes with a new o-ring for the canister lid. The o-ring **must** be replaced with the filter element.

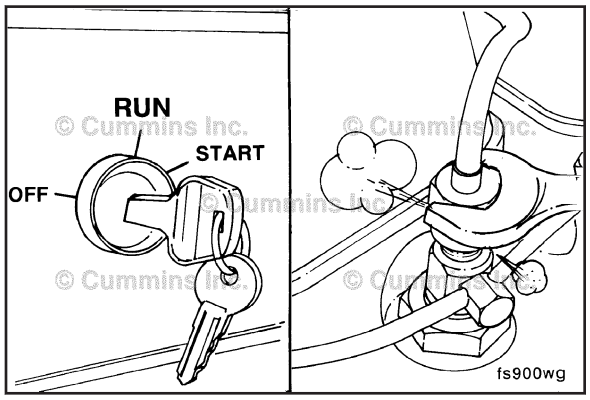
Lubricate the o-ring with clean engine oil.

Hand-tighten the canister lid.



Prime

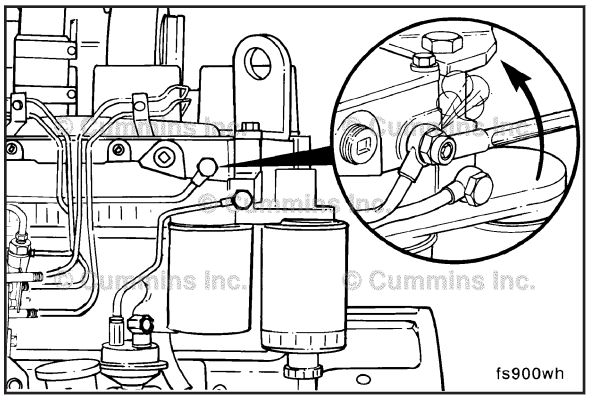
Controlled venting is provided at the injection pump through the fuel drain manifold. Small amounts of air introduced by changing the filters or injection pump supply line will be vented automatically if the fuel filter is changed in accordance with the instructions.



However, manual bleeding will be required if one of the following conditions exists:

- The fuel filter is **not** filled prior to installation
- The fuel injection pump is replaced
- The high-pressure fuel line connections are loosened or the lines are replaced
- It is an initial engine start-up or start-up after an extended period of no engine operation.

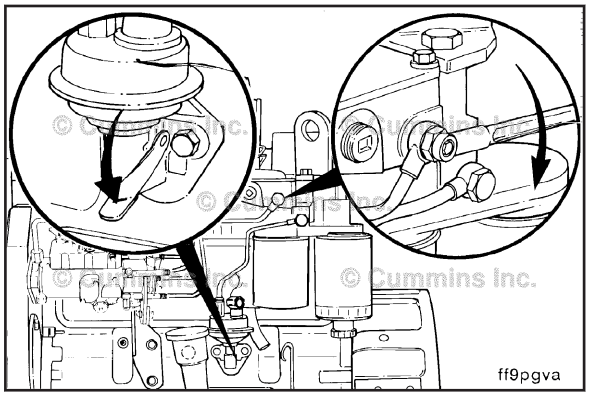
Open the bleed screw.



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

Tighten the bleed screw.

Torque Value: 9 N•m [80 in-lb]

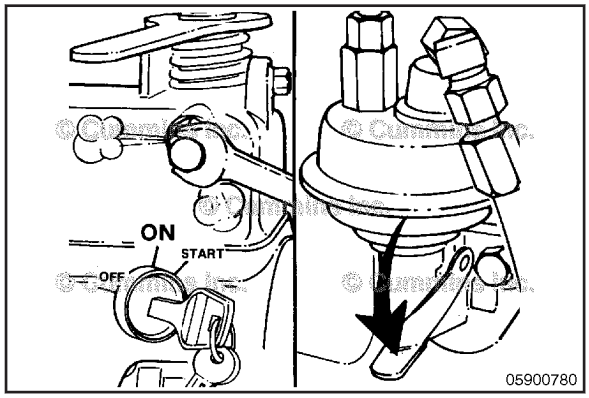


Air and fuel can be vented from the illustrated vent locations on the Bosch® VE fuel injection pumps.

Loosen the vent screw and operate the priming lever on the fuel transfer pump until the fuel injection pump is primed.

Tighten the vent screw.

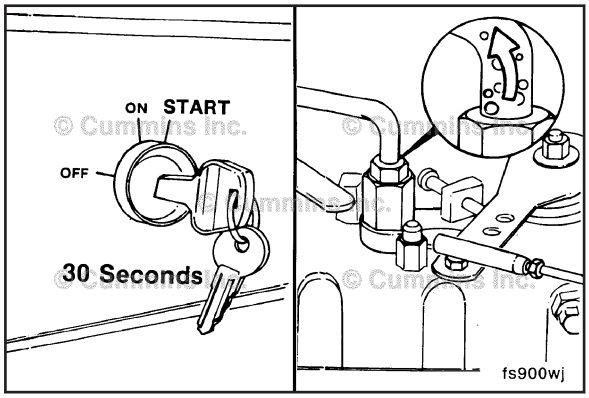
Torque Value: 9 N•m [80 in-lb]

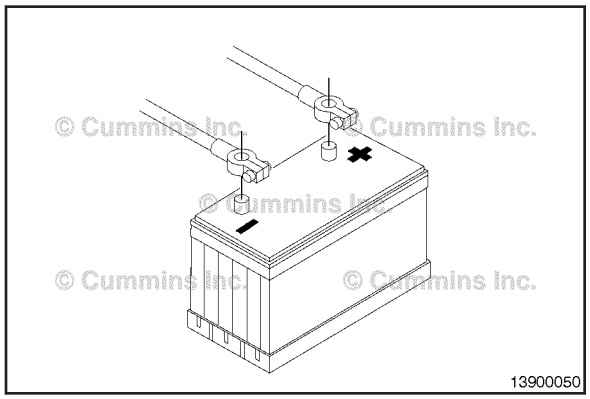


⚠CAUTION⚠
It is necessary to turn the keyswitch to the ON position. Because the engine can start, be sure to follow all safety precautions. Use the normal engine starting procedure.

⚠CAUTION⚠
When using the starting motor to vent the system, do not engage it for more than 30 seconds, or starter damage will occur. Wait 2 minutes before starting the engine again.

Air can also be vented through the fuel drain manifold line by operating the starting motor.



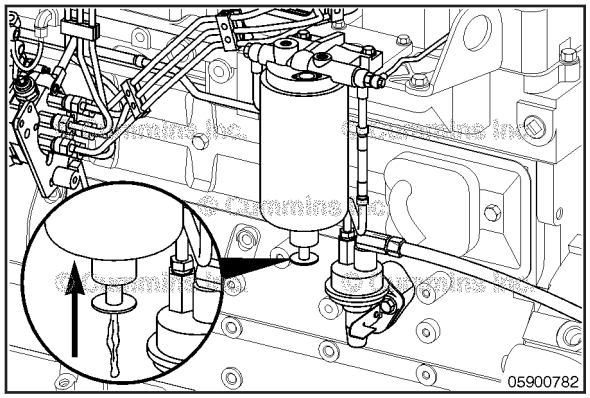


Fuel Filter (Spin-On Type)

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.

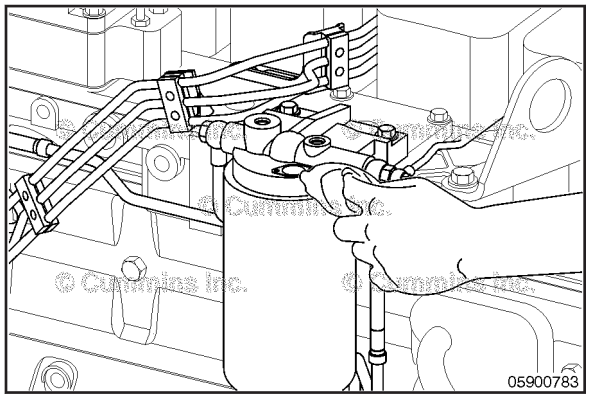
- Disconnect the batteries.



Drain

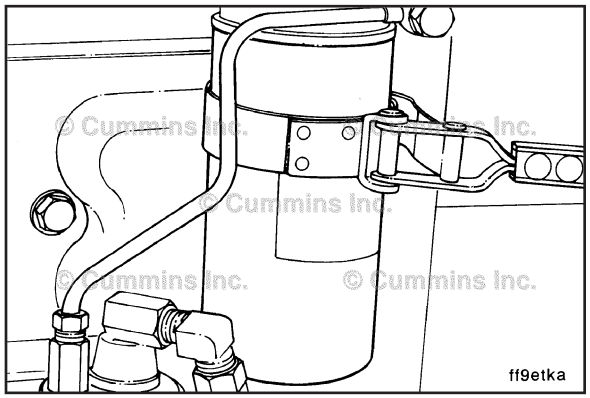
⚠WARNING⚠
Drain the fuel-water separator into a container, and dispose of contents in accordance with local environmental regulations.

If equipped, use the filter drain valve to drain fuel out of the filter for approximately 5 seconds. This will eliminate fuel from running over the top of the filter upon removal.



Remove

Clean the area around the fuel filter head.

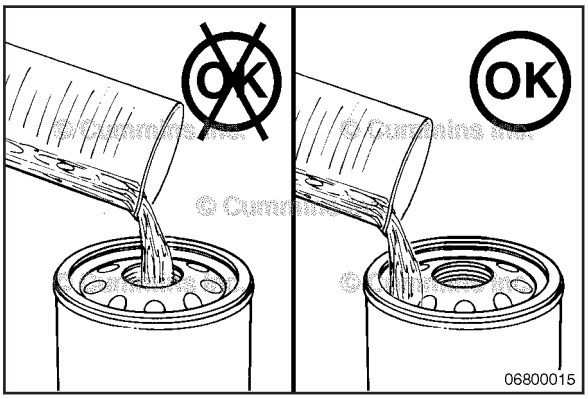


⚠WARNING⚠
Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.

Remove the fuel filter.

Install

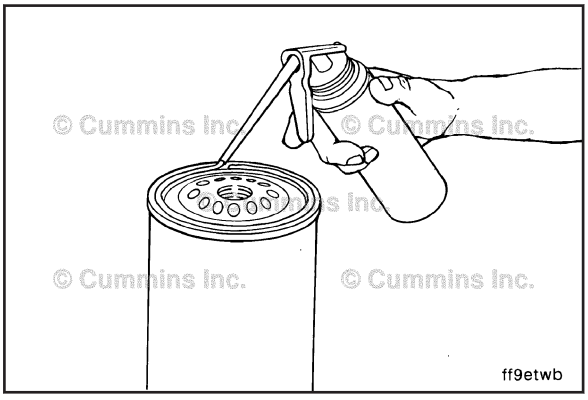
⚠WARNING⚠
Fuel is flammable. Keep all cigarettes, flames, pilot lights, arcing equipment, and switches out of the work area and areas sharing ventilation to reduce the possibility of severe personal injury or death when working on the fuel system.



△CAUTION△
When pre-filling the filter do not pour fuel down the center (clean side) of the filter. Pour clean fuel into the outer openings (dirty side) of the filter. Use a clean side block off plug, if available, to prevent fuel from entering the clean side of the filter. Pre-filling on the clean side of the filter can result in debris entering the fuel system and damaging fuel system components.

Fill the new filter(s) with clean diesel fuel.

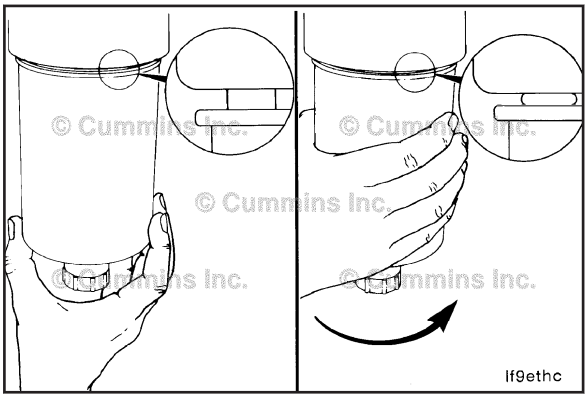
Lubricate the seal with clean lubricating engine oil.

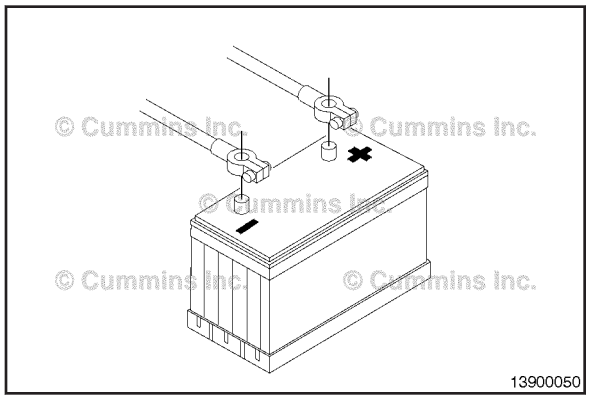


△CAUTION△
Mechanical overtightening can distort the threads as well as damage the filter element seal or filter can.

Install the fuel filter on the fuel filter head. Turn the filter until the gasket contacts the filter head surface.

Tighten the fuel filter an additional ½ to ¾ of a turn after the gasket contacts the fuel filter head surface, or as specified by the fuel filter manufacturer.

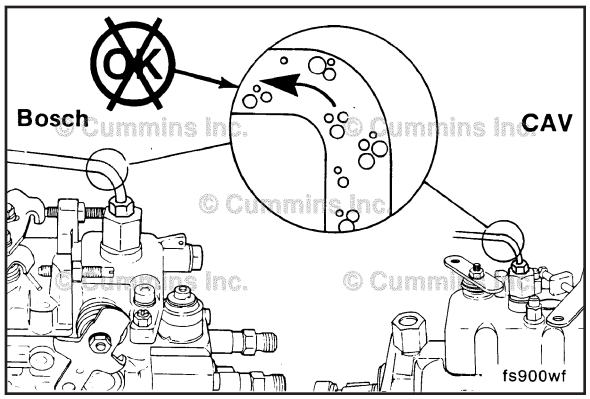




⚠ WARNING ⚠

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.

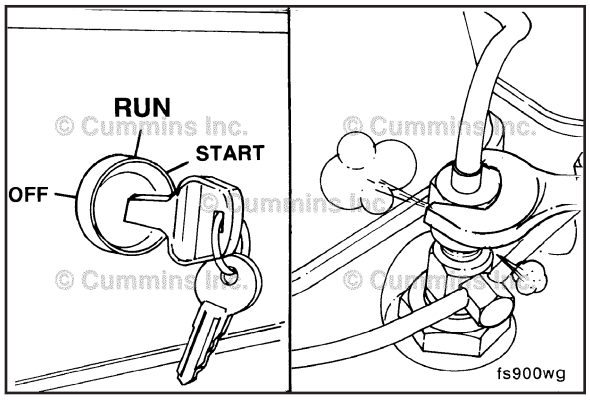
Connect the batteries.



Prime

General Information

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



However, manual bleeding will be required if one of the following conditions exists:

- The fuel filter is **not** filled prior to installation
- The fuel injection pump is replaced
- The high-pressure fuel line connections are loosened, or the lines are replaced
- It is an initial engine start-up or start-up after an extended period of no engine operation.

Refer to Procedure 006-015 (Fuel Filter (Spin-On)) in Section 6 for proper venting of the low pressure side of the fuel system.

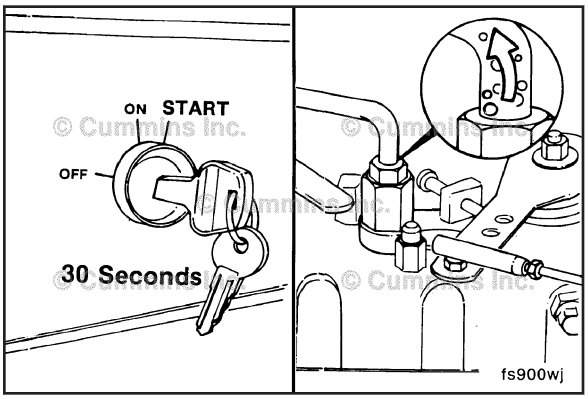
Refer to the Procedure 005-012 (Fuel Injection Pumps, In-Line) in Section 5 to determine if venting the fuel pump is necessary. Or, refer to Procedure 005-014 (Fuel Injection Pumps, Rotary) in Section 5 to determine if venting the fuel pump is necessary.

Refer to Procedure 006-051 Injector Supply Lines (High Pressure) in Section 6 for venting of the high pressure side of the fuel system.

⚠CAUTION⚠
It is necessary to turn the keyswitch to the ON position. Because the engine can start, be sure to follow all safety precautions. Use the normal engine starting procedure.

⚠CAUTION⚠
When using the starting motor to vent the system, do not engage the starter for more than 30 seconds, or starter damage will occur. Wait 2 minutes before starting the engine again.

Air can also be vented through the fuel drain manifold line by operating the starting motor.

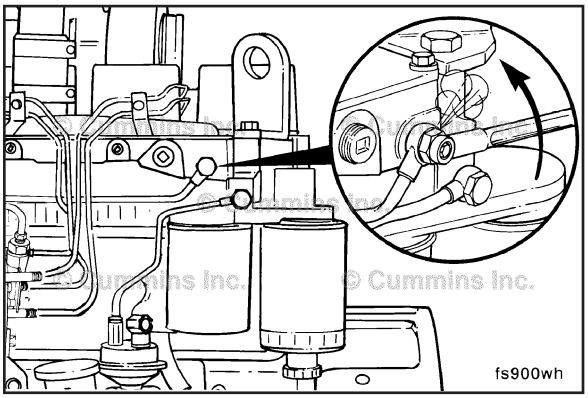


Low Pressure Fuel Line(s)

NOTE: For engines equipped with Distributor type pumps equipped with bleed screws.

Open the bleed screw.

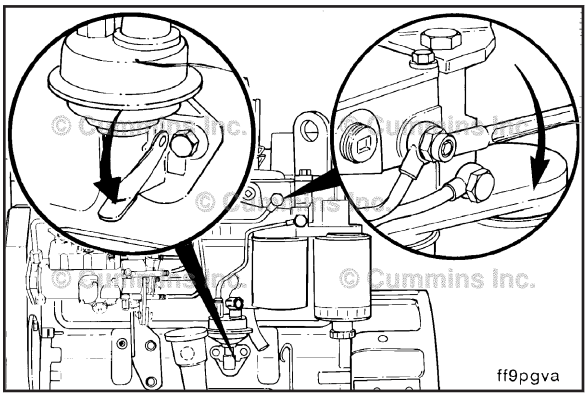
NOTE: If the engine is **not** equipped with a bleed screw, loosen the fitting on the low pressure supply line to the injection pump. Once priming has been completed, tighten the fitting to the specified torque.



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

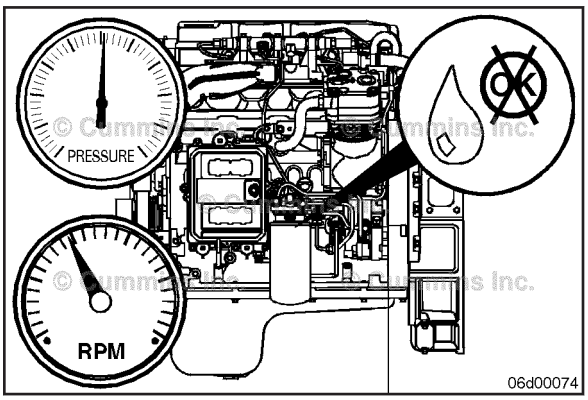
Tighten the bleed screw.

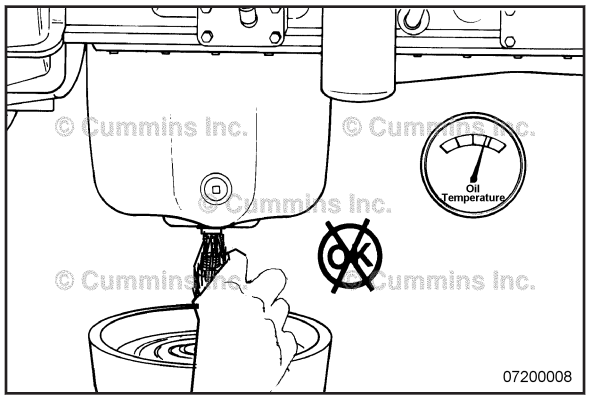
Torque Value: 9 N•m [80 in-lb]



Finishing Steps

- Operate the engine and check for leaks.





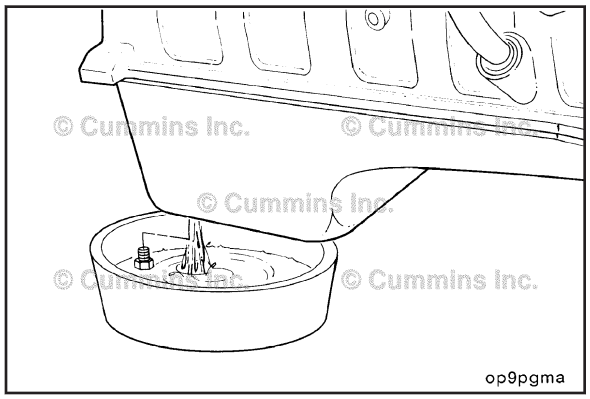
Lubricating Oil and Filters

Drain

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

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

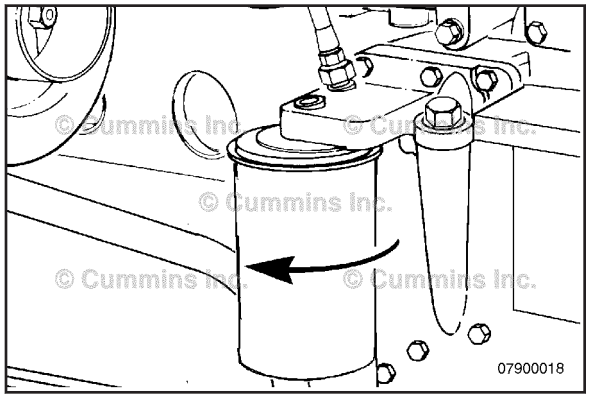
Change the lubricating oil and filter(s) at the specified oil change interval. Refer to Procedure 102-002 (Maintenance Schedule) in Section 2 to find the correct change interval for your application.



Operate the engine until the water temperature reaches 60°C [140°F]. Shut off the engine.

NOTE: Use a container that can hold at least 26 liters [27 qt] of lubricating oil.

Remove the oil drain plug from the bottom of the lubricating oil pan.



Remove

Clean the area around the lubricating oil filter head.

Remove the oil filter.

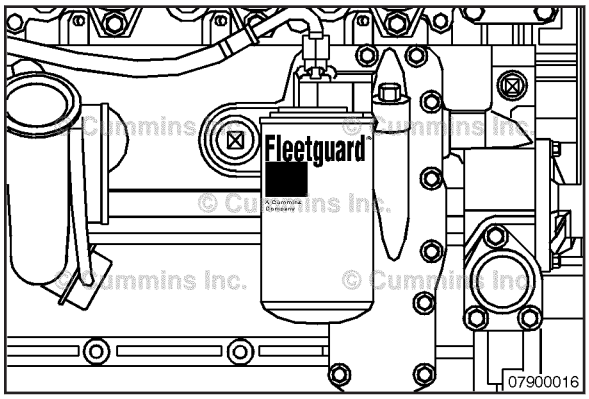
Clean the gasket surface of the filter head.

NOTE: The o-ring can stick on the filter head. Make sure it is removed before installing the new filter.

Install

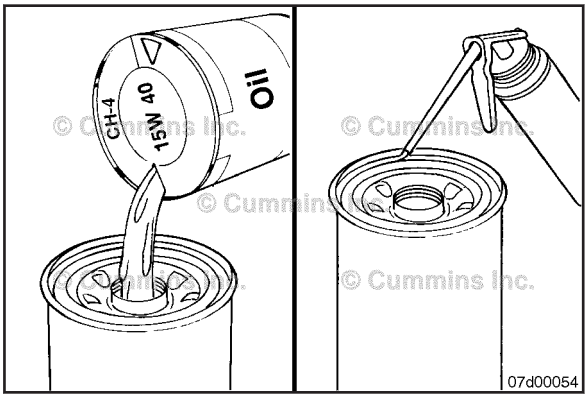
Use the correct oil filter.

Refer to Procedure 018-004 (Cummins/Fleetguard® Filter Specifications) in Section V for oil filter part number(s).



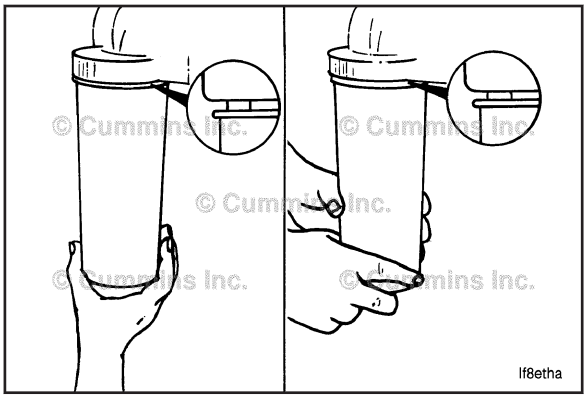
Fill the filter with clean lubricating oil before installation.

Apply a light film of lubricating oil to the gasket sealing surface before installing the filter.



⚠CAUTION⚠
Mechanical overtightening of filter can distort the threads or damage the filter element seal.

Install the filter as specified by the filter manufacturer.



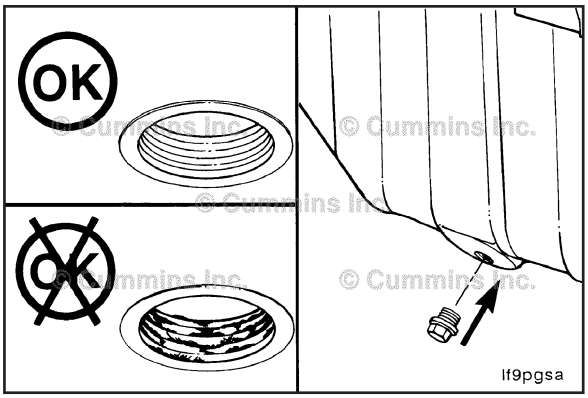
Clean the sealing surface.

Check the oil drain plug threads.

Install the drain plug.

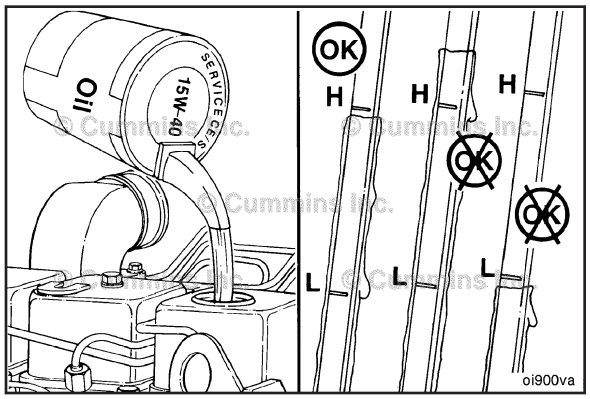
Torque Value:

Steel Pan	60 N•m	[44 ft-lb]
Aluminum Pan	30 N•m	[22 ft-lb]



Fill

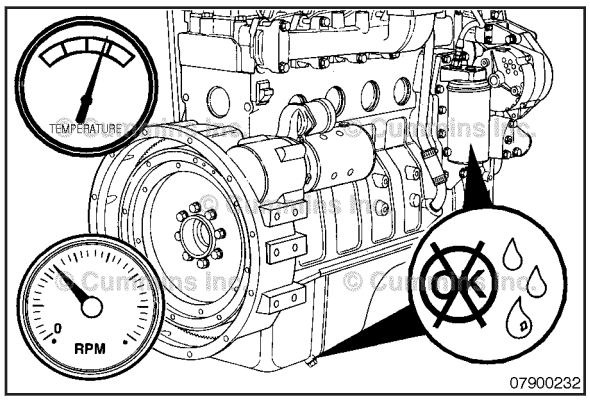
Use a high-quality 15W-40 multiviscosity lubricating oil, such as Valvoline® Premium Blue® or its equivalent, in Cummins engines. Choose the correct lubricating oil for your operating climate as outlined in Procedure 018-003 (Lubricating Oil Recommendations and Specifications) in Section V.



Fill the engine with clean lubricating oil to the proper level. Refer to Procedure 018-017 (Lubricating Oil System) in Section V for lubricating oil capacity.

NOTE: Total system capacity assumes lubricating oil pan plus lubricating oil filter.

Some applications use a slightly different lubricating oil pan capacity. All lubricating oil quantities **must** be adjusted accordingly. Contact a local Cummins Distributor if you have any questions.



Operate the engine and check for leaks at the filters and oil drain plug.

Section 6 - Maintenance Procedures at 1000 Hours or 1 Year

Section Contents

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Maintenance Procedures - Overview

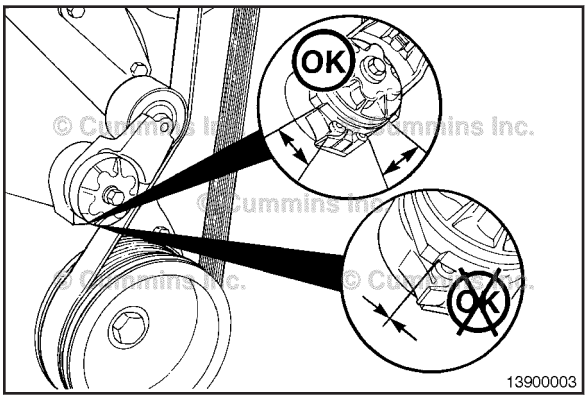
General Information

All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

Cooling Fan Belt Tensioner

Maintenance Check

With the engine turned off, check that neither the top nor bottom tensioner arm stop is touching the cast boss on the tensioner body. If either of the stops is touching a boss, the alternator belt **must** be replaced. Check to make certain the correct belt part number is being used if either condition exists.

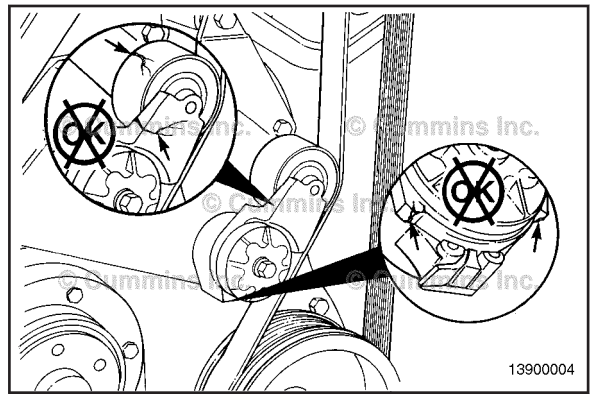


⚠ WARNING ⚠
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

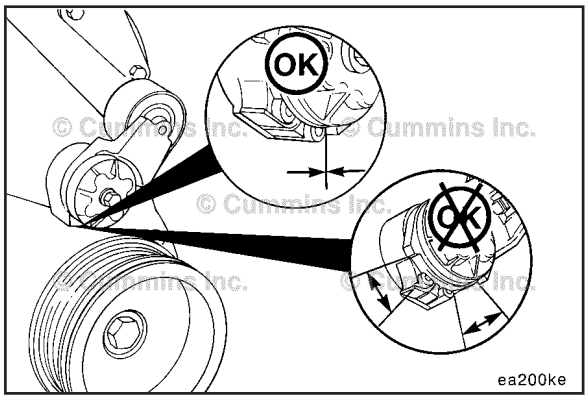
⚠ WARNING ⚠
Wear safety glasses or a face shield, as well as protective clothing, to prevent personal injury when using a steam cleaner or high-pressure water.

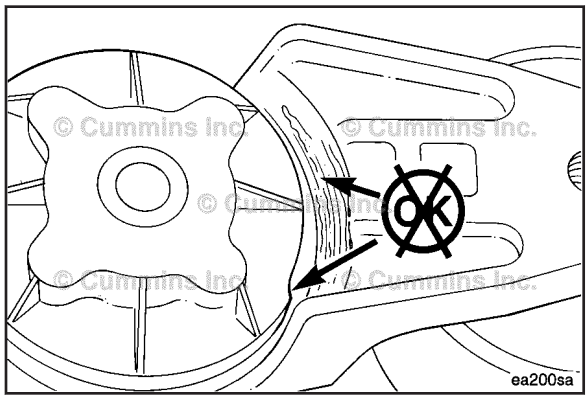
Check the tensioner pulley and body for cracks. If any cracks are noticed, the tensioner **must** be replaced. Refer to a Cummins® Authorized Repair Facility.

Check the tensioner for dirt buildup. If this condition exists, the tensioner **must** be removed and steam-cleaned.

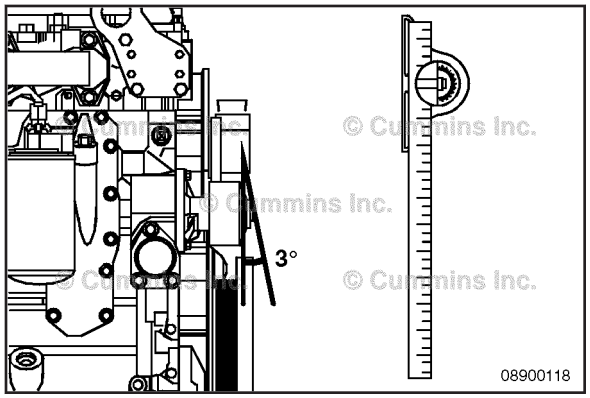


With the cooling fan belt removed, check that the bottom tensioner arm stop is in contact with the bottom tensioner arm stop boss on the tensioner body. If these two are **not** touching, the tensioner **must** be replaced.





Inspect the tensioner for evidence of the pivoting tensioner arm contacting the stationary circular base. If there is evidence of these two areas touching, the pivot tube bushing has failed and the tensioner **must** be replaced.

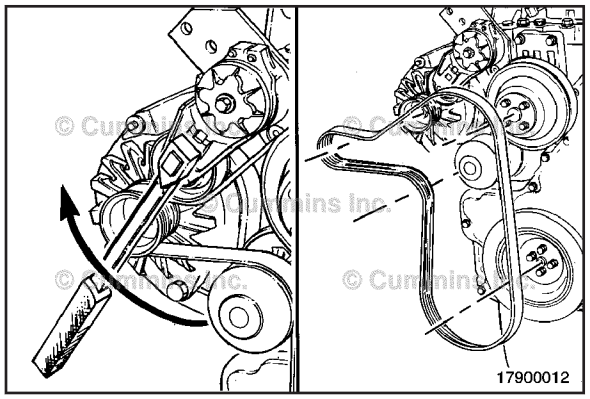


The worn tensioner that has play in it or a belt that “walks” off its pulley possibly indicates pulley misalignment.

NOTE: Maximum pulley misalignment is 3 degrees.

This measurement can be taken with a straightedge and an inclinometer.

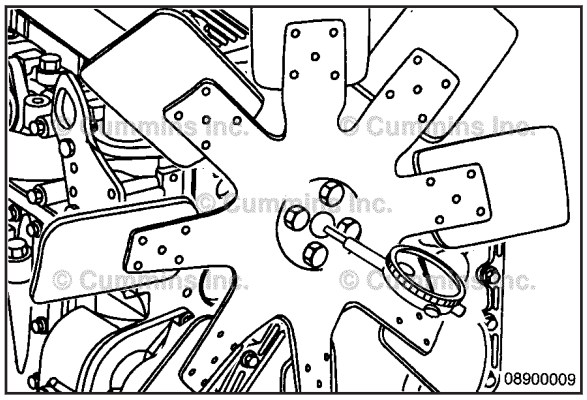
Install the belt.



Fan Hub, Belt Driven

Maintenance Check

Remove the drive belt.



NOTE: The fan hub **must** rotate without any wobble or excessive end play.

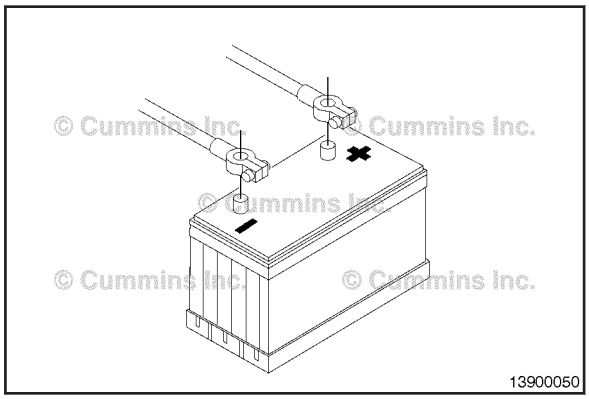
Fan Hub End Play		
mm		**in**
0.15	MAX	0.006

Overhead Set

Preparatory Steps

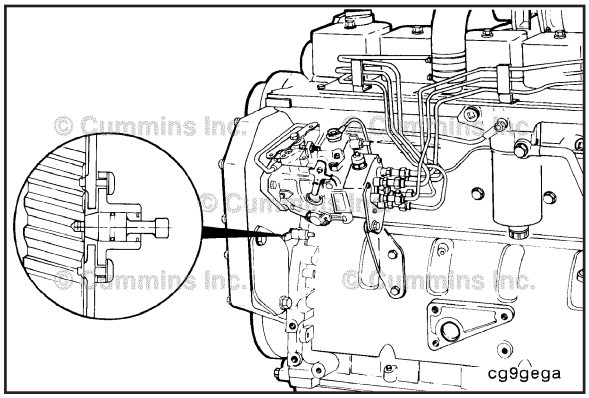
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries.



NOTE: The timing pin is used to accurately locate TDC for setting the overhead. The timing pin is typically located below the fuel pump.

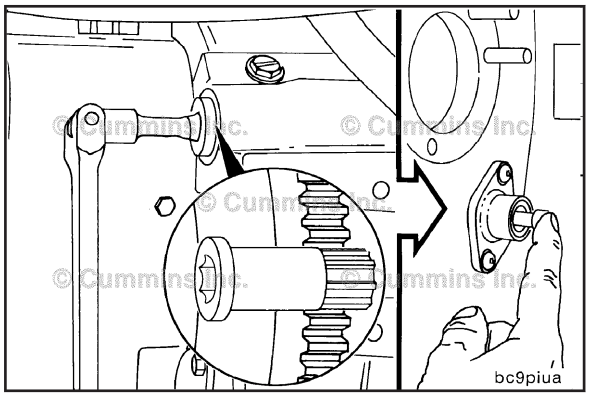
- for front gear train engines, in the front gear housing (shown)
- for rear gear train engines, in the rear gear housing (not shown)



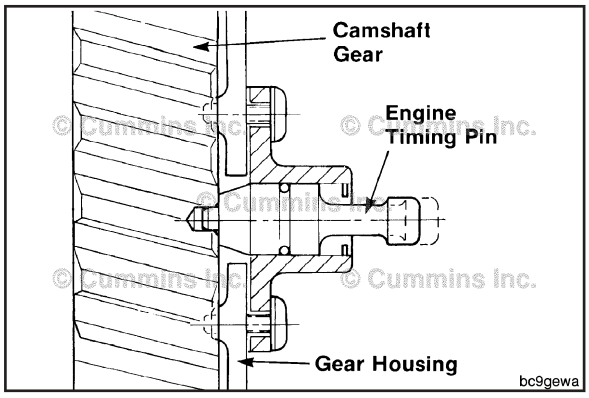
Locate top dead center (TDC) for cylinder number 1 by barring the crankshaft slowly while pressing on the engine timing pin. Barring the engine is recommended from the flywheel on the rear of the engine.

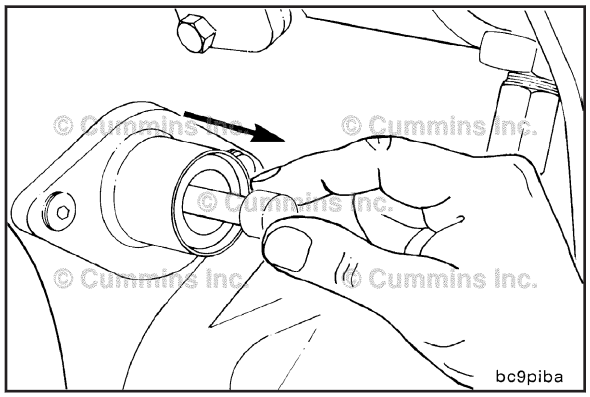
NOTE: Engine coolant temperature **must** be less than 60°C [140°F].

Using the barring tool Part Number 3824591, rotate the crankshaft slowly while pressing on the engine timing pin to locate TDC for cylinder number 1.

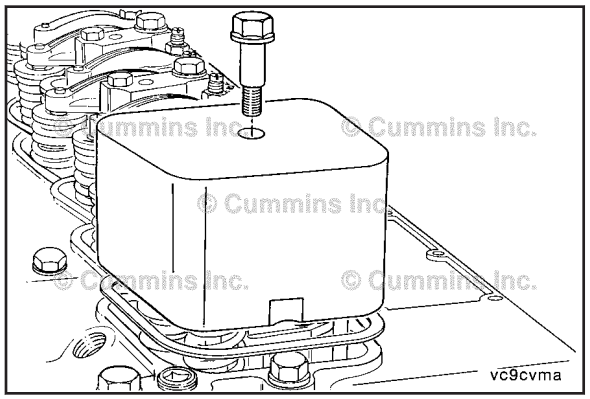


When the timing pin engages in the hole in the camshaft gear, cylinder number 1 is at TDC on the compression stroke.





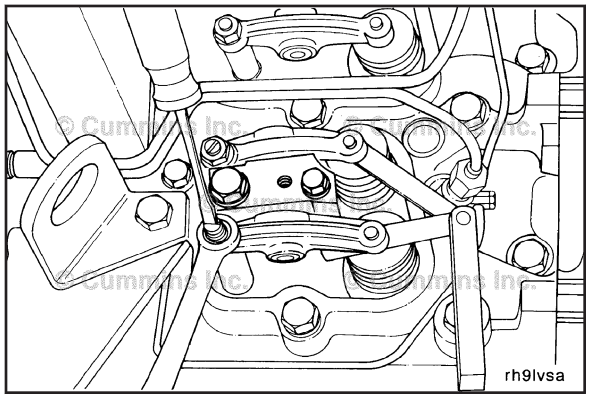
⚠CAUTION⚠
To reduce the possibility of engine or timing pin damage, you must disengage the timing pin after locating top dead center.



Remove

B3.9, B5.9, and B4.5 Engines

Remove the capscrews, capscrew seals, rocker lever covers, and rocker lever cover gaskets.



Adjust

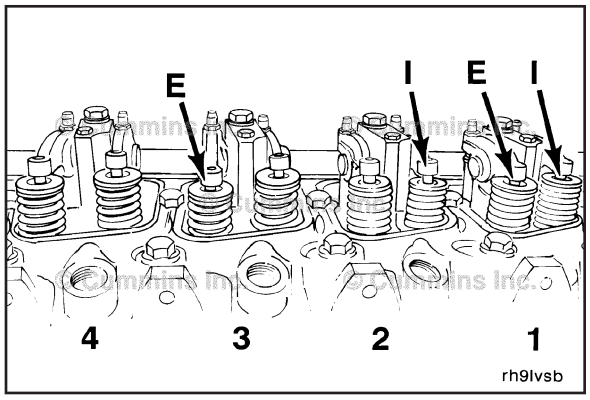
B3.9, B5.9, and B4.5 Engines

NOTE: The clearance is correct when some resistance is “felt” when the feeler gauge is slipped between the valve stem and the rocker lever.

NOTE: Caution **must** be used when setting the exhaust valve lash on marine cylinder heads with rotators. The top of the valve stem is slightly recessed below the top of the valve rotator.

Intake Clearance: 0.254 mm [0.010 in]

Exhaust Clearance: 0.508 mm [0.020 in]



Four-Cylinder Engine Adjustment

Make sure the engine is at top dead center (TDC) for cylinder number 1.

Set **only** valves indicated by the arrows (E = exhaust, I = intake). Do **not** set valves that are **not** indicated.

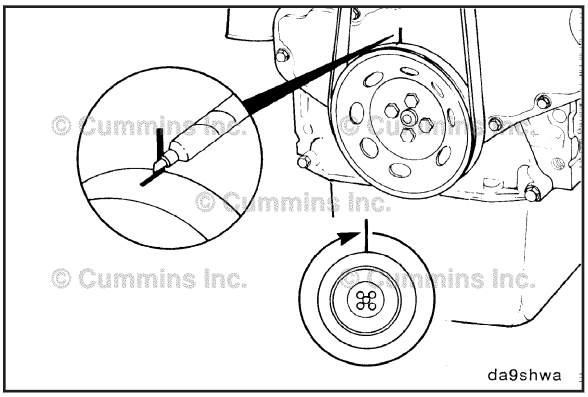
Holding the locknut steady with the wrench, adjust the valve clearance with the screwdriver or Allen wrench.

Tighten the locknut and measure the valve lash again.

Torque Value: 24 N•m [18 ft-lb]

⚠CAUTION⚠
To reduce the possibility of engine or pin damage, be sure the timing pin is disengaged.

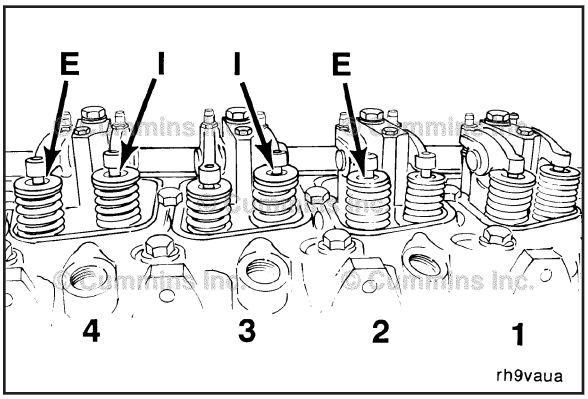
Mark the vibration damper and rotate the crankshaft 360 degrees.



Adjust the valves as indicated in the illustration.

Torque Value: 24 N•m [18 ft-lb]

Set **only** valves indicated by the arrows (E = exhaust, I = intake). Do **not** set valves that are **not** indicated.



Six-Cylinder Engine Valve Adjustment

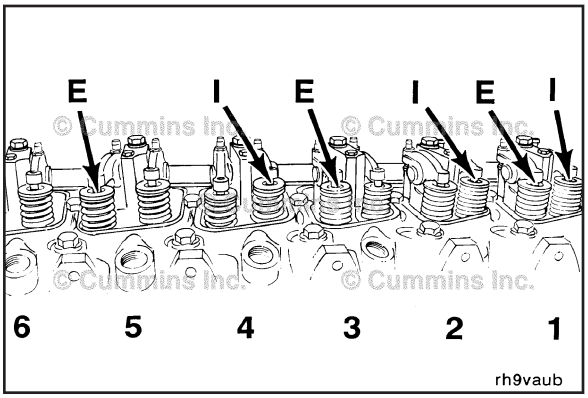
Make sure the engine is at top dead center (TDC) for cylinder number 1.

Set **only** the valves indicated by the arrows in the illustration (E = exhaust, I = intake).

Holding the locknut steady with the wrench, adjust the valve clearance with the screwdriver or Allen wrench.

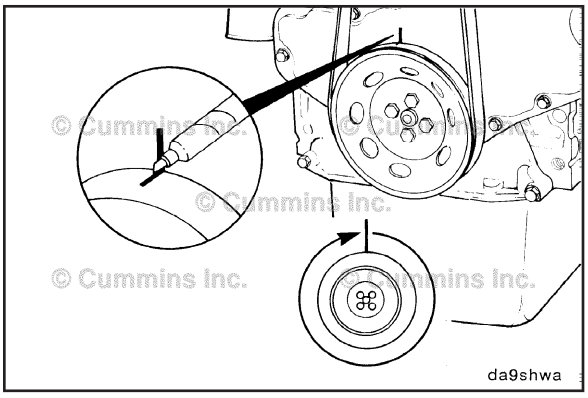
Tighten the locknut, and measure the valve lash again.

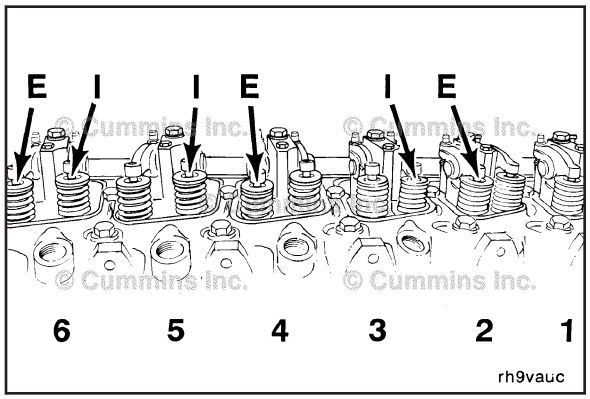
Torque Value: 24 N•m [18 ft-lb]



⚠CAUTION⚠
To reduce the possibility of engine or pin damage, be sure timing pin is disengaged.

Mark the pulley, and rotate the crankshaft 360 degrees.

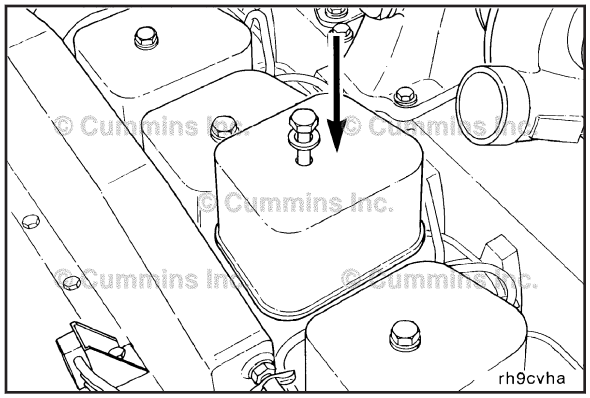




Adjust the valves as indicated in the illustration.

Set **only** the valves indicated by the arrows in the illustration (E = exhaust, I = intake). Do **not** set valves that are **not** indicated.

Torque Value: 24 N•m [18 ft-lb]



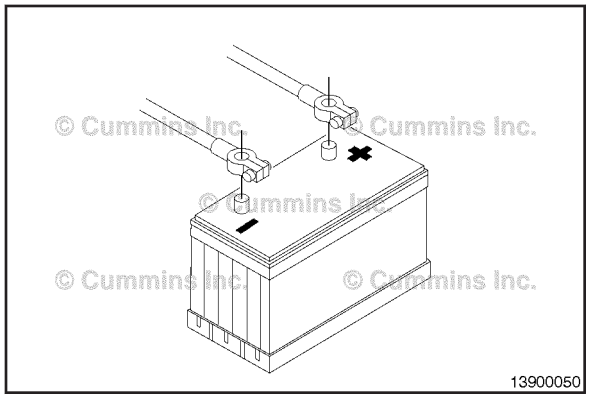
Install

B3.9, B5.9, and B4.5 Engines

Install rocker lever covers with new rocker lever cover gaskets. Next install the capscrews with new capscrew seals.

Tighten the rocker lever cover capscrews.

Torque Value: 24 mm [18 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
- Operate the engine and check for leaks.

Section 7 - Maintenance Procedures at 2000 Hours or 2 Years

Section Contents

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Maintenance Procedures - Overview

General Information

All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

Air Compressor Discharge Lines

General Information

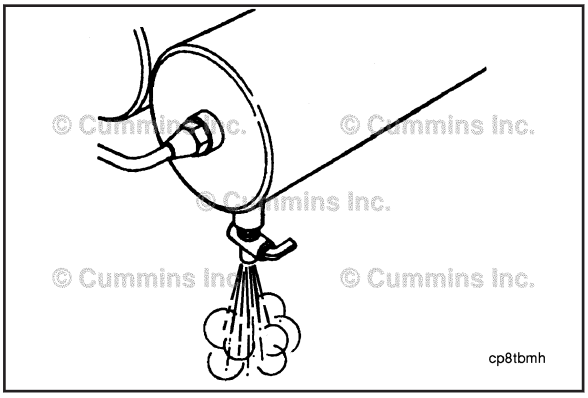
All air compressors have a small amount of lubricating oil carryover that lubricates the piston rings and moving parts. When this lubricating oil is exposed to normal air compressor operating temperatures over time, the lubricating oil will form varnish or carbon deposits. If the following maintenance check are not performed, the air compressor piston rings will wear and not seal correctly.

Maintenance Check

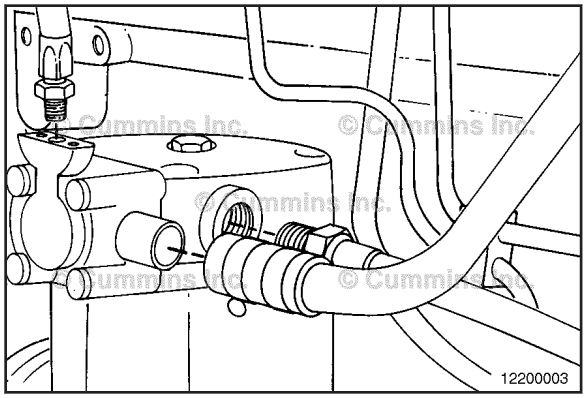
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

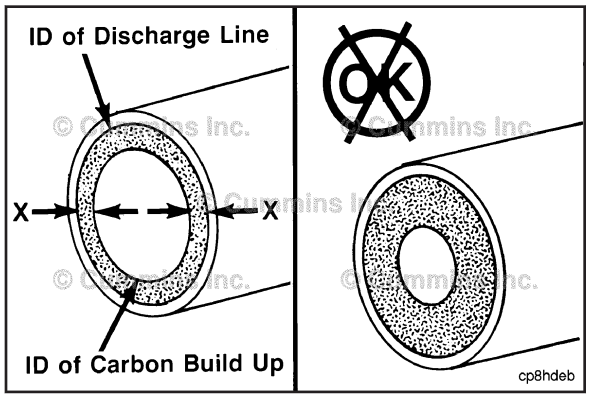
Shut off the engine.

Open the drain valve on the wet tank to release the system air pressure.

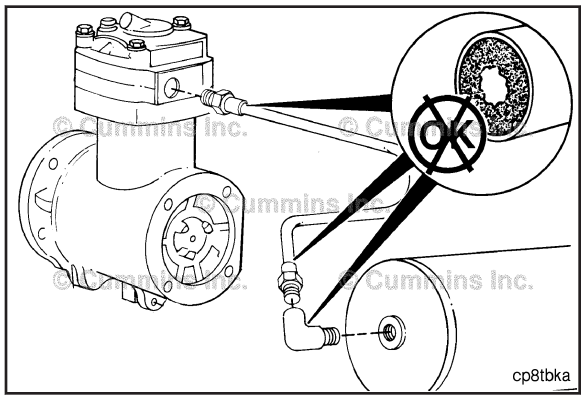


Remove the air compressor discharge line from the air compressor. Location of the air compressor discharge line can be found in Flow Diagram, Compressed Air System in System Diagrams (Section D).

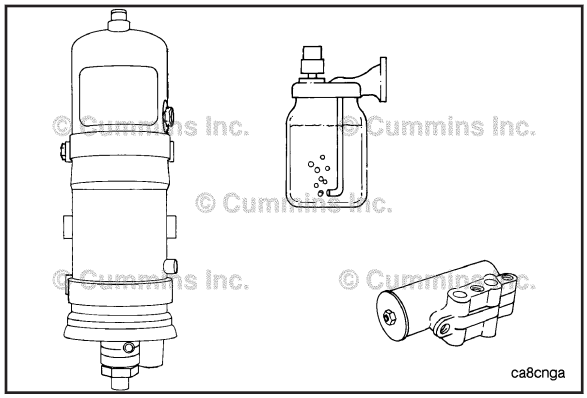




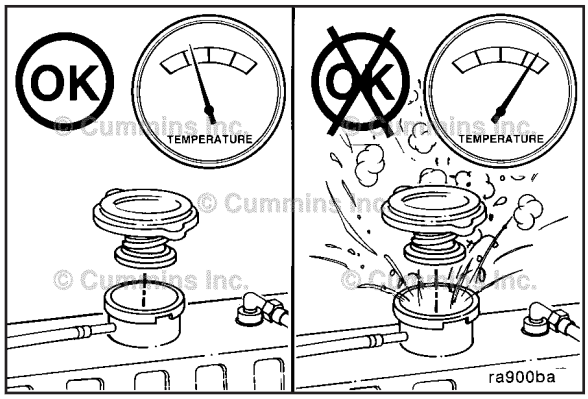
Measure the total carbon deposit thickness inside the air discharge line as shown. If the total carbon deposit (X + X) exceeds 2 mm [1/16 in], clean and inspect the cylinder head, the valve assembly, and the discharge line. Replace if necessary. Contact the Cummins Authorized Repair Location for procedures.



If the total carbon deposit exceeds specifications, continue checking the air discharge line connections up to the first tank until total carbon deposit is less than 2 mm [1/16 in]. Clean or replace any lines or connections that exceed this specification.



Inspect any air driers, splitter valves, pressure relief valves, and alcohol injectors for carbon deposits or malfunctioning parts. Inspect for air leaks. Maintain and repair the parts according to the manufacturer's specifications.



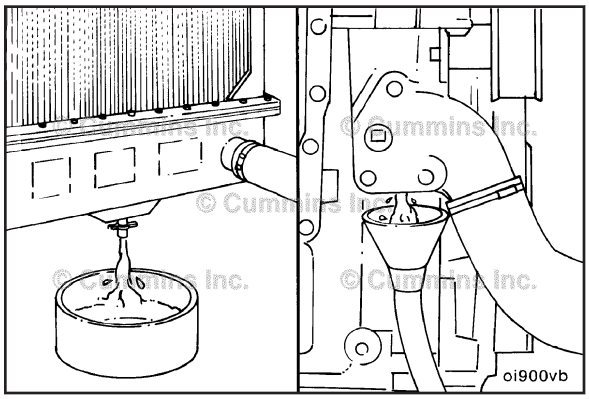
Cooling System

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.

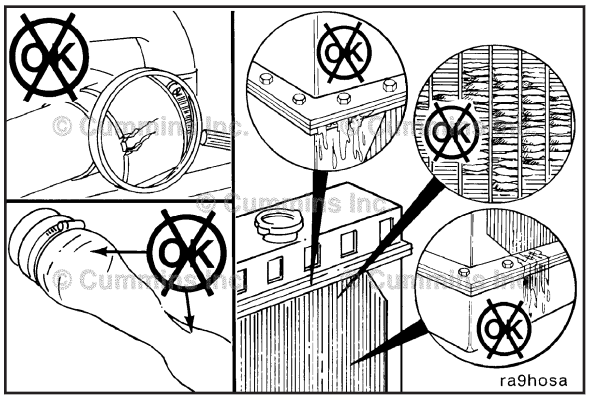
⚠WARNING⚠
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

Drain the cooling system by opening the drain valve on the radiator and removing the plug in the bottom of the water inlet. A drain pan with a capacity of 19 liters [5 gal] will be adequate in most applications.



Check for damaged hoses and loose or damaged hose clamps. Replace as required.

Check the radiator for leaks, damage, and buildup of dirt. Clean and replace as required.



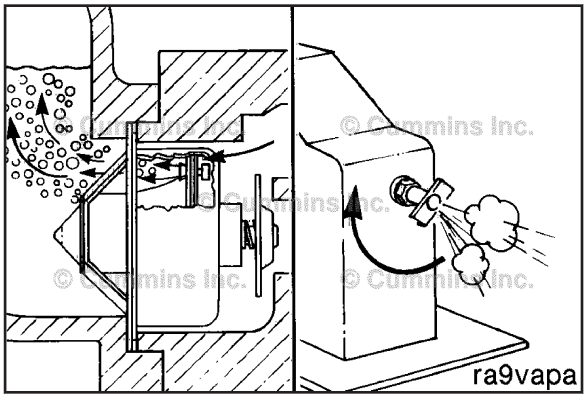
Flush

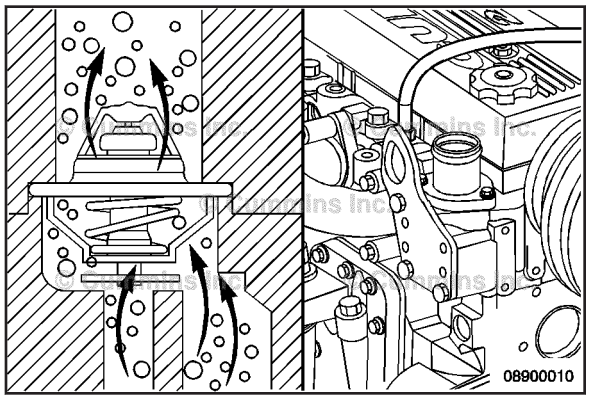
△CAUTION△
During filling, air must be vented from the engine coolant passages. The air vents through the jiggle pin openings to the top radiator hose and out the fill opening. Additional venting is provided for engines equipped with an aftercooler. Open the petcock during filling.

For front gear train engines with aftercoolers, open the petcock during filling for additional venting.

For front gear train engines without aftercoolers, the air vents through the jiggle pin openings in the thermostat to the top radiator hose and out the fill opening.

This provides adequate venting for a fill rate of 19 liters per minute [5 U.S. gallons per minute].





⚠CAUTION⚠

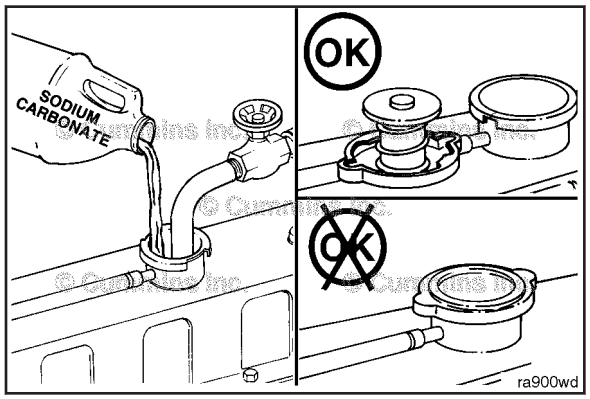
The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented then add mixture to bring the level to the top.

For rear gear train engines, a dearation port next to the water outlet connection vents air to the top tank of the cooling system.

This provides adequate venting for a fill rate of 19 liters per minute [5 U.S. gallons per minute].

NOTE: An alternative to using sodium carbonate, as outlined in this procedure, is to use RESTORE™.

RESTORE™ is a heavy-duty cooling system cleaner that removes corrosion products, silica gel, and other deposits. The performance of RESTORE™ is dependant on time, temperature, and concentration levels. An extremely scaled or flow-restricted system, for example, can require higher concentrations of cleaners, higher temperatures, or longer cleaning times or the use RESTORE Plus™. Up to twice the recommended concentration levels of RESTORE™ can be used safely. RESTORE Plus™ **must** be used only at its recommended concentration level. Extremely scaled or fouled systems can require more than one cleaning.

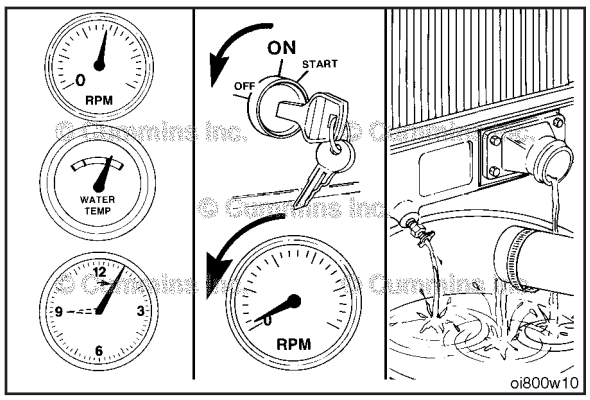


⚠CAUTION⚠

Do not install the radiator cap. The engine is to be operated without the cap for this process.

Fill the system with a mixture of sodium carbonate and water (or a commercially available equivalent).

NOTE: Adequate venting is provided for a fill rate of 19 liters per minute [5 U.S. gallons per minute].



⚠WARNING⚠

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

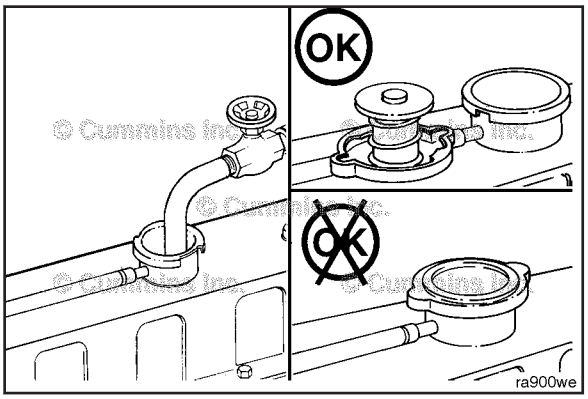
Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

Shut the engine off, and drain the cooling system.

Fill the cooling system with clean water.

NOTE: Be sure to vent the engine and aftercooler, if equipped, for complete filling.

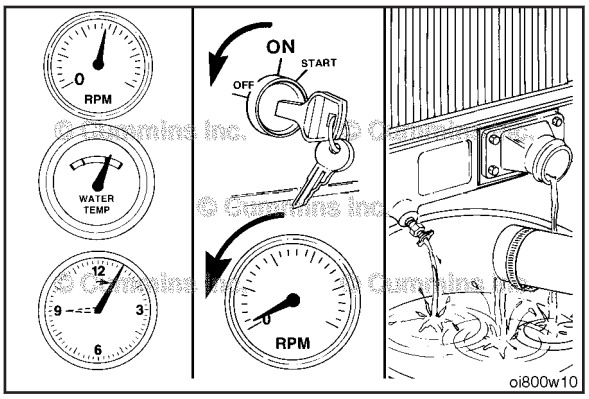
NOTE: Do **not** install the radiator cap.



Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

Shut the engine off, and drain the cooling system.

NOTE: If the water being drained is still dirty, the system **must** be flushed again until the water is clean.



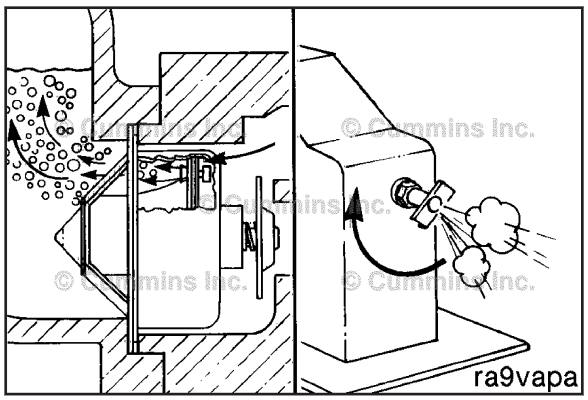
Fill

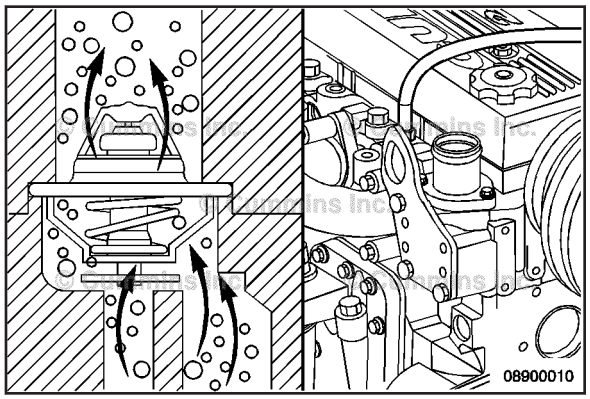
⚠CAUTION⚠
During filling, air must be vented from the engine coolant passages. The air vents through the jiggle pin openings to the top radiator hose and out the fill opening. Additional venting is provided for engines equipped with an aftercooler. Open the petcock during filling.

For front gear train engines with aftercoolers, open the petcock during filling for additional venting.

For front gear train engines without aftercoolers, the air vents through the jiggle pin openings in the thermostat to the top radiator hose and out the fill opening.

This provides adequate venting for a fill rate of 19 liters per minute [5 U.S. gallons per minute].



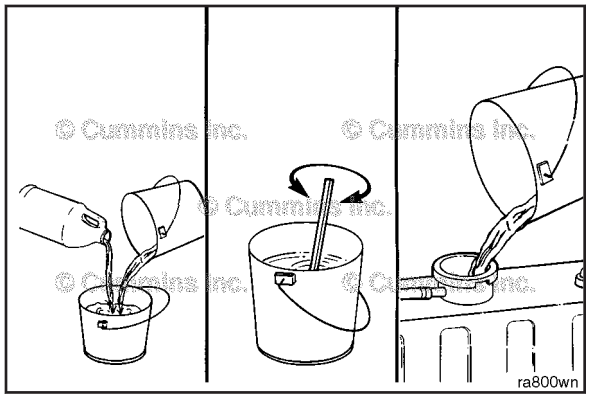


CAUTION

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Be sure to open the petcock on the aftercooler for aftercooled engines. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

For rear gear train engines, a dearation port next to the water outlet connection vents air to the top tank of the cooling system.

This provides adequate venting for a fill rate of 19 liters per minute [5 U.S. gallons per minute].

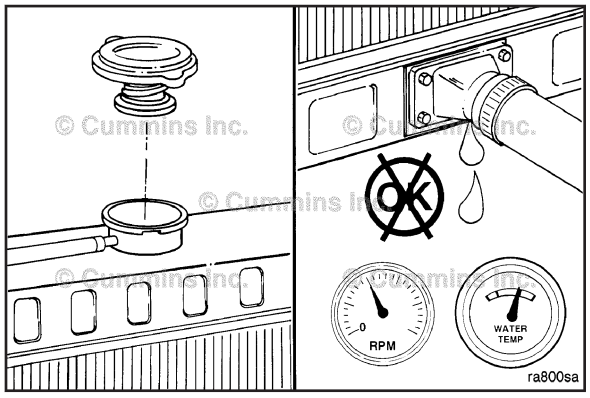


CAUTION

Never use water alone for coolant. Damage from corrosion can be the result of using water alone for coolant.

Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol antifreeze to fill the cooling system. Refer to the Cummins Coolant Requirements and Maintenance, Bulletin 3666132 for engine coolant specifications.

For system capacity, refer to Procedure 018-018 (Cooling System) in Section V.

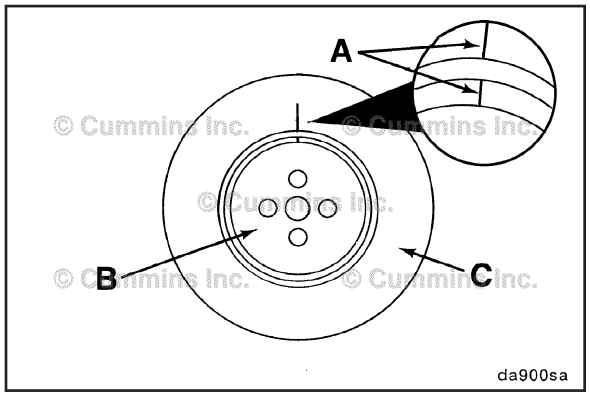


WARNING

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F]. Failure to do so can cause personal injury from heated coolant.

Install the pressure cap. Operate the engine until it reaches a temperature of 80°C [180°F], and check for coolant leaks.

Check the coolant level again to make sure system is full of coolant, or that the coolant level has risen to the hot level in the recovery bottle on the system, if equipped.



Vibration Damper, Rubber

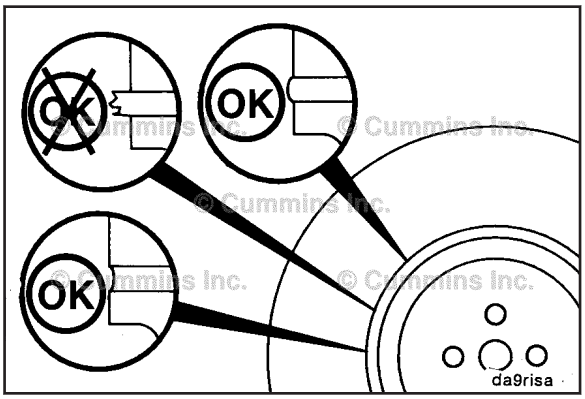
Inspect

Check the index lines (A) in the vibration damper hub (B) and the inertia member (C). If the lines are more than 1.59 mm [1/16 in] out of alignment, replace the vibration damper.

Inspect the rubber member for deterioration. If pieces of rubber are missing or if the elastic member is more than 3.18 mm [1/8 in] below the metal surface, replace the damper.

Look for forward movement of the damper ring on the hub. Replace the vibration damper if any movement is detected.

For vibration damper location, refer to Engine Diagrams in Engine Identification (Section E).



Vibration Damper, Viscous

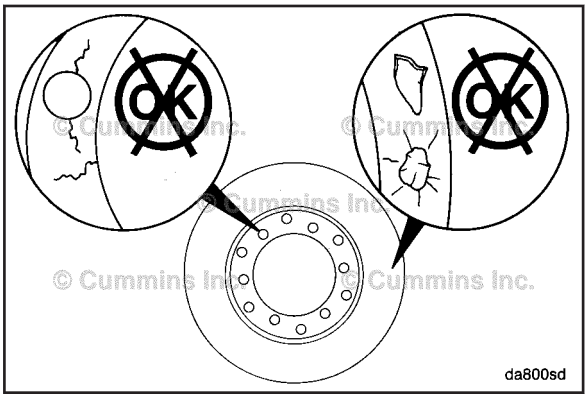
Inspect

⚠CAUTION⚠
The silicone fluid in the vibration damper will become solid after extended service and will make the damper inoperative. An inoperative vibration damper can cause major engine or drivetrain failures.

Check the vibration damper for evidence of fluid loss, dents, and wobble. Inspect the vibration damper thickness for any deformation or raising of the damper cover plate.

If any of these conditions are identified, contact your local Cummins Authorized Repair Location to replace the vibration damper.

For vibration damper location, refer to Engine Diagrams in Engine Identification (Section E).



Notes

Section A - Adjustment, Repair, and Replacement

Section Contents

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Air in Fuel

General Information

⚠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.

⚠WARNING⚠
Do not vent the fuel system on a hot engine; this can cause fuel to spill onto a hot exhaust manifold, which can cause a fire.

The low-pressure fuel system for a Cummins diesel installed in the vehicle consists of the fuel tank, lines between the tank and the engine, transfer pump and lines, and fuel filter and lines. Air or bubbles at the injection pump can cause the engine **not** to operate or erratic engine operation and/or subsequent malfunction of the fuel injection pump. Air can be introduced by leaks in the fuel system prior to the transfer pump since the fuel in the lines is under a vacuum and can draw air into the system. Bubbles can result from any number of restrictions in the system:

- Plugged fuel filter
- Crimped fuel line
- Stopped-up tank module
- Inoperative transfer pump.

If sufficient fuel reaches the injection pump from the low-pressure system then solutions to engine operational problems are elsewhere. The following steps will aid in evaluating low-pressure fuel system performance.

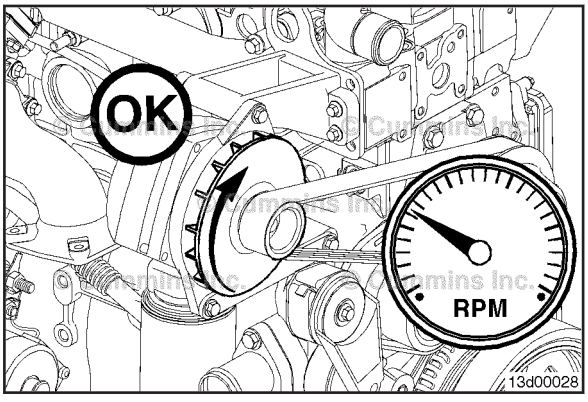
NOTE: For cold-start or performance problems, perform the following steps:

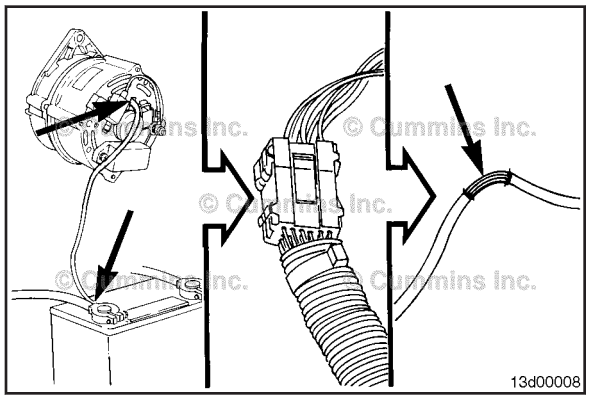
- Leave vehicle outside in cold environment for at least 12 hours
- Perform outlined test
- If the system fails to meet test criteria, replace the fuel lift pump.

Alternator

Initial Check

Check the drive belt and alternator pulley to be sure the alternator is rotating.

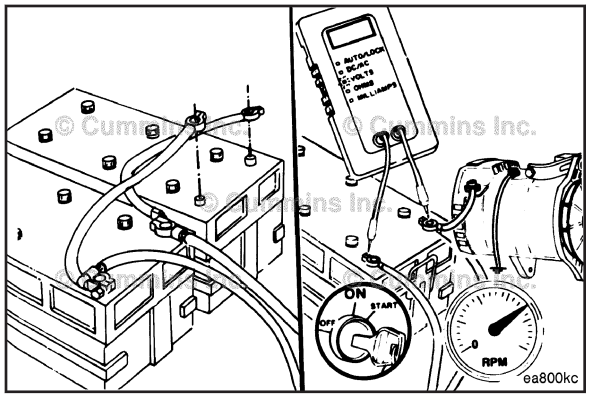




⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Check the battery and all wiring connections.

Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the slip connectors at the alternator and engine compartment bulkhead, and connections at the battery.



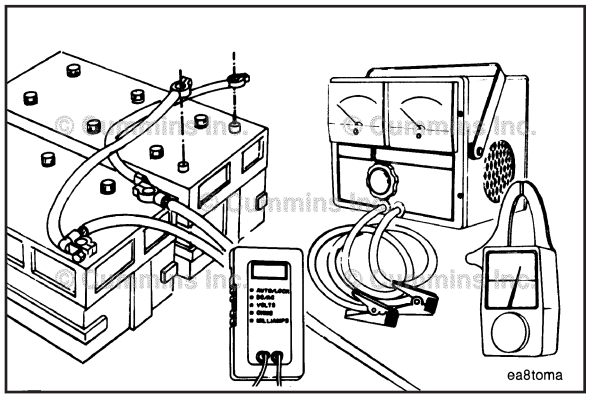
Test

⚠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 bodily injury.

Disconnect any cables that lead to any other battery boxes in the circuit, negative (-) cables first.

Operate the engine at high idle, and measure the alternator voltage output to the batteries with digital multimeter, Part Number 3377161. Refer to the alternator manufacturer's specifications.



⚠WARNING⚠
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⚠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 bodily injury.

Shut off the engine and remove the test equipment.

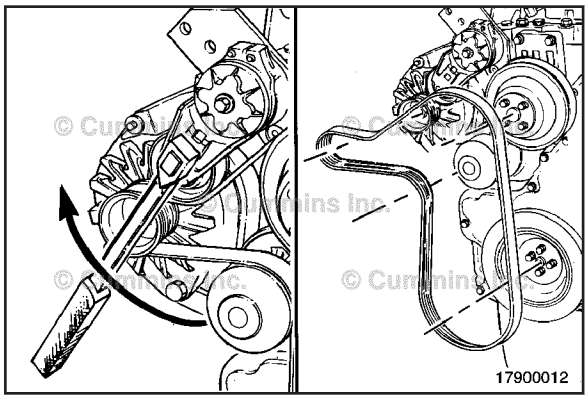
Connect all battery cables, negative (-) cable last.

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 ground cable from the battery terminal.

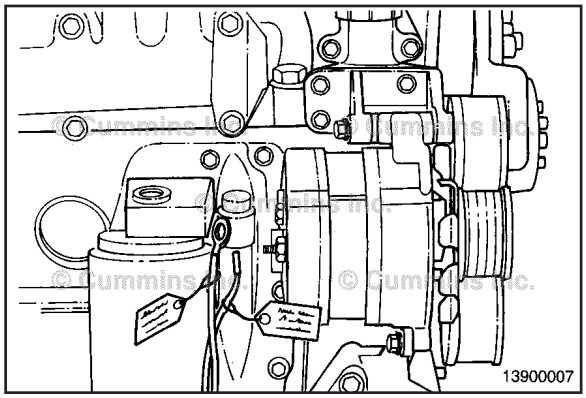
Remove the drive belt from the alternator pulley.



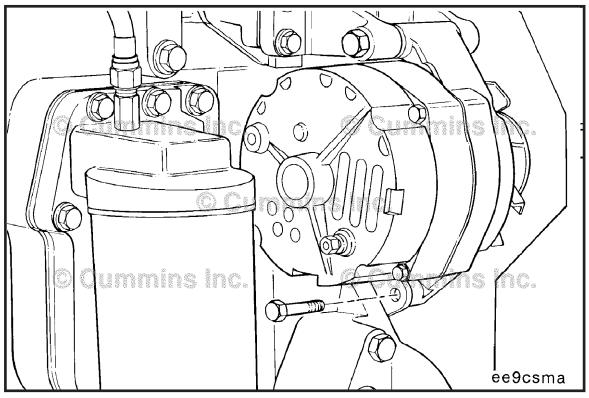
Remove

Remove and tag all wires.

Complete the following steps.

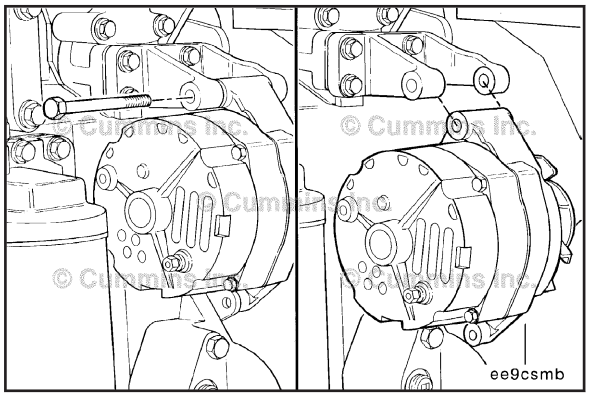


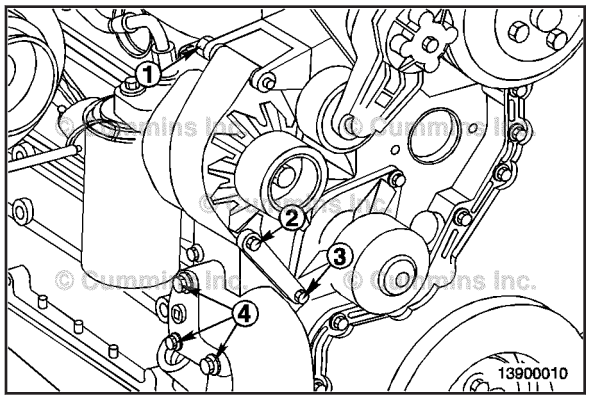
Remove the alternator link capscrew.



Remove the alternator mounting capscrew.

Remove the alternator.



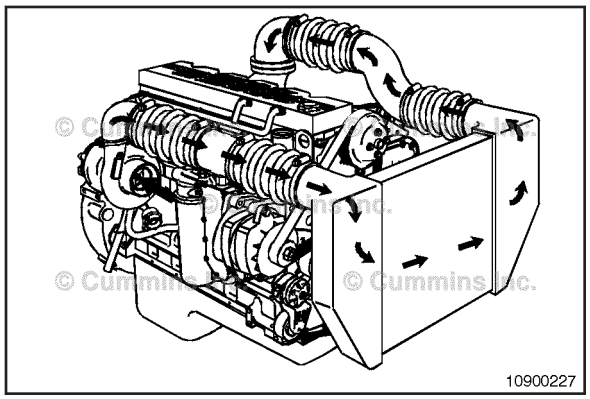


Install

NOTE: Wrench size and torque value are determined by the make and model of alternator. Refer to the Engine Component Torque Values.

To assemble the alternator, the alternator mounting components **must** be tightened in the following sequence:

1. Alternator-to-alternator bracket capscrew
2. Lower brace-to-alternator capscrew
3. Lower alternator brace-to-water pump capscrew
4. Water inlet-to-block capscrews.

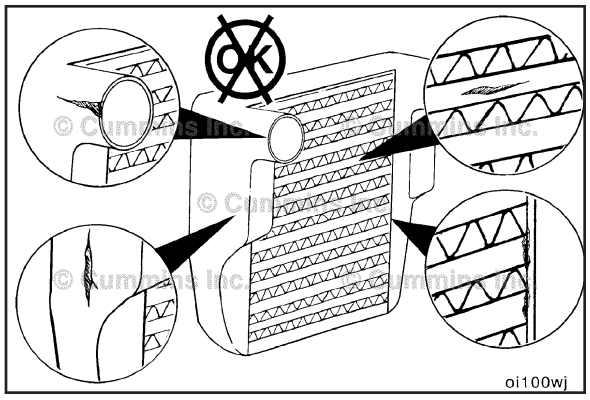


Charge-Air Cooler

General Information

The long-term integrity of the charge air cooler system is the responsibility of the vehicle and component manufacturers; however, the following can be checked by any Cummins Authorized Repair Facility.

NOTE: If the engine experiences a turbocharger failure or any other occasion where oil or debris is put into the charge air cooler, the charge air cooler **must** be cleaned.



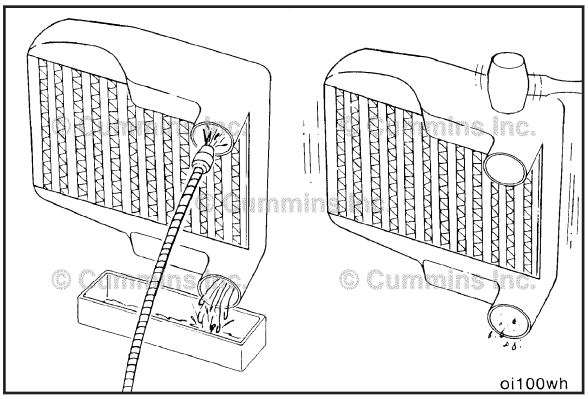
Initial Check

Inspect the charge air cooler for cracks, holes, and damage.

Inspect the tubes, fins, and welds for tears, breaks, or other damage. If any damage causes the charge air cooler to fail the air leak check, the charge air cooler **must** be replaced.

Inspect the charge air cooler plumbing for cracks and damage.

Clean



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

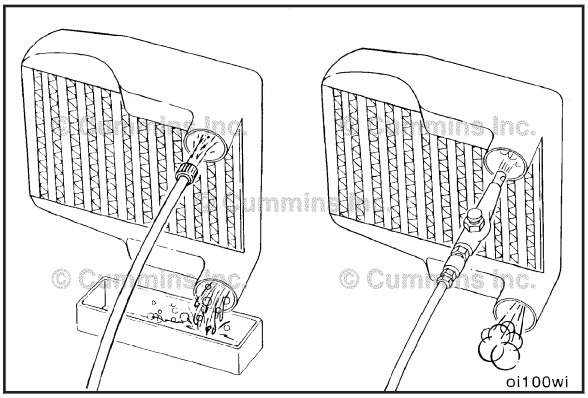
⚠WARNING⚠
Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

△CAUTION△
Do not use caustic cleaners to clean the charge air cooler. Damage to the charge air cooler will result.

Flush the charge air cooler internally with solvent in the opposite direction of normal airflow. Shake the charge air cooler and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris. Continue flushing until all debris or oil is removed (i.e., the water runs clear).

NOTE: Make sure that the tubes are in the vertical direction when flushing.

If the debris can **not** be totally removed from the charge air cooler, the charge air cooler **must** be replaced.



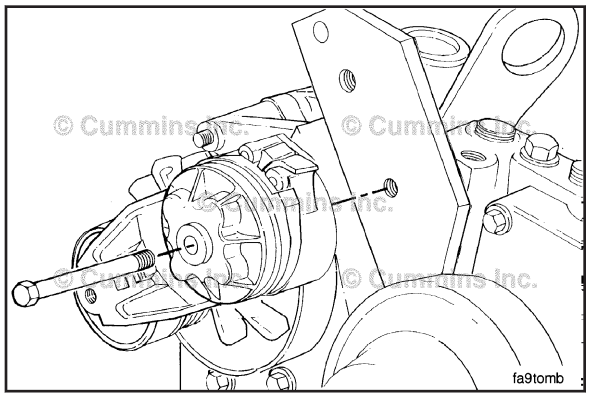
⚠WARNING⚠
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

△CAUTION△
The charge air cooler must be rinsed, dried, and cleaned of solvent, oil, and debris, or engine damage will result.

After the charge air cooler has been thoroughly cleaned of all oil and debris with solvent, wash the charge air cooler internally with hot, soapy water to remove the remaining solvent. Rinse thoroughly with clean water.

Blow compressed air through the inside of the charge air cooler in the opposite direction of normal airflow until the charge air cooler is dry internally.

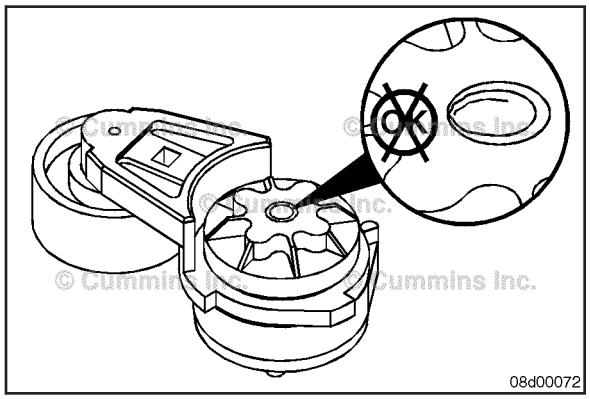


Cooling Fan Belt Tensioner

Remove

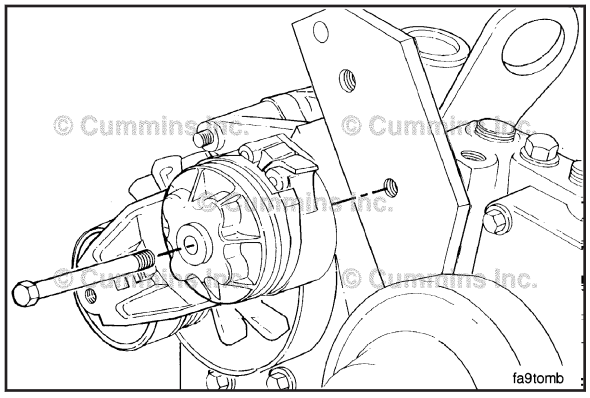
Remove the belt tensioner mounting capscrew.

Remove the belt tensioner from the bracket.



Inspect for Reuse

Inspect the tensioner bushing between the arm and the spring case.

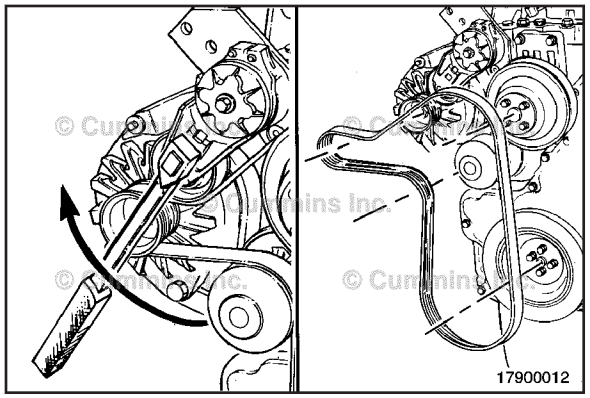


Install

Install the belt tensioner.

Install and tighten the belt tensioner capscrew.

Torque Value: 43 N•m [32 ft-lb]



Lift and hold the tensioner. Install the drive belt and release the tensioner.

Service Tip:

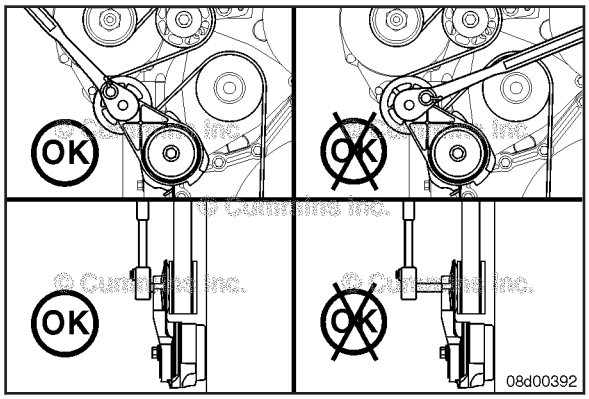
If difficulty is experienced installing the drive belt, for example, the belt seems too short, position the belt over the grooved pulleys first; then, while holding the tensioner up, slide the belt over the water pump pulley.

Drive Belt, Cooling Fan

Remove

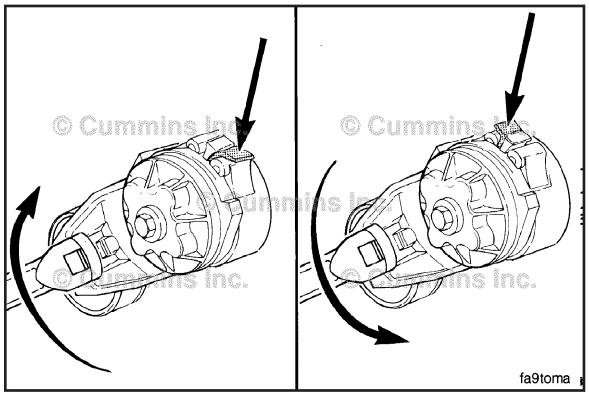
⚠CAUTION⚠
Using a socket extension is not recommended because it can cause axial twisting damage to the belt tensioner.

NOTE: If a socket extension is necessary, support the head of the ratchet with one hand to prevent the belt tensioner arm from being subjected to unintended loading.

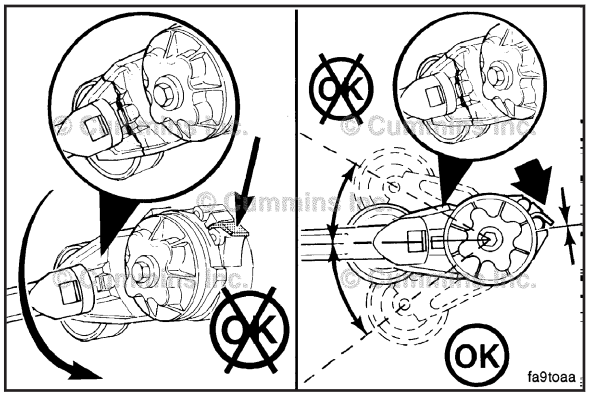


Lift the tensioner to remove the drive belt.

NOTE: The belt tensioner winds in the direction that the spring tang is bent over the tensioner body. To loosen the tension on the belt, rotate the tensioner to wind the spring tighter.



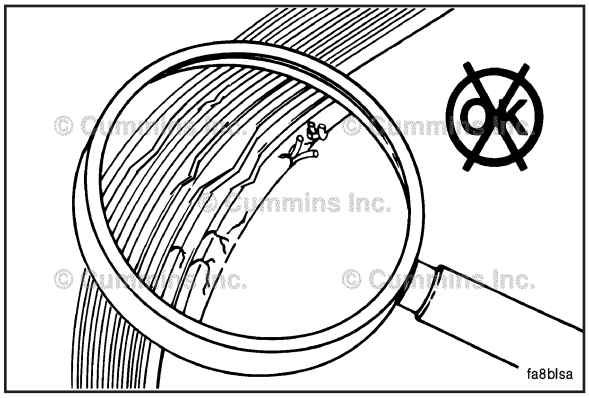
⚠CAUTION⚠
Applying excessive force in the opposite direction of windup or after the tensioner has been wound up to the positive stop can cause the tensioner arm to break.

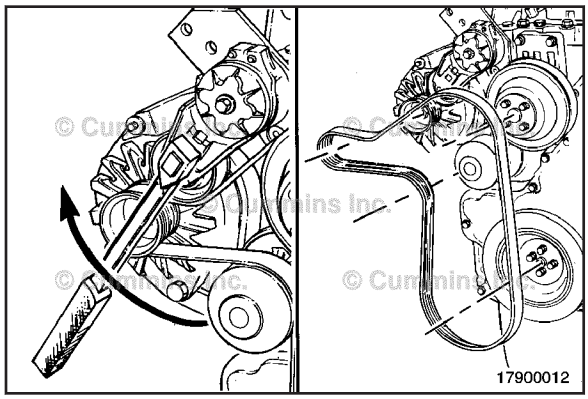


Inspect for Reuse

Inspect the drive belt for:

- Cracks
- Glazing
- Tears or cuts
- Hardening
- Excessive wear.



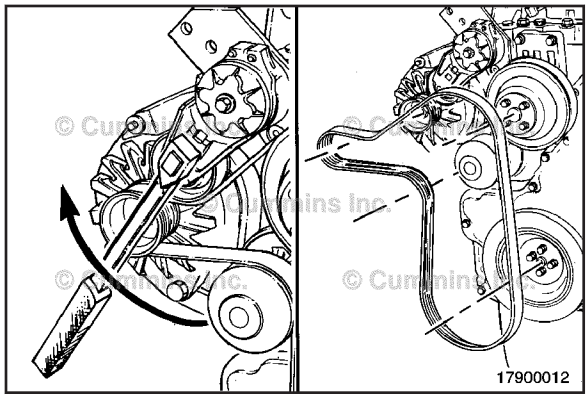


Install

⚠CAUTION⚠

The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

Lift the tensioner to install the drive belt.

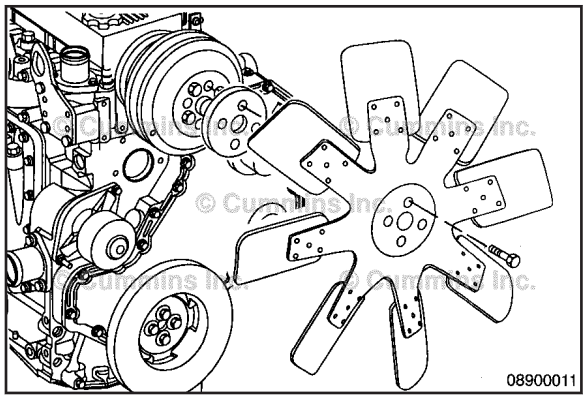


Fan Spacer and Pulley

Preparatory Steps

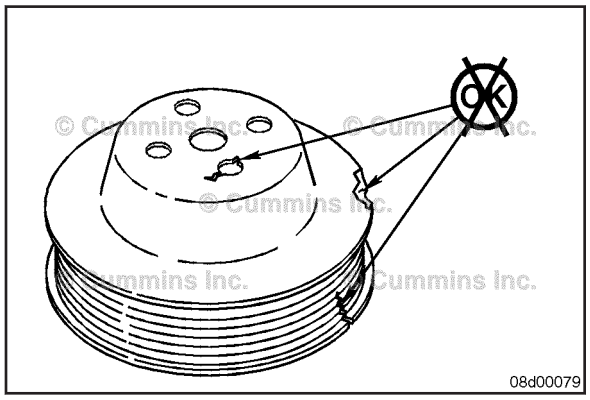
- Remove the drive belt.

NOTE: Loosen the capscrews before removing the belt, and tighten the capscrews after the belt is installed.



Remove

Remove the four capscrews, fan, and spacer.



Inspect for Reuse

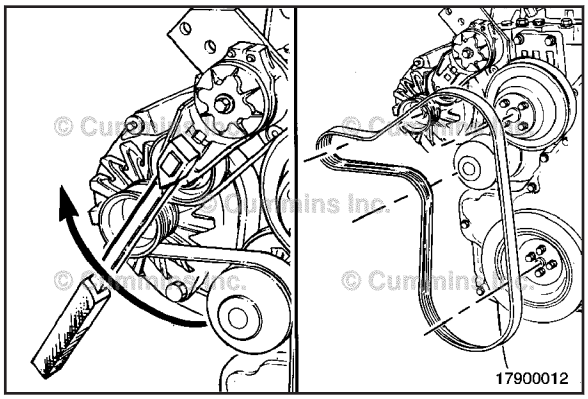
Inspect the fan pulley for cracks near bolt holes.

Check for cracks, loose rivets, and bent or loose blades.

Install

Lift the tensioner, and install the belt.

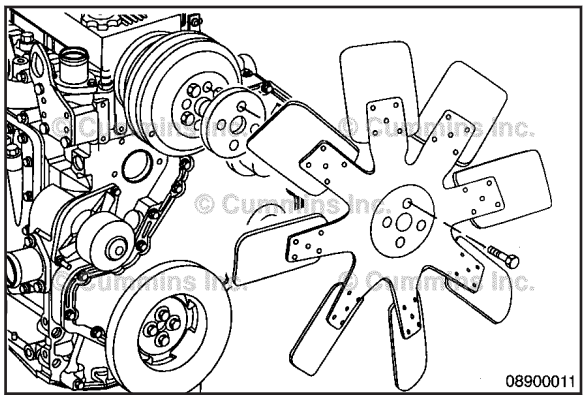
Service Tip: If difficulty is experienced installing the drive belt (the belt seems too short), position the belt over the grooved pulleys first; then, while holding the tensioner up, slide the belt over the water pump pulley.



Install the four capscrews, fan, and spacer.

Torque Value: 24 N•m [212 in-lb]

Torque Value: 43 N•m [32 ft-lb]

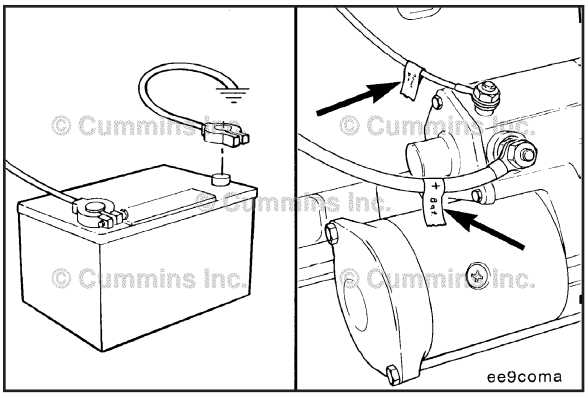


Starting Motor

Preparatory Steps

⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

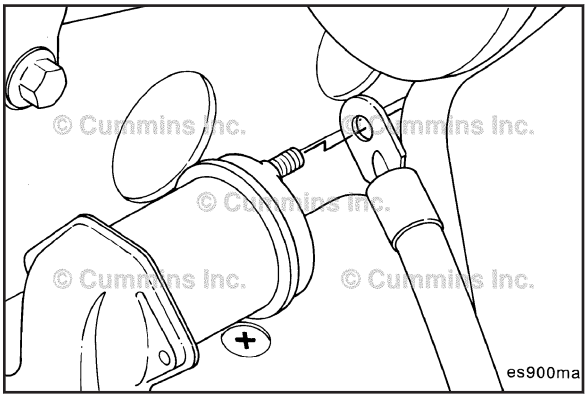
- Disconnect the ground cable from the battery terminal.
- Identify each electrical wire with a tag indicating location.

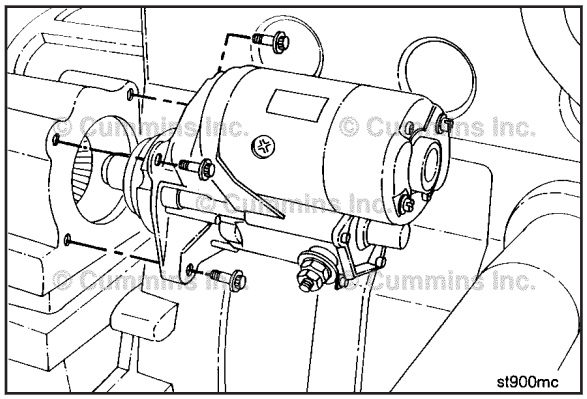


Remove

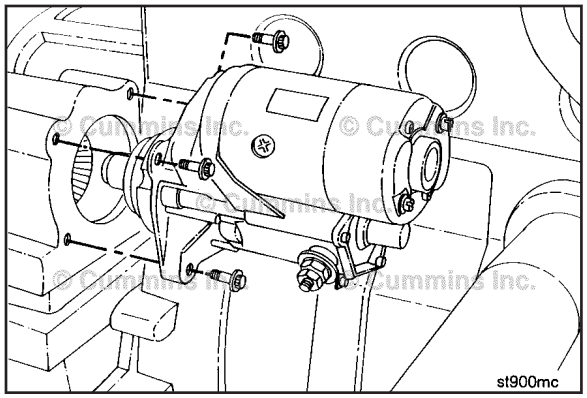
Remove the battery cable from the solenoid.

Remove all other wires connected to the starter.





Remove the starter motor.

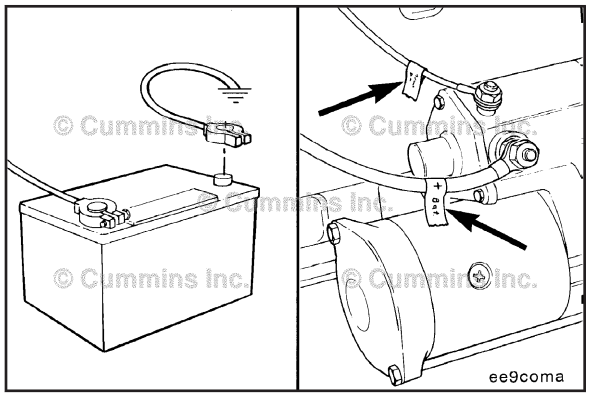


Install

Install the starter motor.

Torque Value: 43 N•m [32 ft-lb]

Connect all cables and all other wires connected to the starter.



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 ground cable from the battery terminal.

Section D - System Diagrams

Section Contents

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System Diagrams - Overview

General Information

The following drawings show the flow through the engine systems. Although parts can change between different applications and installations, the flow remains the same. The systems shown are:

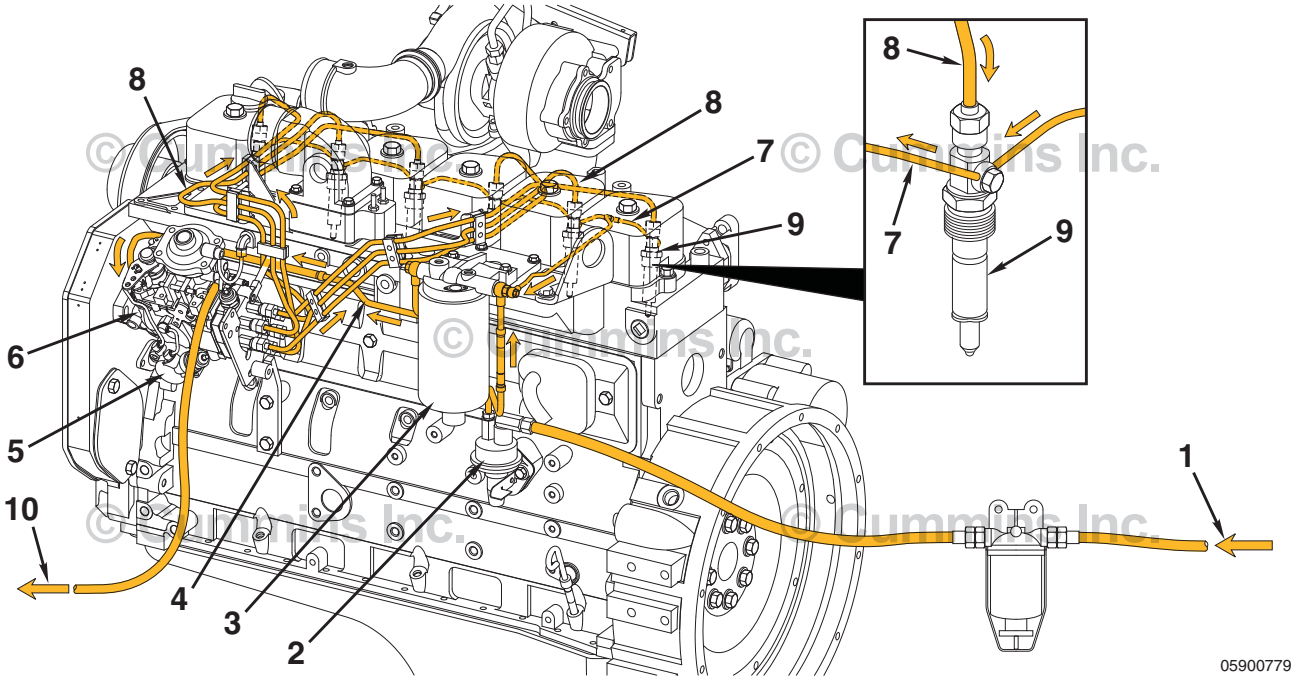
- Fuel System
- Lubricating Oil System
- Coolant System
- Intake Air System
- Exhaust System
- Compressed Air System.

Knowledge of the engine systems can help you in troubleshooting, service, and general maintenance of your engine.

Flow Diagram, Fuel System

Flow Diagram

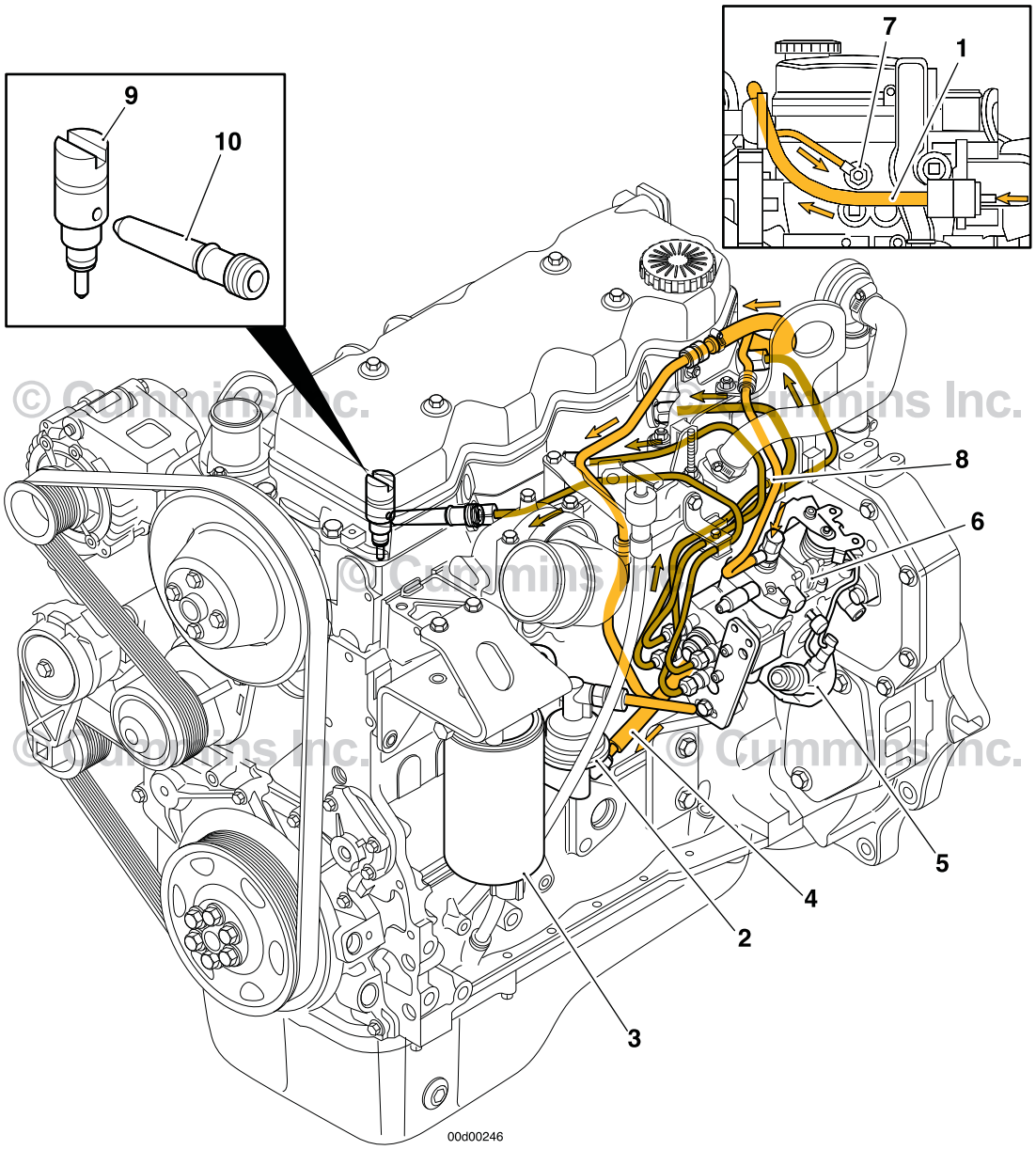
Front Gear Train



Industrial Applications

1. Fuel from supply tank
2. Fuel lift pump
3. Fuel filter/water separator
4. Low-pressure fuel supply lines
5. Bosch® KKSB cold start injection advance
6. Bosch® VE injection pump
7. Fuel drain manifold
8. High-pressure fuel supply lines
9. Bosch® closed nozzle injectors
10. Fuel return to supply tanks.

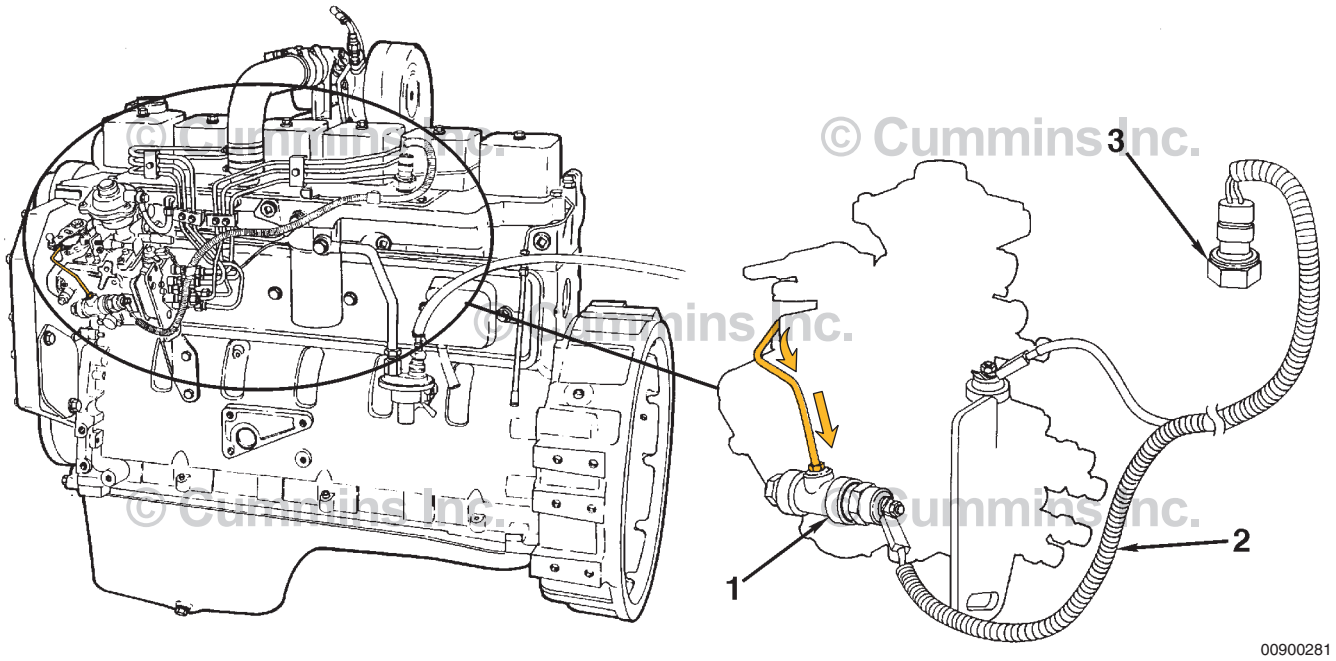
Rear Gear Train



Industrial Applications

1. Fuel from supply tank
2. Fuel lift pump
3. Fuel filter/water separator
4. Low-pressure fuel supply lines
5. Bosch® KKSB cold start injection advance
6. Bosch® VE injection pump
7. Fuel drain manifold and return to supply tanks
8. High-pressure fuel supply lines
9. Bosch® closed nozzle injectors
10. High pressure connector.

Industrial Applications

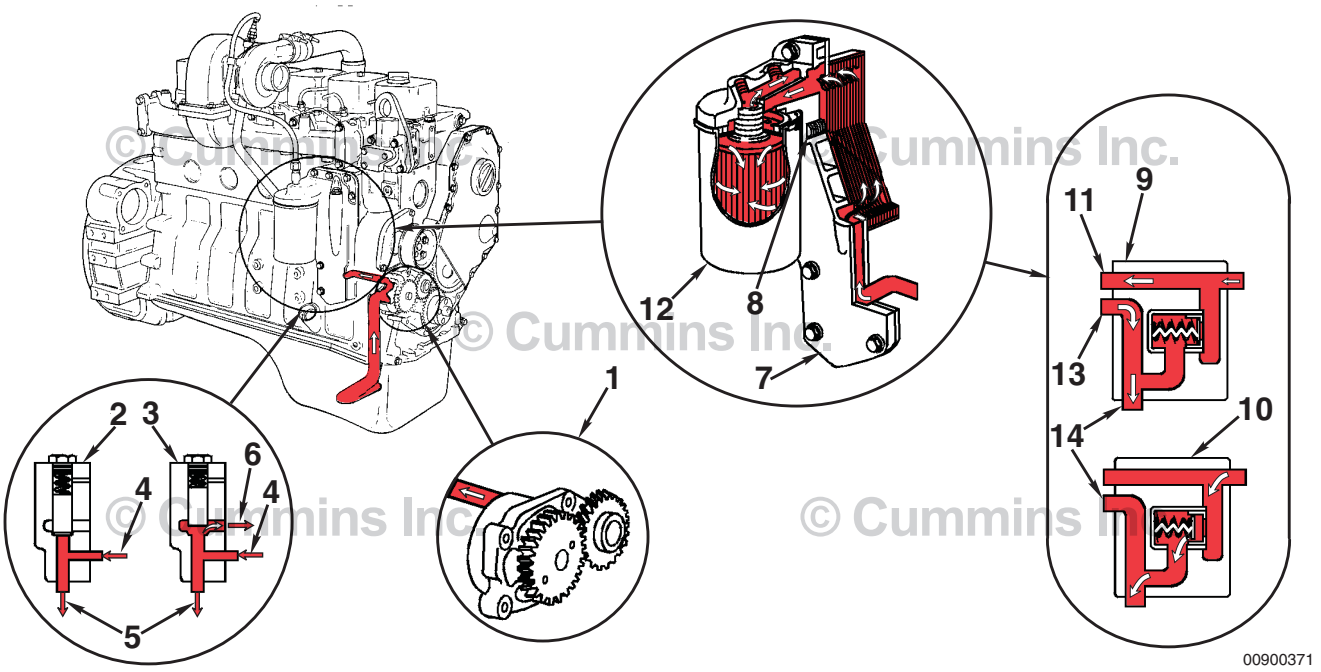


Hydraulic Cold Start Injection Advance (Rotary Pumps Only)

1. KSB valve
2. Wiring harness
3. Temperature switch.

Flow Diagram, Lubricating Oil System

Flow Diagram



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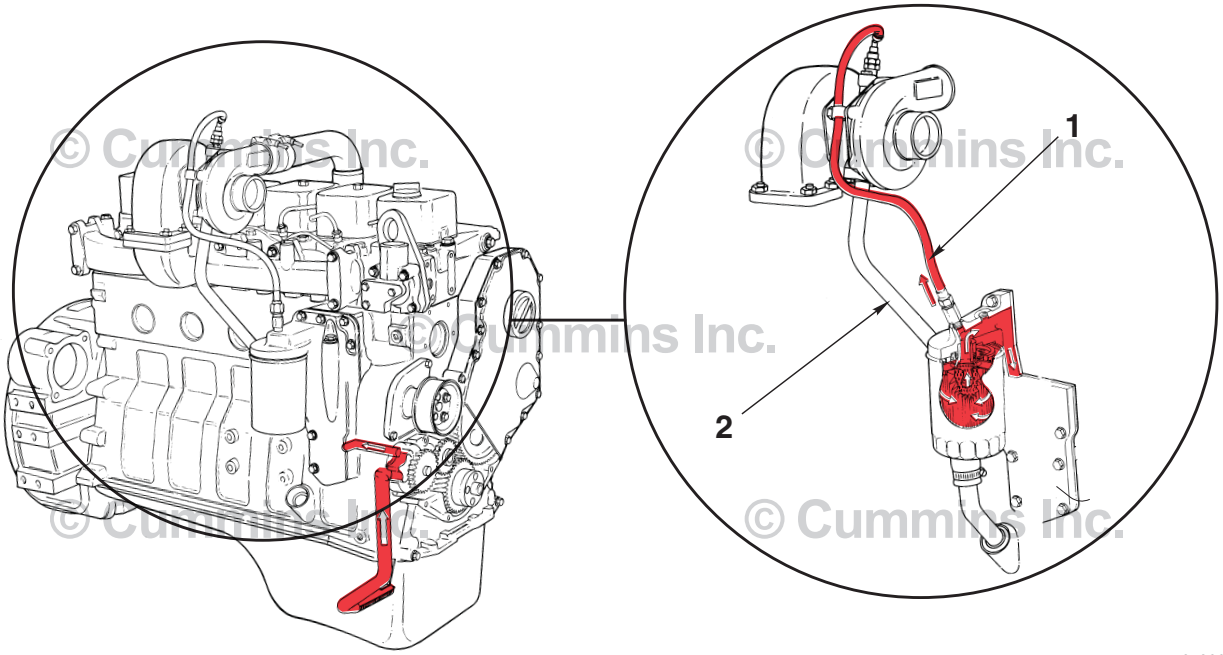
1. Lubricating Oil Pump
2. Pressure Regulating Valve Closed
3. Pressure Regulating Valve Open
4. From Lubricating Oil Pump
5. To Lubricating Oil Cooler
6. To Lubricating Oil Pan
7. Lubricating Oil Cooler
8. Filter Bypass Valve
9. Filter Bypass Valve Closed
10. Filter Bypass Valve Open
11. To Lubricating Oil Filter
12. Lubricating Oil Filter
13. From Lubricating Oil Filter
14. Main Lubricating Oil Rifle.

Lubrication for the Turbocharger



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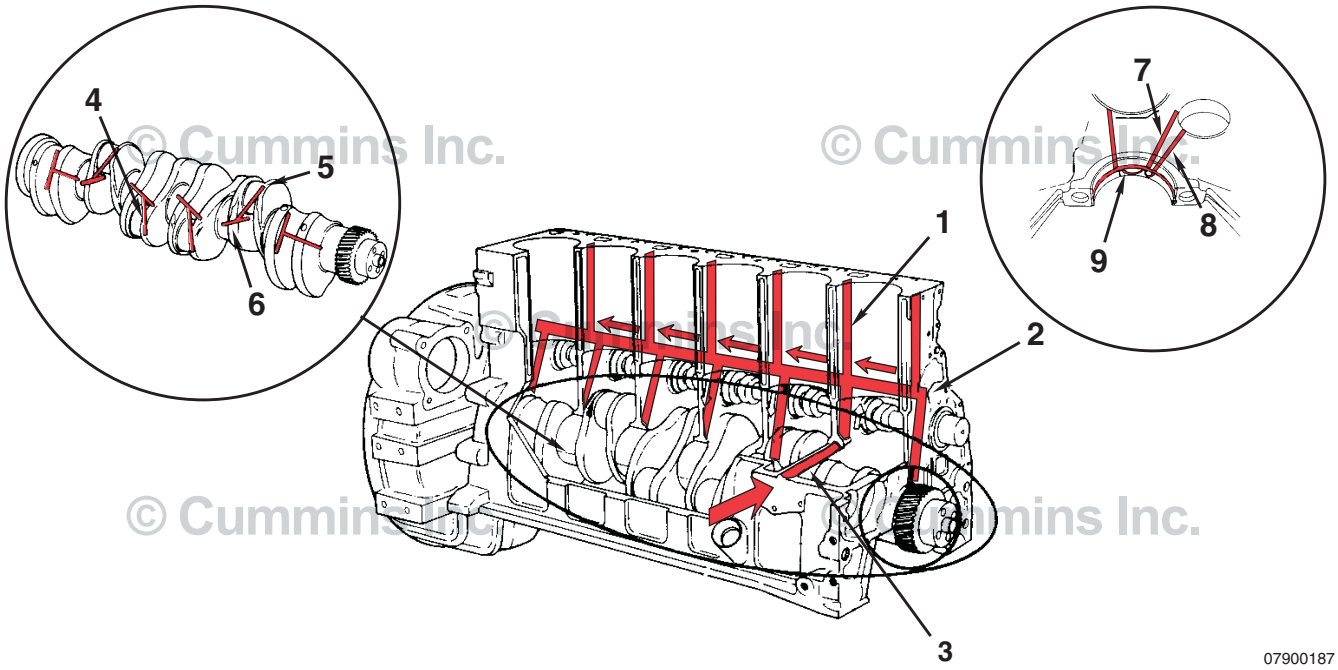
07900188

1. Lubricating Oil Supply
2. Lubricating Oil Drain.

Lubrication for the Power Components



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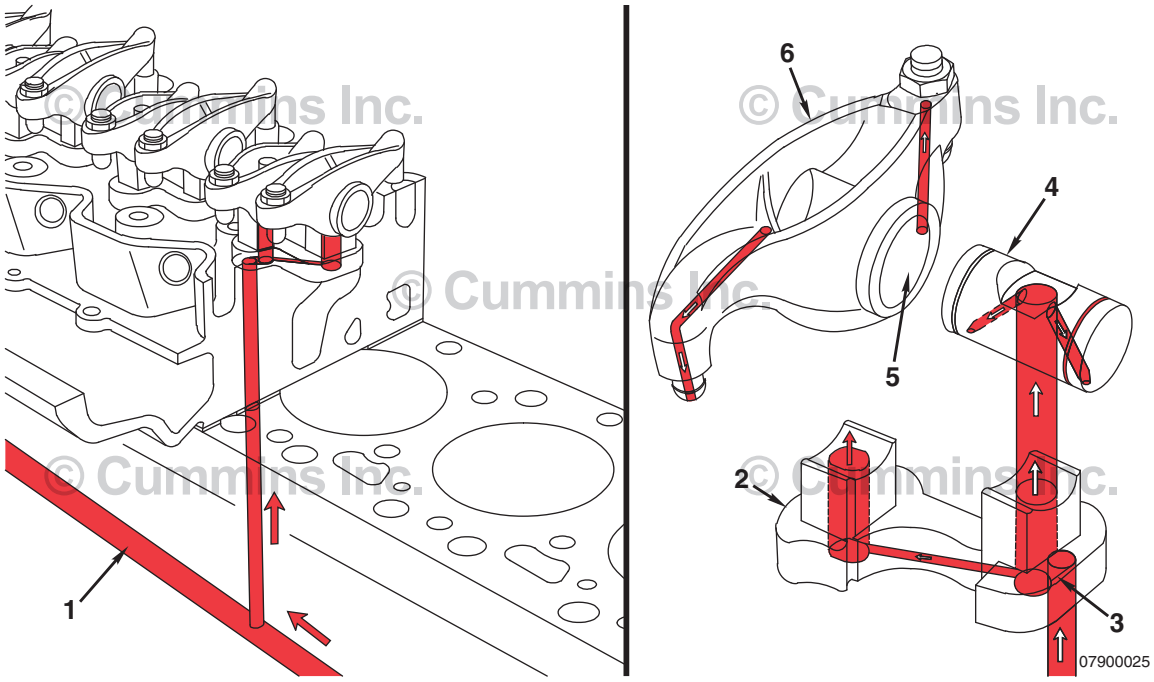
1. To Valve Train
2. Main Lubricating Oil Rifle
3. From Lubricating Oil Cooler
4. Connecting Rod Journal
5. To Connecting Rod Bearing
6. Crankshaft Main Journal
7. From Main Lubricating Oil Rifle
8. To Camshaft
9. To Piston Cooling Nozzle.

Lubrication for the Overhead



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1. Main Lubricating Oil Rifle
2. Rocker Lever Support
3. Transfer Slot
4. Rocker Lever Shaft
5. Rocker Lever Bore
6. Rocker Lever.

Flow Diagram, Cooling System

Flow Diagram

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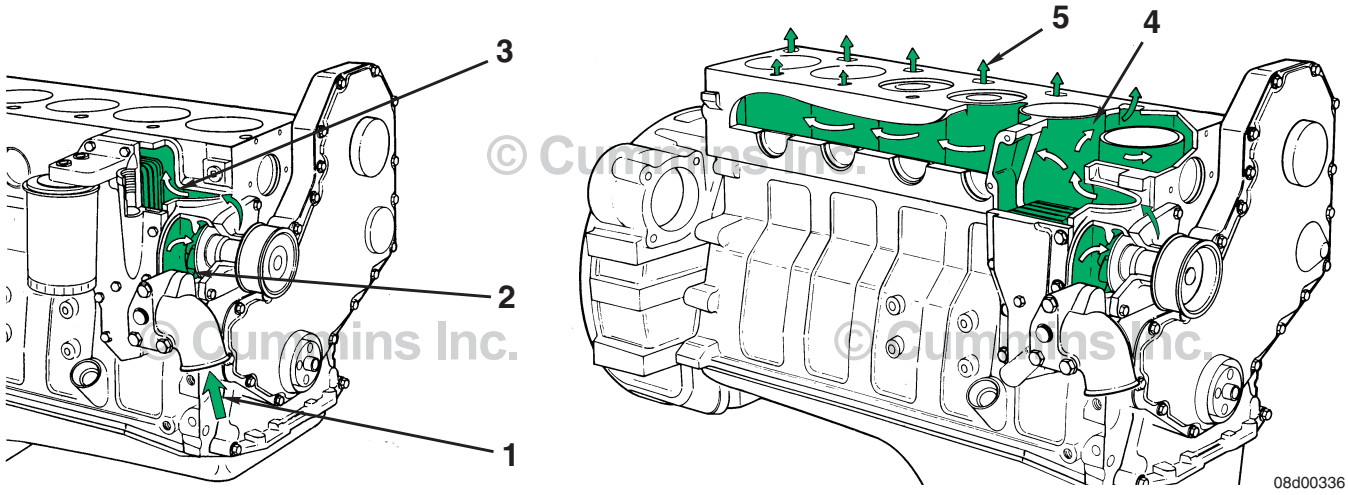
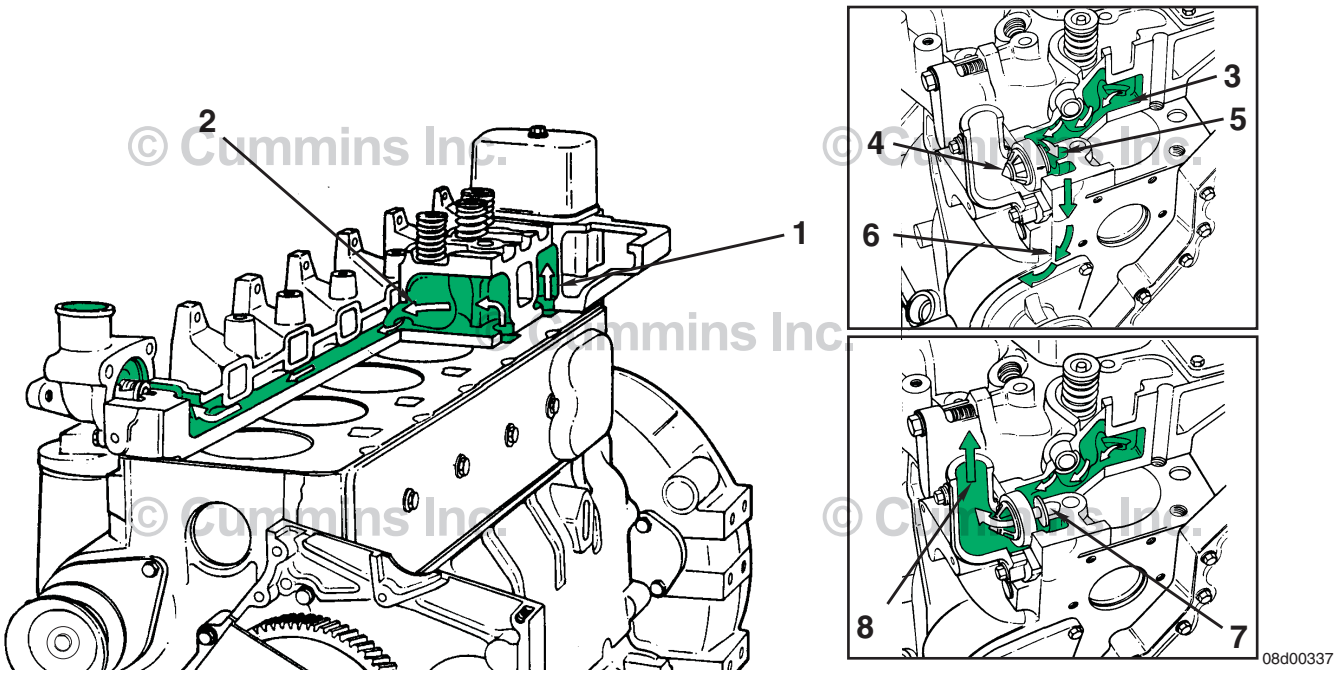


1. Coolant inlet
2. Pump impeller
3. Coolant flow past lubricating oil cooler
4. Coolant flow past cylinders
5. Coolant flow to cylinder head.

Flow Diagram, Cooling System

Flow Diagram



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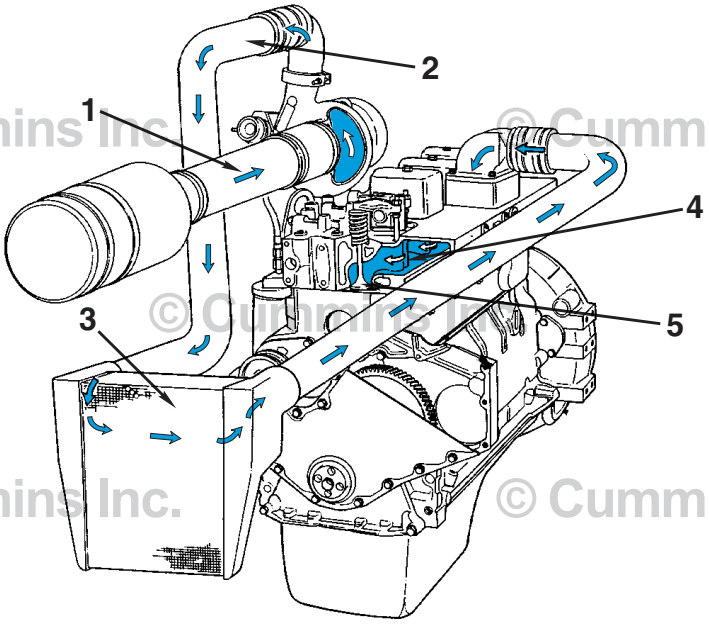
1. Coolant flow from the cylinder head
2. Coolant flow to thermostat housing
3. Coolant flow past injector
4. Thermostat
5. Coolant bypass passage
6. Coolant flow to water pump inlet
7. Coolant bypass closed
8. Coolant flow back to radiator.

Flow Diagram, Air Intake System

Flow Diagram



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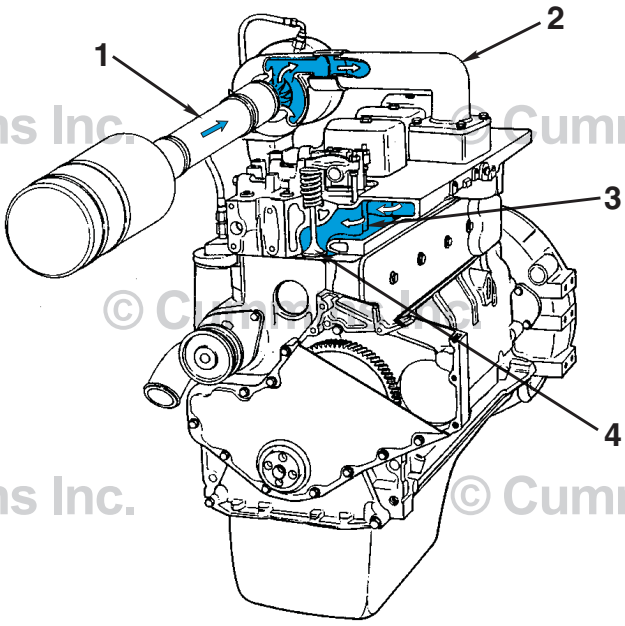
Turbocharged-Charge-Air-Cooled Engine

1. Intake air inlet to turbocharger
2. Turbocharger air to charge air cooler
3. Charge air cooler
4. Intake manifold
5. Intake valve.

Flow Diagram, Air Intake System

Flow Diagram



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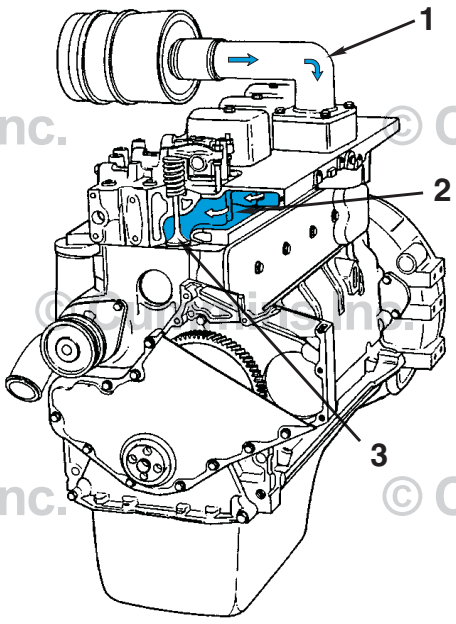
10900256

Turbocharged (only) Engine

1. Intake air inlet to turbocharger
2. Air to intake manifold
3. Intake manifold
4. Intake valve.

Flow Diagram, Air Intake System

Flow Diagram



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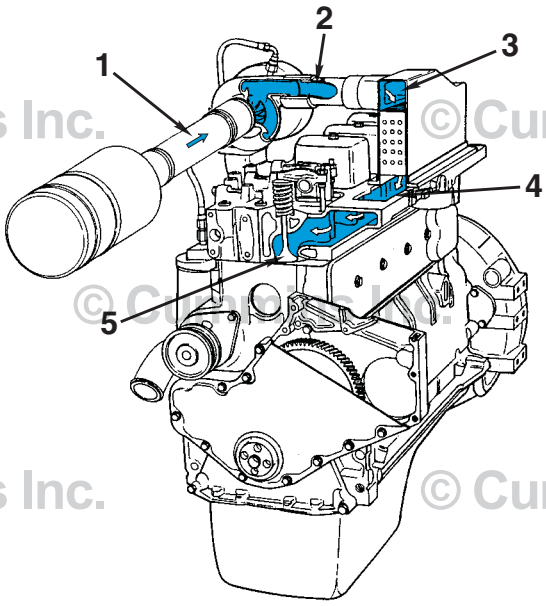
10900254

Naturally Aspirated Engine

1. Intake air inlet
2. Intake manifold
3. Intake valve.

Flow Diagram, Air Intake System

Flow Diagram



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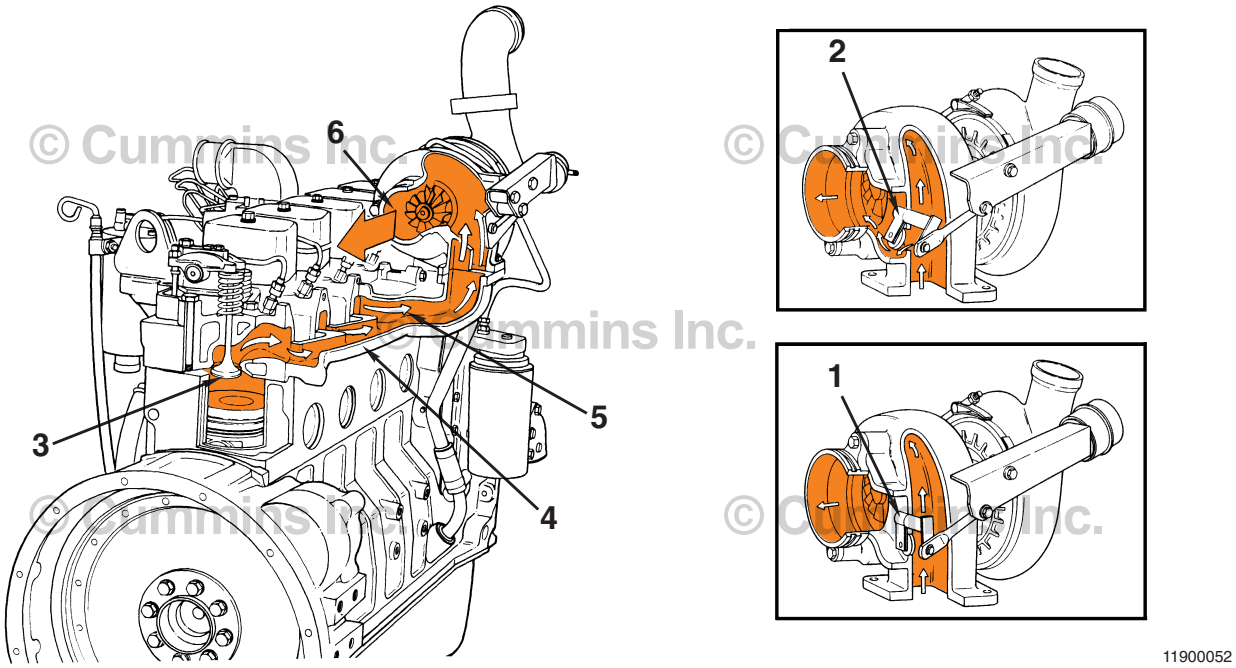
10900255

Turbocharged-Aftercooled Engine

1. Intake air inlet to turbocharger
2. Turbocharger air to aftercooler
3. Aftercooler
4. Intake manifold
5. Intake valve.

Flow Diagram, Exhaust System

Flow Diagram



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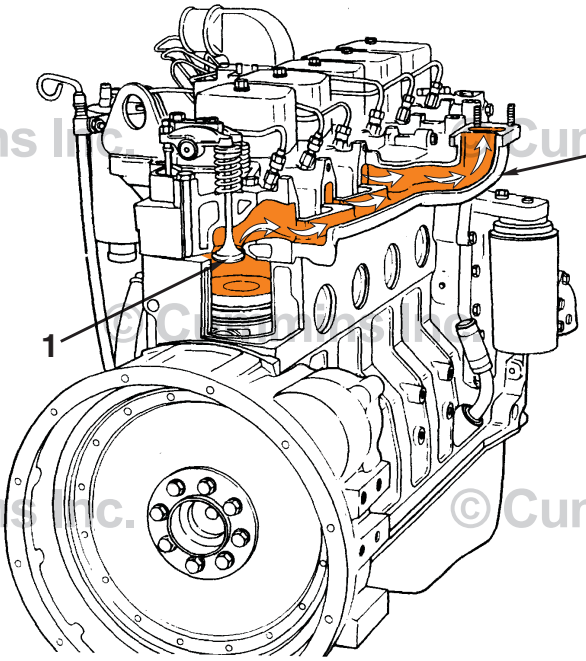
Turbocharged with Wastegate

1. Wastegate closed
2. Wastegate open
3. Exhaust valve
4. Exhaust manifold
5. Turbocharger exhaust inlet
6. Turbocharger exhaust outlet.

Flow Diagram, Exhaust System

Flow Diagram



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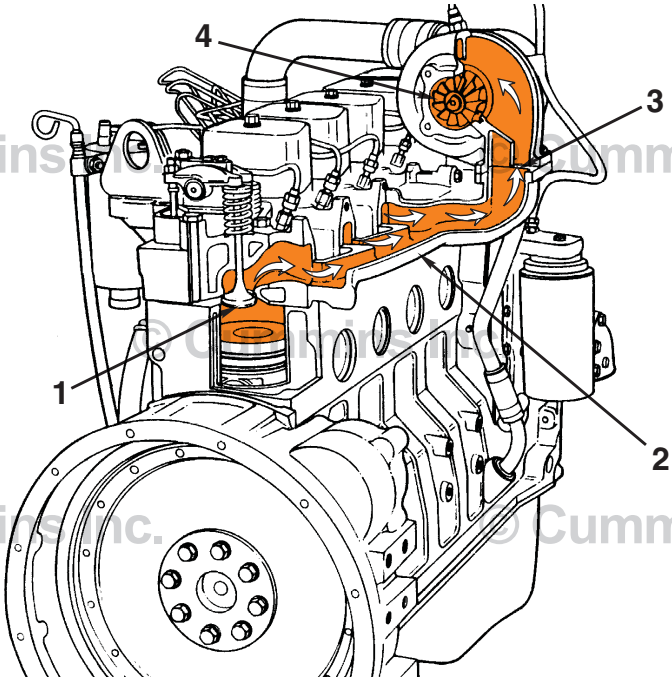
11900053

Naturally Aspirated Engine

1. Exhaust valve
2. Exhaust manifold.

Flow Diagram, Exhaust System

Flow Diagram



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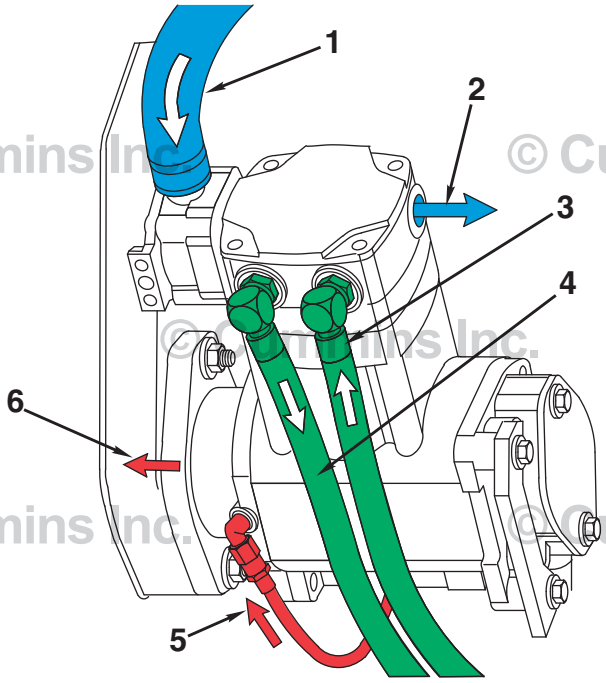
11900054

Turbocharged Engine

1. Exhaust valve
2. Exhaust manifold
3. Turbocharger exhaust inlet
4. Turbocharger exhaust outlet.

Flow Diagram, Compressed Air System

Flow Diagram



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12900030

Flow Diagram, Compressed Air System

Flow Diagram

1. Air In
2. Air Out
3. Coolant In
4. Coolant Out
5. Lubricating Oil In
6. Lubricating Oil Out Is Internal to the Gear Housing.

Notes

Section L - Service Literature

Section Contents

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Additional Service Literature

General Information

The following publications can be purchased by contacting your Cummins distributor:

Bulletin	Title of Publication
3666087	Service Manual, B3.9, B4.5, B4.5 RGT, and B5.9 Series Engines
3666109	Alternative Repair Manual, B and C Series Engines
3379000	Air For Your Engine
3666132	Coolant Requirements and Maintenance
3810340	Cummins Engine Oil Recommendations
3379001	Fuels for Cummins Engines
3379009	Operation - Cold Weather

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

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.

Notes

Section S - Service Assistance

Section Contents

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Routine Service and Parts

General Information

Personnel at Cummins Authorized Repair Locations can assist you with the correct operation and service of your system. Cummins has a worldwide service network of more than 5,000 Distributors and Dealers who have been trained to provide sound advice, expert service, and complete parts support. Check the telephone directory, refer to the directory in this section, or the Service Locator at www.cummins.com for the nearest Cummins Authorized Repair Location.

Emergency and Technical Service

General Information

The Cummins Customer Assistance Center provides a 24-hour, toll free telephone number to aid in technical and emergency service when a Cummins Authorized Repair Location can **not** be reached or is unable to resolve an issue with a Cummins product.

If additional assistance is required, call Toll-Free:

- 1-800-DIESELS
- (1-800-343-7357)
- Includes all 50 states, Bermuda, Puerto Rico, Virgin Islands, and the Bahamas.
- East Asia - Customer Assistance Center also for Chinese Domestic Market support Toll-Free:
- 400-810-5252
- Outside of North America contact your Regional Office. Telephone numbers and addresses are listed in the International Directory.

Problem Solving

General Information

Normally, any problem that arises with the sale, service, or repair of your engine can be handled by a Cummins Authorized Repair Location in your area. Refer to the telephone directory, the directory in this section, or the Service Locator at www.cummins.com for the nearest Cummins Authorized Repair Location. If the problem has **not** been handled satisfactorily, follow the steps outlined below:

- If the disagreement is with a Dealer, talk to the Cummins Distributor with whom he has his service agreement.
- If the disagreement is with a Distributor, call the nearest Cummins Division or Regional Office; however, most problems are solved below the Division or Regional office level. Telephone numbers and addresses are listed in this section. Before calling, write down the following information:
  - Engine model and serial number
  - Type and make of equipment
  - Total kilometers [miles] or hours of operation
  - Warranty start date
  - Nature of problem
  - Summary of the current problem arranged in the order of occurrence
  - Name and location of the Cummins Distributor or Dealer
- If a problem can **not** be resolved satisfactorily through your Cummins Authorized Repair Location or Division Office, contact:
  - Cummins Customer Assistance Center - 41403, Cummins Inc., Box 3005, Columbus, IN 47202-3005
  - Telephone: +1 800-diesels / +1 800-343-7357 (USA Only)

- Telephone: +1 812-377-3000 (International)

Division and Regional Offices - Locations

Australia Regional Office (This office also serves New Zealand)		Cummins Engine Company Pty. Ltd., 2 Caribbean Drive Scoresby, Victoria, 3179, Australia, Telephone: (61-3) 9765-3222, Fax: (61-3) 9763-0079
Cummins Americas Regional Office (This office serves Puerto Rico and South America excluding Brazil)		Cummins Americas Inc., 3350 SW 148 Avenue, Suite 205, Miramar, FL, 33027, U.S.A, Telephone: [1-954] 431-5511, Fax: [1-954] 433-5797
China Beijing		Cummins (China) Investment Co. Ltd, 28F, Tower A, GATEWAY, No.18, Xiaguangli North Road, East Third Ring, Chaoyang District, Beijing, 100027, China, Telephone: [86-10] 84548888, Fax: [86-10] 67876347
Brazil		Cummins Brasil Ltda., Rua Jati, 26607180-900 Guarulhos, Sao Paulo, Brazil, Phone: [55-11] 6465-9811, Fax: [55-11] 6412-1483
Daventry (Africa, Middle East, Czech Republic)		Cummins Engine Company Ltd, Royal Oak Way South, Daventry, Northants, NN11 5NU, United Kingdom, Telephone: [44-1327] 886000, Fax: [44-1327] 886106
Dubai - United Arab Emirates		Cummins Middle East FZE, Units ZF 5/6Jebel Ali Free Zone, P.O.Box No 17636, Dubai, United Arab Emirates, Telephone: [971-4] 883 8998, Fax: [971-4] 883 7971
India - Pune		Cummins India Ltd., Kothrud, Pune, Maharashtra, 411029, India, Telephone: [91-20] 2538-5435 / 0240 / 1105, Fax: [91-20] 2538-0125
Korea - Seoul		Cummins Korea Ltd., 25th floor, ASEM tower,159-1, Samsung-Dong, Kangnam-ku, Seoul, 135-798, South Korea, Telephone: [82-2] 3420-0901, Fax: [82-2] 3452-4113 / 539-6569
SLP Mexico		Cummins, S. de R.L. de C.V., Arquimedes No. 209Col., Polanco, Mexico Distrito Federal, 11560, Mexico, Telephone: [52-5] 254-3822 / 3783 / 3622, Fax: [52-5] 254-3645
Russia - Moscow		Cummins Engine Company, Inc., Park Place, Office E708, 113/1 Leninskiy Prospect, Moscow, 117198, Russia, Telephone: [7-495] 956-51-22 / 23, Fax: [7-495] 956-53-62
Singapore		Cummins Diesel Sales Corporation, 8 Tanjong Penjuru, Singapore, 609019, Singapore, Telephone: [65] 6265-0155,

Distributors and Branches - United States

Alabama	**Birmingham**	Cummins Mid-South, LLC 2200 Pinson Highway P.O. Box 1147 Birmingham, AL 35217 Telephone: (205) 841-0421 FAX: (205) 849-5926
Alabama	**Mobile**	Cummins Mid-South, LLC 1924 N. Beltline Hwy. Mobile, AL 36617 Telephone: (334) 456-2236 FAX: (334) 452-6419
Alaska	**Anchorage**	Cummins Northwest, Inc. 2618 Commercial Drive Anchorage, AK 99501-3095 Telephone: (907) 279-7594 FAX: (907) 276-6340
Arizona	**Phoenix**	Cummins Rocky Mountain, LLC 2239 N. Black Canyon Hgwy Phoenix, AZ 85009 Telephone: (602) 252-8021 FAX: (602) 253-6725
Arkansas	**Little Rock**	Cummins Mid-South, Inc. 6600 Interstate 30 Little Rock, AR 72209 Telephone: Sales: (501) 569-5600 Service: (501) 569-5656 Parts: (501) 569-5613 FAX: (501) 565-2199
California	**San Leandro**	Cummins West, Inc. 14775 Wicks Blvd. San Leandro, CA 94577-6779 Telephone: (510) 351-6101 FAX: (510) 352-3925
California	**Arcata**	Cummins West, Inc. 4751 West End Road Arcata, CA 95521 Telephone: (707) 822-7392 FAX: (707) 822-7585
California	**Bakersfield**	Cummins West, Inc. 4601 East Brundage Lane Bakersfield, CA 93307 Telephone: (805) 325-9404 FAX: (805) 861-8719
California	**Fresno**	Cummins West, Inc. 5333 N Cornelia Ave Fresno, CA 93722 Telephone: (559) 277-6760 FAX: (559) 277-6769

California	**Redding**	Cummins West, Inc. 20247 Charlanne Drive Redding, CA 96002 Telephone: (530) 222-4070 FAX: (530) 224-4075
California	**Stockton**	Cummins West, Inc. 5250 Claremont Ave Suite 204 Stockton, California 95207, USA Telephone: (209) 472-3460 FAX: (209) 472-3450
California	**West Sacramento**	Cummins West, Inc. 875 Riverside Parkway West Sacramento, CA 95605-1502 Telephone: (916) 371-0630 FAX: (916) 371-2849
California	**Los Angeles**	Cummins Cal Pacific Inc. 1939 Deere Avenue (Irvine) Irvine, CA 92606 Telephone: (949) 253-6000 FAX: (949) 253-6070
California	**Montebello**	Cummins Cal Pacific Inc. 1105 South Greenwood Avenue Montebello, CA 90640 Telephone: (323) 728-8111 FAX: (323) 889-7499
California	**Bloomington**	Cummins Cal Pacific Inc. 3061 S. Riverside Avenue Bloomington, CA 92316 Telephone: (909) 877-0433 FAX: (909) 877-3787
California	**San Diego**	Cummins Cal Pacific Inc. 310 N. Johnson Avenue El Cajon, CA 92020 Telephone: (619) 593-3093 FAX: (619) 593-0600
California	**Ventura**	Cummins Cal-Pacific Inc. 3958 Transport St. Ventura, CA 93003 Telephone: (805) 644-7281 FAX: (805) 644-7284
Colorado	**Denver**	Cummins Rocky Mountain, Inc. 8211 East 96th Ave Henderson, Colorado 80640 Telephone: (303) 287-0201 FAX: (303) 288-7080
Colorado	**Grand Junction**	Cummins Rocky Mountain, Inc. 2380 U.S. Highway 6 & 50 P.O. Box 339 Grand Junction, CO 81501 Telephone: (970) 242-5776 FAX: (970) 243-5494

Connecticut	**Rocky Hill**	Cummins Metropower, Inc. 914 Cromwell Ave. Rocky Hill, CT 06067 Telephone: (860) 529-7474 FAX: (860) 529-7524
Florida	**Ft. Myers**	Cummins Power South, LLC 2671 Edison Avenue Ft. Myers, FL 33916 Telephone: (941) 337-1211 FAX: (941) 337-5374
Florida	**Jacksonville**	Cummins Power South 755 Pickettville Rd. Jacksonville, FL 32220 Telephone: (904) 378-1902 FAX: (904) 378-1904
Florida	**Hialeah (Miami)**	Cummins Power South, LLC 9900 N.W. 77th Avenue Hialeah Gardens, FL 33016 Telephone: (305) 821-4200 FAX: (305) 557-2992
Florida	**Ocala**	Cummins Power South, LLC 321 Southwest 52nd Ave. Ocala, FL 34474-1892 Telephone: (352) 861-1122 FAX: (352) 861-1130
Florida	**Orlando**	Cummins Power South, LLC 4020 North Orange Blossom Trail Orlando, FL 32810 Telephone: (407) 298-2080 FAX: (407) 290-8727
Florida	**Tampa**	Cummins Power South, LLC 5421 N. 59th Street Tampa, FL 33610 Telephone: (813) 621-7202 FAX: (813) 621-8250
Florida		Cummins Power South, LLC 5906 Breckenridge Parkway Suite J Tampa, FL 33610 Telephone: (813) 664-5868 FAX: (813) 623-5442
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Section TS - Troubleshooting Symptoms

Section Contents

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Troubleshooting Procedures and Techniques

General Information

This guide describes some typical operating problems, their causes, and some acceptable corrections to those problems. Unless noted otherwise, the problems listed are those which an operator can diagnose and repair.

⚠ WARNING ⚠

Performing troubleshooting procedures NOT outlined in this section can result in equipmentdamage or personal injury or death. Troubleshooting must be performed by trained, experiencedtechnicians. Consult a Cummins Authorized Repair Location for diagnosis and repair beyond thatwhich is outlined, and for symptoms not listed in this section. Before beginning anytroubleshooting, refer to General Safety Instructions in Section i of this manual.

Follow the suggestions below for troubleshooting:

- Study the complaint thoroughly before acting
- Refer to the engine system diagrams
- Do the easiest and most logical things first
- Find and correct the cause of the complaint

Troubleshooting Symptoms Charts

General Information

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

⚠ WARNING ⚠

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

Air Compressor Air Pressure Rises Slowly

Cause	Correction
STEP 1 Air intake system restriction to air compressor is excessive	Replace the air compressor air cleaner (if installed). Check the air intake piping. Check engine air intake restriction if the air compressor inlet is plumbed to the vehicle or equipment intake system. Refer to Procedure 010-059 (Air Cleaner Restriction) in Section 4.

OK
Go To Next Step

STEP 2 Air system leaks	Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manuals. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.

OK
Go To Next Step

STEP 3 Carbon buildup is excessive in the air discharge line, downstream air valves, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line and cylinder head assembly if necessary. Refer to Procedure 012-015 (Air Compressor Discharge Lines) in Section 7.

OK
Go To Next Step

STEP 4
Contact a Cummins® Authorized Repair Facility

Air Compressor Cycles Frequently

Cause	Correction
STEP 1 Air system leaks	Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manuals. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.
OK Go To Next Step	
STEP 2 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. Refer to Procedure 012-015 (Air Compressor Discharge Lines) in Section 7.
OK Go To Next Step	
STEP 3 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 a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Contact a Cummins® Authorized Repair Facility	

Air Compressor Noise is Excessive

Cause	Correction
STEP 1 Carbon buildup is excessive in the air discharge line, downstream air valves, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line and cylinder head assembly if necessary. Refer to Procedure 012-015 (Air Compressor Discharge Lines) in Section 7.
OK Go To Next Step	
STEP 2 Air compressor is sending air pulses into the air tanks	Install a ping tank between the air dryer and the wet tank. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 3 Ice buildup in the air system components	For all models, check for ice in low spots of the air discharge line, dryer inlet, and elbow fittings. On Holset® models, also check the Econ valve (if equipped). Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Contact a Cummins® Authorized Repair Facility	

Air Compressor Pumping Excess Lubricating Oil into the Air System

Cause	Correction
STEP 1 Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002 (Maintenance Schedule) in Section 2.
OK Go To Next Step	
STEP 2 Air intake system restriction to air compressor is excessive	Replace the air compressor air cleaner (if installed). Check the air intake piping. Check engine air intake restriction if the air compressor inlet is plumbed to the vehicle or equipment intake system. Refer to Procedure 010-059 (Air Cleaner Restriction) in Section 4.
OK Go To Next Step	
STEP 3 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 a Cummins Authorized Repair Location.
OK Go To Next Step	
STEP 4 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. Refer to Procedure 012-015 (Air Compressor Discharge Lines) in Section 7.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

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

Cause

STEP 1
Air system leaks

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

Correction

Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manual. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.

Air Compressor Will Not Stop Pumping

Cause

STEP 1
Air system leaks

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

Correction

Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manual. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.

Alternator Not Charging or Insufficient Charging

Cause		Correction
STEP 1 Alternator pulley is loose on the shaft	.....	Tighten the pulley. Refer to OEM service manual.
OK Go To Next Step		
STEP 2 Batteries have malfunctioned	.....	Check the condition of the batteries. Replace the batteries, if necessary. Refer to OEM service manual.
OK Go To Next Step		
STEP 3 Battery cables or connections are loose, broken, or corroded (excessive resistance)	.....	Check the battery cables and connections.
OK Go To Next Step		
STEP 4 Alternator is overloaded, or alternator capacity is below specification	.....	Install an alternator with a higher capacity. Refer tothe OEM service manual.
OK Go To Next Step		
STEP 5 Alternator or voltage regulator is malfunctioning	.....	Test the alternator output. Replace the alternator or voltage regulator if necessary. Refer to the OEM service manual.
OK Go To Next Step		
STEP 6 Battery temperature is above specification	.....	Position the batteries away from heat sources. Refer to the OEM service manual.
OK Go To Next Step		
STEP 7 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.
OK Go To Next Step		
STEP 8 Vehicle gauge is malfunctioning	.....	Check the vehicle gauge. Refer to the OEM service manual.
OK Go To Next Step		
STEP 9 Contact a Cummins® Authorized Repair Facility		

Alternator Overcharging

Cause	Correction
STEP 1 Batteries have failed	Check the condition of the batteries. Replace the batteries, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 2 Voltage regulator is malfunctioning	Check the voltage regulator. Replace the voltage regulator, if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Contact a Cummins® Authorized Repair Facility	

Coolant Contamination

Cause	Correction
STEP 1 Coolant is rusty and has debris	Drain and flush the cooling system. Fill with correct mixture of antifreeze and water. Refer to Procedure 008-018 (Cooling System) in Section 7.
OK Go To Next Step	
STEP 2 Transmission oil cooler or torque converter cooler is leaking	Check the transmission oil cooler and torque converter cooler for coolant leaks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks and cracks. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Cylinder head gasket is leaking	Check the cylinder head gasket. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Coolant Loss - External

Cause	Correction
STEP 1 Coolant level is below specification	Check the coolant level. Check for an external leak. Refer to the OEM service manual. Sample the lubricating oil and have a laboratory check for coolant in the oil (internal leak).
OK Go To Next Step	
STEP 2 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. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Radiator cap is **not** correct, is malfunctioning, or has low-pressure rating	Check the radiator pressure cap. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045 (Radiator Hoses) in Section 4.
OK Go To Next Step	
STEP 5 Coolant fill line is restricted or obstructed	Check the coolant fill line for restrictions or obstructions. Refer to Procedure 008-018 (Cooling System) in Section 7.
OK Go To Next Step	
STEP 6 Coolant is rusty and has debris	Drain and flush the cooling system. Fill with correct mixture of antifreeze and water. Refer to Procedure 008-018 (Cooling System) in Section 7.
OK Go To Next Step	
STEP 7 Engine is overheating	Refer to the Coolant Temperature Above Normal - Sudden Overheat symptom tree.
OK Go To Next Step	
STEP 8 Contact a Cummins® Authorized Repair Facility	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 1 Charge air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Procedure 010-027 (Charge-Air-Cooler) in Section 4 and the OEM service manual.
OK Go To Next Step	
STEP 2 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm^2 [60 in^2] of opening at all times. Refer to Procedure 101-004 (Cold Weather Starting) in Section 1.
OK Go To Next Step	
STEP 3 Coolant level is below specification	Check the coolant level. Check for an external leak. Refer to Procedure 008-018 (Cooling System) in Section 7. Sample the lubricating oil and have a laboratory check for coolant in the oil (internal leak).
OK Go To Next Step	
STEP 4 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 the OEM service manual.
OK Go To Next Step	
STEP 5 Lubricating oil is contaminated with coolant or fuel	Refer to the Lubricating Oil Contaminated symptom tree.
OK Go To Next Step	
STEP 6 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045 (Radiator Hoses) in Section 4.
OK Go To Next Step	
STEP 7 Coolant mixture of antifreeze and water is **not** correct	Verify the concentration of antifreeze in the coolant. Add antifreeze or water to correct the concentration. Refer to Procedure 008-115 (Engine Coolant Antifreeze) in Section 5 and Procedure 018-004 (Coolant Recomendations and Specifications) in Section V.
OK Go To Next Step	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 8 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-043 (Engine Lubricating Oil Level) in Section 3. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recomendations and Specifications) in Section V.

OK
Go To Next Step

STEP 9 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.

OK
Go To Next Step

STEP 10 Fan drive belt is loose, tight, or **not** in alignment	Check the fan drive belt. Refer to Procedure 103-002 (Drive Belts) in Section 3.

OK
Go To Next Step

STEP 11 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
Go To Next Step

STEP 12
Contact a Cummins® Authorized Repair Facility

Coolant Temperature Above Normal - Sudden Overheat

Cause	Correction
STEP 1 Coolant level is below specification	Check the coolant level. Check for an external leak. Refer to Procedure 008-066 (Coolant Level) in Section 3. Sample the lubricating oil and have a laboratory check for coolant in the oil (internal leak).

OK
Go To Next Step

STEP 2 Air in the cooling system	Inspect and vent the cooling system. Refer to Procedure 008-018 (Cooling System) in Section 7.

OK
Go To Next Step

STEP 3 Fan drive belt is broken	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002 (Drive Belt, Cooling Fan) in Section A.

OK
Go To Next Step

STEP 4 Radiator cap is **not** correct, is malfunctioning, or has low-pressure rating	Check the radiator pressure cap. Refer to the OEM service manual.

OK
Go To Next Step

STEP 5 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045 (Radiator Hoses) in Section 4.

OK
Go To Next Step

STEP 6 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.

OK
Go To Next Step

STEP 7 Charge air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Procedure 010-027 (Charge-Air-Cooler) in Section 4 and the OEM service manual.

OK
Go To Next Step

STEP 8 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm^2 [60 in^2] of opening at all times. Refer to Procedure 101-004 (Cold Weather Starting) in Section 1.

OK
Go To Next Step

STEP 9
Contact a Cummins® Authorized Repair Facility

Coolant Temperature Below Normal

Cause	Correction
STEP 1 Coolant temperature gauge or sensor is malfunctioning	Test the gauge and the sensor. Repair or replace, if necessary. Refer to OEM service manual.
OK Go To Next Step	
STEP 2 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 Operation of Diesel Engines in Cold Climates, Bulletin 3379009, and Procedure 101-004 (Cold Weather Starting) in Section 1.
OK Go To Next Step	
STEP 3 Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.
OK Go To Next Step	
STEP 5 Thermostat is **not** correct or is malfunctioning	Check the thermostat for the correct part number and for correct operation. Contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 6 Contact a Cummins® Authorized Repair Facility	

Engine Acceleration or Response Poor

Cause	Correction
STEP 1 Operator technique is **not** correct	Refer to Procedure 101-999 (Operating Instructions — Overview) in Section 1.
OK Go To Next Step	
STEP 2 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 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 Go To Next Step	
STEP 4 Clutch is malfunctioning or is **not** correct	Compare the drivetrain specifications to Cummins recommendations. Check the clutch for correct operation. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Drivetrain is **not** correctly matched to the engine	Check for correct gearing and drivetrain components. Refer to the OEM vehicle specifications.
OK Go To Next Step	
STEP 6 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Intake manifold air temperature is above specification	Refer to the Intake Manifold Air Temperature Above Specification symptom tree.
OK Go To Next Step	
STEP 8 Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027 (Charge-Air-Cooler) in Section 4.
OK Go To Next Step	

Engine Acceleration or Response Poor

Cause	Correction
STEP 9 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 10 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 (Air Intake Piping) in Section 3.
OK Go To Next Step	
STEP 11 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 010-059 (Air Cleaner Restriction) in Section 4.
OK Go To Next Step	
STEP 12 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 13 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Procedure 006-015 (Fuel Filter - Spin-on) or Procedure 006-014 (Fuel Filter - Canister Type) in Section 5.
OK Go To Next Step	
STEP 14 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 15 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 16 Contact a Cummins® Authorized Repair Facility	

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

Cause	Correction
STEP 1 Starting procedure is **not** correct	Verify the correct starting procedure. Refer to Procedure 101-014 (Normal Starting Procedure) in Section 1.
OK Go To Next Step	
STEP 2 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Starting aid, if necessary for cold weather, is malfunctioning	Check for correct operation of the cold weather starting aid. Refer to Procedure 101-004 (Cold Weather Starting) in Section 1. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 4 Engine block heater is malfunctioning (if equipped)	Check the electrical sources and wiring to the cylinder block heater. Replace the block heater, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Fuel heater is malfunctioning (if equipped)	Check the fuel heater and replace, if necessary. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 6 Battery voltage is low	Check the batteries and the unswitched battery supply circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Keyswitch circuit is malfunctioning	Check the vehicle keyswitch circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 Engine cranking speed is too slow	If the cranking speed is slower than 150 rpm, refer to the Engine Will Not Crank or Cranks Slowly symptom tree.
OK Go To Next Step	
STEP 9 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 Go To Next Step	

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

Cause	Correction
STEP 10 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 11 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 12 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 010-059 (Air Cleaner Restriction) in Section 4.
OK Go To Next Step	
STEP 13 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 14 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Procedure 006-014 (Fuel Filter - Canister Type) or Procedure 006-015 (Fuel Filter - Spin-on) in Section 5.
OK Go To Next Step	
STEP 15 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 16 Fuel pump overflow valve is malfunctioning	Check the overflow valve. Replace if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 17 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	

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

Cause

STEP 18
Throttle linkage adjustment is **not** correct

Correction

Check the fuel pump throttle linkage adjustment. Refer to the OEM service manual.

OK
Go To Next Step

STEP 19
Contact a Cummins® Authorized Repair Facility

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

Cause	Correction
STEP 1 Starting procedure is **not** correct	Verify the correct starting procedure. Refer to Procedure 101-014 (Normal Starting Procedure) in Section 1.
OK Go To Next Step	
STEP 2 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 4 Fuel shutoff is malfunctioning	Check for loose wires and verify that the fuel shutoff valve is functioning. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 OEM engine protection system is malfunctioning	Isolate the OEM engine protection system. Follow the OEM service manuals to check for a malfunction.
OK Go To Next Step	
STEP 6 Battery voltage is low	Check the batteries and the unswitched battery supply circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Keyswitch circuit is malfunctioning	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	

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

Cause	Correction
STEP 9 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Procedure 006-014 (Fuel Filter - Canister Type) or Procedure 006-015 (Fuel Filter - Spin-on) in Section 5.
OK Go To Next Step	
STEP 10 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 11 Fuel pump overflow valve is malfunctioning	Check or replace the return overflow valve. Refer to the OEM service manual.
OK Go To Next Step	
STEP 12 Fuel transfer pump malfunctioning	Inspect the fuel transfer pump. Replace if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 13 Fuel drain backup	Verify the fuel return line is plumbed to the bottom of the fuel tank.
OK Go To Next Step	
STEP 14 Throttle linkage misadjusted or damaged	Adjust or repair the linkage. Refer to the OEM service manual.
OK Go To Next Step	
STEP 15 Contact a Cummins® Authorized Repair Facility	

Engine Noise Excessive

Cause	Correction
STEP 1 Fan drive belt is loose, tight, or **not** in alignment	Check the fan drive belt. Refer to Procedure 103-002 (Drive Belts) in Section 3.
OK Go To Next Step	
STEP 2 Lubricating oil is thin or diluted	Refer to Procedure 018-003 (Lubricating Oil Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 3 Vibration damper is damaged	Inspect the vibration damper. Refer to Procedure 001-051 (Vibration Damper - Rubber) or Procedure 001-052 (Vibration Damper - Viscous) in Section 7.
OK Go To Next Step	
STEP 4 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 (Air Intake Piping) in Section 3.
OK Go To Next Step	
STEP 5 Air intake or exhaust piping is contacting the chassis or cab	Inspect the air piping, chassis, and cab for contact points. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 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 010-059 (Air Cleaner Restriction) in Section 4.
OK Go To Next Step	
STEP 7 Coolant temperature is above specification	Refer to the Coolant Temperature is Above Normal - Sudden Overheat or the Coolant Temperature is Above Normal - Gradual Overheat symptom tree.
OK Go To Next Step	
STEP 8 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.
OK Go To Next Step	

Engine Noise Excessive

Cause	Correction
STEP 9 Fan clutch, hydraulic pump, or refrigerant compressor noise is excessive	Isolate each component and check for noise. Refer to the OEM service manual.
OK Go To Next Step	
STEP 10 Fan is loose, damaged, or has excessive hub bearing end play	Check the fan. Refer to Procedure 103-002 (Drive Belts) in Section 3.
OK Go To Next Step	
STEP 11 Contact a Cummins® Authorized Repair Facility	

Engine Noise Excessive — Combustion Knocks

Cause	Correction
STEP 1 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 Operations of Diesel Engines in Cold Weather, Bulletin 3379009, and Procedure 101-004 (Cold Weather Starting) in Section 1.
OK Go To Next Step	
STEP 2 Ether starting aid is malfunctioning	Repair or replace the ether starting aids. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 3 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 4 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Coolant temperature is below specification	Refer to the Coolant Temperature Below Normal symptom tree.
OK Go To Next Step	
STEP 6 Contact a Cummins® Authorized Repair Facility	

Engine Power Output Low

Cause	Correction
STEP 1 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 2 Engine is operating above recommended altitude	Engine power decreases above recommended altitude. Refer to the Engine Data Sheet for specifications.
OK Go To Next Step	
STEP 3 Tachometer is **not** calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer. Replace the tachometer as necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Intake and exhaust system restricted	Check the intake and exhaust systems for restrictions. Inspect the intake air filter and replace as necessary.
OK Go To Next Step	
STEP 5 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 010-059 (Air Cleaner Restriction) in Section 4.
OK Go To Next Step	
STEP 6 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 (Air Intake Piping) in Section 3.
OK Go To Next Step	
STEP 7 Air leak between the turbocharger and the intake manifold	Check for leaks in the air crossover tube, charge air cooler connections, hoses, or through holes in the manifold cover and repair or replace if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027 (Charge-Air-Cooler) in Section 4.
OK Go To Next Step	

Engine Power Output Low

Cause	Correction
STEP 9 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 10 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 11 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to the OEM service manual.
OK Go To Next Step	
STEP 12 Fuel return restriction excessive	Inspect the fuel return lines for restrictions. Refer to the OEM service manual.
OK Go To Next Step	
STEP 13 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 14 Fuel pump overflow valve is malfunctioning	Check the overflow valve. Replace if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 15 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 16 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 Go To Next Step	

Engine Power Output Low

Cause	Correction
STEP 17 Lubricating oil level above specification	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3 and Procedure 018-003 (Lubricating Oil Recommendations and Specifications) in Section V.

OK
Go To Next Step

STEP 18
Contact a Cummins® Authorized Repair Facility

Engine Runs Rough at Idle

Cause	Correction
STEP 1 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 Go To Next Step	
STEP 2 Idle speed is set too low for accessories	Check and adjust the low-idle screw. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Engine Runs Rough or Misfires

Cause	Correction
STEP 1 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 Go To Next Step	
STEP 2 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 4 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Engine Shuts Off Unexpectedly or Dies During Deceleration

Cause	Correction
STEP 1 Engine will **not** restart	Refer to the Engine Difficult to Start or Will Not Start symptom tree.
OK Go To Next Step	
STEP 2 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Fuel shutoff is malfunctioning	Check for loose wires and verify that the fuel shutoff valve is functioning. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 OEM engine protection system is malfunctioning	Isolate the OEM engine protection system. Follow the OEM service manuals to check for a malfunction.
OK Go To Next Step	
STEP 5 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Contact a Cummins® Authorized Repair Facility	

Engine Speed Surges at Low or High Idle

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 2 Engine idle speed is set too low	Adjust the idle speed. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to a Cummins® Authorized Repair Locaton.
OK Go To Next Step	
STEP 5 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 8 Contact a Cummins® Authorized Repair Facility	

Engine Speed Surges Under Load or in Operating Range

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 2 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Idling with excessive load	Use the PTO feature for loaded conditions at low engine speeds. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 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 Go To Next Step	
STEP 7 Clutch is malfunctioning or is **not** correct	Compare the drivetrain specifications to Cummins recommendations. Check the clutch for correct operation. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Engine Starts But Will Not Keep Running

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 2 Idle speed is set too low for accessories	Check and adjust the low-idle screw. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Engine-driven units are engaged	Disengage engine-driven units. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Fuel shutoff is malfunctioning	Check for loose wires and verify that the fuel shutoff valve is functioning. Check to be sure manual shutoff lever is in the run position. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 8 Contact a Cummins® Authorized Repair Facility	

Engine Vibration Excessive

Cause	Correction
STEP 1 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 Procedure 103-002 (Drive Belts) in Section 3.
OK Go To Next Step	
STEP 2 Air compressor pumping time is excessive	Refer to the Air Compressor Cycles Frequently symptom tree.
OK Go To Next Step	
STEP 3 Engine idle speed is set too low	Adjust the idle speed. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Fan is loose, damaged, or has excessive hub bearing end play	Check the fan. Refer to Procedure 008-040 (Fan, Cooling) in Section 3.
OK Go To Next Step	
STEP 6 Engine is misfiring	Refer to the Engine Runs Rough or Misfires symptom tree.
OK Go To Next Step	
STEP 7 Vibration damper is damaged	Inspect the vibration damper. Refer to Procedure 001-051 (Vibration Damper, Rubber) or Procedure 001-052 (Vibration Damper - Viscous) in Section 7.
OK Go To Next Step	
STEP 8 Alternator bearing worn or damaged	Clean and replace the alternator. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Engine Will Not Crank or Cranks Slowly (Air Starter)

Cause	Correction
STEP 1 Air pressure is low in the air tanks	Increase air pressure with an external air source. Refer to the OEM service manual.
OK Go To Next Step	
STEP 2 Engine-driven units are engaged	Disengage engine-driven units. Refer to the OEM Service Manual.
OK Go To Next Step	
STEP 3 Lubricating oil level above specification	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3 and Procedure 018-003 (Lubricating Oil Recommendation and Specifications) in Section V.
OK Go To Next Step	
STEP 4 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 5 Electrical system is "open" (blown fuses, broken wires, or loose connections)	Check the fuses, wires, and connections. Refer to the OEM service manual and manufacturer's wiring diagram.
OK Go To Next Step	
STEP 6 Battery charge is low	Check battery. If the battery is low, check the alternator for proper charging. Charge the battery, and replace if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Keyswitch circuit is malfunctioning	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 Starter solenoid is **not** receiving voltage	Check the battery supply to the starter solenoid. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Starting motor is malfunctioning or starting motor is **not** correct	Check the starting motor operation. Compare the starting motor with the engine and vehicle specifications. Refer to the manufacturer's instructions.
OK Go To Next Step	

Engine Will Not Crank or Cranks Slowly (Air Starter)

Cause	Correction
STEP 10	
Contact a Cummins® Authorized Repair Facility	

Engine Will Not Crank or Cranks Slowly (Electric Starter)

Cause	Correction
STEP 1 Batteries are cold	Check the battery heater. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 2 Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections.
OK Go To Next Step	
STEP 3 Electrical system is "open" (blown fuses, broken wires, or loose connections)	Check the fuses, wires, and connections. Refer to the OEM service manual and manufacturer's wiring diagram.
OK Go To Next Step	
STEP 4 Battery charge is low	Check battery. If the battery is low, check the alternator for proper charging. Charge the battery, and replace if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Keyswitch circuit is malfunctioning	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Starter solenoid is **not** receiving voltage	Check the battery supply to the starter solenoid. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Engine-driven units are engaged	Disengage engine-driven units. Refer to the OEM Service Manual.
OK Go To Next Step	
STEP 8 Lubricating oil level above specification	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3 and Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 9 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Section V.
OK Go To Next Step	

Engine Will Not Crank or Cranks Slowly (Electric Starter)

Cause	Correction
STEP 10	
Contact a Cummins® Authorized Repair Facility	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
STEP 1 Vehicle speed is too low for adequate cooling with high engine load	Reduce the engine load. Increase the engine (fan) rpm by downshifting.
OK Go To Next Step	
STEP 2 Tachometer is **not** calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer. Replace the tachometer as necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Air-fuel tube leaking, wastegate diaphragm ruptured, or wastegate plumbing damaged	Tighten the fittings, repair plumbing, replace wastegate diaphragm. Refer to the OEM service manual or a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Charge air cooler restricted (if equipped)	Inspect the air cooler for internal and external restrictions. Replace the restricted cooler if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Exhaust back pressure too high	Measure and correct if above specification. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 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 Go To Next Step	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
STEP 9 Engine power output is low	Refer to the Engine Power Outlet Low symptom tree.

OK
Go To Next Step

STEP 10
Contact a Cummins® Authorized Repair Facility

Engine Will Not Shut Off

Cause	Correction
STEP 1 Fuel shutoff is malfunctioning	Check for loose wires and verify that the fuel shutoff valve is functioning. Refer to the OEM service manual.

OK
Go To Next Step

STEP 2 Engine running on fumes drawn into the air intake	Inspect the air intake ducts. Locate and isolate the source of the fumes. Make repairs as needed. Refer to the OEM service manual.

OK
Go To Next Step

STEP 3 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks using the combustible gas detector service tool. Refer to the OEM service manual.

OK
Go To Next Step

STEP 4
Contact a Cummins® Authorized Repair Facility

Exhaust Smoke Excessive Under Load

Cause	Correction
STEP 1 Engine is being lugged down	Use lower gear.
OK Go To Next Step	
STEP 2 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe and fuel filters as necessary. Vent air from the system. Refer to Section 5.
OK Go To Next Step	
STEP 3 Air filter is restricted	Check the air filter for restrictions. Refer to Section 4.
OK Go To Next Step	
STEP 4 Intake or exhaust leak	Check intake and exhaust systems for loose or damaged piping connections and/or missing pipe plugs. Check turbocharger and exhaust manifold mounting. Refer to Section 4.
OK Go To Next Step	
STEP 5 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 Go To Next Step	
STEP 6 Air-fuel (AFC) control is leaking or obstructed	Check the AFC for leaks. Repair any leaks found, if necessary. Check and clean AFC tubing and fittings for obstructions. Refer to the OEM service manual or a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 7 Contact a Cummins® Authorized Repair Facility	

Fuel Consumption Excessive

Cause	Correction
STEP 1 Operator technique is **not** correct	Refer to Section 1, Operating Instructions.
OK Go To Next Step	
STEP 2 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Hubometer or odometer is miscalibrated	Check the hubometer and odometer calibrations. Calibrate or replace the hubometer or odometer, if necessary. Calculate fuel consumption with new mileage figures.
OK Go To Next Step	
STEP 4 Hour meter is miscalibrated	Check the hour meter. Calibrate or replace the hour meter if necessary. Calculate fuel consumption with new figures.
OK Go To Next Step	
STEP 5 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Section 3.
OK Go To Next Step	
STEP 6 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 Section 4.
OK Go To Next Step	
STEP 7 Equipment and environmental factors are affecting fuel consumption	Consider ambient temperatures, wind, tire size, axle alignment, routes, and use of aerodynamic aids when evaluating fuel consumption.
OK Go To Next Step	
STEP 8 Lubricating oil level above specification	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to Section V.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Fuel in Coolant

Cause	Correction
STEP 1 Bulk coolant supply is contaminated	Check the bulk coolant supply. Drain the coolant and replace with noncontaminated coolant. Replace the coolant filters. Refer to Section 5.

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

Fuel in the Lubricating Oil

Cause	Correction
STEP 1 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.

OK
Go To Next Step

STEP 2 Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filter(s). Refer to Section 5.

OK
Go To Next Step

STEP 3
Contact a Cummins® Authorized Repair Facility

Fuel or Lubricating Oil Leaking From Exhaust Manifold

Cause	Correction
STEP 1 Intake air restriction is high	Check the air intake system for restriction. Refer to the OEM service manual.
OK Go To Next Step	
STEP 2 Turbocharger drain line is restricted	Remove the turbocharger drain line and check for restriction. Clean or replace the drain line. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 3 Turbocharger oil seal is leaking	Check the turbocharger for oil seals and for leaks. Refer to the Turbocharger Leaks Engine Oil or Fuel Symptom tree.
OK Go To Next Step	
STEP 4 Contact a Cummins® Authorized Repair Facility	

Intake Manifold Air Temperature Above Specification

Cause	Correction
STEP 1 Charge air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Section 4 and the OEM service manual.
OK Go To Next Step	
STEP 2 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm^2 [60 in^2] of opening at all times. Refer to Section 1.
OK Go To Next Step	
STEP 3 Fan drive belt or water pump belt is broken	Check the fan drive belt and water pump belt. Replace the belts if necessary. Refer to Section A.
OK Go To Next Step	
STEP 4 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 the OEM service manual.
OK Go To Next Step	
STEP 5 Radiator shutters are **not** opening completely or the shutterstat setting is wrong	Inspect the radiator shutters. Repair or replace if necessary. Refer to the manufacturer's instructions. Check the shutterstat setting. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Vehicle speed is too low for adequate cooling with high engine load	Reduce the engine load. Increase the engine (fan) rpm by downshifting.
OK Go To Next Step	
STEP 7 Vehicle cooling system is **not** adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM vehicle specifications.
OK Go To Next Step	
STEP 8 Intake manifold temperature gauge is malfunctioning, if equipped	Test the temperature gauge. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Fan is **not** an adequate size for the application	Verify that the fan is the correct size. Refer to the engine and OEM vehicle specifications.
OK Go To Next Step	

Intake Manifold Air Temperature Above Specification

Cause	Correction
STEP 10 Contact a Cummins® Authorized Repair Facility	

Intake Manifold Pressure (Boost) is Below Normal

Cause	Correction
STEP 1 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Section 4.
OK Go To Next Step	
STEP 2 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 Section 4 and Section A.
OK Go To Next Step	
STEP 3 Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Section 4.
OK Go To Next Step	
STEP 4 Engine power output is low	Refer to the Engine Power Output Low symptom tree.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Consumption Excessive

Cause	Correction
STEP 1 Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Section 3 .
OK Go To Next Step	
STEP 2 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Section 5 . Use the oil recommended in Section V.
OK Go To Next Step	
STEP 3 Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Section 2 .
OK Go To Next Step	
STEP 4 Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to Section V for specifications.
OK Go To Next Step	
STEP 5 Verify the oil consumption rate	Check the amount of oil added versus the hours of operation.
OK Go To Next Step	
STEP 6 Air compressor is pumping lubricating oil into the air system	Check the air lines for carbon buildup and lubricating oil. Refer to a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 7 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Contaminated

Cause	Correction
STEP 1 Lubricating oil sludge is excessive	Change the oil and filters. Refer to the Lubricating Oil Sludge in the Crankcase Excessive symptom tree.
OK Go To Next Step	
STEP 2 Lubricating oil is contaminated with coolant or fuel	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 3 Fuel lift pump is malfunctioning	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filter(s). Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Loss

Cause	Correction
STEP 1 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 Go To Next Step	
STEP 2 Lubricating oil level below specification	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3.
OK Go To Next Step	
STEP 3 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 4 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 toa Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks and cracks. Refer to the OEM service manual or a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Air compressor is pumping lubricating oil into the air system	Check the air lines for carbon buildup and lubricating oil. Refer to the OEM service manual or a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Blowby excessive	Check for excessive blowby. Refer to the OEM service manual or a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Turbocharger oil seal is leaking	Check the turbocharger for oil seals and for leaks. Refer to the Turbocharger Leaks Engine Oil or Fuel symptom tree.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Pressure High

Cause		Correction
STEP 1 Coolant temperature is below specification	.....	Refer to the Coolant Temperature Below Normal symptom tree.

OK
Go To Next Step

STEP 2 Lubricating oil does **not** meet specifications for operating conditions	.....	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Section V.

OK
Go To Next Step

STEP 3 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 tothe OEM service manual.

OK
Go To Next Step

STEP 4
Contact a Cummins® Authorized Repair Facility

Lubricating Oil Pressure Low

Cause	Correction
STEP 1 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5 . Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 2 Lubricating oil is diluted with water	Check for a missing dipstick, rain caps, or oil fill caps. Change the oil. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Lubricating oil filter is plugged	Change the oil and filter. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5 . Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 4 Lubricating oil is contaminated with coolant or fuel	Refer to the Lubricating Oil Contaminated symptom tree.
OK Go To Next Step	
STEP 5 Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-043 (Lubricating Oil Level) in Section 3. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 7 Engine angularity during operation exceeds specification	Refer to the Engine Data Sheet, the OEM service manual, or a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 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 the OEM service manual.
OK Go To Next Step	

Lubricating Oil Pressure Low

Cause	Correction
STEP 9 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Sludge in the Crankcase Excessive

Cause	Correction
STEP 1 Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filter(s). Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications in Section V.

OK
Go To Next Step

STEP 2 Coolant temperature is below specification	Refer to the Coolant Temperature Below Normal symptom tree.

OK
Go To Next Step

STEP 3 Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-018 (Crankcase Breather Tube) in Section 3.

OK
Go To Next Step

STEP 4 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.

OK
Go To Next Step

STEP 5 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-002 (Lubricating Oil and Filters) in Section 5. Use the oil recommended in Procedure 018-003 (Lubricating Oil Recommendations and Specifications) in Section V.

OK
Go To Next Step

STEP 6
Contact a Cummins® Authorized Repair Facility

Smoke, Black — Excessive

Cause	Correction
STEP 1 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 010-059 (Air Cleaner Restriction) in Section 4.
OK Go To Next Step	
STEP 2 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 (Air Intake Piping) in Section 3.
OK Go To Next Step	
STEP 3 Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027 (Charge-Air-Cooler) in Section 4.
OK Go To Next Step	
STEP 4 Contact a Cummins® Authorized Repair Facility	

Smoke, White — Excessive

Cause	Correction
STEP 1 Starting procedure is **not** correct	Verify the correct starting procedure. Refer to Procedure 101-014 (Normal Starting Procedure) in Section 1.
OK Go To Next Step	
STEP 2 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 Go To Next Step	
STEP 3 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 Operating Diesel Engine in Cold Weather, Bulletin 3379009, and Procedure 101-004 (Cold Weather Starting) in Section 1.
OK Go To Next Step	
STEP 4 Starting aid is malfunctioning	Check for correct operation of cold-starting aid. Refer to Procedure 101-004 (Cold Weather Starting) in Section 1. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 5 Coolant temperature is below specification	Refer to the Coolant Temperature is Below Normal symptom tree.
OK Go To Next Step	
STEP 6 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 Procedure 018-002 (Fuel Recommendations and Specifications) in Section V.
OK Go To Next Step	
STEP 7 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 (Air Intake Piping) in Section 3.
OK Go To Next Step	
STEP 8 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 010-059 (Air Cleaner Restriction) in Section 3.
OK Go To Next Step	

Smoke, White — Excessive

Cause	Correction
STEP 9 Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027 (Charge-Air-Cooler) in Section 4.

OK
Go To Next Step

STEP 10
Contact a Cummins® Authorized Repair Facility

Turbocharger Leaks Engine Oil or Fuel

Cause	Correction
STEP 1 Engine is operating for extended periods under light or no-load conditions (slobbering)	Review the engine operating instructions. Refer to Procedure 101-999 (Operating Instructions - Overview) in Section 1.
OK Go To Next Step	
STEP 2 Lubricating oil or fuel is entering the turbocharger	Remove the intake and exhaust piping, and check for oil or fuel. Refer to Procedure 010-058 (Air Intake Piping) in Section 3.
OK Go To Next Step	
STEP 3 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 a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Turbocharger oil supply line loose or leaking	Check and tighten oil supply line fitting(s), if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Section V - Maintenance Specifications

Section Contents

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General Engine

Specifications

Horsepower.....Refer to engine dataplate
Engine Weight (Dry) Less Flywheel and Electronics
B4.5 (naturally aspirated).....326 kg [721 lb]
B4.5 and B3.9 (turbocharged).....338 kg [745 lb]
B5.9.....432 kg [952 lb]
Compression Ratio.....18:1
Bore
B3.9, B4.5, and B5.9.....102 mm [4.02 in]
Stroke
B4.5.....138 mm [5.42 in]
B3.9 and B5.9.....120 mm [4.72 in]
Displacement
B3.9.....3.9 liters [238 C.I.D.]
B4.5.....4.5 liters [275 C.I.D.]
B5.9.....5.9 liters [359 C.I.D.]
Firing Order
B3.9 and B4.5.....1-3-4-2
B5.9.....1-5-3-6-2-4
Valve Clearance
Intake.....0.25 mm [0.010 in]
Exhaust.....0.51 mm [0.020 in]
Crankshaft Rotation (viewed from the front of the engine)..... **Clockwise**

Fuel System

Specifications

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

Distributor-Type and In-Line-Type Fuel Injection Pumps

Engine Idle Speed.....700 to 1000 rpm
Maximum Fuel Inlet Restriction to Lift Pump.....14 kPa [4 in Hg]
Maximum Allowable Return Line Restriction.....69 kPa [20 in Hg]
Maximum Allowable Return Line Restriction - 4B/BT and 6B/6BT Engines.....259 kPa [10.2 in Hg]
Maximum Allowable Return Line Restriction - 4BTA Engine.....517 kPa [20.4 in Hg]
Maximum Fuel Pump Restriction 4B and 6B Engines (with clean filter).....63.5 kPa [2.5 in Hg]
Maximum Fuel Pump Restriction 4B and 6B Engines (with dirty filter).....100 kPa [4 in Hg]
Fuel Pressure Range at Fuel Filter Outlet (engine cranking).....21 to 28 kPa [3 to 4 psi]
Fuel Pressure Range at Fuel Filter Inlet (engine running at idle).....34 to 48 kPa [5 to 7 psi]
Maximum Pressure Drop across Fuel Filter.....34 kPa [5 psi]
Fuel Drain Line Maximum Restriction.....70 kPa [10 psi]
Fuel Transfer Pump Minimum Output Pressure (low flow).....37.9 kPa [5.5 psi]
Fuel Transfer Pump Minimum Output Pressure (high flow).....172 kPa [25 psi]
Minimum Fuel Injection Pump Gallery Pressure (low flow fuel transfer pump).....82.7 kPa [12 psi]
Minimum Fuel Injection Pump Gallery Pressure (high flow fuel transfer pump).....140 kPa [20 psi]
Fuel Inlet Maximum Temperature.....70°C [158°F]
Engine Minimum Cranking Speed.....110 rpm

Lubricating Oil System

Specifications

Oil Pressure
- Low Idle (minimum allowed).....69 kPa [10 psi]
- At Rated Speed (minimum allowed).....207 kPa [30 psi]

Regulated Pressure
- B3.9, B4.5, and B5.9.....345 kPa [50 psi]
- B4.5 RGT.....448 kPa [65 psi] to 517kPa [75 psi]

Oil Capacity of Standard Engine
Standard - Oil Pan Only
- B3.9 and B4.5.....9.5 liters [10 qt]
- B4.5 RGT.....11 liters [11.6 qt]
- B5.9.....14.2 liters [15 qt]

Oil Capacity of Standard Engine
Total System - Standard Oil Pan
- B3.9 and B4.5.....10.9 liters [11.5 qt]
- B4.5 RGT.....13 liters [13.7 qt]
- B5.9.....16.3 liters [17.2 qt]

Oil Capacity of Standard Engine
Oil Pan Low — High - Standard Oil Pan
- B3.9 and B4.5.....8.5 to 9.5 liters [9 to 10 qt]
- B4.5 RGT.....9 to 11 liters [9.6 to 11.6 qt]
- B5.9.....12 to 14.2 liters [13 to 15 qt]

Oil Capacity of Standard Engine
Deep Sump - Oil Pan Only
- B3.9 and B4.5.....14.5 liters [15.3 qt]
- B4.5 RGT.....16 liters [16.9 qt]
- B5.9.....24.0 liters [25.4 qt]

Oil Capacity of Standard Engine
Total System - Deep Sump Oil Pan
- B3.9 and B4.5.....15.9 liters [16.8 qt]
- B4.5 RGT.....18 liters [19.0 qt]
- B5.9.....26.1 liters [27.6 qt]

Oil Capacity of Standard Engine
Oil Pan Low — High - Deep Sump Oil Pan
- B3.9 and B4.5.....11.5 to 14.5 liters [12.1 to 15.3 qt]
- B4.5 RGT.....10 to 16 liters [10.3 to 16.9 qt]
- B5.9.....16.5 to 24.0 liters [17.4 to 25.4 qt]

NOTE: If the type/oil capacity of the oil pan in **not** known:
1. Contact a local Cummins Distributor/Dealer
2. Determine the capacity of the oil pan option for the engine being serviced by using QuickServe OnLine and the engine serial number
3. Fill the lubricating oil pan to the smallest oil pan capacity listed for the engine being serviced. Then add 0.95 liters [1 qt] of oil at a time until it reaches the high mark on the dipstick. Record the number of quarts added so that capacity is known the next time the oil is drained.

Cooling System

Specifications

Coolant Capacity (engine only)
- B3.9 and B4.5.....7.9 liters [8.3 qt]
- B4.5 RGT.....8.5 liters [8.9 qt]
- B5.9.....9.8 liters [10.4 qt]

Standard Modulating Thermostat - Range
- B3.9, B4.5 and B5.9.....82 to 93°C [180 to 199°F]
- B4.5 RGT.....88 to 97°C [190 to 207°F

Maximum Allowed Operating Temperature
- B3.9, B4.5 and B5.9.....102°C [215°F]
- B4.5 RGT.....107°C [225°F]

Minimum Recommended Operating Temperature.....71°C [160°F]
Minimum Recommended Pressure Cap.....48 kPa [7 psi]
Maximum Recommended Pressure Cap.....103 kPa [15 psi]

Air Intake System

Specifications

Maximum Intake Restriction

Clean Air Filter Element.....254 mm H_2O [10 in H_2O]
Dirty Air Filter Element.....635 mm H_2O [25.0 in H_2O]

Recommended Intake Piping Size (inner diameter)

B3.9, B4.5 and B4.5 RGT.....76 mm [3 in]
B5.9.....101.6 mm [4 in]

Exhaust System

Specifications

Maximum Back Pressure from Piping and Silencer (combined)

Hg.....76 mm Hg [3 in Hg]
H_2O.....1016 mm H_2O [40 in H_2O]

Recommended Exhaust Piping Size (inner diameter)

B3.9, B4.5 and B4.5 RGT.....76 mm [3 in]
B5.9.....101.6 mm [4 in]

Electrical System

Specifications

Minimum Recommended Battery Capacity @ −18°C [0°F]

12-VDC Starter
With Light Accessories(1)
B3.9, B4.5 and B4.5 RGT.....625 CCA
B5.9.....800 CCA
12-VDC Starter
With Heavy Accessories(2)
B3.9, B4.5 and B4.5 RGT.....800 CCA
B5.9.....950 CCA
24-VDC Starter
With Light Accessories(1)
B3.9, B4.5 and B4.5 RGT.....400 CCA
B5.9.....400 CCA
24-VDC Starter
With Heavy Accessories(2)
B3.9, B4.5 and B4.5 RGT.....400 CCA
B5.9.....475 CCA
Maximum Allowable Starting Circuit Resistance
12-VDC.....0.001 ohm
24-VDC.....0.002 ohms

1. Typical light accessories include alternator, small steering pump, and disengaged clutch.
2. Typical heavy accessories include hydraulic pump and torque converter.

Batteries (Specific Gravity)	
Specific Gravity at 27° C [80° F]	**State of Change**
1.260 to 1.280	100%
1.230 to 1.250	75%
1.200 to 1.220	50%
1.170 to 1.190	25%
1.110 to 1.130	Discharged

Cummins/Fleetguard® Filter Specifications

General Information

Fleetguard® is a subsidiary of Cummins Inc. Fleetguard® filters are developed through joint testing at Cummins and Fleetguard®. Fleetguard® filters are standard on new Cummins engines. Cummins Inc. recommends their use.

Fleetguard® products meet all Cummins Source Approval Test standards to provide the quality filtration necessary to achieve the engine's design life. If other brands are substituted, the purchaser should insist on products that the supplier has tested to meet Cummins high-quality standards.

Cummins can **not** be responsible for problems caused by nongenuine filters that do **not** meet Cummins performance or durability requirements.

Filter Part Numbers						
	Lubricating Oil Filter B3.9	**Lubricating Oil Filter B4.5**	**Lubricating Oil Filter B5.9**	**Fuel Filter B3.9**	**Fuel Filter B4.5**	**Fuel Filter B5.9**
Cummins Part Number	**3934429**	**3934429**	**3934430**	**3966139**	**3991350**	**3900632**
Fleetguard® Part Number	LF9100	LF9100	LF9098	FF9413	FS19608	FF9417

Fuel Recommendations and Specifications

Fuel Recommendations

⚠ WARNING ⚠

Do not mix gasoline, alcohol, or gasohol with diesel fuel. This mixture can cause an explosion.

⚠ CAUTION ⚠

Due to the precise tolerances of diesel injection systems, it is extremely important that the fuel be kept clean and free of dirt or water. Dirt or water in the system can cause severe damage to both the fuel pump and the fuel injectors.

Cummins Inc. recommends the use of ASTM number 2D fuel. The use of number 2 diesel fuel will result in optimum engine performance.

At operating temperatures below 0°C [32°F], acceptable performance can be obtained by using blends of number 2D and number 1D.

NOTE: Lighter fuels can reduce fuel economy.

NOTE: Engines equipped with diesel particulate filters require the use of diesel fuel with 30 ppm sulfur maximum. There are no acceptable substitutes.

The viscosity of the fuel **must** be kept above 1.3 cSt at 40°C [104°F] to provide adequate pumping and lubricating characteristics to fuel system components.

The following chart lists acceptable substitute fuels for this engine.

Acceptable Substitute Fuels									
Number 1D Diesel(1) (2) (3)	**Number 2D Diesel(3)**	**Number 1K Kerosene**	**Jet-A**	**Jet-A1**	**JP-5**	**JP-8**	**Jet-B**	**JP-4**	**CITE**
A	OK	**Not** OK	A	A	A	A	**Not** OK	**Not** OK	**Not** OK
An "A" means OK **only** if fuel lubricity is adequate. This means the BOCLE number is 3100 or greater as measured by ASTM specification D6078, Scuffing Load Ball On Cylinder Evaluator (SLBOCLE). Lubricity can also be measured by ASTM, specification D6079, ISO 12156, High Frequency Reciprocating Rig (HFRR) in which the fuel **must** have a wear scar diameter of 0.45 mm [0.02 in] or less.									
Any adjustment to compensate for reduced performance with a fuel system using alternate fuel is **not** warrantable.									
Winter blend fuels, such as found at commercial fuel-dispensing outlets, are combinations of number 1D and 2D diesel fuels and are acceptable.									

Additional information for fuel recommendations and specifications can be found in Fuel for Cummins Engines, Bulletin 3379001. See ordering information in the back of this manual.

Lubricating Oil Recommendations and Specifications

General Information

⚠CAUTION⚠

Extending the oil and filter change interval beyond the recommendations will decrease the engine life due to factors such as corrosion, deposits, and wear.

⚠CAUTION⚠

A sulfated ash limit of 1.85 percent has been placed on all engine lubricating oils recommended for use in Cummins engines. Higher ash oils can cause valve and/or piston damage and lead to excessive oil consumption.

The use of quality engine lubricating oils, combined with appropriate oil drain and filter change intervals, is a critical factor in maintaining engine performance and durability. Extending the oil and filter change interval beyond the recommendations will decrease engine life due to factors such as corrosion, deposits, and wear. Reference Procedure 102-002 in Section 2 to determine which oil drain interval to use for the application.

Cummins Inc. recommends the use of high-quality SAE 15W-40 heavy-duty engine oil, such as Valvoline® Premium Blue® (USA) or Valvoline Premium Blue Extra (International).

NOTE: The responsibility is with the owner. If recommendations are ignored, warranty could be affected.

API: American Petroleum Institue

CES: Cummins® Engineering Standard

ACEA - Association des Constructeurs European d' Association

JAMA - Japanese Automobile Manufacturerrs Association

Table 1: Cummins® Engineering Standards (CES) for Lubricants

Cummins Engineering Standard Classification (CES)	North American Classification	International Classifications	Comments
Obsolete. Do **not** use.	API CD API CE	ACEA E-1	Obsolete. Do **not** use.
	API CG-4/SH		
CES-20075[1]	API CF-4/SG	ACEA E-2	Minimum acceptable oil classification for MidRange engines, but is **not** recommended.
		ACEA E-3	
		JAMA DH-1	
CES-20071[2]	API CH-4 4/SJ	ACEA E5	Acceptable oil classification for MidRange engines.
CES-20076[2]			
CES-20077[2]			
CES-20078	API CI-4	ACEA E7	Excellent oil for MidRange engines.
CES-20081	API1 CJ-4	ACEA E9	Excellent oil for MidRange engines where ultra-low sulfur diesel fuel is used.[3]
		JAMA DH-2	

Table Notes

1 For MidRange engines, in areas where CH-4/SJ or CG-4/SH oils are **not** available, refer to the oil drain intervals in Section 2. As an alternative, oils meeting CES-20075 can be used, but the oil drain interval and filter change interval **must** be reduced by half.

2 Outside North America, where oil meeting CES-20071, CES-20076, or CES20077 might **not** be available, Cummins Inc. primary recommendation is for an oil meeting Global DHD-1, as jointly developed by EMA, ACEA, and JAMA.

3 Ultra-low sulfur diesel fuel is defined as diesel fuel **not** exceeding 0.0015 (15 ppm) mass percent sulfur content (ultra-low diesel fuel is also defined by ASTM S-15).

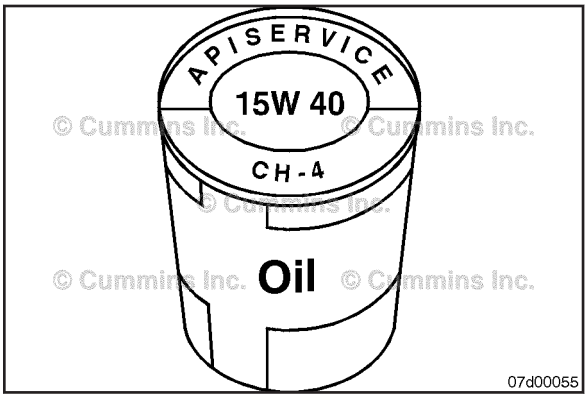
A sulfated ash limit of 1.0 mass percent is suggested for optimum valve and piston deposit and oil consumption control.

For further details and discussion of engine lubricating oils for Cummins engines, refer to Cummins Engine Oil Recommendations, Bulletin 3810340.

The API service symbols are shown in the accompanying illustration. The upper half of the symbols display the appropriate oil categories.

The lower half can contain words to describe oil energy-conserving features.

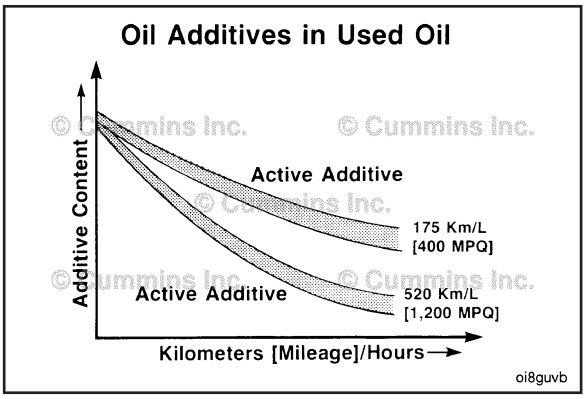
The center section identifies the SAE oil viscosity grade.



As the engine oil becomes contaminated, essential oil additives are depleted. Lubricating oils protect the engine as long as these additives are functioning properly. Progressive contamination of the oil between oil and filter change intervals is normal. The amount of contamination will vary, depending on the operation of the engine, kilometers or miles on the oil, fuel consumed, and new oil added.

Extending oil and filter change intervals beyond the recommendations will decrease engine life due to factors such as corrosion, deposits, and wear.

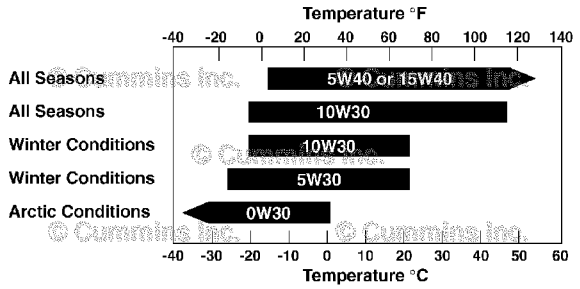
Reference the oil drain chart in this section to determine which oil drain interval to use for your application.



The primary Cummins Inc. recommendation is for the use of 15W-40 multigrade lubricating oil for normal operation at ambient temperatures above -15°C [5°F]. The use of multigrade oil reduces deposit formation, improves engine cranking in low temperature conditions, and increases engine durability by maintaining lubrication during high temperature operating conditions. Since multigrade oils have been shown to provide approximately 30 percent lower oil consumption compared with monograde oils, it is important to use multigrade oils to be certain the engine will meet applicable emissions requirements.

Use of "synthetic engine oils" (those made with API group 3 or group 4 base stocks) is permitted, subject to the same performance and viscosity limitations of petroleum (mineral) based engine oils. The same oil change intervals that are applied to petroleum (mineral) based engine oils **must** be applied to synthetic oils.

For further details and discussion of engine lubricating oils for Cummins® engines, refer to the latest revision of Cummins® Engine Oil Recommendations, Bulletin 3810340.



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While the preferred viscosity grade is 15W-40, lower viscosity multigrade oils can be used in colder climates. See the accompanying chart. Any viscosity grade lower than 15W-40 must still meet CES 20081.

Synthetic engine oils, API Group III and Group IV basestocks, are recommended for use in Cummins® engines operating in ambient temperature conditions consistently below -25°C [-13°F]. Synthetic 0W-30 oils that meet the requirements of API Group III or Group IV basestocks, can be used in operations where the ambient temperature never exceeds 0°C [32°F]. Multiviscosity oils rated 0W-30 do **not** offer the same level of protection against fuel dilution as do higher multigrade oils. Higher cylinder wear can be experienced when using 0W-30 oils in high-load situations.

As these oils have directionally thinner oil films than 15W-40 oils, top-quality Fleetguard® filters **must** be used above 20°C [70°F]. Some oil suppliers might claim better fuel economy for these oils. Cummins Inc. can neither approve nor disapprove any product **not** manufactured by Cummins Inc. These claims are between the customer and the oil supplier. Obtain a commitment from the oil supplier that the oil will give satisfactory performance in Cummins® engines, or do **not** use the oil.

New Engine Break-in Oils

Special “break-in” engine lubricating oils are **not** recommended for new or rebuilt Cummins® engines. Use the same type of oil during the break-in as is used in normal operation.

AfterMarket Oil Additive Usage

Cummins Inc. does **not** recommend the use of aftertreatment oil additives. Present high-quality fully additive engine lubricating oils are very sophisticated, with precise amounts of additives blended into the lubricating oil to meet stringent requirements. These oils meet performance characteristics that conform to the lubricant industry standards. Aftermarket lubricating oil additives are **not** necessary to enhance engine oil performance, and in some cases, can reduce the finished oil's ability to protect the engine.

Coolant Recommendations and Specifications

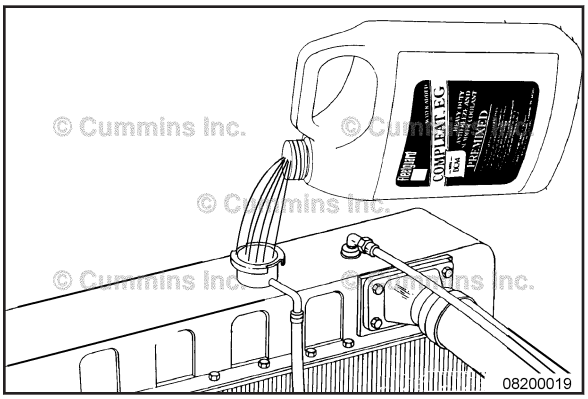
Fully Formulated Coolant/Antifreeze

Cummins Inc. recommends the use of fully formulated antifreeze/coolant meeting Cummins® Engineering Standard (C.E.S.) 14603. For further details and discussion of coolant for Cummins® engines, refer to Coolant Requirements and Maintenance, Bulletin 3666132.

Cummins Inc. recommends using either a 50/50 mixture of good-quality water and fully formulated antifreeze, or fully formulated coolant when filling the cooling system.

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

Water Quality	
Calcium Magnesium (hardness)	**Maximum 170 ppm as ($CaCO_3$ + $MgCO^3$)**
Chloride	40 ppm as (Cl)
Sulfur	100 ppm as (SO_4)



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Cummins Inc. recommends Cummins Filtration™ antifreeze coolants including Compleat ES™ containing DCA4 Plus, Fleetcool™ EX containing DCA2 Plus, and ES Optimax™ Organic Acid Technology (OAT), which meet the requirements of Cummins® Engineering Standard 14603. However, Cummins Inc., Chevron Corporation and Shell have agreed that Chevron Texaco™, Shell Rotella™ and their private label counterpart Extended Life OAT coolants, which do **not** meet the elastomer compatibility section of Cummins® Engineering Standard 14603, are acceptable for extended service interval use, assuming the initial coolant fill requirements were met from the vehicle's original equipment manufacturer (OEM).

MidRange, Heavy Duty and High Horsepower engine overhauls, or repairs involving the replacement of the following components, using this Extended Life OAT coolant, **must** discard the coolant and replace it with new coolant.

- Rocker lever housing gasket
- Lubricating oil cooler housing gasket
- Cylinder head gasket
- Thermostat housing gasket

If the replacement coolant is Chevron Texaco™, Shell Rotella™ or their private label counterpart Extended Life OAT coolants, which do **not** meet the elastomer compatibility section of Cummins® Engineering Standard 14603, the coolant **must** be treated by adding 0.24 liters [8 oz] of liquid silicate fluid for every 45.5 liters [12 gal] of total coolant system volume. It is critical to **not** overtreat the coolant with silicate fluid.

To obtain order forms or ask questions relative to ordering the silicate fluid, contact:

- Silicate Fluid Order Program
- P.O. Box 27388
- Houston, TX
- 77277-7388
- Phone: 800-346-9041
- Fax: 800-876-5317

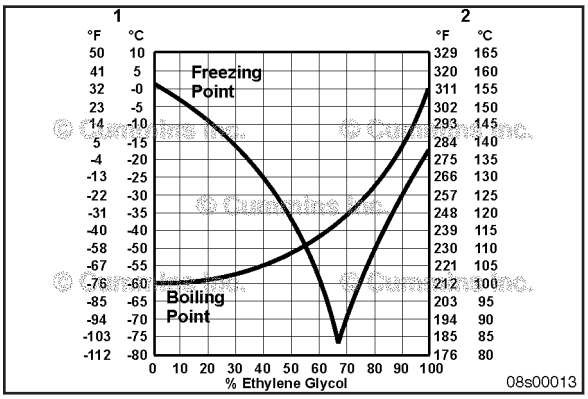
For further details and discussion of engine coolant for Cummins® engines, refer to Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.

Fully formulated antifreeze **must** be mixed with good-quality water at a 50/50 ratio (40- to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-33°F] freezing point and a 108°C [226°F] boiling point, which is adequate for locations in North America. The actual lowest freezing point of ethylene glycol antifreeze is at 68 percent. Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silica gel problem.

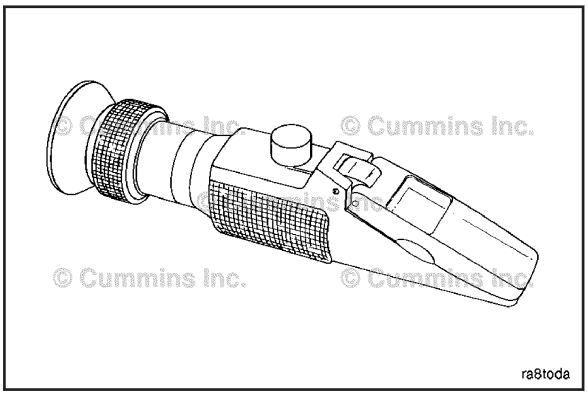
Legend

1 Freezing Point Temperature Scale

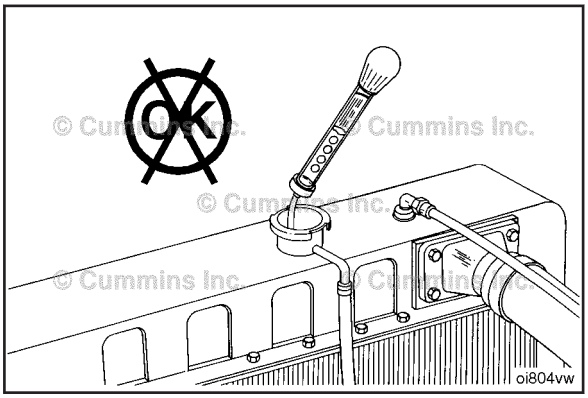
2 Boiling Point Temperature Scale



A refractometer **must** be used to measure the freezing point of the coolant accurately. Use Cummins Filtration™ refractometer, Part Number CC2800 or CC2806.



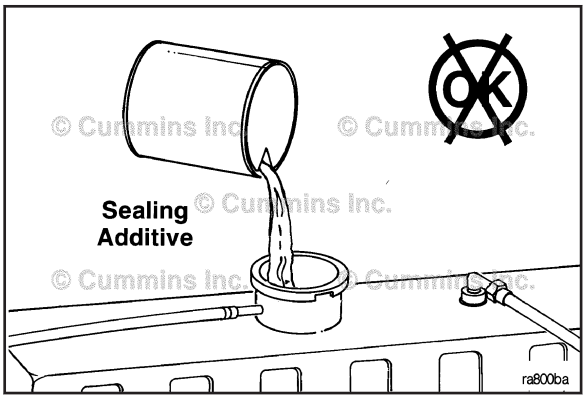
Do **not** use a floating ball hydrometer. Floating ball hydrometers can give incorrect readings.

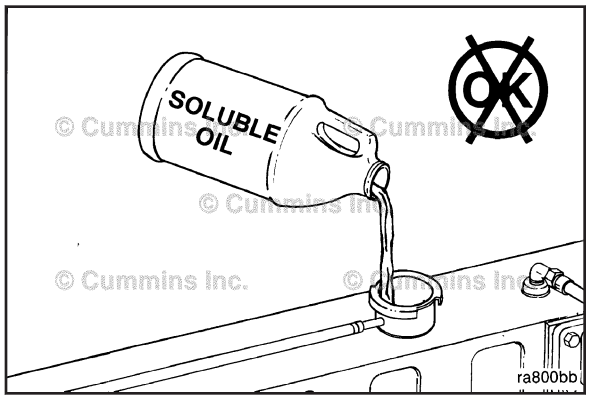


Cooling System Sealing Additives

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

- Build up in coolant low-flow areas
- Plug the radiator and oil cooler
- Possibly damage the water pump seal.





Cooling System Soluble Oils

Do **not** use soluble oils in the cooling system. The use of soluble oils will:

- Corrode brass and copper
- Damage heat transfer surfaces
- Damage seals and hoses.

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.

Engine Component Torque Values

General Information

Component	Wrench Size	N•m	ft-lb or in-lb
Aftercooler Mounting	10 mm	24	18 ft-lb
Aftercooler Water Hose Clamp	8 mm	5	44 in-lb
Alternator Link (Delco 10-15 SI)	13 mm	24	18 ft-lb
Alternator Link (Delco 20-27 SI)	3/4 in	43	32 ft-lb
Alternator Mtg. Bolt 10-15 SI	15 mm	43	32 ft-lb
Alternator Mtg. 27 SI	18 mm	77	57 ft-lb
Alternator Support (Upper)	10 mm	24	18 ft-lb
Belt Tensioner Flat Bracket	Allen 5 mm	24	18 ft-lb
Belt Tensioner Mounting	15 mm	43	32 ft-lb
Crankshaft Damper and Pulley	15 mm	137	101 ft-lb
Crossover Clamp	5/16 in	5	44 in-lb
Tee Bolt Type Clamp	11 mm	8	71 in-lb
Exhaust Outlet Pipe, V Band Clamp	7/16 in	8	71 in-lb
Fan Bracket Mounting	10 mm	24	18 ft-lb
Fan Pulley	10 mm	24	18 ft-lb
Fan Pulley	13 mm	43	32 ft-lb
Fuel Filter	75 to 85 mm	Install as specified by filter manufacturer	
Fuel Filter Adapter Nut	24 mm	32	24 ft-lb
Lubricating Oil Filter	75 to 85 mm	3/4 Turn after Contact	
Lubricating Oil Cooler Assembly	10 mm	24	18 ft-lb
Lubricating Oil Pan Drain Plug (steel)	17 mm	80	59 ft-lb
Lubricating Oil Pan Drain Plug (aluminum)	17 mm	30	22 ft-lb
Lubricating Oil Pan Heater Plug	27 mm	80	59 ft-lb
Lubricating Oil Pressure Regulator Plug	19 mm	80	59 ft-lb
Starter Mounting	10 mm	43	32 ft-lb
Thermostat Housing	10 mm	24	18 ft-lb
Water Inlet Connection	15 mm	43	32 ft-lb
Water Pump Mounting	13 mm	24	18 ft-lb
Rocker Lever Cover	15 mm	24	18 ft-lb
Water-in-Fuel Sensor	19 mm	Hand-Tighten	
Top - Load Filter Lid	10 mm	Hand-Tighten	

Sealants

General Information

Use the sealants listed below or sealants containing equivalent properties unless specified otherwise in a procedure or step.

Item Description	Sealing Method
Pipe Plugs	Precoated teflon or pipe sealer
Cup Plugs	Loctite™ 277 or 11,264
O-Rings	Lubriplate™ 105
Rear Camshaft Expansion Plug	Precoated or Loctite™ 59,241 liquid teflon
Fuel Block Mounting Studs	Loctite™ 609
Turbocharger Drain in Block	Loctite™ 277 or 11,264
Front Seal in Gear Cover	Loctite™ 277 or 11,264
Rear Seal in Rear Cover	No sealant
Oil Pan at T-Joint	Three-Bond™ 1207C (Cummins® Part Number 3823494)

Capscrew Markings and Torque Values

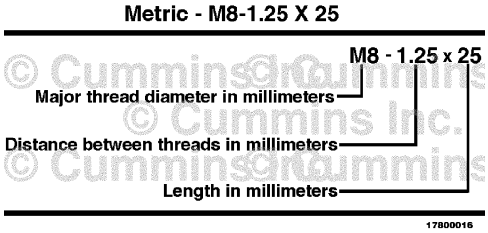
General Information

⚠CAUTION⚠

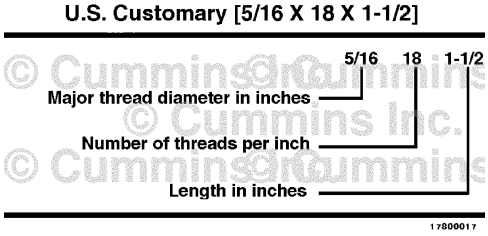
When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

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:

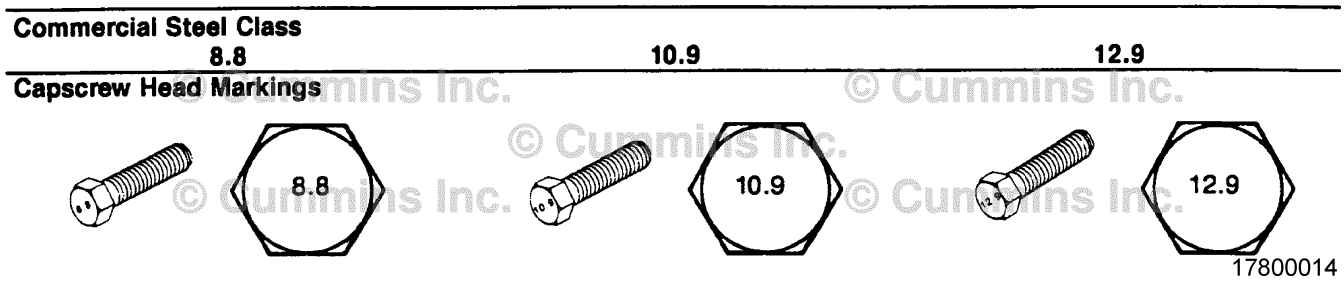


- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the 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.

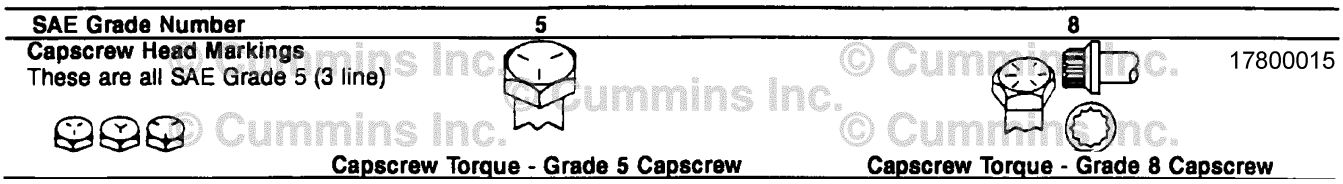
Capscrew Markings and Torque Values - Metric



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

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
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



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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

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

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.					

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

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.

Tap Size		Drill
60%	75%	Size
		48
		1.95mm
		5/64
	3-48	47
		2.00mm
	M2.5x.45	2.05mm
		46
3-48	3056	45
		2.10mm
M2.5x.45	M2.6x.45	2.15mm
3-56	4-36	44
		2.20mm
M2.6x.45		2.25mm
4-36	4-40	43
		2.30mm
		2.35mm
4-40	4-48	42
		3/32
	M3x.6	2.40mm
4-48		41
		2.45mm
		40
M3x.6	M3x.5	2.50mm
		39
	5-40	38
M3x.5		2.60mm
5-40	5-44	37
		2.70mm
5-44	6-32	36
		2.75mm
		7/64
		35
		2.80mm
		34
6-32	6-40	33
	M3.5x6	2.90mm
		32
M3.5x6		3.00mm
6-40		31
		3.10mm
		1/8
		3.20mm
	M4x.75	3.25mm
		30
	M4x.7	3.30mm
M4x.75		3.40mm
M4x.7	8-32	29
		3.50mm
	8-36	28
8-32		9/64
		3.60mm
8-36		27
		3.70mm
		26
	M4.5x.75	3.75mm
	10-24	25
		3.80mm
		24
M4.5x.75		3.90mm
		23
		5/32
10-24		22
	M5x1	4.00mm
	10-32	21
		20
	M5x.9	4.10mm
M5x1	M5x.8	4.20mm
10-32		19
M5x.9		4.25mm
M5x.8		4.30mm
		18
		11/64
		17

Tap Size		Drill
60%	75%	Size
		4.40mm
	12-24	16
		4.50mm
		15
	M5.5x.9	4.60mm
12-24	12-28	14
		13
		4.70mm
M5.5x.9		4.75mm
12-28		3/16
		12
		4.80mm
		11
		4.90mm
		10
		9
	M6x1	5.00mm
		8
		5.10mm
	1/4-20	7
		13/64
		6
M6x1		5.20mm
		5
	M6x.75	5.25mm
		5.30mm
1/4-20		4
M6x.75		5.40mm
	1/4-28	3
		5.50mm
		7/32
		5.60mm
1/4-28		2
		5.70mm
		5.75mm
		1
		5.80mm
		5.90mm
		A
		15/64
	M7x1	6.00mm
		B
		6.10mm
		C
M7x1		6.20mm
		D
	M7x.75	6.25mm
		6.30mm
		E
		1/4
M7x.75		6.40mm
		6.50mm
	5/16-18	F
		6.60mm
		G
		6.70mm
		17/64
	M8x1.25	6.75mm
5/16-18		H
		6.80mm
		6.90mm
	5.16-24	I
M8x1.25	M8x1	7.00mm
		J
		7.10mm
5/16-24		K
		9/32
M8x1		7.20mm
		7.25mm
		7.30mm
		L
		7.40mm
		M

Tap Size		Drill
60%	75%	Size
		7.50mm
		19/64
		7.60mm
		N
		7.70mm
	M9x1.25	7.75mm
		7.80mm
		7.90mm
	3/8-16	5/16
M9x1.25	M9x1	8.00mm
		O
		8.10mm
M9x1		8.20mm
		P
		8.25mm
		8.30mm
3/8-16	1/8-27NPT	21/64
		8.40mm
	3/8-24	Q
	M10x1.5	8.50mm
		8.60mm
		R
3/8-24		8.70mm
1/8-27NPT		11/32
	M10x1.25	8.75mm
M10x1.5		8.80mm
		S
		8.90mm
M10x1.25	M10x1	9.00mm
		T
		9.10mm
		23/64
M10x1		9.20mm
		9.30mm
	7/16-14	U
		9.40mm
	M11x1.5	9.50mm
		3/8
		V
		9.60mm
		9.70mm
		9.75mm
M11x1.5		9.80mm
7/16-14		W
		9.90mm
	7/16-20	25/64
		10.00mm
7/16-20		X
	M12x1.75	10.20mm
		Y
		13/32
M12x1.75	M12x1.5	Z
	1/2-13	10.50mm
M12x1.5	M12x1.25	27/64
M12x1.25		10.75mm
1/2-13		11.00mm
1/4-18NPT		7/16
		11.25mm
		11.50mm
		29/64
		11.75mm
		11.50mm
	1/2-20	29/64
	9/16-12	15/32
	M14x2	12.00m
		12.25mm
9/16-12		31/64
M14x2	M14x1.5	12.50mm
	9/16-18	1/2
M14x1.5	M14x1.25	12.75mm
M14x1.25		13.00mm
9/16-18		33/64

Tap Size		Drill
60%	75%	Size
		13.25mm
	5/8-11	17/32
	M15x1.5	13.50mm
M15x1.5		13.75mm
5/8-11		35/64
	M16x2	14.00mm
		14.25mm
	5/8-18	9/16
M16x2	M16x1.5	14.50mm
5/8-18		37/64
		14.75mm
M16x1.5		15.00mm
		19.32
		15.25mm
		39/64
	M17x1.5	15.50mm
M17x1.5	M18x2.5	15.75mm
		5/8
M18x2.5	M18x2	16.00mm
M18x2		16.25mm
3/4-10		41/64
M18x1.5		16.50mm
3/4-10	M19x2.5	21/32
M18x1.5		16.75mm
M19x2.5		17.00mm
		43/64
		17.25mm
3/4-16	3/4-16	11/16
	M20x2.5	17.50mm
		17.75mm
		45/64
M20x2.5	M20x2	18.00mm
M20x2		18.25mm
		23/32
	M20x1.5	18.50mm
		47/64
M20x1.5		18.75mm
		19.00mm
		3/4
		19.25mm
	7/8-9	49/64
	M22x2.5	19.50mm
7/8-9		25/32
		19.75mm
M22x2.5	M22x2	20.00mm
	7/8-14	51/64
M22x2		20.25mm
	M22x1.5	20.50mm
7/8-14		13/16
		20.75mm
M22x1.5	M24x3	21.00mm
		53/64
		21/25mm
		27/32
M24x3		21.50mm
		21.75mm
		55/64
	M24x2	22.00mm
	1"-8	7/8
M24x2		22.25mm
	M24x1.5	22.50mm
1"-8		57/64
M24x1.5		22.75mm
	M25x2	23.00mm
	1"-12	29/32
M25x2		23.25mm
1"x12	1"-14	59/64
	M25x1.5	23.50mm
M20x1.5		23.75mm
1"-14		15/16

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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

Section W - Warranty

Section Contents

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All Engines United States And Canada Industrial (Off-Highway)

Coverage

Products Warranted

This Warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in Industrial (Off-Highway) applications in the United States* and Canada, except for Engines used in marine, generator drive and certain defense applications, for which different Warranty Coverage is provided.

Base Engine Warranty

This Warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failures).

Coverage begins with the sale of the Engine by Cummins. Coverage continues for two years or 2,000 hours of operation, whichever occurs first, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first. If the 2,000 hour limit is exceeded during the first year, Coverage continues until the end of the first year.

Engine aftertreatment components included in the Cummins Critical Parts List (CPL) and marked with a Cummins part number are covered under Base Engine Warranty.

Additional Coverage is outlined in the Emission Warranty section.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts).

Bushing and bearing failures are not covered.

This Coverage begins with the expiration of the Base Engine Warranty and ends three years or 10,000 (3,000 hours for A Series Engines) hours of operation from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or from when the Engine has been operated for 50 hours, whichever occurs first.

Consumer Products

The Warranty on Consumer Products in the United States* is a LIMITED Warranty. **CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied Warranties applicable to Consumer Products in the United States* terminate concurrently with the expiration of the express Warranties applicable to the product. In the United States*, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied Warranty lasts, so the limitations or exclusions herein may not apply to you.

These Warranties are made to all Owners in the chain of distribution and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins Responsibilities

During The Base Engine Warranty

Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure.

Cummins will pay for the lubricating oil, antifreeze, filter elements and other maintenance items that are not reusable due to the Warrantable Failure.

Cummins will pay reasonable costs for mechanics to travel to and from the equipment site, including meals, mileage and lodging, when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During The Extended Major Components Warranty

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner Responsibilities

During The Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items provided during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

During The Extended Major Components Warranty

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor to remove and reinstall the Engine. When Cummins elects to repair a part instead of replacing it, Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During The Base Engine And Extended Major Components Warranties
Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable Warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the Engine available for repair by such facility. Service locations are listed on the Cummins Worldwide Service Locator at cummins.com.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin #3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:	
EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil, fuel or diesel exhaust fluid or by water, dirt or other contaminants in the fuel, oil or diesel exhaust fluid.

For power units and fire pumps (package units), this Warranty applies to accessories, except for clutches and filters, supplied by Cummins which bear the name of another company.

For all other Industrial engines (except those previously mentioned), this Warranty does not apply to accessories which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans**, air conditioning compressors, clutches, filters, transmissions, torque converters, steering pumps, and non-Cummins fan drives, Engine compression brakes and air compressors.

Cummins Compusave units are covered by a separate Warranty.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failures of belts and hoses supplied by Cummins are not covered beyond the first 500 hours or one year of operation, whichever occurs first.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins approved rebuilt parts or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining Coverage hereunder.

For all A Series Applications, including Industrial, travel reimbursement for non-transportable equipment will be limited to 4.0 hours, $0.25/mile and 250 miles maximum. Any costs beyond this limit are the customer's responsibility.

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Emission Warranty

Products Warranted

This Emission Warranty applies to new Engines marketed by Cummins that are used in the United States* and Canada in vehicles designed for Industrial Off-Highway use. This Warranty applies to Engines delivered to the ultimate purchaser on or after April 1, 1999, for Engines up to 750 horsepower and on or after January 1, 2000, for Engines 751 horsepower and over.

Coverage

Cummins warrants to the ultimate purchaser and each subsequent purchaser that the Engine is designed, built and equipped so as to conform at the time of sale by Cummins with all U.S. Federal emission regulations applicable at the time of manufacture and that it is free from defects in workmanship or material which would cause it not to meet these regulations within the longer of the following periods: (A) ***Five years or 3,000 hours of operation for industrial applications, five years or 3,500 hours of operation for industrial spark-ignited Engines (GTA855, G855, G5.9C, G8.3-C, GTA8.9E, QSK19G) and five years or 2,500 hours of operation for industrial spark-ignited Engines (GKTA19-GC), whichever occurs first, as measured from the date of delivery of the Engine to the ultimate purchaser, or (B) The Base Engine Warranty.

If the vehicle in which the Engine is installed is registered in the state of California, a separate California Emission Warranty also applies.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin #3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:	
EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Failures, other than those resulting from defects in materials or workmanship, are not covered by this Warranty.

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolant or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil, fuel or diesel exhaust fluid or by water, dirt or other contaminants in the fuel, oil or diesel exhaust fluid.

Cummins is not responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all business costs or other losses resulting from a Warrantable Failure.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

* United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico and the U.S. Virgin Islands.

** Alternators, starters, and fans ARE covered for the duration of the Base Engine Warranty on A Series and B3.3 Engines.

** Alternators and starters are covered for the duration of the Base Engine Warranty on QSK23 Engines.

*** Emissions Warranty for BLPG Industrial Off-Highway Engines is 5 years / 3,500 hours.

All Engines International Industrial (Off-Highway)

Coverage

Products Warranted

This Warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in Industrial (Off-Highway) applications anywhere in the world where Cummins approved service is available, except the United States and Canada. Different Warranty Coverage is provided for Engines used in marine, generator drive and certain defense applications.

Base Engine Warranty

This Warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failure).

Coverage begins with the sale of the Engine by Cummins. Coverage continues for two years or 2,000 hours of operation, whichever occurs first, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first. If the 2,000 hour limit is exceeded during the first year, Coverage continues until the end of the first year.

Engine aftertreatment components included in the Cummins Critical Parts List (CPL) and marked with a Cummins part number are covered under Base Engine Warranty.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts).

Bushing and bearing failures are not covered.

This Coverage begins with the expiration of the Base Engine Warranty and ends three years or 10,000 hours (3,000 hours for A Series Engines) of operation, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first.

These Warranties are made to all Owners in the chain of distribution, and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins Responsibilities

During The Base Engine Warranty

Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure.

Cummins will pay for the lubricating oil, antifreeze, filter elements and other maintenance items that are not reusable due to a Warrantable Failure.

Cummins will pay reasonable costs for mechanics to travel to and from the equipment site, including meals, mileage and lodging, when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During The Extended Major Components Warranty

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner Responsibilities

During The Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

During The Extended Major Components Warranty

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor to remove and reinstall the Engine. When Cummins elects to repair a part instead of replacing it, Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During The Base Engine Warranty And Extended Major Components Warranties

Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable Warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the product available for repair by such facility. Service locations are listed in the Cummins Worldwide Service Locator at cummins.com.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin #3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:	
EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil, fuel or diesel exhaust fluid or by water, dirt or other contaminants in the fuel, oil or diesel exhaust fluid.

For power units and fire pumps (package units) the Warranty applies to accessories, except for clutches and filters supplied by Cummins which bear the name of another company.

Except for the accessories noted previously, Cummins does not warrant accessories which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans*, air conditioning compressors, clutches, filters, transmissions, torque converters, steering pumps, non-Cummins fan drives and air cleaners.

Cummins Compusave units are covered by a separate Warranty.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failures of belts and hoses supplied by Cummins are not covered beyond the first 500 hours or one year of operation, whichever occurs first.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins approved rebuilt parts or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining Coverage hereunder.

For all A Series Applications, including Industrial, travel reimbursement for non-transportable equipment will be limited to 4.0 hours, $0.25/mile and 250 miles maximum. Any costs beyond this limit are the customer's responsibility.

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In the case of consumer sales, in some countries, the Owner has statutory rights which cannot be affected or limited by the terms of this Warranty.

Nothing in this Warranty excludes or restricts any contractual rights the Owner may have against third parties.

* Alternators, starters, and fans ARE covered for the duration of the Base Engine Warranty on A Series and B3.3 Engines.

* Alternators and starters are covered for the duration of the Base Engine Warranty on QSK23 Engines.

California Emission Control System Warranty, Off-Highway

Products Warranted

This Emission Control System Warranty applies to off-road diesel engines certified with the California Air Resources Board beginning with the year 1996 for engines up to 750 horsepower, beginning with the year 2000 for 751 horsepower and over, marketed by Cummins, and registered in California for use in industrial off-highway applications.

Your Warranty Rights and Obligations

The California Air Resources Board and Cummins Engine Company, Inc., are pleased to explain the emission control system warranty on your engine. In California, new off-road diesel engines must be designed, built and equipped to meet the State's stringent anti-smog standards. Cummins must warrant the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel injection system and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Cummins will repair your off-road diesel engine at no cost to you including diagnosis, parts and labor.

Manufacturer's Warranty Coverage

This warranty coverage is provided for 5 years or 3,000 hours of engine operation, whichever first occurs from the date of delivery of the engine to the first user. If any emission-related part on your engine is defective, the part will be repaired or replaced by Cummins.

Coverage

This emission control system warranty applies only to the following A series, B3.3, B3.9, B4.5^{S}, B5.9, B6.7^{S}, QSB3.9-30, QSB4.5-30, QSB5.9-30, QSB5.9-44, C8.3, QSC8.3, and QSL9 emission control parts:

Fuel Pump	Intake Manifold
Static Timing	Charge Air Cooler
Delivery Valve	Aftercooler
Injection Control Valve Module	
	Exhaust Manifold
Injectors	
Calibration	Oxidation Catalyst
Needle	
Nozzle	Electronic Control System
Spring	Control Module
	Boost Pressure Sensor
Turbocharger	Coolant Temperature Sensor
Compressor Wheel	Fuel Pressure Sensor
Turbine Wheel	
Turbine Oil Seal	
Wastegate Valve	

Owner's Warranty Responsibilities

As the off-road diesel engine owner, you are responsible for the performance of the required maintenance listed in your Cummins Operation and Maintenance Manual. Cummins recommends that you retain all receipts covering maintenance on your off-road diesel engine, but Cummins cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.

You are responsible for presenting your off-road diesel engine to a Cummins dealer as soon as a problem exists. The warranty repairs should be completed in a reasonable amount of time, not to exceed 30 days.

As the off-road diesel engine owner, you should also be aware that Cummins may deny you warranty coverage if your off-road diesel engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.

If you have any questions regarding your warranty rights and responsibilities, you should contact Cummins Customer Assistance Department at 1-800-343-7357 (1-800-DIESELS) or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731.

Prior to the expiration of the applicable warranty, Owner must give notice of any warranted emission control failure to a Cummins distributor, authorized dealer or other repair location approved by Cummins and deliver the engine to such facility for repair. Repair locations are listed in Cummins United States and Canada Service Directory.

Owner is responsible for incidental costs such as: communication expenses, meals, lodging incurred by Owner or employees of Owner as a result of a warrantable failure.

Owner is responsible for business costs and losses, "downtime" expenses, and cargo damage resulting from a warrantable failure. CUMMINS IS NOT RESPONSIBLE FOR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCIDENTAL OR CONSEQUENTIAL DAMAGES INCLUDE BUT ARE NOT LIMITED TO FINES, THEFT, VANDALISM OR COLLISIONS.

Replacement Parts

Cummins recommends that any service parts used for maintenance, repair or replacement of emission control systems be new, genuine Cummins or Cummins approved rebuilt parts and assemblies, and that the engine be serviced by a Cummins distributor, authorized dealer or the repair location approved by Cummins. The owner may elect to have maintenance, replacement or repair of the emission control parts performed by a facility other than a Cummins distributor, an authorized dealer or a repair location approved by Cummins, and may elect to use parts other than new genuine Cummins or Cummins approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts will not be covered under this emission control system warranty.

Cummins Responsibilities

Repairs and service will be performed by any Cummins distributor, authorized dealer or other repair location approved by Cummins using new, genuine Cummins or Cummins approved rebuilt parts and assemblies. Cummins will repair any of the emission control parts found by Cummins to be defective without charge for parts or labor (including diagnosis which results in determination that there has been a failure of a warranted emission control part).

Emergency Repairs

In the case of an emergency where a Cummins distributor, authorized dealer, or other repair location approved by Cummins is not available, repairs may be performed by any available repair location using any replacement parts. Cummins will reimburse the Owner for expenses (including diagnosis), not to exceed the manufacturer's suggested retail price for all warranted parts replaced and labor charges based on the manufacturer's recommended time allowance for the warranty repair and the geographically appropriate hourly labor rate. A part not being available within 30 days or a repair not being complete within 30 days constitutes an emergency. Replaced parts and paid invoices must be presented at a Cummins authorized repair facility as a condition of reimbursement for emergency repairs not performed by a Cummins distributor, authorized dealer, or other repair location approved by Cummins.

Warranty Limitations

Cummins is not responsible for failures resulting from Owner or operator abuse or neglect, such as: operation without adequate coolant, fuel or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or air intake systems; improper storage, starting, warm-up, run-in or shutdown practices.

The manufacturer warrants to the ultimate purchaser and each subsequent purchaser that the engine is designed, built, and equipped so as to conform with all applicable regulations adopted by the Air Resources Board, and that it is free from defects in materials and workmanship which cause the failure of a warranted part.

Any warranted part which is not scheduled for replacement as required maintenance, or which is scheduled only for regular inspection to the effect of "repair or replace as necessary" is warranted for the warranty period.

Any warranted part which is scheduled for replacement as required maintenance is warranted for the period of time prior to the first scheduled replacement point for that part.

The owner will not be charged for diagnostic labor which leads to the determination that a warranted part is defective, if the diagnostic work is performed at a warranty station.

The manufacturer is liable for damages to other engine components caused by the failure under warranty of any warranted part.

Cummins is not responsible for failures resulting from improper repair or the use of parts which are not genuine Cummins or Cummins approved parts.

These warranties, together with the express commercial warranties and emission warranty are the sole warranties of Cummins. There are no other warranties, express or implied, or of merchantability or fitness for a particular purpose.

Notes

NOTES

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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