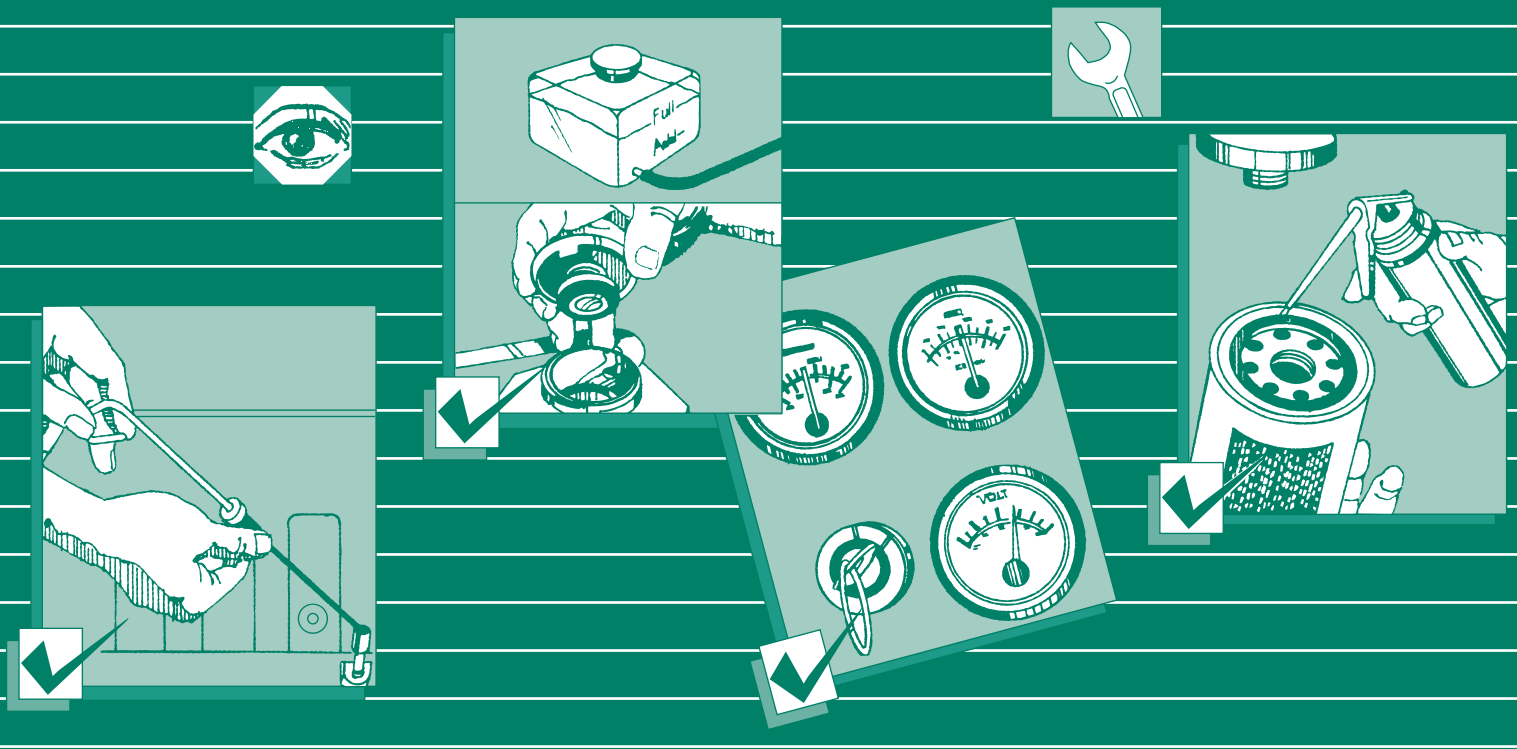
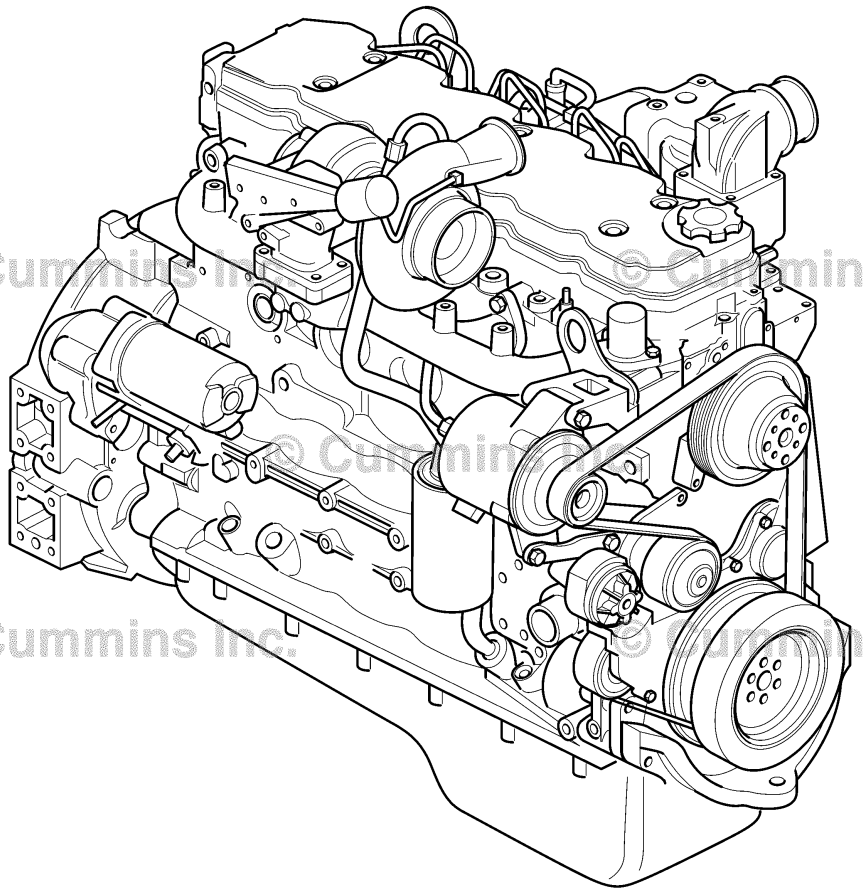
Operation and Maintenance Manual
QSB4.5 and QSB6.7 Engine



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

Operation and Maintenance Manual
QSB4.5 and QSB6.7 Engine



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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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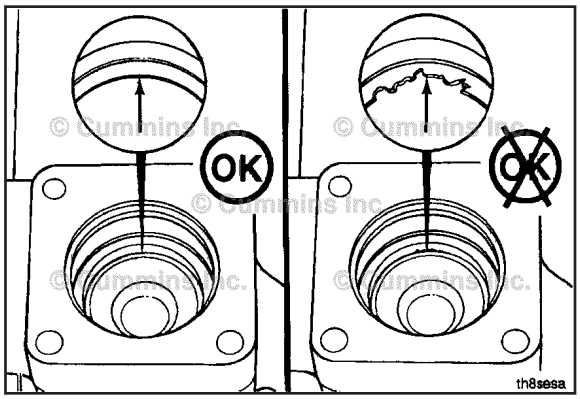
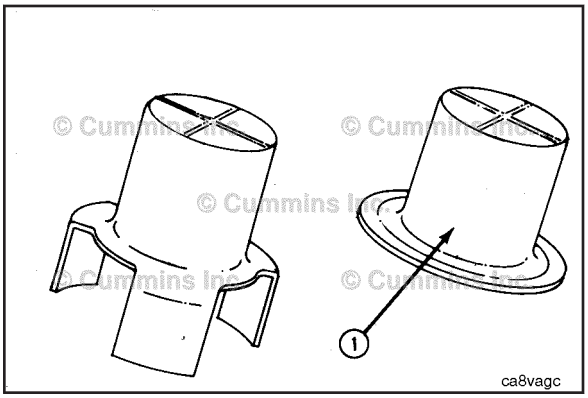
Illustrations

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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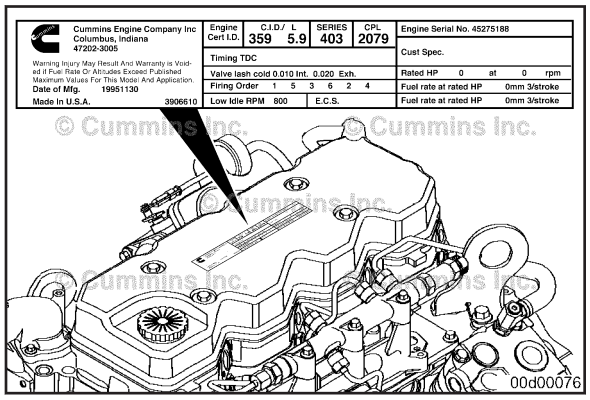
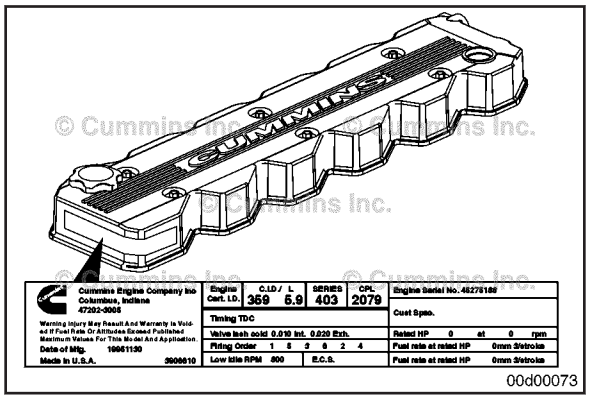
Engine Identification

Engine Dataplate

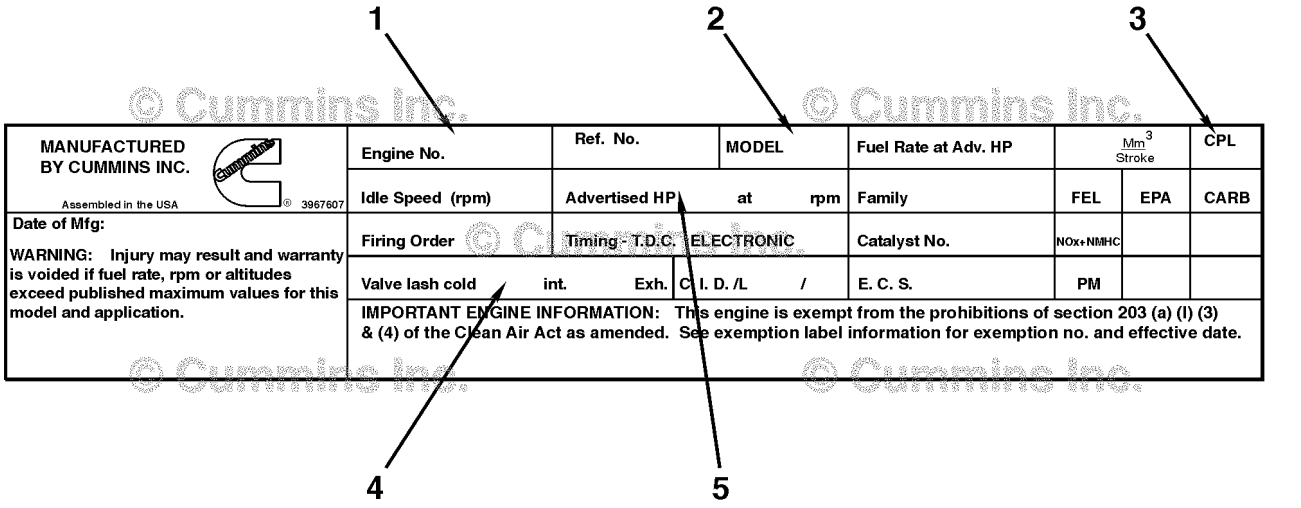




The engine dataplate provides important information about the engine. The engine serial number (ESN) and control part list (CPL) provide information for service and for ordering parts. The engine dataplate **must not** be changed unless approved by Cummins Inc.

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.

NOTE: The engines covered by this manual are produced worldwide. The dataplates used on engines may differ in appearance and location of information. The following illustrations show examples of common dataplates used and the information contained on the dataplate.



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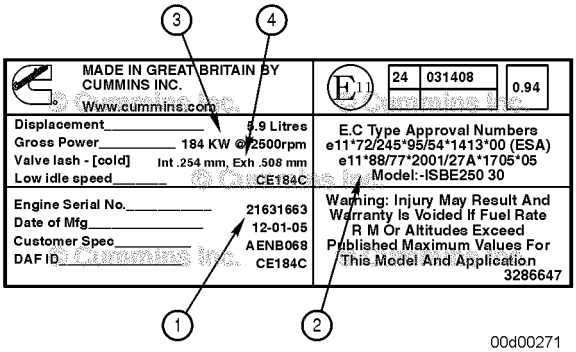
1 Engine serial number
2 Engine model information
3 Control parts list (CPL)
4 Valve lash (overhead) setting
5 Horsepower and rpm rating.



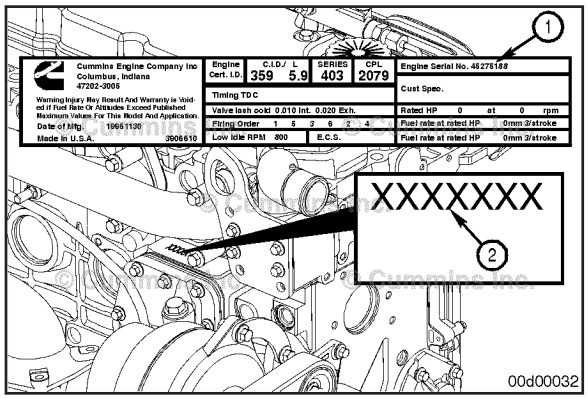
1 Engine serial number

2 Engine model information

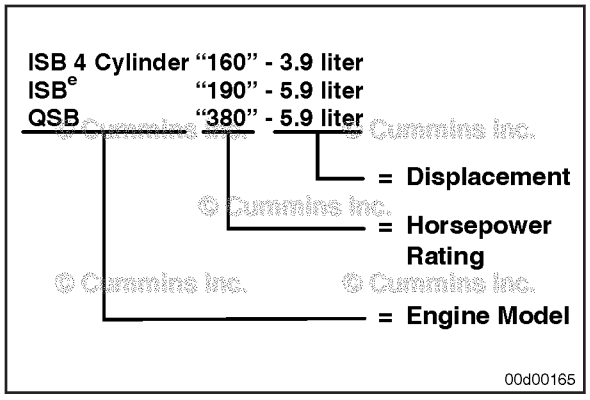
3 Horsepower and rpm rating

4 Valve lash (overhead) setting.

NOTE: Depending on the manufacturing plant, calibration data may also be found on the engine dataplate.



NOTE: If the engine dataplate (1) is **not** legible, the engine serial number (2) can be found on the engine block, on top of the lubricating oil cooler housing. Additional engine information can be found on the electronic control module (ECM) dataplate.



Cummins® Engine Nomenclature

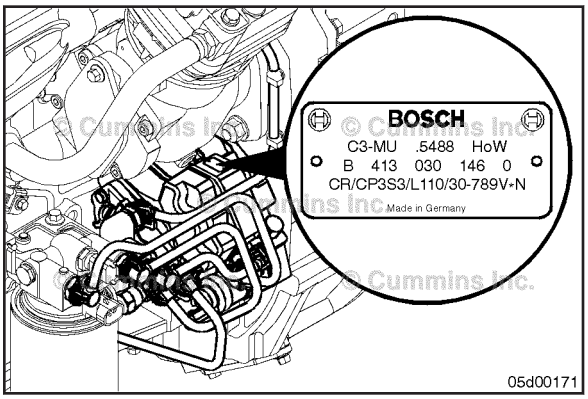
The Cummins® engine nomenclature provides the data as shown in the illustration.

Fuel Injection Pump Dataplate

The Bosch™ fuel injection pump dataplate is located on the fuel pump.

The dataplate contains the following information to assist in servicing or replacement:

- Pump serial number
- Cummins® part number
- Factory code
- Bosch™ part number
- Date code.



ECM Dataplate

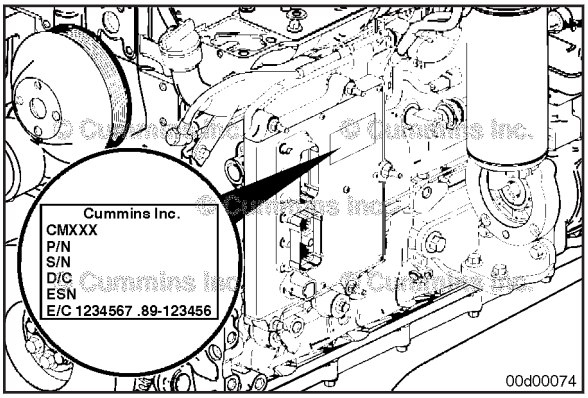
The electronic control module (ECM) dataplate shows information about the ECM and how the ECM was programmed. The dataplate is located on the ECM.

The following information is available on the ECM dataplate:

- ECM part number (PN)
- ECM serial number (SN)
- ECM date code (DC)
- Engine serial number (ESN)
- ECM code: Identifies the software in the ECM.

NOTE: Have the ECM code for the engine available when communicating with a Cummins® Authorized Repair Location.

NOTE: The presence of an ECM dataplate depends on the manufacturing plant and the date the engine was manufactured. If an ECM dataplate was **not** installed by the manufacturing plant, calibraton data can be found on the engine dataplate.

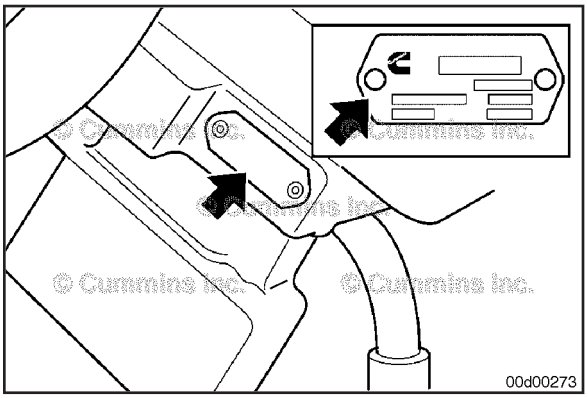


Air Compressor

NOTE: Not all engines are equipped with an air compressor.

The Cummins® branded air compressor dataplate, identified by the Cummins Inc. logo, is typically located on the side of the air compressor. The dataplate contains the following information to assist in servicing or replacement:

- Cummins® part number
- Serial number
- Date code.



Engine Diagrams

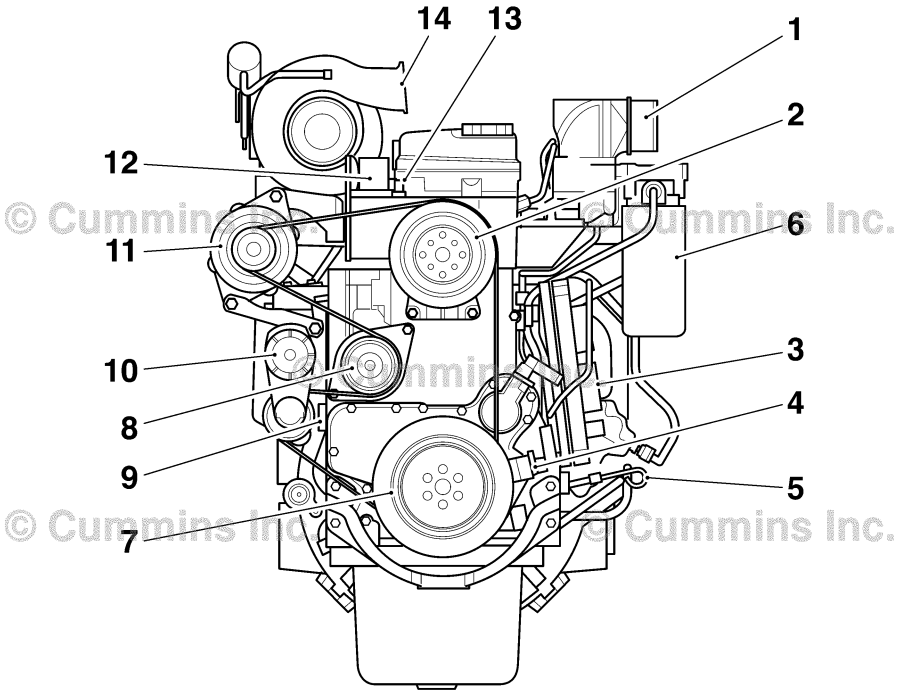
Engine Views

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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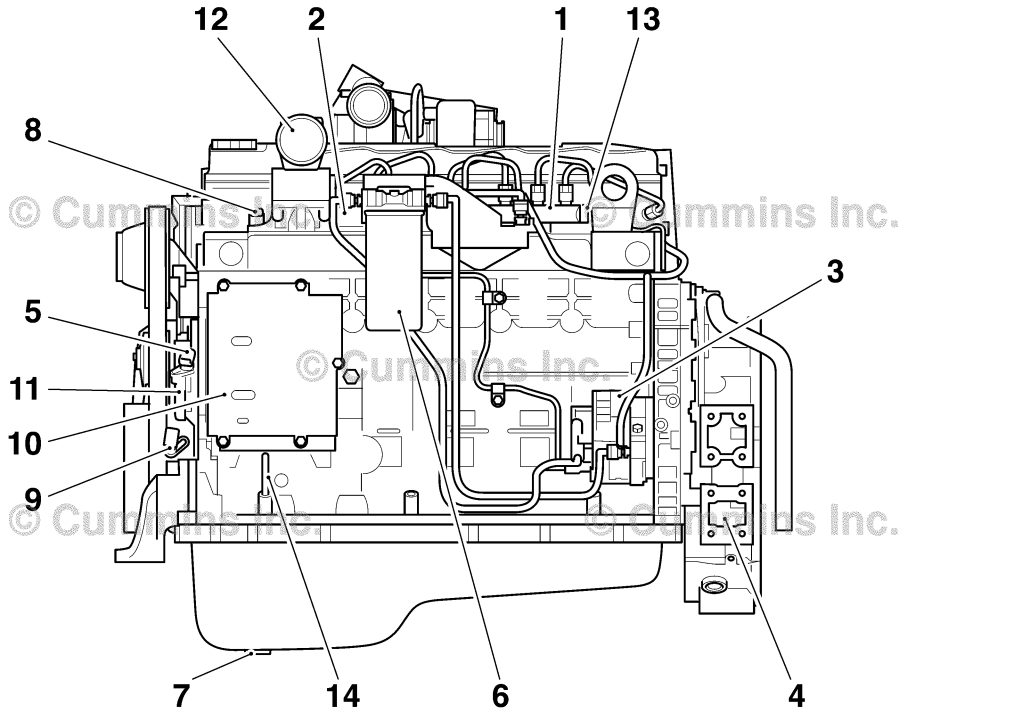
QSB 6.7 Engine - Front View

1 Air inlet
2 Fan drive
3 Electronic control module
4 Engine speed sensor (crankshaft)
5 Dipstick
6 Fuel filter
7 Vibration damper
8 Water pump
9 Starter
10 Belt tensioner
11 Alternator
12 Coolant outlet
13 Coolant temperature sensor
14 Turbocharger air outlet.

Engine Diagrams

Engine Views

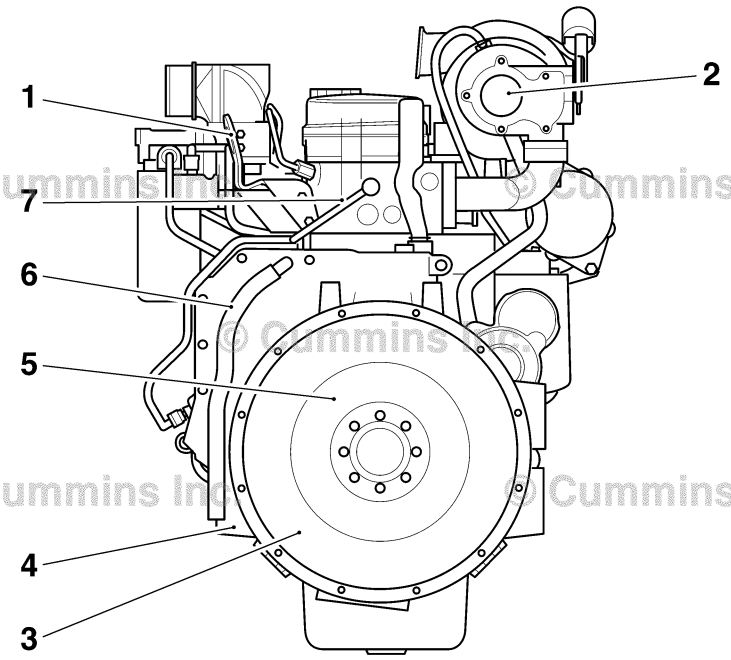


QSB 6.7 Engine - Left Side View

1 Fuel rail
2 Intake pressure and temperature sensor
3 Bosch™ fuel pump
4 Flywheel housing
5 Oil pressure switch
6 Fuel filter
7 Oil pan drain plug
8 Barometric pressure sensor
9 Engine speed sensor (crankshaft)
10 Electronic control module
11 Engine position sensor (camshaft)
12 Air intake inlet
13 Rail pressure sensor
14 Dipstick.

Engine Diagrams

Engine Views



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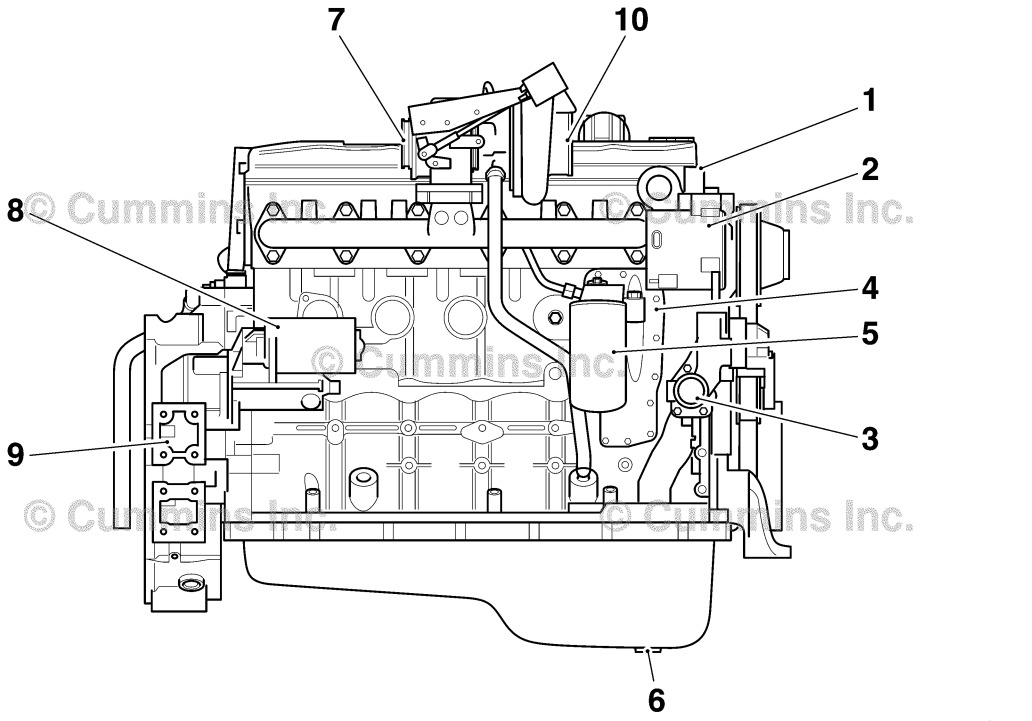
QSB 6.7 Engine - Rear View

1 Rear engine lifting bracket
2 Turbocharger exhaust outlet
3 Clutch mounting holes
4 Flywheel housing
5 Flywheel/flexplate
6 Crankcase breather tube
7 Injector drain line.

Engine Diagrams

Engine Views

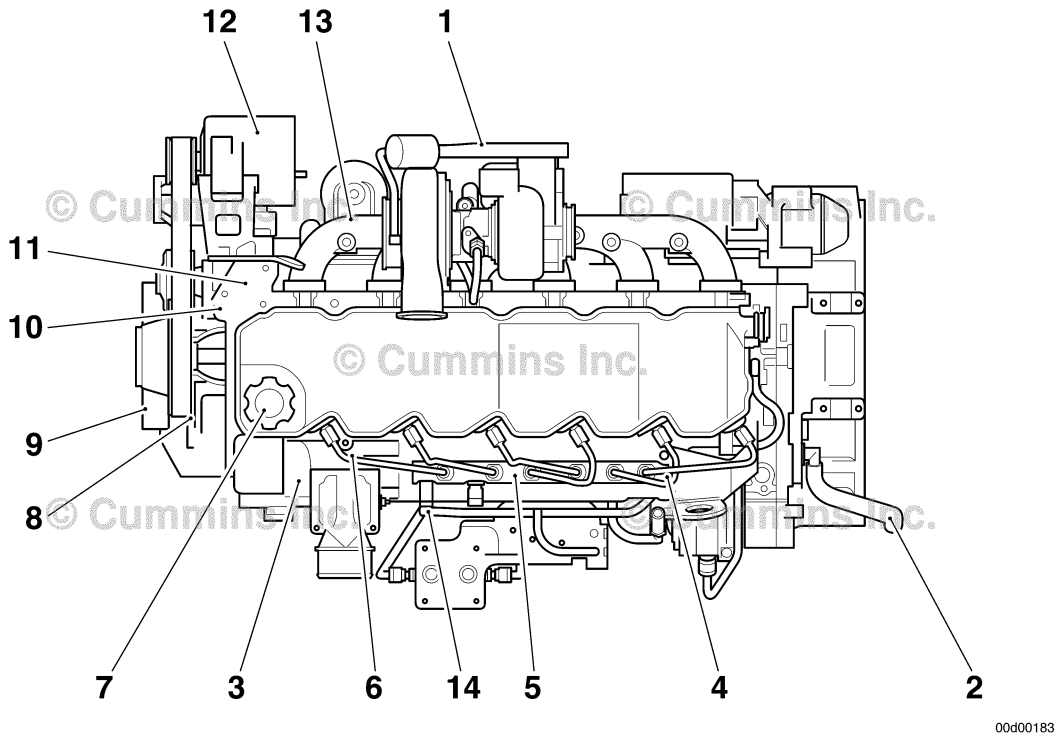


QSB 6.7 Engine - Right Side View

1 Coolant outlet
2 Alternator
3 Coolant inlet
4 Lubricating oil cooler
5 Oil filter
6 Oil pan drain plug
7 Turbocharger exhaust outlet
8 Starter
9 Flywheel housing
10 Turbocharger compressor inlet.

Engine Diagrams

Engine Views

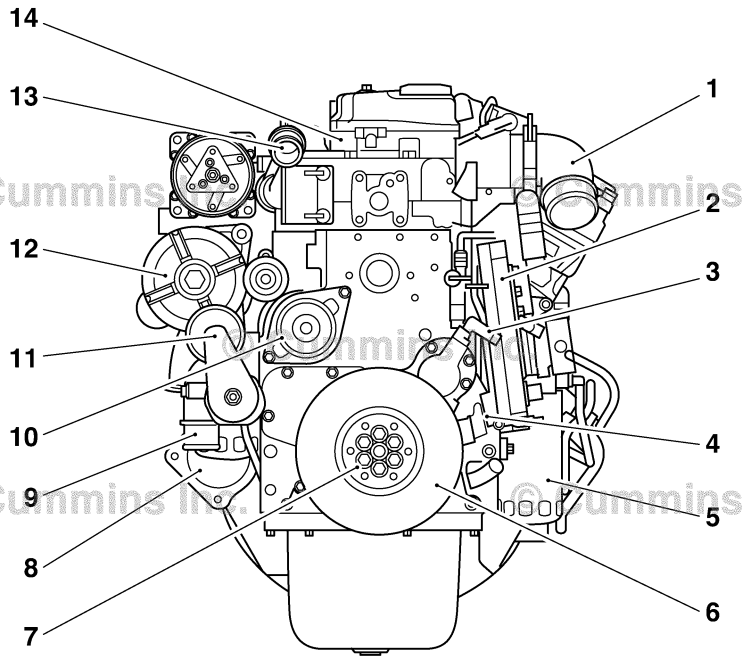


QSB 6.7 Engine - Top View

1 Turbocharger wastegate
2 Crankcase breather
3 Barometric pressure/temperature sensor
4 Fuel rail pressure sensor
5 Fuel rail
6 High-pressure fuel lines
7 Oil fill cap
8 Tone wheel
9 Vibration damper
10 Coolant temperature sensor
11 Coolant outlet
12 Alternator
13 Exhaust manifold
14 Rail pressure relief valve.

Engine Diagrams

Engine Views



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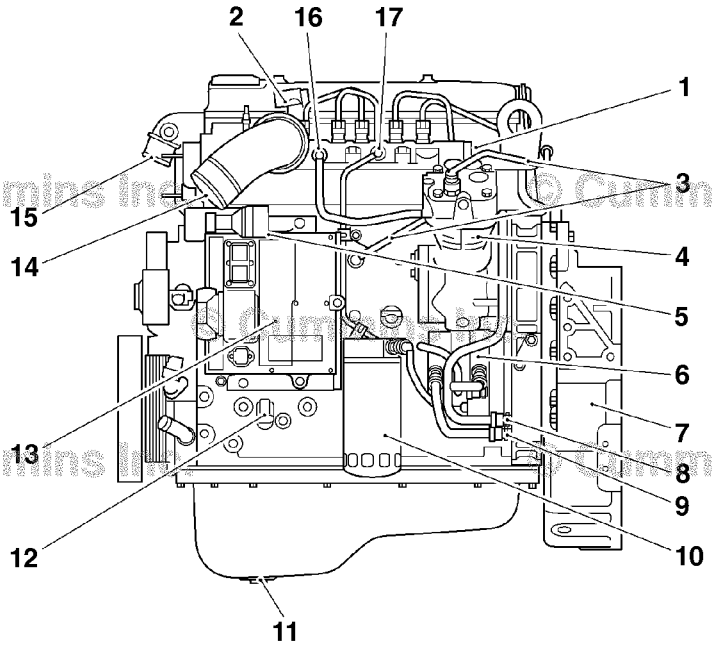
QSB 4.5 Engine - Front View

1 Air inlet
2 Electronic control module
3 Engine speed sensor (camshaft)
4 Engine speed sensor (crankshaft)
5 Fuel filter
6 Vibration damper (Optional)
7 Fan or PTO drive flange mounting
8 Starter mounting location
9 Coolant inlet
10 Water pump
11 Belt tensioner
12 Alternator
13 Coolant outlet
14 Coolant temperature sensor.

Engine Diagrams

Engine Views

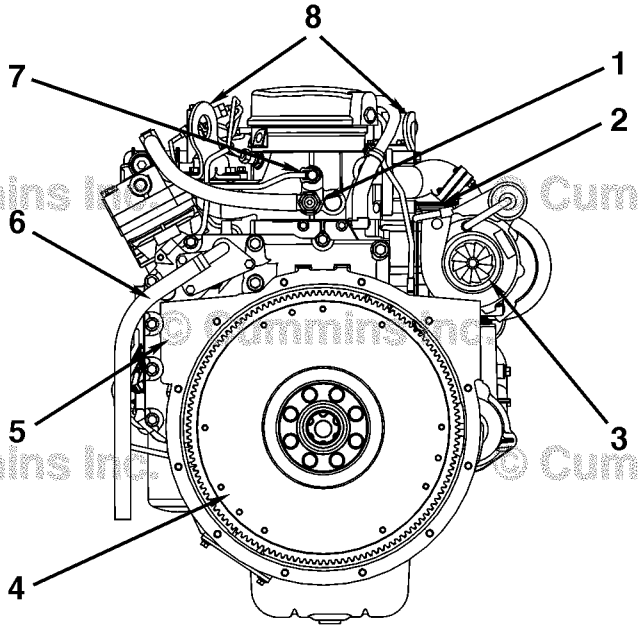


QSB 4.5 Engine - Left Side View

1 Fuel rail pressure sensor
2 Intake manifold pressure/temperature sensor
3 Air compressor coolant pipes
4 Air compressor
5 Ambient air pressure sensor
6 Bosch™ fuel pump
7 Flywheel housing
8 Fuel return
9 Fuel inlet
10 Fuel filter
11 Oil pan drain plug
12 Dipstick/oil level sensor
13 Electronic control module
14 Air intake inlet
15 Coolant outlet
16 Fuel rail pressure relief valve
17 Fuel rail.

Engine Diagrams

Engine Views



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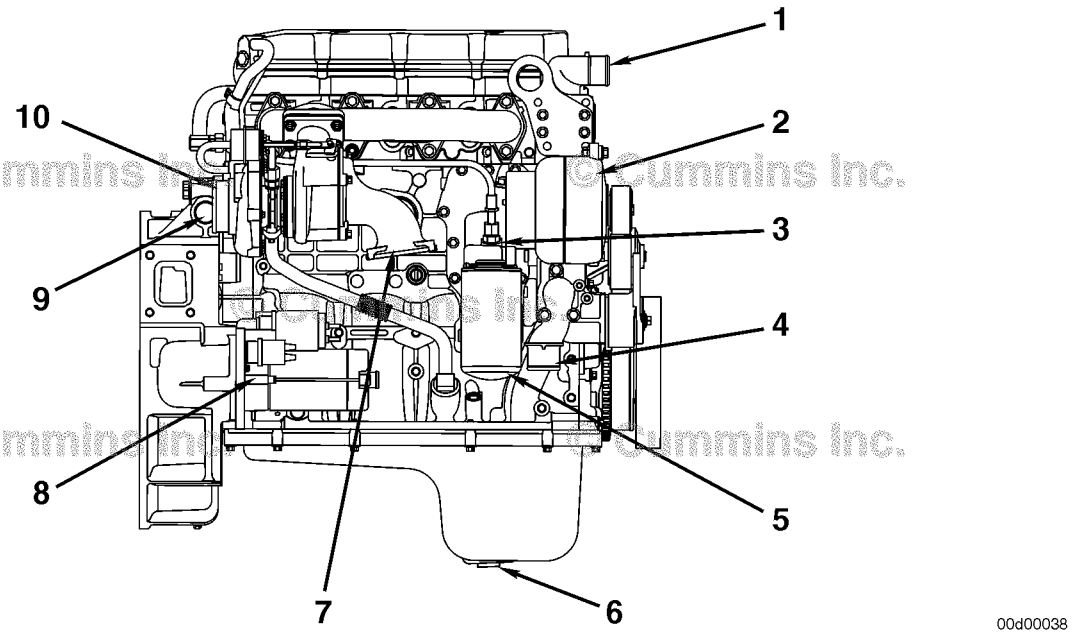
QSB4.5 Engine - Rear View

1 Coolant connection for air compressor
2 Air outlet from turbocharger
3 Air inlet to turbocharger
4 Flywheel
5 Flywheel housing
6 Crankcase breather tube
7 Fuel return line
8 Engine lifting brackets.

Engine Diagrams

Engine Views

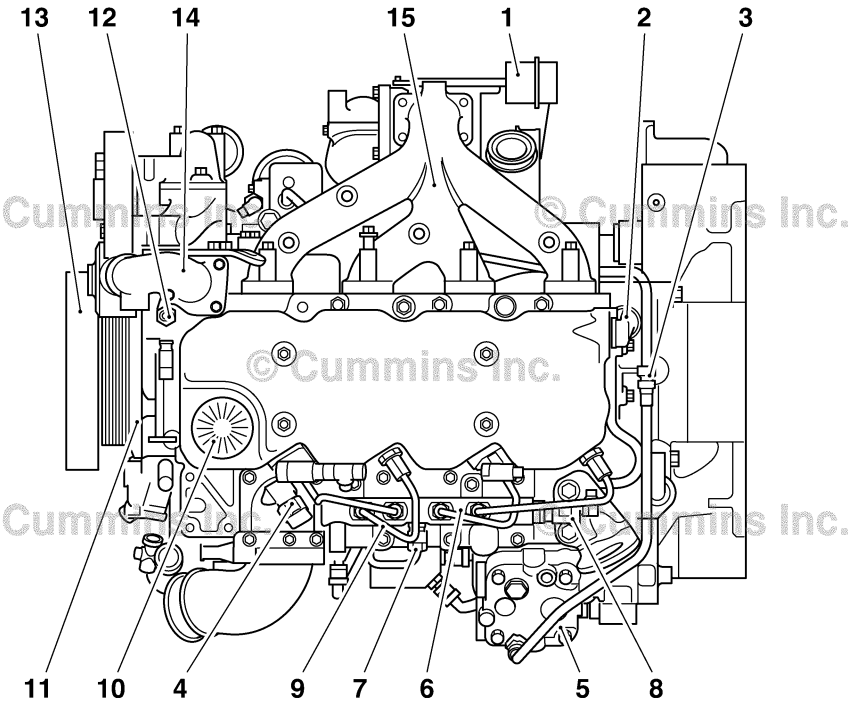


QSB4.5 Engine - Right Side View

1 Coolant outlet
2 Alternator
3 Oil cooler
4 Coolant inlet
5 Oil filter
6 Oil pan drain plug
7 Turbocharger exhaust outlet
8 Starter
9 Flywheel housing
10 Turbocharger compressor inlet.

Engine Diagrams

Engine Views



QSB4.5 Engine - Top View

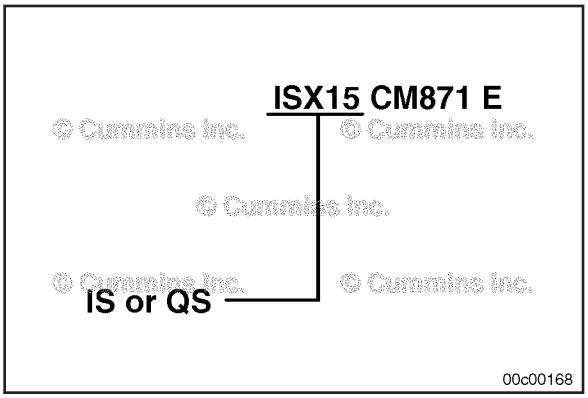
1 Turbocharger wastegate actuator
2 Crankcase breather
3 Air compressor coolant connection
4 Intake manifold pressure/temperature sensor
5 Air compressor
6 Fuel rail
7 High-pressure supply line (pump to rail)
8 Fuel rail pressure sensor
9 High-pressure fuel lines
10 Oil fill cap
11 Tone wheel
12 Coolant temperature sensor
13 Vibration damper (Optional)
14 Coolant outlet
15 Exhaust manifold.

Cummins® Service Engine Model Product Identification

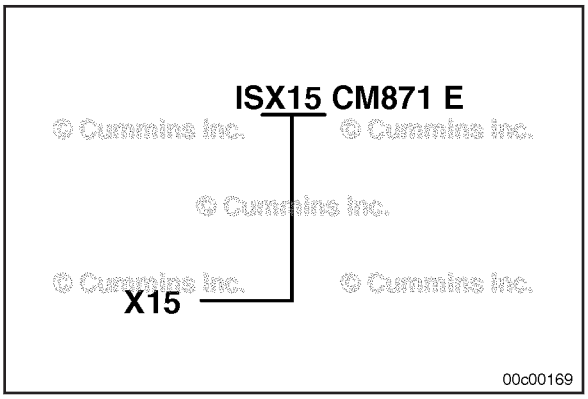
General Information

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.

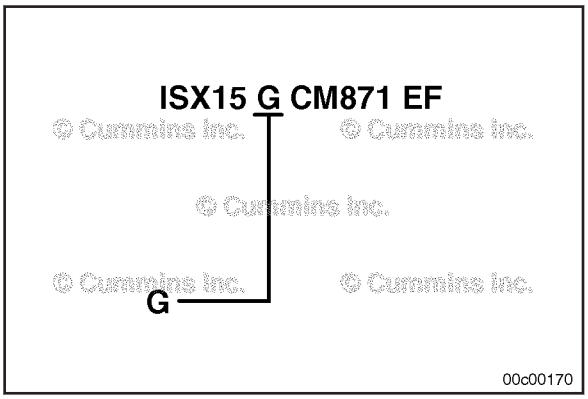
Electronic engines are identified by the first two letters, either an "IS" for On-Highway automotive or "QS" for Off-Highway industrial market applications.

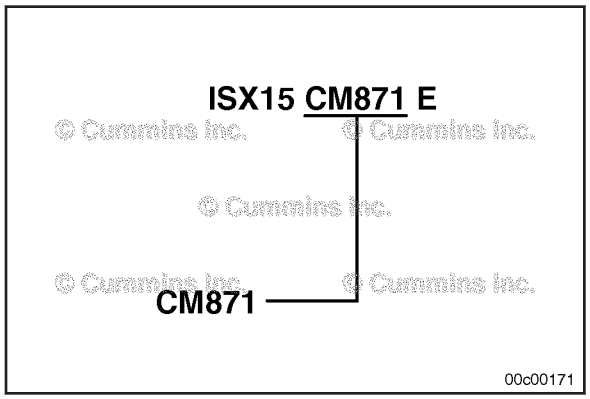


The third letter is the engine platform designation followed by the engine liter size.

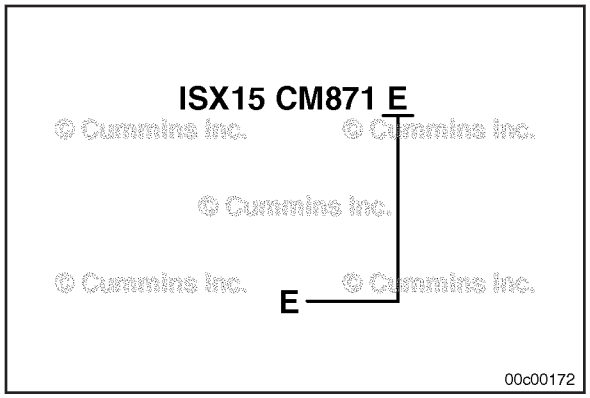


If the engine operates on a fuel type other than diesel, the type will be identified after the liter size.

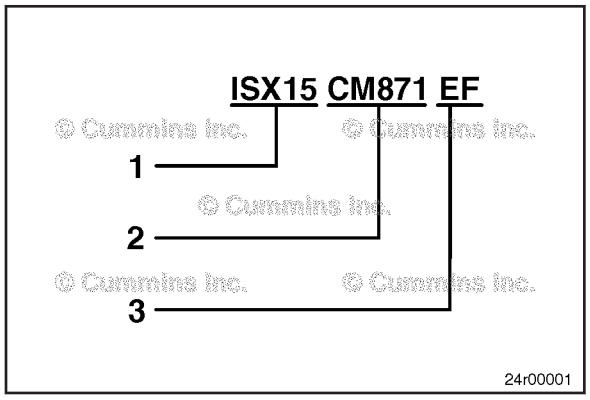




The control system is identified with the letters "CM" followed by the control system model number.



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.

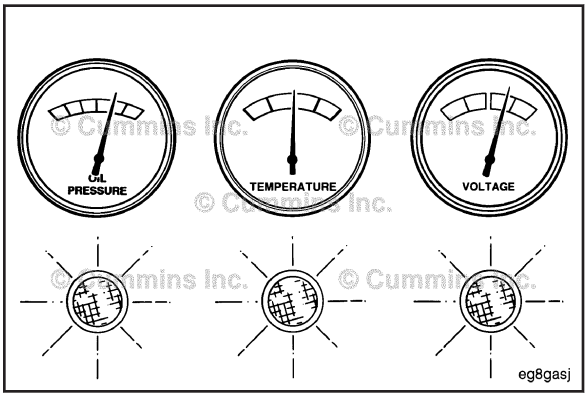
Follow the daily maintenance checks listed in Maintenance Guidelines (Section 2).

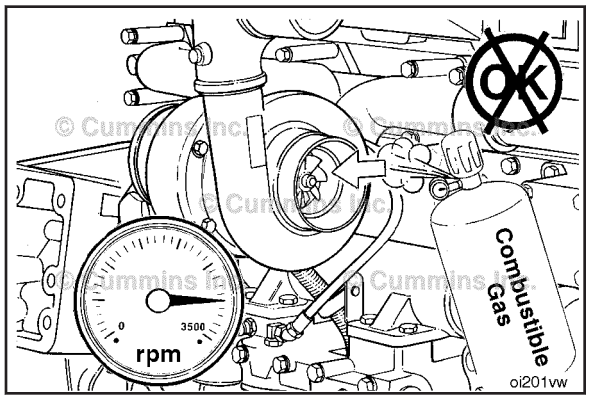
The new Cummins® engine associated with this manual does **not** require a "break-in" procedure. This section of the manual provides all of the necessary information required for proper engine operation.

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.

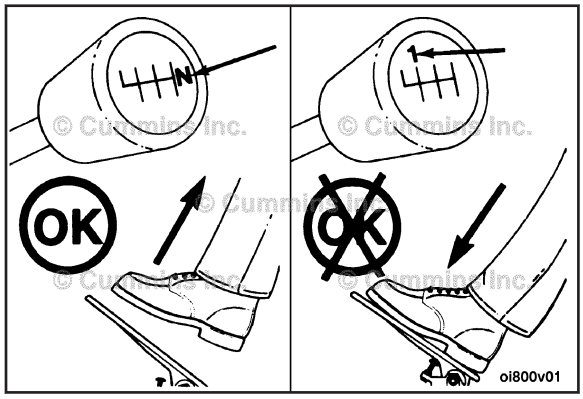




⚠WARNING⚠
Do not operate a diesel engine where there are or can BE COMBUSTIBLE vapors. These vapors can be sucked through the air intake system and cause engine acceleration and over speeding that can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available, 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

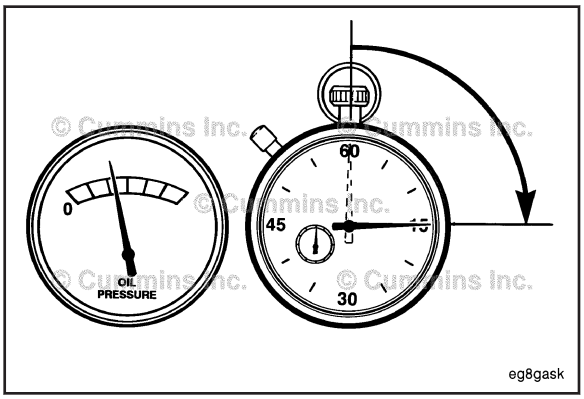
⚠WARNING⚠
Do not depress the accelerator pedal or move the accelerator lever from the idle position while cranking the engine. This can result in engine overspeed and severe damage to the engine.

△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).

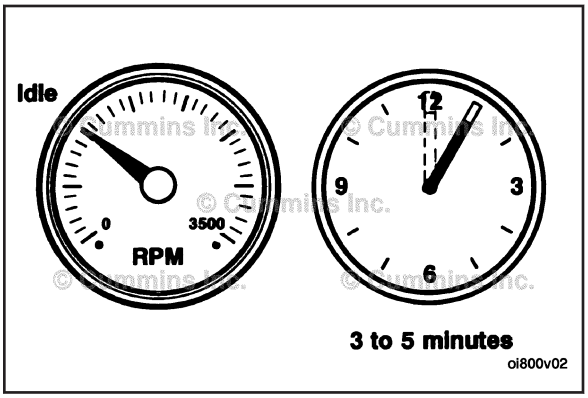
NOTE: Engines equipped with air starting motors require a minimum of 480 kPa [70 psi].

- 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.

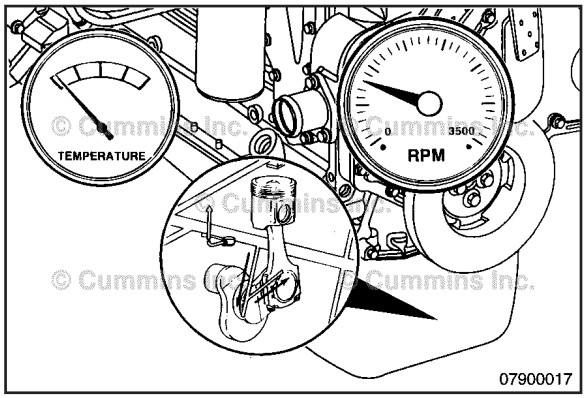
⚠CAUTION⚠
The engine must have adequate oil pressure within 15 seconds after starting. If the WARNING lamp indicating low oil pressure has not gone out or there is no oil pressure indicated on a gauge within 15 seconds, shut off the engine immediately to avoid engine damage. The low oil pressure troubleshooting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



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

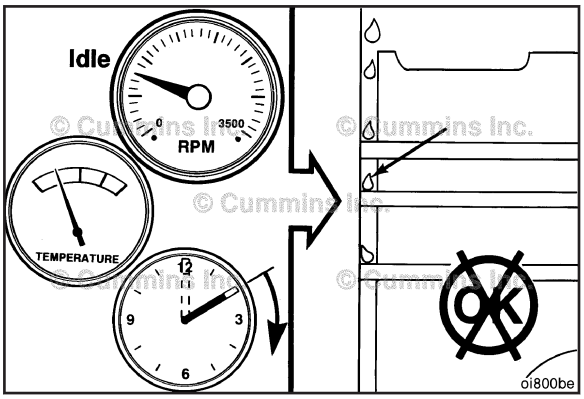


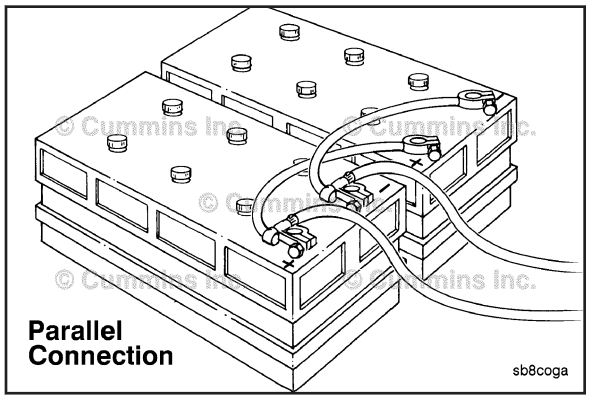
After starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.



⚠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

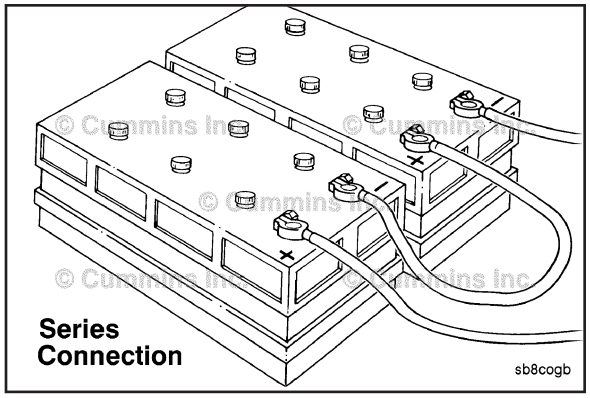
⚠WARNING⚠
Batteries can emit explosive gases. To avoid personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative(-) battery cable last.

△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.

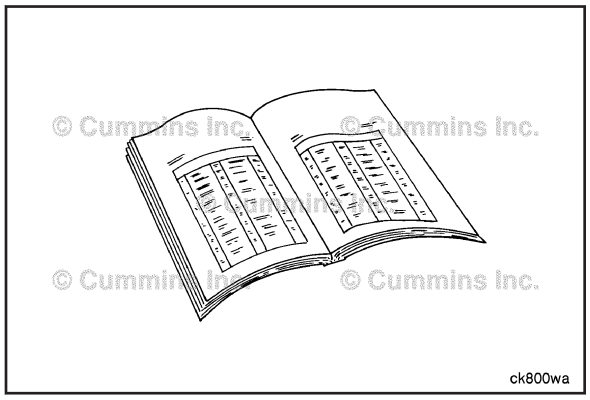
This illustration shows a typical parallel battery connection. This arrangement doubles the cranking amperage.

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

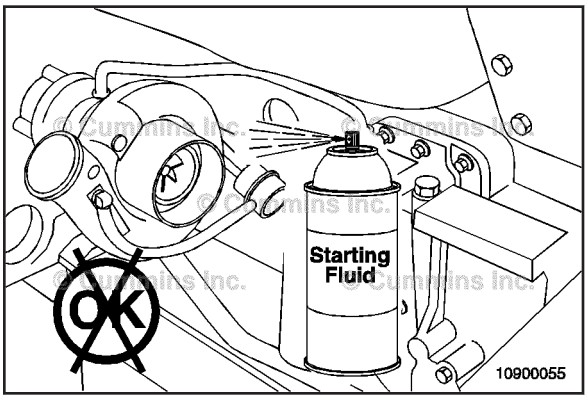
General Information

△CAUTION△
To reduce the possibility of damage to the lubricating oil pan, due to the composite materials used in the manufacture of the lubricating oil pan, under no circumstances should an external heat source be applied directly or indirectly to the lubricating oil pan.

Follow the Normal Starting Procedure in this section. If equipped with an intake air heater, the Wait-To-Start lamp will stay on longer.

Refer to the OEM service manual for any additional cold weather starting procedures.

Using Starting Aids



⚠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.

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

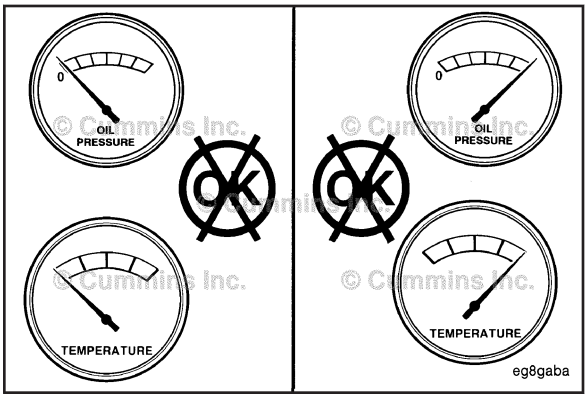
Starting Procedure After Extended Shutdown or Oil Change

General Information

Follow the Normal Starting Procedure in this section. The engine will **not** start until the minimum cranking oil pressure is detected by the ECM. It can take more cranking time to start the engine after an extended shut down or oil change.

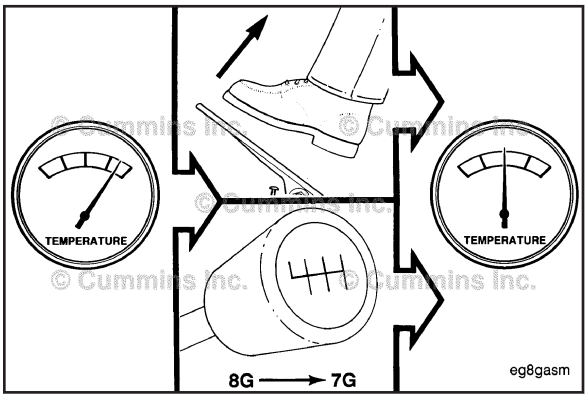
Operating the Engine

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.

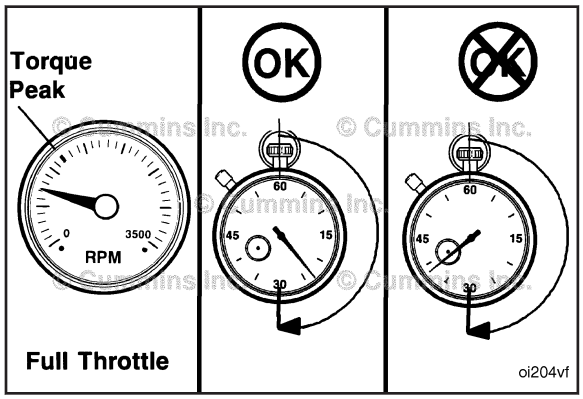
Continuous operation with engine coolant temperature above or below the engine coolant temperature specifications listed in Maintenance Specifications (Section V) can damage the engine.



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).



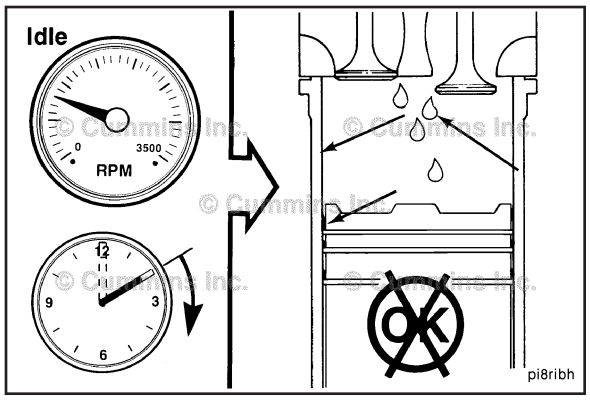
Engine Operating Range

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

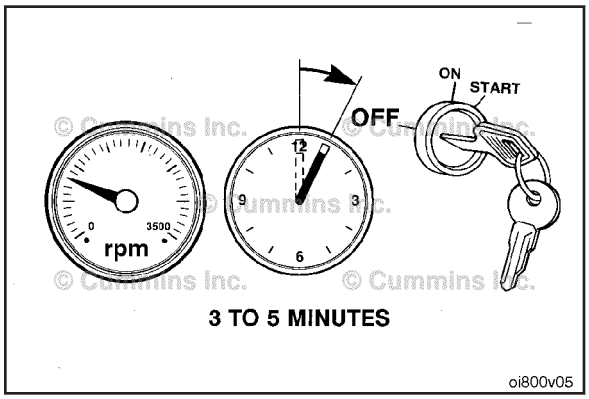
General Information

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.



Electronic Controlled Fuel System

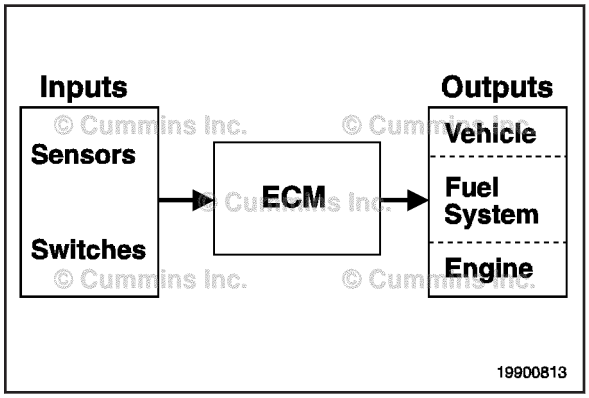
General Information

The engine control system is an electronically operated fuel control system that also provides many operator and vehicle or equipment features.

The base functions of the control system include fueling and timing control, limiting the engine speed operating range between the low- and high-idle set points, and optimizing engine performance.

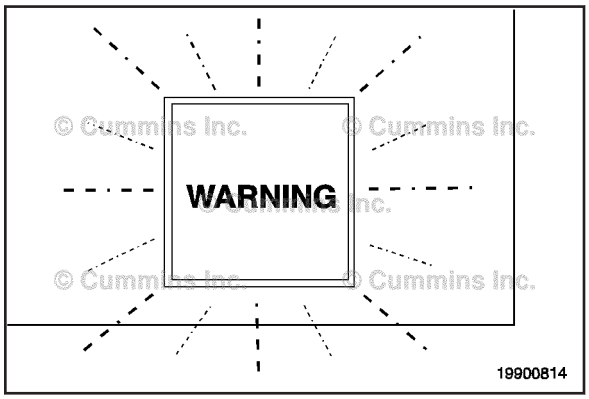
The control system uses inputs from the operator and its sensors to determine the fueling and timing required to operate at the desired engine speed.

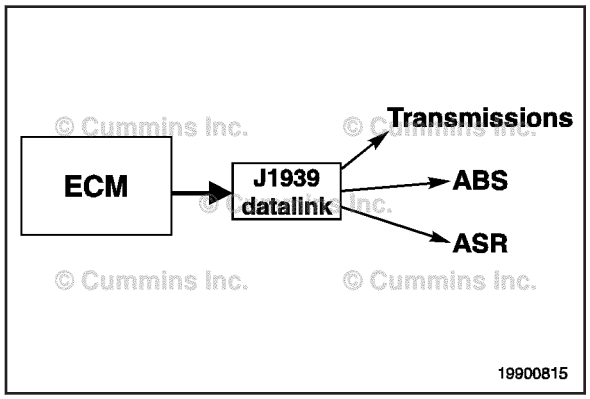
The engine control module (ECM) is the control center of the system. It processes all of the inputs and sends commands to the fuel system and vehicle and engine control devices.



The ECM performs diagnostic tests on most of its circuits and will activate a fault code if a problem is detected in one of these circuits. Along with the fault code identifying the problem, a snapshot of the engine's operating parameters at the time of fault activation is also stored in memory.

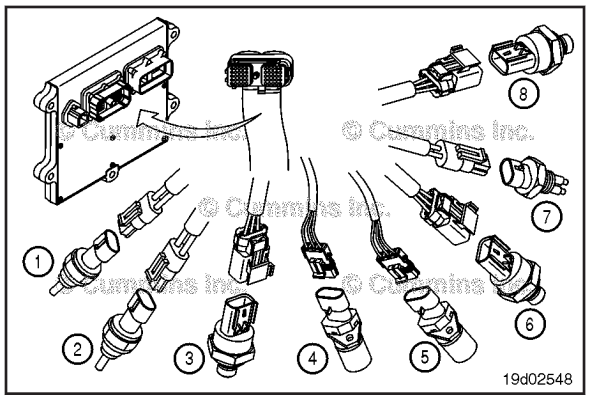
Some fault codes will cause a diagnostic lamp to activate to signal the driver.





The ECM communicates with service tools and some other vehicle controllers such as transmissions, antilock brake system, and antislip reduction through an SAE J1939 data link.

Some vehicles and equipment will have J1939 networks on them that link many of the "smart" controllers together. Vehicle control devices can temporarily command engine speed or torque to perform one of the devices' functions, such as transmission shifting or antilock braking.



The control system uses a number of sensors to provide information on engine operating parameters. These sensors include:

- Coolant temperature sensor
- Intake air pressure and temperature sensor
- Barometric pressure sensor
- Oil pressure switch
- Engine speed sensor
- Engine position sensor
- Water-in-fuel sensor
- Rail pressure sensor.

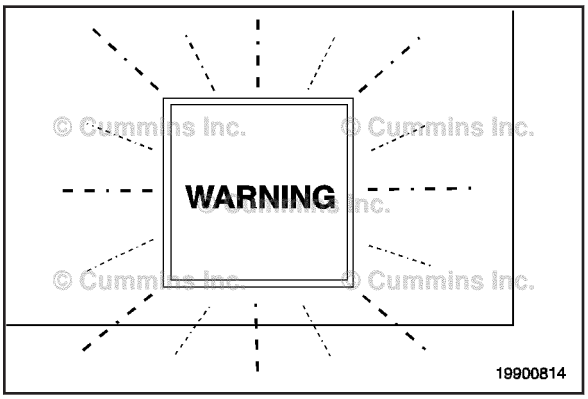
The following inputs are provided by OEM-selected devices:

- Accelerator pedal position sensor
- Idle validation switch
- Engine coolant level sensor
- Vehicle speed sensors
- Feature control switches (i.e., cruise control switches)
- Fan control switch
- Air conditioner pressure switch
- Remote accelerator
- Remote PTO .

NOTE: These inputs are application-dependent. Some applications will **not** use all of these inputs.

Engine Protection System

The engines are equipped with an engine protection system. The system monitors critical engine temperatures and pressures and will log diagnostic faults when an over or under normal operation condition occurs. If an out-of-range condition exists and engine derate action is to be initiated, the operator will be alerted by an in-cab WARNING lamp. The WARNING lamp will blink or flash when out-of-range conditions continue to worsen. When the red STOP lamp is illuminated, the driver **must** pull to the side of the work area, when it is safe to do so, to reduce the possibility of engine damage.

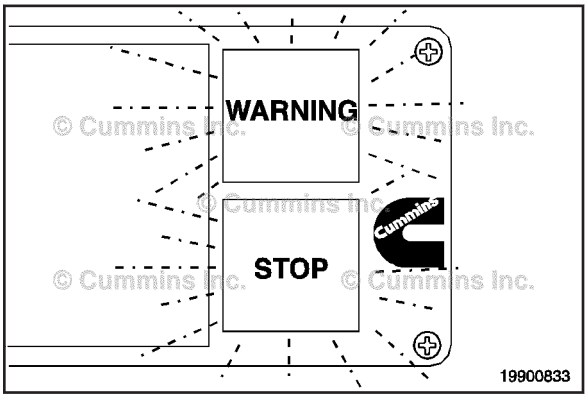


NOTE: Engine power and speed will be gradually reduced, depending on the level of severity of the observed condition. The engine protection system will **not** shutdown the engine unless the engine protection shut down feature has been enabled.

Engine Protection Shutdown

This feature automatically shuts off the engine when the temperature, pressure, and coolant level sensors indicate the engine is operating over or under normal operating conditions.

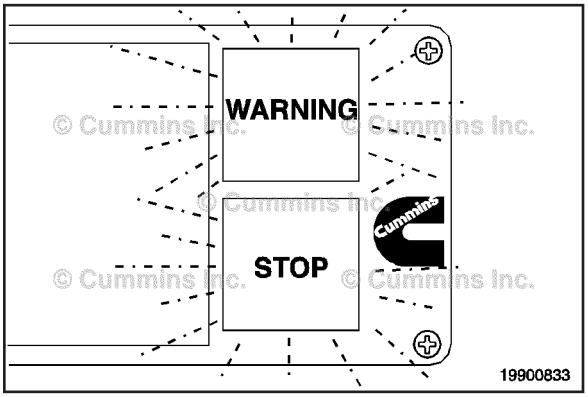
The red STOP lamp in the cab will flash for 30 seconds prior to shut down to alert the driver.

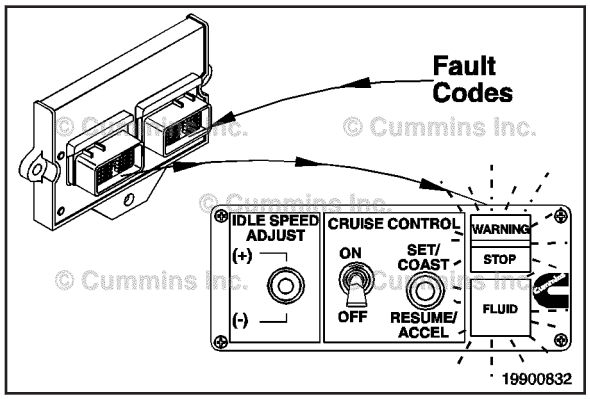


Engine Protection Shutdown Manual Override

This feature allows the operator to override a pending engine shutdown. Prior to engine shutdown, the red STOP lamp will flash for 30 seconds to notify the operator that the engine is about to shut down. The operator can override the engine shut down through use of an OEM switch, such as the clutch switch.

If the vehicle is **not** equipped with a clutch switch, then the OEM will provide a dash-mounted switch marked as the ENGINE PROTECTION SHUTDOWN OVERRIDE switch. When the operator triggers this switch while the red lamp is flashing, a timer within the ECM will reset and allow the engine to operate for an additional 30 seconds before engine shutdown occurs. Each time the operator triggers the override switch, the timer within the ECM is reset, allowing the engine to operate for an additional 30 seconds.

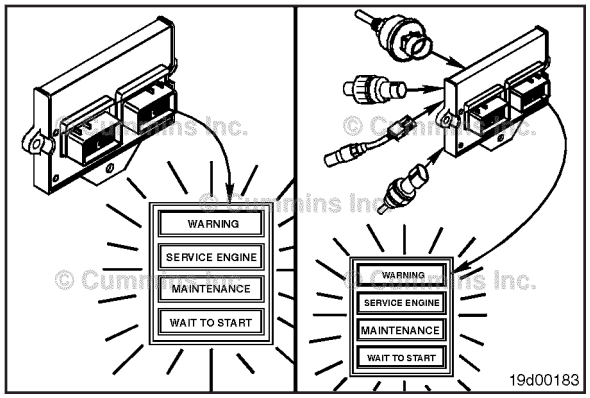




Diagnostic Fault Codes

The control system can show and record operation anomalies that present themselves as fault codes. These codes will make troubleshooting easier. The fault codes are recorded in the ECM. They can be read using the fault lamps in the dash or with INSITE™ electronic service tool.

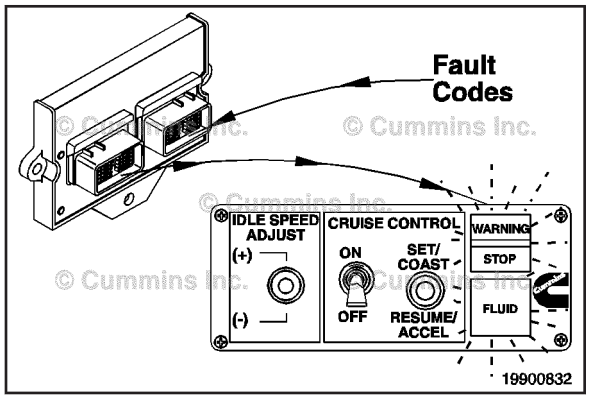
NOTE: Not all engine or control system anomalies are shown as fault codes.



There are three types of system codes:

- Engine electronic control system fault codes
- Engine protection system fault codes
- Engine maintenance indicator codes.

All fault codes recorded will either be active (fault code is currently active on the engine) or inactive (fault code was active at some time, but is **not** active at the moment).

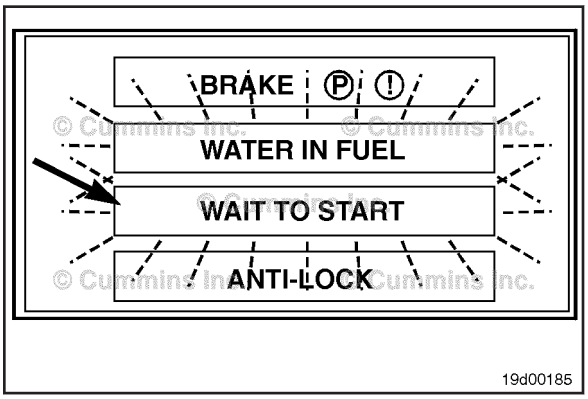


Most of the electronic fault codes will light a lamp when they are active. There are three possible lamps that can be lit when a fault is active:

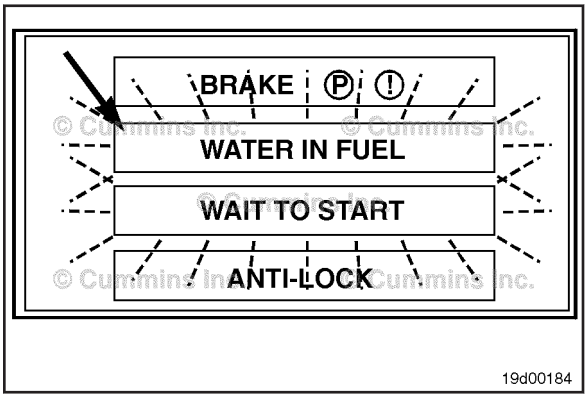
- The WARNING or CHECK ENGINE lamp is yellow and indicates the need to repair the fault at the first available opportunity.
- The STOP or STOP ENGINE lamp is red and indicates the need to stop the engine as soon as it can be safely done. The engine should remain shut down until the fault can be repaired.
- The MAINTENANCE or FLUID lamp will illuminate when an engine maintenance function needs to be performed.

NOTE: The names and colors of these lamps can vary by equipment manufacturer.

Some vehicles will also have a WAIT-TO-START lamp and a WATER-IN-FUEL lamp. The WAIT-TO-START lamp is illuminated during the preheating time that takes place at keyswitch ON during cold-weather starting. To minimize cranking time during cold-weather starting, the engine should **not** be cranked until the WAIT-TO-START lamp has been extinguished.



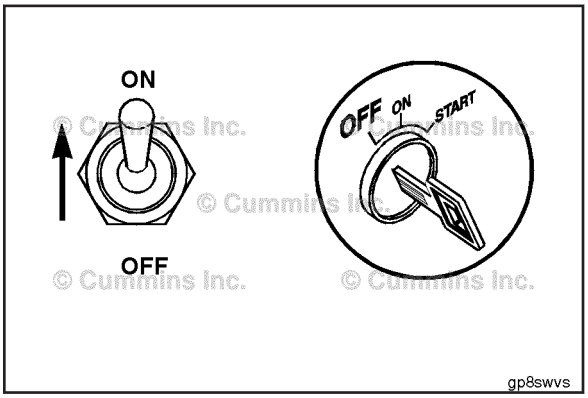
The WATER-IN-FUEL lamp indicates that the engine's water-in-fuel separator needs to have the water drained out of it. This task should be performed as soon as possible whenever this lamp is illuminated. Some vehicle manufacturers will combine the functions of the MAINTENANCE and WATER-IN-FUEL lamps. In these cases, the MAINTENANCE lamp would indicate a WATER-IN-FUEL warning, in addition to other maintenance indicators.



There are two ways to check for active engine electronic fuel system fault codes and maintenance indicator codes, depending on whether the engine is equipped with a diagnostic switch.

Vehicle with Diagnostic Switch

- Turn the keyswitch to the OFF position. Move the diagnostic switch to the ON position, or connect the shorting plug into the diagnostic connector. Turn the vehicle keyswitch to the ON position.

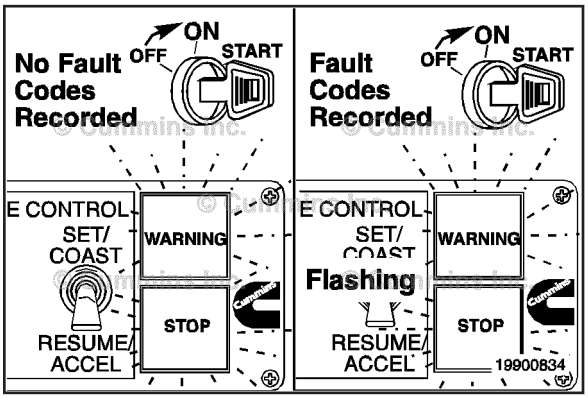


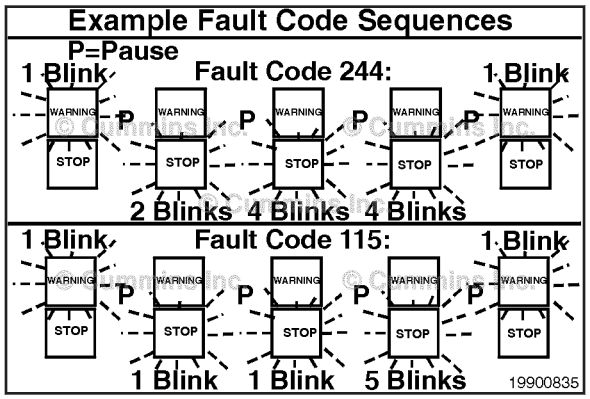
Vehicle without Diagnostic Switch

- Turn the vehicle keyswitch to the ON position. With the keyswitch on and the engine **not** operating, cycle the accelerator pedal to full throttle and back to the idle position three times.

If no active fault codes are recorded, both lights will come on and stay on.

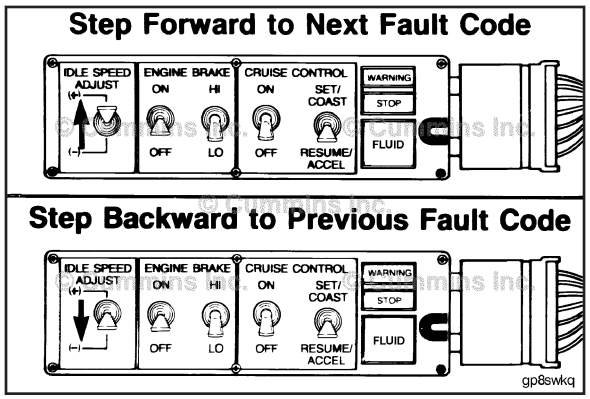
If active fault codes are recorded, both lights will come on momentarily, then begin to flash the code of the recorded fault(s).





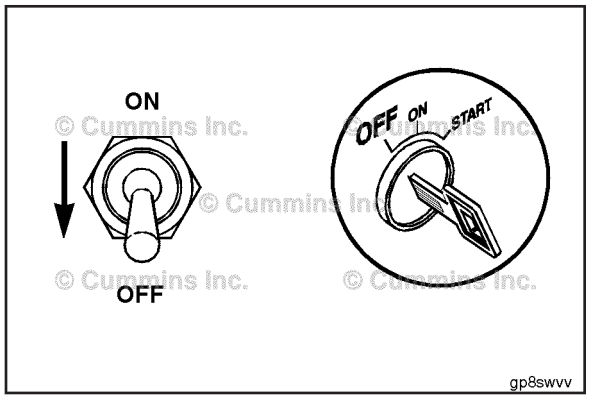
The fault code will flash in the following sequence:

- First, a WARNING (yellow) lamp will flash.
- Then there will be a short 1- or 2-second pause, after which the number of the recorded fault code will flash in STOP (red) lamp. There will be a 1- or 2-second pause between each number.
- When the number has finished flashing in red, a yellow lamp will appear again. The three-digit code will repeat in the same sequence.



The lights flash each fault code out two times before advancing to the next code. To skip to the next fault code sooner, move the idle speed adjust switch, if equipped momentarily to the "(+)" position. The previous fault code can be accessed by momentarily moving the idle speed adjust switch, if equipped to the "(-)" position. If **only** one active fault is recorded, the control system will continuously display the same fault code, even when either the "(+)" or "(-)" switch is depressed.

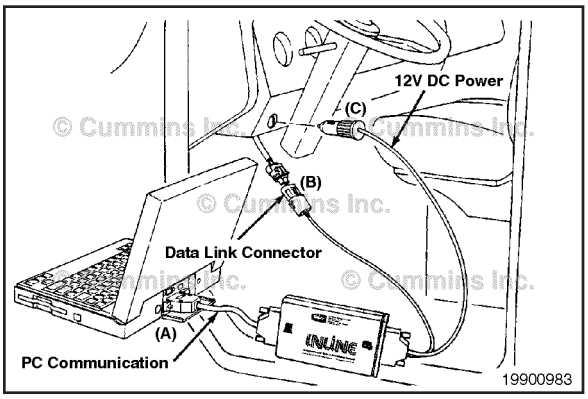
The explanation and correction of the fault codes are explained in Section TF in the ISB, ISBe2, ISBe3, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 CM850 Electronic Control System Troubleshooting and Repair Manual, Bulletin Number 4021416.



When **not** using the diagnostic system, turn off the diagnostic switch, or remove the shorting plug. If the diagnostic switch is left on or the shorting plug in, the ECM will **not** log some faults.

Fault Code Snapshot Data

Use INSITE™ electronic service tool to obtain the additional fault cod date information. The snapshot data records the value or state of the control system sensors and switches at the time a fault occurrs. This data is stored for the first occurrence of the fault, since it was last cleared, and for the most recent occurrence. This data can be very valuable when trying to re-create or determine engine operating conditions at the time of a fault.



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	Use or Additional Description
ST-1273	Pressure gauge	Measure Intake Manifold Pressure
3400158	Filter wrench	Oil and Fuel Filters
3824591	Barring tool	Rotate the engine
CC-2800	Refractometer	Check antifreeze concentration and battery specific gravity
3164488	Digital multimeter	Measure Voltage on electrical equipment
3822525	Belt tensioner gauge (click type)	Check belt tension (6 to 12 v-ribbed belts)
3164795	Torque wrench	Dial type 3/8 drive 0-28 Nm [0-250 in-lb]
3164794	Torque wrench	Micro-adjust 3/8 drive 14-136 Nm [10-100 ft-lb]
3164797	Torque wrench	Micro-adjust 1/2 drive 68-339 Nm [50-250 ft-lb]

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[3] .....Section 3

- Air Intake Piping - Check
- Engine Lubricating Oil Level - Check
- Air Tanks and Reservoirs - Drain
- Crankcase Breather Tube - Inspect
- Engine Coolant Level - Check
- Fuel-Water Separator - Drain

Maintenance Procedures at 250 Hours or 3 Months[3] .....Section 4

- Air Cleaner Restriction - Check[5]
- Air Compressor Mounting Hardware - Check
- Charge-Air Cooler - Check
- Charge-Air Piping - Check
- Radiator Hoses - Check
- Air Intake Piping - Inspect
- Fan, Cooling - Check
- Coolant Level - Check
- Drive Belts - Check

Maintenance Procedures at 500 Hours or 6 Months[1, 2, 3]Section 5 .....Section 5

- Engine Coolant - Antifreeze Check
- Fuel Filter (Spin-On Type) - Change
- Lubricating Oil and Filters - Change
- Radiator Pressure Cap - Check

Maintenance Procedures at 1000 Hours or 1 Year[3] .....Section 6

- Cooling Fan Belt Tensioner - Check
- Fan Hub, Belt-Driven - Check

Maintenance Procedures at 2000 Hours or 2 Years[2, 3] .....Section 7

- Air Compressor Discharge Line - Check
- Cooling System - Flush[4]
- Vibration Damper, Rubber - Check
- Vibration Damper, Viscous - Check

Maintenance Procedures at 5000 Hours or 4 Years[3] .....Section 8

- Overhead Set - Adjust

1 The lubricating oil and lubricating oil filter interval is determined by the sulfur content of the fuel used, the lubricating oil type used, and the engine rating. See the Oil Drain Intervals in this section.

2 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 or 2000 hours, whichever occurs first. Antifreeze is essential for freeze, overheat, and corrosion protection.

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

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

5 If a separate air filter is used for the air compressor air supply, please reference the original equipment manufacturer (OEM) Manual for Maintenance Guidelines and Schedule.

Oil Drain Intervals

See table 1 to determine the maximum recommended oil change and filter change interval in hours or months, whichever comes first.

Table 1: Recommended Oil Change and Filter Change Intervals

American Petroleum Institute Classification (API)	European Classification (ACEA)	Fuel Sulfur Content	Engine Rating is 261 Hp [195 kW] or greater	Engine Rating is 260 Hp [194 kW] or less
CJ-4 (CES 20081)	ACEA E9	< 500 ppm	250 hours or 6 months	500 hours or 6 months
	JAMA DH-2	500 to 5000 ppm	200 hours* or 6 months	400 hours* or 6 months
CI-4 (CES 20078)	ACEA E7	up to 5000 ppm	250 hours or 6 months	500 hours or 6 months
API CH-4/SJ (CES 20071, 20076, or 20077)	ACEA E5 JAMA DH-1	up to 5000 ppm	250 hours or 3 months	500 hours or 6 months
API CF-4/SG (CES 20075)	ACEA E3 ACEA E2	up to 5000 ppm	125 hours or 6 weeks	250 hours or 3 months
API CD API CE API CG-4/SH	ACEA E1	up to 5000 ppm	**Obsolete. Do not Use**	**Obsolete. Do Not Use**

* The oil drain interval **must** be reduced by 20 percent if American Petroleum Institute (API) CJ-4 (Cummins® Engineering Standard 20081) lubricating oil is used with diesel fuel containing 0.05 to 0.5 mass percent [500 to 5000 ppm] sulfur content.

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.

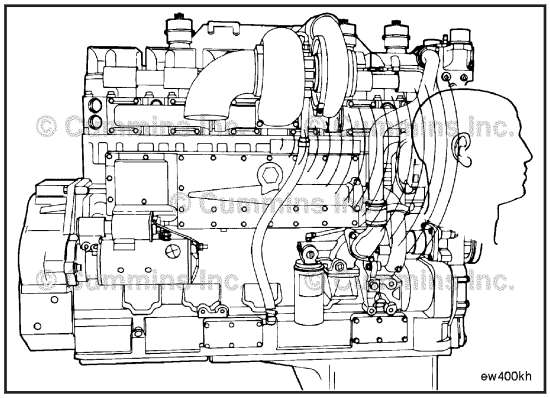
Comparison and intelligent interpretation of the daily report, along with a practical follow-up action, will eliminate most failures and emergency repairs.

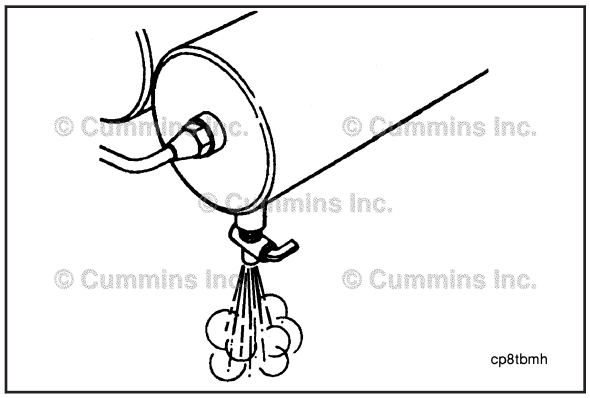
Report to the maintenance department any of the following conditions that may apply:

- 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.

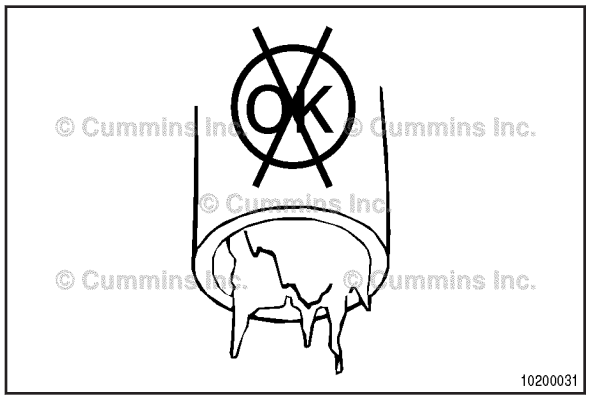




Air Tanks and Reservoirs

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.

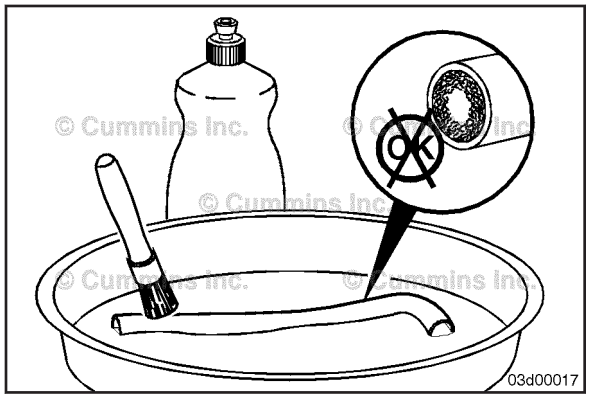


Crankcase Breather Tube

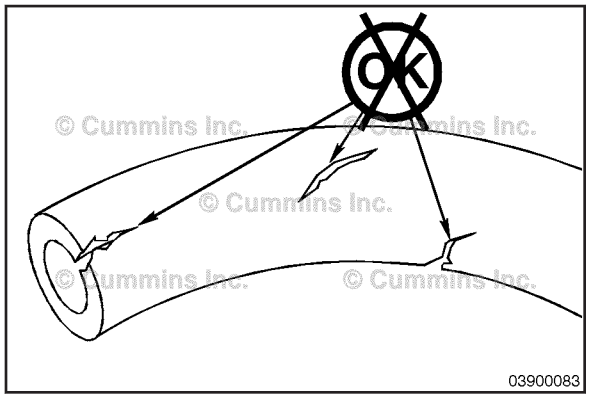
Maintenance Check

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.

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.

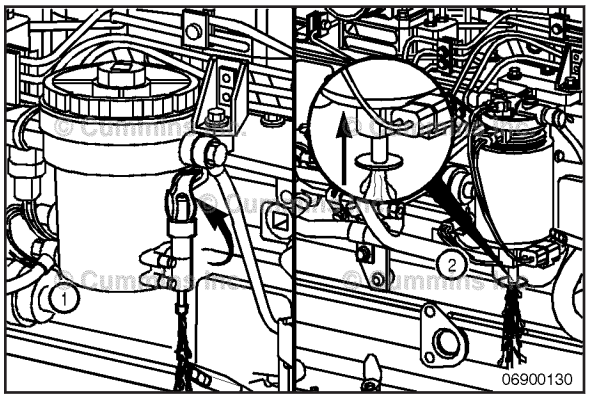
Drain the water and sediment from the separator daily.

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

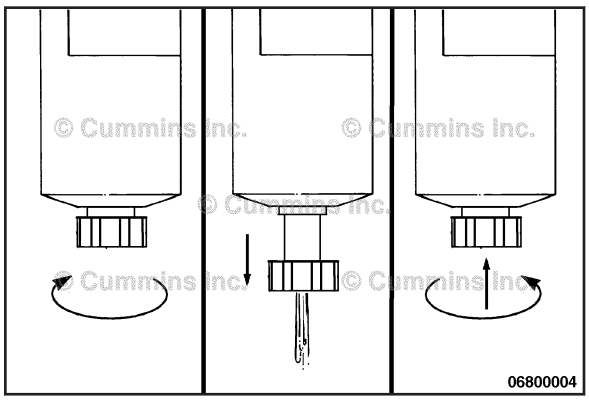
Shut off the engine.

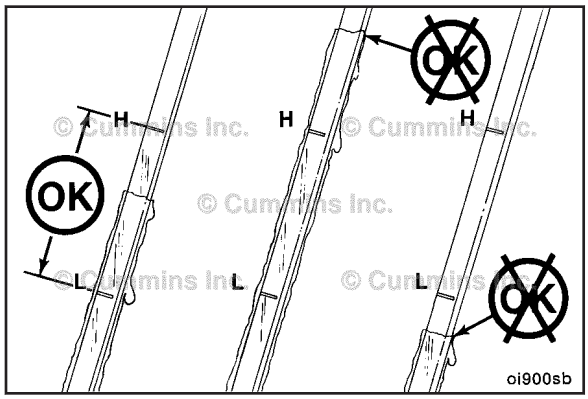
Use your hand to open the drain valve. Turn the valve **counterclockwise** approximately 3½ turns until the valve drops down 25.4mm [1 in] and draining occurs.

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⚠

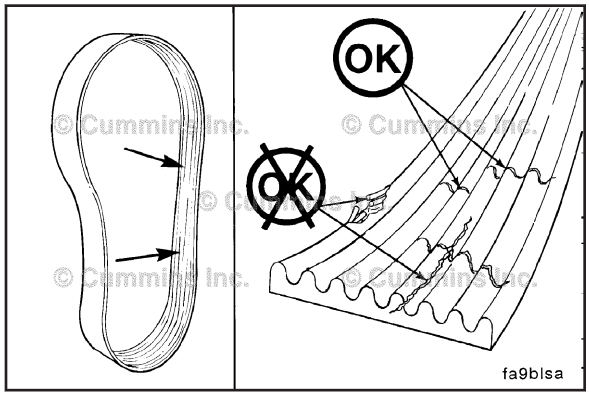
Never operate the engine with oil level below the L (low) mark or above the H (high) mark. Poor engine performance or engine damage can occur.

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).



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.

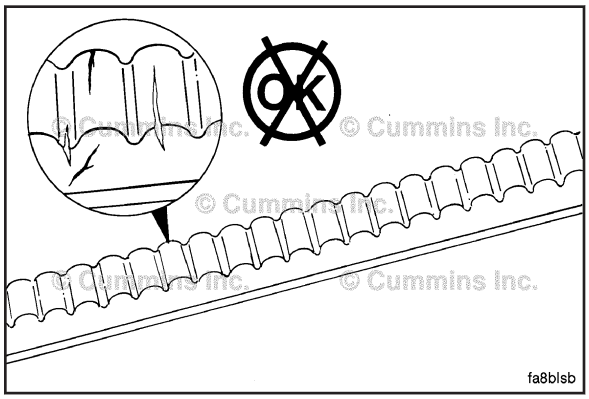
Cogged Belt

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

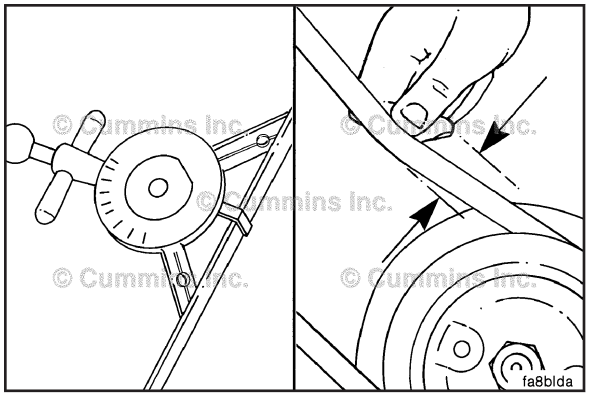


Measure the belt tension in the center span of the pulleys.

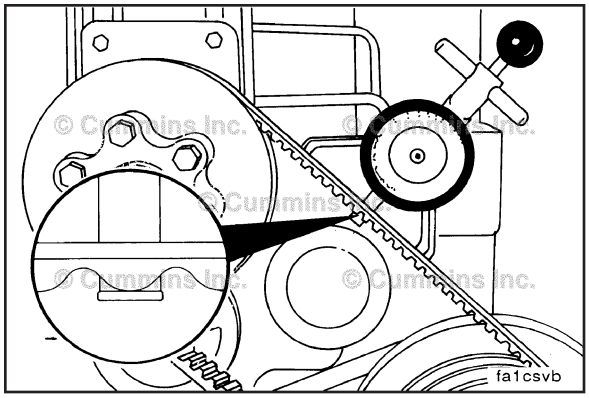
Refer to the Belt Tension Chart in Section V for the correct gauge and tension value for the belt width used.

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.



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

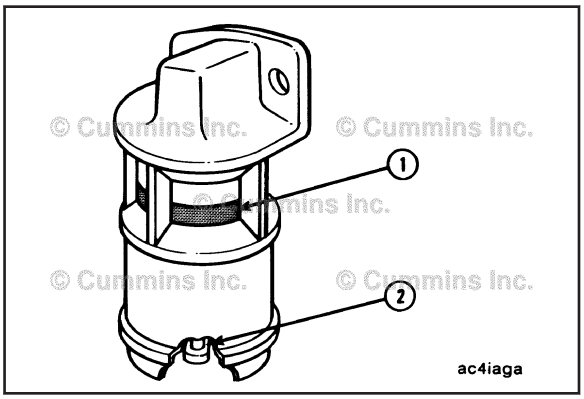
⚠CAUTION⚠

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.

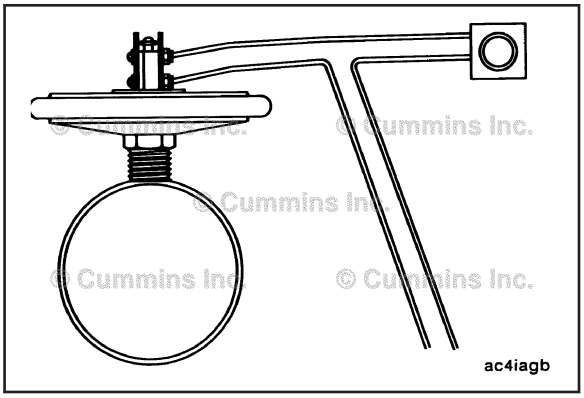
A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in the air cleaner outlet or on the instrument panel. The red flag (1) in the window gradually rises as the cartridge loads with dirt. After changing or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

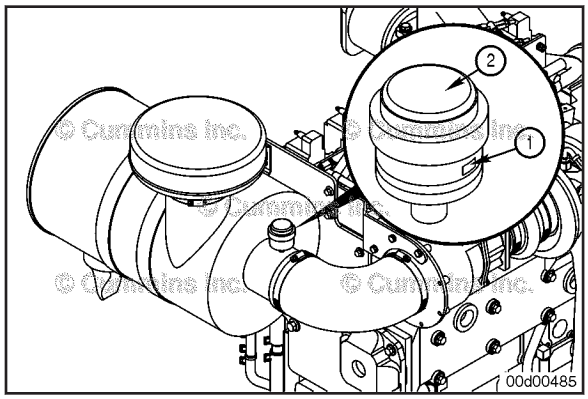
Restriction or vacuum indicators need to be installed as close as possible to the turbocharger air inlet in order to obtain a true indication of restrictions.



Vacuum Indicator

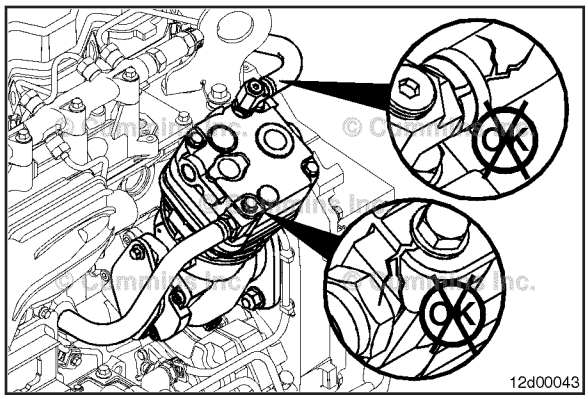
Vacuum switches actuate a warning light on the instrument panel when the air restriction becomes excessive.





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.

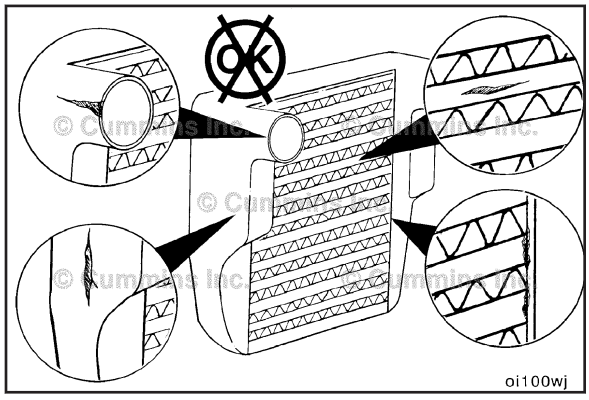
Inspect the air compressor mounting nuts, including support bracket, for loose or damaged hardware.

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

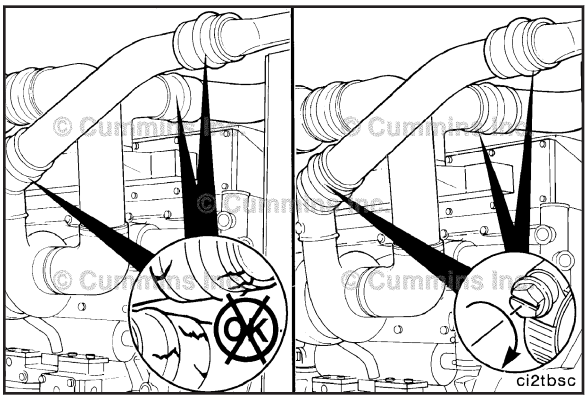
Maintenance Check

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.



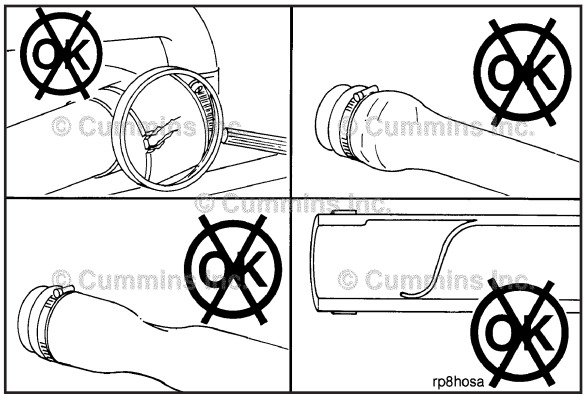
Radiator Hoses

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.



Air Intake Piping

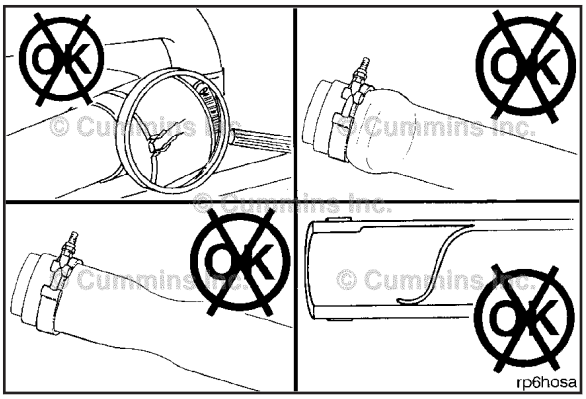
Maintenance Check

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]

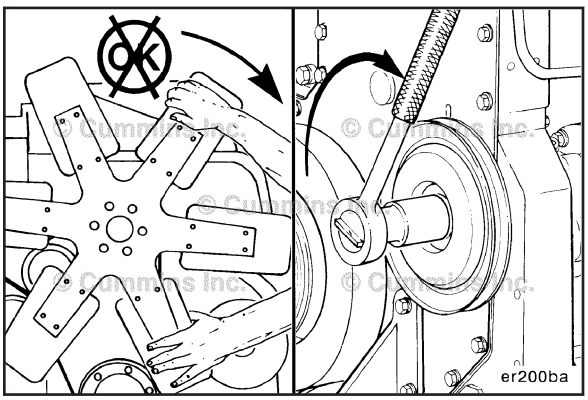
Check for corrosion under the clamps and hoses of the intake system piping. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean, as required.

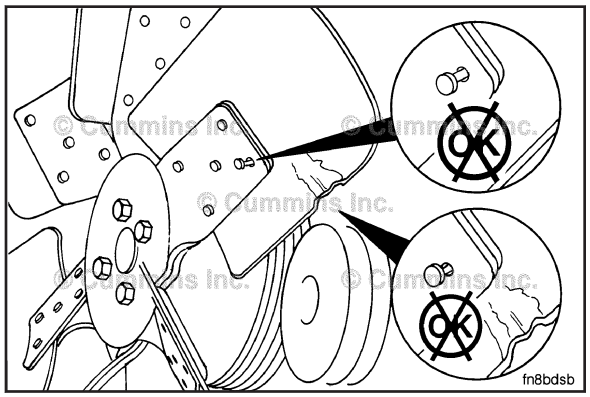


Fan, Cooling

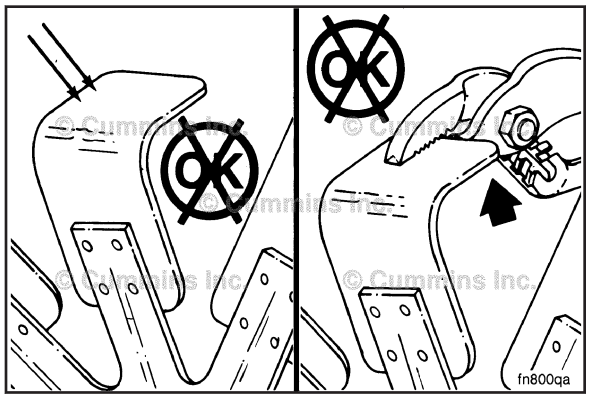
Inspect for Reuse

⚠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.

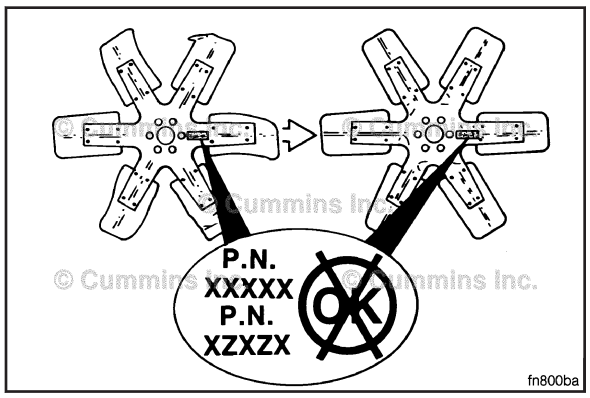




A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, and bent or loose blades. Check the fan to make sure it is securely mounted. Tighten the capscrews, if necessary.

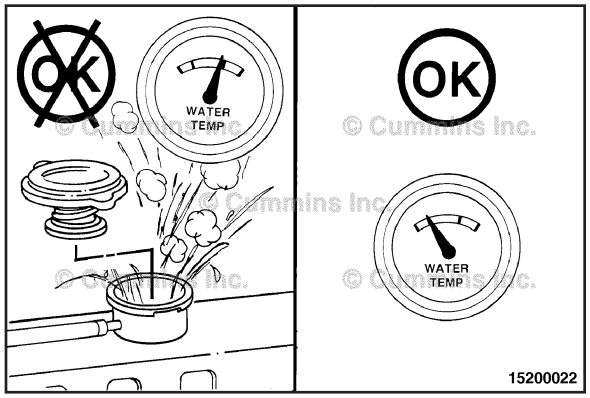


⚠WARNING⚠
Do not straighten a bent fan blade or continue to use a damaged fan. A bent or damaged fan blade can fail during operation and cause personal injury or property damage.



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.



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.

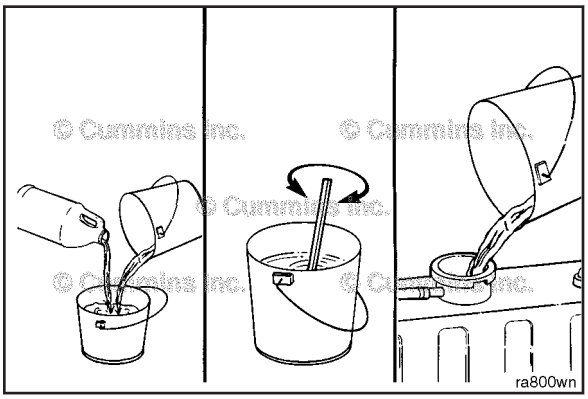
The coolant level **must** be checked daily.

⚠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.

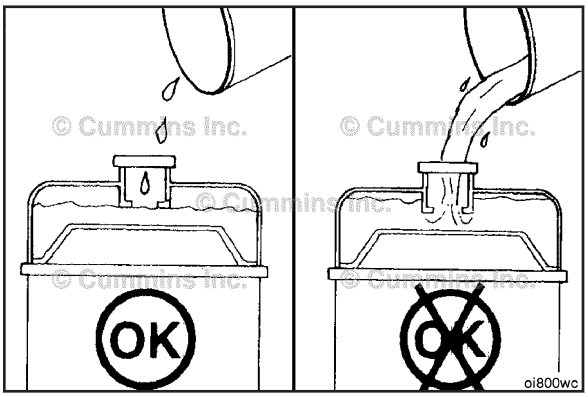
Coolant added to the engine **must** be mixed with the correct proportions of antifreeze, supplemental coolant additive, and water to avoid engine damage.

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.



Notes

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.

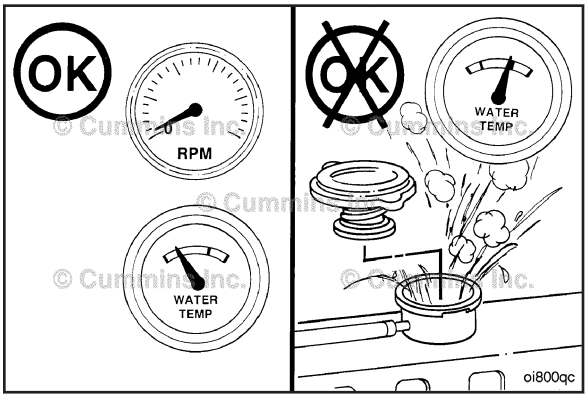
Cooling System

General Information

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

NOTE: Never use a sealing additive to stop leaks in the coolant system. This can result in coolant system plugging and inadequate coolant flow, causing the engine to overheat.

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

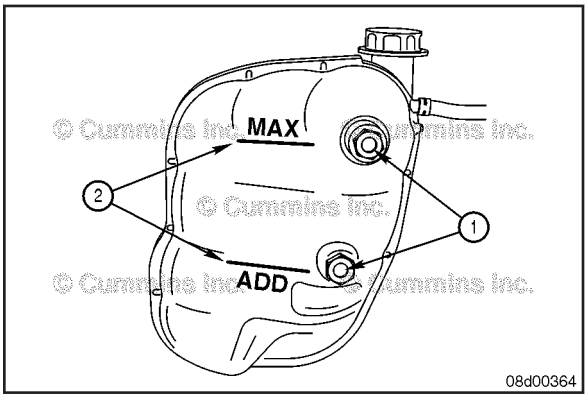


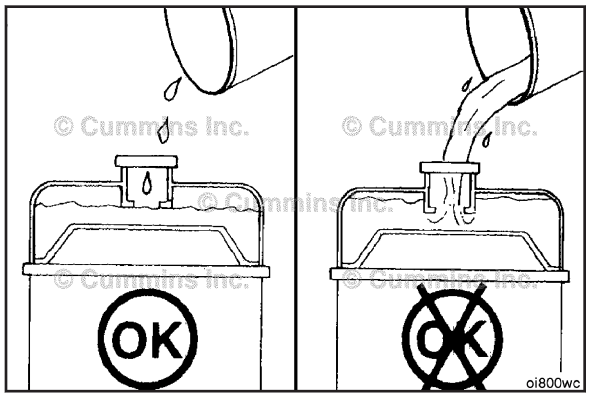
⚠CAUTION⚠
Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool below 50°C [120°F] before adding coolant.

On applications that use a coolant recovery system, check to make sure the coolant is at the appropriate level in the coolant recovery tank for the engine temperature.

Many coolant recovery/expansion tanks, also called "top tanks", have sight glasses (1) or are made of a clear material (**not** shown) to aid in checking the coolant level (2) without removing the radiator cap.

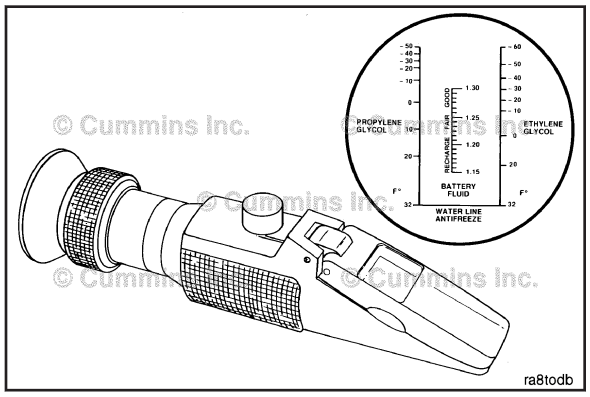
It is important to understand the impact of temperature on the expansion of the coolant. Most "top tanks" do **not** have a provision for a "FULL HOT" coolant level. Filling the "top tank" while hot will result in a low operating level once the system has cooled.





Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill or recovery/expansion tank.

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



Maintenance Check

⚠CAUTION⚠

Over-concentration 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 as it broadens the operating temperature by lowering the coolant's freezing point and by raising its boiling point.

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

Drain

⚠WARNING⚠
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Position the vehicle or equipment on a level surface.

Isolate the engine from the vehicle cooling system by closing coolant flow valves to the equipment heating systems before initiating repair. This will prevent the heater circuit from draining, minimizing the chance for air pockets to be present during the fill process. Refer to the OEM service manual for system isolation valve locations.

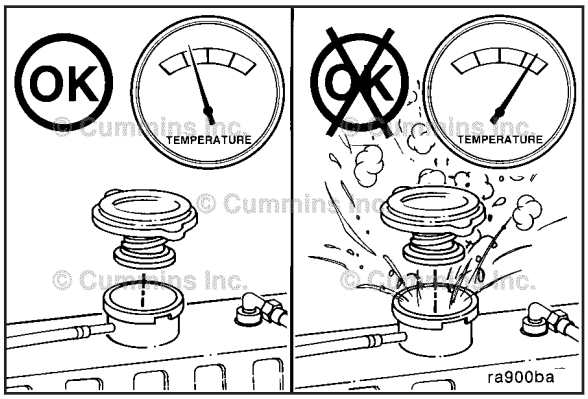
This air can be very difficult to purge in some applications that have several feet of plumbing and multiple heater cores.

NOTE: If the coolant is being changed, or if the cooling system is being flushed, it is desirable to leave the coolant flow valves to the equipment heating systems open, in order to completely drain the system.

Use the OEM service manual for any special coolant drain and fill requirements.

These special instructions can also be located near the cooling system access or fill door on the vehicle.

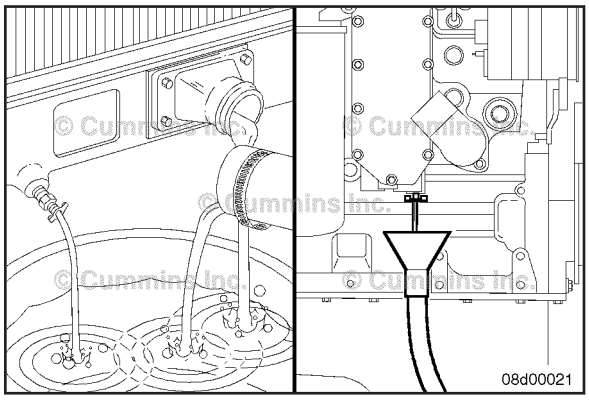
Remove all cooling system fill caps to allow the coolant to drain completely.



⚠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 opening the drain valve on the bottom of the engine oil cooler housing. A drain pan with a capacity of 57 liters [15 gal] is adequate for most applications.

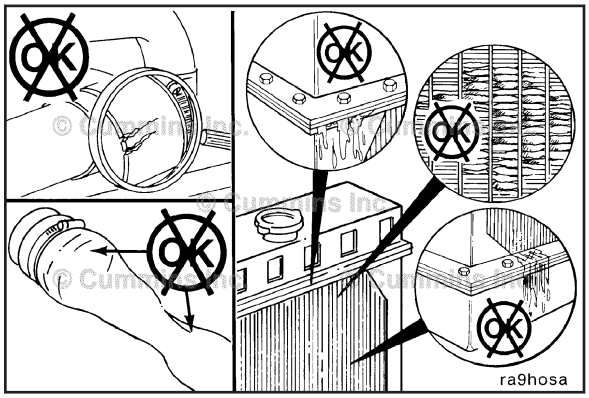
After the cooling system is completely drained, close the drain valves. Refer to the OEM service manual for complete cooling system drain information.

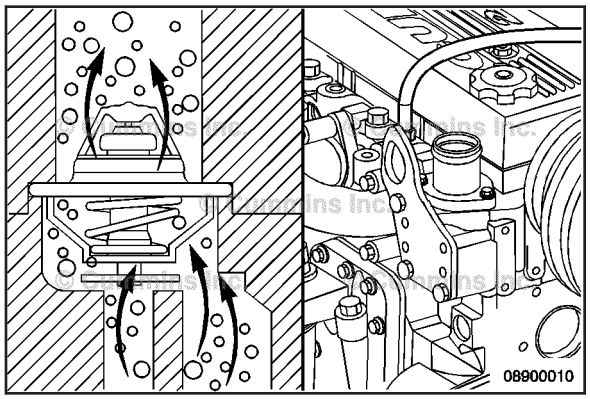


Check for damaged hoses and loose or damaged hose clamps.

Check the radiator for leaks, damage, and buildup of dirt.

Clean and replace as required.





Flush

⚠CAUTION⚠

The system must be filled properly to prevent air locks or serious engine damage can result. 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.

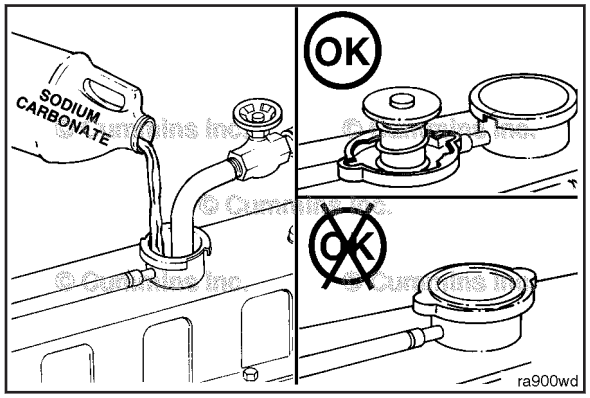
To be sure air is vented during the fill process:

- Some thermostat have check balls that allow air to vent through the thermostat when the thermostat is closed.
- An air vent port connection, which connects to the top tank/coolant recovery tank of the cooling system, is located next to the water outlet.

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

NOTE: An alternate 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 dependent on time, temperature, and concentration levels. An extremely scaled or flow-restricted system, for example, can require higher concentrations of cleaners, higher temperatures, longer cleaning time, or the use of 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.



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

⚠ WARNING ⚠
Coolant is toxic. Keep away from children and pets. Dispose of in accordance with local environmental regulations.

⚠ WARNING ⚠
Do not stand near surge tank or radiator while operating engine with pressure cap off. If the vehicle is equipped with a fill door on side of surge tank, keep it closed due to coolant expansion.

⚠ CAUTION ⚠
Do not operate engine with the pressure cap off at temperatures above 200 degrees F. This can result in potential engine damage by cavitation of the water pump and localized boiling.

⚠ CAUTION ⚠
Before topping off coolant, allow the system temperature to cool to ambient. This will ensure that an adequate amount of coolant is available to the water pump during all periods of operation.

⚠ CAUTION ⚠
Do not relieve the system pressure while hot in order to "top off" immediately before returning the vehicle to service. The system will not be able to generate the pressure through the expansion of the coolant necessary for operation. This can result in potential engine damage by cavitation of the water pump and localized boiling.

Fill the cooling system with a mixture of sodium carbonate and water (or a commercially available equivalent) to the capacity or level stated in the OEM service manual.

NOTE: Adequate venting is provided for a maximum fill rate of 19 liters [5 gal] per minute.

Unless indicated otherwise by the OEM instructions, it is critical that all shutoff valves be returned to their open positions once the system has been refilled and the deaeration process is about to begin. This will help to make sure as much air as possible will be purged from the cooling system. See the OEM service manual for valve locations.

Wait 2 to 3 minutes without starting engine, to allow the system to naturally purge entrained air and the coolant level to stabilize.

Add plain water to bring the level back to FULL.

Turn all cab heater switches to HIGH in order to allow maximum coolant flow through heater core(s). The blower **MUST** be turned ON.

With the cooling system fill cap removed:

- Operate the engine at LOW Idle for 2 minutes.
- Turn off the engine and add plain water to bring the level back to FULL.

With the cooling system fill cap removed:

- Start the engine.

NOTE: 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.

Operate the engine at HIGH idle until the thermostat opens.

Allow the engine to return to LOW idle for 2 minutes before shutting it down. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

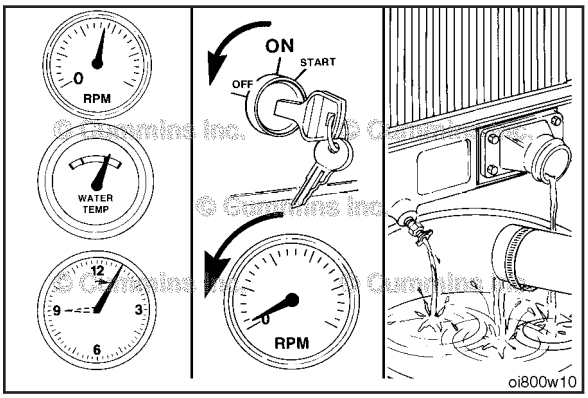
Turn off the engine and check the coolant level according to the OEM service manual recommendations and add, if necessary, to bring it back to the FULL level.

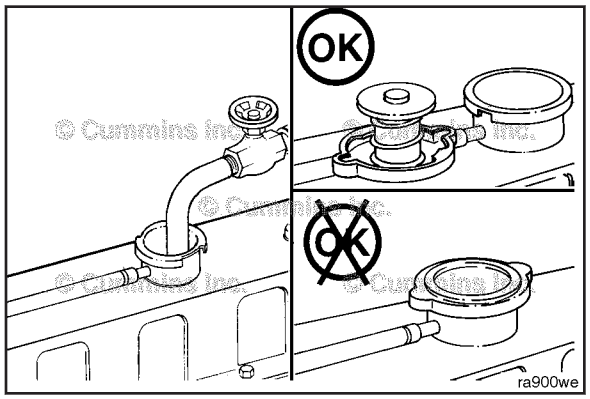
Install the cooling system cap.

Operate the engine for 1 to 1½ hours with the coolant temperature above 80°C [176°F].

Shut the engine off. Allow the coolant temperature to drop to 50° C [122° F] before draining the cooling system.

Drain the cooling system.





⚠WARNING⚠
Do not stand near the surge tank or radiator while operating the engine with the pressure cap off. If the vehicle is equipped with a fill door on side of the surge tank, keep it closed due to coolant expansion.

△CAUTION△
Do not operate the engine with the pressure cap off a temperatures above 93°C [200°F]. This can result in potential engine damage by cavitation of the water pump and localized boiling.

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

Fill the cooling system with good quality water to the capacity or level stated in the OEM service manual.

Unless indicated otherwise by OEM instructions, it is critical that all shutoff valves be returned to their open positions once the system has been refilled and the deaeration process is about to begin. This will help to make sure as much air as possible will be purged from the cooling system. See the OEM service manual for valve locations.

Wait 2 to 3 minutes, without starting the engine, to allow the system to naturally purge entrained air and the coolant level to stabilize.

Add plain water to bring the level back to FULL.

Turn all cab heater switches to HIGH in order to allow maximum coolant flow through heater core(s). The blower **MUST** be turned ON.

With the cooling system fill cap removed:

- Operate the engine at LOW IDLE for 2 minutes.
- Turn off the engine and add plain water to bring the level back to FULL.

With the cooling system fill cap removed:

- Start the engine
- Operate the engine at HIGH IDLE until the thermostat opens.

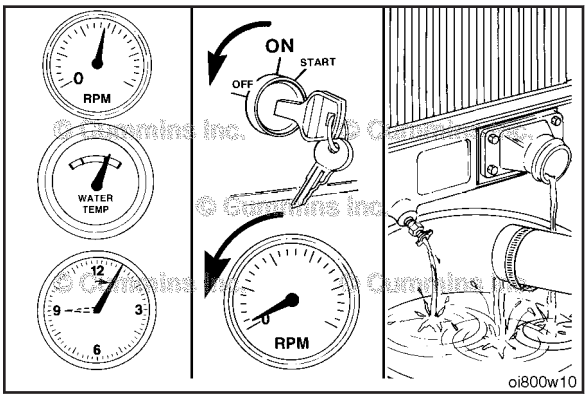
NOTE: After starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

Allow the engine to return to LOW idle for 2 minutes before shutting it down. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

Shut the engine OFF, allow the cooling system to cool to 50°C [122°F].

Drain the cooling system.

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



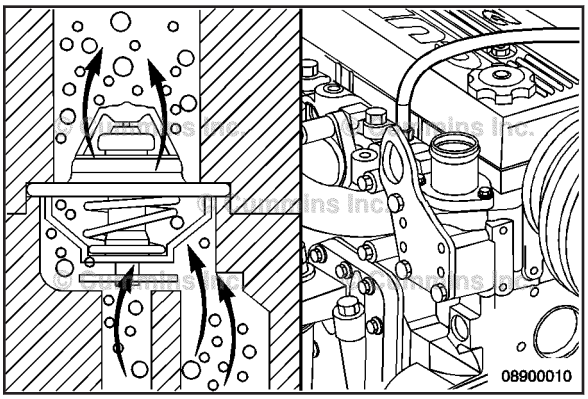
Fill

⚠CAUTION⚠
The system must be filled properly to prevent air locks or serious engine damage can result. 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.

Make sure air is vented during the fill process:

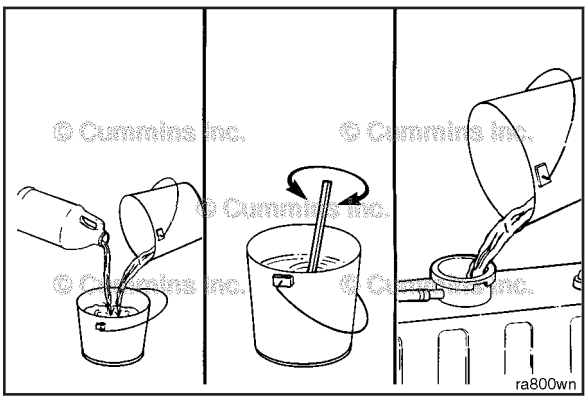
- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- An air vent port connection, which connects to the top tank/coolant recovery tank of the cooling system, is located next to the water outlet.

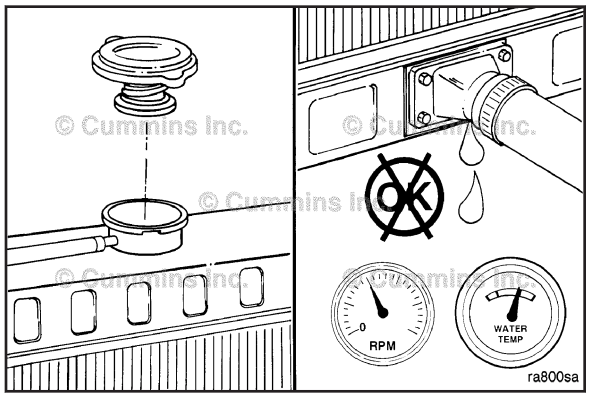
The system has a designed fill rate of 19 liters [5 gal] per minute.



⚠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. Verify the coolant recommendations and specifications. Refer to Procedure 018-004 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] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

⚠WARNING⚠
Do not stand near the surge tank or radiator while operating the engine with the pressure cap off. If the vehicle is equipped with a fill door on side of the surge tank, keep it closed due to coolant expansion.

△CAUTION△
Do not operate the engine with the pressure cap off a temperatures above 93°C [200°F]. This can result in potential engine damage by cavitation of the water pump and localized boiling.

△CAUTION△
Topping off the system while hot is not recommended when using the fill door on transit bus applications equipped with surge tanks. Bringing the level to the bottom of the door while the system is hot will not provide adequate volume of coolant for lower operating temperatures. This can result in cavitation of the water pump and greatly increase the potential for engine damage.

△CAUTION△
Before topping off coolant, allow the system temperature to cool to ambient. This will make sure that an adequate amount of coolant is available to the water pump during all periods of operation.

△CAUTION△
Engine and component damage may result if adequate cool down time is not given after the cooling system pressure has been relieved in order to "top off". System pressure is ONLY generated with temperature rise of the coolant, closing the cooling system while hot will not allow for pressure to build.

Remove the cooling system fill cap.

Fill the cooling system to the capacity or level stated in the OEM service manual, using a mixture of 50 percent water and 50 percent ethylene glycol or propylene glycol antifreeze.

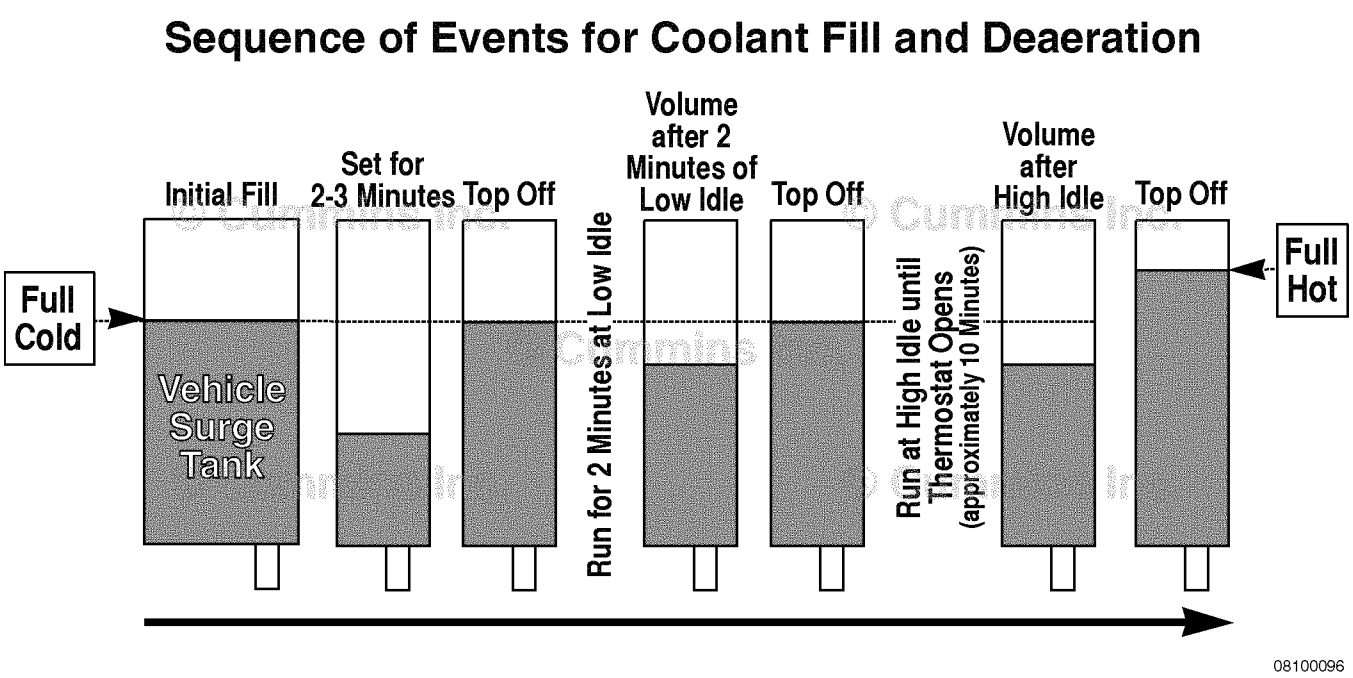


Figure 1: Sequence of Events for Coolant Fill and Deaeration.

NOTE: If all coolant drained from the system was collected, the same volume or more **must** go back into the system. If any drained coolant remains after filling, this is an indication of an air pocket which **must** be purged before returning the vehicle to service.

Unless indicated otherwise by OEM instructions, it is critical that all shutoff valves be returned to their open positions once the system has been refilled and the deaeration process is about to begin. This will help to make sure as much air as possible will be purged from the heating circuit. See the OEM service manual for valve locations.

Wait 2 to 3 minutes, without starting the engine, to allow the system to naturally purge entrained air and for the coolant level to stabilize.

Add 50/50 mixture to bring the coolant level back to the FULL cold level.

Turn all cab heater switches to HIGH in order to allow maximum coolant flow through the heater core(s). The blower **MUST** be turned ON.

With the cooling system fill cap removed:

- Operate the engine at LOW IDLE for 2 minutes.
- Shut the engine OFF and add coolant to bring the level back to the FULL cold level, using 50/50 mixture.

With the cooling system fill cap removed:

NOTE: 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.

- Start the engine.
- Operate the engine at HIGH IDLE until the thermostats open.

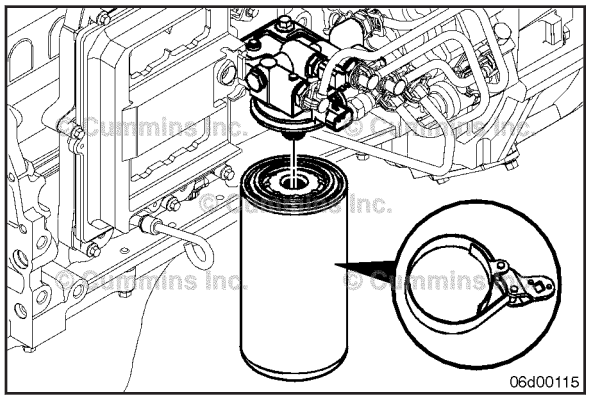
Allow the engine to idle 2 minutes before shutting it down. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

- Shut the engine OFF.
- Top off coolant to the FULL hot level.
- It is the responsibility of the customer to check the cold coolant level and top up if necessary.

NOTE: Certain applications may require an additional 10 minutes of operation time at HIGH IDLE for complete deaeration. For best results, reference the OEM coolant fill procedure for specific instructions.

Install the pressure cap. Operate the engine until it reaches a temperature of 80°C [176°F] and check for coolant leaks.

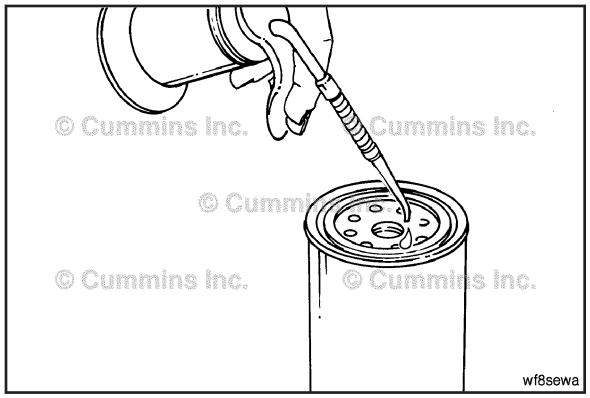
Reference Figure 1 for a graphic explanation of the fill process.



Fuel Filter (Spin-On Type)

Remove

Remove the spin-on fuel filter with fuel filter wrench, Part Number 3398231.

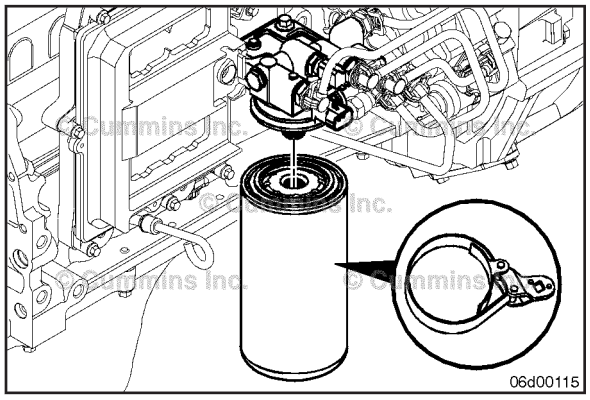


Install

NOTE: Do **not** pre-fill an on-engine fuel filter.

⚠CAUTION⚠
Do not pre-fill an on-engine fuel filter with fuel. The system must be primed after the fuel filter is installed. Pre-filling the fuel filter can result in debris entering the fuel system and damaging fuel system components.

Lubricate the o-ring seal with clean lubricating oil.



⚠CAUTION⚠
Mechanical overtightening will distort the threads, filter element seal, or filter can.

Use the correct fuel filter. See Cummins®/Fleetguard®/ Nelson® filter specifications for the correct part number.

Install the filter on the filter head. Tighten the filter until the gasket contacts the filter head surface.

Tighten the fuel filter an additional 3/4 turn after contact, or consult the filter manufacturers instructions.

Prime fuel system after fuel filter installation.

Prime

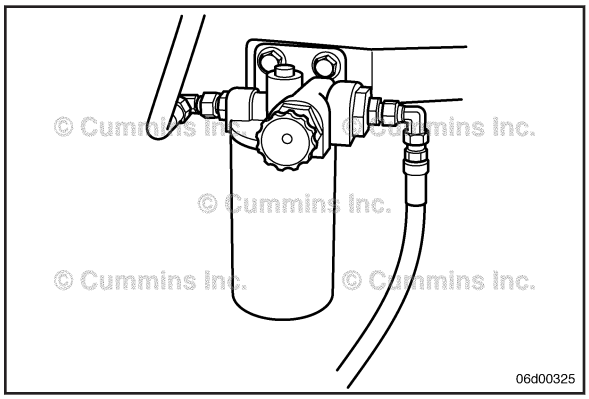
⚠WARNING⚠
The fuel pump high-pressure fuel lines and fuel rail contain very high-pressure fuel. Never loosen any fittings while the engine is running. Personal injury and property damage can result.

To prime the engine use the OEM installed priming device. Typically, a priming pump is installed at or near the pre-filter. See the OEM's instructions for the number of strokes (hand primer) or the cycle time (electric priming pump) needed to prime the low pressure system.

NOTE: It is **not** necessary to vent air from the high pressure system before starting the engine.

NOTE: To prevent damage to the hand pump priming seals, clean the fuel pump head and priming pump with Quick Dry Spray Cleaner, Part Number 3824510, or equivalent, and compressed air prior to priming the fuel system.

Operate the engine and check for leaks.



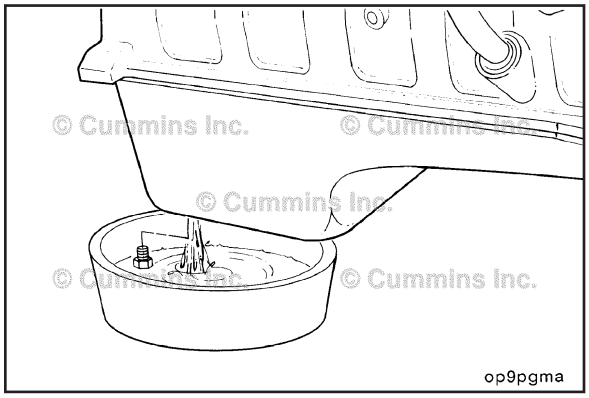
Lubricating Oil and Filters

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. See the Maintenance Schedule to find the correct change interval for your application.

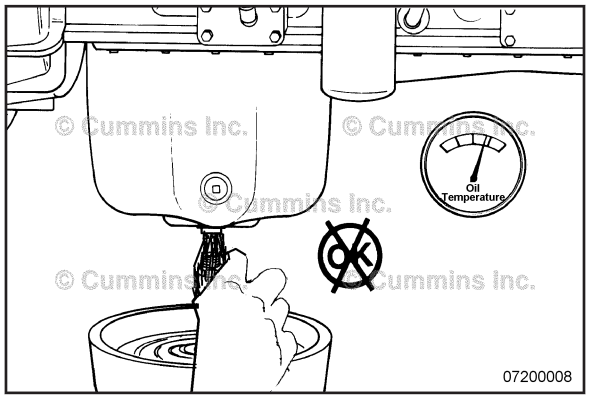


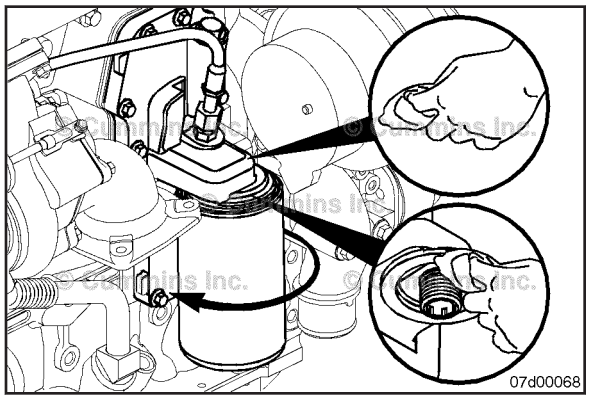
NOTE: For most engines, use a container that can hold at least 20 liters [21 qt] of lubricating oil. Some engines can be equipped with an increased capacity oil pan requiring a container that will hold 28 liters [30 qt] of lubricating oil.

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

Shut off the engine.

Remove the oil drain plug. Drain the oil immediately to be sure all the oil and suspended contaminants are removed from the engine.





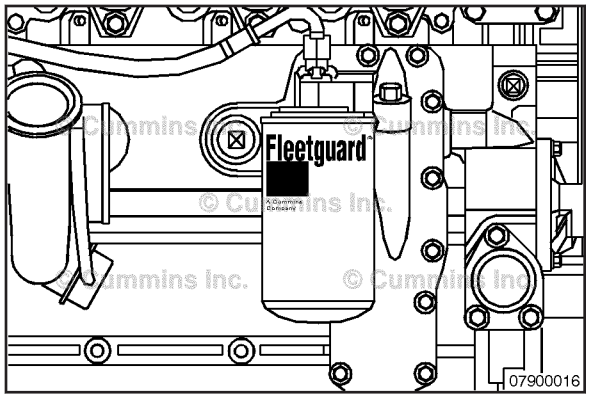
Remove

Clean the area around the lubricating oil filter head.

Use the oil filter wrench, Part Number 3400158, to remove the filter.

Clean the gasket surface of the filter head.

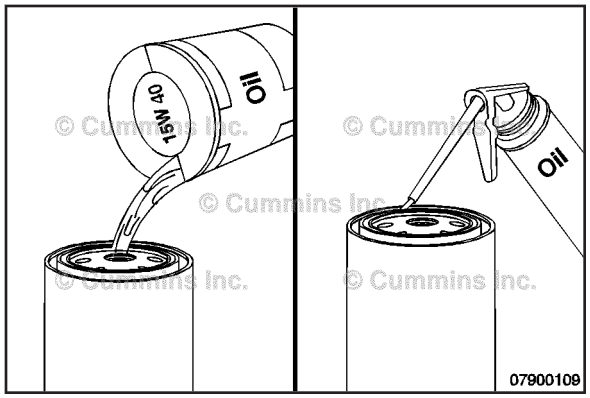
NOTE: The o-ring can stick on the filter head. Be sure it is removed before installing the new filter.



Install

Use the correct oil filter.

See the Cummins®/Fleetguard®/Nelson filter specifications for the correct oil filter part number.



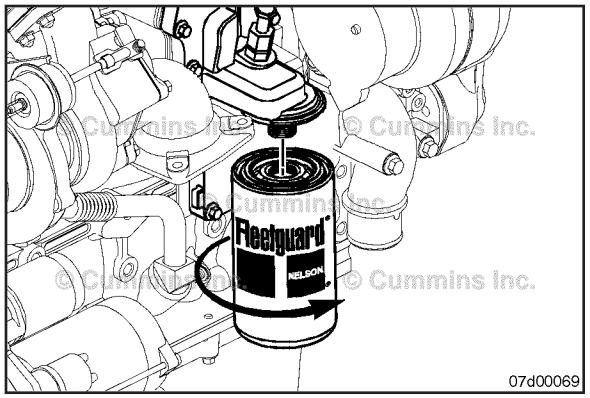
⚠CAUTION⚠
The lack of lubrication during the delay until the filter is pumped full of oil at start-up can damage the engine.

Use clean 15W-40 oil to coat the gasket surface of the filter.

Fill the filter with clean 15W-40 oil.

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

NOTE: Be careful that **no** debris is poured into the filter. If using an oil supply with a metallic or plastic seal under the cap, be careful to peel the seal back. Puncturing the seal with a knife or sharp object can create debris in the oil container.

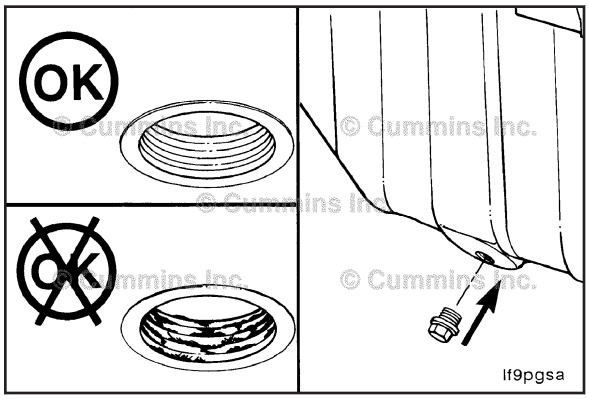


⚠CAUTION⚠
Mechanical overtightening of filter can distort the threads or damage the filter element seal.

Install the filter on the oil filter head. Tighten the filter until the gasket contacts the filter head surface.

Tighten 3/4 to 1 turn after the gasket makes contact with the filter head.

Fill



Clean and check the lubricating oil drain plug threads and sealing surface. Use a new sealing washer, if damaged.

Install the lubricating oil pan drain plug.

Automotive and Industrial Applications:

Steel Oil Pan Drain Plug Torque			
	N•m		ft-lb
M18	60	MIN	44
M22	80	MIN	59

Cast Aluminum Oil Pan Drain Plug Torque			
	N•m		ft-lb
M22	60	MIN	44

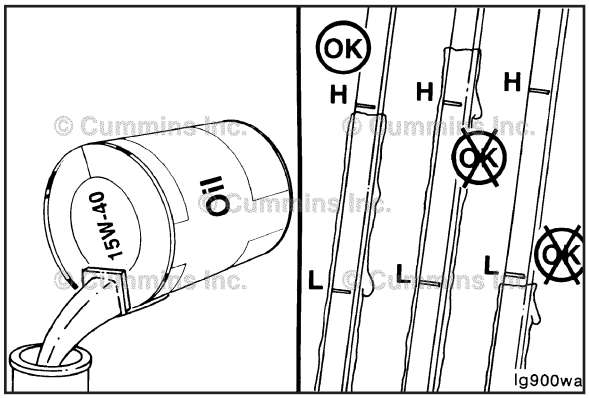
NOTE: Use a high-quality 15W-40 multiviscosity lubricating oil, such as Valvoline Premium Blue®, or its equivalent, in Cummins® engines. Choose the correct lubricating oil for your operating climate as outlined in Section V.

Fill the engine with clean lubricating oil to the proper level. Refer to Procedure 018-017 in Section V.

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

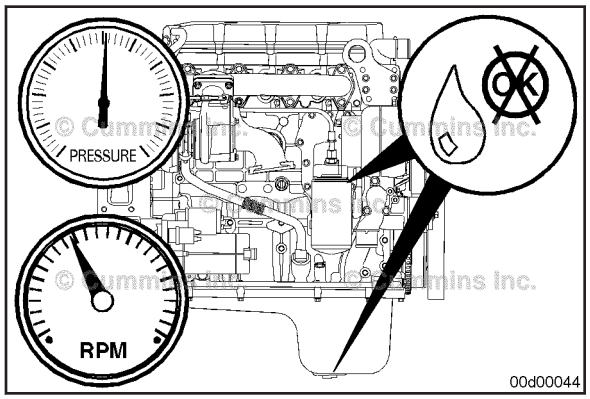
Some applications use a slightly different lubricating oil pan capacity, and all lubricating oil quantities **must** be adjusted accordingly. Contact a local Cummins® Distributor if there are any questions.

The oil capacity for the engine can also be found by entering the engine serial number in Quickserve® Online. (See section E of this manual to locate the ESN) Click on the "Parts" section , and select the Oil Pan. A description of the oil pan used on the engine, including fluid capacities, will be displayed.



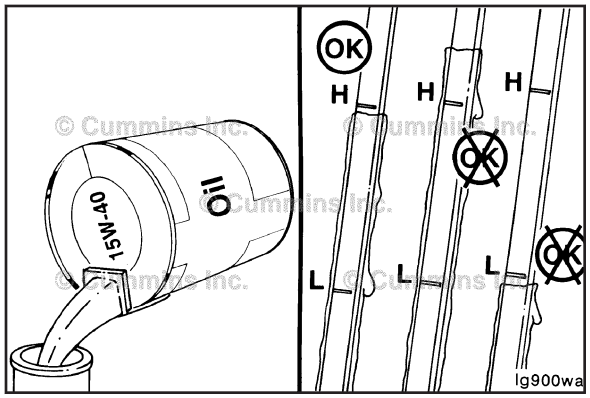
Service Tip:

If the oil capacity of the oil pan is **not** known, fill the lubricating oil pan to the smallest oil pan capacity**.** Refer to Procedure 018-017 in Section V. Then add 1 quart 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.



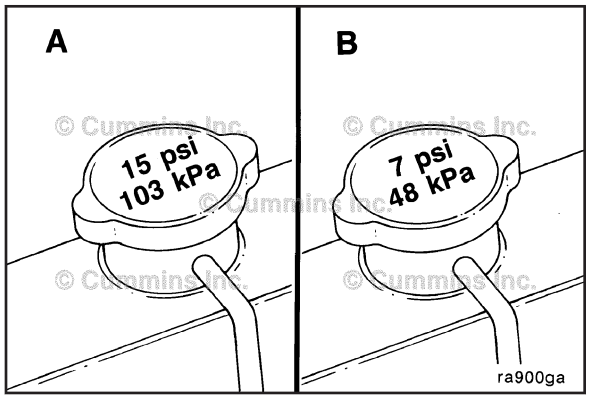
Idle the engine to inspect for leaks at the drain plug and, if replaced, the oil filter seal.

NOTE: Engine oil pressure **must** be indicated on the gauge within 15 seconds after starting. If oil pressure is **not** registered within 15 seconds, shut off the engine immediately to avoid engine damage. Confirm that the correct oil level is in the oil pan.



Shut off the engine. Wait approximately 5 minutes to let the oil drain from the upper parts of the engine. Check the level again.

Add oil as necessary to bring the oil level to the H (high) mark on the dipstick.

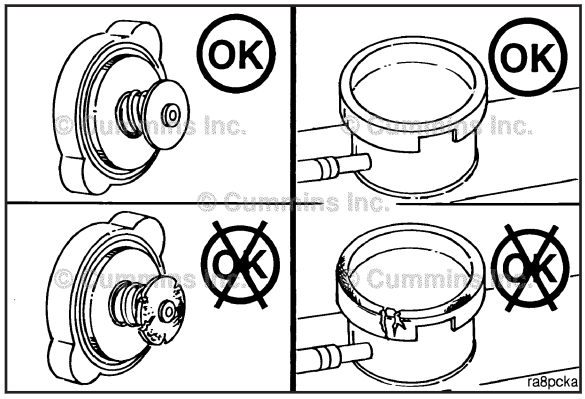


Radiator Pressure Cap

General Information

The cooling system is designed to use a pressure cap to prevent boiling of the coolant. Refer to the OEM's cooling system specifications for the correct radiator pressure cap for your application.

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



Inspect for Reuse

Be sure the correct radiator pressure cap is being used.

Inspect the rubber seal of the pressure cap for damage.

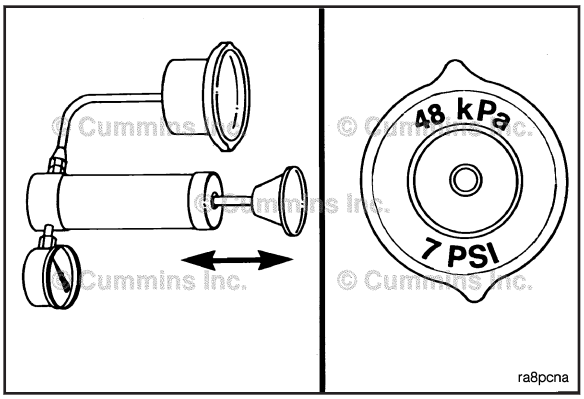
Inspect the radiator fill neck for cracks or other damage.

Refer to the OEM service manual for instructions if the fill neck is damaged.

Pressure-test the radiator cap. Refer to the OEM service manual for radiator cap test procedures.

The pressure cap **must** seal within 14 kPa [2 psi] of the value stated on the cap, or it **must** be replaced.

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



Notes

Section 6 - Maintenance Procedures at 1000 Hours or 1 Year

Section Contents

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Maintenance Procedures - Overview

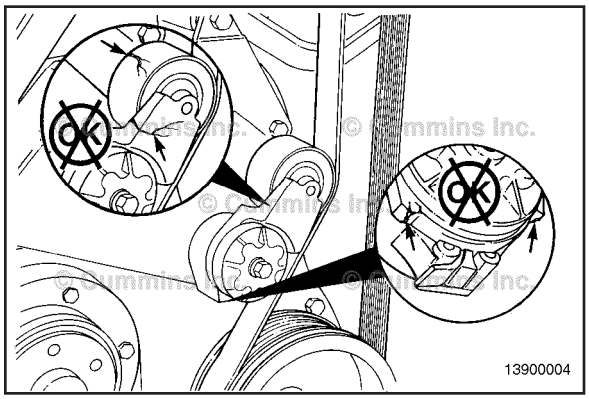
General Information

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

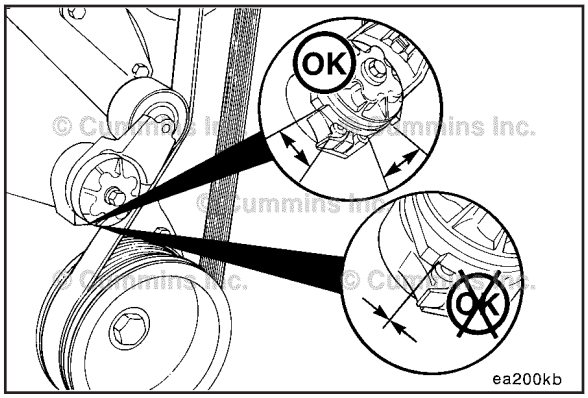
With the engine stopped, check the tensioner arm, pulley, and stops for cracks. If any cracks are found, the tensioner **must** be replaced.



With the belt installed, verify that neither tensioner arm stop is in contact with the spring case stop. If either of the stops is touching:

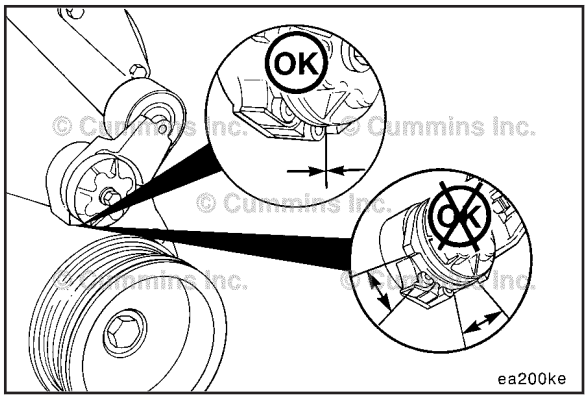
- Verify the correct belt part number is installed.
- If the correct belt is installed, replace the belt. Refer to Procedure 008-002 in Section A.

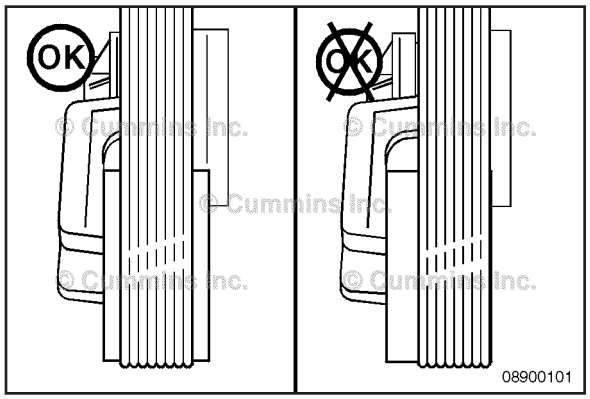
After replacing the belt, if the tensioner arm stops are still in contact with the spring case stop, replace the tensioner.



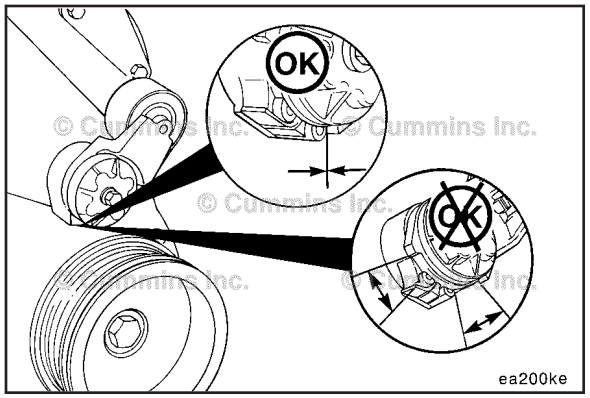
With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop. If these two are **not** touching, the tensioner **must** be replaced.

After replacing the belt, if the tensioner arm stop is still in contact with the spring case stop, the tensioner MUST be replaced.



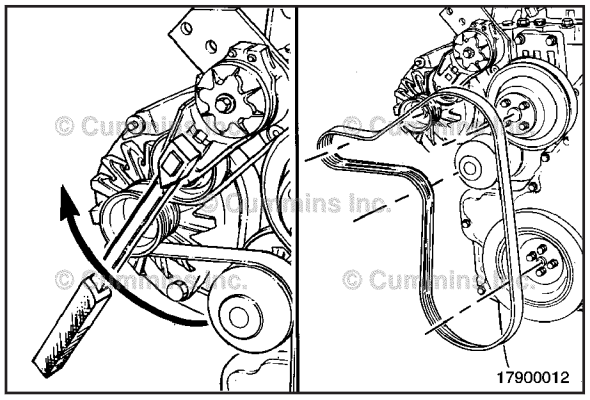


Check the location of the drive belt on the belt tensioner pulley. The belt should be centered on, or close to the middle of, the pulley. Misaligned belts, either too far forward or backward, can cause belt wear, belt roll-offs, or increase uneven tensioner bushing wear.



Remove the drive belt. Refer to Procedure 008-002 in Section A.

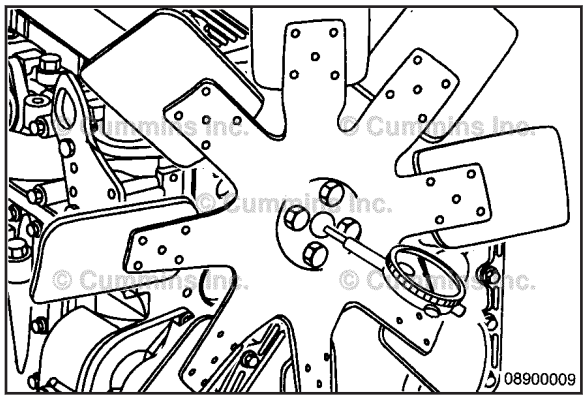
With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop. If they are not touching, the tensioner **must** be replaced.



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

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

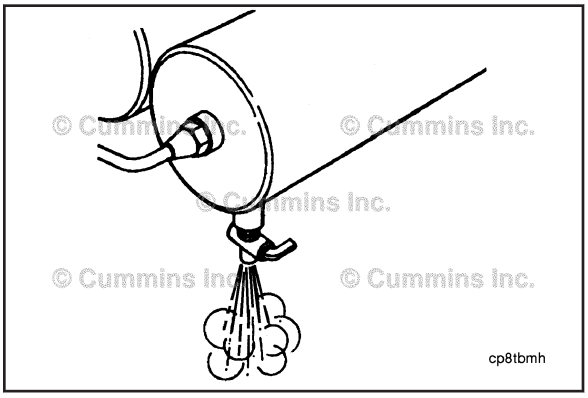
All air compressors have a small amount of lubricating oil carryover that lubricates the piston rings and moving parts. When this lubricating oil is exposed to normal air compressor operating temperatures over time, the lubricating oil will form varnish or carbon deposits. If the following maintenance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

Maintenance Check

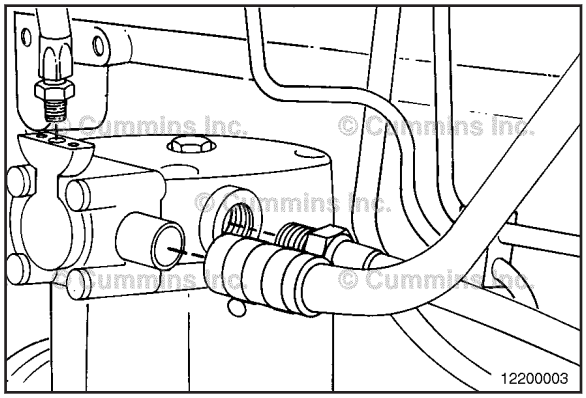
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

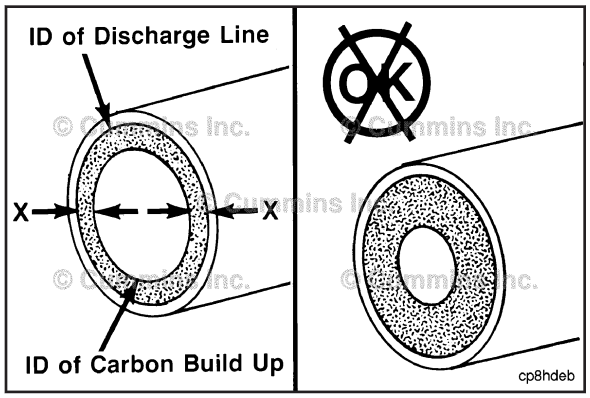
Shut off the engine.

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

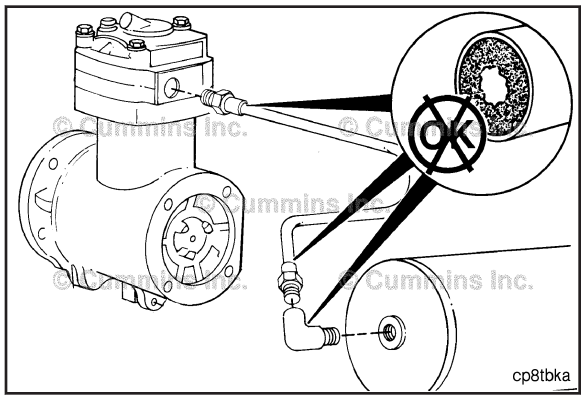


Remove the air compressor discharge line from the air compressor. Location of the air compressor discharge line can be found in Flow Diagram, Compressed Air System in System Diagrams (Section D).

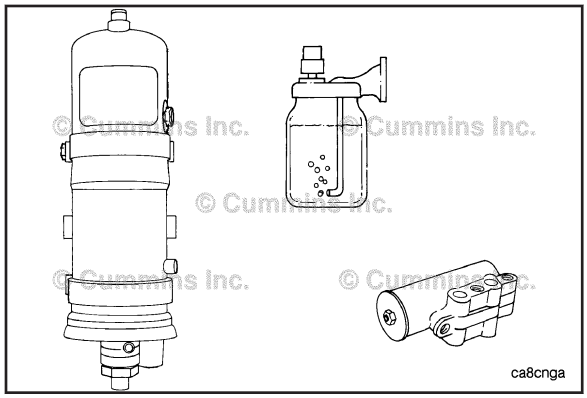




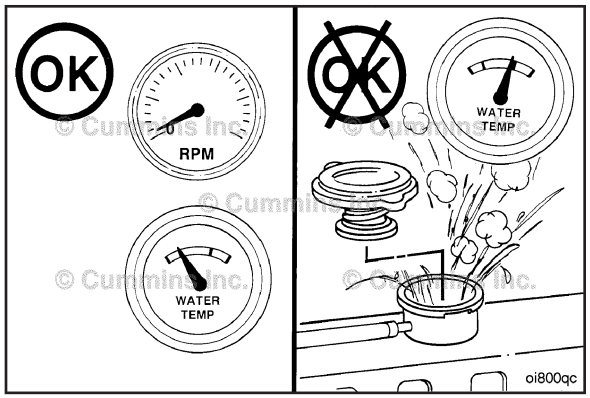
Measure the total carbon deposit thickness inside the air discharge line as shown. If the total carbon deposit (X + X) exceeds 2 mm [1/16 in], clean and inspect the cylinder head, the valve assembly, and the discharge line. Replace if necessary. Contact the Cummins Authorized Repair Location for procedures.



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

General Information

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

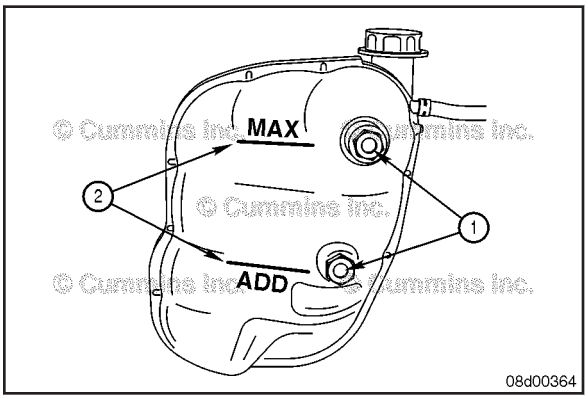
NOTE: Never use a sealing additive to stop leaks in the coolant system. This can result in coolant system plugging and inadequate coolant flow, causing the engine to overheat.

The engine 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 below 50°C [120°F] before adding coolant.

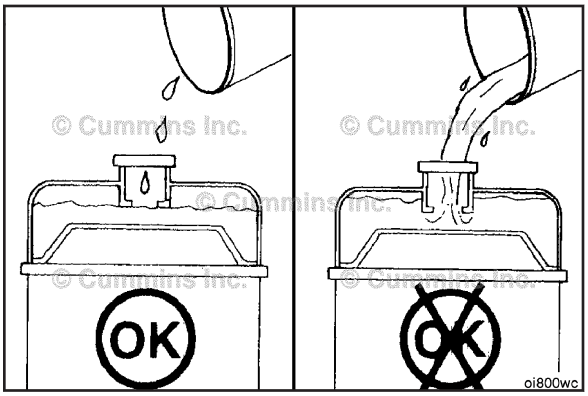
On applications that use a coolant recovery system, check to make sure the coolant is at the appropriate level on the coolant recovery tank, for the engine temperature.

Many coolant recovery/expansion tanks, also called “top tanks”, have sight glasses (1) or are made of a clear material (not shown) to aid in checking the coolant level (2) without removing the radiator cap.



Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill or recovery/expansion tank.

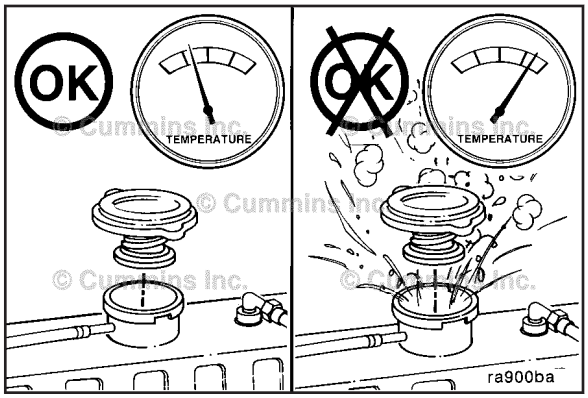
NOTE: Some radiators have two fill necks, both of which **must** be filled when the cooling system is drained.



Drain

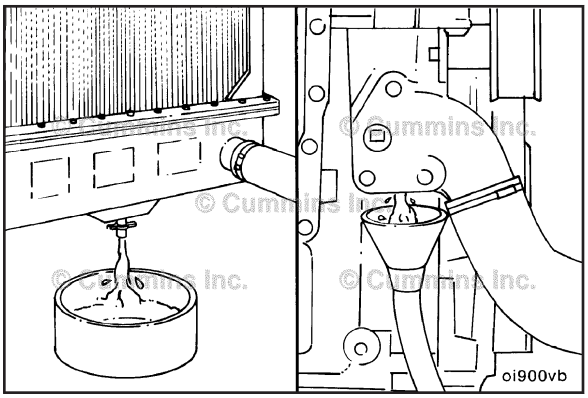
⚠WARNING⚠
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

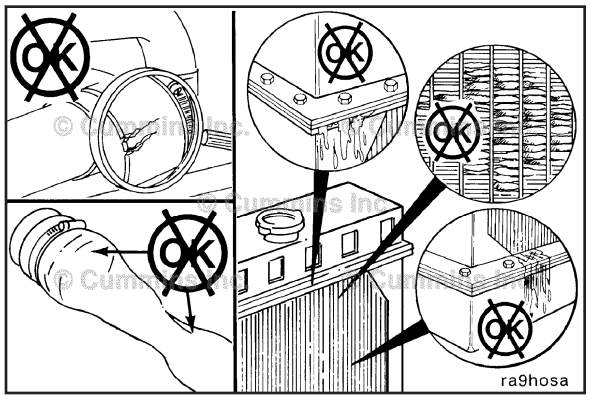
Remove the radiator/expansion tank cap.



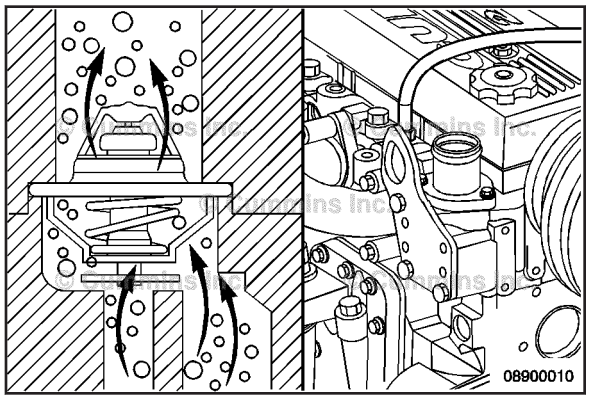
⚠WARNING⚠
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

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⚠

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.

To be sure air is vented during the fill process:

- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- A deaeration port is located next to the water outlet connection which connects to the top tank/coolant recovery tank of the cooling system.

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

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

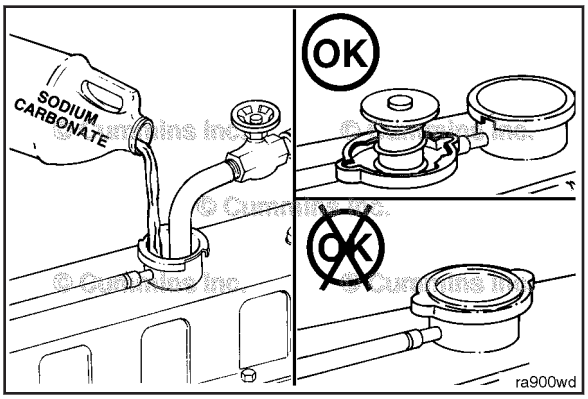
RESTORE™ is a heavy-duty cooling system cleaner that removes corrosion products, silica gel, and other deposits. The performance of RESTORE™ is dependent on time, temperature, and concentration levels. An extremely scaled or flow-restricted system, for example, can require higher concentrations of cleaners, higher temperatures, or longer cleaning times or the use of 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 [5 gal.] per minute.

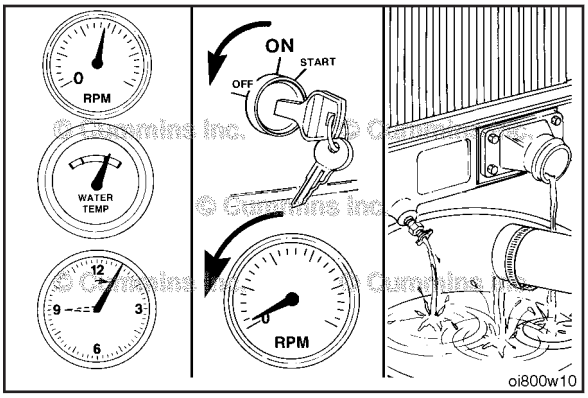


⚠WARNING⚠

Coolant is toxic. Keep away from children and pets. Dispose of in accordance with local environmental regulations.

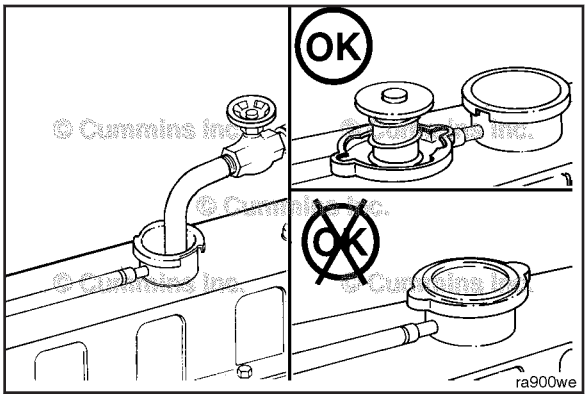
Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

Shut the engine off, and drain the cooling system.



Fill the cooling system with clean water.

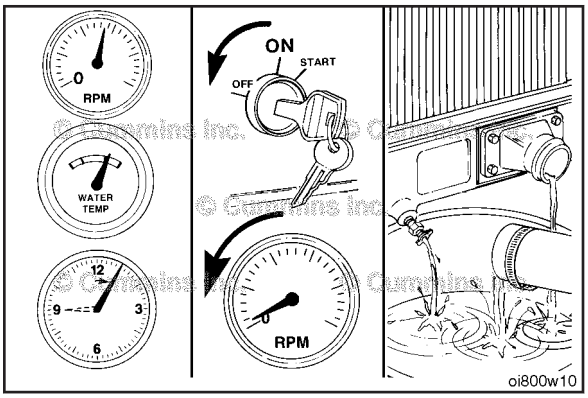
NOTE: Do **not** install the radiator cap.

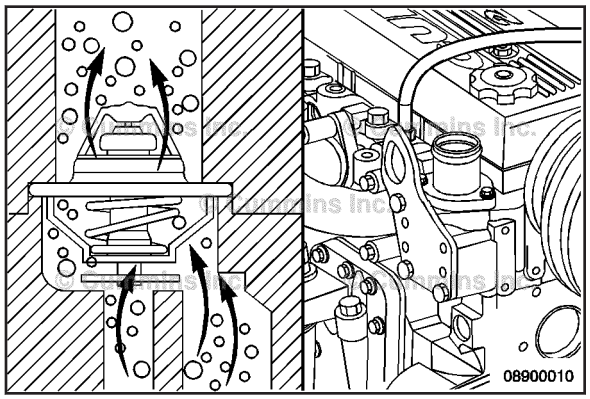


Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

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.





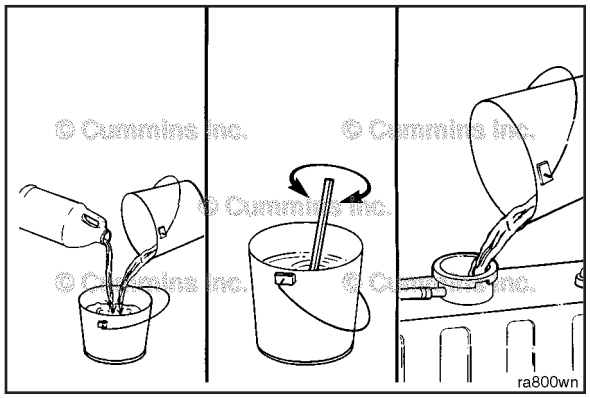
Fill

⚠CAUTION⚠
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.

To be sure air is vented during the fill process:

- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- A deaeration port is located next to the water outlet connection which connects to the top tank/coolant recovery tank of the cooling system.

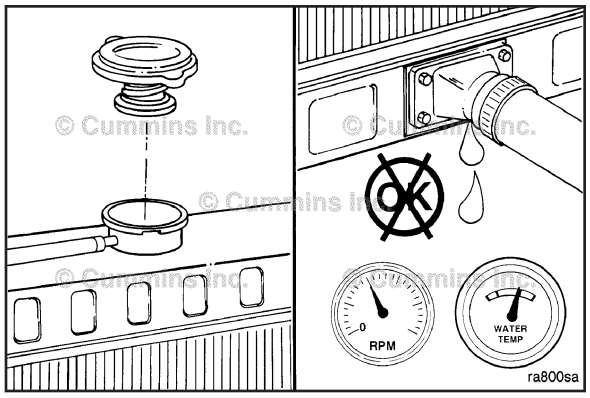
The system has a design fill rate of 19 liters [5 gal.] per minute.



⚠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 cooling 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] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

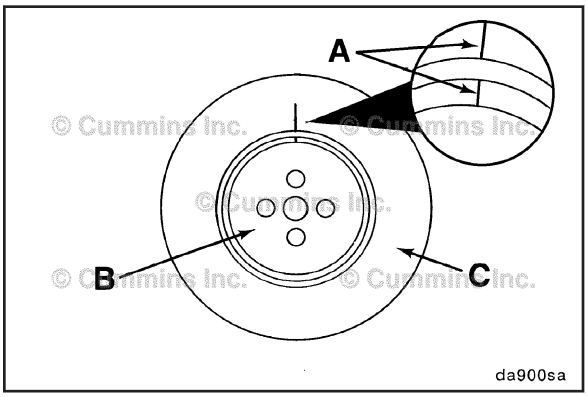
Install the pressure cap. Operate the engine until it reaches a temperature of 80°C [180°F] and check for coolant leaks.

Check the coolant level again to make certain the system is full of coolant or that the coolant level has risen to the hot level in the recovery/expansion tank in the system, if so equipped.

Vibration Damper, Rubber

Inspect

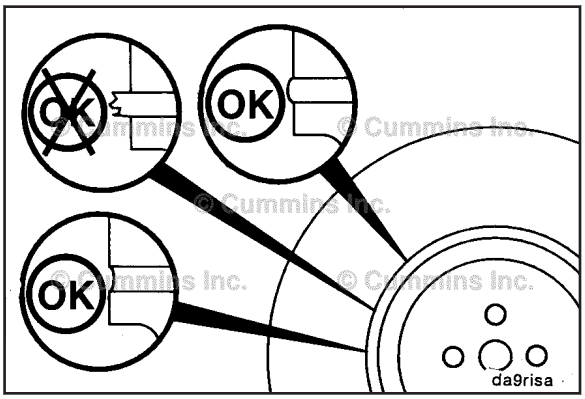
Check the index lines (A) in the vibration damper hub (B) and the inertia member (C). If the lines are more than 1.59 mm [1/16 in] out of alignment, replace the vibration damper.



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

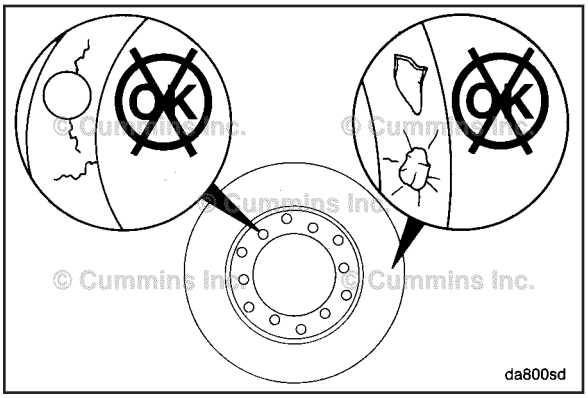
⚠CAUTION⚠

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 8 - Maintenance Procedures at 5000 Hours or 4 Years

Section Contents

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Maintenance Procedures - Overview

General Information

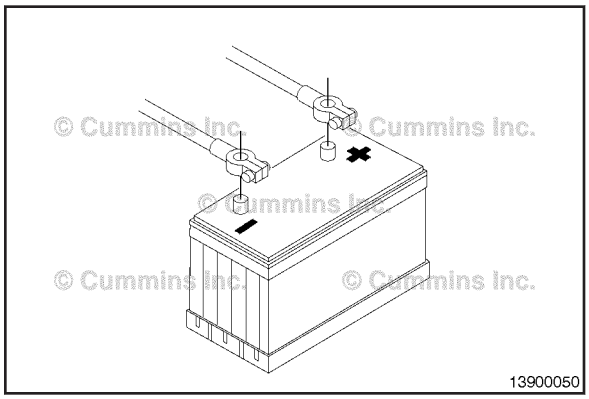
All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

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.

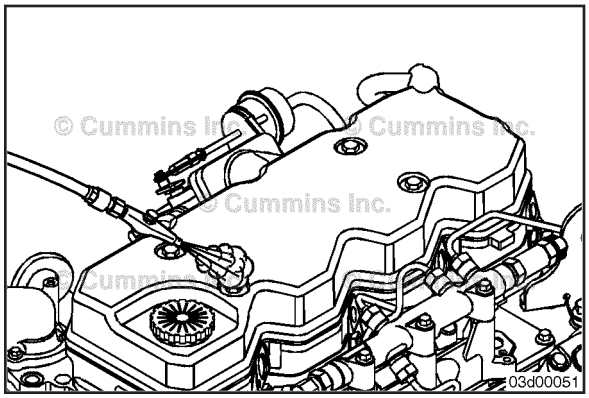
- Disconnect the batteries. Refer to the original equipment manufacturer (OEM) service manual.

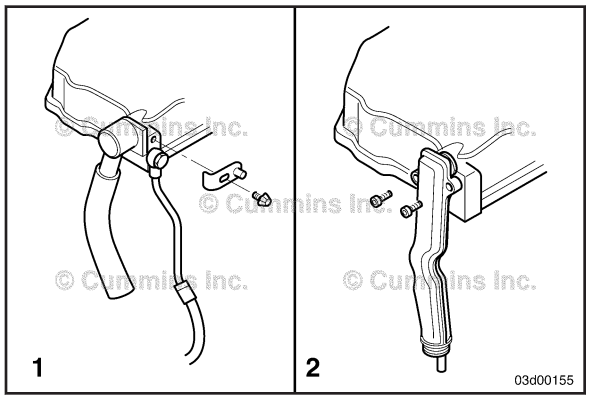


Remove

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

Prior to removing any components, use compressed air to remove any loose debris from around the mounting fasteners and sealing joints.



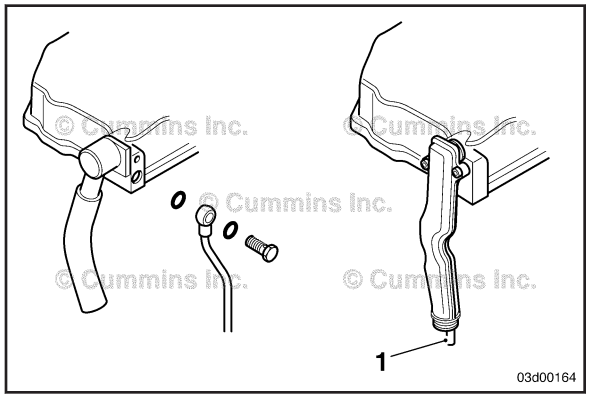


Disconnect the breather tube connection at the back of the rocker lever cover.

In general, two types of breather tube connections are used at the rocker lever cover:

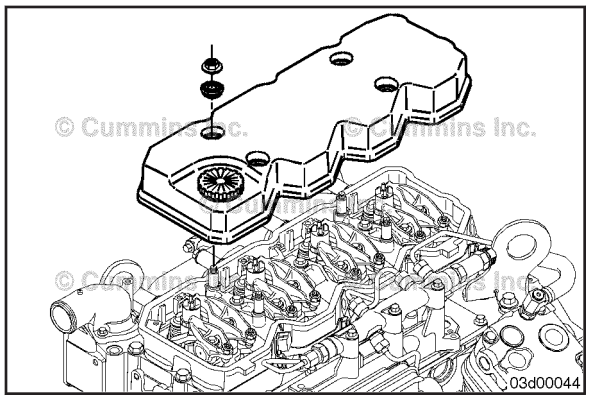
- A clamping plate and capscrew hold the breather tube connection to the rocker lever cover. Remove the capscrew and clamping plate to disconnect the breather tube connection from the rocker lever cover.
- One or two capscrew(s) directly mount the breather tube connection to the rocker lever cover. Remove the capscrew(s) to disconnect the breather tube connection from the rocker lever cover.

NOTE: Some breather tube connections use internal Torx™ capscrews to secure the breather tube connection to the rocker lever cover.



If equipped, at the rear of the rocker lever cover, remove the banjo bolt and sealing washers connecting the breather oil drain line to the rocker lever cover.

NOTE: Not all engines with an internal mounted crankcase breather are equipped with an external breather oil drain line. On some engines the breather oil drain line is internal to the breather connection tube (1).



NOTE: Do **not** remove the rocker lever gasket on engines in which the rocker lever cover gasket is fit into a groove at the base of the rocker lever cover. The gasket is reusable. Once the gasket is removed from the rocker lever cover, it **must** be replaced.

Remove the mounting nuts and isolators from the rocker lever cover.

NOTE: If equipped, it may be necessary to gently pry the breather tube connection from the back of the rocker lever cover while removing.

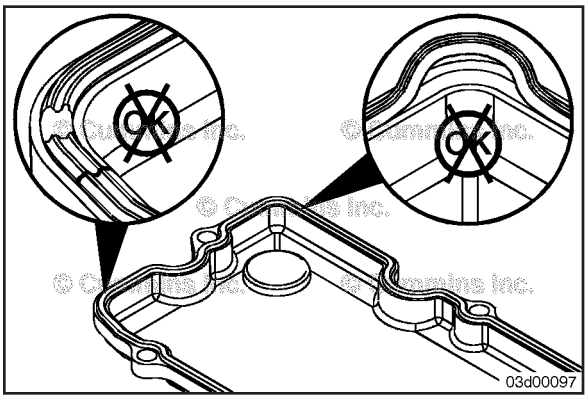
Remove the rocker lever cover.

NOTE: Check the gasket while it is installed in the valve cover. Once the gasket is removed from the cover it **must** be replaced.

Check the gasket for cracks on the sealing surface.

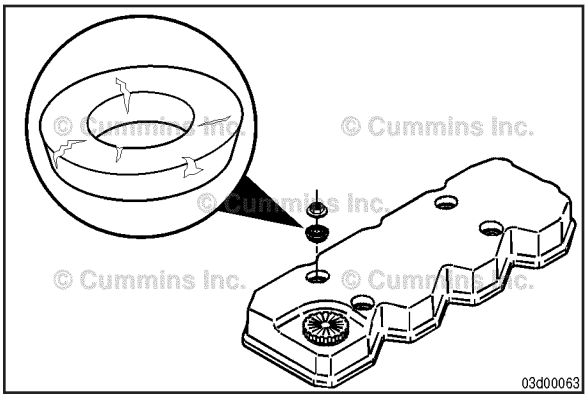
Replace the gasket if damage is present.

Replace the gasket if it is removed from the groove in the rocker lever cover.



Inspect the rubber isolators for cracks.

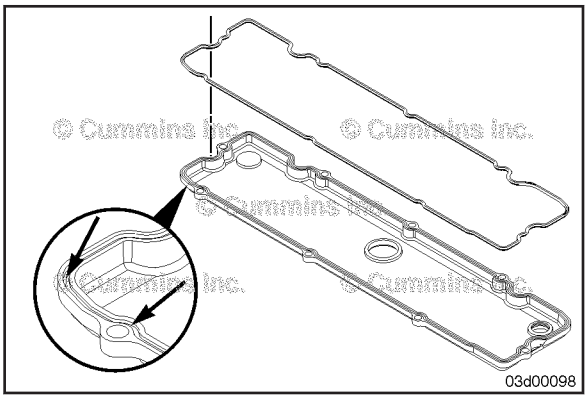
Replace if cracked or broken.



NOTE: If the gasket has been removed from the rocker lever cover, a new gasket **must** be used.

If replacing the press-in rocker lever gasket, the following installation procedure **must** be used.

- Press the molded gasket into the corners of the rocker lever cover
- Press the rest of the gasket into the rocker lever cover.

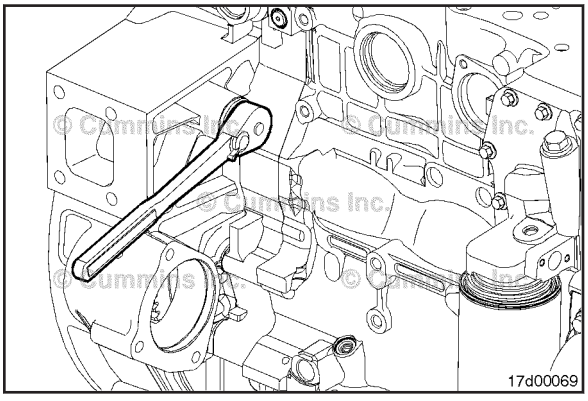


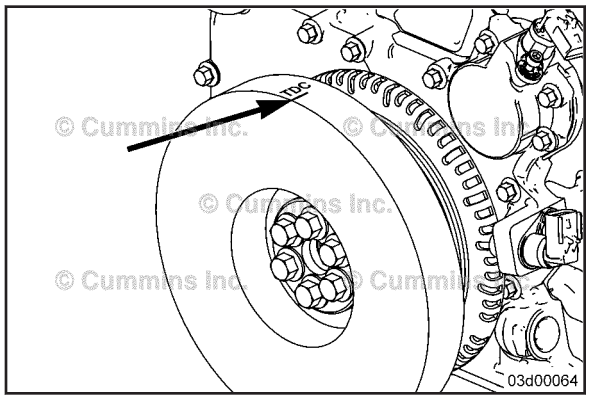
Adjust

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

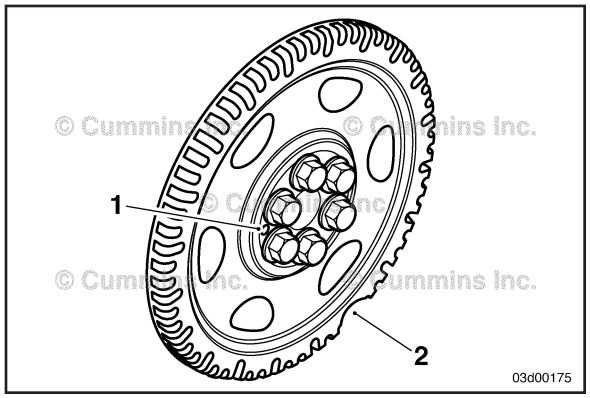
Use the barring tool, Part Number 3824591, to rotate the crankshaft until the number 1 cylinder is at TDC.

TDC can be determined by the following method:

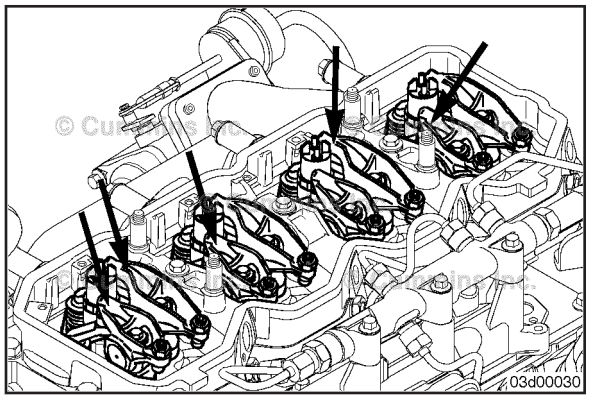




Align the vibration damper/crankshaft speed indicator ring so the TDC indicator is at the 12 o'clock position. If both number 1 cylinder rocker levers are loose, move to the following steps. If both number 1 cylinder rocker levers are **not** loose, rotate the crankshaft 360 degrees.



NOTE: If no TDC mark is present on either the vibration damper or the crankshaft speed indicator ring, align the large gap in the crankshaft speed indicator ring to the 5 o'clock position (2). The dowel pin will be visible in the 9 o'clock position (1). Check that both number 1 cylinder rocker levers are loose. If they are **not** loose, rotate the crankshaft 360 degrees and check again.

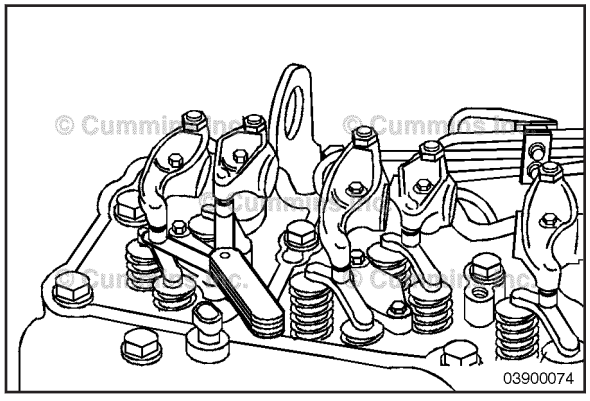


With the engine in this position, lash can be checked on the following rocker arms:

(E = exhaust, I = Intake)

Four-cylinder 1I, 1E, 2I, and 3E

Six-cylinder 1I, 1E, 2I, 3E, 4I, and 5E.



Lash Check Limits

	mm		in
Intake	0.152	MIN	0.006
	0.381	MAX	0.015
Exhaust	0.381	MIN	0.015
	0.762	MAX	0.030

NOTE: Checking the overhead setting is usually performed as part of a troubleshooting procedure, and resetting is **not** required during checks, as long as the lash measurements are within the above ranges.

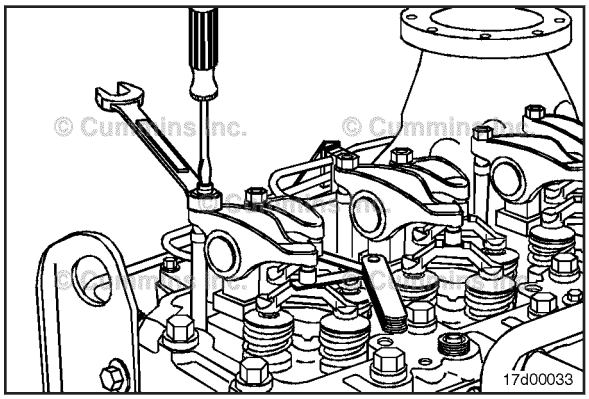
NOTE: The clearance is correct when some resistance is “felt” when the feeler gauge is slipped between the crosshead and the rocker lever socket.

Measure lash by inserting a feeler gauge between the crosshead and the rocker lever socket. If the lash measurement is out of specification, loosen the locknut, and adjust the lash to nominal specifications.

Lash Specifications		
	mm	in
Intake	0.254	0.010
Exhaust	0.508	0.020

Tighten the locknut and measure.

Torque Value: 24 N•m [212 in-lb]



Use the barring tool, Part Number 3824591, to rotate the crankshaft 360 degrees.

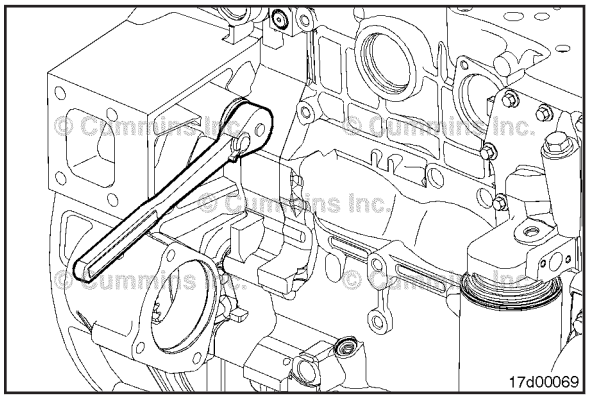
Following the same steps and specifications as previously stated, measure lash for the following rockers:

(E = Exhaust, I = Intake).

Four-cylinder 2E, 3I, 4E, and 4I:

Six-cylinder 2E, 3I, 4E, 5I, 6I, and 6E.

Reset if out of specification.



Install

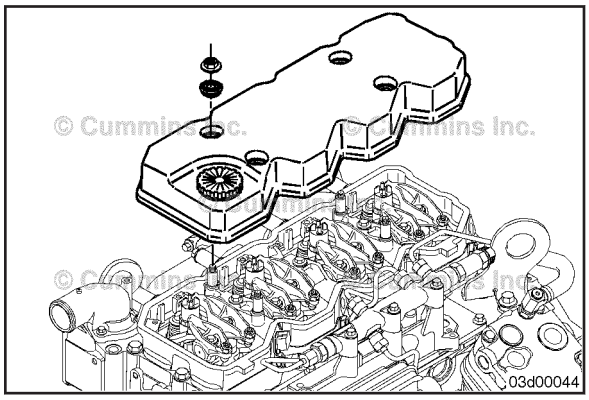
Stud Mounted Rocker Lever Cover.

Install the rocker lever cover over the mounting capscrews.

Install the isolators and mounting nuts.

Tighten the mounting nuts.

Torque Value: 24 N•m [212 in-lb]



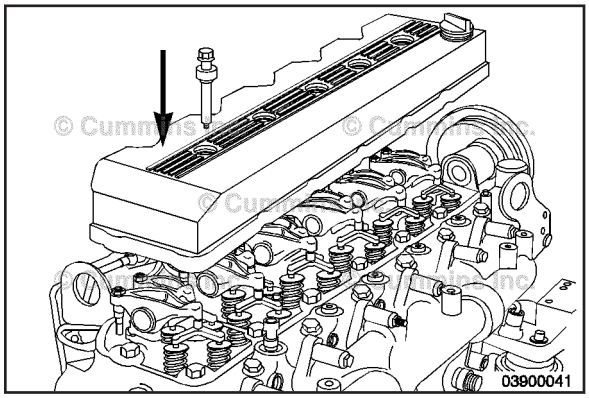
Capscrew Mounted Rocker Lever Cover.

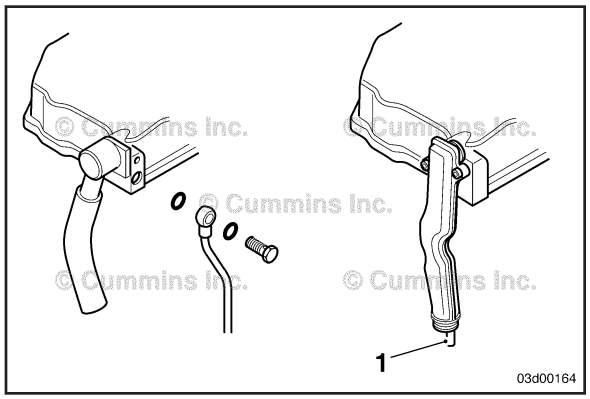
Install the rocker lever cover.

Install the mounting capscrews and isolators.

Tighten the mounting capscrews.

Torque Value: 24 N•m [212 in-lb]

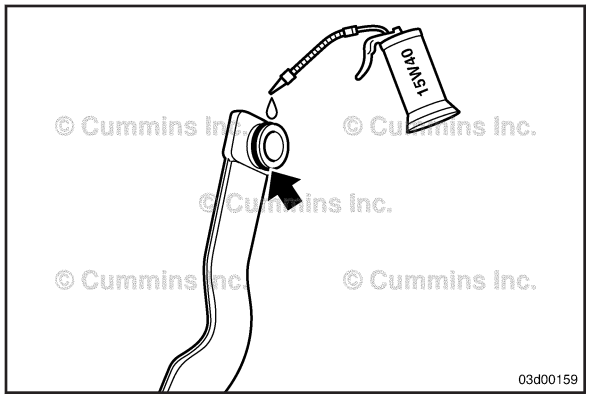




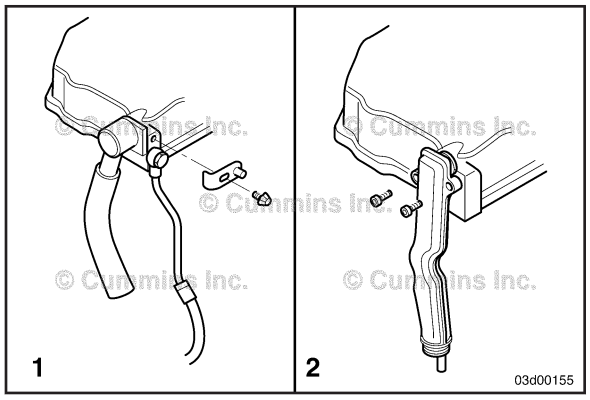
If equipped, at the rear of the rocker lever cover, install the banjo bolt and sealing washers connecting the breather oil drain line to the rocker lever cover.

Torque Value: 12 N•m [106 in-lb]

Not all engines with an internal mounted crankcase breather are equipped with an external breather oil drain line. On some engines the breather oil drain line is internal to the breather connection tube (1).



Prior to connecting the breather connection tube to the rocker lever cover, apply clean engine oil to the o-ring located on the breather tube connection.



Connect the breather tube connection to the rocker lever cover.

In general, two types of breather tube connections are used at the rocker lever cover:

- A clamping plate and capscrew hold the breather tube connection to the rocker lever cover. Install the capscrew and clamping plate to connect the breather tube connection to the rocker lever cover.
- One or two capscrew(s) directly mount the breather tube connection to the rocker lever cover. Install the capscrew(s) to connect the breather tube connection to the rocker lever cover.

Tighten the Capscrew(s).

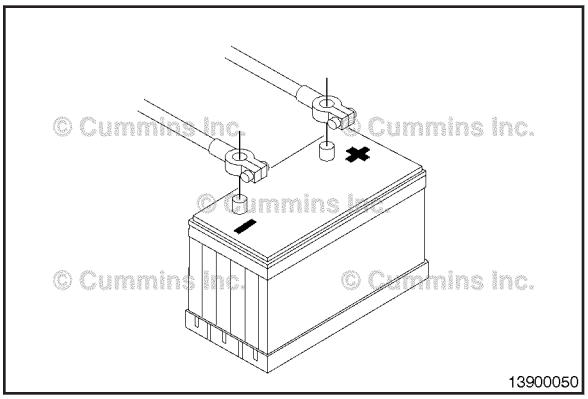
Torque Value: 10 N•m [89 in-lb]

Some breather tube connections use internal Torx™ capscrews to secure the breather tube connection to the rocker lever cover.

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. Refer to the OEM service manual.
- Operate the engine and check for leaks.



Notes

Section A - Adjustment, Repair, and Replacement

Section Contents

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Alternator

General Information

Due to the number of different alternator brands and configurations, the following procedure has been generalized to cover the most common configurations. Consult the alternator manufacturer for any information that is **not** covered in this procedure.

Typical Delco™ Alternator Wiring System

Indicator (I) Terminal

The main function of the indicator (I) terminal is to indicate if the alternator is working correctly. Typically, an indicator light is wired to this terminal. If the alternator is **not** charging properly, the light turns on. Another function of the indicator (I) terminal is that it can be used to supply up to 1 ampere of output at system voltage.

Lamp (L) Terminal

Similar to the I terminal, the L terminal is used to indicate if the alternator is working correctly. The difference between the L terminal and the I terminal is that the L terminal is a current sink **only** and can **not** be used to reduce turn on speed.

Relay (R) Terminal

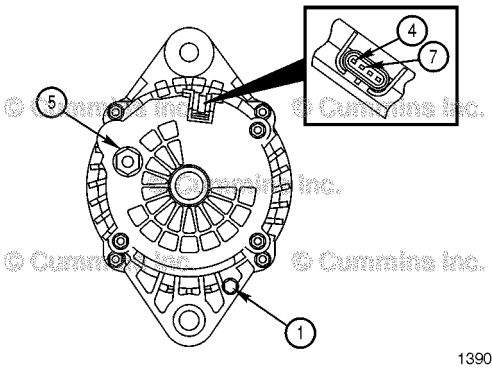
The function of the relay (R) terminal varies. It can supply up to 4 amperes of output at one-half nominal alternator voltage to power items such as a tachometer or an hour meter.

One-Wire System

This is the simplest of the wiring systems because the **only** wires connected to the alternator are at the battery (BAT) and ground terminals. (See the illustrations below.) Connecting to the R terminal, L terminal, and I terminal is optional.

Three-Wire System

This system requires more wiring because it has a battery (BAT) terminal, R terminal, two blade terminals identified as number 1 and number 2, and a ground terminal. Typically, in the three-wire system, the number 1 blade terminal serves as the I terminal. (See the illustrations below.) The advantage of the three-wire system is that it provides the same features as the one-wire system, plus remote sense. By connecting the number 2 blade terminal to the battery's positive (+) terminal, the voltage is both sensed and regulated at the battery, instead of at the alternator. This eliminates the potential for voltage losses in the wiring from the alternator to the battery.

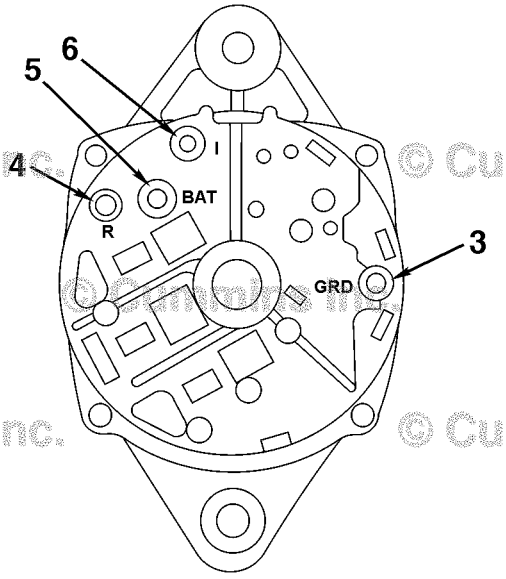


One Wire System, Typical Alternator (Delco-Remy™) with Combined Metri-Pack™ Connector

One Wire System, Typical Alternator (Delco-Remy™) with Combined Metri-Pack™ Connector		
1	GRD*	Ground
4	R*	Charge indicator, automatic lockout system, tachometer**
5	BAT	Battery
7	L	Lamp Terminal

***Not** all alternators have this feature.

**Provides voltage pulses at about one-half system voltage at a frequency of one-tenth of alternator rpm.



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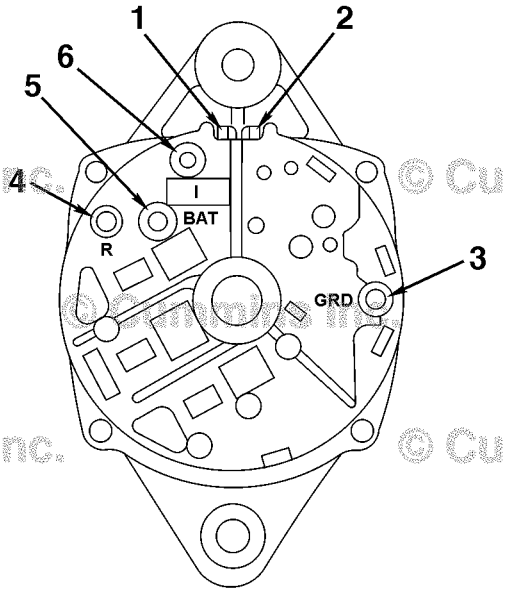
One Wire System, Typical Alternator (Delco-Remy™

One Wire System, Typical Alternator (Delco-Remy™)		
3	GRD*	Ground
4	R*	Charge indicator, automatic lockout system, tachometer**
5	BAT	Battery
6	I*	Indicator light

***Not** all alternators have this feature.

**Provides voltage pulses at about one-half system voltage at a frequency of one-tenth of alternator rpm.



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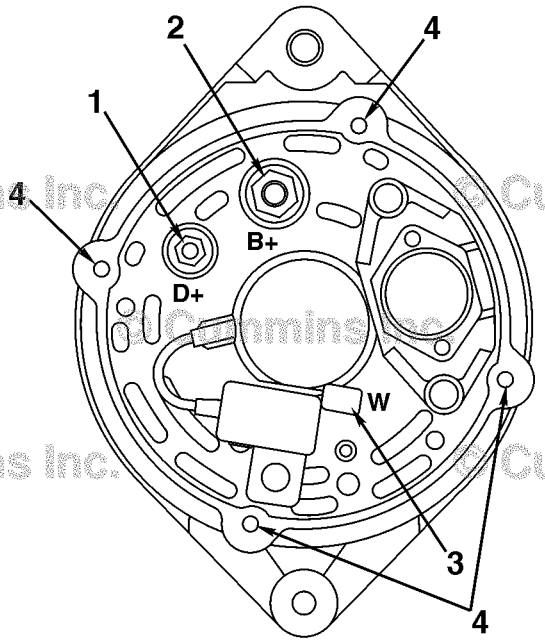
Three Wire System, Typical Alternator (Delco-Remy™)

Three Wire System, Typical Alternator (Delco-Remy™)		
Key	**Terminal**	**Connected To**
1	Blade number 1*	Indicator light
2	Blade number 2	Voltage sense
3	GRD*	Ground
4	R*	Charge indicator, automatic lockout system, tachometer**
5	BAT	Battery
6	I*	Indicator light

***Not** all alternators have this feature.

**Provides voltage pulses at about one-half system voltage at a frequency of one-tenth of alternator rpm.



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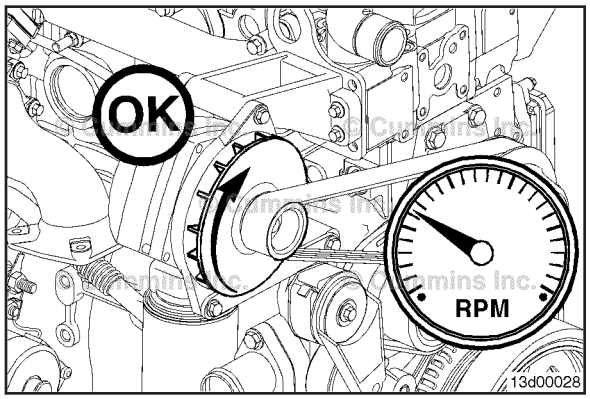
Typical Alternator (Bosch™ K1)

Typical Bosch™ K1 Wiring System		
Key	**Terminal**	**Connected to**
1	D+	Electrical charging system status light
2	B+	Positive battery
3	W	Tachometer
4	—	Ground/assembly

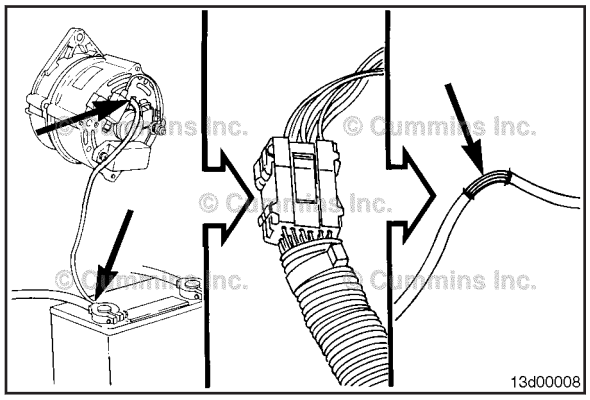


Initial Check

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

If any problems exist, check the following:

- If the drive belt is slipping on the alternator pulley. Refer to Procedure 008-002 in Section A.
- Use the following procedure to inspect the belt tensioner. Refer to Procedure 008-087 in Section A .
- Remove the drive belt. Refer to Procedure 008-002 in Section A. Check if the alternator pulley is loose on the shaft. If loose, remove the pulley and inspect for damage. Refer to the alternator manufacturer's and/or OEM service manual.
- If the alternator will **not** rotate or does **not** rotate freely, the alternator **must** be replaced. See the Remove and Install sections of this procedure.

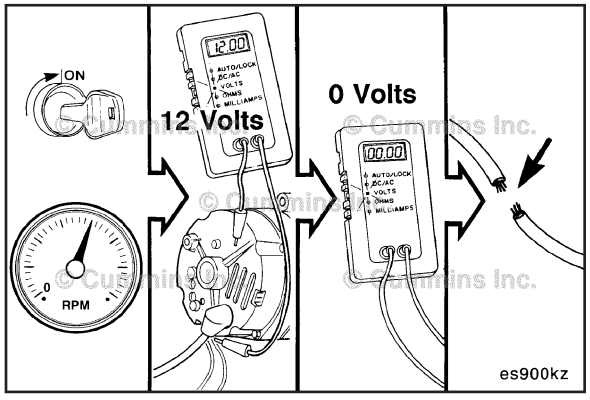


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Check the battery and all wiring connections.

Inspect the wiring for damage.

Check all connections for tightness and cleanliness. This includes the slip connectors at the alternator and engine compartment bulkhead, and the connections at the battery.



Test

NOTE: Any multimeter reading of zero voltage indicates an open circuit.

Check for open circuits.

Turn the keyswitch to the ON position.

Connect a multimeter, Part Number 3164488 or 3164489, to the following locations:

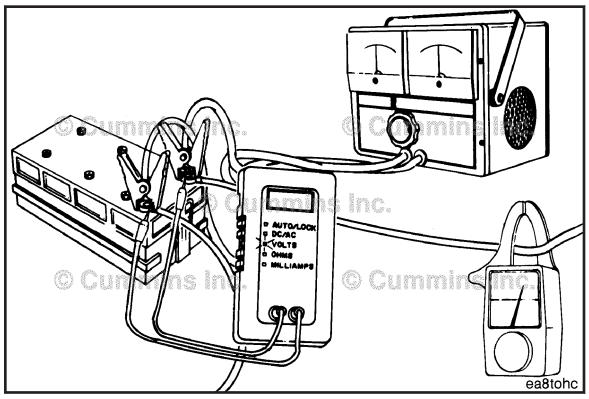
Delco™ Alternators

- Alternator “BAT” terminal to ground
- Alternator blade terminal “number 1” to ground
- Alternator blade terminal “number 2” to ground.

Locate and repair the open circuit.

Connect a carbon-pile load (battery/alternator tester) across the batteries in one of the battery boxes.

Clamp an induction pickup-type ampere-hour meter around the battery cable; or use the digital multimeter, Part Number 3164488 or 3164489, with the clamp-on current probe, Part Number 3164490.

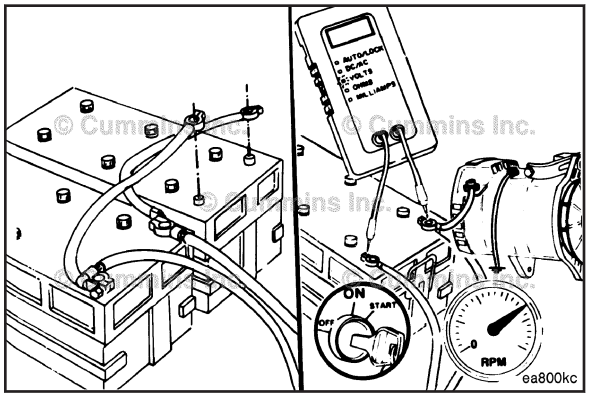


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠WARNING⚠
Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

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 3164488 or 3164489. Refer to the OEM specifications.

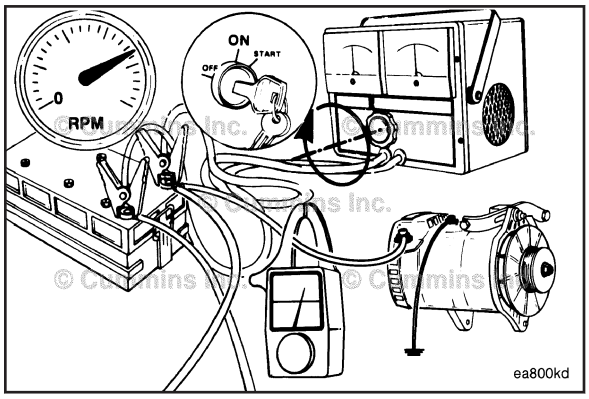


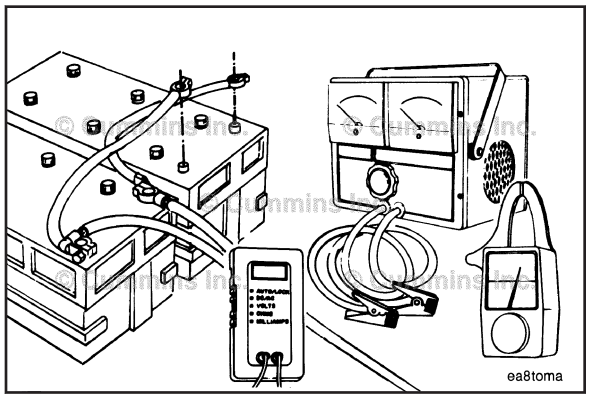
Operate the engine at high idle and adjust the carbon-pile load-testing equipment to apply the maximum rated amperage load to the alternator. Refer to the OEM specifications.

NOTE: The alternator maximum rated amperage output is normally stamped or labeled on the alternator.

Measure the alternator amperage output. Refer to the OEM specifications.

If the alternator output (amps) is **not** within 10 percent of rated output, repair or replace the alternator. Refer to the OEM service manual for repair procedures.



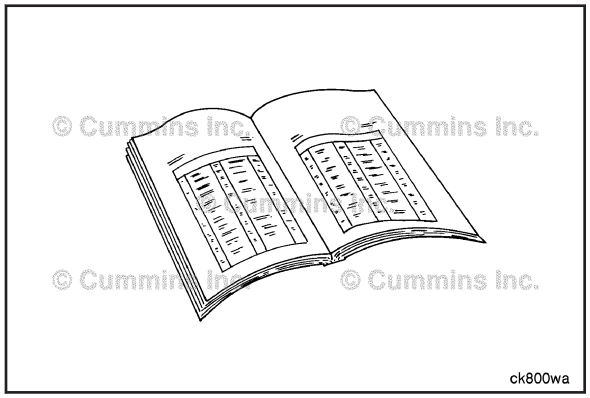


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠WARNING⚠
Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

Shut off the engine, and remove the test equipment.

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

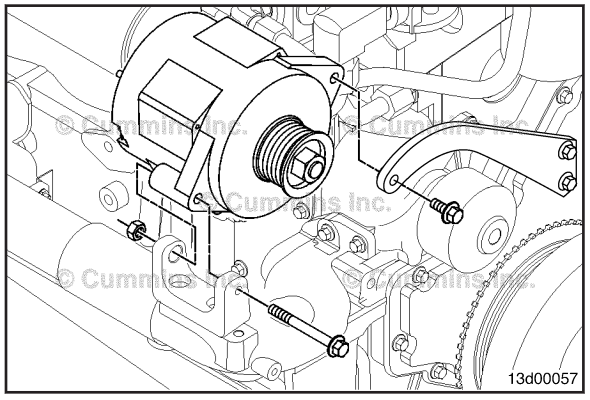


Preparatory Steps

⚠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.

⚠WARNING⚠
Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

- Disconnect the batteries. Refer to the OEM service manual.
- Remove the drive belt from the alternator pulley. Refer to Procedure 008-002 in Section A.
- Tag and label all wires on the alternator.
- Disconnect the wires.



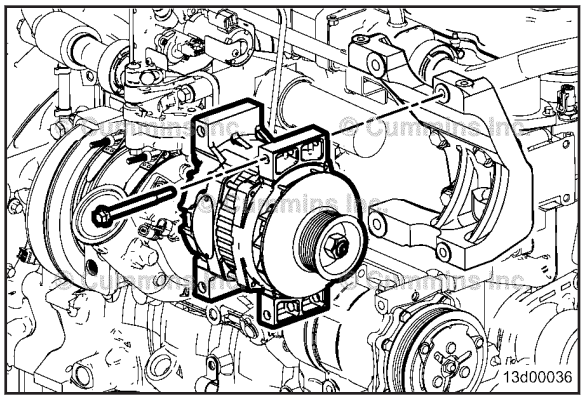
Remove

Spool Mount

- Remove the upper alternator link capscrew.
- Remove the mounting capscrew and nut at the bottom of the alternator and the alternator mounting bracket.
- Remove the alternator.

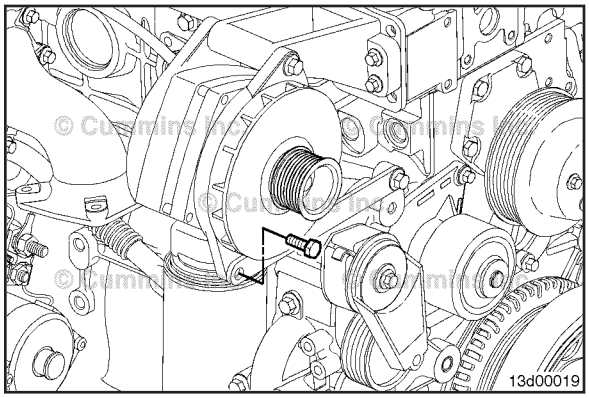
Pad Mount

- Remove the alternator mounting capscrews.
- Remove the alternator.



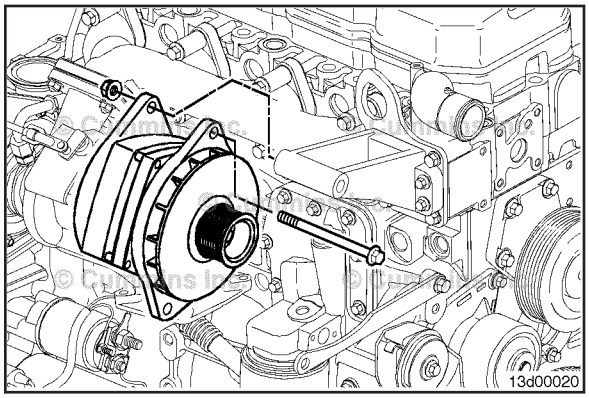
Hinge Mount

- Remove the alternator link capscrew.



Remove the alternator mounting capscrew.

Remove the alternator.



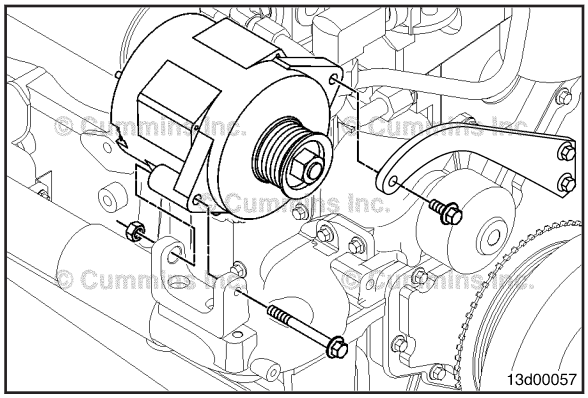
Install

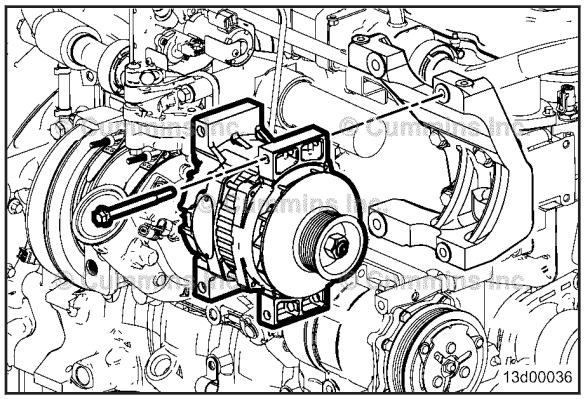
Spool Mount

- Install the alternator and the bottom alternator mounting capscrew and nut.
- Tighten the capscrews.

Torque Value:
Lower Mounting Capscrew
Step 1 40 N•m [30 ft-lb]

Torque Value:
Upper Link Mounting Capscrew
Step 1 24 N•m [212 in-lb]



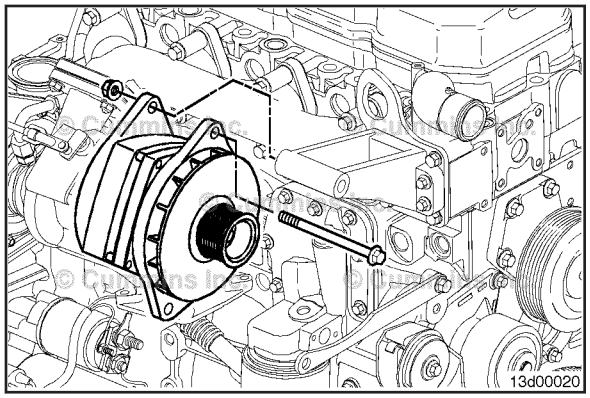


Pad Mount

- Install the alternator.
- Install and tighten the alternator mounting capscrews.

Torque Value:
M10 Capscrew
Step 1 36 N•m [27 ft-lb]

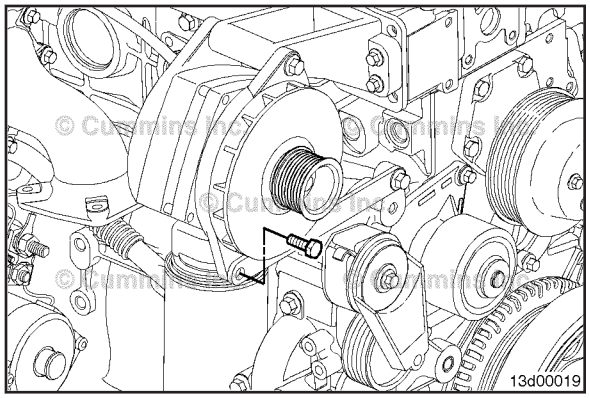
Torque Value:
M12 Capscrew
Step 1 64 N•m [47 ft-lb]



Hinge Mount

- Install the alternator.
- Install and tighten the alternator mounting capscrew.

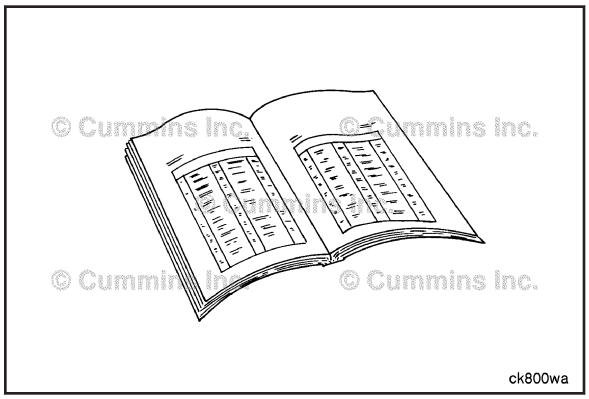
Torque Value: 40 N•m [30 ft-lb]



Install the alternator link capscrew.

Torque Value: 24 N•m [212 in-lb]

Finishing Steps



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

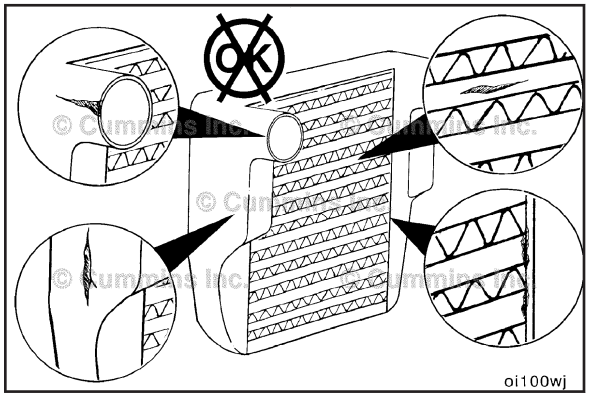
⚠WARNING⚠
Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

- Connect all wires to the alternator.
- Install the drive belt. Refer to Procedure 008-002 in Section A.
- Connect the batteries. Refer to the OEM service manual.
- Operate engine to check for proper operation.

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.



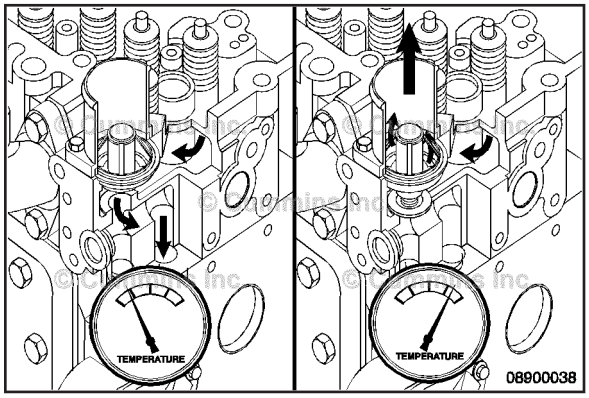
Coolant Thermostat

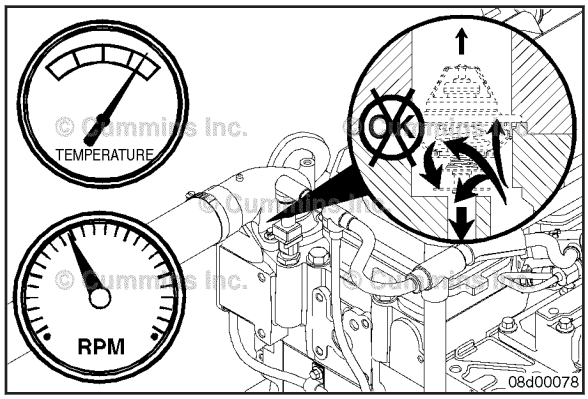
General Information

The thermostat controls the engine coolant temperature. When the coolant temperature is below the operating range, engine coolant is bypassed back to the inlet of the water pump. When the engine coolant temperature reaches the operating range, the thermostat opens, seals off the bypass, and forces engine coolant to flow to the radiator or the heat exchanger.

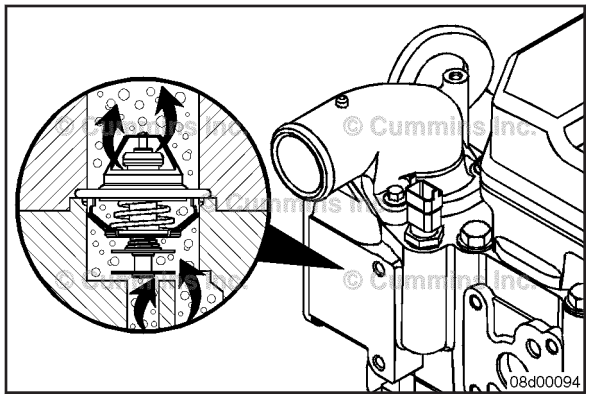
NOTE: Some applications use an OEM supplied remote mounted thermostat. Refer to the OEM service manual for location. Refer to the OEM service manual for remote mounted thermostat removal and installation instructions.

An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.





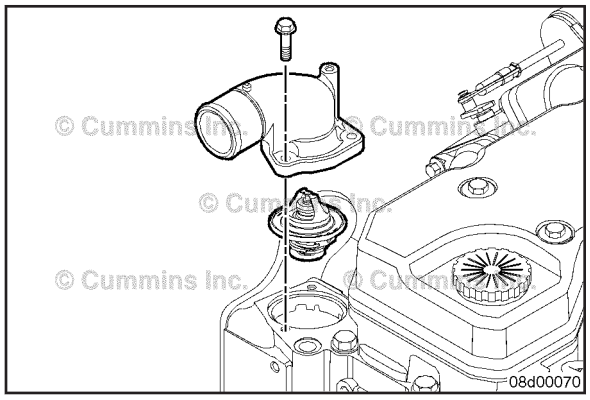
⚠CAUTION⚠
Never operate the engine without a thermostat. Without a thermostat, the path of least resistance for the coolant is through the bypass to the water pump inlet. This can cause the engine to overheat.



⚠CAUTION⚠
A missing check ball can cause the engine to run cold, resulting in engine damage.

The thermostat contains two check balls to vent air past the thermostat when it is closed. This helps to vent air during the cooling system fill process.

NOTE: Some off-highway applications use a thermostat with one check ball. When replacing a thermostat, always be sure to use the same part number. Though an incorrect thermostat will physically fit, it will lead to improper engine operation.

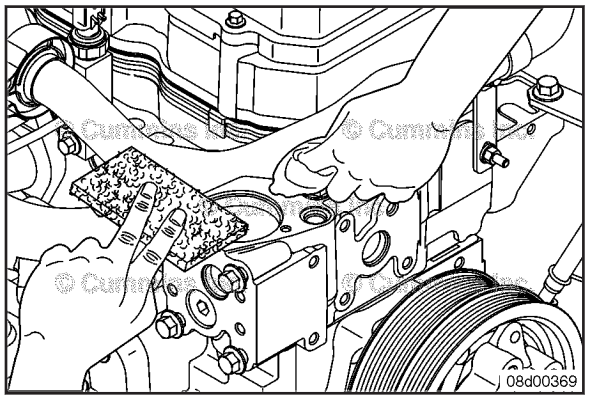


Remove

Remove the water outlet connection capscrews.

Remove the water outlet connection.

Remove the thermostat.



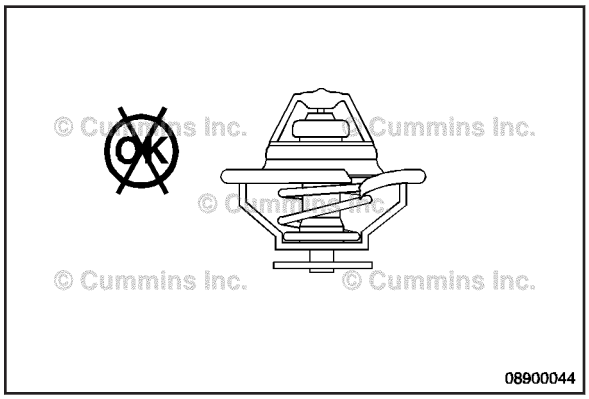
Clean and Inspect for Reuse

⚠CAUTION⚠
Do not let any debris fall into the thermostat cavity when cleaning the gasket surfaces. Damage to the cooling system and engine can occur.

Clean the mating surfaces with an abrasive pad, Part Number 3823258 or equivalent, and a clean cloth.

Inspect the thermostat for external damage. Also inspect for cracks, embedded debris, missing check balls, damaged seat, and other damage.

Replace the thermostat if any damage is found.

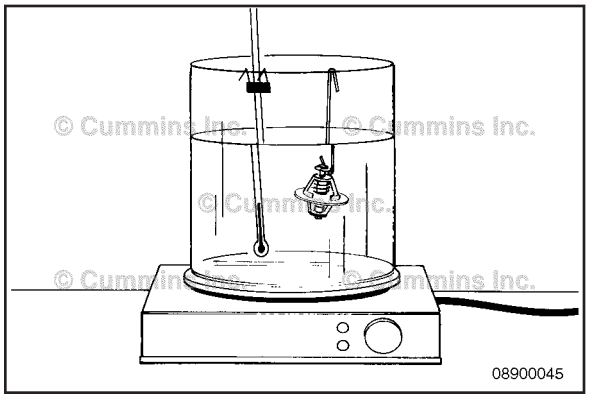


Measure

If the thermostat is suspected to be malfunctioning, the opening temperature of the thermostat should be measured to determine if the thermostat is functioning properly.

NOTE: Do **not** allow the thermostat or thermometer to touch the container.

Suspend the thermostat and a 100°C [212°F] thermometer in a container of water.



Heat the water and check the thermostat as follows:

NOTE: There are two different temperature range thermostats available, depending on the application. The nominal operating temperature is stamped on the thermostat. To verify the correct temperature range thermostat is installed, make sure to reference the appropriate part information resources.

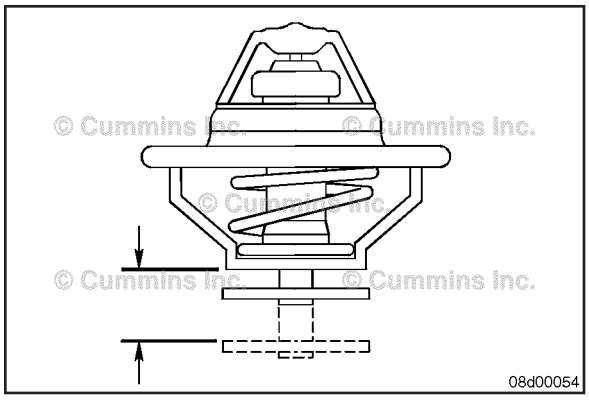
The thermostat **must** meet the following criteria:

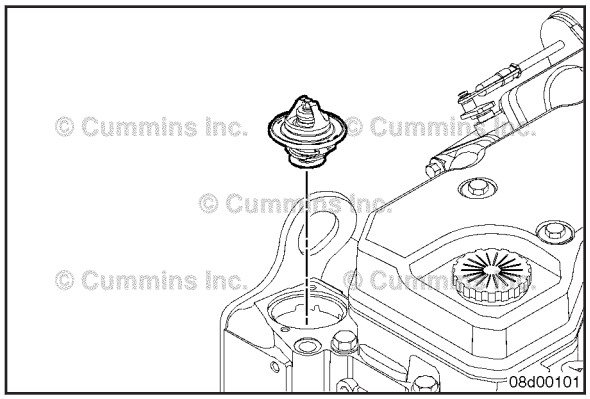
82°C [180°F] Nominal Temperature Thermostat

Thermostat Opening Temperature			
	°C		°F
Initial Opening	79	MIN	175
	83	MAX	182
Fully Opened	94	MAX	202

88°C [190°F] Nominal Temperature Thermostat

Thermostat Opening Temperature			
	°C		°F
Initial Opening	86	MIN	186
	89	MAX	193
Fully Opened	97	MAX	207





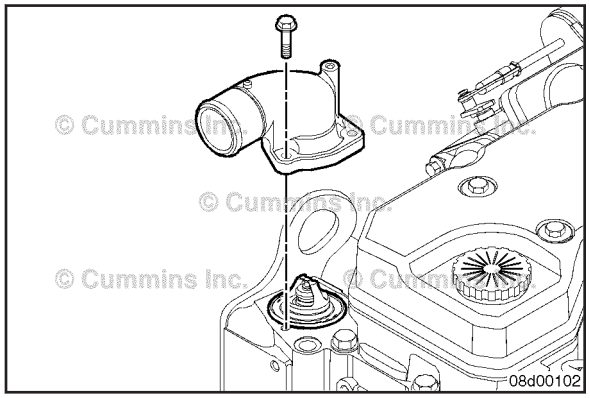
Install

⚠CAUTION⚠

Always use the correct thermostat and do not operate the engine without a thermostat installed. The engine can overheat if operated without a thermostat because the path of least resistance for the coolant is through the bypass to the pump inlet. An incorrect thermostat can cause the engine to overheat or run too cold.

NOTE: If a previously installed thermostat is being used, make sure a new thermostat seal is used.

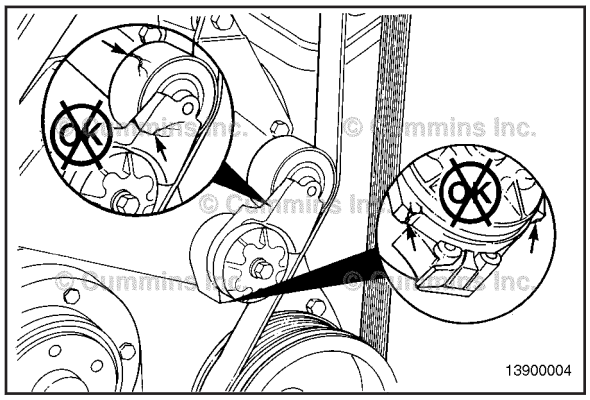
Install the thermostat into the thermostat housing.



Install the water outlet connection and mounting capscrews.

Tighten the capscrews.

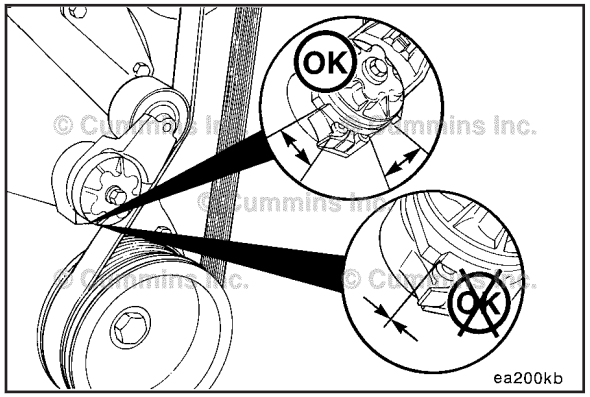
Torque Value: 10 N•m [89 in-lb]



Cooling Fan Belt Tensioner

Maintenance Check

With the engine stopped, check the tensioner arm, pulley, and stops for cracks. If any cracks are found, the tensioner **must** be replaced.



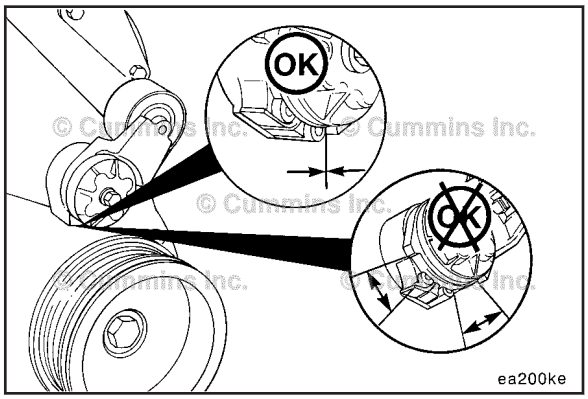
With the belt installed, verify that neither tensioner arm stop is in contact with the spring case stop. If either of the stops is touching:

- Verify the correct belt part number is installed.
- If the correct belt is installed, replace the belt. Refer to Procedure 008-002 in Section A.

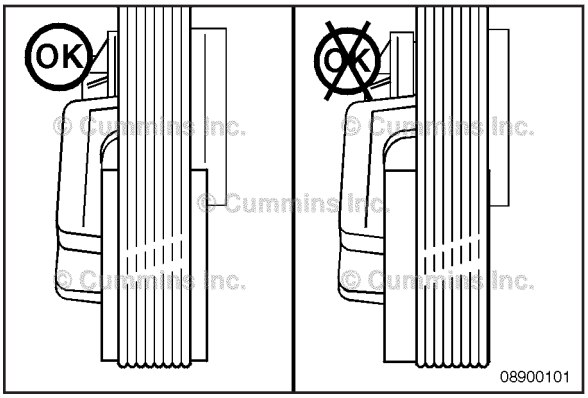
After replacing the belt, if the tensioner arm stops are still in contact with the spring case stop, replace the tensioner.

With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop. If these two are **not** touching, the tensioner **must** be replaced.

After replacing the belt, if the tensioner arm stop is still in contact with the spring case stop, the tensioner MUST be replaced.

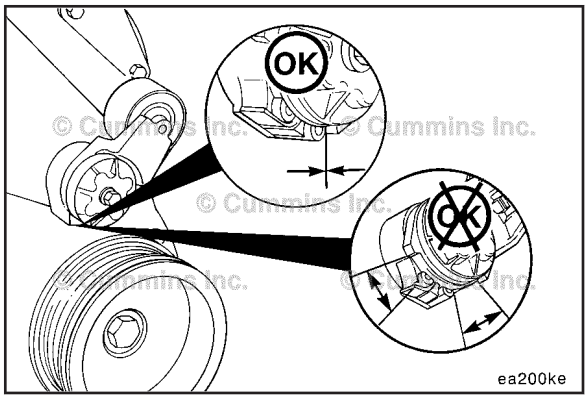


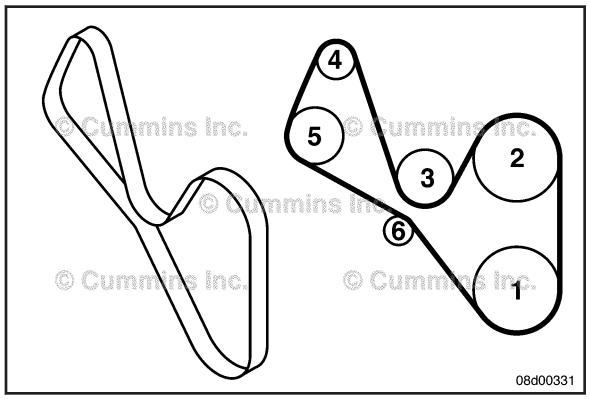
Check the location of the drive belt on the belt tensioner pulley. The belt should be centered on, or close to the middle of, the pulley. Misaligned belts, either too far forward or backward, can cause belt wear, belt roll-offs, or increase uneven tensioner bushing wear.



Remove the drive belt. Refer to Procedure 008-002 in Section A.

With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop. If they are not touching, the tensioner **must** be replaced.





Drive Belt, Cooling Fan

General Information

Due to the number of drive belt arrangements, this procedure does **not** cover all available cooling fan drive belt routing.

To make sure the cooling fan drive belt is routed correctly upon installation, make a diagram of the cooling fan belt routing prior to removing the belt as shown in the illustration.

The cooling fan belt routing typically consists of the following components, but may **not** include all of them:

1 Crankshaft pulley/vibration damper

2 Fan pulley

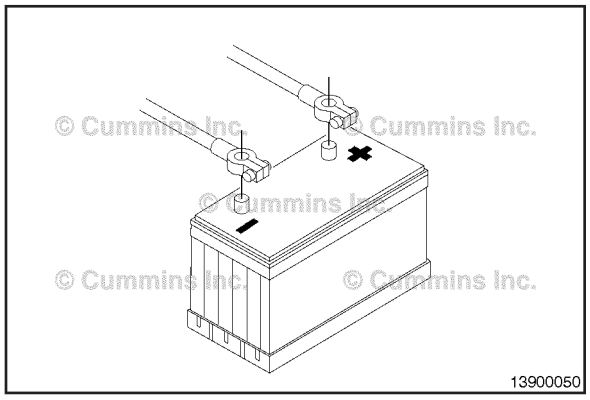
3 Water pump pulley

4 Refrigerant compressor pulley

5 Alternator pulley

6 Tensioner idler pulley.

NOTE: Some engine driven belts are installed/supplied by the vehicle's original equipment manufacturer (OEM). See the OEM service manual for removal and installation instructions.

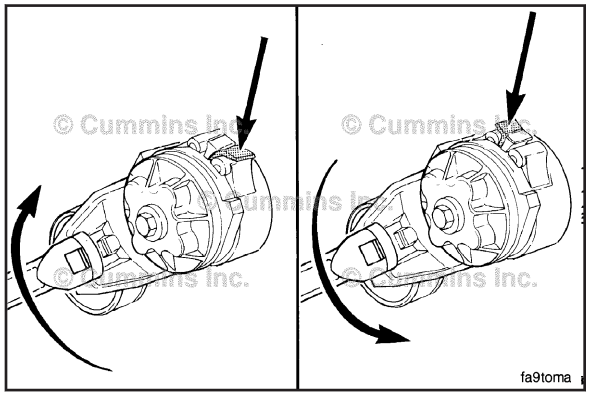


Preparatory Steps

⚠WARNING⚠

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

- Disconnect the batteries. Refer to the OEM service manual.



Remove

⚠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.

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.

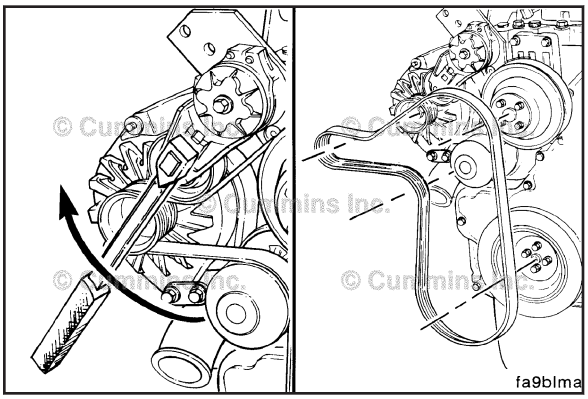
⚠CAUTION⚠
Applying excessive force in the opposite direction of windup or after the tensioner has been wound up to the positive stop can cause the tensioner arm to break.

NOTE: Make a diagram of the belt arrangement prior to removing the drive belt. This aids in installation and proper routing of the cooling fan drive belt.

NOTE: The location of the belt tensioner can vary, depending on the front engine accessory arrangement.

Pivot the tensioner in the direction of the spring tang to remove the belt.

Remove the belt.



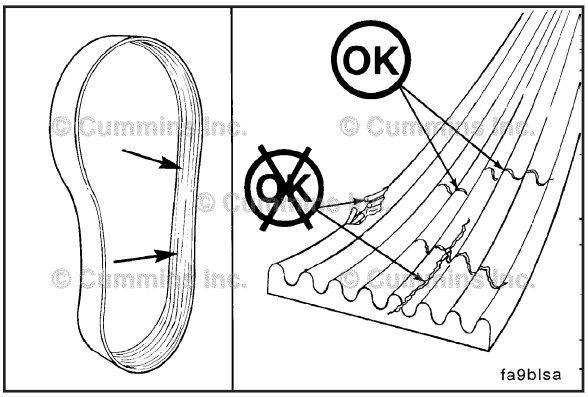
Clean and Inspect for Reuse

Inspect the drive belt for damage.

Transverse (across the belt) cracks are acceptable.

Longitudinal (direction of belt ribs) cracks that intersect with transverse cracks are **not** acceptable.

If the belt is frayed, punctured, or material is missing, the belt is unacceptable for reuse and **must** be replaced.



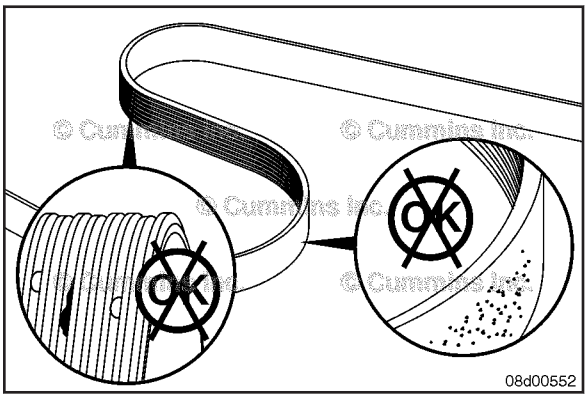
Inspect the belt grooves for:

- Embedded debris
- Uneven/excessive rib wear
- Exposed belt cords.

Inspect the backside of the belt for:

- Glazing (high heat)
- Embedded debris
- Exposed belt cords.

If any of the above conditions are present, the belt is unacceptable for reuse and **must** be replaced.



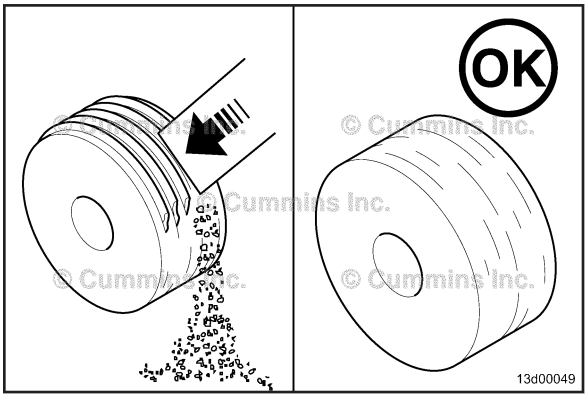
Inspect the idler and drive pulleys for wear or cracks.

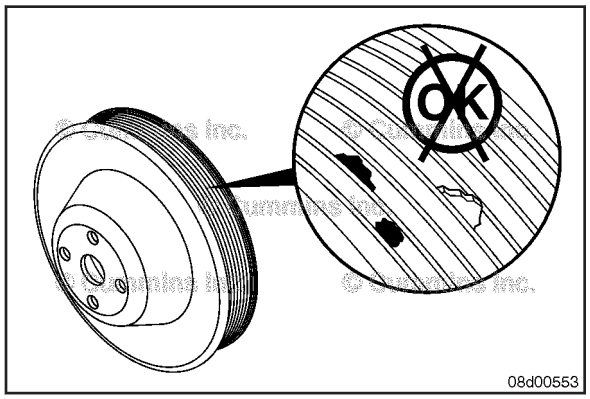
Plastic pulleys often have a build-up of road dirt and belt material that is **not** to be confused with wear.

The dirt can be removed with a suitable tool to check for wear.

Clean, check, and reuse all pulleys in the front end accessory drive if **not** damaged, rather than replacing. Pulleys damaged from embedded debris **MUST** be replaced.

Inspect the tensioner. Refer to Procedure 008-087 in Section A.

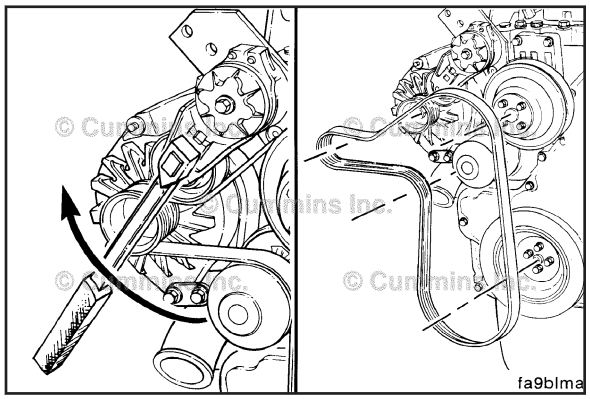




Inspect all system pulleys for embedded debris:

- Rocks, stones
- Metal
- Belt material.

Remove the debris from the grooves of the pulley. If the pulley has been deformed as a result of foreign material embedment, the pulley **MUST** be replaced.



Install

⚠CAUTION⚠

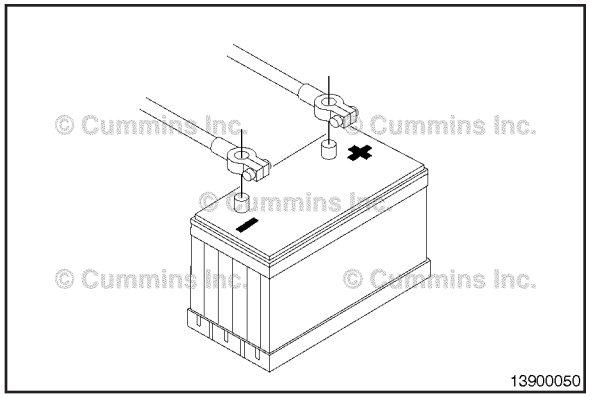
The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

Route the drive belt on the engine using the belt diagram created in the Remove section. Do **not** install the belt over the water pump pulley at this time.

Pivot the tensioner in the direction of the spring tang and install the drive belt, slipping the belt over the water pump pulley last.

Slowly release the tensioner to apply tension to the drive belt.

Check the alignment of the belt with the tensioner and the rest of the front end accessory drive.



Finishing Steps

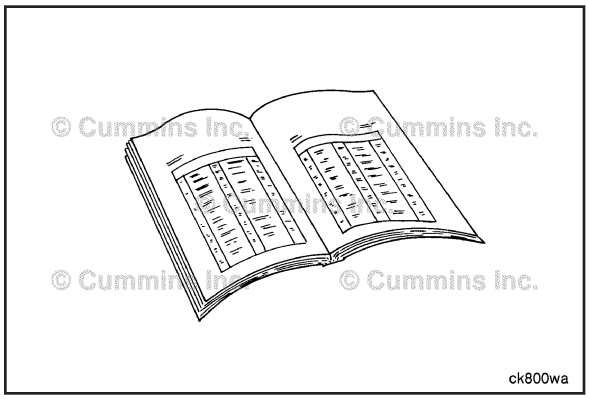
⚠WARNING⚠

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. Refer to the OEM service manual.
- Operate the engine and check for belt squeal. Excessive belt squeal indicates belt slippage.
- If belt squeal is present, check the routing of the belt to make sure that the belt is installed correctly on each pulley.

Fan Spacer and Pulley

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.

NOTE: Prior to removing the drive belt, loosen the fan pulley and cooling fan (if equipped) mounting capscrews.

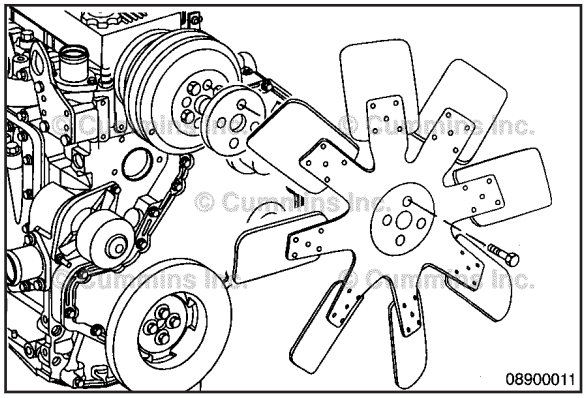
- Disconnect the batteries. Refer to the OEM service manual for instructions.
- Remove the drive belt. Refer to Procedure 008-002 in Section A.

Remove

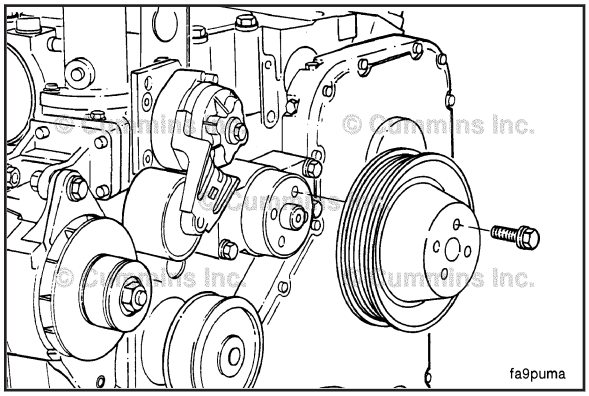
NOTE: Some applications do **not** have a cooling fan or the cooling fan is located elsewhere on the application.

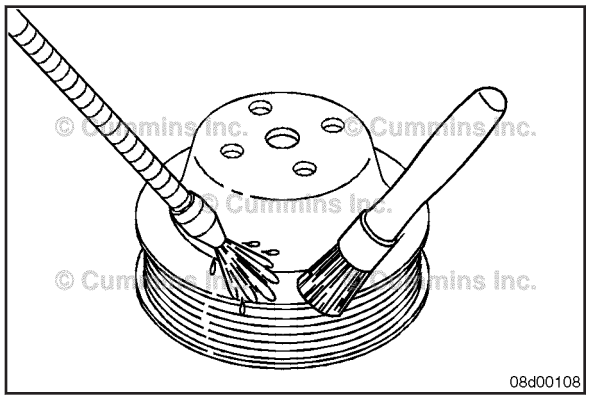
If equipped, remove the cooling fan. Refer to the OEM service manual for instructions.

For engines equipped with an engine driven cooling fan, the fan holds the fan pulley and spacer in place. Remove the fan pulley and spacer.



If the engine is **not** equipped with an engine driven cooling fan, remove the fan pulley mounting capscrews and fan pulley.

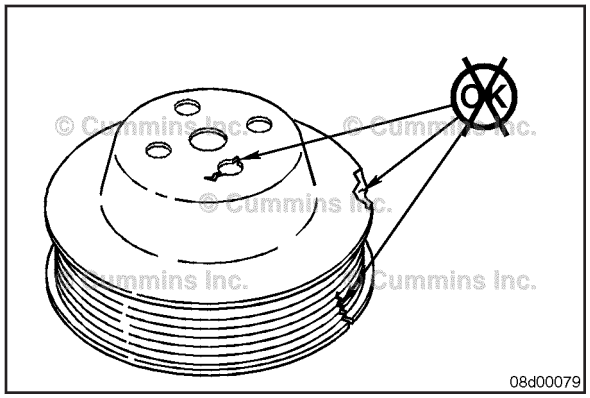




Clean and Inspect for Reuse

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

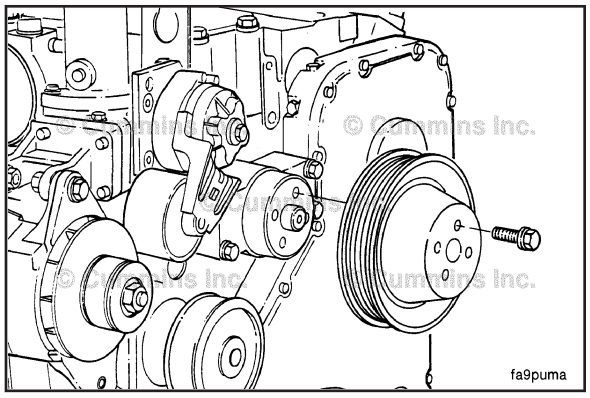
Clean the fan pulley and spacer with solvent and dry with compressed air.



Inspect the fan pulley for cracks near the bolt holes and for damage at the drive belt contact surface.

If damage is found on the fan pulley, the fan hub **must** also be inspected. Refer to Procedure 008-036 in Section 8.

Replace the pulley if any damage is found.



Install

NOTE: Use the tension of the drive belt to hold the cooling fan in place when tightening the mounting capscrews. Do **not** hold the fan blades to keep the cooling fan from rotating.

If the engine is **not** equipped with an engine driven cooling fan, install the fan pulley mounting capscrews and fan pulley.

Do **not** tighten the mounting capscrews at this time. Tighten the mounting capscrews after the drive belt is installed.

Torque Value:
M6 10 N•m [89 in-lb]

Torque Value:
M10 43 N•m [32 ft-lb]

Torque Value:
M12 77 N•m [57 ft-lb]

NOTE: Some applications do **not** have a cooling fan or the cooling fan is located elsewhere on the application.

For engines equipped with an engine driven cooling fan, the fan holds the fan pulley and spacer in place. Install the fan pulley and spacer.

If removed, install the cooling fan. Refer to the OEM service manual for instructions.

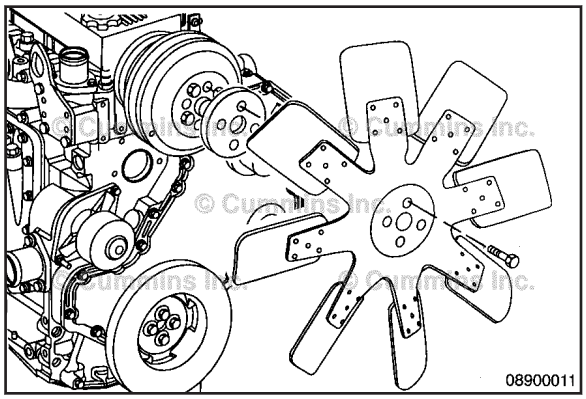
NOTE: Use the tension of the drive belt to hold the cooling fan in place when tightening the mounting capscrews. Do **not** hold the fan blades to keep the cooling fan from rotating.

Do **not** tighten the mounting capscrews at this time. Tighten the mounting capscrews after the drive belt is installed.

Torque Value:
M6 10 N•m [89 in-lb]

Torque Value:
M10 43 N•m [32 ft-lb]

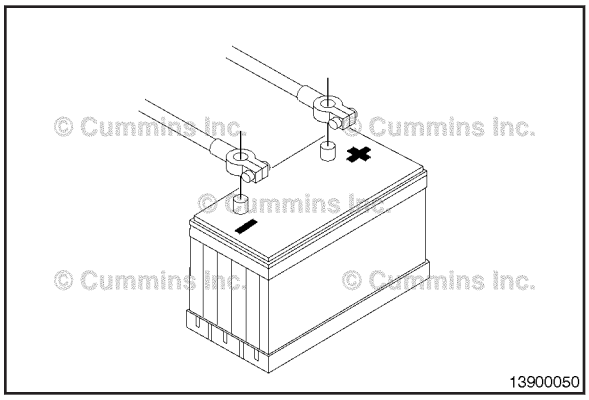
Torque Value:
M12 77 N•m [57 ft-lb]



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. Refer to the OEM instructions.
- Start the engine and check for proper operation.



Starting Motor

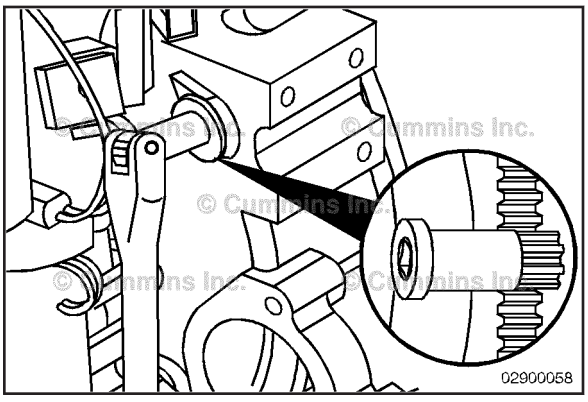
Rotation Check

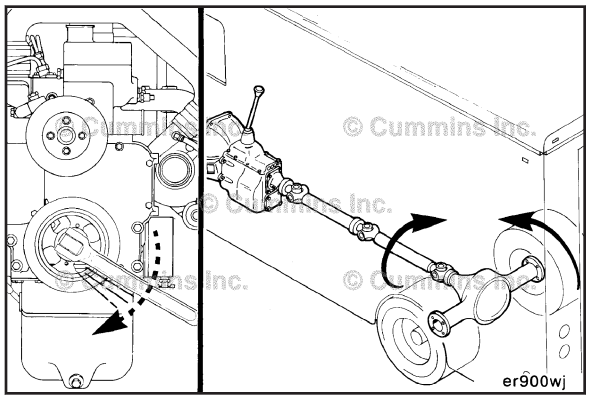
If the starter solenoid is making a sound but the engine is **not** rotating, turn the keyswitch to the OFF position, and attempt to bar the crankshaft in both directions.

Bar the engine with the barring tool, Part Number 3824591.

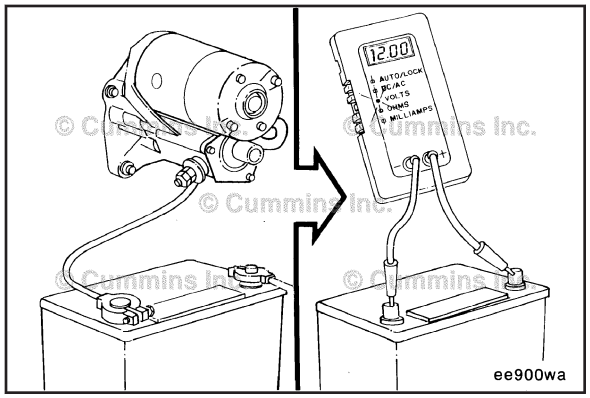
If the crankshaft will bar over, attempt to start the engine. If the starter motor cranks the engine, check the starter motor pinion gear and flywheel ring gear for damage.

If damage to the starter motor pinion gear and/or flywheel ring gear is found when replacing the components, make sure to measure the distance from the starting motor mounting flange to the forward face of the front side of the flywheel ring gear. Follow the measure step of this procedure.





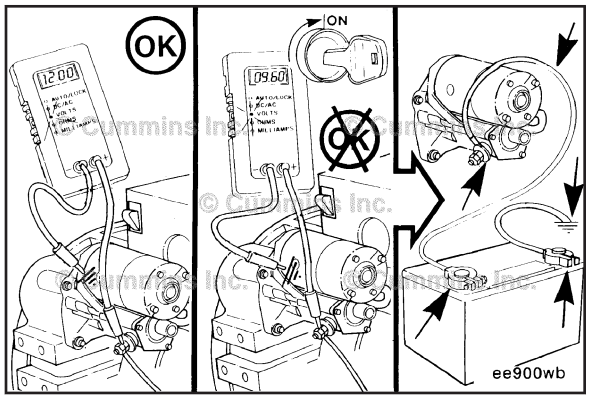
If the crankshaft does **not** rotate or requires more than the normal effort to bar, check for an internal malfunction or a problem with the drive unit and/or accessories.



If the engine cranking speed is too slow/will **not** crank at all, and the engine rotates freely:

Make sure the wiring connections are clean, tight, and **not** damaged.

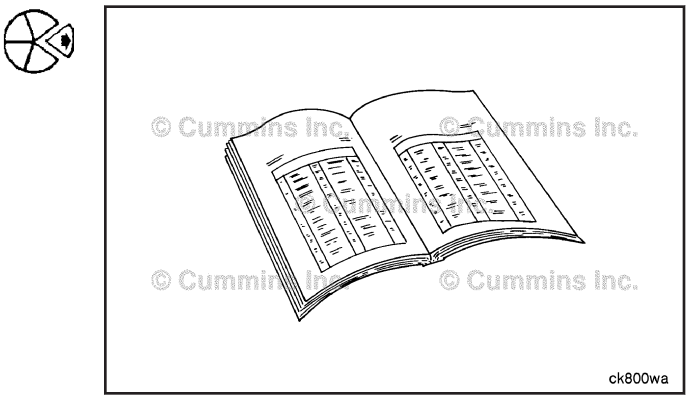
Check the battery voltage. Refer to the OEM service manual.



Check the voltage at the starting motor during cranking. If the voltage drops more than 2.4-VDC on a 12 volt system and 4.8-VDC on a 24 volt system, check that all connections are clean and tight.

If the cables are correct and the voltage drop exceeds the limit, replace the starting motor.

Preparatory Steps



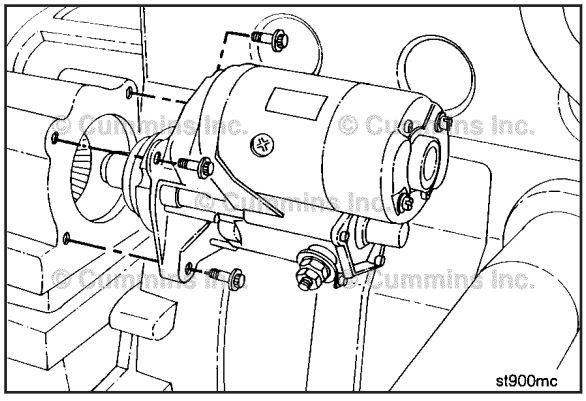
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

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

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

- Disconnect the batteries. Refer to the OEM service manual.

Remove



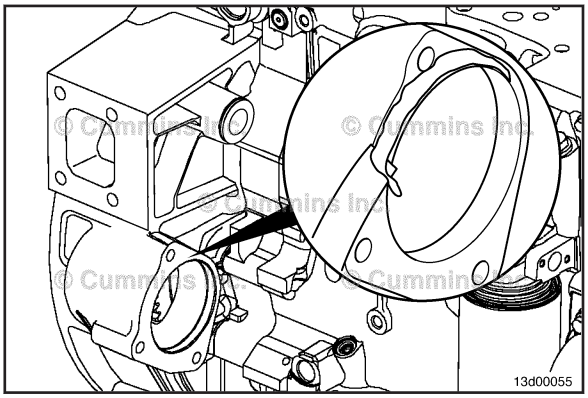
Identify each wire with a tag inicating its location on the starting motor.

Remove the electrical connections from the starting motor.

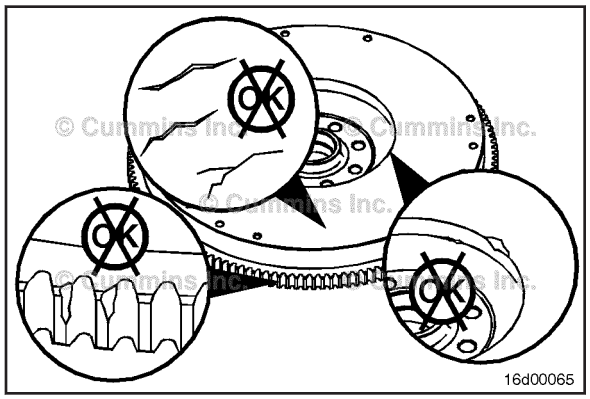
Remove the three capscrews and the starting motor.

NOTE: If equipped with a starting motor spacer, remove the spacer and clean all surfaces between the starting motor, starting motor spacer, and flywheel housing with a wire brush.

Clean and Inspect for Reuse

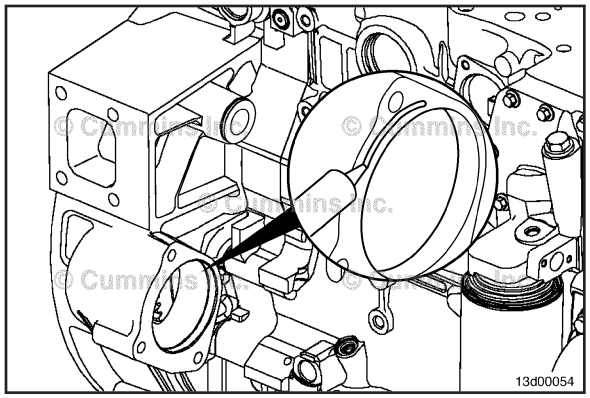


For engines that use wet flywheel housings, clean any left over sealant from the starting motor mounting flange on both the flywheel housing and starting motor. Make sure these surfaces are clean of oil and debris.



Inspect the starter motor pinion gear and/or flywheel ring gear for chipping or uneven wear.

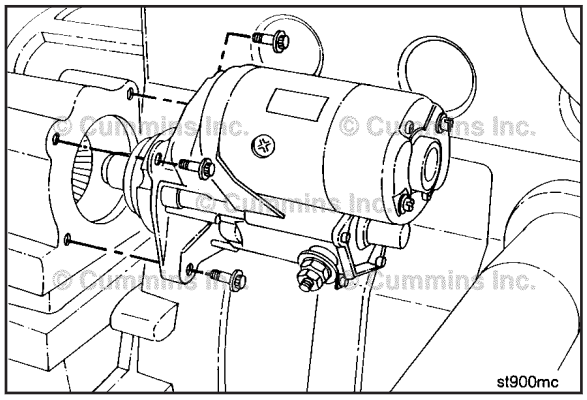
NOTE: If the starter motor pinion gear and/or flywheel ring gear teeth are damaged, they **must** be replaced.



Install

For engines with wet flywheel housings, apply a 1.5 to 2.0 mm [0.06 to 0.09 in] wide bead of sealant, Part Number 3164067, to the flywheel housing starting motor mounting flange.

NOTE: If a starting motor spacer is required, make sure to apply sealant to the side of the spacer that contacts the starting motor.



Install the three capscrews, the starting motor, and starting motor spacer, if required.

Torque Value: 43 N•m [32 ft-lb]

Cummins® Branded Starters

⚠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.

⚠CAUTION⚠
Do not overtighten the electrical connections. Starter damage can result.

NOTE: Use the location tags to help identify where each wire connection goes.

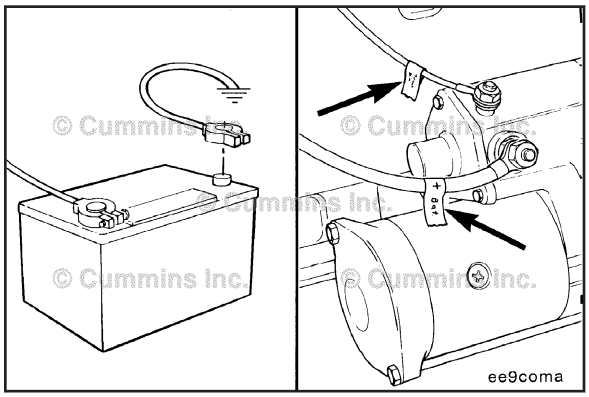
Connect the electrical connections to the starter motor.

Torque Value:
M5
Step 1 4 N•m [35 in-lb]

Torque Value:
M10
Step 1 21 N•m [185 in-lb]

Install the jump start protection (JSP) cover and nut on the M terminal post.

NOTE: The JPS cover nut is the third nut on the M terminal, M5 terminal size. Failure to observe the proper torque specification can result in loss of conductivity to the M lead and result in a no crank condition for the starter and engine.



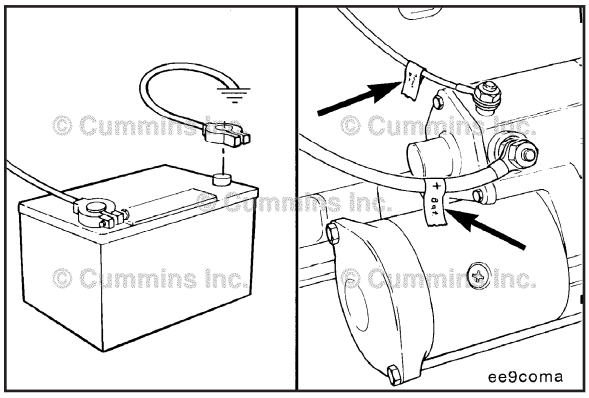
Non-Cummins® Branded Starters

⚠CAUTION⚠
Do not overtighten the electrical connections. Starter damage can result.

NOTE: Use the location tags to help identify where each wire connection goes.

Connect the electrical connection to the starting motor.

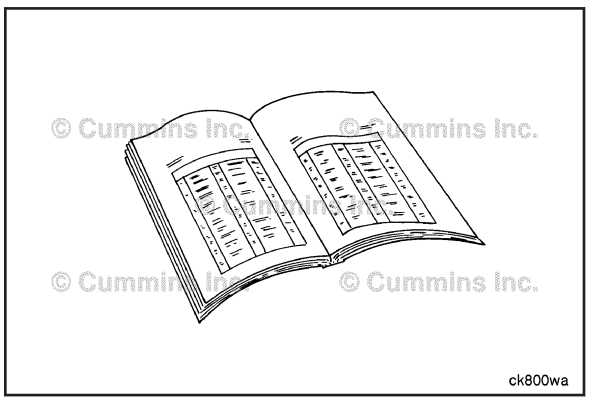
For Non-Cummins® branded starters, refer to the OEM service manual for torque specifications.



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. Refer to the OEM service manual.
- Operate the starter to check for proper function.



Notes

Section D - System Diagrams

Section Contents

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System Diagrams - Overview

General Information

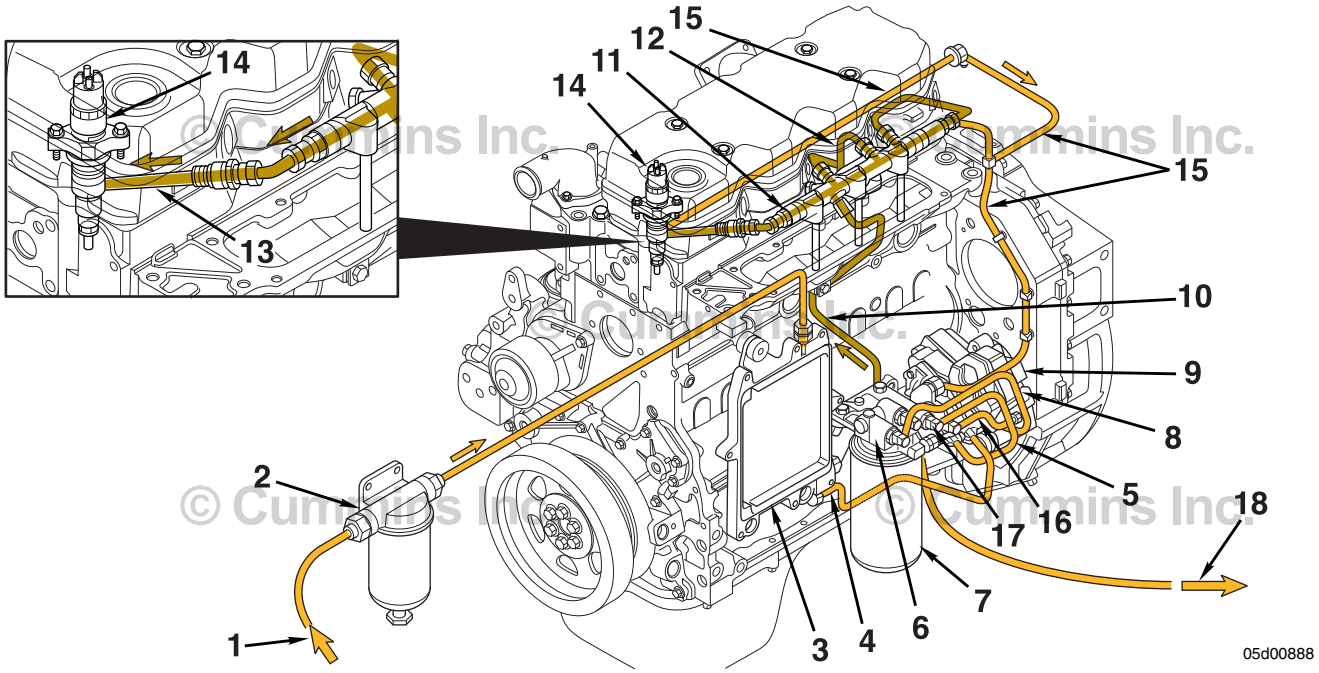
The following drawings show the flow through the engine systems. Although parts can change between different applications and installations, the flow remains the same. The systems shown are:

- 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

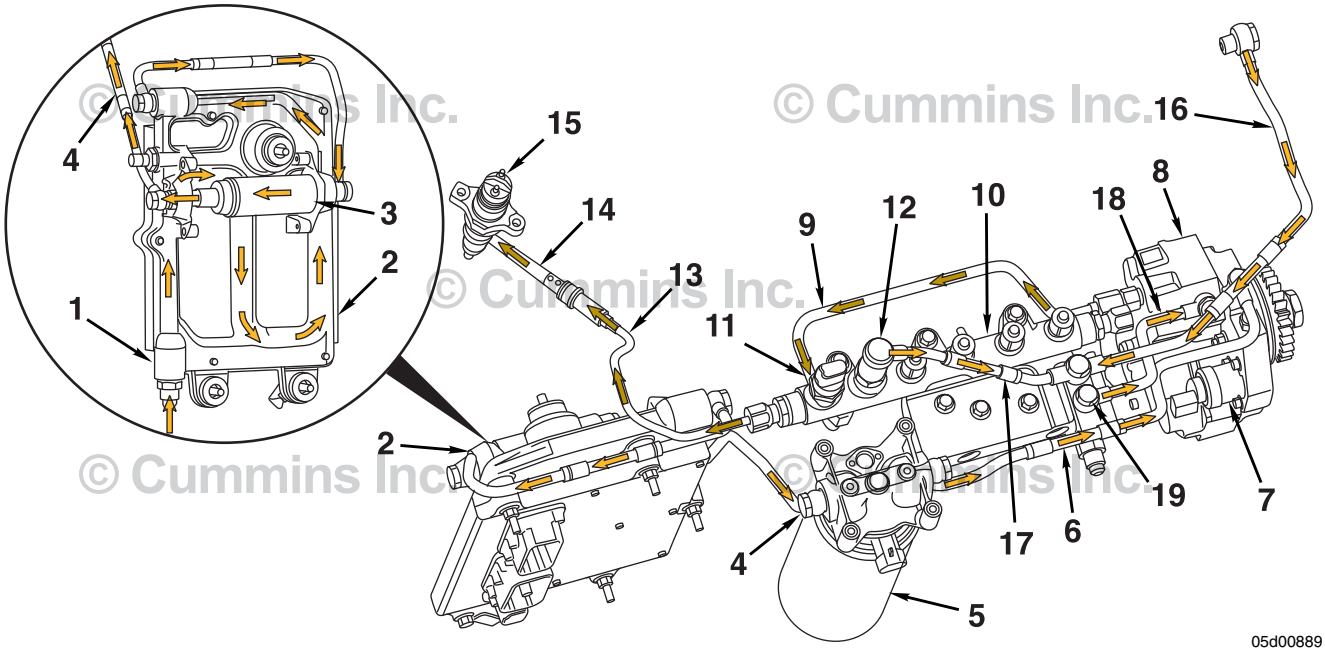
Flow Diagram



1 From fuel supply tank
2 Water/fuel separator (**not** mounted on engine)
3 ECM cooling plate *
4 To fuel gear pump
5 To fuel filter
6 Fuel filter head
7 Fuel filter
8 To high-pressure pump
9 High-pressure pump
10 To fuel rail
11 Fuel rail
12 To injectors
13 High-pressure connector
14 Injector
15 Fuel return from injectors and fuel rail to fuel filter head
16 Fuel return from high-pressure pump to fuel filter head
17 Fuel return manifold
18 To fuel supply tank.

NOTE: * Engines are either equipped with an air cooled or fuel cooled ECM. If an air cooled ECM is used, the fuel enters the engine from the OEM connection at the gear pump inlet.

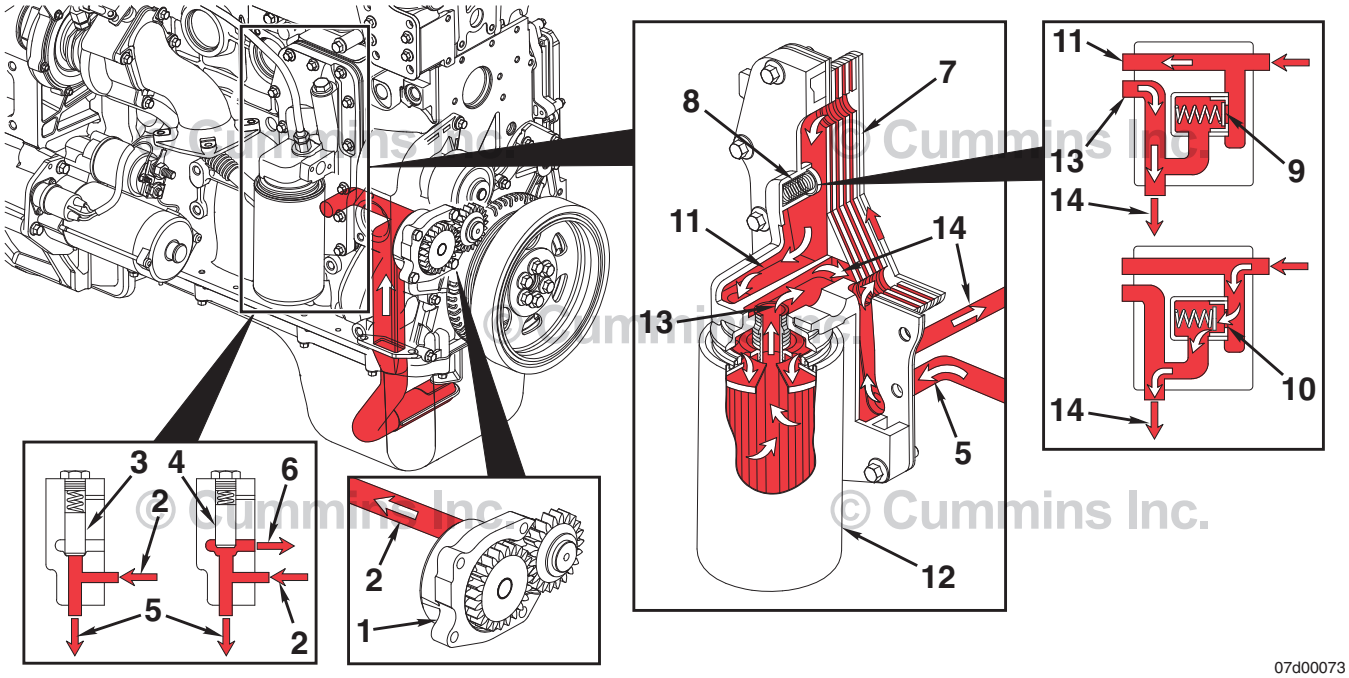
With Electric Lift Pump(s)



1 Fuel inlet - ECM cooling plate
2 ECM cooling plate
3 Lift pump
4 Fuel line (from lift pump to fuel filter)
5 Fuel filter
6 Fuel pump inlet to gear pump
7 EFC actuator
8 Fuel pump
9 High-pressure fuel line (fuel pump to rail)
10 Fuel rail
11 Fuel rail pressure sensor
12 Fuel pressure relief valve
13 High-pressure fuel line (fuel rail to fuel injector)
14 High-pressure connector to fuel injector
15 Fuel injector
16 Injector return line
17 Pressure relief return line
18 Fuel pump return line
19 Fuel return manifold.

Flow Diagram, Lubricating Oil System

Flow Diagram

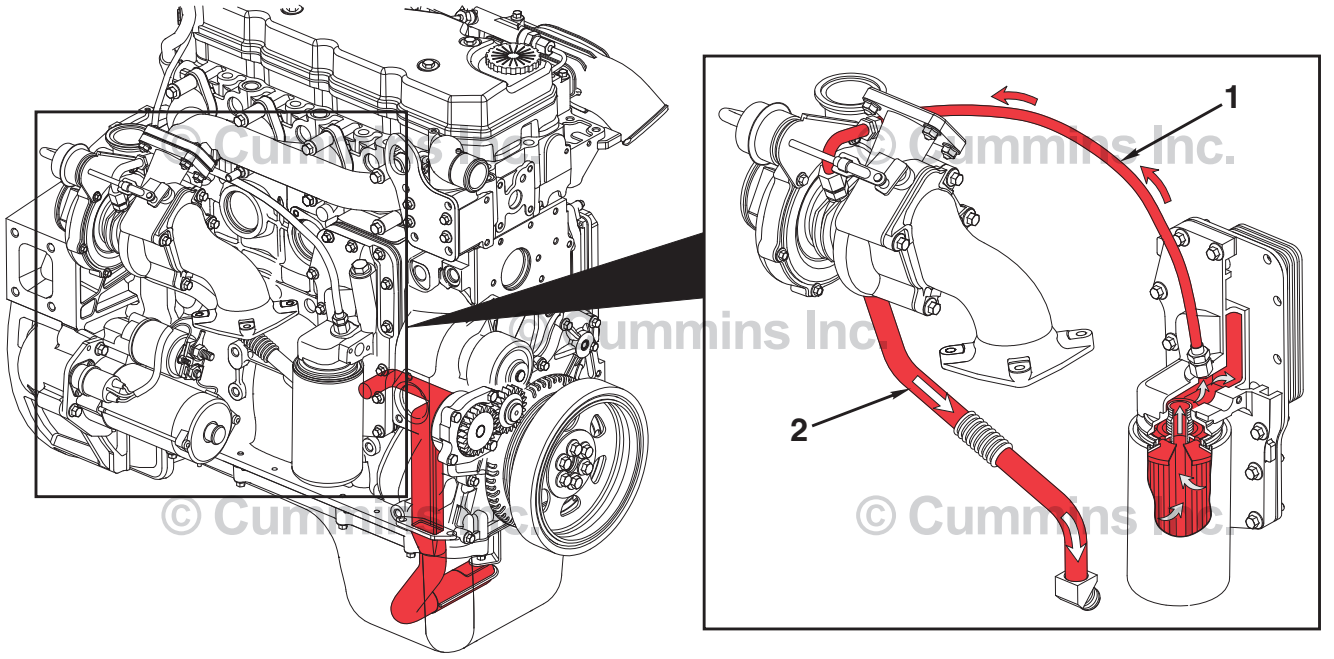


Lubricating Oil Cooler Flow

1 Lubricating oil pump
2 From lubricating oil pump
3 Pressure regulating valve closed
4 Pressure regulating valve open
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 Full-flow lubricating oil filter
13 From lubricating oil filter
14 Main lubricating oil rifle.

Flow Diagram, Lubricating Oil System

Flow Diagram



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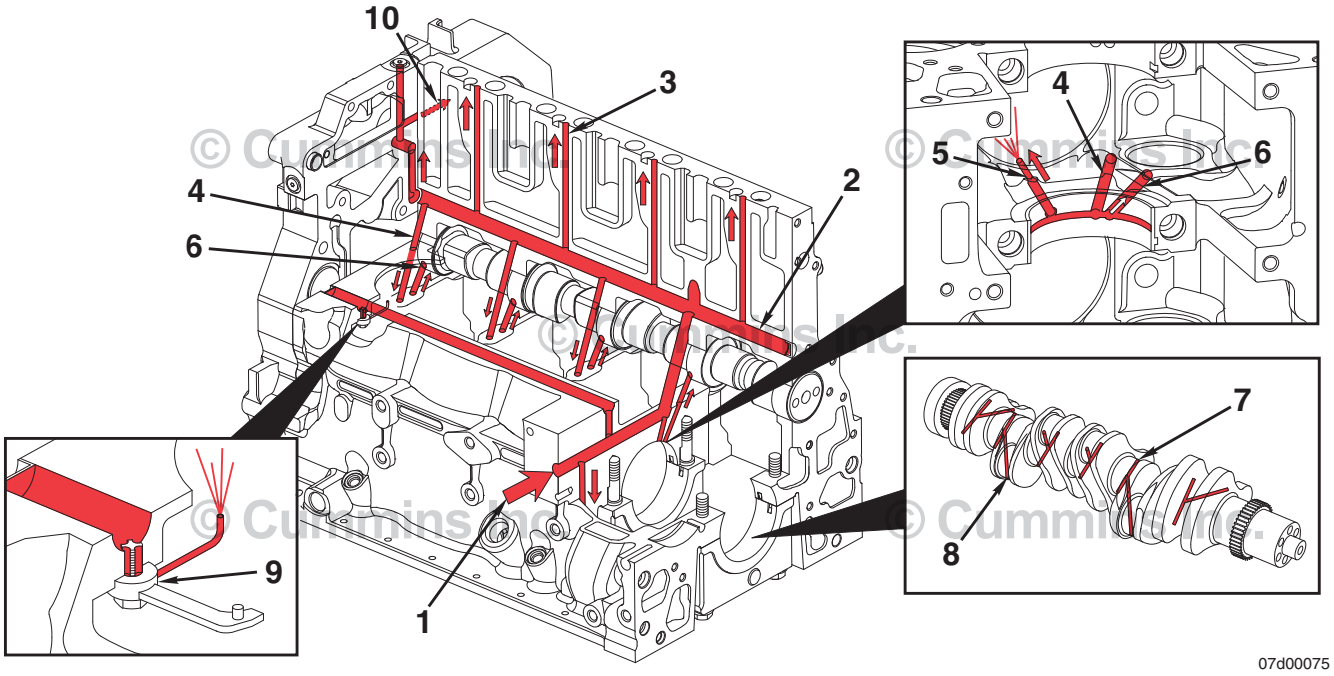
Lubrication for the Turbocharger

1 Turbocharger lubricating oil supply

2 Turbocharger lubricating oil drain.

Flow Diagram, Lubricating Oil System

Flow Diagram

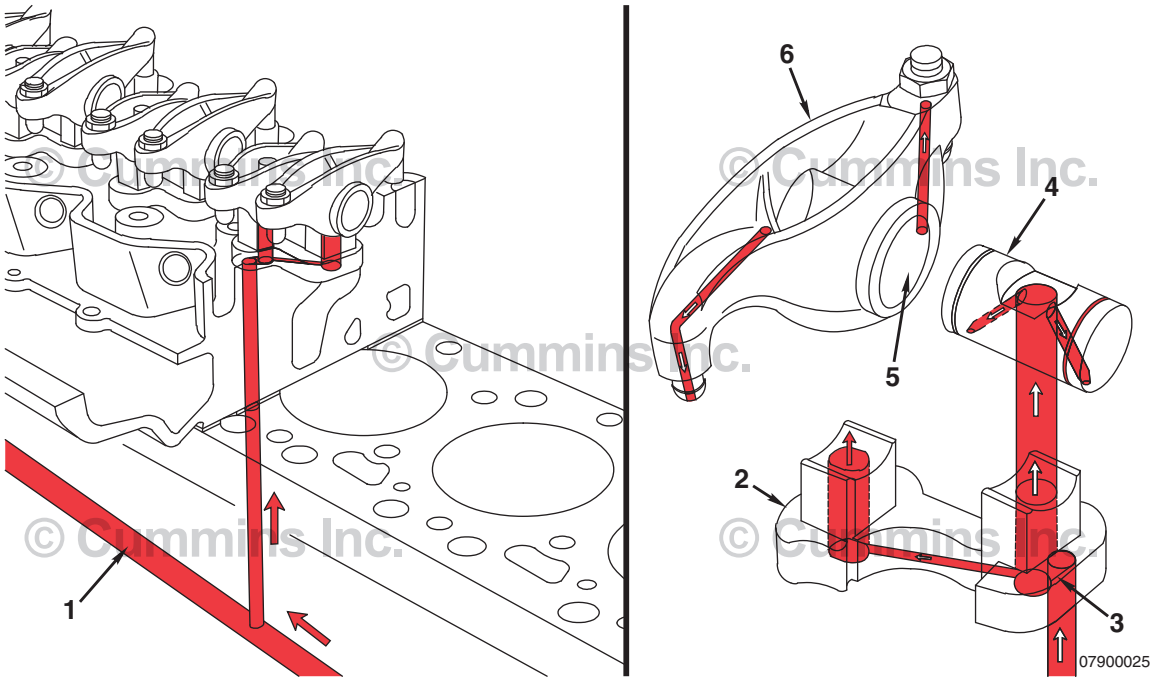


Lubrication for the Power Components

1 From lubricating oil cooler
2 Main lubricating oil rifle
3 To valve train
4 From main lubricating oil rifle
5 To piston-cooling nozzle
6 To camshaft
7 Crankshaft main journal
8 Oil supply to rod bearings
9 Directed piston-cooling nozzle
10 To internal lubrication of air compressor.

Flow Diagram, Lubricating Oil System

Flow Diagram



Lubrication for the Overhead Components

1 Main lubricating oil rifle

2 Rocker lever support

3 Transfer slot

4 Rocker lever shaft

5 Rocker lever bore

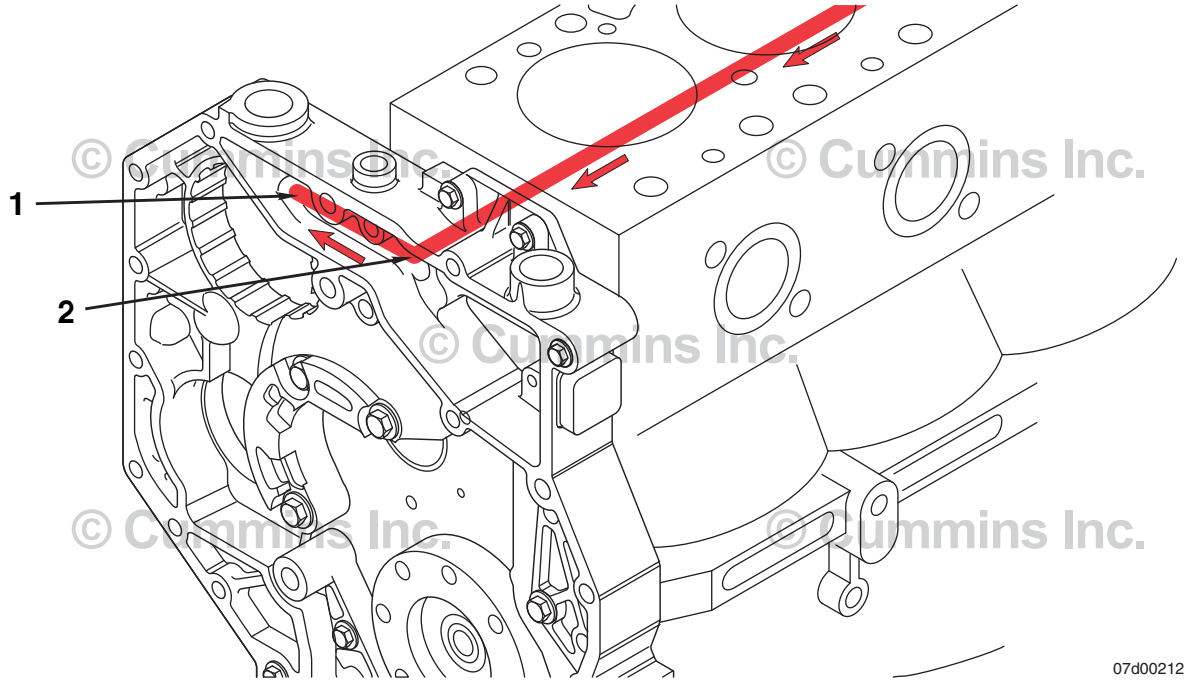
6 Rocker lever.

Overhead Components

From the cylinder block, the drilling continues in the cylinder head to a drilling in the rocker lever pedestal. Internal drillings in the pedestal supply lubricating oil to the rocker shaft, push rod socket, and crosshead pad. Residual oil from the overhead lubricates the camshaft and tappets.

Flow Diagram, Lubricating Oil System

Flow Diagram



Lubrication for the Accessory Drive

1 Oil supply to accessory drive

2 Oil feed from block.

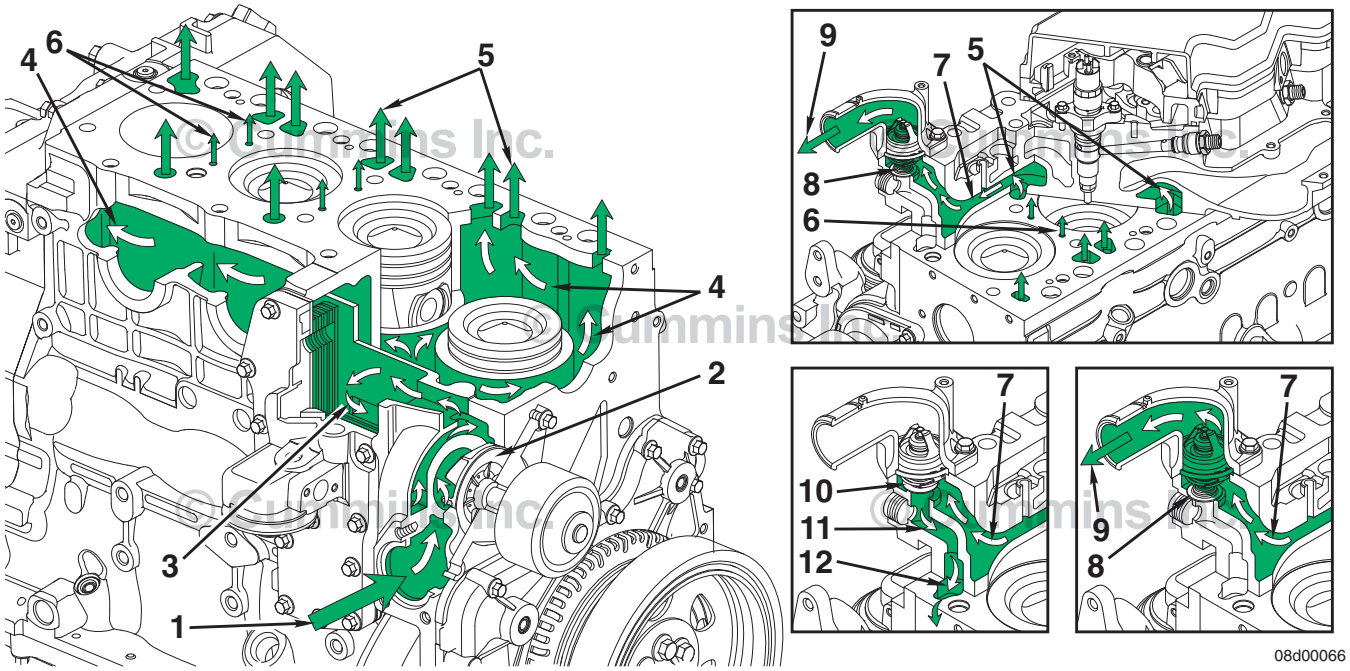
NOTE: Oil returns to pan through the gear housing

Accessory Drive (Rear Gear Train Engines **Only**)

From the main oil rifle, oil is supplied to a drilling in the rear gear housing that feeds the accessory drive. Return oil from the accessory drive is returned to the oil pan through the rear gear housing.

Flow Diagram, Cooling System

Flow Diagram

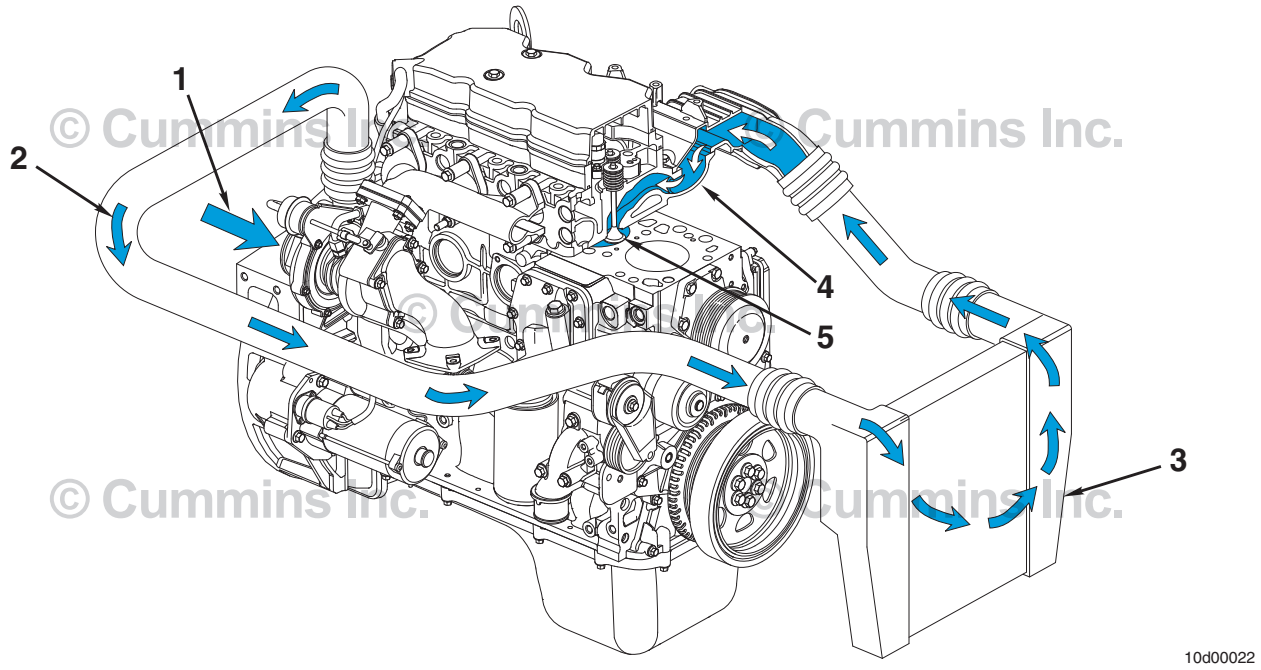


1 Coolant inlet
2 Pump impeller
3 Coolant flow past lubricating oil cooler
4 Coolant flow past cylinders
5 Coolant flow from cylinder block to cylinder head
6 Coolant flow between cylinders
7 Coolant flow to thermostat housing
8 Thermostat open - bypass passage closed
9 Coolant flow back to radiator
10 Thermostat closed - bypass passage open
11 Coolant bypass in cylinder head
12 Coolant flow to water pump inlet.

NOTE: Some applications use an OEM supplied remote mounted thermostat. Refer to the OEM service manual for location.

Flow Diagram, Air Intake System

Flow Diagram



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

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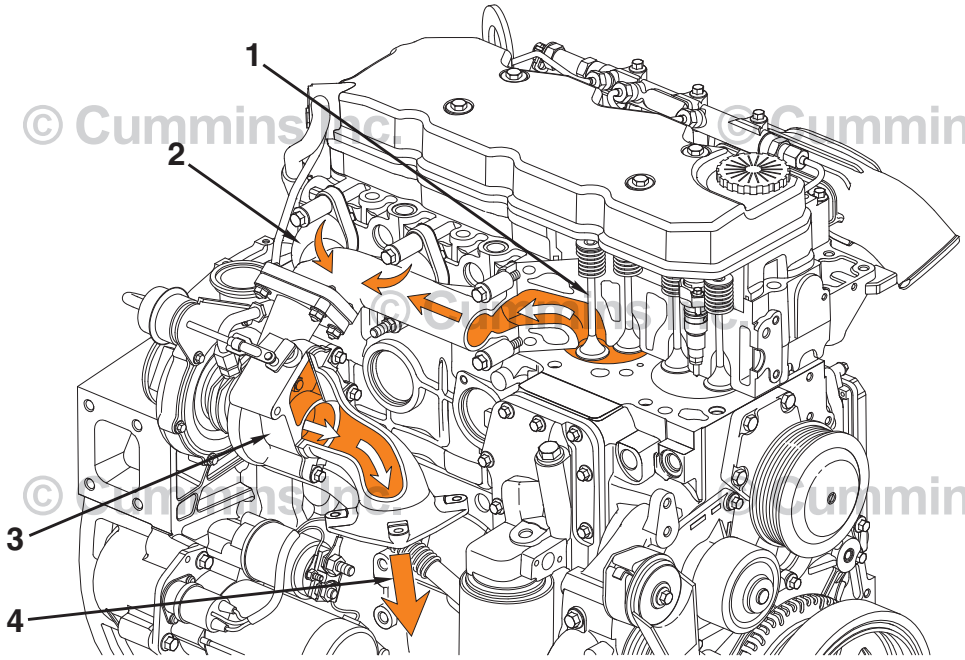
Flow Diagram, Exhaust System

Flow Diagram

Without EGR



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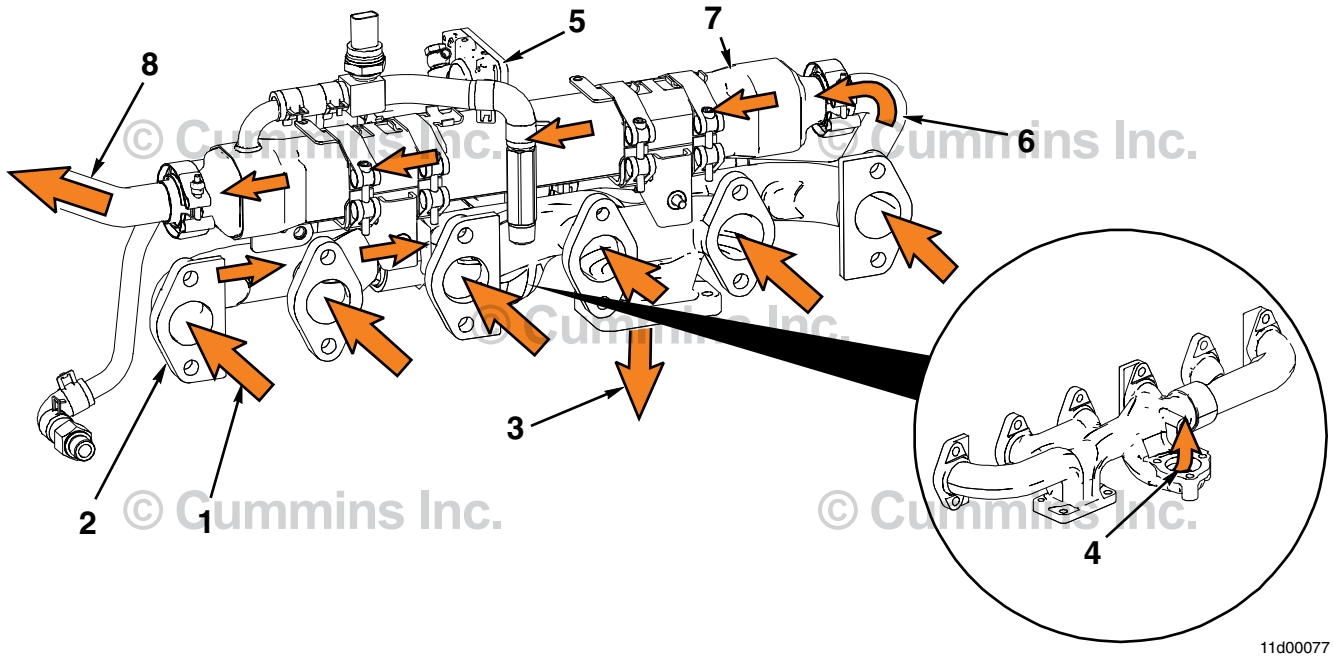
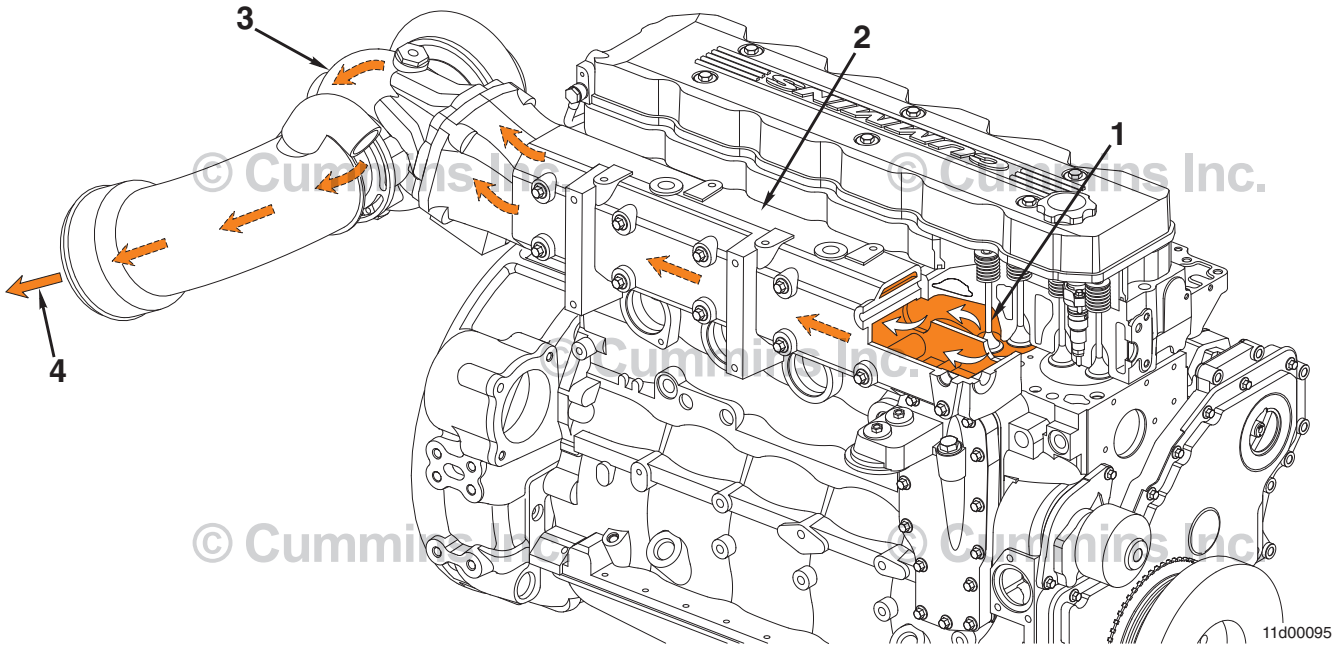
1 Exhaust valve
2 Exhaust manifold
3 Turbocharger
4 Turbocharger exhaust outlet.

With EGR



1 Exhaust gas to manifold
2 Exhaust manifold
3 Exhaust gas to turbocharger
4 Exhaust gas to exhaust gas recirculation (EGR) valve
5 EGR valve
6 Exhaust gas from EGR valve to EGR cooler connection
7 EGR cooler
8 Cooled exhaust gas to EGR connection tube and EGR mixer.

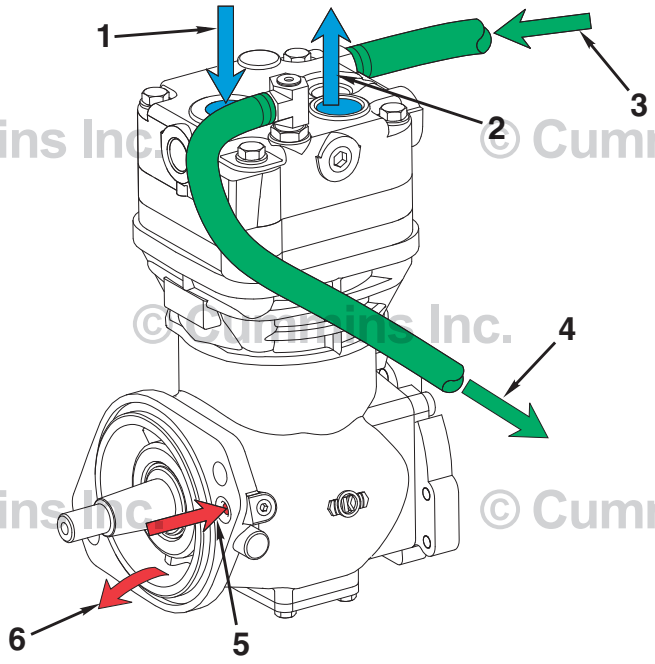
Marine Applications



1 Exhaust valve
2 Exhaust manifold (wet)
3 Turbocharger (water cooled)
4 Exhaust outlet.

Flow Diagram, Compressed Air System

Flow Diagram



12d00045

1 Air in
2 Air out
3 Coolant in
4 Coolant out
5 Lubricating oil in (internal to the gear housing)
6 Lubricating oil out (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:

Additional Service Literature	
4021271	ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual
4021578	ISB CM2100 and CM2150 Service Manual
4021597	ISBe and ISDe CM2150 Service Manual
4022188	ISB4.5, ISB6.7, ISD4.5, and ISD6.7 CM2150 SN Service Manual
4022254	ISB6.7 CM2250 Service Manual
4021416	ISB, ISBe2, ISBe3, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 CM850 Electronic Control System Troubleshooting and Repair Manual
4021570	ISB, ISC, ISL, ISDe, and QSB3.3 CM2150 Electronic Control System Troubleshooting and Repair Manual
4021524	QSB4.5, QSB6.7, QSB8.3 and QSL9 CM850 Electronic Control Module Wiring Diagram
4022225	Troubleshooting and Repair Manual, CM2250 Electronic Control System
4021532	ISBe4 with CM850 Electronic Control Module Wiring Diagram (1)
4021572	ISB CM2150 Wiring Diagram
4021625	ISDe and ISBe with CM2150 Control Module Wiring Diagram
4021670	ISBe2 / ISBe3 CM850 Wiring Diagram
4022230	ISB6.7 CM2250 Wiring Diagram
4021531	QSB4.5 and QSB6.7 Operation and Maintenance Manual
4021546	ISBe4 (Common Rail Fuel System) Operation and Maintenance Manual
4021602	ISB CM2150 Operation and Maintenance Manual
4021619	ISBe and ISDe CM2150 Operation and Maintenance Manual
4021680	ISBe2 and ISBe3 CM850 Operation and Maintenance Manual
4022189	ISB4.5, ISB6.7, ISD4.5, and ISD6.7 CM2150 SN Operation and Maintenance Manual
4022263	ISB6.7 CM2250 Operation and Maintenance Manual
4021601	ISB CM2150 Owners Manual
4021620	ISBe and ISDe CM2150 Owners Manual
4021681	ISBe2 and ISBe3 CM850 Owners Manual
4022220	ISB4.5, ISB6.7, ISD4.5, and ISD6.7 CM2150 SN Owners Manual
4022262	ISB6.7 CM2250 Owners Manual
3379000	Air for Your Engine
3379001	Fuels for Cummins® Engines
3379009	Operation of Diesel Engines in Cold Climates
3666132	Cummins® Coolant Requirements and Maintenance
3387266-R	Cold Weather Operation
3810340	Cummins® Engine Oil and Oil Analysis Recommendations

Additional Service Literature	
4021566	Diesel Exhaust Fluid (DEF) Specifications for Cummins® Selective Catalytic Reduction (SCR) Systems
(1) Revision 01 or newer is required for ISBe4+/ISBe5- (Minus)	

Service Literature Ordering Location

Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at https://store.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 contain 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.

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 Cummins QuickServe Online.

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 Distributors, Original Equipment Manufacturers and Cummins Factory personnel order by calling Iron Mountain Fulfillment Services (IMFS) at 1-800-646-5609.
- International Distributors and Original Equipment Manufacturers order the CPC from their regional Cummins Parts Distribution Centers (PDC).
- International PDC orders are called into Iron Mountain at (++) 630-283-2420.
- Retail Credit Card Orders require a 2 step ordering process.

Ordering On-Line

Access the Cummins QSOL store at https://store.cummins.com

- Find the Customized Parts Catalog button located on the left of the homepage
- Select format. Your Price is also shown here
- Finalize Shopping Cart and Check Process as described on the website

North America call Iron Mountain Fulfillment Services (IMFS) at 800-646-5609, International customers call (++) 630-283-2420. Provide IMFS the catalog detail as described on the website. This step is required until we have our On Line form available.

Required information needed for your Customized Parts Catalog Order.

- Customer Name
- Street Address
- Company Name (optional)
- Telephone no.
- Credit Card No.
- Cummins Engine Serial Number (located on the engine data plate)

Unfortunately not all Cummins Engines can be supported by Customized Parts Catalogs. 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.

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
Florida		Cummins Power South, LLC 5912 E. Hillsborough Avenue Tampa, FL 33610 Telephone: (813) 626-1101 FAX: (813) 628-8888
Florida		Cummins Power South, LLC 6606 N. 56th Street Tampa, FL 33610 Telephone: (813) 623-3330 FAX: (813) 628-4162

Georgia	**Atlanta**	Cummins South, Inc. 100 University Ave. S.W. Atlanta, Georgia 30315-2202 Telephone: (404) 527-7800 FAX: (404) 527-7832
Georgia		Cummins South, Inc. 5125 Georgia Highway 85 College Park, GA 30349 Telephone: (404) 763-0151 FAX: (404) 766-2132
Georgia	**Albany**	Cummins South, Inc. 1915 W. Oakridge Drive Albany, GA 31707-4938 Telephone: (912) 888-6210 FAX: (912) 883-1670
Georgia	**Augusta**	Cummins South, Inc. 1255 New Savannah Road Augusta, GA 30901-3891 Telephone: (706) 722-8825 FAX: (706) 722-7553
Georgia	**Savannah**	Cummins South, Inc. 8 Interchange Court Savannah, GA 31401-1627 Telephone: (912) 232-5565 FAX: (912) 232-5145
Hawaii	**Kapolei**	Cummins West Inc. 91-230 Kalaeloa Blvd. Kapolei, HI 96707 Telephone: (808) 682-8110 FAX: (808) 682-8477
Idaho	**Boise**	Cummins Rocky Mountain, LLC 8949 So. Federal Way City Boise, Idaho 84716 Telephone: (208) 336-5000 FAX: (208) 338-5436
Illinois	**Chicago**	Cummins Power, LLC 7145 Santa Fe Drive Hodgkins, IL 60525 Telephone: (708) 579-9222 FAX: (708) 352-7547
Illinois	**Bloomington**	Cummins Mid-States Power, Inc. (at U.S. 51 N and I-55) 414 W. Northtown Road Bloomington-Normal, IL 61761 Telephone: (309) 452-4454 FAX: (309) 452-1642
Illinois	**Onan Branch**	Cummins/Onan Northern Illinois 8745 W. 82nd Place Justin, IL 60458 Telephone: (708) 563-7070 FAX: (708) 563-7095

Illinois	**Madison**	Cummins MId-South, LLC 222 SR-203 Madison, Illinois 62060 Telephone: (618) 798-9512 FAX: (618) 798-9521
Illinois	**Rock Island**	Cummins Central Power, LLC 7820 - 42nd Street West Rock Island, IL 61201 Telephone: (309) 787-4300 FAX: (309) 787-4397
Indiana	**Indianapolis**	Cummins Mid-States Power, Inc. P.O. Box 42917 3762 West Morris Street Indianapolis, IN 46242-0917 Telephone: (317) 243-7979 FAX: (317) 240-1925
Indiana		Cummins Mid-States Power, Inc. P.O. Box 42917 3661 West Morris St Indianapolis, IN 46241 Telephone: (317) 486-5287 FAX: (317) 486-5281
Indiana		Cummins Mid-States Power, Inc. 4301 W. Morris St. 3762 West Morris Street Indianapolis, IN 46241 Telephone: (317) 240-1967 FAX: (317) 240-1975
Indiana	**Evansville**	Cummins Cumberland, Inc. 7901 Highway 41 North Evansville, IN 47725 Telephone: (812) 867-4400 FAX: (812) 867-4411
Indiana	**Ft. Wayne**	Cummins Mid-States Power, Inc. 3415 Coliseum Blvd. West (At Jct. I-69 & 30/33) Ft. Wayne, IN 46808 Telephone: (219) 482-3691 FAX: (219) 484-8930
Indiana	**Gary**	Cummins Northern Illinois, Inc. 1440 Texas Street Gary, IN 46402 Telephone: (219) 885-5591 FAX: (219) 883-4817
Indiana	**Indianapolis**	Cummins Mid-States Power, Inc. 3661 West Morris St Indianapolis, IN 46241 Telephone: (317) 486-5287 FAX: (317) 486-5281
Iowa	**Cedar Rapids**	Cummins Central Power, LLC 625 - 33rd Avenue SW Cedar Rapids, IA 52404 Telephone: (319) 366-7537 (24 hours) FAX: (319) 366-7562

Iowa	**Des Moines**	Cummins Central Power, LLC 1680 N.E. 51st Avenue Des Moines, IA 50313 Telephone: (515) 262-9591 Parts: (515) 262-9744 FAX: (515) 262-0626
Kansas	**Colby**	Cummins Central Power, LLC 1880 South Range Colby, KS 67701 Telephone: (785) 462-3945 FAX: (785) 462-3970
Kansas	**Garden City**	Cummins Central Power, LLC 1285 Acraway Garden City, KS 67846 Telephone: (316) 275-2277 FAX: (316) 275-2533
Kansas	**Wichita**	Cummins Central Power, LLC 5101 North Broadway Wichita, KS 67219 Telephone: (316) 838-0875 FAX: (316) 838-0704
Kentucky	**Louisville**	Cummins Cumberland, Inc. (Corporate Office) 2301 Nelsonville Parkway Louisville, KY 40223 Telephone: (502) 254-7375 FAX: (502) 254-1215
Kentucky	**Hazard**	Cummins Cumberland, Inc. Highway 15 South Hazard, KY 41701 Telephone: (606) 436-5718 FAX: (606) 436-5038
Kentucky	**Louisville**	Cummins Cumberland, Inc. 9820 Bluegrass Parkway Louisville, KY 40299 Telephone: (502) 491-4263 FAX: (502) 499-0896
Louisiana	**Morgan City**	Cummins Mid-South, LLC 9508 Highway 90 E Amelia, LA 70340 Telephone: (504) 631-0576 FAX: (504) 631-0081
Louisiana	**New Orleans**	Cummins Mid-South, LLC 110 E. Airline Highway Kenner, LA 70062 Telephone: (504) 465-3412 FAX: (504) 465-3408
Maine	**Scarborough**	Cummins Northeast, Inc. 10 Gibson Road Scarborough, ME 04074 Telephone: (207) 883-8155 FAX: (207) 883-5526

Maryland	**Baltimore**	Cummins Power Systems, Inc. 1907 Park 100 Drive MD 21061 Telephone: (410) 590-8700 FAX: (410) 590-8731
Massachusetts	**Boston**	Cummins Northeast, Inc. 100 Allied Drive Dedham, MA 02026 Telephone: (781) 329-1750 FAX: (781) 329-4428
Massachusetts	**Springfield**	Cummins Northeast, Inc. 177 Rocus Street Springfield, MA 01104 Telephone: (413) 737-2659 FAX: (413) 731-1082
Michigan	**Detroit (New Hudson)**	Standby Power, Div. of Cummins Bridgeway, LLC 21810 Clessie Ct New Hudson, Michigan 48165 Telephone: (248) 573-1600
Michigan		Cummins Bridgeway, LLC 54240 Grand River Ave New Hudson, Michigan 48165 Telephone: (517) 573-1900
Michigan	**Grand Rapids**	Cummins Bridgeway, LLC 3715 Clay Avenue, S.W. Grand Rapids, MI 49508 Telephone: (616) 538-2250 FAX: (616) 538-3830
Michigan	**Grand Rapids**	Standby Power, Inc. 7580 Expressway Drive S.W. Grand Rapids, MI 49548 Telephone: (616) 281-2211 FAX: (616) 281-3177
Michigan	**Iron Mountain**	Cummins NPower, LLC 1901 Stevenson Avenue Iron Mountain, MI 49801 Telephone: (906) 774-2424 FAX: (906) 774-1190
Michigan	**Saginaw**	Cummins Bridgeway, LLC 722 N. Outer Drive Saginaw, MI 48605 Telephone: (989) 752-5200 FAX:(989) 752-4194
Minnesota	**St. Paul**	Cummins NPower, LLC 3030 Centre Pointe Drive Suite 500 Roseville, MN 55113 Telephone: (651) 636-1000 FAX: (651) 638-2442
Minnesota	**Duluth**	Cummins NPower, LLC 3115 Truck Center Drive Duluth, MN 55806-1786 Telephone: (218) 628-3641 FAX: (218) 628-0488

Mississippi	**Jackson**	Cummins Mid-South, LLC 325 New Highway 49 South Jackson, MS 39288-4224 Telephone: (601) 939-7016 FAX: (601) 932-7399
Missouri	**Kansas City**	Cummins Central Power, LLC 8201 NE Parvin Road Kansas City, MO 64161 Telephone: (816) 414-8200 FAX: (816) 414-8299
Missouri	**Joplin**	Cummins Central Power, LLC 3507 East 20th Street Joplin, MO 64801 Telephone: (417) 623-1661 FAX: (417) 623-1817
Missouri	**Springfield**	Cummins Central Power, LLC 3637 East Kearney Springfield, MO 65803 Telephone: (417) 862-0777 FAX: (417) 862-4429
Missouri	**Columbia**	Cummins Mid-South, LLC 5221 Highway 763 North Columbia, MO 65205 Telephone: (314) 449-3711 FAX: (314) 449-3712
Missouri	**Sikeston**	Cummins Mid-South, LLC 101 Keystone Drive Sikeston, MO 63801 Telephone: (573) 472-0303 FAX: (573) 472-0306
Missouri	**Industrial Power Branch**	Cummins Mid-South, LLC 3256 E. Outer Road Scott City, MO 63780 Telephone: (573) 335-7399 FAX: (573) 335-7062
Montana	**Billings**	Cummins Rocky Mountain, LLC 5151 Midland Road Billings, MT 59101 Telephone: (406) 245-4194 FAX: (406) 245-7923 Toll Free #: (800) 332-7788
Montana	**Missoula**	Cummins Northwest, Inc. 4950 North Reserve Street Missoula, MT 59802-1498 Telephone: (406) 728-1300 FAX: (406) 728-8523
Nebraska	**Omaha**	Cummins Great Plains Diesel, Inc. 5515 Center Street Omaha, NE 68106 Telephone: (402) 551-7678 (24 Hours) FAX: (402) 551-1952

Nebraska	**Kearney**	Cummins Central Power, LLC 515 Central Avenue Kearney, NE 68847 Telephone: (308) 234-1994 FAX: (308) 234-5776
Nevada	**Elko**	Cummins Rocky Mountain, LLC 5370 East Idaho Street Elko, NV 89801 Telephone: (702) 738-6405 FAX: (702) 738-1719
Nevada	**Las Vegas**	Cummins Rocky Mountain, LLC 2750 Losee Road North Las Vegas, NV 89030 Telephone: (702) 399-2614 FAX: (702) 399-7457
Nevada	**Sparks**	Cummins Rocky Mountain, LLC 150 Glendale Avenue Sparks, NV 89431 Telephone: (775) 331-4983 FAX: (775) 331-7429
New Jersey	**Newark**	Cummins Metropower, Inc. 41-85 Doremus Ave. Newark, NJ 07105 Telephone: (973) 491-0100 FAX: (973) 578-8873
New Mexico	**Albuquerque**	Cummins Rocky Mountain, LLC 1921 Broadway N.E. Albuquerque, NM 87102 Telephone: (505) 247-2441 FAX: (505) 842-0436
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Regional Office - Daventry

Cummins Engine Co. Ltd (Serving Czech Republic), (Middle East), (Africa)
Royal Oak Way South
Daventry, Northamptonshire
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Brussels
Telephone: (44-1327) 886 000
Fax: (44-1327) 886 100

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Cumbrasa Regional Office - Brazil

Cummins Brasil Ltda.
Rua Jati, 266
07180-900 Guarulhos
Sao Paulo, Brazil
Telephone: (55-11) 6465-9811
Fax: (55-11) 6412-1483

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Cummins India Ltd.	
Kothrud Pune ZIP / Postal Code: 411038 India Telephone: +91-20-2538 5435 or 2538 0240 Fax: +91-20-2538 0125 www.cumminsindia.com	
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Cummins, S. de R.L. de C.V. Arquimedes No. 209 Col. Polanco 4605 Modern Lane Mexico, Distrito Federal ZIP / Postal Code: 11560 Mexico Telephone: (52-5) 254-3822 / 3783 / 3622 Fax: (52-5) 254-3645	

Country Covered:		
	Mexico	Costa Rica
	Guatemala	Nicaragua
	Honduras	Panama

Moscow Regional Office - Russia	
Cummins Engine Co., Inc. Park Place Office E708 113/1 Leninsky Prospect Russia 117198 Telephone: (7-495) 956-51-22 / 23 Fax: (7-495) 956-53-62	

Countries Covered:		
	Armenia	
	Azerbaijan	Moldova
	Belarus	Russia
	Tajikistan	
	Georgia	Turkmenistan
	Kyrgyzstan	Ukranie
	Kazakhstar	Uzbekistan

Southeast Asia Regional Office - Singapore **Singapore**	
Cummins Diesel Sales Corporation 8 Tanjong Penjuru ZIP / Postal Code: 609019 Singapore Telephone: (65) 265-0155 Fax - Parts/MIS/Shipping: (65) 6264-0664	

Countries Covered:

- Bangladesh
- Brunei
- Cambodia
- Indonesia
- Laos
- Malaysia
- Philippines
- Singapore
- Sri Lanka
- Thailand
- Vietnam

Latin America Regional Office - Miramar (U.S.A.)	
Cummins Americas, Inc. 3350 SW 148 Avenue Suite 205 Miramar, FL 33027 U.S.A. Telephone: (954) 431-5511 Fax: (954) 433-5797	

Countries Covered:

- Argentina
- Bolivia
- Chile
- Colombia
- Dominican Republic
- El Salvador
- Eucador
- Costa Rica
- Dominican
- Paraguay
- Peru
- Uruguay
- Venezuela
- Honduras
- Nicaragua

Distributors - International - Locations

Cummins Middle East FZE	**Cummins Middle East FZE**	P.O. Box No 17636, Units ZF 05 & 06Jebel Ali Free Zone, DubaiUnited Arab EmiratesTelephone: 00 9714 8838998Fax: 00 9714 8838997,
United Arab Emirates	**Cummins Emirates Sales & Service LLC**	P.O. Box No 54044Al Quoz Industrial Estate, DubaiUnited Arab EmiratesTelephone: 00 9714 3478184Fax: 00 9714 3478185Toll Free: 800 4184 ,
United Arab Emirates	**Cummins Emirates Sales & Service LLC**	P.O. Box No 70242, Abu DhabiUnited Arab EmiratesTelephone: 00 9712 6722980Fax: 00 9712 6722981,
ALBANIA		(Please contact the Central & Eastern European Regional Office)Cummins Diesel Deutschland GmbHGross-GerauOdenwaldstraße 23Groß-GerauZIP / Postal Code: 64521GermanyTelephone: (49-6152) 174-0Fax: (49-6152) 174-141,
ALGERIA		(Please contact) Cummins Diesel S.A.39 rue AmpèreBP 190Chassieu cédex 69680FranceTelephone: (33-4) 72 22 92 72Fax: (33-4) 78 90 19 56,
ALGERIA		-See SOUTH PACIFIC ISLANDS(Please contact) Cummins2 Caribbean DriveScoresby 3179VictoriaAUSTRALIATelephone: (61-3) 9765-3222Fax: (61-3) 9763-0079,
ANDORRA		- See European Regional Office - Mechelen ,
ANDORRA		Cummins Belgium Egide Walschaertsstraat, 2Industriepark Zuid2800 MechelenBelgiumEuropeTelephone: (32-15) 47 91 00Fax: (32-15) 27 56 86,
ANDORRA		,
ANGOLA	**(Please contact) Cummins Diesel South Africa (Pty) Ltd**	13 Eastern Service RoadKelvin (Neighbourhood), AlexandraRua Major Kahangulo, 134/140Gauteng, South AfricaZIP / Postal Code: 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
ANTIGUA		Miami (Office In U.S.A.)Cummins Power South, LLC9900 N.W. 77 Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
ARGENTINA	**Buenos Aires**	Distribuidora Cummins, S.A.Ruta Panamericana KM 32.5El Talar de Pacheco, Buenos AiresZIP / Postal Code: CP 1618Argentina Telephone: (54-11) 4736-6400Fax: (54-11) 4736-6479 / 6466 ,
ARUBA, ISLAND OF		(Please contact) Cummins Power South, LLC9900 N W 77th Ave.Hialeah Gardens, Florida 33016Telephone: (1-305) 821-4200Fax: (1-305) 557-2992,
AUSTRALIA	**Bunbury**	Cummins11 Dryanda CourtPictonBunbury, Western Australia 6229Telephone: (61-8) 9725-6777Fax: (61-8) 9725-6444,

AUSTRALIA	**Cairns**	Cummins11 Liberty Street Cairns, Queensland 4870AustraliaTelephone: (61-7) 935-2999 Fax: (61-7) 4035 2909,
AUSTRALIA	**Campbellfield**	Cummins1788-1800 Hume Highway Campbellfield, Victoria 3061AustraliaTelephone: (613) 9357-9200 Fax: (613) 9357 9916,
AUSTRALIA	**Dandenong**	Cummins46 Greens Road Dandenong, Victoria 3175 Australia Telephone: (613) 9706-8088Fax: (613) 9706 8016,
AUSTRALIA	**Darwin**	CumminsLot 1758 Graffin Crescent Winnellie, Darwin Northern Territory 0820 AustraliaTelephone: (61-8) 8947-0766 Fax: (61-8) 8984 4569,
AUSTRALIA	**Devonport**	Cummins2 Matthews Way Devonport, Tasmania 7310 AustraliaTelephone: (61-3) 6424-8800 Fax: (61-3) 6424 2200,
AUSTRALIA	**Emerald**	Cummins23 Old Sheepyard PlaceEmerald, Queensland 4720AustraliaTelephone: (61-7) 4982 4022Fax: (61-7) 4982 4159,
AUSTRALIA	**Grafton**	Cummins18 - 20 Induna StreetSouth Grafton, New South Wales 2460AustraliaTelephone: (61-2) 6641 1000Fax: (61-2) 6641 1099,
AUSTRALIA	**Hexham**	Cummins Engine Company, Pty. Ltd.21 Galleghan Street Hexham Newcastle, New South Wales, Australia 2322Telephone: (61-2) 4964-8466 Fax: (61-2) 4964-8616,
AUSTRALIA	**Kalgoorlie**	CumminsLot 62 Great Eastern HighwayCnr Hunter StreetKalgoorlie, Western AustraliaZIP / Postal Code: 6430AustraliaTelephone: (61-8) 9080 1300Fax: (61-8) 9091 7933,
AUSTRALIA	**Karratha**	Cummins1964 Anderson RoadKarratha, Western Australia 6714AustraliaTelephone: (61-8) 9144 4646 Fax: (61-8) 9143 1507,
AUSTRALIA	**Laverton**	Cummins191-195 Boundary RoadLaverton North, Victoria 3026AustraliaTelephone: (61-3) 8368 0800Fax: (61-3) 9360 0438,
AUSTRALIA	**Leeton**	Cummins29 Brady WayLeeton, NSW 2705AustraliaTelephone: (61-2) 6953-3077Fax: (61-2) 6953-3109,
AUSTRALIA	**Mackay**	Cummins46 Southgate DrivePaget, QueenslandZIP / Postal Code: 4740AustraliaTelephone: (61-7) 4952 8100Fax: (61-7) 4952 5631,
AUSTRALIA	**Mount Gambier**	Cummins2 Avey RoadMount Gambier, South Australia 5290AustraliaTelephone: (61-8) 8725 6422Fax: (61-8) 8724 9764,
AUSTRALIA	**Penrith**	CumminsTotal Truck Centre141 Coreen AvenuePenrith, New South Wales 2750AustraliaTelephone: (61-2) 4731 2188Fax: (61-2) 4731 1140,

AUSTRALIA	**Queanbeyan**	Cummins15-17 Bayldon RoadQueanbeyan, New South Wales 2620AustraliaTelephone: (61-2) 6297 3433Fax: (61-2) 6297 6709,
AUSTRALIA	**Swan Hill**	Cummins5 McAllister RoadSwan Hill, Victoria 3585AustraliaTelephone: (61-3) 5033 1511Fax: (61-3) 5032 9662,
AUSTRALIA	**Tamworth**	CumminsLot 65 Gunnedah RoadTamworth, New South Wales 2340AustraliaTelephone: (61-2) 6765 5455Fax: (61-2) 6765 5443,
AUSTRALIA	**Townsville**	Cummins704-710 Ingham RoadTownsville, Queensland 4810AustraliaTelephone: (61-7) 4774 7733 Fax: (61-7) 4774 7640,
AUSTRALIA	**Welshpool**	Cummins443 Horrie Miller DriveIndustrial ParkPerth International Airport, Western Australia 6105AustraliaTelephone: (61-7) 9475 8777Fax: (61-7) 9475 8666,
AUSTRALIA	**Wetherill Park**	Cummins492-494 Victoria StreetWetherill Park, New South Wales 2164AustraliaTelephone: (61-2) 9616 5300Fax: (61-2) 9616 5399,
AUSTRALIA	**Wodonga**	Cummins9 - 11 McKoy StreetWodonga, Victoria 3690AustraliaTelephone: (61-2) 6024 3655Fax: (61-2) 6024 3102,
AUSTRIA	**Neudörfl**	CumminsBickfordstraße 25Neudörfl, Burgenland 7201Austria Telephone: (43-2622) 77418 0Fax: (43-2622) 77418 4,
BAHAMAS	**Miami (Office in U.S.A.)**	Cummins Power South, LLC9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992 ,
BAHRAIN	**Bahrain**	Yusuf Bin Ahmed Kanoo W.L.L.Commercial Division832 Majlees Al Tawoon Highway, Al-Hamriya 611, SitraManamaZIP / Postal Code: Kingdom of BahrainBahrain Telephone: (973) 17 738200Fax: (973) 17 732828,
BALEARIC ISLANDS	**Madrid (Office in Spain)**	Cummins Ventas y Servicio, S.A.Torrelaguna, 56 Madrid 28027SpainTelephone: (34-91) 367-2000 376-2404Fax: (34-91) 407 6604,
BANGLADESH	**Jakson International Ltd.**	87 Suhrawardi Avenue (5th Floor) Baridhara, Dhaka-1212, Bangladesh Cell: +8801730358629 Tel: +88029893621, 9895783 Fax: +88029863307,
BARBADOS	**Miami (Office in U.S.A.)**	Cummins Power South, LLC900 N W 77th Ave.Hialeah Gardens, Florida 33016Telephone: (305) 821-821-4200Fax: (305) 557-2992,
BELGIUM	**Mechelen**	Cummins Distributor Egide Walschaertsstraat, 2Industriepark ZuidMechelenZIP / Postal Code: 2800BelgiumTelephone: (32-15) 479 100Fax: (32-15) 275 686,
BELIZE	**Tampa (Office in U.S.A.)**	Cummins Power South, LLC5421 N. 59th Street Tampa, FL 33610 Telephone: (813) 621-7202 Fax: (813) 621-8250,
BENIN		- See Togo ,

BENIN	**TOGOMAT s.a.**	Zone Industrielle CNPPMELomeTogoTelephone: (228) 2272395Fax: (228) 2270310,
BERMUDA	**Bronx (Office in U.S.A.)**	Cummins Metropower, Inc. 890 Zerega Avenue Bronx, NY 10473 Telephone: (718) 892-2400Fax: (718) 892-0055,
BHUTAN	**Pune (Office in India)**	Cummins Diesel Sales & Service (India) Ltd35A/1/2, Erandawana Pune, Maharashtra 411038IndiaTelephone: (91-20) 25431234 / 25430666 25431703Fax: (91-20) 25439490,
BOTSWANA- See Southern Africa Regional Office - Kelvin	**Cummins Diesel South Africa (Pty)**	9 Impala Road Kelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South AfricaTelephone: (27-11) 321 8800Fax: (27-11) 444 3254,
BRAZIL	**Belo Horizonte**	Distribuidora Cummins Minas Ltda.Anel Rodoviario, Km 01 - Bairro Olhos D'Agua NorteBelo Horizonte, Minas Gerais 31950Brazil Telephone: (55-31) 3288-1344Fax: (55-31) 3288-1141,
BRAZIL	**Campo Grande**	Cummins Distribuidora de Motores Diesel e Equipamentos Ltda. Av. Rod. BR 163, nr. 5185Campo Grande, MATO GROSSO DO SUL 79060BrazilTelephone: (55-67) 387-8707Fax: (55-67) 387-8707,
BRAZIL	**Curitiba**	Distribuidora Parana de Motores Cummins Ltda.Abel Scuissiato 3020, Bairro AtubaCuritiba, PARANA 83408Brazil Telephone: (55-41) 3675-4500Fax: (55-41) 3675-6077,
BRAZIL	**Fortaleza**	Distribuidora Cummins Diesel do Nordeste LtdaBR 116, km.10 - nr.10.001, MessejanaFortaleza, CEARAZIP / Postal Code: 60871Brazil Telephone: (55-85) 4011-6400Fax: (55-85) 4011-6400,
BRAZIL	**Goianian**	Distribuidora Cummins Centro Oeste Ltda.Centro Oeste Ltda. Av. Caiapo , 777 Bairro Santa GenovevaGoiania, GOIAS 74672Brazil Telephone: (55-62) 269-1010 / 1011Fax: (55-62) 269-1032 / 1021,
BRAZIL	**Manaus**	Powertech Comercial Ltda.Av. Efigenio Sales 1717 - Parque 10Estrada da Ponta Negra, 6080 - SaoManaus, AMAZONAS 69060Brazil Telephone: (55-92) 642-2014Fax: (55-92) 236-6711,
BRAZIL	**Porto Alegre**	Distribuidora Meridional Motores Cummins Ltda.Av. Assis Brasil , 9000 SarandiPorto Alegre, RIO GRANDE DO SUL 91140BrazilTelephone: (55-51) 3021-2288Fax: (55-51) 3364-2288,
BRAZIL	**Rio de Janeiro**	Cummins Distribuidora de Motores Diesel e Equipamentos Ltda.Av. Brasil, 20289BotafogoRio de Janeiro, RIO DE JANEIRO 21515BrazilTelephone: (55-21) 2196-3131Fax: (55-21) 2196-3121,
BRAZIL	**Sao Paulo**	Cummins Distribuidora de Motores Diesel e Equipamentos Ltda.Rua Coronel Euclides Machado, 52Freguesia do OSao Paulo, SAO PAULO 02713BrazilTelephone: (55-11) 3931-2900Fax: (55-11) 3931-2900,

BRITISH VIRGIN ISLANDS		- See Puerto Rico ,
BRITISH VIRGIN ISLANDS	**Cummins de Puerto Rico, Inc.**	Calle 1 G1Urb. Industrial, Barrio PalmasCataño 00962Puerto RicoTelephone: (787) 275-2000Fax: (787) 275-2030,
BRUNEI		- See Malaysia ,
BRUNEI	**Scott & English (M) Sdn Bhd**	12 Jalan U1/15, Seksyen U1Hicom-Glenmarie Industrial ParkShah Alam, Selangor Darul Ehsan 40150MalaysiaTelephone: (60-3) 7805-1111Fax: (60-3) 7803-5122,
BURKINA - FASO		- See North/West/East and Central Africa Regional Office - Daventry,
BURKINA - FASO	**Cummins Engine Company Ltd**	Royal Oak Way SouthDaventry, NorthantsZIP / Postal Code: NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
BULGARIA		-See Germany Regional Office - Gross-Gerau ,
BULGARIA	**Cummins Diesel Deutschland GmbH**	Odenwaldstraße 23Groß-Gerau, Hessen 64521GermanyTelephone: (49-6152) 174-0Fax: (49-6152) 174-141,
BURMA	**Kuala Lumpur (Office In Malaysia)**	Scott & English (M) Sdn Bhd12 Jalan U1/15, Seksyen U1Hicom-Glenmarie Industrial ParkShah Alam, Selangor Darul Ehsan 40150MalaysiaTelephone: (60-3) 7805-1111Fax: (60-3) 7803-5122,
BURUNDI	**Brussels (Office in Belgium)**	Cummins Belgium N.V./S.A.Egide Walschaertsstraat, 2Industriepark ZuidMechelen 2800BelgiumTelephone: (32-15) 479 100Fax: (32-15) 275 686,
CAMBODIA		Scott & English (Cambodia) Ltd.No. 20A E0/E1 Russian BoulevardPhnom PenhCambodiaTelephone: (855-23) 723741Fax: (855-23) 723741,
CANARY ISLANDS	**Madrid (Office in Spain)**	Cummins Ventas y Servico S. A.Torrelaguna 56Madrid 28027Spain Telephone: (34-91) 367 20 00 / 367 24 04Fax: (34-91) 407 66 04,
CAPE VERDE		- See ECV PortugalElectro Central Vulcanizadora, LdaRua Conselheiro Martins de CarvalhoLote 1480 ResteloLisbonZIP / Postal Code: 1400PortugalTelephone: (351-21) 3034800Fax: (351-21) 3034801 / 2,
CENTRAL AFRICAN REPUBLIC		- See North/West Africa Regional Office - DaventryCummins Engine Company LtdRoyal Oak Way SouthDaventry, Northants NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
CHAD		- See North/West/East and Central Africa Regional Office - DaventryCummins Engine Company LtdRoyal Oak Way SouthDaventry, Northants NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,

CHILE	**Santiago**	Distribuidora Cummins Chile, S.A. Avda. Americo Vespucio # 0631Santiago, QuilicuraZIP / Postal Code: 873-0596Chile Telephone: (56-2) 655-7253 / 7245Fax: (56-2) 655-7216 / 7436,
CHINA, PEOPLE'S REPUBLIC	**Beijing**	Cummins Engine (Beijing) Co., Ltd.No. 8, Wan Yuan StreetBeijing Economic and Technology Development ZoneBeijing, 100176People's Republic of ChinaTelephone: (86-10) 67882258Fax: (86-10) 67882285,
CHINA, PEOPLE'S REPUBLIC	**Shenyang**	Cummins Engine (China) Investment Co., Ltd. ShenYangWorkshop & Branch OfficeNo.5-2 Seventh StreetShenyang Economic-Technological Development AreaShenyang, Liaoning 110141ChinaTelephone: (86-24) 25506611Fax: (86-24) 25365599,
CHINA, PEOPLE'S REPUBLIC	**Kunming**	Cummins (China) Investment Co. Ltd. Kunming BranchRoom 606, Hongta MansionNo.155 Beijing RoadKunming, Yunnan 650011Telephone: (86-871) 3579471/511/579/958Fax: (86-871) 3579210,
CHINA, PEOPLE'S REPUBLIC	**Shanghai**	Cummins (China) Investment Co., Ltd. Shanghai Distributor BranchNo. 581, New jin Qiao RoadPu Dong New AreaShanghai, Shanghai 201206ChinaTelephone: (86-21) 50318966Fax: (86-21) 50318528,
CHINA, PEOPLE'S REPUBLIC	**Urumqi**	Cummins Engine (China) Investment Co., Ltd Urumqi BranchNo.7,Shanghai Rd.Urumqi, Xinjiang 830011ChinaTelephone: (86-991) 3780332/5/6/7/8/9Fax: (86-991) 3780334,
CHINA, PEOPLE'S REPUBLIC	**Wuhan**	Cummins Engine (China) Investment Co., Ltd. Wuhan BranchNo.2 Zhang Po Road, Dong Xi Hu DistrictA-Kaili Commercial BuildingWuhan, Hubei 430040ChinaTelephone: (86-27) 83081677Fax: (86-27) 83259369 / 83259370,
CHINA, PEOPLE'S REPUBLIC	**Guangzhou**	Cummins (China) Investment Co., Ltd. Guangzhou BranchG/F, Unit 1 & 2, Block 5, Xing Hui YuanNO. 46, Jinsui Road, Zhu Jiang New City,Guangzhou, Guangdong 510623ChinaTelephone: (86-20) 38621009Fax: (86-20) 38621144,
CHINA, PEOPLE'S REPUBLIC	**Shenzhen**	Shenzhen Chongfa Cummins Engine Company Ltd.Tian An Che Gong Miao Industrial Estate, Unit F2.6 - 2DShenzhen Shennan Da DaoShenzhen, Guangdong 518040ChinaTelephone: (86-755) 83415479Fax: (86-755) 83415480,
COLOMBIA	**Barranquilla**	Cummins de Colombia, S.A.Calle 65 (Avenida Murillo) #6-31Diagonal a Gran AbastosSoledad, AtlanticoColombiaTelephone: (57-53) 282600 / 282601 / 282602 / 282603 / 282604Fax: (57-53) 282640 / 282641,
COLOMBIA	**Bogota**	Cummins de los Andes S.A. Avenida Ciudad de CaliNo. 11-22Location: Bogota, CundinamarcaColombiaTelephone: (57-1) 294-8444Fax: (57-1) 2294-8431,

COLOMBIA	**Bucaramanga**	Cummins API Ltda. Kilómetro 7 Vía a Girón - Zona Industrial A.A. 1821Bucaramanga, Colombia Bucaramanga, Santander ColombiaTelephone: (57-76) 468060 / 469262 / 469263Fax: (57-76) 468065,
COLOMBIA	**Cali**	TecnodieselLimitadaApartado Aereo No. 6398 Carrera 8, No. 27-43Cali, ValleColombiaTelephone: (57-2) 442-2422Fax: (57-2) 442-1798,
COLOMBIA	**Medellin**	EquitelCarrera 52, # 10-184 Medellin, AntioquiaColombiaTelephone: (57-4) 255-4200Fax: (57-4) 255-4104,
COLOMBIA	**Pereira**	Tecnodiesel Limitada Carrera 16 No. 9 - 68Avenida Simon Bolivar, DosquebradasPereira, RisaraldaColombiaTelephone: (57-63) 306102Fax: (57-63) 300062,
COMOROS		- See Southern Africa Regional Office - Kelvin ,
COMOROS		Cummins Diesel South Africa (Pty) Ltd9 Impala RoadKelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South AfricaTelephone: (27-11) 321 8800Fax: (27-11) 444 3254,
CONGO, PEOPLE'S REPUBLIC	**Mechelen (Office in Belgium)**	Cummins Belgium N.V./S.A.Egide Walschaertsstraat, 2Industriepark ZuidMechelen 2800BelgiumTelephone: (32-15) 479 100Fax: (32-15) 275 686,
CORSICA		- See France (Please contact) Cummins Diesel S.A. 39 rue AmpèreBP 190Chassieu cédex 69680Telephone: (33-4) 479 100Fax: (33-4) 78 90 19 56,
COSTA RICA	**San Jose**	Oficina Regional Cummins de Centro AmericaUrbanización Rincón Verde DosCasa 13ESan Pablo de HeredíaCosta RicaTelephone: (506) 238-1160Fax: (506) 238-1108,
CYPRUS	**Nicosia**	Alexander Dimitriou & Sons Limited158 Limassol AveLatsiaNicosia CY-2235CyprusTelephone: (357-22) 715 300Fax: (357-22) 715 400,
CZECH REPUBLIC		- See Central & Eastern EuropeCummins Czech Republic s.r.o.Komercni zona Pruhonice CestliceObchodni 132Praha, Prague 251 01Czech RepublicTelephone: (420-272) 680 110Fax: (420-272) 680 090,
DENMARK	**Glostrup**	Cummins Diesel Salg & Service A/SHovedvejen 233B, OstedRoskilde 4000 Denmark Telephone: (45-46) 42 35 50Fax: (45-46) 42 30 50,
DJIBOUTI		- See North/West/East and Central Africa,
DJIBOUTI		Cummins Engine Company LtdRoyal Oak Way South Daventry, NorthantsZIP / Postal Code: NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,

DOMINICAN REPUBLIC	**Santo Domingo**	Argico C. por A.Calle Jose A. Soler No.3Esq. Lope de Vega Santo Domingo, Distrito NacionalDominican RepublicTelephone: (809) 562-6281Fax: (809) 562-4233 ,
DUBAI		- See United Arab Emirates ,
DUBAI		Cummins Middle East FZEP.O. Box No 17636, Units ZF 05 & 06Jebel Ali Free Zone, DubaiUnited Arab EmiratesTelephone: (00 9714) 8838998 Fax: (00 9714) 8838997,
DUBAI	**United Arab Emirates**	Cummins Emirates Sales & Service LLCP.O. Box No 54044United Arab EmiratesTelephone: (00 9714) 3478184Fax: (00 9714) 3478185Toll Free: (800) 4184 ,
ECUADOR	**Guayaquil**	Indusur S.A.Ave. Carlos Julio Arosemena Km. 4Guayaquil, GuayasEcuadorTelephone: (593-4) 220-1177 / 220-0655Fax: (593-4) 220-1052,
ECUADOR	**Quito**	Rectificadora Botar S.A. Av. 10 de Agosto # 5980Quito, PichinchaEcuadorTelephone: (593-2) 2265-177 / 2265-209 / 2265-225 / 2265-193Fax: (593-2) 2459-031,
EGYPT	**Cairo**	Egyptian International Motors CO. Ltd (EIM)Autostrade RoadAl-Mugattam, CairoEgyptTelephone: (20-2) 5061600 / 1 / 2Fax: (20-2) 5065620,
EL SALVADOR	**San Salvador**	Maquinaria Salvadoreña, S.A. de C.V.Blvd. Ejercito Nacional y 54 Ave. Norte Edificio MAQSA San SalvadorEl SalvadorEl SalvadorTelephone: (503) 2293-1666Fax: (503) 2293-1656,
ENGLAND		- See United Kingdom ,
ENGLAND		Cummins UKRutherford DrivePark Farm SouthWellingborough, NorthantsZIP / Postal Code: NN8 6ANUnited KingdomTelephone: (44-1933) 334200Fax: (44-1933) 334198,
EQUATORIAL GUINEA		- See North/West/East and Central Africa Regional Office - Daventry ,
EQUATORIAL GUINEA		Cummins Engine Company LtdRoyal Oak Way SouthDaventry, NorthantsZIP / Postal Code: NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
ESTONIA		Cummins Czech Republic s.r.o.Komercni zona Pruhonice CestliceObchodni 132Praha, Prague 251 01Czech RepublicTelephone: (420-272) 680 110Fax: (420-272) 680 090,
FAROE ISLANDS	**Wellingborough (Office in United Kingdom)**	Cummins UKRutherford Drive Park Farm SouthWellingborough, Northants NN8 6ANEngland Telephone: (44-1933) 334200Fax: (44-1933) 334198,
FERNANDO PO		- See Spain ,
FERNANDO PO		Cummins Ventas y Servico S. A.Torrelaguna 56Madrid 28027SpainTelephone: (34-91) 367 20 00 / 367 24 04Fax: (34-91) 407 66 04,

FIJI		- See Cummins New Zealand,
FIJI		Cummins9 Langley RoadManukau City Centre, Auckland 1702New ZealandTelephone: (64-3) 277 1000Fax: (64-3) 277 1001,
FINLAND	**Helsinki**	Machinery OyAnsatie 5VantaaZIP / Postal Code: FIN-01741FinlandTelephone: (358-9) 89551,
FRANCE	**Lyon**	CUMMINS DIESEL S.A.39 rue Ampère BP 190Chassieu cédex 69680 FranceTelephone: (33-4) 72 22 92 72 Fax: (33-4) 78 90 19 56,
GABON		- See North/West/East and Central Africa Regional Office - Daventry ,
GAMBIA		Matforce10 Avenue FaidherbeDakarSenegalTelephone: (221-8) 399500Fax: (221-8) 399531 / 399550,
GEORGIA		- See Moscow Regional Office - Moscow ,
GEORGIA		Cummins Engine Company, Inc.Park PlaceOffice E708, 113/1 Leninskiy ProspectMoscowZIP / Postal Code: 117198RussiaTelephone: (7-495) 956-51-22 / 23Fax: (7-495) 956-53-62,
GERMANY	**Gross-Gerau**	Cummins Diesel Deutschland GmbHOdenwaldstraße 23Groß-Gerau, Hessen 64521 GermanyTelephone: (49-6152) 174-0 Fax: (49-6152) 174-141,
GHANA	**Accra**	J&D Diesels and SystemsP.O. Box c2381CantonmentsAccra, Ghana Telephone: (233-21) 30-14-51Fax: (233-21) 301 201,
GREECE	**Athens**	ERGOTRAK Industrial Machinery & Equipment Trading Company14 km. National Road of Athens-LamiaKifissia 14510GreeceTelephone: (30-210) 6293400 / 41Fax: (30-210) 6201845,
GREENLAND		- See DenmarkCummins Diesel Salg & Service A/SHovedvejen 233B, OstedRoskilde 4000Denmark Telephone: (45-46) 42 35 50Fax: (45-46) 42 30 50,
GRENADA	**Miami (Office in U.S.A.)**	Cummins Power South, LLC 9900 N W 77th Ave. Hialeah Gardens, Florida 33016Telephone: (305) 821-4200Fax: (305) 557-2992,
GUADELOUPE	**Miami (Office in U.S.A.)**	Cummins Power South, LLC 9900 N W 77th Ave.Hialeah Gardens, Florida 33016Telephone: (305) 821-4200Fax: (305) 557-2992,
GUAM	**Barrigada**	Mid-Pac Far East, Inc. Airport Industrial Park 825 Tiyan Parkway Barrigada, Guam 96931Telephone: (671) 632-5160Fax: (671) 632-5186,
GUATEMALA	**Guatemala City**	Maquinaria y Equipos, S.A. Carretera a Amatitlan, Kilómetro 12, Zona 12, Guatemala City GuatemalaGuatemala Telephone: (502) 2477-2746 / 2477-2747 / 2477-2748 / 2477-2749 / 2477-2750Fax: (502) 2477-3929 ,

GUINEA	**Mechelen (Office in Belgium)**	Cummins Belgium N.V./S.A.Egide Walschaertsstraat, 2Industriepark ZuidMechelen 2800BelgiumTelephone: (32-15) 479 100Fax: (32-15) 275 686,
GUINEA BISSAU		- See North/West/East and Central Africa Regional Office - DaventryCummins Engine Company LtdRoyal Oak Way SouthDaventry, Northants NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
GUYANA	**Miami (Office in U.S.A.)**	Cummins Power South, LLC 9900 N.W. 77 Court Hialeah Gardens, FL 33016 Telephone: (305) 821-4200 Fax: (305) 557-2992,
GUYANA, FRENCH	**See France**	CUMMINS DIESEL S.A.39 rue AmpèreBP 190Chassieu cédex 69680FranceTelephone: (33-4) 72 22 92 72Fax: (33-4) 78 90 19 56,
HAITI	**Miami (Office in U.S.A.)**	Cummins Power South, LLC9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200 Fax: (305) 557-2992,
HOLLAND	**- See Netherlands**	Cummins Holland B VGalvanistraat 35Dordrecht, Zuid-Holland 3316 GHNetherlandsTelephone: (31-78) 6181200Fax: (31-78) 6176579,
HONDURAS	**Tegucigalpa**	Comercial Laeisz Honduras, S.A.Desvio Colonia La Pradera,Blvd. ToncontinTegucigalpaHondurasTelephone: (504) 233-5615 / 234-7072Fax: (504) 233-9531 / 234-3718,
HONG KONG	**Kowloon**	Cummins Hong Kong Ltd.2/F Unison Industrial Centre27-31 Au Pui Wan Street, Fo Tan, Shatin, N.T.Hong Kong, Hong KongHong Kong S.A.R.ong Kong Telephone: (852) 2606-5678 Fax: (852) 2691-1641,
ICELAND	**Velasalan H.F.**	Ananaustrum 1Reykjavik 121 IcelandTelephone: (354) 5526122Fax: (354) 580 5301,
INDIA	**Pune**	Cummins Diesel Sales & Service (India) Ltd 35A/1/2, Erandawana Pune, Maharashtra 411038 Telephone: (91-20)25431234 , 25430666, 25431703Fax: (91-20) 25439490,
INDIA	**Kolkata**	Cummins Diesel Sales & Service (India) Ltd94, Tivoli Court, 1/C Ballygunge Circular RoadKolkata, West Bengal 700019India Telephone: (91-33) 22472481 / 22470774 / 22478065Fax: (91-33) 22473833,
INDIA	**New Delhi**	Cummins Diesel Sales & Service (India) Ltd.911-912, Hemkunt Tower,98 Nehru Place New Delhi, Delhi 110019IndiaTelephone: (91-11) 26431051 / 26445756 / 26445759 / 26416947Fax: (91-11) 26212817,
INDIA	**Raipur**	Cummins Diesel Sales & Service (India) Ltd.Vanijya Bhavan' 1st Floor, Sai Nagar FafadihDevendra Nagar RoadRaipur, Madhya Pradesh 492009IndiaTelephone: (91-771) 2521101 / 2521102Fax: (91-771) 2521103,

INDIA	**Ranchi**	Cummins Diesel Sales & Service (India) Ltd.`Shanti Kunj' C-202, Vidyalaya Marg Road No. 01, Ashok Nagar,Ranchi, Jharkhand 834002India Telephone: (91-651) 2241948 / 2241521Fax: (91-651) 2242815,
INDONESIA	**Jakarta**	P.T. Alltrak 1978 J1. R.S.C. Veteran No. 4 Bintaro, Rempoa Jakarta 12330 IndonesiaTelephone: (62-21) 736-1978 / 3301 / 5085Fax: (62-21) 736-1977 / 3302,
IRAQ		- See Middle East Regional Office or United Arab Emirates,
IRAQ		Cummins Emirates Sales & Service LLCP.O. Box No 54044Al Quoz Industrial Estate, DubaiUnited Arab EmiratesTelephone: 00 9714 3478184Fax: 00 9714 3478185Toll Free: 800 4184 ,
IRELAND	**Wellingborough (Office inEngland)**	Cummins UKRutherford DrivePark Farm SouthWellingborough, Northants NN8 6ANUnited KingdomTelephone: (44-1933) 334200Fax: (44-1933) 334198,
ISRAEL	**Tel Aviv**	Israel Engines & Trailers 33 Hahashmal StreetTel Aviv 61003IsraelTelephone: (972-3) 7106222Fax: (972-3) 5604540,
ITALY	**Milan**	Cummins Italia S.p.A.Via Einaudi, 5Peschiera Borromeo, Milano 20068ItalyTelephone: (39-02) 51 65 581Fax: (39-02) 51 65 58 56 ,
IVORY COAST		- See Cote d' IvoireSte. des Ets. Lemercier et Fils10 rue des BrasseursAbidjan 15Cote d'IvoireCote d'IvoireTelephone: (225-21) 352522 / 350687 / 350676Fax: (225-21) 358562 / 243938,
JAMAICA		Cummins Power South, LLC9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
JAPAN	**Tokyo**	Cummins Japan Ltd.2-11, Higashi-Kojiya 6-chomeOta-ku, Tokyo 144-0033Japan Telephone: (81-3) 5735-0600Fax: (81-3) 5735-0605,
JORDAN	**Amman**	SETI Jordan Ltd.Bayader Wadi AlseerIndustrial StreetAmman, JordanJordanTelephone: (962-6) 582 7300 / 4261Fax: (962-6) 585 6854,
KENYA	**Nairobi**	Simba Colt Motors LtdCummins Engine Division, PO Box 48296, Code 00100Shimo-La-Tewa Road,NairobiKenyaTelephone: (254-20) 650029Fax: (254-20) 534870 ,
KOREA - SOUTH KOREA	**Seoul**	Cummins Diesel Sales & Service Co., Ltd. 354-4, Chonheung-ri, Songgo-eupChonan-city, Choongchungnam-do 330-836South Korea Telephone: (82-41) 620-9202/3Fax: (82-41) 621-9121 to 2,
KOREA - SOUTH KOREA		Cummins Korea Ltd2nd Floor, Choyang Bldg.113 Samsung Dong, Kangnam-kuSeoul, KoreaTelephone: (82-2) 3420-0901Fax: (82-2) 3452-4113 / 539-6569,

KUWAIT	**Kuwait**	General Transportation & Equipment Co. (GTE)(Sales Department) Safat 13011KuwaitTelephone: (965) 483 3380/1/2Fax: (965) 481 2860,
LAOS		Diethelm & Co. LtdBan Phonsinouan, Unit 18,New Road Sisattanak District,VientianeLaos P.D.R.Telephone: (856-21) 453 100Fax: (856-21) 453-103,
LATVIA	**Please contact the Central & Eastern European Regional Office**	Cummins Diesel Deutschland GmbHOdenwaldstraße 23Groß-GerauZIP / Postal Code: 64521GermanyTelephone: (49-6152) 174-0Fax: (49-6152) 174-141,
LEBANON	**Beirut**	S.E.T.I. Charles Keller SALCorniche du Fleuve BeirutLebanonLebanonTelephone: (961-1) 425040 / 425041 / 426042Fax: (961-1) 425637 / 425389,
LESOTHO	**- See South Africa**	Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
LIBYA	**- See North/West Africa Regional Office - Daventry**	Cummins Engine Company LtdRoyal Oak Way SouthDaventry, Northants NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
LIECHTENSTEIN	**- See Switzerland**	AKSA Wurenlos AGGrosszelgstrasse 15Wuerenlos CH-5436SwitzerlandTelephone: (41-56) 436 77 00Fax: (41-56) 436 77 19,
LUXEMBOURG		Cummins Diesel Deutschland GmbH Odenwaldstraße 23Groß-Gerau, Hessen 64521GermanyTelephone: (49-6152) 174-0Fax: (49-6152) 174-141,
MACAU	**- See Hong Kong**	Cummins Hong Kong Ltd.2/F Unison Industrial Centre27-31 Au Pui Wan Street, Fo Tan, Shatin, N.T.ccccHong Kong, Hong KongHong Kong S.A.R.Telephone: (852) 2606-5678Fax: (852) 2691-1641,
MADAGASCAR	**- See Southern Africa Regional Office**	Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South Africa 2054ZIP South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
MADEIRA ISLANDS	**- See Portugal**	Electro Central Vulcanizadora, LdaRua Conselheiro Martins de CarvalhoLote 1480 Restelo Lisbon 1400PortugalTelephone: (351-21) 3034800Fax: (351-21) 3034801 / 2,
MALAYSIA	**Kuala Lumpur**	Scott & English (M) Sdn Bhd 12 Jalan U1/15, Seksyen U1 Hicom-Glenmarie Industrial ParkShah Alam, Selangor Darul Ehsan 40150MalaysiaTelephone: (60-3) 7805-1111Fax: (60-3) 7803-5122,
MALI	**- See Senegal (Matforce)**	Matforce10 Avenue FaidherbeDakarSenegalTelephone: (221-8) 399500Fax: (221-8) 399531 / 399550,

MALTA	**Valletta**	International Machinery LtdRegency House254 Republic Street Valletta, MaltaMaltaTelephone: (356-21) 232620 / 233343Fax: (356-21) 235484 / 247571,
MARTINIQUE		Cummins Power South, LLC9900 N.W. 77 Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
MEXICO	**Guadalajara**	Distribuidora Megamak de OccidenteMetalurgia No. 2980 Fracc. Alamo IndustrialGuadalajara, Jalisco 45560MexicoTelephone: (52-3) 666-0329 / 666-0383Fax: (52-3) 666-0333,
MEXICO	**Monterrey**	Converto Dexel Monterrey Privada Nazry Hasbun #2, Carr. Migue Aleman 14.8Parque Industrial HasnaApodaca, Nuevo León 66473MexicoTelephone: (52-81) 81310200Fax: (52-81) 81310200,
MEXICO	**Merida**	Distribuidora Megamak del SuresteAv. Aviacion Civil No. 647Col. Sambula Merida, Yucatan 97259MexicoTelephone: (52-9) 930-1300Fax: (52-9) 930-1315,
MEXICO	**Puebla**	Cummins De Oriente, S.A. de C.V. Km. 10+400 Carr. Fed. Puegla-TlaxcalaPuebla, Puebla 72100Mexico Telephone: (52-2) 248-7674 / 5 / 30-5083 / 6Fax: (52-2) 249-7679,
MEXICO	**Queretaro**	Converto Dexel QueretaroBlvd. Bernardo Quintana No. 518, Col. ArboledasQueretaro, Queretaro ZIP / Postal Code: 76140Mexico Telephone: (52-442) 211-8700Fax: (52-442) 211-8700,
MOROCCO	**Casablanca**	Groupe Auto Hall44 avenue Lalla YacoutCasablancaMoroccoTelephone: (212-22) 442121 / 317044 / 317052Fax: (212-22) 318915 / 315633,
MOZAMBIQUE	**- See Southern Africa Regional Office - Kelvin**	Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
NEPAL	**Pune (Office in India)**	Cummins Diesel Sales &Service (India) Ltd. 35A/1/2, Erandawana Pune, Maharashtra 411038IndiaTelephone: (91-20) 25431234 / 25430666 / 25431703Fax: (91-20) 25439490,
NETHERLANDS	**Dordrecht**	Cummins Holland B V Galvanistraat 35 Dordrecht, Zuid-Holland 3316 GHNetherlandsTelephone: (31-78) 6181200Fax: (31-78) 6176579,
NETHERLANDS ANTILLES		Cummins Power South, LLC 9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
NEW GUINEA	**- See Papua New Guinea**	CumminsMacdhui StreetLaePapua New GuineaTelephone: (675) 472 3699Fax: (675) 472 3803,

NEW GUINEA	**- See Papua New Guinea**	CumminsMacdhui StreetLaePapua New GuineaTelephone: (675) 472 3699Fax: (675) 472 3803,
New Zealand	**Auckland**	Cummins9 Langley RoadManukau City Centre, South Auckland 1702 New Zealand Telephone: (64-9) 277 1000Fax: (64-9) 277 1001,
New Zealand	**Christchurch**	Cummins33 Parkhouse RoadChristchurchNew ZealandTelephone: (64-3) 348 8170Fax: (64-3) 348 8007,
New Zealand	**Dunedin**	Cummins8 Devon StreetDunedinNew ZealandTelephone: (64-3) 477 8818Fax: (64-3) 477 8061,
New Zealand	**Palmerston North**	Cummins852 - 860 Tremaine AvenuePalmerston North, Wanganui-Manawatu 5301New ZealandTelephone: (64-3) 356 2209Fax: (64-3) 356 9130,
New Zealand	**Rotorua**	Cummins328 Te Ngae RoadBay of PlentyRotoruaNew ZealandTelephone: (64-7) 345 6699Fax: (64-7) 345 6694,
NICARAGUA	**Managua**	F. Alf. Pellas, S.A.Gadala Maria Cuatro Cuadras OesteBarrio AcahualincaManagua, NicaraguaNicaraguaTelephone: (505) 268-2244Fax: (505) 266-1060,
NIGERIA	**Lagos**	Scoa Power (A Division of Scoa Nigeria Plc) 15, Creek RoadApapaLagosNigeriaTelephone: (234-1) 5873623 / 5877322Fax: (234-1) 5450646,
NIGERIA	**Paris (Office in France)**	SCOA InterImmeublearie JosepheRue du Marechal de Lattre de Tassigny78990 Elancourt, FranceFrance Telephone: (33-1) 30 688 268Fax: (33-1) 30 688 269,
NORTHERN IRELAND	**- See United Kingdom**	Cummins Engine Company LtdRoyal Oak Way SouthDaventry, NorthantsZIP / Postal Code: NN11 5NUUnited Kingdom Telephone: (44-1327) 886000Fax: (44-1327) 886106,
NORWAY	**Oslo**	Cummins Norway A SHestehagen 3 Postboks 151 Drobak 1441Norway Telephone: (47) 64 90 70 80Fax: (47) 64 90 70 90,
OMAN	**Ruwi**	Universal Engineering Services LLCPO Box 2688Ruwi 112OmanTelephone: (968) 597531 / 597537Fax: (968) 597514,
PAKISTAN	**Karachi**	Cummins Sales & Service Pakistan2 Bangalore Town Main Shahrah-e-Faisal Karachi 75350 Pakistan Telephone: +92-21-4539603 / 4539604/ 4539605Fax: +92-21-4532519,
PANAMA	**Panama City**	Grupo Tiesa, S.A. Via Transistmica Milla 8 Frente a BacardiPartilloPanama Panama Telephone: (507) 231-0266Fax: (507) 231-2535,
PARAGUAY	**Asuncion**	De La Sobera S.A.Eusebio Ayala 1947P.O. Box 1160 AsuncionParaguay Telephone: (595) 21 202 913,

PERU	**Lima**	Mitsui Maquinarias Peru, S.A.Av. Nicolas Ayllon 2648Parcela Rustica Sta. Angelica AteLima ZIP / Postal Code: 03PeruTelephone: (51-1) 326-4957Fax: (51-1) 326-4954,
PHILIPPINES	**EDSA**	Cummins Sales & Service Philippines, Inc.Lot 1 & 2, Block 15, LIIP Avenue,Laguna International Industrial Park, Mamplasan, BinanLagunaPhilippinesTelephone: (63-2) 843-0630 Fax: (63-2) 539-0290,
POLAND		Cummins Engine Company Limited Sp. z.o.o. Oddzial w Polsceul. Stawowa 119Krakow 31-346Poland Telephone: (48-12) 661 53 05 & (48-12) 661 53 25Fax: (48-12) 661 53 15,
PORTUGAL	**Lisbon**	Electro Central Vulcanizadora, Lda Rua Conselheiro Martins de CarvalhoLisbonZIP / Postal Code: 1400PortugalTelephone: (351-21) 3034800Fax: (351-21) 3034801 / 2,
QATAR	**Doha**	Jaidah Motors & Trading Co. P.O. Box 150 Doha, Qatar (Arabian Gulf) Telephone: (974) 4466888Fax: (974) 441 4100 / 441 5400,
REUNION	**- See Lyon Regional Office - Lyon**	CUMMINS DIESEL S.A.39 rue AmpèreBP 190Chassieu cédex 69680FranceTelephone: (33-4) 72 22 92 72Fax: (33-4) 78 90 19 56,
RIO DE ORO	**- See Spain**	Cummins Ventas y Servico S. A.Torrelaguna 56Madrid 28027SpainTelephone: (34-91) 367 20 00 / 367 24 04Fax: (34-91) 407 66 04,
ROMANIA	**- See Germany Regional Office - Gross-Gerau**	Cummins Diesel Deutschland GmbHOdenwaldstraße 23Groß-Gerau, Hessen 64521GermanyTelephone: (49-6152) 174-0Fax: (49-6152) 174-141,
RUSSIA		OOO CumminsKlyazma 1GKhimki Disctrict, Moscow Region 141400RussiaTelephone: (7-495) 540 86 24 / 25Fax: (7-495) 540 86 99,
RWANDA	**Mechelen**	Cummins Belgium N.V./S.A. Egide Walschaertsstraat, 2Industriepark ZuidMechelen 2800BelgiumTelephone: (32-15) 479 100Fax: (32-15)275 686,
ST. LUCIA		Cummins Power South, LLC9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
ST. LUCIA	**Miami (Office in U.S.A.)**	Cummins Power South, LLC 9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
SAN MARINO	**- See Italy**	Cummins Italia S.p.A.ItalyVia Einaudi, 5Peschiera Borromeo, Milano 20068Telephone: (39-02) 51 65 581Fax: (39-02) 51 65 58 56 ,
SAO TOME AND PRINCIPE	**- See North/West/East and Central Africa Regional Office - Daventry, England**	Cummins Engine Company LtdRoyal Oak Way SouthDaventry, NorthantsZIP / Postal Code: NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,

SAUDI ARABIA	**Al-Khobar**	General Contracting Company - OLAYANP.O. Box 356 King Abdul Aziz Road Al-KhobarSaudi Arabia Telephone: (966-3) 882-0888Fax: (966-3) 8828560 / 8827914,
SCOTLAND	**- See United Kingdom**	Cummins UKRutherford DrivePark Farm SouthWellingborough, NorthantsZIP / Postal Code: NN8 6ANUnited KingdomTelephone: (44-1933) 334200Fax: (44-1933) 334198,
SENEGAL	**Dakar**	Matforce 10 Avenue FaidherbeDakarSenegal Telephone: (221-8) 399500 Fax: (221-8) 399531/399550 Equipements et Services (Mining Only) BP 15372-Fann Dakar Senegal Contacts: Mr. Jean Smets Tel: (221-8) 60 77 76 & 24 73 62 Fax: (221-8) 60 95 98,
SEYCHELLES	**- See North/West/East & Central Africa Regional Office - Daventry, England**	Cummins Engine Company LtdRoyal Oak Way SouthDaventry, NorthantsZIP / Postal Code: NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
SIERRA LEONE	**- See North/West/East and Central Africa Regional Office - Daventry**	Cummins Engine Company LtdRoyal Oak Way SouthDaventry, NorthantsZIP / Postal Code: NN11 5NUUnited KingdomTelephone: (44-1327) 886000Fax: (44-1327) 886106,
SINGAPORE	**Singapore**	Cummins Engine (Singapore) Pte Ltd8 Tanjong Penjuru Singapore 609019SingaporeTelephone: (65) 6261-3555Fax: (65) 6261-2405,
SLOVAKIA		- See European Regional Office - Gross-Gerau,
SOLOMON ISLANDS	**The Czech branch covers sales and service for the Czech Republic and Slovakia**	Cummins Czech Republic s.r.o.Komercni zona Pruhonice CestliceObchodni 132Praha, Prague 251 01Czech RepublicTelephone: (420-272) 680 110Fax: (420-272) 680 090,
SOLOMON ISLANDS	**-See SOUTH PACIFIC ISLANDS**	(Please contact) Cummins2 Caribbean DriveScoresby 3179VictoriaTelephone: (61-3) 9765-3222Fax: (61-3) 9763-0079,
SOMALIA	**- see Southern Africa Regional Office**	(Please contact) Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
SOUTH AFRICA	**Johannesburg**	Cummins Diesel South Africa (Pty) Ltd 13 Eastern Service Road Kelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South Africa Telephone: (27-11) 321 8700Fax: (27-11) 444 2012 ,
SOUTHWEST AFRICA	**- see Southern Africa Regional Office**	(Please contact) Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South Africa 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012 ,
SPAIN	**Madrid**	Cummins Ventas y Servico S. A.Torrelaguna, 56 Madrid 28027Spain Telephone: (34-91) 367 20 00 / 367 24 04Fax: (34-91) 407 66 04,

SPANISH GUINEA	**- See Spain**	Cummins Ventas y Servico S. A.Torrelaguna, 56 Madrid 28027Spain Telephone: (34-91) 367 20 00 / 367 24 04Fax: (34-91) 407 66 04,
SRI LANKA	**Colombo**	Trade Promoters Ltd 272/25, Sudharshana MawathaMalabe Sri Lanka Telephone: (94-11) 2413002Fax: (94-11) 5550034,
SUDAN	**- See Middle East Regional Office - United Arab Emirates**	United Arab EmiratesCummins Middle East FZEUnits ZF 5/6Jebel Ali Free ZoneP.O.Box No 17636DubaiUnited Arab EmiratesTelephone: (971-4) 883 8998Fax: (971-4) 883 7971,
SURINAM		Cummins Power South, LLC9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,
SWAZILAND	**- See South Africa**	Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South AfricaZIP / Postal Code: 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
SWEDEN	**Stockholm**	Cummins Sweden Maskingata 17CBrista IndustriomadeMärsta, Stockholm 195 60Sweden Telephone: (46-8) 595 133 90Fax: (46-8) 595 133 99,
SWITZERLAND	**Regensdorf**	AKSA Wurenlos AGGrosszelgstrasse 15Wuerenlos CH-5436Switzerland Telephone: (41-1) 436 77 00Fax: (41-56) 436 77 19,
SYRIA	**Damascus**	Puzant Yacoubian & Sons Yacoubian BuildingAbou Baker El Saddik StreetDamascusSyriaTelephone: (963-11) 212 8600Fax: (963-11) 212 8611,
TAHITI, ISLAND OF	**- See French Polynesia**	Cummins MerCruiser Diesel245 Brisbane RoadBiggera Waters, Queensland 4216AustraliaTelephone: (61-7) 5500 9060Fax: (61-7) 5500 9070,
TAIWAN		Cummins Taiwan Pte. Ltd.No.49 Ting Hu RoadTkuei Shan HsiangTaoyuan, Taiwan 104TaiwanTelephone: (886-3) 211-5160Fax: (886-2) 211-4158,
TANZANIA	**- See South African Regional Office - Kelvin, South Africa**	Cummins Diesel South Africa (Pty) Ltd13 Eastern Service RoadKelvin (Neighbourhood), AlexandraGauteng, South AfricaZIP / Postal Code: 2054South AfricaTelephone: (27-11) 321 8700Fax: (27-11) 444 2012,
THAILAND	**Bangkok**	DKSH (Thailand) Ltd1696 New Petchburi Road Bangkok 10310Thailand Telephone: (66-2) 254-4900 / 454-2173Fax: (66-2) 253-5560 / 652-9417 / 8 / 9,
TOGO (and BENIN)	**Lome**	TOGOMAT s.a.Zone Industrielle CNPPMELomeTogo Telephone: (228) 2272395Fax: (228) 2270310,
TONGA, ISLAND OF	**-See SOUTH PACIFIC ISLANDS**	(Please contact) Cummins2 Caribbean DriveScoresby 3179VictoriaAUSTRALIATelephone: (61-3) 9765-3222Fax: (61-3) 9763-0079,
TRINIDAD and TOBAGO		Cummins Power South, LLC 9900 N W 77th Ave.Hialeah Gardens, FL 33016 Telephone: (305) 821-4200Fax: (305) 557-2992,

TURKEY	**Istanbul**	Hamamcioglu Muesseseleri Ticaret T.A.S. Okul Cad. No. 1334956 Orhanli - P.K. 62 TuzlaIstanbulTurkey Telephone: (90-216) 394 3210Fax: (90-216) 394 3208 / 9,
UKRAINE	**- See Moscow Regional Office - Moscow**	Cummins Engine Company, Inc.Park PlaceOffice E708, 113/1 Leninskiy ProspectMoscow 117198RussiaTelephone: (7-495) 956-51-22 / 23 Fax: (7-495) 956-53-62 ,
UNITED ARAB EMIRATES	**Dhabi**	Cummins Middle East FZE Units ZF 05&06Jebel Ali Free ZoneDhabiUnited Arab Emirates Telephone: (971-4) 883 8998Fax: (971-4) 883 7971,
UNITED KINGDOM	**Wellingborough**	Cummins UKRutherford DrivePark Farm SouthWellingborough, Northants NN8 6ANUnited Kingdom Telephone: (44-1933) 334200Fax: (44-1933) 334198,
VATICAN CITY	**- See Italy**	Cummins Italia S.p.A.Via Einaudi, 5Peschiera Borromeo, Milano 20068ItalyTelephone: (39-02) 51 65 581Fax: (39-02) 51 65 58 56 ,
VENEZUELA	**Caracas**	Dieselval, C.A.Ave. Lisandro Alvarado, Sector La FloridaEdificio DieselvalValencia, CaraboboVenezuela ZIP / Postal Code: VenezuelaVenezuelaTelephone: (58-241) 8353074 / 8355265Fax: (58-241) 8314553 / 8314818,
VIETNAM	**Hanoi**	Diethelm & Co. Ltd., Engrg.94, Tran Quoc Toan Street,Hoan Kiem DistrictHanoiVietnam Telephone: (84-4) 9424-725Fax: (84-4) 9424-730,
VIETNAM	**Ho Chi Minh City**	Diethelm & Co. Ltd., Engrg.189 Dien Bien Phu Street, Ward 15Binh Thanh DistrictHo Chi Minh City, S.R. Vietnam Telephone: (84-8) 5121-334Fax: (84-8) 5121-335,
WESTERN SAMOA	**-See SOUTH PACIFIC ISLANDS**	(Please contact) Cummins2 Caribbean DriveScoresby 3179VictoriaAUSTRALIATelephone: (61-3) 9765-3222Fax: (61-3) 9763-0079,
YEMEN	**Sana'a**	Zubieri Trading CompanyAl Qiyadah StreetSana'aRepublic of YemenTelephone: (967-1) 223943 / 224051Fax: (967-1) 221611 / 245838,
SERBIA & MONTENEGRO		Cummins Dizel Motori Prodaja i ServisAutoput, 2211080 ZemumBeograd, Serbia & MontenegroSerbia & MontenegroTelephone: (381-11) 314 90 71Fax: (381-11) 314 91 27,
ZAMBIA	**Ndola**	Cummins Zambia LtdLufunza AvenueNdola, ZambiaZambiaTelephone: (260-2) 610 729Fax: (260-2) 612 756,
ZIMBABWE	**Harare**	Cummins Zimbabwe (Pvt) Ltd. 72 Birmingham RoadSoutherton, ZimbabweZimbabwe Telephones: (263-4) 621871 / 2 / 3 / 4 / 5Fax: (263-4) 621880,

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 Section 3 and 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.

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 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.
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 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 an Authorized Cummins Repair Facility.
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 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 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 Section 3.
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 an Authorized Cummins Repair Facility.
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 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	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 manual.

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

Air Compressor Will Not Stop Pumping

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 manual.

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

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 to the 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 an Authorized Cummins Repair Facility.
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 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 Facility.
OK Go To Next Step	
STEP 4 Cylinder head gasket is leaking	Check the cylinder head gasket. Refer to a Cummins Authorized Repair Facility.
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	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to the OEM service manual.
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 Section A.
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 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 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 Section 7.
OK Go To Next Step	
STEP 7 Engine is overheating	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 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 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 Coolant level is below specification	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to Section 7.
OK Go To Next Step	
STEP 4 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 5 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 6 Lubricating oil is contaminated with coolant or fuel	Refer to the Lubricating Oil Contaminated symptom tree.
OK Go To Next Step	
STEP 7 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Section 4.
OK Go To Next Step	
STEP 8 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 Section 5 and Section V.
OK Go To Next Step	
STEP 9 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Section 3. Use the oil recommended in Section V.
OK Go To Next Step	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 10 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.

OK
Go To Next Step

STEP 11 Fan drive belt is loose, tight, or **not** in alignment	Check the fan drive belt. Refer to Section 4.

OK
Go To Next Step

STEP 12 Vehicle cooling system is **not** adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM specifications.

OK
Go To Next Step

STEP 13
Contact a Cummins® Authorized Repair Facility

Coolant Temperature Above Normal - Sudden Overheat

Cause	Correction
STEP 1 Coolant level is below specification	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to Section 3.
OK Go To Next Step	
STEP 2 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 3 Air in the cooling system	Inspect and vent the cooling system. Refer to Section 7.
OK Go To Next Step	
STEP 4 Fan drive belt is broken	Check the fan drive belt. Replace the belt, if necessary. Refer to Section A.
OK Go To Next Step	
STEP 5 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 6 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Section 4.
OK Go To Next Step	
STEP 7 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.
OK Go To Next Step	
STEP 8 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 9 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	

Coolant Temperature Above Normal - Sudden Overheat

Cause **Correction**

STEP 10

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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
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 Cold Weather Operation, Bulletin 3387266, and Section 1.
OK Go To Next Step	
STEP 4 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 5 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.
OK Go To Next Step	
STEP 6 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 7 Contact a Cummins® Authorized Repair Facility	

Engine Acceleration or Response Poor

Cause	Correction
STEP 1 Operator technique is **not** correct	Refer to Section 1, Operating Instructions.
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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 7 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 8 Intake manifold air temperature is above specification	Refer to the Intake Manifold Air Temperature Above Specification symptom tree.
OK Go To Next Step	
STEP 9 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	

Engine Acceleration or Response Poor

Cause	Correction
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.
OK Go To Next Step	
STEP 11 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 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 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 Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 14 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to Section 5. Check the fuel suction line for restriction 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 Section 5.
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 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 Electronic fault codes are active or high counts of inactive fault codes	Review instructions for reading active fault codes. Contact a Cummins® Authorized Repair Location, if fault codes are active.
OK Go To Next Step	
STEP 4 Starting aid, if necessary for cold weather, is malfunctioning	Check for correct operation of the cold weather starting aid. Refer to Cold Weather Starting Aids in Section 1. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 5 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 6 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 7 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 8 Keyswitch circuit is malfunctioning	Check the vehicle keyswitch circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Engine cranking speed is too slow	Determine 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	

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

Cause	Correction
STEP 10 Vehicle parasitics are excessive	Check the vehicle for brakes dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.

OK
Go To Next Step

STEP 11 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 12 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.

OK
Go To Next Step

STEP 13 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Section 4.

OK
Go To Next Step

STEP 14 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of known high quality fuel. Refer to Fuel Recommendations and Specifications in Section V.

OK
Go To Next Step

STEP 15 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Check the fuel suction line for restriction. Refer to Section 5.

OK
Go To Next Step

STEP 16 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to Section 5.

OK
Go To Next Step

STEP 17
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 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 Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 4 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
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 an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 8 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK Go To Next Step	

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

Cause	Correction
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.

OK
Go To Next Step

STEP 11 Electronic control module (ECM) is locked up	Disconnect the battery cables for 30 seconds. Connect the battery cables, and start the engine.

OK
Go To Next Step

STEP 12 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to Section 5. Check the fuel suction line for restriction Section 5.

OK
Go To Next Step

STEP 13 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to Section 5.

OK
Go To Next Step

STEP 14 Fuel drain backup	Verify the fuel return line is plumbed to the bottom of the fuel tank.

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 Section 3 .
OK Go To Next Step	
STEP 2 Lubricating oil is thin or diluted	Refer to the Lubricating Oil Specifications in Section V. If the oil pressure is low, refer to the Lubricating Oil Pressure Low troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 3 Vibration damper is damaged or loose	Inspect the vibration damper. Contact a Cummins® Authorized Repair Location.
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 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 restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Section 4 .
OK Go To Next Step	
STEP 7 Coolant temperature is above specification	Refer to the Coolant Temperature is Above Normal - Sudden Overheator 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	
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	

Engine Noise Excessive

Cause		Correction
STEP 10 Fan is loose, damaged, or has excessive hub bearing end clearance	.....	Check the fan. Refer to 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 Cold Weather Operation, see Bulletin 3387266, and 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 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.
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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 2 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 3 Engine is operating above recommended altitude	Engine power decreases above recommended altitude. Refer to the OEM's altitude operation guidelines..
OK Go To Next Step	
STEP 4 Tachometer is **not** calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 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 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 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 8 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	

Engine Power Output Low

Cause	Correction
STEP 9 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 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.
OK Go To Next Step	
STEP 12 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 13 Fuel return restriction excessive	Inspect the fuel return lines for restrictions. Refer to the OEM service manual.
OK Go To Next Step	
STEP 14 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to Section 5. Check the fuel suction line for restriction Section 5.
OK Go To Next Step	
STEP 15 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 16 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 17 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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 3 Idle speed is set too low for accessories	Check and adjust the low-idle screw. Refer to a Cummins Authorized Repair Facility.
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.
OK Go To Next Step	
STEP 5 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to Section 5. Check the fuel suction line for restriction Section 5.
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 Section 5.
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 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 9 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 10 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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
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 Section 5.
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 Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 5 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 6 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Section 5.
OK Go To Next Step	
STEP 7 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to Section 5.
OK Go To Next Step	
STEP 8 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 an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 9 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.
OK Go To Next Step	

Engine Runs Rough or Misfires

Cause	Correction
STEP 10 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.

OK
Go To Next Step

STEP 11
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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 4 Idle shutdown or PTO shutdown features are activated	Check the time limit on idle and PTO shutdowns with an electronic service tool. Refer to Electronic Controlled Fuel System in Section 1.
OK Go To Next Step	
STEP 5 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 6 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 7 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to the OEM service manual.
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. Refer to Section 5.
OK Go To Next Step	
STEP 9 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 an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 3 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 4 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
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 Section 5.
OK Go To Next Step	
STEP 6 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Section 5.
OK Go To Next Step	
STEP 7 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to Section 5.
OK Go To Next Step	
STEP 8 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 an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 9 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 10 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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 3 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
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 Section 5.
OK Go To Next Step	
STEP 5 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Section 5.
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 Section 5.
OK Go To Next Step	
STEP 7 Idling with excessive load	Use the PTO feature for loaded conditions at low engine speeds. Refer to Section 1.
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	
STEP 9 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	

Engine Speed Surges Under Load or in Operating Range

Cause

STEP 10

Fuel grade is **not** correct for the application or the fuel quality is poor

.....

Correction

Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in Section V.

OK

Go To Next Step

STEP 11

Contact a Cummins® Authorized Repair Facility

Engine Speed Surges in PTO or Cruise Control

Cause	Correction
STEP 1 Engine speed also surges at idle	Refer to the Engine Speed Surges at Low or High Idle symptom tree.
OK Go To Next Step	
STEP 2 Engine speed surges while in the normal operating range and **not** in PTO or cruise control	Refer to the Engine Speed Surges Under Load or in Operating Range symptom tree.
OK Go To Next Step	
STEP 3 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 4 Moisture in the wiring harness connectors	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 5 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Section 5.
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 Section 5.
OK Go To Next Step	
STEP 7 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 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 4 Idle speed is set too low for accessories	Check and adjust the low-idle screw. Refer to a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 5 Engine-driven units are engaged	Disengage engine-driven units. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 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.
OK Go To Next Step	
STEP 7 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to Section 5. Check the fuel suction line for restrictionSection 5.
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 Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 9 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 Section 3 and Section 4.
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 (electronically controlled fuel systems)	Verify the correct idle speed setting. Increase the idle speed with the idle increment switch or an electronic service tool. Refer to Section 1.
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 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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 8 Vibration damper is damaged	Inspect the vibration damper. Refer to Section 7.
OK Go To Next Step	
STEP 9 Alternator bearing worn or damaged	Clean and replace the alternator. Refer to the OEM service manual.
OK Go To Next Step	
STEP 10 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 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 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 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 Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 10 Contact a Cummins® Authorized Repair Facility	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
STEP 1 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 2 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 3 Tachometer is **not** calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 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 an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 5 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 6 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 7 Exhaust back pressure too high	Measure and correct if above specification. Refer to an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 8 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 an Authorized Cummins Repair Facility.
OK Go To Next Step	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
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	
STEP 10 Engine power output is low	Refer to the Engine Power Outlet Low symptom tree.
OK Go To Next Step	
STEP 11 Contact a Cummins® Authorized Repair Facility	

Fault Code Warning Lamps Stay On (No Apparent Reason)

Cause	Correction
STEP 1 Diagnostic shorting plug is installed	Remove the diagnostic shorting plug.

OK
Go To Next Step

STEP 2 Diagnostic switch is in the ON position	Turn off the diagnostic switch.

OK
Go To Next Step

STEP 3 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.

OK
Go To Next Step

STEP 4
Contact a Cummins® Authorized Repair Facility

Fault Code Warning Lamps Do Not Illuminate

Cause		Correction
STEP 1 Keyswitch is in the OFF position	.....	Turn the keyswitch to the ON position.

OK
Go To Next Step

STEP 2 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	.....	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to the OEM service manual.

OK
Go To Next Step

STEP 3 Idle shutdown or PTO shutdown features are activated	.....	Check the time limit on idle and PTO shutdowns with an electronic service tool. Refer to Section 1.

OK
Go To Next Step

STEP 4
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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 3 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 4 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 5 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 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 Section 3.
OK Go To Next Step	
STEP 7 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 8 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	

Fuel Consumption Excessive

Cause	Correction
STEP 9 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 10
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	

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 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 5 Engine power output is low	Refer to the Engine Power Output Low symptom tree.
OK Go To Next Step	
STEP 6 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 Section 5. Use the oil recommended 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 an Authorized Cummins Repair Facility.
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 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 is below specification	Check the oil level. Verify the dipstick calibration and the oil pan capacity. Fill the system to the specified level. Refer to Section V.
OK Go To Next Step	
STEP 3 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 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 to an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 5 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 6 Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks and cracks. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 7 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 an Authorized Cummins Repair Facility.
OK Go To Next Step	
STEP 8 Blowby excessive	Check for excessive blowby. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
OK Go To Next Step	

Lubricating Oil Loss

Cause	Correction
STEP 9 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 10
Contact a Cummins® Authorized Repair Facility

Lubricating Oil Pressure High

Cause	Correction
STEP 1 Coolant temperature is above 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 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 to the OEM service manual.
OK Go To Next Step	
STEP 4 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Pressure Low

Cause	Correction
STEP 1 Engine angularity during operation exceeds specification	Refer to the Engine Data Sheet.
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 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 4 Lubricating oil filter is plugged	Change the oil and filter. Refer to Section 5. Use the oil recommended in Section V.
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 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 7 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 8 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 9 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 10 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 Section 5. Use the oil recommended 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 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 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 Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 6 Contact a Cummins® Authorized Repair Facility	

Smoke, Black — Excessive

Cause	Correction
STEP 1 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
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.
OK Go To Next Step	
STEP 3 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 4 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 5 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 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 Cold Weather Operation, Bulletin 3387266, and Section 1.
OK Go To Next Step	
STEP 4 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Section 1. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 5 Starting aid is malfunctioning	Check for correct operation of cold-starting aid. Refer to Cold Weather Starting Aids in Section 1. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 6 Coolant temperature is below specification	Refer to the Coolant Temperature is Below Normal symptom tree.
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 Fuel Recommendations and Specifications in Section V.
OK Go To Next Step	
STEP 8 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	

Smoke, White — Excessive

Cause	Correction
STEP 9 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 3.

OK
Go To Next Step

STEP 10 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 11
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 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 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 an Authorized Cummins Repair Facility.
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 an Authorized Cummins Repair Facility.
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

Listed below are the general specifications for this engine.

Bore and Stroke.....107 mm [4.21 in] x 124 mm [4.88 in]
Horsepower.....Refer to engine dataplate
Displacement
Four-Cylinder Engine.....4.5 liters [274 C.I.D.]
Six-Cylinder Engine.....6.7 liters [409 C.I.D.]
Firing Order
Four-Cylinder Engine.....1-3-4-2
Six-Cylinder Engine..... 1-5-3-6-2-4
Engine Weight (with standard accessories):
Dry Weight for 4.5 Liters [274 C.I.D.].....374 kg [825 lb]
Dry Weight for 6.7 Liters [409 C.I.D.].....485 kg [1070 lb]
Crankshaft Rotation (viewed from the front of the engine).....Clockwise
Valve Clearance:
Intake.....0.254 mm [0.010 in]
Exhaust.....0.508 mm [0.020 in]

NOTE: The engine features a no-adjust overhead. The valve train is designed such that adjustment of the valve lash is **not** required for normal service until the first overhead set adjustment recommended under Maintenance Schedule in Section 2 of this manual. The valve train operates acceptably within the limits of 0.152- to 0.381-mm [0.006- to 0.015-in] intake valve lash and 0.381- to 0.762-mm [0.015- to 0.030-in] exhaust valve lash.

Fuel System

Specifications

For performance and fuel rate values, refer to the Engine Data Sheet.

Maximum Fuel Inlet Restriction - With gear pump **only** (no engine mounted electric fuel lift pump) (at gear pump inlet) .....50.7 kPa [7.3 psi]
Rail Pressure - 4.5 liters [275 C.I.D.] and 6.7 liters [409 C.I.D.] .....250 to 1600 bar [3626 to 23,206 psi]
Fuel Pressure Range at Fuel Filter Inlet and Outlet (engine cranking) - With gear pump **only** (no electric fuel lift pump) .....303 to 1103 kPa [44 to 160 psi]
Fuel Pressure Range at Fuel Filter Inlet and Outlet (engine running) - With gear pump **only** (no electric fuel lift pump). . 503 to 1303 kPa [73 to 189 psi]
Maximum Pressure Drop across Fuel Filter - With gear pump **only** (no electric fuel lift pump).....200 kPa [29 psi]
Maximum Fuel Drain Line Restriction.....20 kPa [2.9 psi]
Maximum Fuel Inlet Temperature.....70°C [158°F]

Lubricating Oil System

Specifications

Oil Pressure
- Low idle (minimum allowed).....69 kPa [10 psi]
- At rated (minimum allowed).....207 kPa [30 psi]

Oil-regulating valve-opening pressure range.....448 kPa [65 psi] to 517 kPa [75 psi]
Oil filter differential pressure to open bypass.....345 kPa [50 psi]
Lubricating Oil Filter Capacity.....0.95 liters [1 qt]

Oil Capacity of Standard Engine (four-cylinder)
4.5 liters [275 C.I.D.] Engines (Suspended Oil Pan)
- Pan **only** .....11 liters [11.6 qt]
- Total system.....13 liters [13.7 qt]
- High to low (on dipstick).....1.9 liters [2.0 qt]

Oil Capacity of Standard Engine (four-cylinder)
4.5 liters [275 C.I.D.] Engines (Aluminium Oil Pan)
- Pan **only** .....13 liters [13.7 qt]
- Total system.....15 liters [15.9 qt]
- High to low (on dipstick).....3.0 liters [3.2 qt]

Oil Capacity of Standard Engine (four-cylinder)
4.5 liters [275 C.I.D.] Engines (High Capacity Oil Pan)
- Pan **only** .....16 liters [16.9 qt]
- Total system.....18 liters [19.0 qt]
- High to low (on dipstick).....6.0 liters [6.3 qt]

Oil Capacity of Standard Engine (six-cylinder)
6.7 liters [409 C.I.D] Engines (Standard Oil Pan)
- Pan **only** .....14.2 liters [15.0 qt]
- Total System.....16.7 liters [17.6 qt]
- High to Low (on dipstick).....1.9 liters [2.0 qt]

Oil Capacity of Standard Engine (six-cylinder)
6.7 liters [409 C.I.D] Engines (Suspended Oil Pan)
- Pan **only** .....17.2 liters [18.5 qt]
- Total System.....19.7 liters [20.8 qt]
- High to Low (on dipstick).....2.8 liters [3.0 qt]

Oil Capacity of Standard Engine (six-cylinder)
6.7 liters [409 C.I.D] Engines (High Capacity Oil Pan)
- Pan **only** .....23.9 liters [25.3 qt]
- Total System.....26.4 liters [27.9 qt]
- High to Low (on dipstick).....7.4 liters [7.8 qt]

Maximum Oil Temperature
- For 4.5 liters [275 C.I.D.] and 6.7 liters [409 C.I.D.] Engines.....138°C [280°F]

NOTE: If the type/oil capacity of the oil pan is **not** known:

- Contact a Cummins® Distributor/Dealer.
- Determine the capacity of the oil pan option for the engine being serviced by using QuickServe™ Online and the engine serial number.
- 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 (four-cylinder engine **only**).....8.5 liters [2.2 gal]
Coolant Capacity (six-cylinder engine **only**).....10 liters [2.6 gal]
Standard Modulating Thermostat - Range - Industrial Applications.....88 to 97°C [190 to 207°F]
Maximum Allowed Operating Temperature - Industrial Applications .....107°C [225°F]
Minimum Recommended Operating Temperature.....71°C [160°F]
Minimum Recommended Pressure Cap - Industrial Applications.....50 kPa [7 psi]

Air Intake System

Specifications

Maximum Intake Restriction (clean air filter element).....254 mm H_2O [10.0 in H_2O]
Maximum Intake Restriction (dirty air filter element).....635 mm H_2O [25.0 in H_2O]

Exhaust System

Specifications

Maximum Back Pressure measured at the turbocharger outlet (exhaust manifold outlet for naturally aspirated engines):

Without Aftertreatment SCR Catalyst.....10 kPa [1.5 psi]
With Aftertreatment SCR Catalyst.....20 kPa [2.9 psi]

Electrical System

Specifications

Recommended Battery Capacity

System Voltage		Ambient Temperature		
-18°C [0°F]		-29°C [-20°F]		
	Cold Cranking Amperes	Reserve Capacity (minutes)[1]	Cold Cranking Amperes	Reserve Capacity (minutes)[1]
6 cylinder engines				
12-VDC	1500	260	1900	260
24-VDC [2]	750	130	950	130
4 cylinder engines				
12-VDC	1200	260	1500	260
24-VDC [2]	600	260	750	260
[1] The number of plates within a given battery size determines reserve capacity. Reserve capacity is the length of time for which a battery at 27°C [81°F] can supply 25 amperes at 10.5-VDC or greater.				
[2] Cold cranking amp(s)(CCA) ratings are based on two 12-VDC batteries in series.				

Batteries (Specific Gravity)

Specific Gravity at 27°C [81°F]	State of Charge
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®/Nelson® is a subsidiary of Cummins Inc. Fleetguard®/Nelson® filters are developed through joint testing at Cummins® and Fleetguard®/Nelson®. Fleetguard®/Nelson® filters are standard on new Cummins® engines. Cummins Inc. recommends their use.

Fleetguard®/Nelson® 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 **must** insist on products that the supplier has tested to meet Cummins Inc. high-quality standards.

Cummins Inc. can **not** be responsible for problems caused by non-genuine filters that do **not** meet Cummins Inc. performance or durability requirements.

Filter Part Numbers

Lubricating Oil Filter	
Cummins® Part Number	3937736
Fleetguard®/Nelson® Part Number	LF3970

Fuel Filter (Primary)	
Cummins® Part Number	3978040
Fleetguard®/Nelson® Part Number	FF5421

Fuel Filter (Prefilter with WIF Sensor)	
Cummins® Part Number	3973233
Fleetguard®/Nelson® Part Number	FS19732

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.

⚠ CAUTION ⚠

Lighter fuels can reduce fuel economy or possibly damage fuel system components.

Cummins Inc. recommends the use of ASTM number 2D fuel. The use of number 2D 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.

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.									

NOTE: Cummins Inc. recommends that the cetane number of diesel fuel be a minimum of 45 for engines that are expected to operate at temperatures below 0°C [32°F] and a minimum of 40 for engines that are operated at temperatures above 0°C [32°F].

NOTE: Using diesel fuel with lower than recommended cetane number can cause hard starting, instability, and excessive white smoke. To maintain satisfactory operation at low ambient temperatures, it is important to specify diesel fuel of the correct cetane number.

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⚠

The fuel sulphur content should not exceed 0.5 mass percent sulphur. If the fuel sulphur content is greater than 0.5 mass percent sulphur, seek advice from your local Cummins® Distributor. For recommendations of fuel for Cummins® engines, refer to Fuel for Cummins® Engines, Bulletin 3379001.

⚠CAUTION⚠

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

⚠CAUTION⚠

Cummins Inc. does not recommend the use of A.C.E.A. E4/MB 228.5 formulation oils, which do not attain one or more of the following lubricant qualifications: A.P.I. CH-4. CI-4, A.C.E.A. E5. E7, C.E.S. 20071, C.E.S. 20072, C.E.S. 20076, C.E.S. 20077, C.E.S. 20078. If A.C.E.A. E4/MB 228.5 formulation oils, which do not comply with the oil specifications listed above, are used in Cummins® automotive engines, problems such as wear to overhead, sliding tappets, camshaft and crankshaft bearings may be experienced.

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.

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

NOTE: A.C.E.A. = Association des Constructeurs Européen d'Automobiles, A.P.I. = American Petroleum Institute and C.E.S. = Cummins® Engineering Standard.

Cummins Inc. recommends the use of a high-quality SAE 15W-40 heavy-duty engine oil, such as Valvoline Premium Blue™, which meets or exceeds the American Petroleum Institute (API) performance classification CH-4/SJ or CI-4/SK and the Association des Constructeurs Européen d'Automobiles (A.C.E.A.) performance classification E5 or E7.

Cummins® Engineering Standard Classifications (CES)	American Petroleum Institute Classification (API)	European Classification (ACEA)	Comments
	API CD API CE	ACEA E-1, ACEA E-2	**OBSOLETE. DO NOT USE.**
CES-20075	API CF-4/SG, API CG-4/SH	ACEA E-3	Minimum acceptable oil classification for Midrange engines. (1)
CES-20071, CES-20072, CES-20076, CES-20077	API CH-4/SJ	ACEA E-5, E-7	Good oil classification for Midrange engines without EGR.
CES-20078	API CI-4/SK		Excellent oil for Midrange engines.
1. CG-4/SH and E-3 oils can be used in areas where none of the recommended oils are available, but the oil drain interval **must** be reduced by one half of the interval given in the maintenance schedule. See the oil drain interval information in Section 2.			

A sulfated ash limit of 1.0 mass percent is suggested for optimum valve and piston deposit, and oil consumption control. The sulfated ash **must not** exceed 1.85 mass percent.

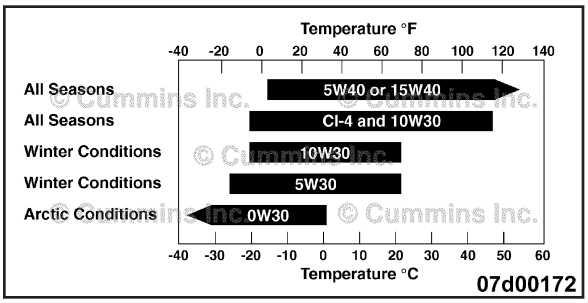
Special “break-in” oils are **not** recommended for use in new or rebuilt Cummins® engines. Use the same lubricating oil that will be used in normal engine operations.

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 **must** be applied to synthetic oils that are applied to petroleum (mineral) based engine oils.

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

⚠CAUTION⚠

An SAE 10W-30 designation on a product is a viscosity designation only. This designation alone does not imply that the product meets Cummins Inc. requirements. Only 10W30 oils with diesel performance credentials listed in table above can be used in Cummins® engines if the reduced ambient temperature indicated in chart above is observed.

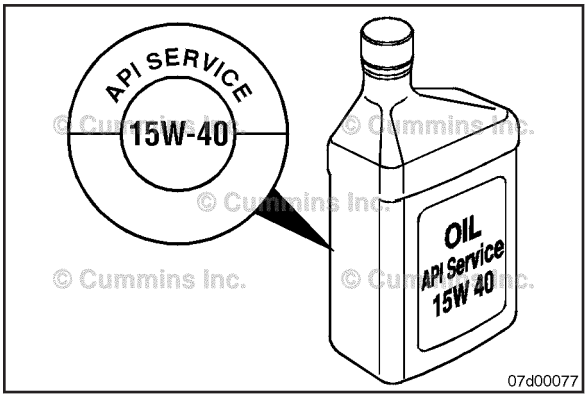


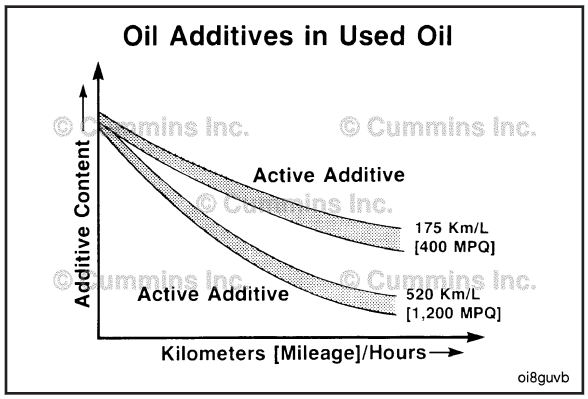
The primary Cummins Inc. recommendation is for the use of 15W-40 multigrade for normal operation at ambient temperatures above -15°C [5°F]. The use of multigrade oil reduces deposit formation, improves engine cranking in low temperature conditions and increases engine durability by maintaining lubrication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

Oils meeting a 10W30 viscosity grade, **must** meet a minimum High Temperature/High Shear viscosity of 3.5 cSt., and ring wear/liner wear requirements of Cummins® and Mack™ tests. Thus, they can by used over a wider temperature range than 10W30 oils meeting older API performance classifications. As these oils will 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 oil supplier. Obtain the oil supplier's commitment that the oil will give satisfactory performance in Cummins® engines or do **not** use the oil.

An example of the API service symbols are shown in the accompanying illustration. The upper half of the symbol displays the appropriate oil categories.

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.

See the oil drain chart in Section 2 to determine which oil drain interval to use for your application.

New Engine Break-in Oils

△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.

△CAUTION△

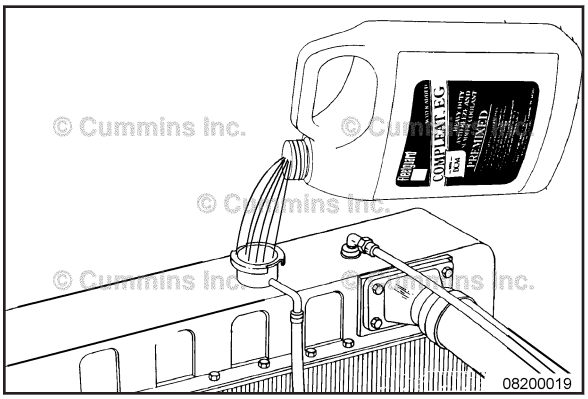
The use of a synthetic-base oil does not justify extended oil change intervals. Extended oil change intervals can decrease engine life due to factors such as corrosion, deposits, and wear.

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.

Additional information regarding lubricating oil availability throughout the world is available in the EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines. The data book can be ordered from: Engine Manufacturers Association, Two North LaSalle Street, Chicago, IL 60602; (312) 827-8733, (www.enginemanufacturers.org).

Coolant Recommendations and Specifications

Fully Formulated Coolant/Antifreeze



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

Typically, antifreeze/coolants meeting ASTM4985 (GM6038M specification) or ASTM D6210 criteria are acceptable antifreeze/coolants for engines covered by the manual.

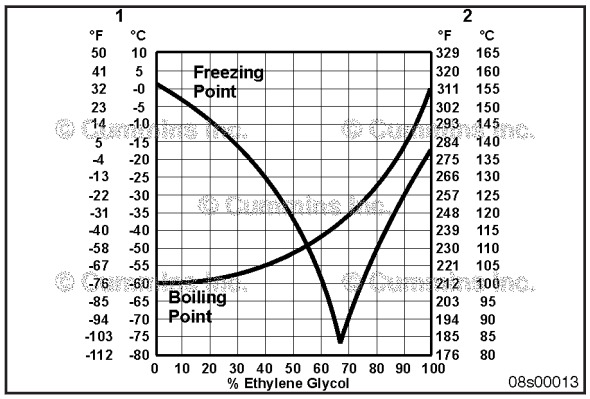
Low-silicate antifreeze/coolants meeting ASTM D4985 (GM6038M specification) are **not** adequate for extended service intervals.

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)

Cummins Inc. recommends using Fleetguard® Compleat. It is available in both glycol forms (ethylene and propylene).

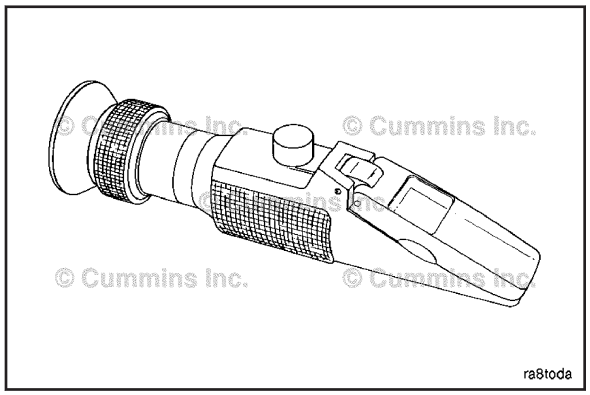


Fully formulated antifreeze **must** be mixed with good-quality water at a 50/50 ratio (40- to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-33°F] freezing point and a 108°C [226°F] boiling point, which is adequate for locations in North America. The actual lowest 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.

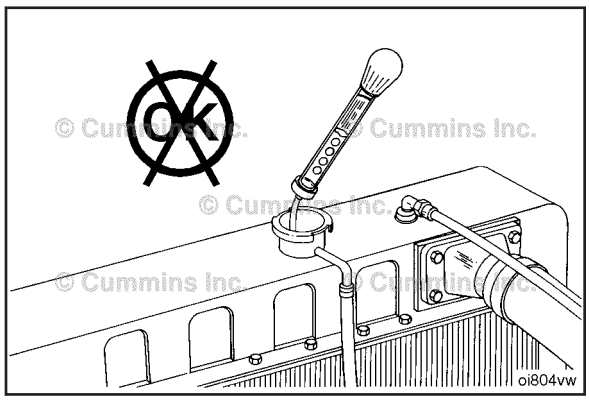
Legend

1 Freezing Point Temperature Scale

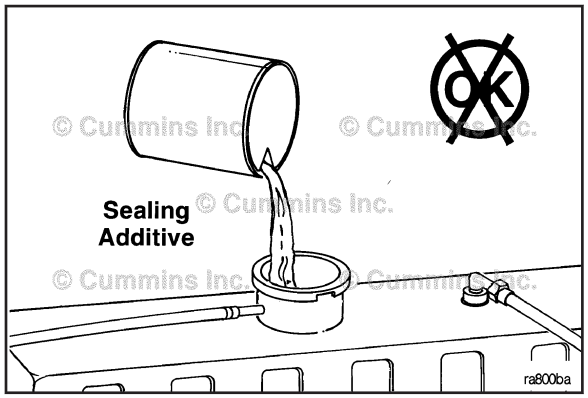
2 Boiling Point Temperature Scale



A refractometer **must** be used to measure the freezing point of the coolant **accurately**. Use Fleetguard® refractometer, Part Number C2800.



Do **not** use a floating ball hydrometer. The use of floating ball hydrometers can give an incorrect reading.



Cooling System Sealing Additives

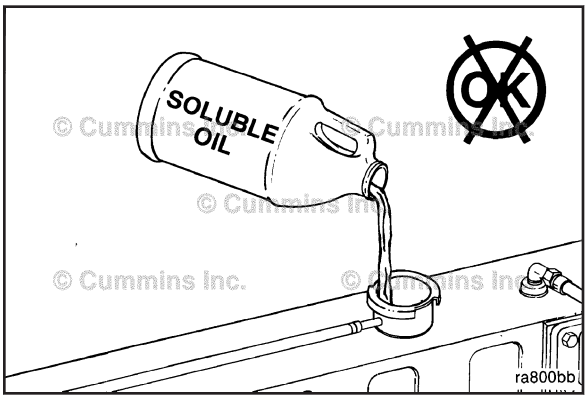
Do **not** use sealing additives in the cooling system. The use of sealing additives will:

- Buildup 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.

Sealants

General Information

Use the sealants listed below or sealants containing equivalent properties.

Item	Cummins Part Number	Generic Description
Pipe Plugs	3375066	Teflon Pipe Sealant
Cup Plugs	3375068	Sealant
O-Rings	3163087	Assembly Lube
Oil Pan T-Joint	3164067	RTV Sealant
Flywheel Housing to Rear Gear Housing Joint	3164070	RTV Sealant
Front Gear Cover to Block Joint	3164070	RTV Sealant
Rear Gear Housing to Block Joint	3164070	RTV Sealant
Intake Manifold to Cylinder Head Joint	3164070	RTV Sealant

Capscrew Markings and Torque Values

General Information

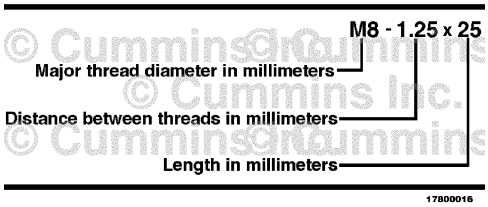
⚠CAUTION⚠

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.

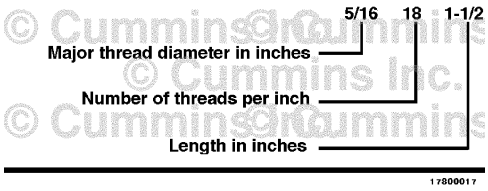
The following examples indicate how capscrews are identified:

Metric - M8-1.25 X 25



- **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.

U.S. Customary [5/16 X 18 X 1-1/2]



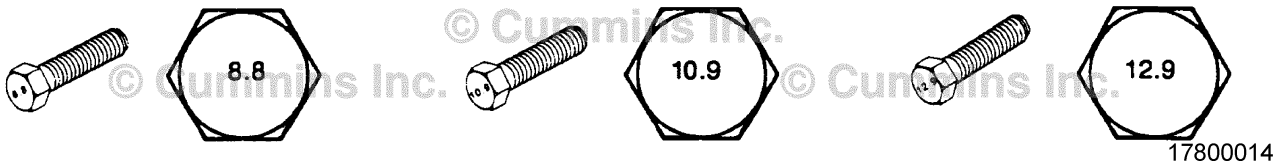
- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the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

Commercial Steel Class

8.8	10.9	12.9

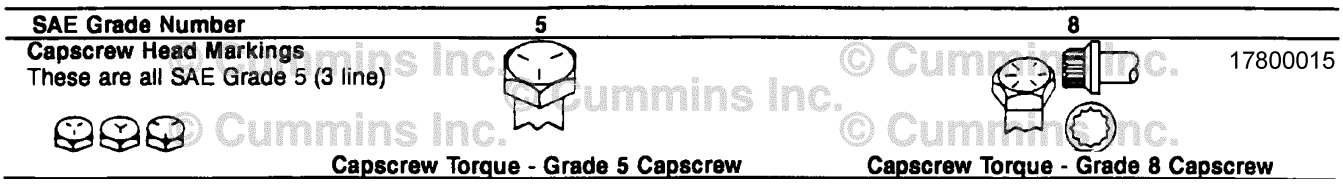
Capscrew Head Markings



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



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

Notes

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, QSF2.8, QSF3.8, and QSL9 emission control parts:

EPA Diesel

Aftertreatment System Component
Aftertreatment Electrical Connections
Aftertreatment Fuel Drain Valve
Aftertreatment Fuel Injector/Regulator
Aftertreatment Fuel Pressure Sensor
Aftertreatment Fuel Shut-Off Valve
Aftertreatment Injector Manifold
Aftertreatment Inlet and Outlet Modules
Aftertreatment Temperature Interface Module
Aftertreatment Temperature Sensors

Base Engine System Component
Camshaft
Camshaft Injector Lobe
Camshaft Valve Lobe
Coolant Temperature Sensor
Crankcase Breather
Engine Oil Pressure Sensor
Engine Speed, Position Sensor, Cam Position Sensor
Exhaust Valve
Static Cam Timing

Aftertreatment System (cont') Component
Decomposition Tube
DEF Dosing Controller (DCU)
DEF Dosing Unit (Pump)
DEF Dosing Valve
Diesel Oxidation Catalyst
Diesel Particulate Filter (except for ash maintenance)
Diesel Particulate Filter Differential Pressure Sensor
NH3 Sensor
NOx Sensors
SCR Catalyst

EGR System Component
EGR Cooler
EGR Differential Pressure Sensor
EGR Mixer/Venturi
EGR Temperature Sensor
EGR Valve

Air Handling Component
Barometric Air Pressure Sensor
Exhaust Gas Pressure Sensor
Exhaust Manifold
Grid Heater
Humidity Sensor
Intake Air Throttle Actuator
Intake Manifold
Intake Manifold Air Temperature Sensor

Electronic Control System Component
Engine Control Module
Wiring Harness Circuits Connected at Both Ends to Emissions Warrantable Components
Engine Control Module Calibration
Engine Control Module Calibration

Air Handling (cont') Component
Intake Manifold Temperature/Pressure Sensor
Turbocharger Actuator
Turbocharger Assembly
Turbocharger Compressor Inlet Air Temperature Sensor
Turbocharger Speed Sensor

Fuel System Component
Fuel Control Valve
Fuel Lines
Fuel Pressure Sensor
Fuel Pump
Fueling/Timing Actuators

EPA Diesel

Ignition System Component
Ignition Coils
Ignition Control Module

Fuel System (cont') Component
Injector
Secondary Fuel Pressure/Temperature Sensor

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.

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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.

Cummins Inc.
Box 3005
Columbus, Indiana, U.S.A., 47202

Registered Office
Cummins Ltd.
49 - 51 Gresham Road,
Staines,
Middlesex TW18 2BD,
England
Registration 573951 England

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

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