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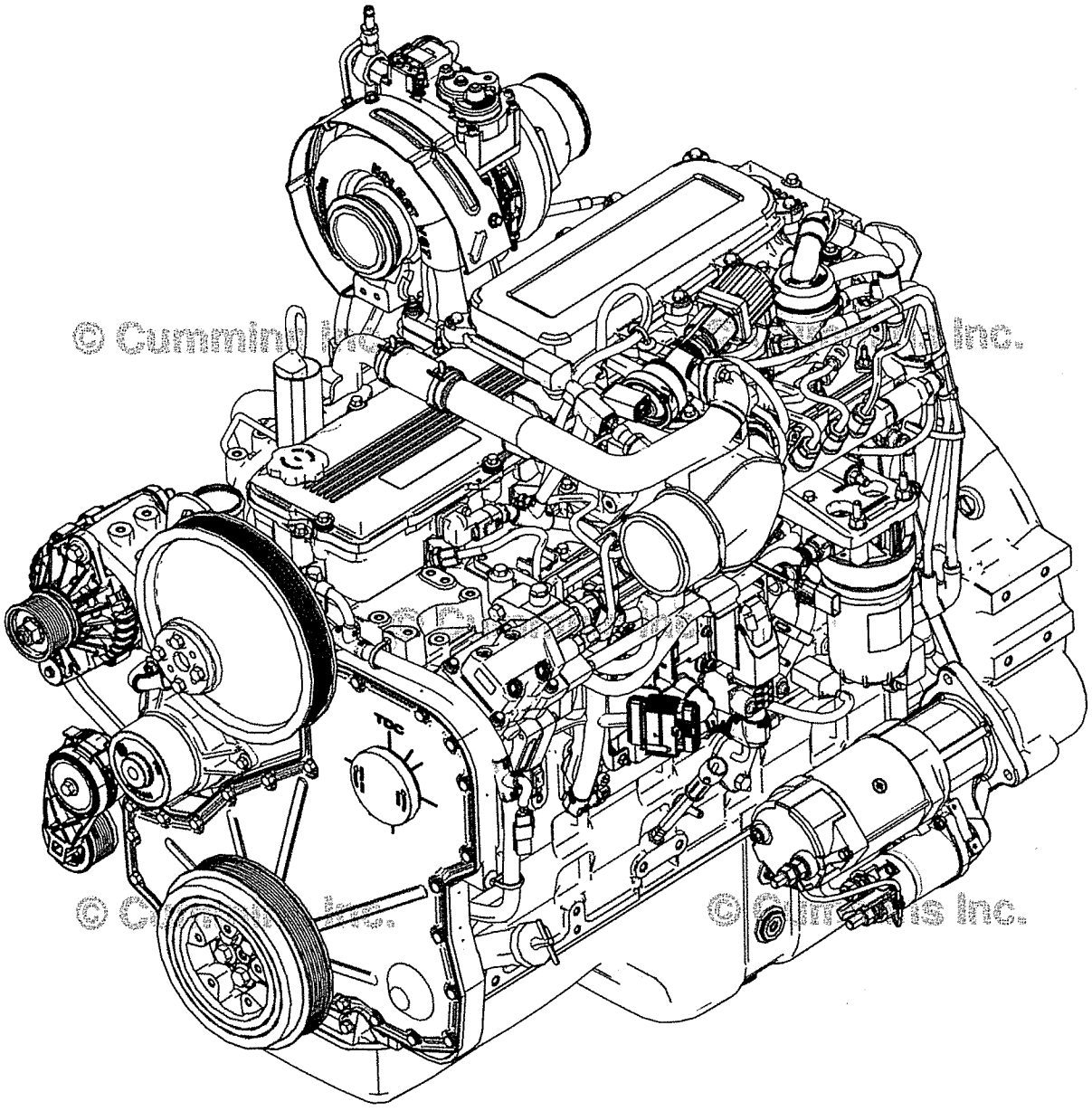
Operation and Maintenance Manual
QSL9 CM2350 L102



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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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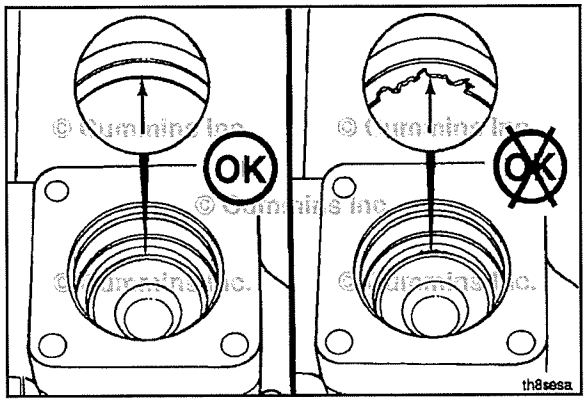
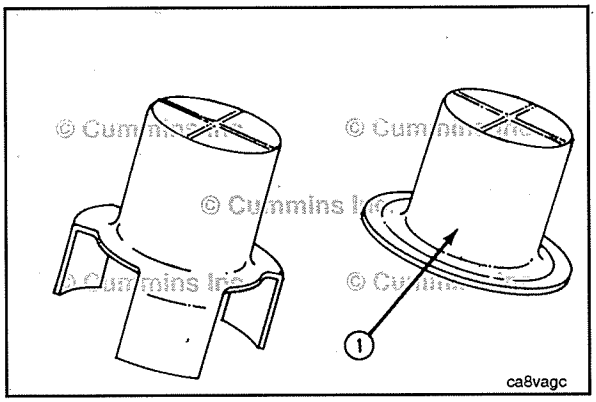
Illustrations

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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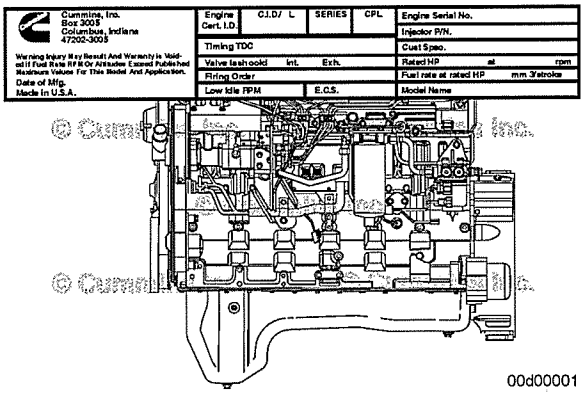
Engine Identification

Engine Dataplate



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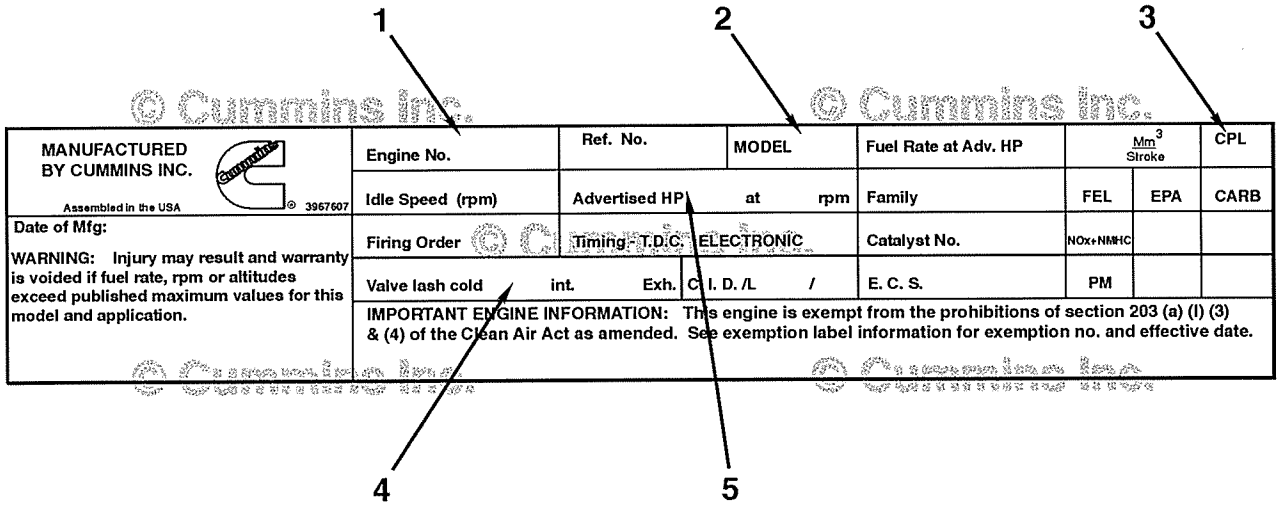
The engine dataplate provides important information about the engine. The engine serial number (ESN) and control part list (CPL) provide information for service and for ordering parts. The engine dataplate **must not** be changed unless approved by Cummins Inc.

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.



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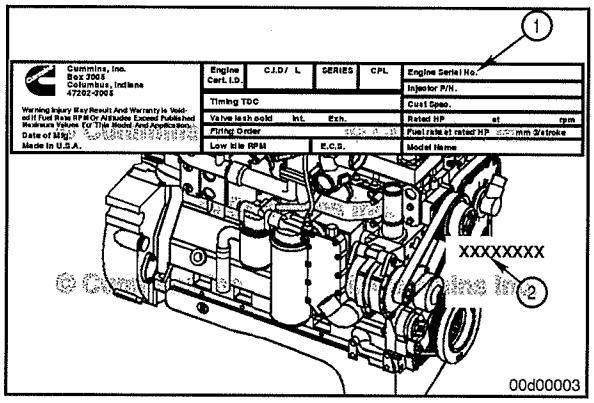
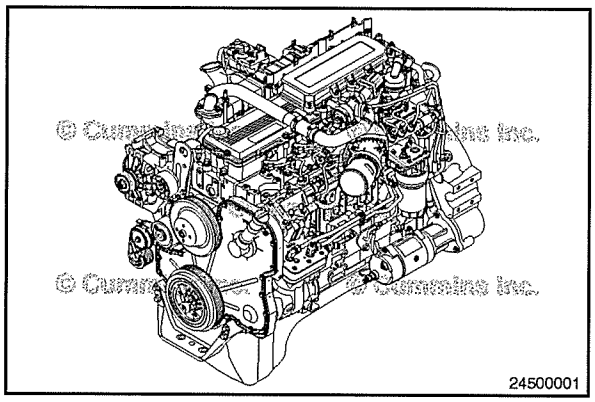
1 Engine serial number (ESN)
2 Engine model information
3 Control parts list (CPL)
4 Valve lash (overhead) setting
5 Horsepower and rpm rating.

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



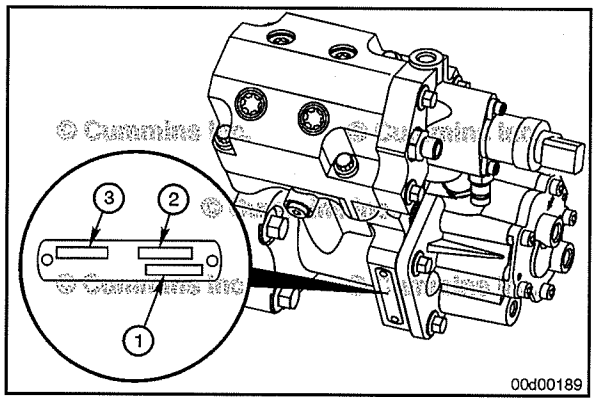
If the engine dataplate (1) is **not** legible, the engine serial number (ESN) (2) can be found on the engine block, on top of the lubricating oil cooler housing. Additional engine information is on the engine control module dataplate.



Cummins® Engine Nomenclature

The Cummins® Service Engine Model Identification procedure describes how to use the Cummins® Service Model Name to identify an engine. Refer to Procedure 100-005 in Section E.

The Cummins® Product Technology procedure provides the Cummins® Service Model Name and describes the unique technology used by the engine covered by this manual. Refer to Procedure 100-006 in section E



Fuel Pump Dataplate

The fuel pump dataplate is located on the side of the high-pressure pump. The dataplate contains the following information:

1 Cummins® part number

2 Pump serial number

3 Factory code.

Engine Control Module Dataplate

The engine control module (ECM) dataplate is located on the front of the ECM.

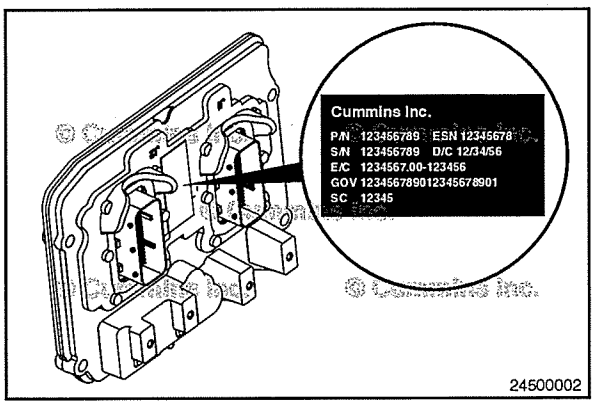
The following information is found on the engine control module dataplate:

- 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: 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, calibration data can be found on the engine dataplate.

NOTE: Not all engines will have ECM dataplates.

Engines covered by this manual are equipped with a CM2350 ECM. A CM2350 engine control module has two 96-pin connectors.



Air Compressor

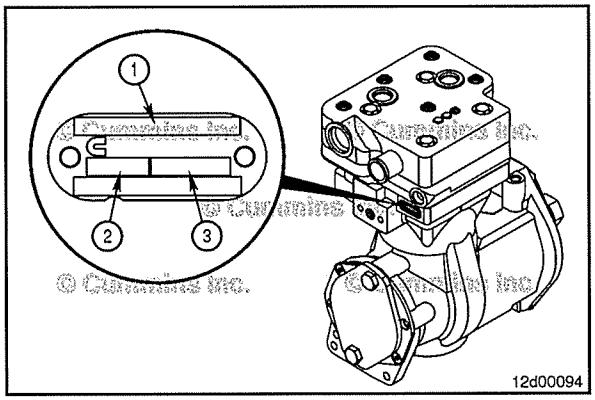
NOTE: Not all engines are equipped with an air compressor.

The Cummins® branded air compressor dataplate, identified by the Cummins Inc. logo on the dataplate, is typically located on the rear side of the air compressor. The dataplate contains the following information that assists in service or replacement.

1 Cummins® part number

2 Date code

3 Serial number.

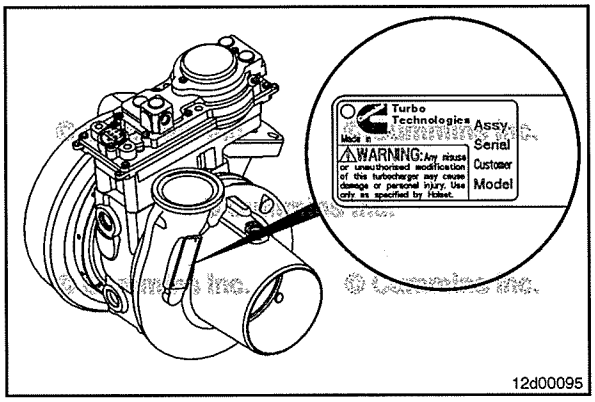


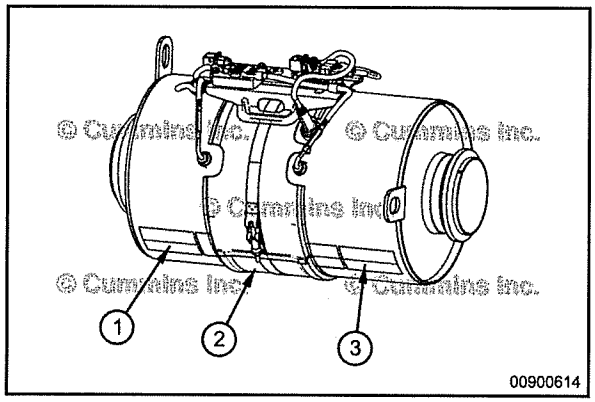
Variable Geometry Turbocharger

The variable geometry turbocharger dataplate is located on the turbocharger inlet compressor housing. The dataplate contains the following information which will assist in service or replacement.

- Cummins® assembly part number
- Serial number
- Customer number
- Model number.

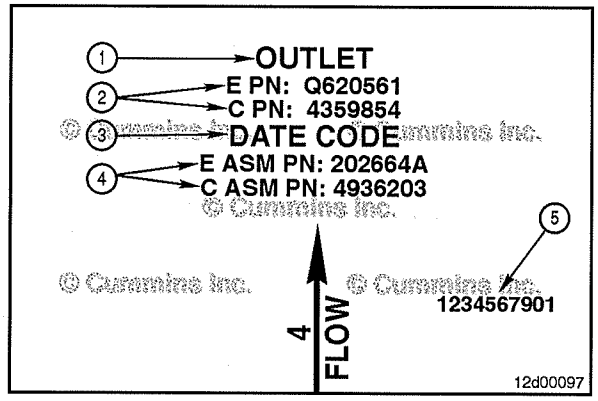
NOTE: The electronic actuator on the variable geometry turbocharger is a serviceable component and has a separate dataplate that assists in service or replacement.





Exhaust System

The diesel oxidation catalyst (DOC) aftertreatment assembly has important information for service and replacement stamped into the canister.



A typical aftertreatment information stamping can provide the following:

1 Section name

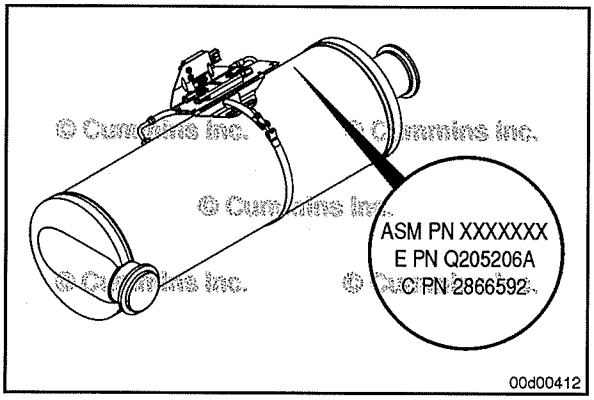
2 Part number

3 Date code

4 Assembly number (**only** located on the outlet section)

5 Serial number.

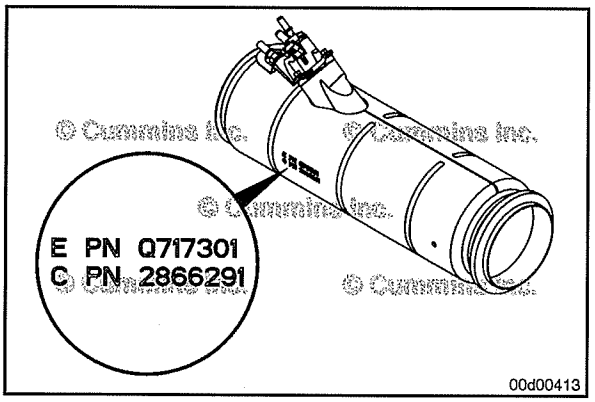
NOTE: Some aftertreatment components could possibly **only** have the Cummins Emission Solutions™ part number for cross referencing and part number identification. Reference to QuickServe® Online.



The aftertreatment selective catalytic reduction catalyst identification is located on the side of the part and contains the following information to assist in service or replacement:

- Assembly part number
- Cummins Emission Solutions™ part number
- Cummins® part number.

NOTE: Some aftertreatment components could possibly **only** have the Cummins Emission Solutions™ part number for cross referencing and part number identification. Reference to QuickServe® Online.



The aftertreatment decomposition tube identification is located on the side of the part and contains the following information to assist in service or replacement:

- Cummins Emission Solutions™ part number
- Cummins® part number.

NOTE: Some aftertreatment components may **only** have the Cummins Emission Solutions™ part number for cross referencing and part number identification. Reference to QuickServe® Online.

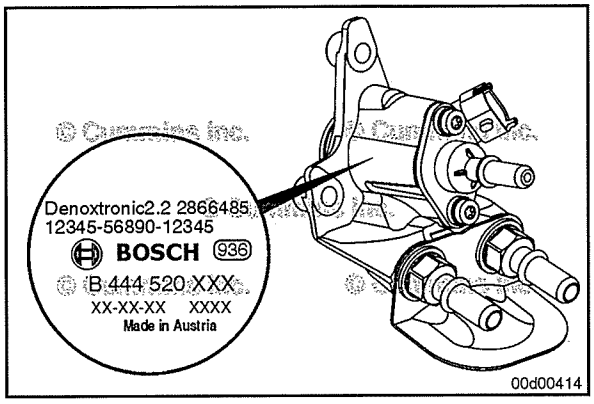
The aftertreament diesel exhaust fluid dosing valve identification is located on the side of the valve and contains the following information to assist in service or replacement:

- Cummins® part number
- Cummins Emission Solutions™ part number
- Bosch™ part number
- Bosch™ production data (date code and serial number).

Example:

- 2866485 is the Cummins® part number
- 12345-67890-12345 is the Cummins Emission Solutions™ part number
- B 444 606 XXX is the Bosch™ part number
- XX-XX-XX is the date code
- XXXX is the serial number.

NOTE: Some aftertreatment components may **only** have the Cummins Emission Solutions™ part number for cross referencing and part number identification. Reference to QuickServe® Online.



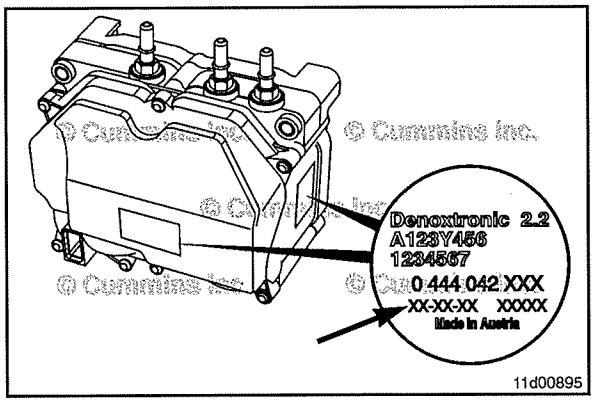
The aftertreament diesel exhaust fluid dosing unit identification is located on the side of the part and contains the following information to assist in servicing or replacement:

- Cummins Emission Solutions™ part number
- Cummins® part number
- Bosch™ part number
- Bosch™ production data (date code and serial number).

Example:

- A123Y456 is the Cummins Emission Solutions™ part number
- 1234567 is the Cummins® part number
- 0 444 042 XXX is the Bosch™ part number
- XX-XX-XX is the date code
- XXXXX is the serial number.

NOTE: Some aftertreatment components may **only** have the Cummins Emission Solutions™ part number for cross referencing and part number identification. Reference to QuickServe® Online.



Engine Diagrams

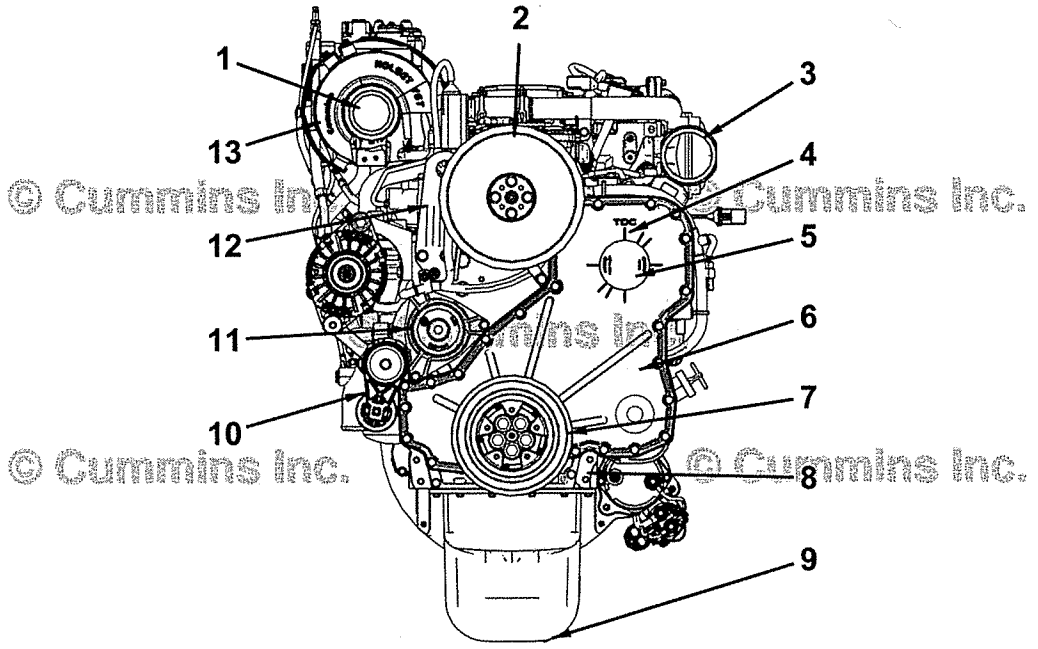
Engine Views

The following illustrations provide 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.

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

Engine Diagrams

Engine Views



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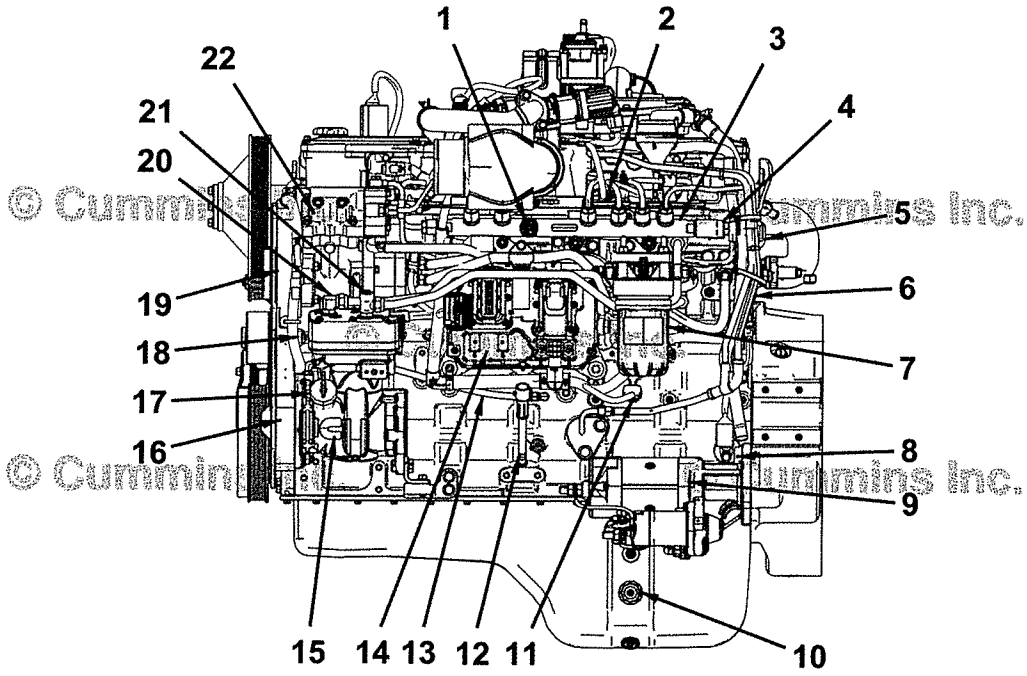
Front View - QSL9 CM2350

1 Turbocharger compressor air inlet
2 Fan pulley
3 Air intake connection
4 Top dead center indicator
5 Fuel pump drive gear access cover
6 Front gear cover
7 Vibration damper
8 Front engine mounting bracket
9 Engine lubricating oil pan drain plug
10 Belt tensioner
11 Water pump
12 Front engine lifting bracket
13 Turbocharger.

Engine Diagrams

Engine Views



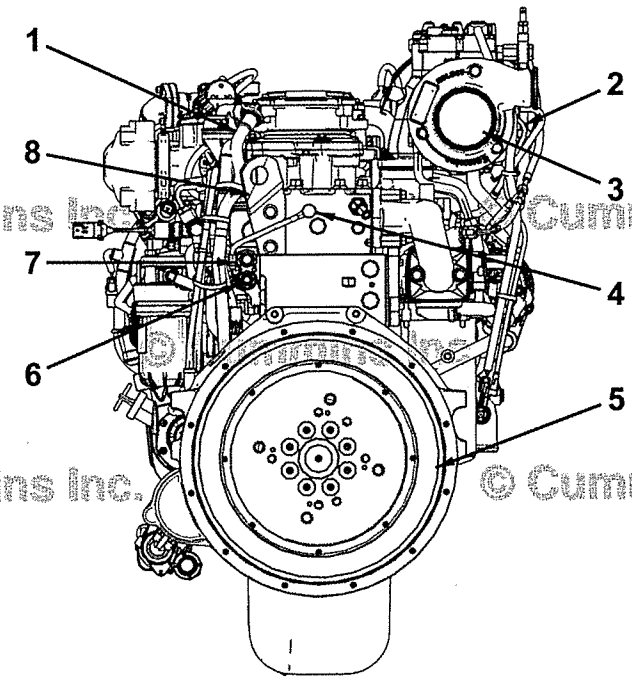
Left View - QSL9 CM2350

1 Fuel rail pressure sensor
2 Intake manifold temperature and pressure sensor
3 Fuel rail
4 Fuel rail high pressure relief valve
5 Fuel drain line
6 Crankcase breather oil drain tubes
7 Fuel filter
8 Crankshaft speed sensor
9 Starter
10 Engine oil heater mounting boss
11 Lubricating oil pressure sensor
12 Dipstick location
13 Air compressor oil supply line
14 Engine control module (ECM)
15 Air compressor
16 Gear housing
17 Engine lubricating oil fill location
18 Camshaft speed sensor
19 Engine dataplate
20 Air compressor coolant drain line
21 Air compressor coolant supply line
22 Fuel pump.

NOTE: The fuel lift pump is behind the ECM and is not shown in the illustration.

Engine Diagrams

Engine Views



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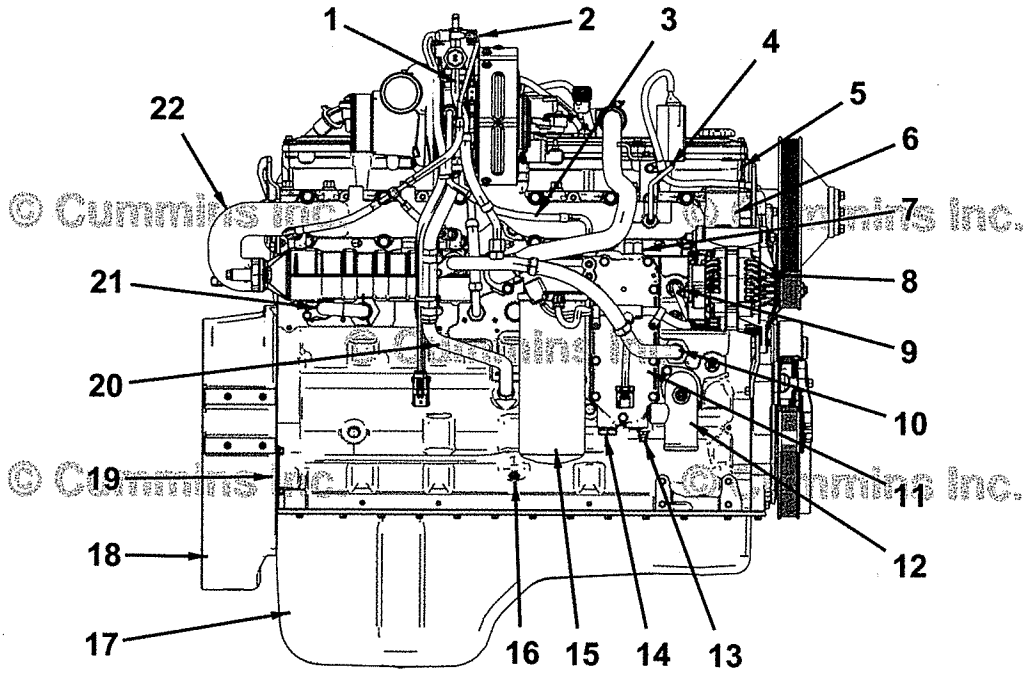
Rear View - QSL9 CM2350

1 Crankcase breather draft tube
2 Turbocharger speed sensor
3 Turbocharger exhaust outlet
4 Injector drain line connection
5 Flywheel
6 Original equipment manufacturer (OEM) fuel supply line connection
7 OEM fuel drain line connection
8 Rear engine lifting bracket.

Engine Diagrams

Engine Views

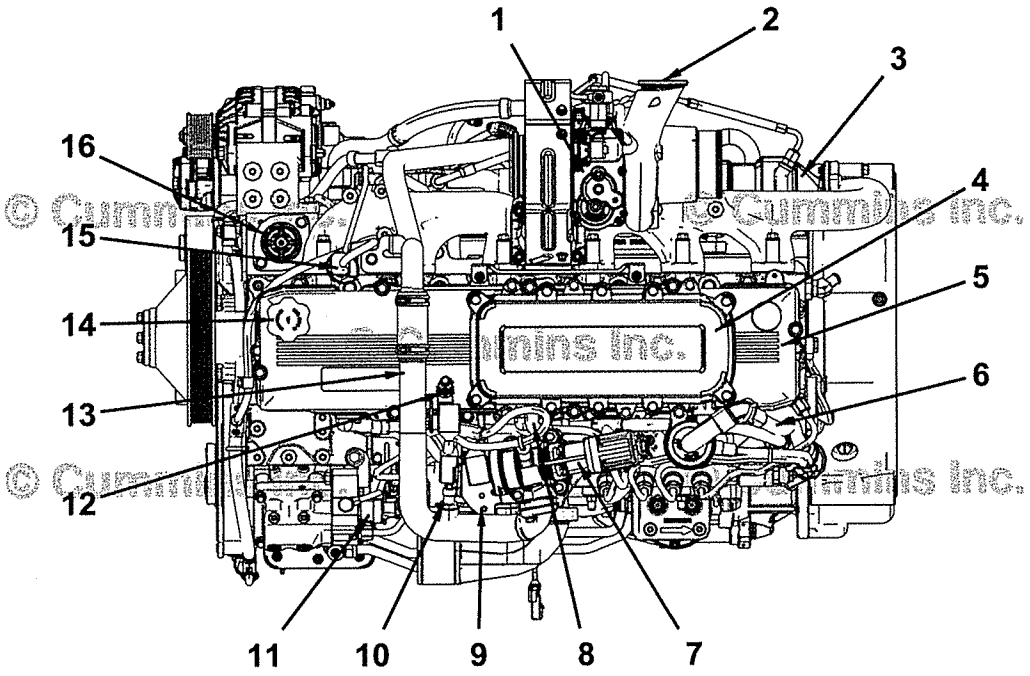


Right View - QSL9 CM2350

1 Turbocharger and actuator coolant supply
2 Turbocharger and actuator coolant drain
3 Turbocharger oil supply line
4 Exhaust gas pressure sensor tube
5 Rocker lever housing
6 Coolant outlet connection
7 Lubricating oil thermostat
8 Alternator
9 Coolant temperature sensor
10 Exhaust gas recirculation (EGR) cooler coolant return
11 Lubricating oil cooler
12 Coolant inlet connection
13 Coolant drain petcock
14 Lubricating oil pressure regulator
15 Lubricating oil filter
16 Dipstick location
17 Lubricating oil pan
18 Flywheel housing
19 Engine barring port
20 Turbocharger oil drain line
21 EGR cooler coolant supply
22 Exhaust manifold.

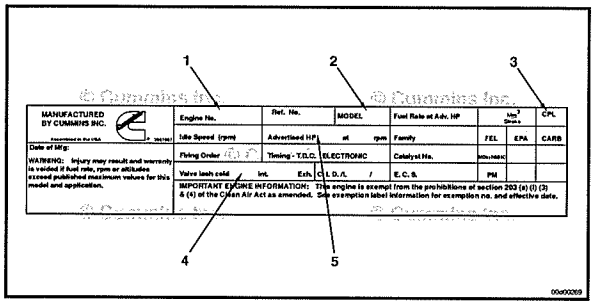
Engine Diagrams

Engine Views



Top View - QSL9 CM2350

1 Turbocharger actuator
2 Turbocharger compressor air outlet
3 EGR cooler
4 Crankcase breather
5 Rocker lever cover
6 Crankcase breather draft tube
7 EGR valve
8 Crankcase breather oil drain tubes
9 EGR differential pressure sensor
10 Exhaust gas temperature sensor
11 Fuel pump actuator
12 Crankcase pressure sensor
13 EGR crossover tube
14 Engine oil fill
15 Exhaust gas pressure sensor
16 Thermostat.



Cummins® Service Engine Model Identification

General Information

The Cummins® Service Engine Model Identification procedure describes:

- The purpose of the Cummins® Service Model Name.
- How to interpret a Cummins® Service Model Name to identify a Cummins® Engine.

This includes 2013 and later products.

The Cummins® Service Model Name differs from the Cummins® marketing model name. Service model names are more specific and help to match the correct Cummins® service information to the correct engine. Marketing engine model names are more generic and can capture multiple engine variations in the same model name.

Marketing Engine Model Name	Service Model Name
ISX15	ISX15 CM2350 X101

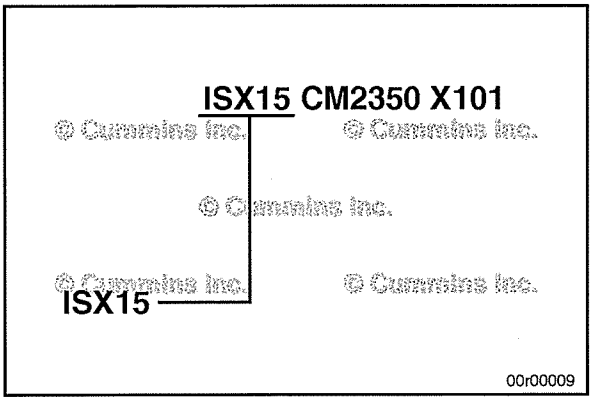
Marketing engine model names (2) can be found on the engine dataplate, Cummins® brochures, and Cummins® promotional literature.

Examples of Cummins® service information and products that use service model names:

- QuickServe™ Online
- INSITE™ electronic service tool
- Owner's Manual
- Operation and Maintenance Manual
- Master Repair Manual
- Service Manual
- Wiring Diagram
- Fault Code Troubleshooting Manual
- Standard Repair Times
- Technical Service Bulletins
- Service Bulletins

The Cummins® Service Model Name begins with the marketing engine model name.

NOTE: For engines released specifically for the European market, marketing model names may include an "e" between the engine platform designation and the engine liter displacement. Service model names will not display this "e".



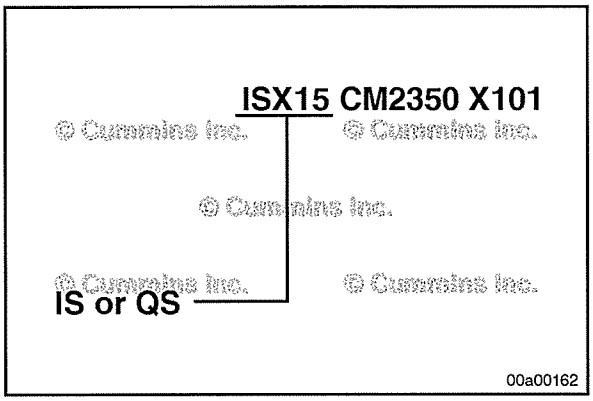
Typically, the first two letters of the marketing model name contain an "IS" or "QS" if the engine is an electronic engine.

"IS" prefix designates and On-Highway automotive engine.

"QS" prefix designates an Off-Highway industrial engine.

NOTE: Not all electronic engines use the "IS" or "QS" prefix. To verify if the engine is an electronic engine, check to see if an electronic control system is listed in the service model name. The control system that is identified as part of the service model name is referenced later in this procedure.

Non-electronic engines do not have an "IS" or "QS" prefix and do not have an electronic control system listed in the service model name.

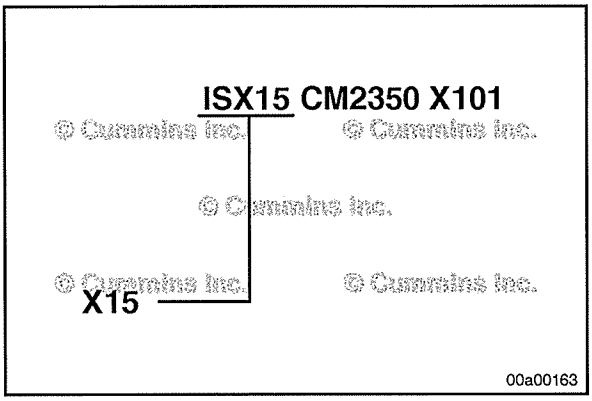


Typically, the third letter is the engine platform/series designation followed by the engine liter displacement. For the example shown in the graphic, the engine is a:

X Series engine

15 Liters in Displacement

NOTE: Some legacy engines will use the cubic inch rather than liter for engine displacement.

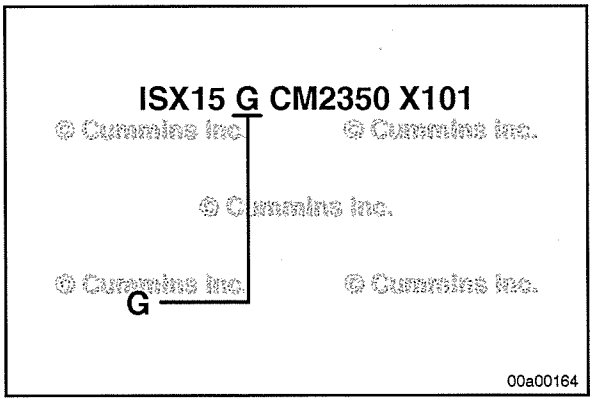


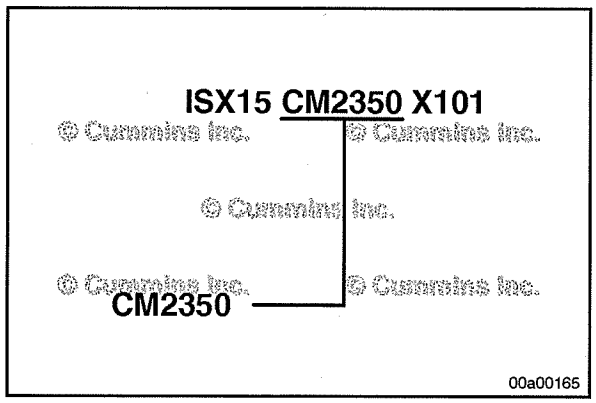
If a "G" indicator is located after the liter displacement, the engine is fueled by natural gas.

NOTE: Not all engines fueled by natural gas will have a "G" located after the displacement.

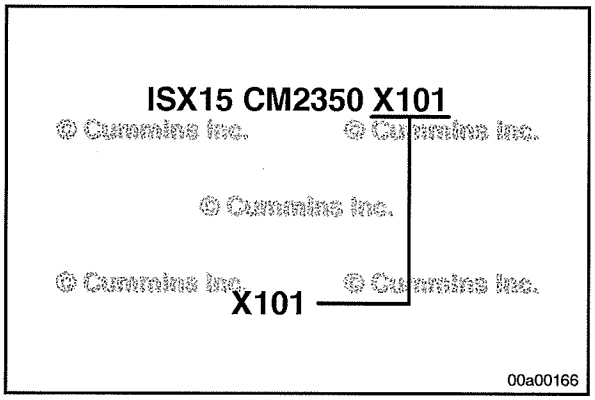
If a "M" is located after the liter displacement, the engine is in a marine application.

NOTE: Not all engines used in a marine application will have "M" located after the displacement.





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



The identifier after the control system is a letter and number combination to identify variations between products.

The letter is the engine platform designation.

The number increments as new variations of the engine platform/series are released. The first number is 101.

Cummins® Product Technology

General Information

The service model name for this product is **QSL9 CM2350 L102**.

This engine is being released to meet the following emission regulations:

- United States and Canada
- Tier 4 (EPA Final)
- European Union
- Stage IV (Euro)
- Japan
- Korea (South).

This engine has the following Agency defined Emissions Control System (ECS) hardware, which can also be found on the engine dataplate. Use the following procedure for the location of the engine dataplate. Refer to Procedure 100-001 in Section E.

EPA Products

- Engine Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Oxidation Catalyst (OC)
- Selective Catalytic Reduction - Urea (SCR-U)
- Turbocharger (TC).

This engine uses the following product technology:

Engine

- Number of Cylinders - 6
- Engine Configuration - Inline
- Cylinder Block Material - Cast Iron
- Cylinder Head Material - Cast Iron
- Camshaft Location - Cylinder Block.

Electronic Control System

- Control Module: CM2350
- Engine Coolant Level Sensor
- Engine Coolant Temperature Sensor
- Engine Oil Pressure Sensor
- Engine Oil Pressure Switch
- Engine Oil Level Sensor
- Fuel Rail Pressure Sensor
- Fuel Pump Actuator
- Water-in-Fuel Sensor
- Camshaft Position Sensor
- Crankshaft Position Sensor
- EGR Differential Pressure Sensor
- Exhaust Gas Pressure Sensor
- EGR Temperature Sensor
- Intake Manifold Pressure/Temperature Sensor
- Turbocharger Speed Sensor

- Turbocharger Compressor Intake Pressure/Temperature Sensor
- Ambient Air Temperature Sensor
- Crankcase Pressure Sensor
- Aftertreatment Exhaust Gas Temperature Sensor
- Diesel Exhaust Fluid Quality Sensor
- Aftertreatment Intake mono-nitrogen oxides (NOx) Sensor
- Aftertreatment Outlet NOx Sensor.

Air Handling

- Turbocharger (Single)
- Variable Geometry
- Intake Air Heater.

Fuel System

- Diesel
- Common Rail Fuel System
- Cummins XPI Common Rail Fuel System.

Exhaust System

- Exhaust Gas Recirculation (EGR)
- Aftertreatment Fuel Injection
- Internal
- Diesel Oxidation Catalyst (DOC)
- Selective Catalytic Reduction (SCR) Catalyst
- Aftertreatment Diesel Exhaust Fluid Dosing System
- Airless Diesel Exhaust Fluid Dosing Unit
- Integrated Diesel Exhaust Fluid Controller (controlled by the engine's ECM).

Market applications that will use this engine include, but are **not** limited to:

Industrial

- Agriculture
- Construction
- Fire Pump
- Locomotive
- Power Unit
- Rail Car
- Oil and Gas
- Welding
- Air Compressor
- Underground Mining
- Track Maintenance.

Section 1 - Operating Instructions

Section Contents

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Operating Instructions - Overview

General Information

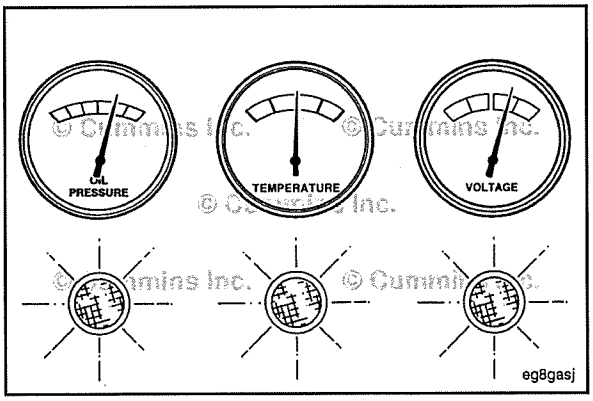
Correct care of your engine will result in longer life, better performance, and more economical operation.

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

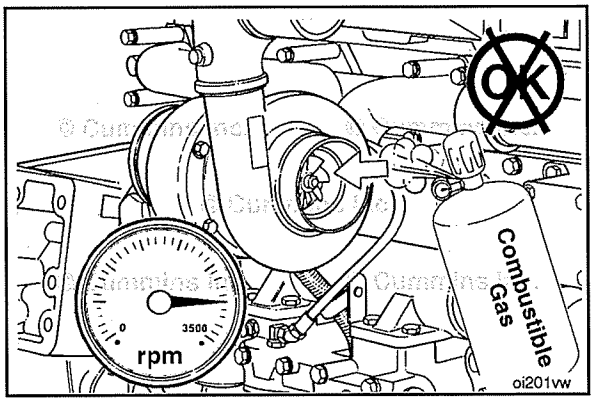
The new Cummins® engine associated with this manual does **not** require a "break-in" procedure. This section of the manual provides all of the necessary information required for proper engine operation.

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.

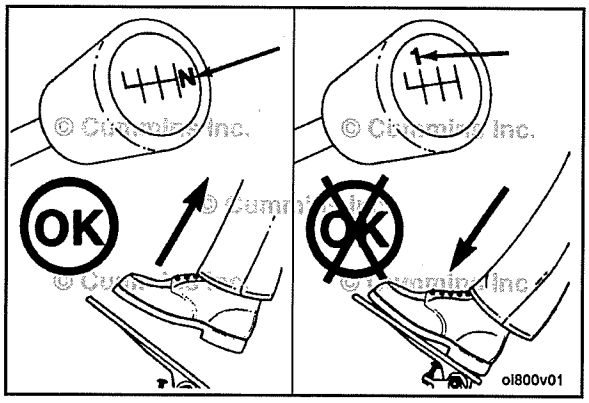


⚠WARNING⚠
Do not operate a diesel engine where there are or can BE COMBUSTIBLE vapors. These vapors can be sucked through the air intake system and cause engine acceleration and over speeding that can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available,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

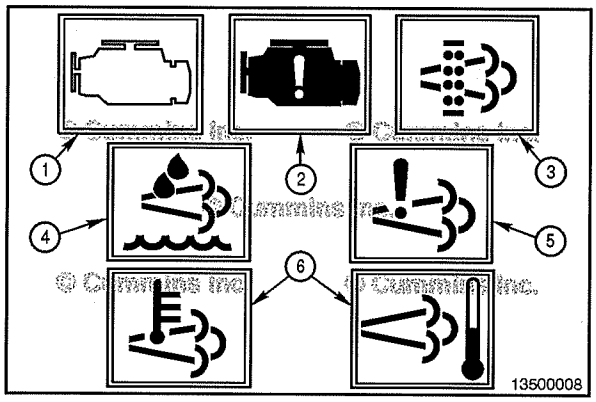


Normal Starting Procedure

Starting

Disengage the driven unit, or, if equipped, put the transmission in neutral.

With the accelerator pedal or lever in the idle position, turn the keyswitch to the ON position.



With the key in the ON position, the engine indicator lamps will come on momentarily and then go out. The engine indicator lamps include:

1 WARNING (or CHECK ENGINE) lamp, amber in color

2 STOP (or STOP ENGINE) lamp, red in color

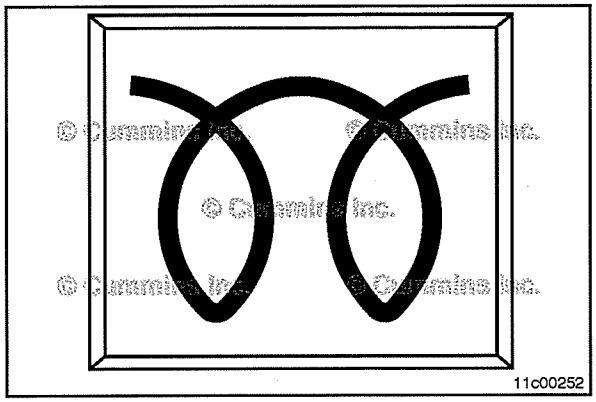
3 SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM CLEANING lamp, amber in color

4 DIESEL EXHAUST FLUID lamp, amber in color

5 SCR SYSTEM CLEANING INHIBIT lamp, amber in color.

Additionally, some engines have an additional lamp, (6) HIGH EXHAUST SYSTEM TEMPERATURE, which is amber in color. If any of the lamps remain on or begin to flash, see the following procedure. Refer to Procedure 101-048 in Section 1.

⚠CAUTION⚠
Do not engage the starting motor for more than 30 seconds or damage to the starting motor can result. Wait 2 minutes between each attempt to start (electrical starting motors only).



Under cold conditions, the WAIT-TO-START lamp (generally a yellow lamp using a symbol similar to the graphic, or the words WAIT TO START) will also illuminate at key ON, and will stay on for a period of up to 30 seconds.

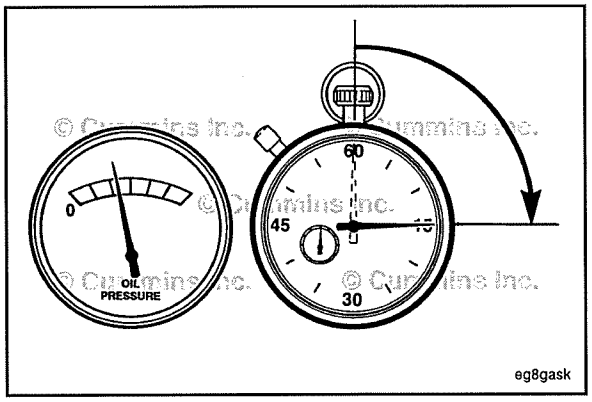
NOTE: The length of time the WAIT-TO-START lamp remains illuminated depends on the ambient temperature. The lower the ambient temperature, the longer the lamp will be illuminated.

Once the WAIT-TO-START lamp turns off, turn the key to the start position to start the engine. If the engine will not start reference the appropriate Troubleshooting Symptoms tree in Section TS in the Operation and Maintenance manual.

NOTE: Some engines are equipped with an engine starting motor protection feature. If the starting motor is engaged for 30 or more seconds, without the engine starting, the starter will be locked out from operating, allowing for proper cooling of the starting motor. During this time, the WAIT TO START lamp will flash for 2 minutes. Once the lamp discontinues flashing, the starting motor will be allowed to function.

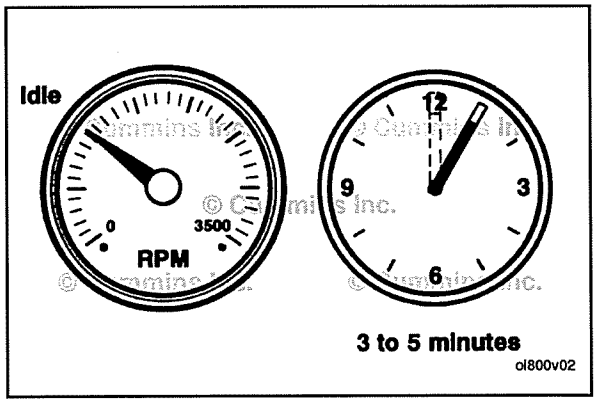
NOTE: Engines equipped with air starting motors require a minimum of 480 kPa [70 psi].

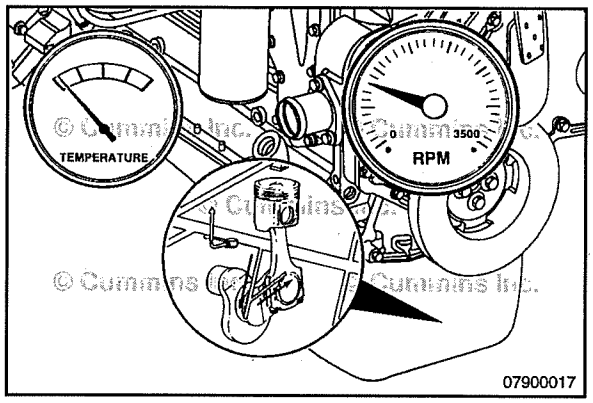
⚠CAUTION⚠
The engine must have adequate oil pressure within 15 seconds after starting. If the WARNING lamp indicating low oil pressure has not gone out or there is no oil pressure indicated on a gauge within 15 seconds, shut the engine OFF immediately to reduce the possibility of engine damage.



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

NOTE: After the engine is started, the voltmeter, if equipped, may show a gauge fluctuation under certain engine temperature conditions (both warm and cold). This cycling operation is caused by the post-heat cycle of the intake manifold heater system. The number of cycles and the length of the cycling operation is controlled by the engine control module. The cycling action will cause temporary dimming of the headlamps, interior lamps, and other vehicle electrical accessories.





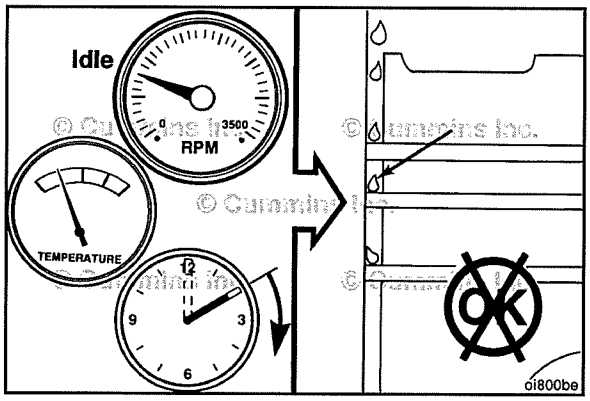
After starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

NOTE: For engines equipped with engine warm-up protection feature; this feature limits engine speed and torque following engine start-up until sufficient oil pressure is available to the engine components. This feature reduces the risk of engine part damage due to operating at engine speeds too high or excessive loads before adequate oil pressure is achieved.

Some engines are equipped with a Fast Idle Warm Up feature. When enabled, this feature elevates the idle speed of the engine in cold ambient conditions in order to shorten the time necessary to warm up the engine. When the idle speed is elevated, the engine noise may change. This is normal. To bring the engine back to low idle speed:

- For vehicles equipped with a manual transmission and clutch switch: Depress the clutch pedal.
- For vehicles equipped with a brake switch: Depress the service brake pedal.
- Depress the accelerator pedal.

For more information on the Fast Idle Warm Up feature, contact a Cummins® Authorized Repair Location.



⚠CAUTION⚠

Do not operate the 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 buildup in the cylinder
- Cylinder head valve sticking
- Reduced performance.

Jump Starting

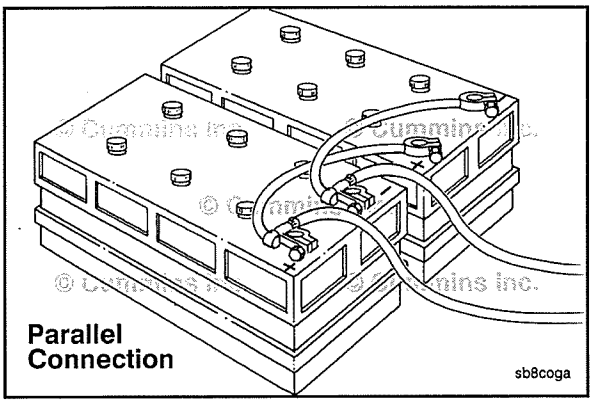
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠CAUTION⚠
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 reduce the possibility of damage to engine parts, do not connect the jumper starting or battery charging cable to any fuel system or electronic component.

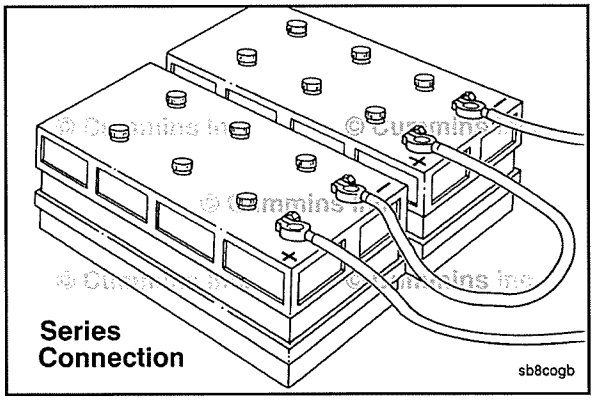
This illustration shows a typical parallel battery connection. This arrangement doubles the cranking amperage.

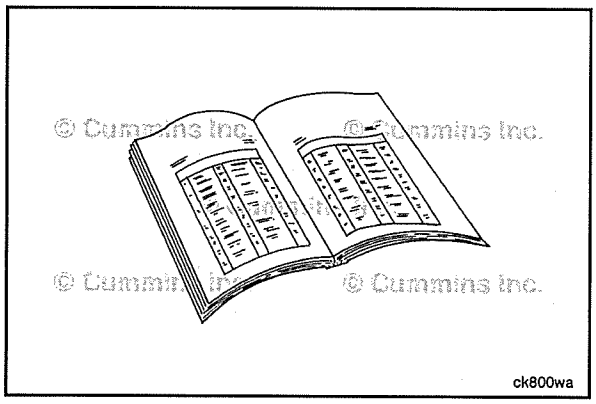
NOTE: Always reference the relevant OEM literature for jump starting procedures. Failure to follow correct procedures can result in damage to the engine control module and other electrical equipment.



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 engine control module and other electrical equipment.





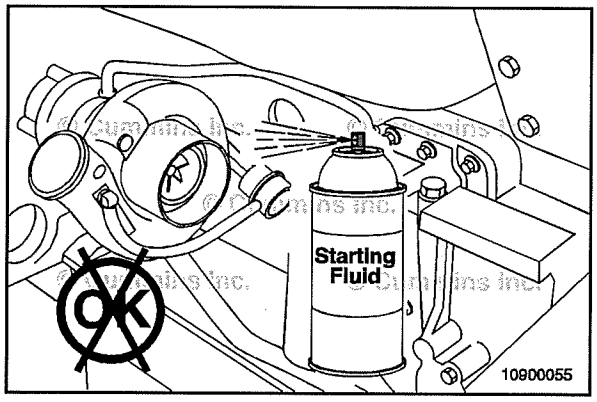
Cold Weather Starting

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

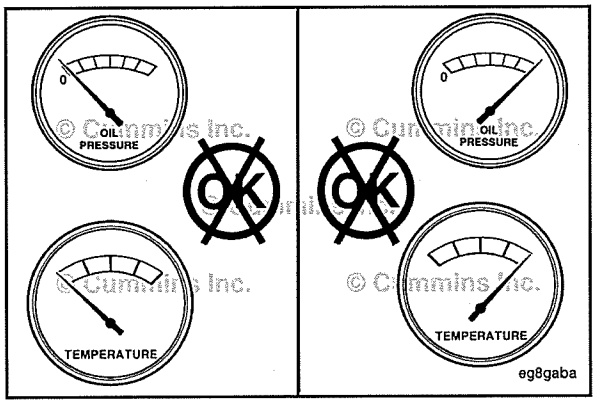
Follow the Normal Starting Procedure in this section. The engine will **not** start until the minimum cranking oil pressure is detected by the ECM. It can take more cranking time to start the engine after an extended shut down or oil change.

Operating the Engine

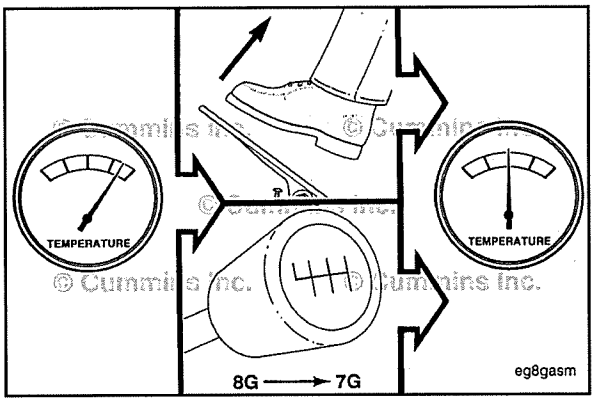
Normal

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.



⚠CAUTION⚠

Do not idle for extended periods of time. Excessive idle time can cause poor engine performance.

Internal combustion engines **must not** operate at low idle speed for extended periods of time. This operating condition may lead to poor engine performance. The idle shutdown feature, available on most Cummins® engines, can be programmed to shut the engine down after a period of low idle speed operation with no driver activity. A flashing warning lamp will inform the driver of an impending shutdown. If an engine **must** idle for an extended period of time, it should be done at fast idle (1000 rpm or greater). The Power Take-Off (PTO) feature, available on most Cummins® engines, can be programmed to adjust engine speed with the use of OEM switches to pre-programmed set points.

Ambient Temperature

0 to -32°C [32 to -25°F]

Use 50-percent ethylene glycol antifreeze and 50-percent water for the engine coolant mixture.

The Diesel fuel **must** have maximum cloud and pour points 6°C [10°F] lower than the ambient temperature in which the engine operates.

-32 to -54°C [-25 to -65°F]

Use 60-percent ethylene glycol antifreeze and 40-percent water for the engine coolant mixture.

The Diesel fuel **must** have maximum cloud and pour points 6°C [10°F] lower than the ambient temperature in which the engine operates.

The cold weather operating aid is required for cold weather situations.

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).

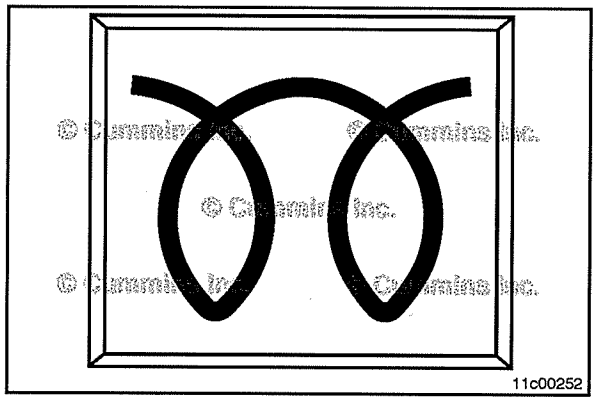
Engine Indicator Lamps

General Information

The following engine indicator lamps cover **only** the lamps controlled by the engine control module (ECM). The equipment manufacturer can provide additional indicator lamps. Refer to the original equipment manufacturer (OEM) service manual for additional lamp information.

The regulated engine derate conditions vary depending on the OEM and local regulaltions. Refer to the OEM service manual for additional derate information.

NOTE: The start and permit switches, as well as the SCR/exhaust system cleaning lamp, are common with other Cummins systems utilizing a diesel particulate filter (DPF). Some OEMs, documentation, and tools may reference these as Aftertreatment Diesel Particulate Filter Regeneration or Aftertreatment Regeneration parameters.



Wait to Start Lamp

The WAIT TO START lamp illuminates when the intake air heater needs to warm the intake air prior to starting the engine.

The time for the WAIT TO START lamp to be on will vary, depending on the ambient air temperature. Refer to Procedure 101-014 in Section 1.

For vehicles equipped with an engine starting motor protection feature, another function of the WAIT TO START lamp is to flash for two minutes if the starting motor is engaged for 30 seconds or more.

The WAIT TO START lamp can look like:

- The words WAIT TO START spelled out
- A symbol similar to the graphic
- The color of the symbol or words can vary, based on the manufacturer of the vehicle, but will typically be red or amber.

Check Engine Lamp

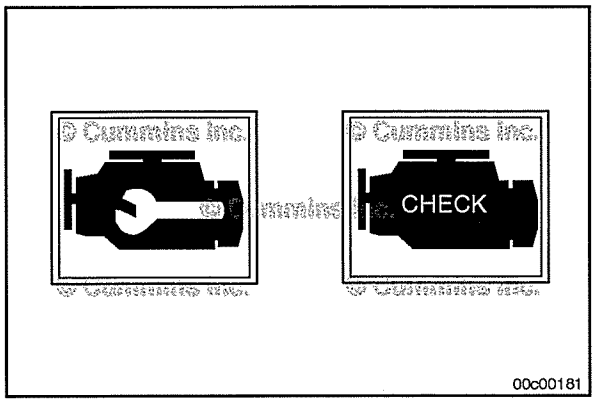
The CHECK ENGINE lamp illuminates when the engine needs to be serviced at the first available opportunity.

The CHECK ENGINE lamp is amber, and can look like:

- The words WARNING or CHECK ENGINE spelled out
- A symbol of an engine, similar to the graphic.

Another function of the CHECK ENGINE lamp is to flash for 30 seconds at key ON when one of the following occurs. This flashing function is referred to as the MAINTENANCE lamp. The MAINTENANCE lamp could flash for any of the following reasons:

- Maintenance required (if the Maintenance Monitor is enabled)
- Water-in-fuel is detected
- Coolant level is low.



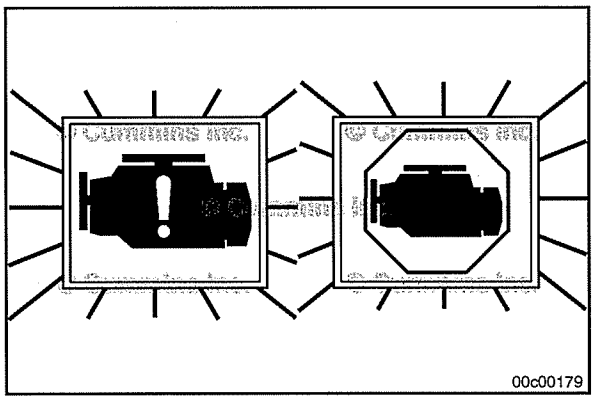
Stop Engine Lamp

The STOP ENGINE lamp indicates, when illuminated, the need to stop the engine as soon as it can be safely done. The engine **must** remain shut down until the engine can be repaired.

For engines with the Engine Protection Shutdown feature enabled, if the STOP ENGINE lamp begins to flash, the engine will automatically shut down after 30 seconds. The flashing STOP engine lamp alerts the operator to the impending shutdown.

The STOP ENGINE lamp is red in color, and can look like:

- The words STOP or STOP ENGINE spelled out
- A symbol of an engine with an exclamation point in the center, similar to the graphic.



SCR System Cleaning Lamp

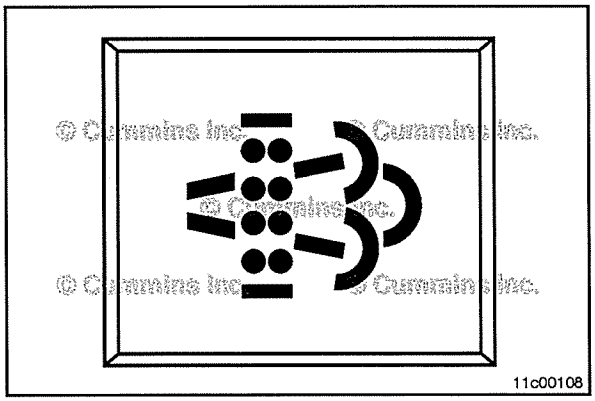
The SCR SYSTEM CLEANING lamp indicates the status of the aftertreatment SCR system cleaning events.

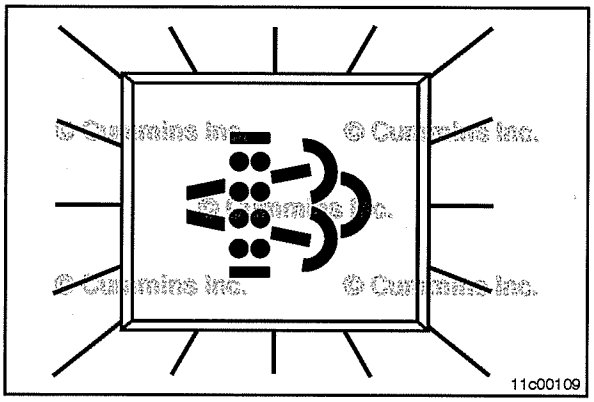
An illuminated SCR SYSTEM CLEANING lamp indicates that the aftertreatment SCR system needs to be cleaned at the next opportunity. This can be accomplished by:

1 Changing to a more challenging duty cycle, such as highway driving, for at least 20 minutes

2 Performing a stationary SCR/exhaust system cleaning. Refer to Procedure 101-050 in Section 1.

NOTE: Stationary SCR/exhaust system cleaning is considered a normal practice and is **not** covered by Cummins Inc. warranty.





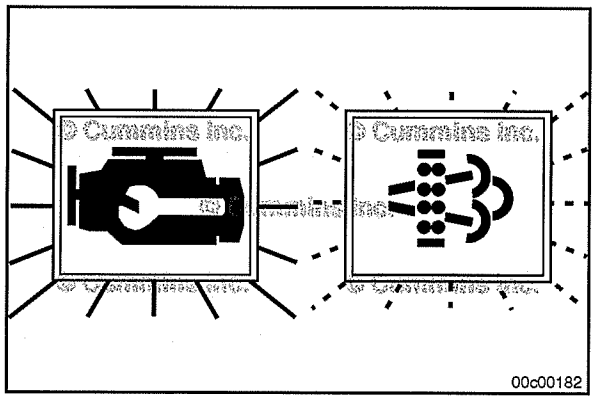
A flashing SCR SYSTEM CLEANING lamp indicates the status of a non-mission (stationary) SCR/ exhaust system cleaning when the SCR System Cleaning Start switch has been activated. See the following procedure for more information on the Start Conditioning switch. Refer to Procedure 101-050 in Section 1. When this lamp is flashing, the operator should:

1 Keep the exhaust outlet away from people and anything that can burn, melt, or explode.

2 Nothing within 0.6 m [2 ft] of the exhaust outlet.

3 Nothing that can burn, melt, or explode within 1.5 m [5 ft] (such as gasoline, wood, paper, plastics, fabric, compressed gas containers, or hydraulic lines).

4 In an emergency, turn the engine off to stop the flow of exhaust.

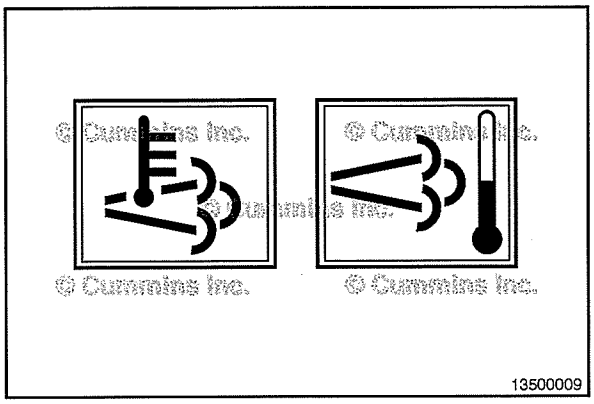


A solid SCR SYSTEM CLEANING lamp combined with an illuminated WARNING or CHECK ENGINE lamp indicates that the aftertreatment SCR needs to be cleaned immediately. Engine power will be reduced automatically if action is **not** taken.

When these lamps are illuminated, a stationary SCR/ exhaust system cleaning is required. Refer to Procedure 101-050 in Section 1.

NOTE: If a stationary SCR/exhaust system cleaning is **not** performed, the STOP ENGINE lamp will illuminate and the vehicle will need to be taken to a Cummins® Authorized Repair Location.

High Exhaust System Temperature Lamp



⚠WARNING⚠
When this lamp is illuminated, the exhaust gas temperature could reach 800°C [1500°F], which is hot enough to ignite or melt common materials, and to burn people.

The HIGH EXHAUST SYSTEM TEMPERATURE lamp indicates, when illuminated, that exhaust temperatures are high. The lamp could illuminate during normal engine operation or during SCR/exhaust system cleaning.

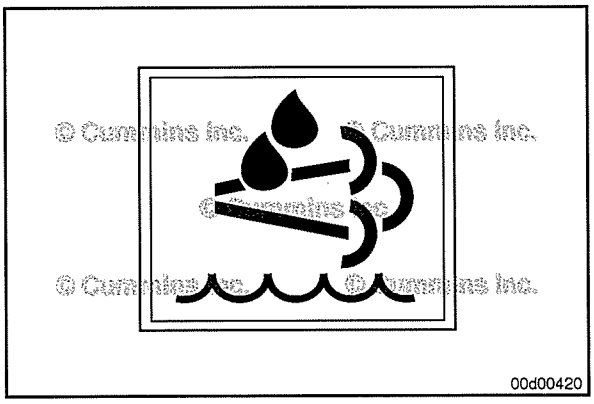
NOTE: The OEM determines whether or **not** the HIGH EXHAUST SYSTEM TEMPERATURE lamp is installed on the vehicle. The OEM also specifies the temperatures, vehicle speeds, and other conditions at which the lamp illuminates. Refer to the OEM service manual for additional information regarding this lamp.

When this lamp is illuminated, be sure the exhaust pipe outlet is **not** directed at any surface or material that can melt, burn, or explode.

- Keep the exhaust outlet away from people and anything that can burn, melt, or explode.
- Nothing within 0.6 m [2 ft] of the exhaust outlet.
- Nothing that can burn, melt, or explode within 1.5 m [5 ft] (such as gasoline, wood, paper, plastics, fabric, compressed gas containers, or hydraulic lines).
- In an emergency, turn the engine off to stop the flow of exhaust.

NOTE: The HIGH EXHAUST SYSTEM TEMPERATURE lamp does **not** signify the need for any kind of vehicle or engine service; It merely alerts the vehicle operator to high exhaust temperatures. It will be common for the HIGH EXHAUST SYSTEM TEMPERATURE lamp to illuminate on and off during normal vehicle operation as the engine completes SCR/exhaust system cleaning.

Aftertreatment Diesel Exhaust Fluid Lamp

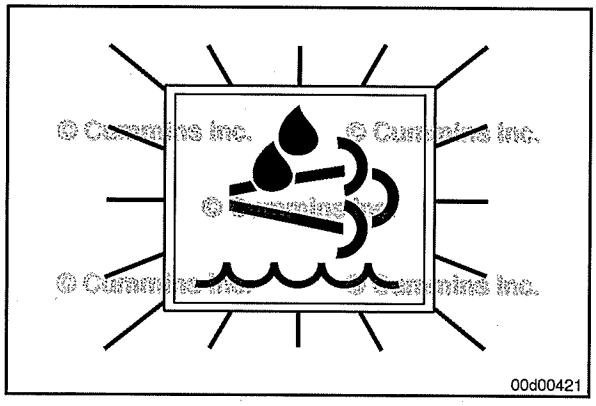


The AFTERTREATMENT DIESEL EXHAUST FLUID lamp indicates, when illuminated or flashing, that the diesel exhaust fluid (DEF) level is low.

NOTE: The OEM determines whether or not the AFTERTREATMENT DIESEL EXHAUST FLUID lamp is installed on the vehicle. The OEM also specifies the level at which the lamp will illuminate or blink. Refer to the OEM service manual for additional information regarding this lamp.

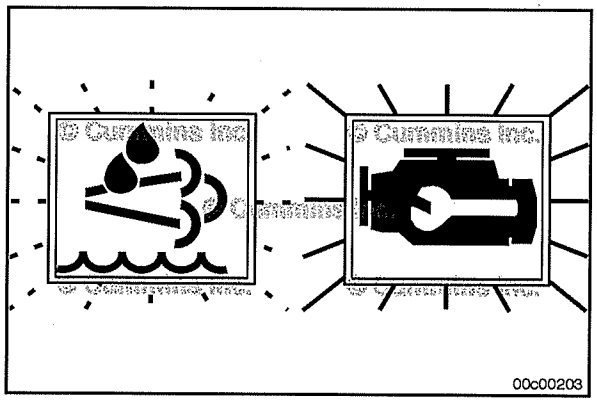
An illuminated AFTERTREATMENT DIESEL EXHAUST FLUID lamp indicates that the DEF level has fallen below the initial warning level. This can be corrected by filling the DEF tank with DEF.

NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.



A flashing AFTERTREATMENT DIESEL EXHAUST FLUID lamp indicates that the DEF level has fallen below the critical warning level. This can be corrected by filling the DEF tank with DEF.

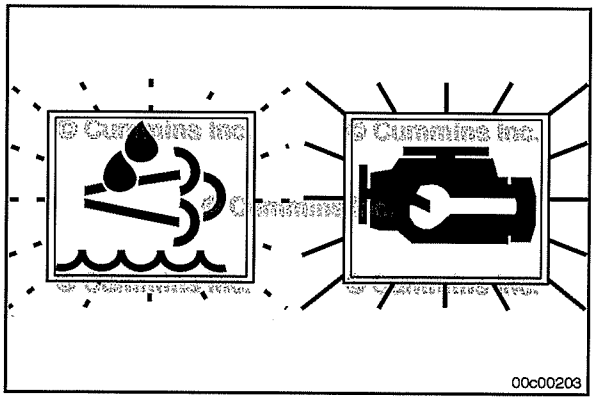
NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.



A flashing AFTERTREATMENT DIESEL EXHAUST FLUID lamp combined with an illuminated WARNING or CHECK ENGINE lamp indicates that the DEF level has fallen below the initial derate level. The engine power will be limited automatically. This can be corrected by filling the DEF tank with DEF.

If corrective action is **not** taken, engine power will be further limited to the secondary derate level.

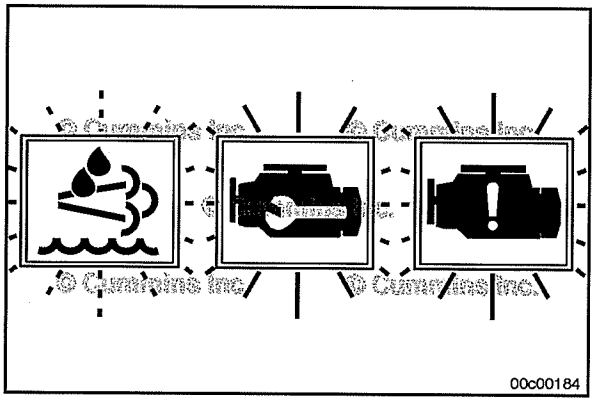
NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.



Allowing the DEF tank to become empty will cause the aftertreatment DEF dosing system to lose prime. A loss of prime condition may cause fault codes to become active.

If corrective action is **not** taken within 30 minutes of the CHECK ENGINE lamp illumination, the engine will enter the final derate level, which may include throttle lock or engine shutdown with possible restart limitations.

NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.



If the engine has been shut down or has idled for an extended period of time after the DEF gauge indicates empty, the STOP ENGINE lamp will also be illuminated along with the flashing AFTERTREATMENT DIESEL EXHAUST FLUID lamp and illuminated CHECK ENGINE lamp. The engine will enter the final derate level which may include low idle lock or engine shutdown with restart limitations.

NOTE: Some emergency vehicles may perform differently from the description above.

NOTE: In order to remove the final derate, the DEF tank must be filled to above 10 percent gauge reading.

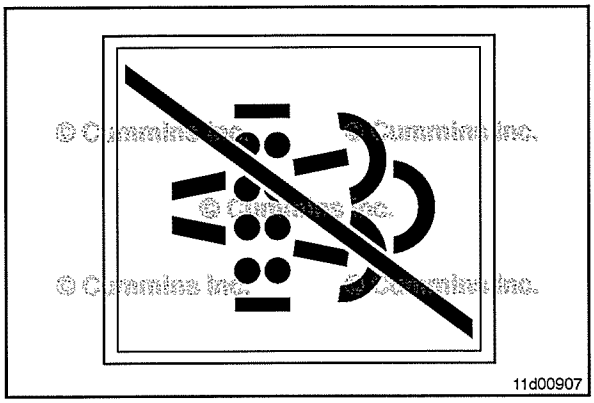
NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.

SCR System Cleaning Inhibited Lamp

The SCR SYSTEM CLEANING DISABLED (INHIBIT) LAMP indicates that the inhibit switch is active, therefore automatic and manual (non-mission) SCR/exhaust system cleaning can **not** occur.

An illuminated SCR SYSTEM CLEANING DISABLED (INHIBIT) lamp indicates that the inhibit switch is active and automatic or manual (non-mission) SCR/exhaust system cleaning will **not** occur. This can be corrected by switching the inhibit switch to permit mode. Refer to Procedure 101-050 in Section 1.

NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.



Unique Operating Characteristics of an Engine with Airless Selective Catalytic Reduction (SCR)

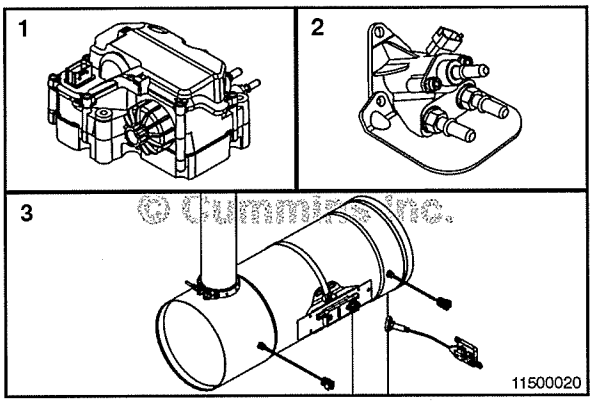
General Information

The selective catalytic reduction (SCR) system is used to decrease the mono-nitrogen oxides (NOx) emissions from the vehicle tailpipe. The system is composed of several main components:

1 Aftertreatment diesel exhaust fluid (DEF) dosing unit

2 Aftertreatment DEF dosing valve

3 Aftertreatment SCR catalyst.



NOTE: It is unlawful to tamper with, modify, or remove any component of the SCR system. It is also unlawful to use DEF that does **not** meet the specifications provided or to operate the vehicle/equipment with no DEF.

DEF is required for an engine equipped with a SCR system. DEF is a fluid that is sprayed into the exhaust gas prior to the aftertreatment SCR catalyst. The DEF vaporizes and decomposes to form carbon dioxide and ammonia. The ammonia reacts with the NOx emissions over the aftertreatment SCR catalyst to form nitrogen and water.

DEF:

- can have a slight ammonia smell
- is colorless
- is non-toxic and non-polluting
- is non-flammable
- urea is naturally occurring and is biodegradable.

See the following procedure for DEF specifications. Refer to Procedure 018-026 in Section V.

NOTE: Cummins Inc. supplies the aftertreatment DEF dosing unit, aftertreatment DEF dosing valve, and the aftertreatment SCR catalyst. The vehicle manufacturer supplies the DEF tank, the DEF lines, the DEF tank temperature and level sensor, the DEF quality sensor, and all wiring between the components.

The aftertreatment DEF dosing unit pumps DEF from the DEF tank to the aftertreatment DEF dosing valve. The aftertreatment DEF dosing unit is electrically heated, and contains a filter that is a maintenance item.

NOTE: Refer to the Maintenance Schedule for the aftertreatment DEF dosing unit filter maintenance interval.

The aftertreatment DEF dosing valve is coolant cooled, and sprays DEF into the exhaust.

The engine control module controls the amount of DEF sprayed into the exhaust. It also controls the DEF tank heater and DEF line heaters.

The aftertreatment SCR catalyst uses DEF to reduce the NOx emissions by converting the engine out NOx into nitrogen and water. The aftertreatment SCR catalyst itself requires no maintenance.

A vehicle with SCR will be equipped with an additional lamp on the dashboard, the aftertreatment DEF lamp. This lamp, along with the check engine lamp and stop engine lamp, alert the operator to the level of DEF in the tank. As the DEF tank level approaches empty, the aftertreatment DEF lamp will illuminate and engine power will be reduced. Attempting to operate the vehicle with no DEF in the tank will result in the vehicle speed being limited to 8 km/h [5 mph].

NOTE: See Section 1 for additional information on the aftertreatment diesel fluid lamp and associated engine derates.

DEF is sprayed into the exhaust when the temperature in the aftertreatment SCR catalyst reaches approximately 250°C [482°F]. The amount of DEF consumed will differ from vehicle to vehicle, as DEF consumption depends on engine speed and load.

Even though DEF freezes at approximately -12°C [11°F], the SCR system is designed to be frozen and thawed. The DEF tank is heated by engine coolant, and the DEF lines and aftertreatment DEF dosing unit are electrically heated. No operator interaction is needed when operating in cold temperatures; heating and thawing are controlled automatically by the engine control module (ECM).

After turning the keyswitch OFF on a vehicle with SCR, a pumping sound may be heard from underneath the vehicle. This sound is the aftertreatment DEF dosing unit purging any unused DEF from the system and returning it to the tank. This is normal system operation. The purge process takes approximately 60 seconds to complete. Do **not** disconnect the vehicle batteries during this process to avoid system damage.

Under certain conditions (cold or very dry), water condensation, in the form of water vapor, can be seen coming from the vehicle tailpipe. This is normal operation and will clear within a few minutes of normal vehicle operation.

Selective Catalytic Reduction (SCR) System Cleaning

SCR/exhaust system cleaning (also referred to as Aftertreatment Regeneration) occurs to diminish DEF deposits and condition the aftertreatment system. SCR/exhaust system cleaning utilizes the diesel oxidation catalyst (DOC) to build heat in the aftertreatment system.

The cleaning process requires heat to occur, and can be classified into two different types: passive SCR/exhaust system cleaning and active SCR/exhaust system cleaning.

Passive Selective Catalytic Reduction (SCR) System Cleaning

Passive SCR/exhaust system cleaning occurs when the exhaust temperatures are naturally high enough to meet cleaning requirements. This occurs during high engine duty cycles.

Since passive SCR/exhaust system cleaning occurs naturally, it is considered to be normal engine operation. No fuel is added to the exhaust stream during passive cleaning.

Active Selective Catalytic Reduction (SCR) System Cleaning

Active SCR/exhaust system cleaning occurs when the exhaust temperatures are **not** naturally high enough to meet cleaning requirements.

Active SCR/exhaust system cleaning requires assistance from the engine in order to increase the exhaust temperature. This is typically done by injecting a small amount of diesel fuel into the exhaust stream (called aftertreatment injection) which is then oxidized by the aftertreatment DOC. The oxidation of this additional fuel creates the heat needed to condition the aftertreatment system.

For active SCR/exhaust system cleaning to occur, the ECM **must** determine that the aftertreatment timer or duty cycle-based algorithms have reached a specified limit. Once this limit is reached, the engine will alter its operation in order to create exhaust temperatures high enough to actively regenerate the aftertreatment system.

Active SCR/exhaust system cleaning will occur more frequently in equipment with low load, or stop-and-go duty cycles.

Active SCR/exhaust system cleaning is largely transparent to the equipment operator. The equipment operator may notice an increase in turbocharger noise during an active SCR/exhaust system cleaning event, and may notice that the high exhaust temperature lamp is illuminated, if the exhaust temperature is greater than the high exhaust system temperature threshold set by the equipment original equpment manufacturer (OEM).

During active SCR/exhaust system cleaning, the exhaust temperature can be hotter than when the engine is operating at full load. The exhaust temperature during a normal active SCR/exhaust system cleaning event could reach 650°C [1202°F].

NOTE: Use the following procedure for additional information about the engine indicator lamps. Refer to Procedure 101-048 in Section 1.

⚠WARNING⚠

During Selective Catalytic Reduction (SCR) system cleaning, exhaust gas temperature can reach 800°C [1500°F], and exhaust system surface temperature can exceed 700°C [1300°F], which is hot enough to ignite or melt common materials, and to burn people. The exhaust and exhaust components can remain hot after the vehicle has stopped moving. To avoid the risk of fire, property damage, burns, or other serious personal injury, allow the exhaust system to cool before beginning this procedure or repair and make sure that no combustible materials are located where they are likely to come in contact with hot exhaust or exhaust components.

Manual (Non-Mission) Selective Catalytic Reduction (SCR) System Cleaning

Under some operating conditions, such as low speed, low load, or stop-and-go duty cycles, the engine may **not** have enough opportunity to regenerate the aftertreatment system during normal operation. When this occurs, the engine will illuminate the SCR cleaning lamp to inform the operator that assistance is required, typically in the form of a manual (non-mission) SCR/exhaust system cleaning.

Manual (non-mission) SCR/exhaust system cleaning is a form of active cleaning that is initiated by the equipment operator when **not** in operation.

Manual (non-mission) SCR/exhaust system cleaning requires an elevated engine speed of approximately 1000 rpm. The length of a manual (non-mission) SCR/exhaust system cleaning will vary depending on ECM algorithms, but will typically take anywhere from 20 to 60 minutes to complete.

A manual (non-mission) SCR/exhaust system cleaning can be initiated one of several ways:

- An equipment mounted manual (non-mission) SCR system cleaning switch. Use the owner's manual for the location and operation of this switch (this switch may also be called a "parked SCR/exhaust system cleaning" switch or "start" switch). The mounted manual (non-mission) SCR/exhaust system cleaning switch will **only** initiate a manual (non-mission) SCR/exhaust system cleaning when the SCR system cleaning lamp is illuminated.
- INSITE™ electronic service tool can initiate a manual (non-mission) SCR/exhaust system cleaning by starting the "SCR Performance Test".

NOTE: The start and permit switches as well as the aftertreatment lamp are common with other Cummins systems utilizing a Diesel Particulate Filter. Some OEMs, documentation, and tools may reference these as Aftertreatment Diesel Particulate Filter Regeneration or Aftertreatment Regeneration parameters.

To perform a manual (non-mission) SCR/exhaust system cleaning, follow the steps listed:

- Select an appropriate location to park the equipment.

- Choose a surface that will **not** burn or melt under high exhaust temperatures (such as clean concrete or gravel, **not** grass or asphalt).
- Make sure there are no items within 0.6 m [2 ft] of the exhaust outlet.
- Items that can burn, melt, or explode **must** be kept at least 1.5 m [5 ft] from the exhaust outlet (such as gasoline, paper, plastics, fabrics, compressed gas containers, hydraulic lines).
- Make sure that there are no gases or vapors nearby that could burn, explode, or contribute to a fire (such as LP gas, gasoline vapors, oxygen, nitrous oxide).
- Park the vehicle securely. Place the transmission in park, if provided, otherwise in neutral. Set wheel chocks at the front and rear of at least one tire.
- Set up a safe exhaust area. If bystanders might enter the area, set up barriers to keep people at least 1.5 m [5 ft] from the exhaust outlet during the manual (non-mission) SCR/exhaust system cleaning. When indoors, attach an exhaust discharge pipe rated for at least 816°C [1500°F].
- Keep a fire extinguisher nearby.
- Check the exhaust system surfaces. Confirm that nothing is on or near the exhaust system surfaces (such as tools, rags, grease, or debris).
- The clutch pedal is released.
- The brake pedal is released.
- The transmission is in neutral or park.
- Power takeoff (PTO) or Remote PTO is off.
- The vehicle speed is 0 mph.
- The throttle pedal is released.
- Initiate the manual (non-mission) SCR/exhaust system cleaning by toggling the equipment mounted manual (non-mission) SCR system cleaning switch or by using INSITE™ electronic service tool.
- Once the manual (non-mission) SCR/exhaust system cleaning is initiated, the engine speed may increase, the turbocharger noise will increase, the high exhaust system temperature lamp may illuminate, and the SCR system cleaning lamp will blink.
- When the engine ECM detects that the cleaning has been completed, the engine will automatically return to normal idle speed, if increased.
- Monitor the vehicle and surrounding area during the stationary (parked) SCR/exhaust system cleaning. If any unsafe condition occurs, shut off the engine immediately.

To stop a manual (non-mission) SCR/exhaust system cleaning before it has completed, depress the clutch, brake, or throttle pedal, set the SCR system cleaning permit switch to the inhibit position, or turn off the engine.

Once the manual (non-mission) SCR/exhaust system cleaning is complete, exhaust gas and surface temperatures will remain elevated for 3 to 5 minutes.

NOTE: If the low idle engine speed is 1000 rpm or greater, the engine speed will not increase when a manual (non-mission) SCR/exhaust system cleaning is initiated.

Aftertreatment Switches

The vehicle manufacturer has installed two switches that interact with the aftertreatment system:

- A stationary (parked) SCR system cleaning switch (can also be called a "start" switch or "parked SCR/exhaust system cleaning" switch)
- An active SCR system cleaning permit switch (can also be called an "inhibit" switch, "disable" switch, or "stop" switch).

Refer to the vehicle owner's manual for the location and presence of these switches.

The stationary (parked) SCR system cleaning switch is used to initiate a stationary (or parked) SCR/exhaust system cleaning. See the following procedure for further information on aftertreatment SCR/exhaust system cleaning. Refer to Procedure 101-050 in Section 1. The active SCR system cleaning permit switch is used to disable active SCR/exhaust system cleaning.

The permit switch **must only** be used for special circumstances where it is desirable to **not** allow an active SCR/exhaust system cleaning event. Prolonged engine operation with this switch engaged may result in illumination of the SCR system cleaning lamp.

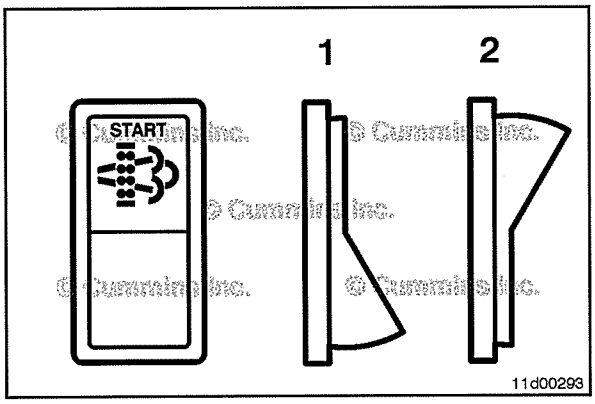
The aftertreatment switches are typically used in two configurations:

- A two position switch that is used to activate stationary (parked) SCR/exhaust system cleaning
- A three position switch that is used to activate stationary (parked) SCR/exhaust system cleaning and also disable active SCR/exhaust system cleaning.

The examples below are generic and show two typical switch configurations. Use the vehicle owners manual for the location and presence of these switches.

A two position switch (ON and OFF positions) will, when in the ON position (1), activate a stationary (or parked) SCR/exhaust system cleaning.

The switch should be left in the OFF position (2) when the switch is **not** being used.

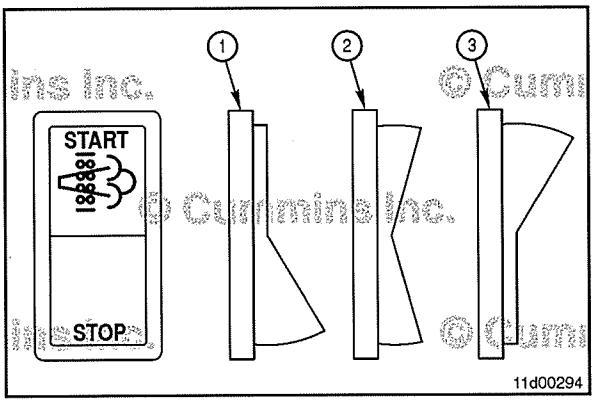


A three position switch (ON, NEUTRAL, and OFF positions) will typically have both "start" and "permit" functions.

In the ON position (1), the "start" switch is depressed, which will activate a stationary (or parked) SCR/exhaust system cleaning.

In NEUTRAL position (2), neither the "start" switch or "permit" switch is depressed as the switch is in the neutral position. This position is recommended for normal engine operation.

In OFF position (3), the "permit" switch is depressed. When the switch is in this position, active cleaning of the aftertreatment will **not** be allowed.



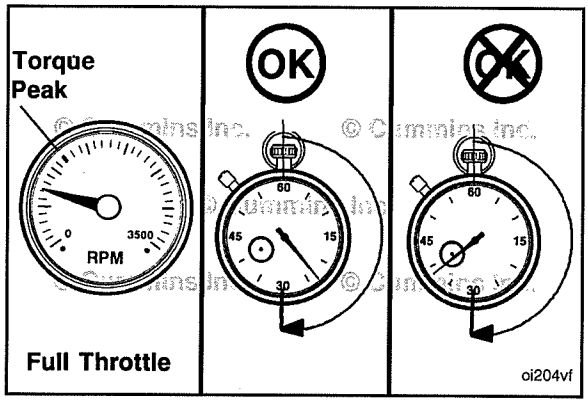
Aftertreatment Derates

The engines supported by this manual are required to meet Tier 4 Final/Stage IV Midrange Aftertreatment regulations. These regulations exist to make sure the engine is operated within emissions limits. The ECM continuously monitors the engine and aftertreatment system to detect malfunctions that adversely affect emissions. Once a malfunction is detected the operator is alerted by one of the engine indicator lamps and a fault code, which identifies the likely malfunction, is stored in the ECM. For more information on the engine indicator lamps. Refer to Procedure 101-048 in Section 1.

If the malfunction is not resolved within the allotted time, the engine will not respond to the throttle or it will shut down. The operator will be alerted that there is a need for corrective action through a series of derates prior to the regulated final derate is applied. For more information on the derate strategy refer to the OEM service manual.

The following are some of the aftertreatment components that can cause derates:

- DEF level below operating condition or malfunction
- DEF quality outside of operating condition or malfunction
- NOx sensor tampering or malfunction
- Exhaust gas temperature sensor tampering or malfunction
- DEF dosing unit tampering or malfunction
- DEF dosing valve tampering or malfunction
- EGR valve tampering or malfunction.



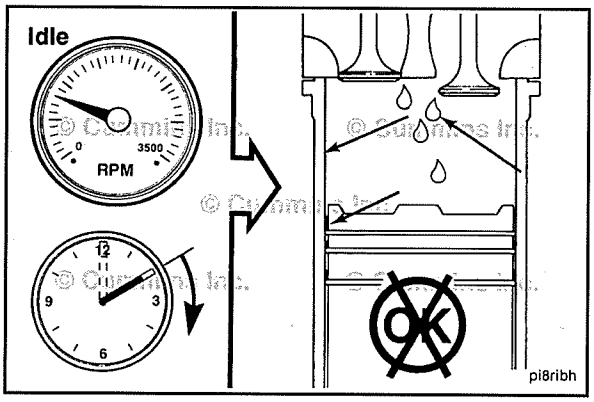
Engine Operating Range

General Information

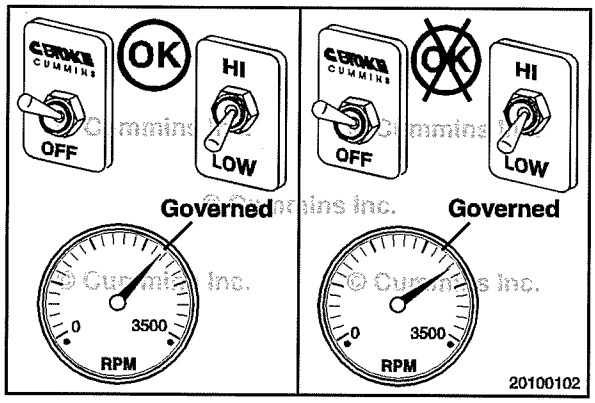
⚠CAUTION⚠
Do not operate the engine at full throttle below peak torque rpm (refer to engine dataplate for peak torque rpm) for more than 30 seconds. Operating the engine at full throttle below peak torque will shorten engine life to overhaul, can cause serious engine damage, and is considered engine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

General Information

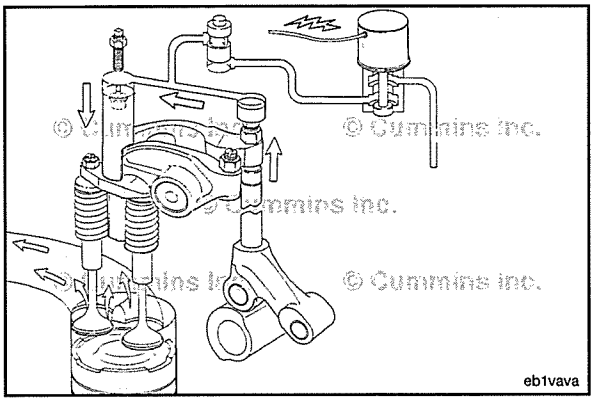
⚠CAUTION⚠
Do not exceed governed engine speed when operating engine brakes. Engine damage can occur. The engine brakes are designed to assist the vehicle's service brakes to slow the vehicle down. Never use only the engine brakes to stop the vehicle. If other engine brakes are used, see the component manufacturer's manual.

Some engines are equipped with engine brakes.

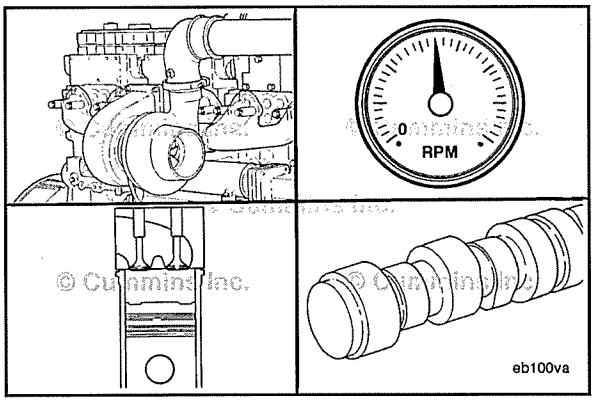
Engine brakes are devices that use the energy of engine compression to provide vehicle retardation. Engine brakes provide the maximum retarding power at rated speed; therefore, gear selection is important.

The engine brakes convert the engine to an energy-absorbing device to reduce vehicle speed.

This is accomplished by a hydraulic circuit that opens the exhaust valves near the end of the compression stroke.

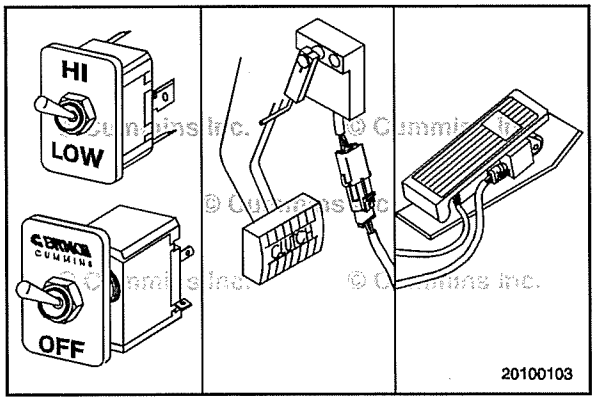


The amount of braking power available in a given engine series varies. Braking power depends on turbocharger boost pressure, engine speed, compression ratio, injector timing, and when the engine brakes open the exhaust valves.



Engine brake controls, with the fuel system, consists of the following:

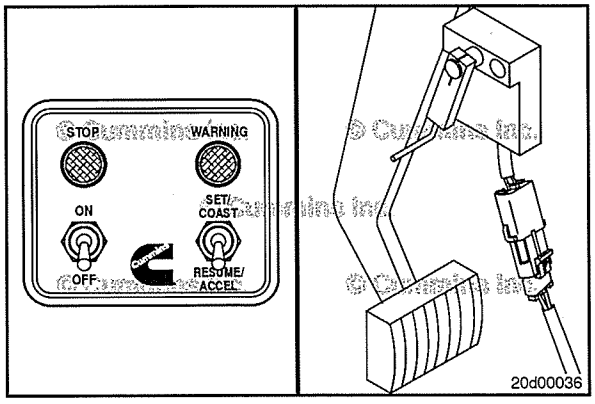
- A two-position selector switch
- An ON/OFFf switch
- A clutch switch
- A throttle sensor.

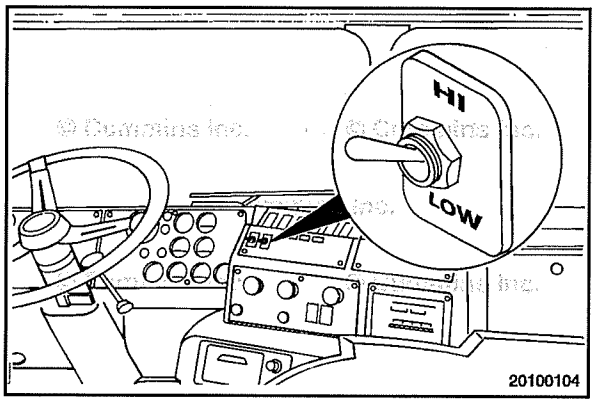


Other switches for cruise control that affect engine brake operations are:

- Cruise control ON/OFF switch (if Cruise Control actuator feature is selected).
- Service brake switch (if service brake actuator feature is selected).

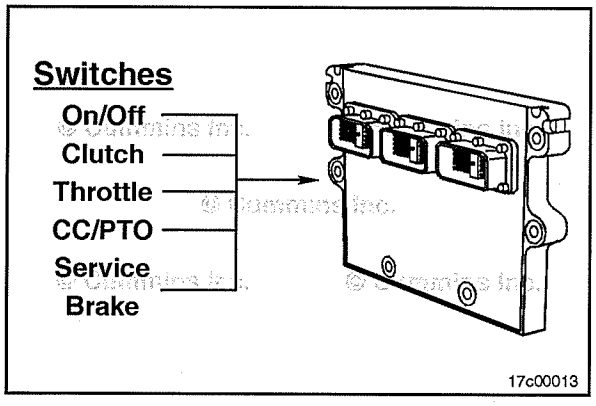
The engine control module (ECM) allows the engine brakes to operate while the cruise control is turned ON.





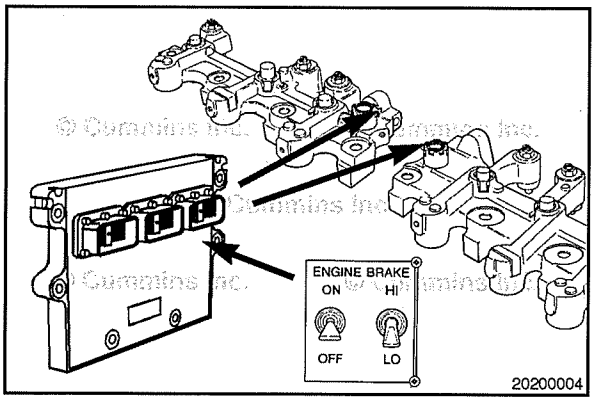
The two-position selector switch is located next to the ON/OFF switch in the cab, and allows you to select the retarding power of one or two brakes.

LOW activates the engine brake on three cylinders, and HI activates the engine brake on six cylinders.



Signals from the ON/OFF switch, clutch switch, throttle sensor, and the cruise/PTO switches are fed into the ECM.

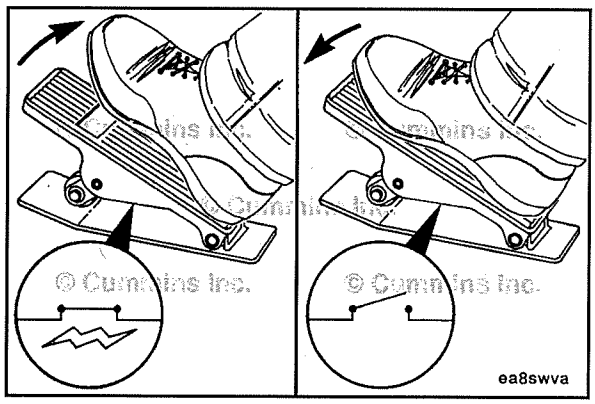
NOTE: Any one of these switches can de-activate the engine brakes.



The ECM then electronically enables or disables the engine brakes.

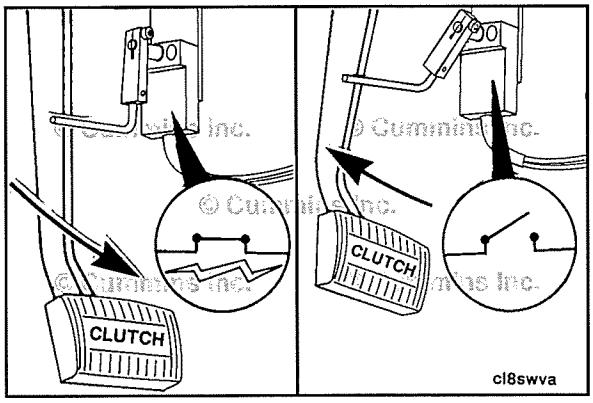
NOTE: Engine brakes can **not** be enabled:

- When cruise control is active and the engine brakes in cruise control feature is turned off
- When engine speed goes below 850 rpm
- When an electronic fault code is active.



The throttle sensor is part of the accelerator pedal assembly located in the cab and will deactivate the engine brakes when the acceleration pedal is depressed.

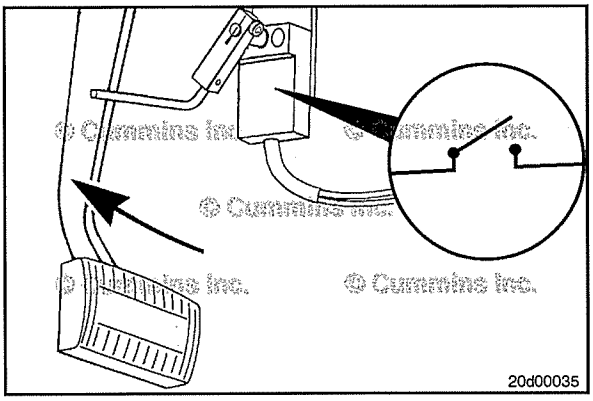
The clutch switch uses the motion of the clutch linkage to deactivate the engine brakes when the clutch pedal is depressed.



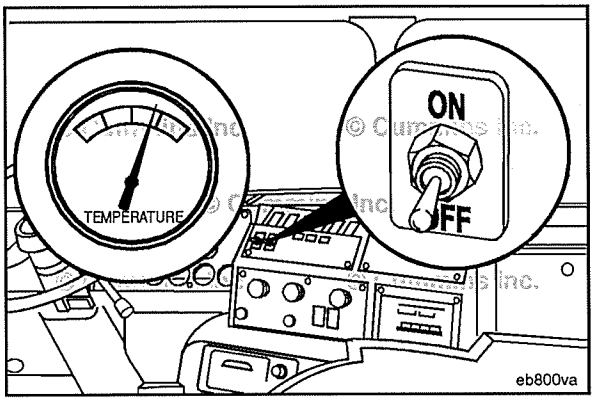
The service brake switch is attached to the service brake.

Applying the service brakes while in cruise control will disengage the cruise control and enable the engine brakes.

If the pedal-activated engine brake feature is enabled, the service brake pedal **must** be tapped before the engine brakes will be activated.



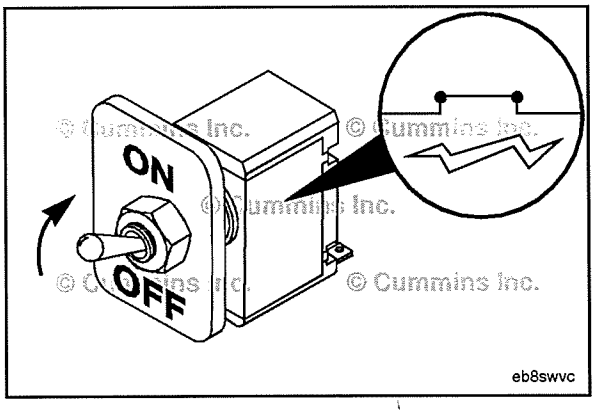
Idle the engine 3 to 5 minutes at approximately 1000 rpm to warm the engine before activating the engine brakes. Do **not** operate the engine brake until the engine oil temperature is above 30°C [86°F].

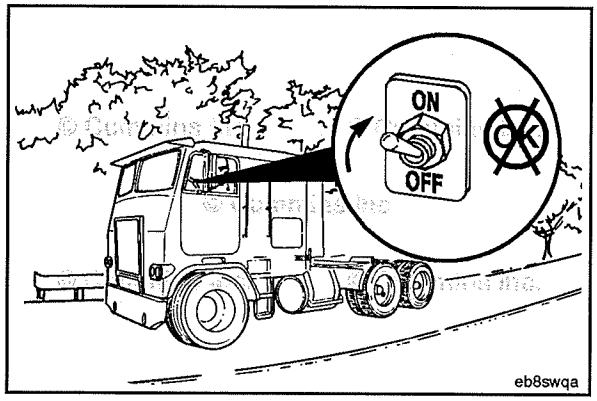


To activate the engine brakes, switch the ON/OFF switch to the ON position. Once activated, the operation of the engine brake is fully automatic.

NOTE: See the "Tips for Operation" steps in this section for specific information about engine brake operation under certain road conditions.

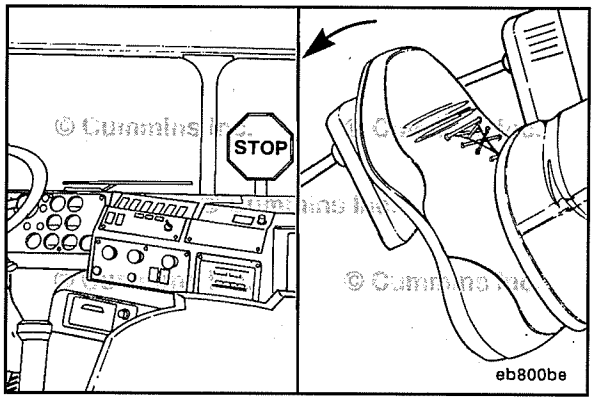
NOTE: Some vehicles have an additional pedal that **must** be pressed for the engine brakes to activate. It is **not** fully automatic.





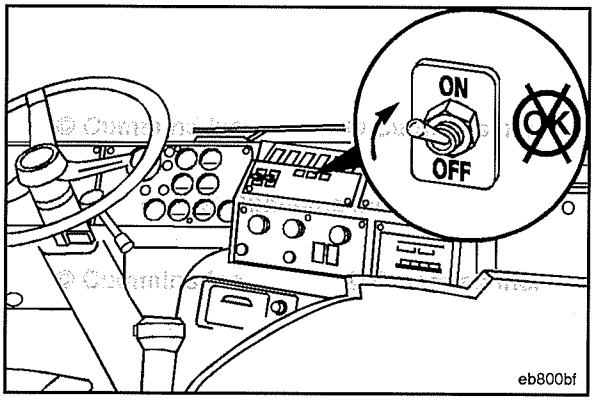
⚠WARNING⚠
Do not use engine brakes while bobtailing or pulling an empty trailer. With the engine brakes in operation, wheel lockup can occur more quickly when the service brakes are applied, especially on vehicles with single-drive axles.

Make sure the engine brakes are switched to the OFF position when bobtailing or pulling an empty trailer.

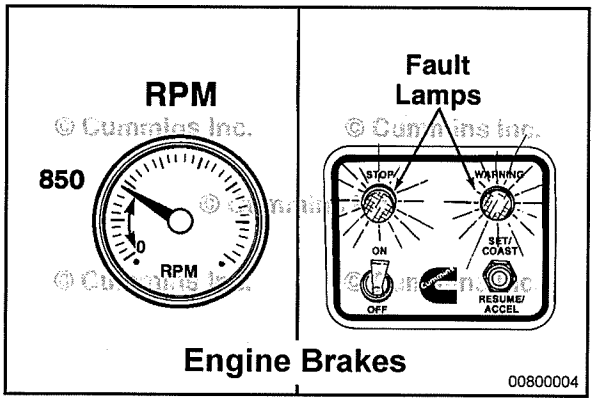


NOTE: The engine brakes are designed to assist the vehicle's service brakes when slowing the vehicle to a stop.

Remember, service brakes will be required to bring the vehicle to a stop.



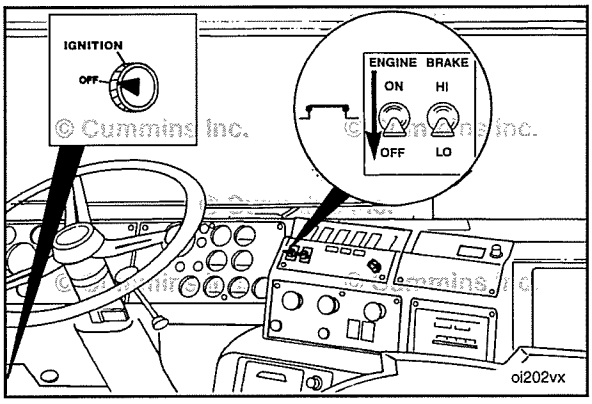
△CAUTION△
Do not use the engine brakes to aid in clutchless gear shifting. This can cause the engine to stall or lead to engine damage.



The ECM will disable the engine brakes when engine speed is below 850 rpm or when an electronic fault code is active.

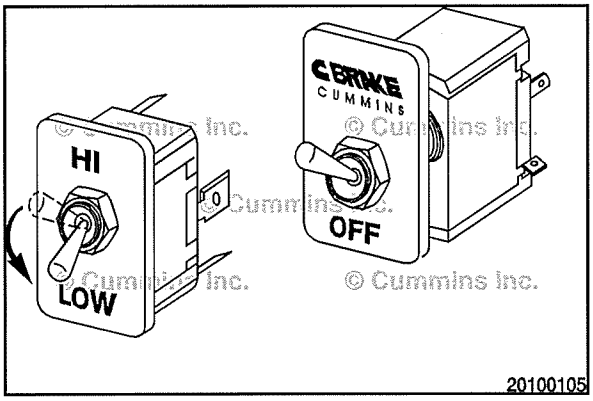
⚠CAUTION⚠
Do not operate the engine if the engine brake will not deactivate. To do so will cause severe engine damage.

If the engine brakes will **not** shut off, shut off the engine immediately, and contact a Cummins® Authorized Repair Location.

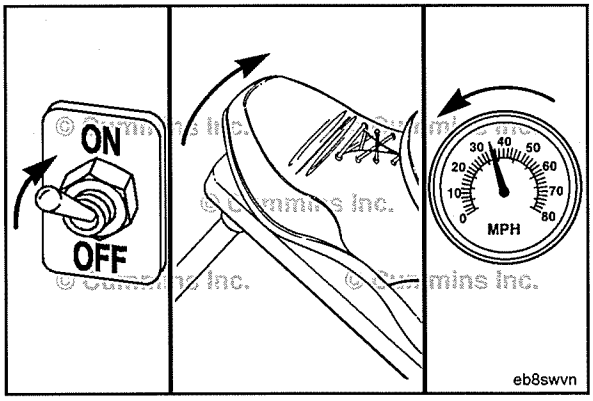


Tips for Operation on Level and Dry Pavement

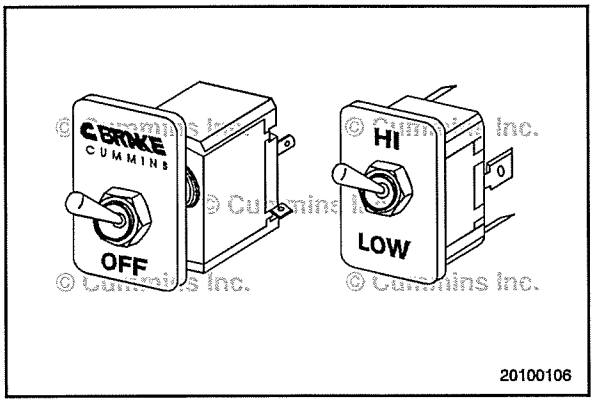
For operation on dry and relatively flat surfaces, when greater retarding power is **not** required, put the two-position selector switch in the LOW position.

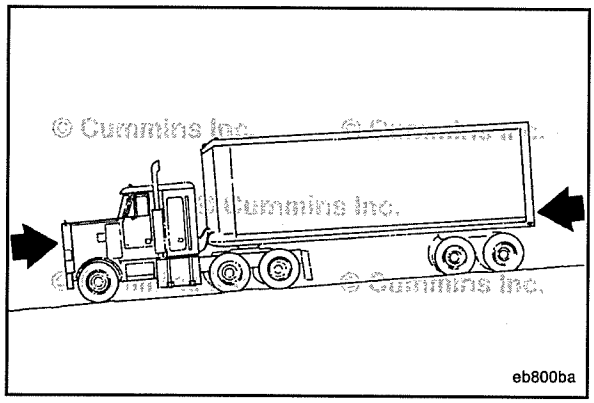


To reduce vehicle speed, put the engine brake ON/OFF switch in the ON position. Remove your foot from the accelerator pedal and clutch pedal. The engine brakes will immediately begin to operate, slowing the vehicle.



For operation on dry pavement when maximum retarding power is required, put the two-position selector switch in the HI position.





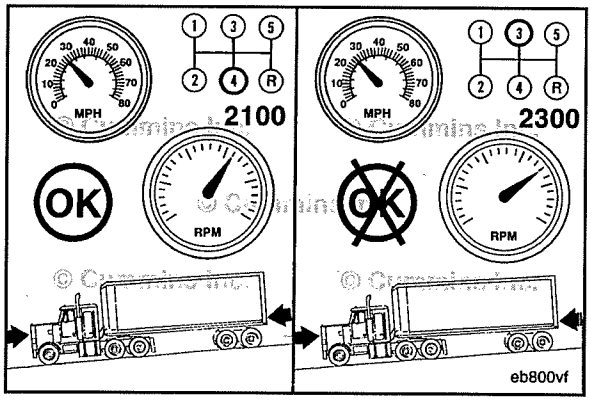
Tips for Operation on Grades with Dry Pavement

⚠WARNING⚠
To reduce the possibility of personal injury or property damage, always be prepared to use the vehicle service brakes for emergency stopping. The safe control speed of a vehicle will vary with the size of the load, the type of load, the grade, and the road conditions.

Control speed is the speed at which the forces pushing a vehicle down a grade are equal to the forces holding it back.

Vehicles equipped with properly operated engine brakes are often capable of traveling downhill at slightly higher control speeds than vehicles **not** equipped with engine brakes.

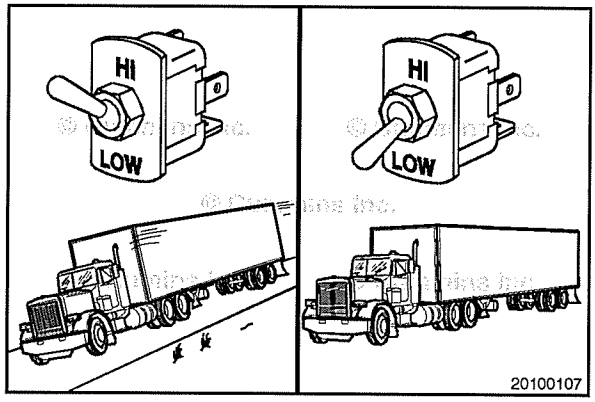
NOTE: Always be prepared to use the vehicle service brakes for emergency stopping.



△CAUTION△
Never exceed governed engine speed because engine damage can occur.

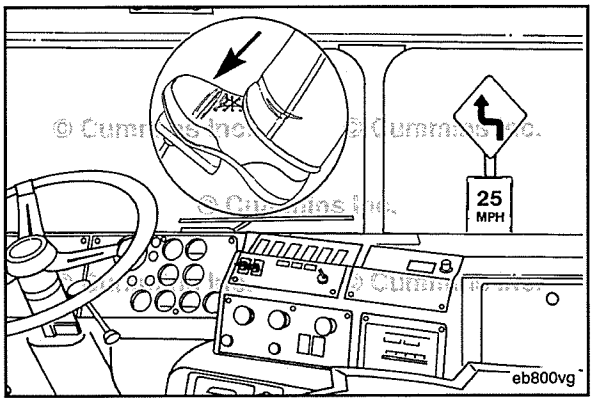
Once you have determined what the safe speed is for your vehicle, operate the engine brakes with the transmission in the lowest gear that will **not** cause the engine speed to exceed the rated engine speed.

NOTE: The optimum braking power of the engine brakes is reached at rated engine speed. Correct gear selection, therefore, is critical.

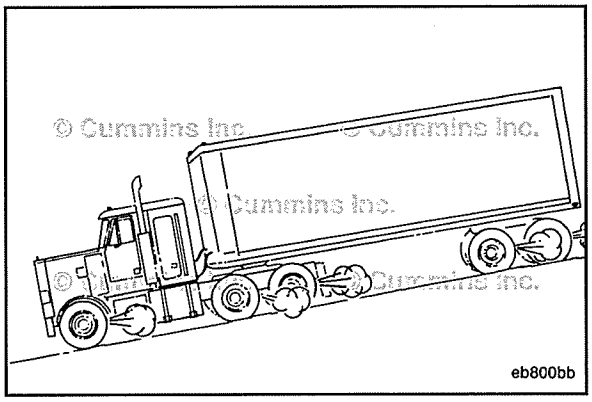


The two-position selector switch can be used to vary braking power as road conditions change.

Vehicle service brakes **must** be used when additional braking power is required.

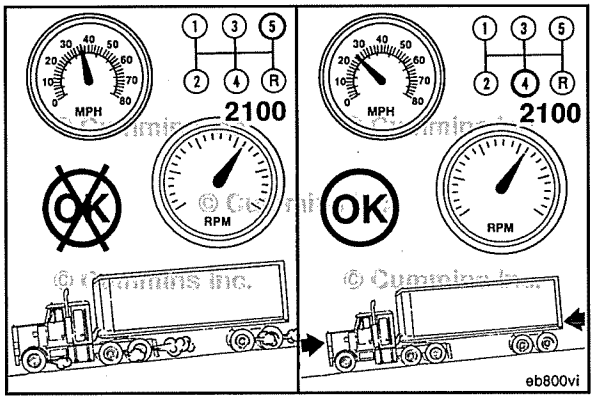


⚠WARNING⚠
Frequent use of the service brakes will cause them to heat up, reducing their ability to slow or stop the vehicle.



If frequent use of the vehicle service brakes is required, it is recommended that a slower control speed be used by selecting a lower transmission gear.

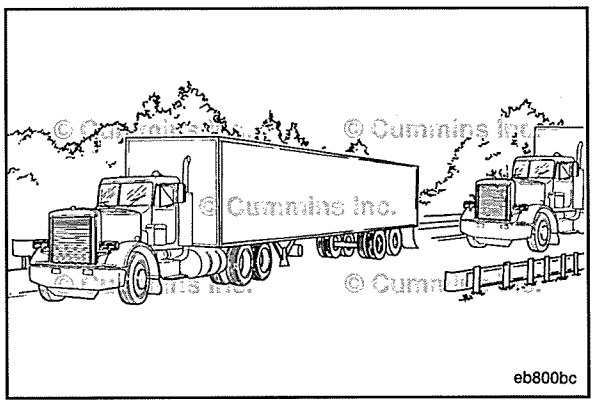
NOTE: The longer or steeper the hill, the more important it is to use your engine brakes. Make maximum use of your engine brakes by gearing down and letting the engine brakes do the work.

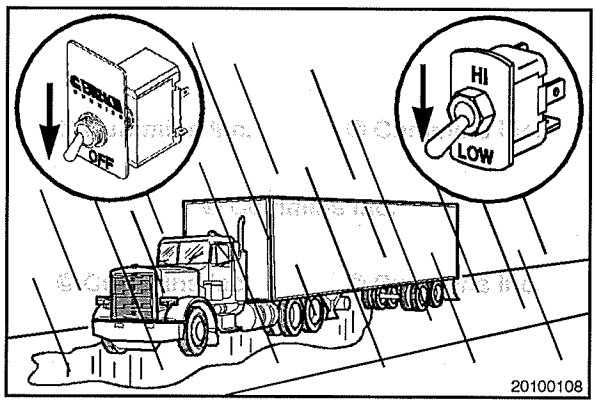


Tips for Operation on Slick Roads

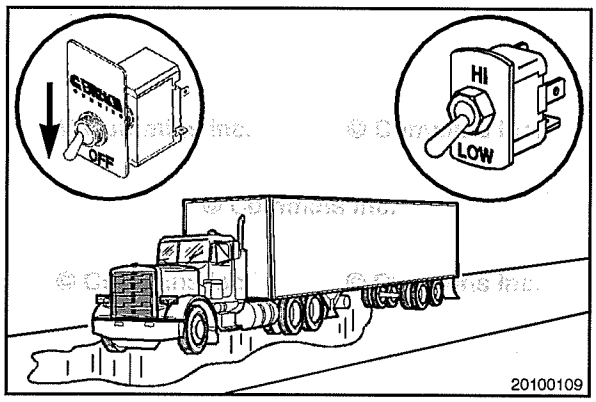
⚠WARNING⚠
To reduce the possibility of personal injury or property damage, always allow for extra distance between your vehicle and other objects when using the service brakes or engine brakes on slick roads.

The operation of any vehicle is difficult to predict on slick roads. The first 10 to 15 minutes of rainfall are the most dangerous, as road dirt and oil mixed with rain create a very slippery surface.



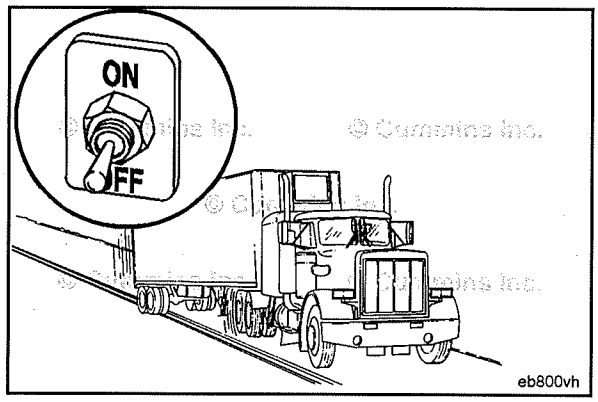


⚠WARNING⚠
To reduce the possibility of personal injury or property damage, reduce the retarding power or turn "OFF" the engine brakes on slick roads. Using engine brakes on wet or slippery roads can cause overbraking, especially on vehicles with light loads or single-drive axles. Stopping distance can actually increase, or the vehicle can skid or jackknife.



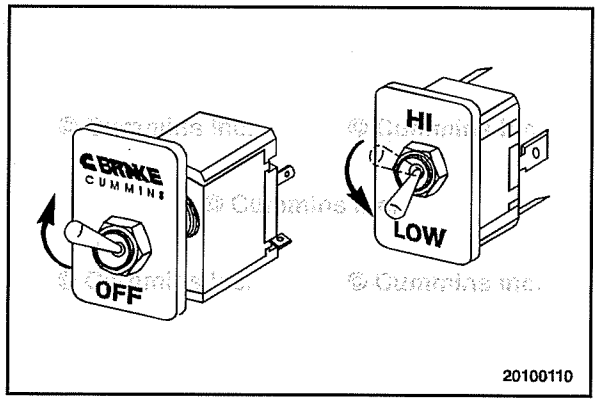
When driving on slick roads, start with the ON/OFF switch in the "OFF" position and the two-position selector switch in the LOW position.

If your tractor is equipped with a twin-screw rear axle, position the power divider switch in the unlocked position.



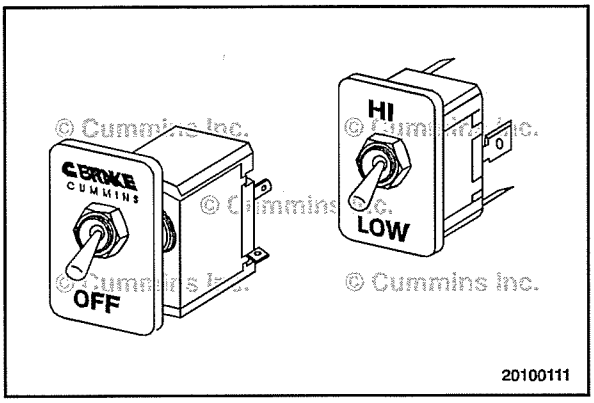
Remove your foot from the accelerator pedal to make sure the vehicle will maintain traction with the retarding power of the engine alone.

If the vehicle drive wheels begin to skid or if there is a fishtailing motion, do **not** activate the engine brakes.

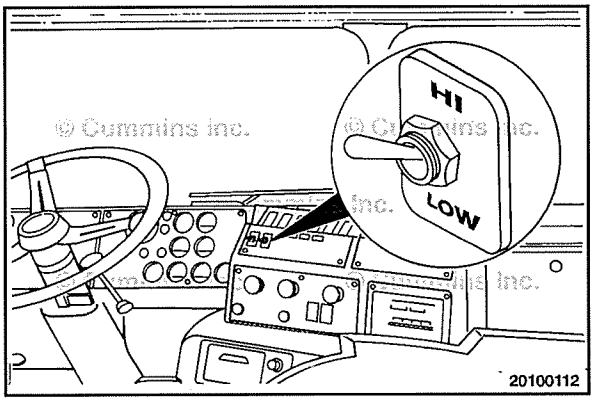


If traction is maintained using the retarding power of the engine alone and more braking power is required, switch the two-position selector switch to the LOW position and activate the engine brakes by switching the ON/OFF switch to the ON position.

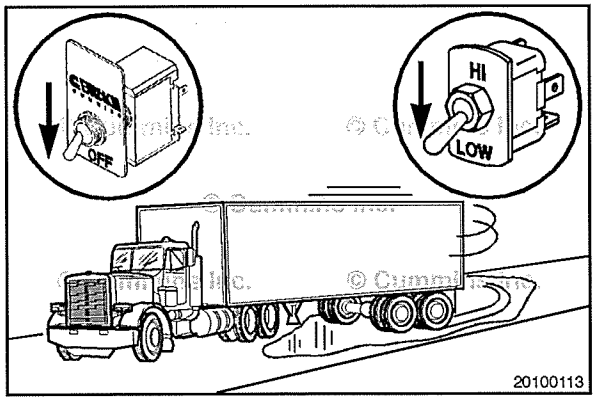
If the vehicle's drive wheels begin to skid or there is a fishtailing motion, switch the ON/OFF switch to the OFF position.

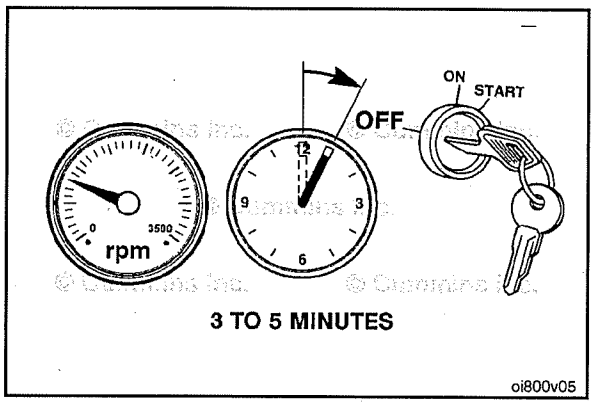


If traction is maintained when the engine brakes are activated and more braking power is required, move the two-position selector switch to the HI position.



Again, if the vehicle has lost traction or if there is a fishtailing motion, switch the ON/OFF switch to the OFF position. Do **not** attempt to use the engine brakes in the HI position.





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 addressed by this manual has an electronically controlled fuel system that provides many operator and vehicle/equipment features.

The base functions of the control system include fueling and timing control, limiting the engine speed operating range between the low- and the high-idle set points, and optimizing engine performance while maintaining emissions compliance. The system also controls the engine brakes.

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 at the required emissions level.

Engine Control Module Inputs

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, vehicle/equipment 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 engine operating parameters at the time of fault activation is also stored in the memory.

Active fault codes will cause a diagnostic lamp to activate as a signal to the operator.

The ECM can communicate with service tools and some other vehicle/equipment controllers (such as transmissions, anti-lock braking controllers, anti-slip regulation systems, electronic dash displays, and so on) through the society of automotive engineers (SAE) J1939 data link.

Some vehicles and equipment will have SAE J1939 networks on them that link many of the "smart" controllers together. The vehicle/equipment control device can temporarily command engine speed or torque to perform one of its functions (that is, transmission shifting, anti-lock braking, and so on).

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

- Engine coolant temperature sensor
- Intake manifold temperature/pressure sensor
- Engine oil pressure switch
- Engine speed (crankshaft position) sensor
- Camshaft position sensor

- Ambient air pressure/temperature sensor
- Fuel rail pressure sensor
- Water-in-fuel sensor
- Turbocharger speed sensor
- Variable geometry turbocharger (VGT) actuator
- Exhaust gas recirculation (EGR) valve
- Exhaust pressure sensor
- EGR temperature sensor
- EGR differential pressure sensor
- Crankcase pressure sensor
- Aftertreatment temperature sensor(s)
- Aftertreatment mono-nitrogen oxides (NOx) sensor(s)
- Diesel exhaust fluid (DEF) temperature, level, and quality sensor
- Oil level sensor
- Accelerator pedal/lever position sensor
- Exhaust brake selector switches
- 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 power takeoff (PTO).

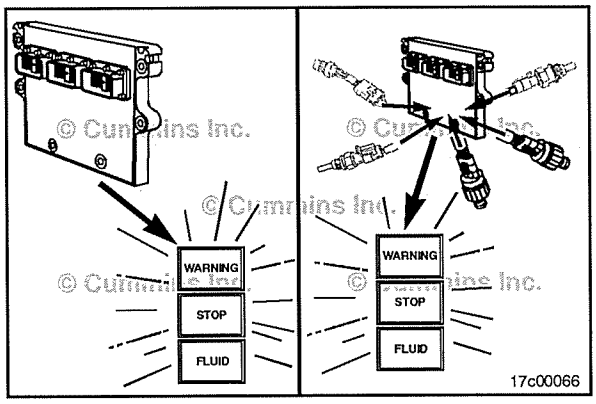
NOTE: These inputs are application dependent. Some applications will **not** use all of these inputs.

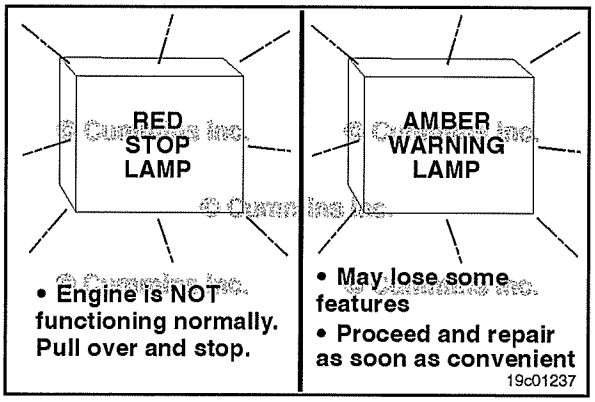
Diagnostic Fault Codes

The electronic engine control system can display and record certain detectable fault conditions. These malfunctions are displayed as fault codes, which make troubleshooting easier. The fault codes are retained in the ECM.

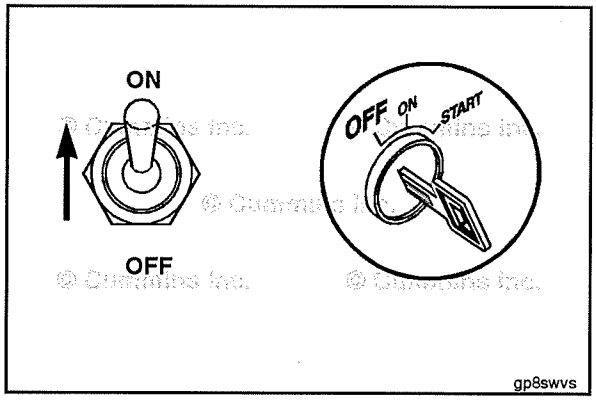
There are two types of diagnostic codes:

- Engine electronic control system fault codes are to inform the operator that there is a problem with the control system that will require troubleshooting.
- Information and engine protection fault codes inform the operator that the control system that has detected an engine condition outsideof the normal operating range.



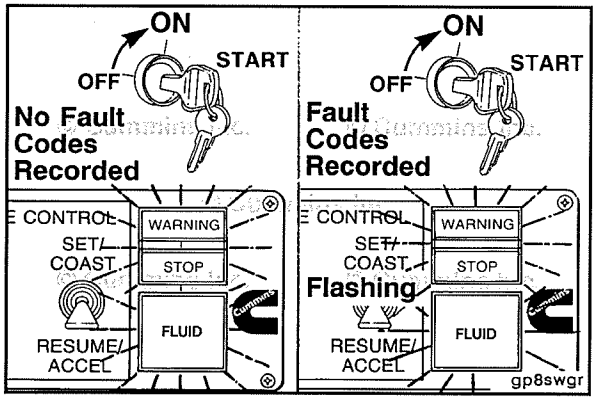


All fault codes recorded will either be active (fault code is presently active on the engine) or inactive (fault code was active at some time, but is **not** presently active).



Fault codes can be accessed in at least two different ways; using the electronic service tool, or through fault code flash out.

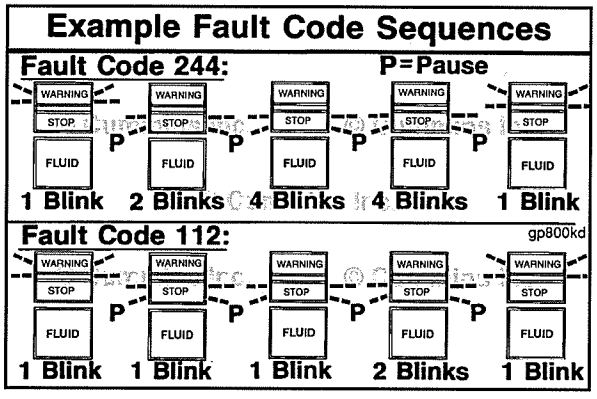
To check for active engine electronic fuel system and engine protection system fault codes, turn the keyswitch OFF and move the diagnostic switch to the ON position.



Turn the vehicle keyswitch to the ON position.

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

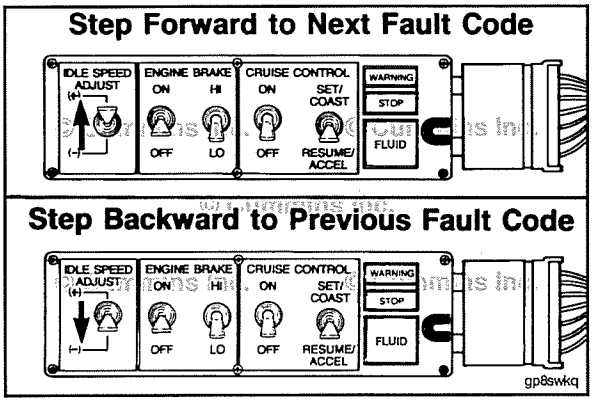
If active fault codes are recorded, both lights will come on momentarily, then begin to flash the code of the recorded faults.



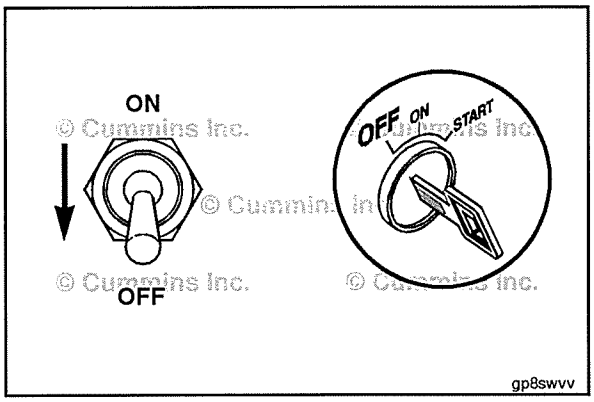
The fault code will flash in the following sequence:

- First, a WARNING (amber) light 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).
- There will be a 1 or 2 second pause between each number.
- When the number has finished flashing in red, an amber light will appear again.

The lights flash each fault code out three times before advancing to the next code. To skip to the next fault code, move the Increment/Decrement switch, if equipped, momentarily to the increment (+) position. You can go back to the previous fault code by momentarily moving the Increment/Decrement switch, if equipped, to the decrement (-) position. If only one active fault is recorded, the same fault code will continuously be displayed when either (+) or (-) switch is depressed.

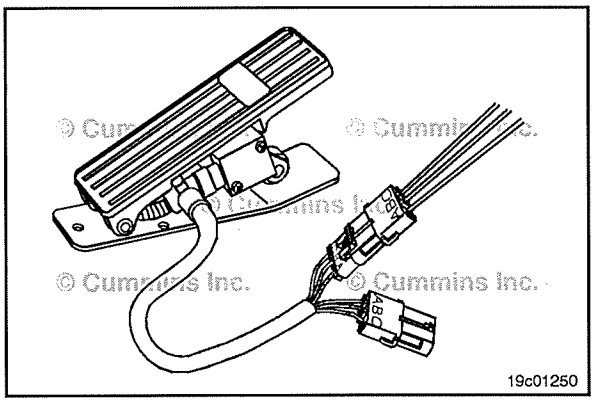


When **not** using the diagnostic system, turn off the diagnostic switch.



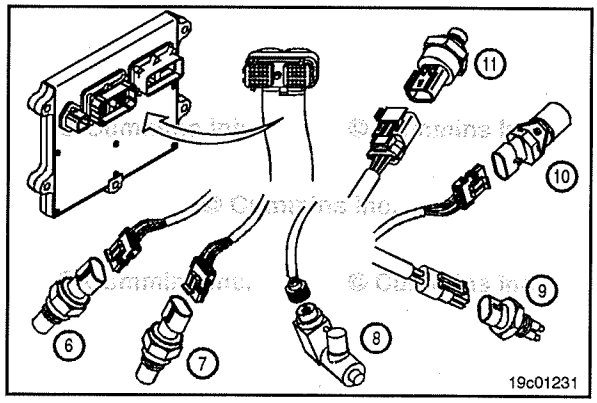
Throttle Activated Diagnostic Switch

The throttle-activated diagnostic switch feature is intended to eliminate the need for a dash-mounted diagnostic switch, which is used to activate the fault code flashout on the lamps. The fault code flashout will be activated through a simple sequence of throttle movements. When this feature is enabled, the engine is in stop state and the keyswitch is turned ON. Every successive cycle of the throttle will lead to the next fault code to be flashed on the lamps, in the same manner as if the increment switch were depressed.



To activate this feature, the engine **must** be stopped and the keyswitch turned to the ON position. Then depress the accelerator pedal completely three times. The feature should then be enabled. Transitioning to the next fault code will happen automatically after the first fault code is flashed out twice or if the throttle pedal is cycled.

NOTE: There is an optional, error sensitive mode for this feature. If any of the throttle-related errors occur, this feature will turn on the diagnostic switch automatically when the engine is stopped and the keyswitch is ON. During this mode, **only** the increment switch can be used to flash out the next fault code.

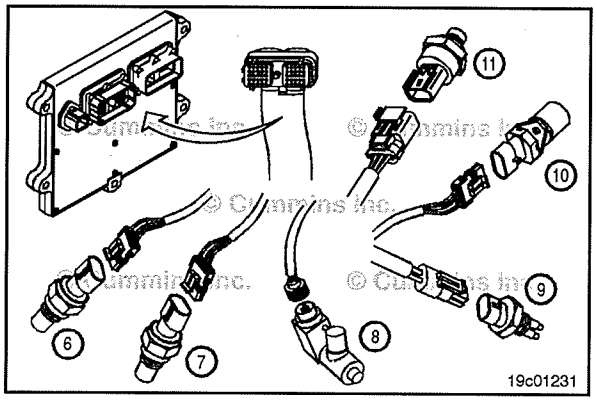


Engine Protection System

⚠CAUTION⚠
When the red STOP lamp is illuminated, the operator must stop the vehicle/equipment when it is safe to do so, to reduce the possibility of engine damage.

The engines addressed by this manual 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 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 STOP lamp will blink or flash when out-of-range conditions continue to worsen. The operator **must** stop the vehicle/equipment, when it is safe to do so, to reduce the possibility of engine damage.

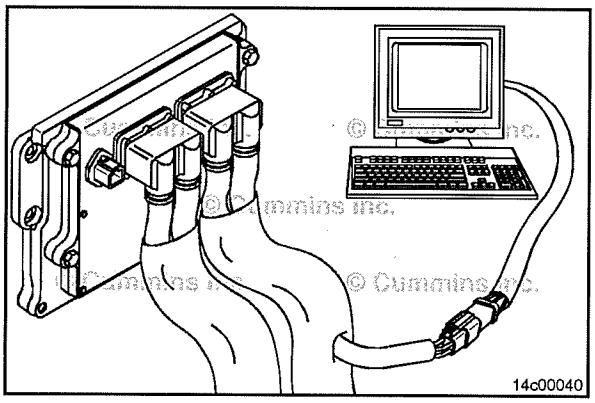
NOTE: Engine power and speed will gradually be reduced, depending on the level of severity of the observed condition. The engine protection system will **not** shut down the engine unless the engine protection shutdown feature has been enabled.



Fault Code Snapshot Data

When a diagnostic fault code is recorded in the ECM, the ECM input and output data is recorded from all sensors and switches. Snapshot data allows the relationships between ECM inputs and outputs to be viewed and used during troubleshooting.

Fault code snapshot data can **only** be viewed using INSITE™ electronic service tool.



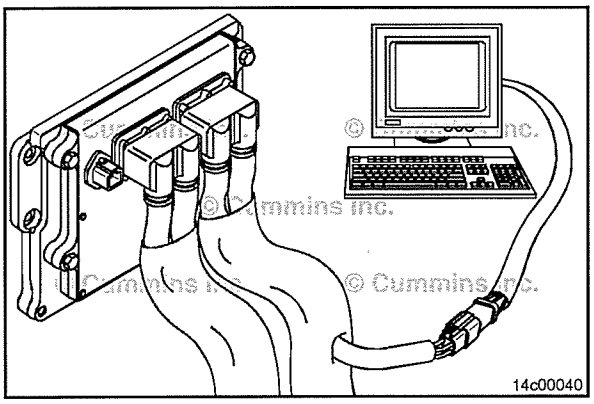
INSITE™ Electronic Service Tool Description

INSITE™ electronic service tool is a service tool for the electronic engine control system. Use INSITE™ electronic service tool to:

- Program customer specified information into the ECM (parameter and features)
- Aid in troubleshooting the engine
- Change the engine power or rated speed calibration
- Transfer new or update calibration files to the ECM
- Create and view trip reports, etc.

INSITE™ Electronic Service Tool Monitor Mode

The INSITE™ electronic service tool monitor mode is a useful troubleshooting aid that displays the key ECM inputs and outputs. This feature can be used to spot constant or intermittent out-of-range values.



Electromagnetic Interference (EMI)

General Information

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

System EMI Susceptibility

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

System EMI Radiation Levels

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

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

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

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

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

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

Notes

Section 2 - Maintenance Guidelines

Section Contents

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Maintenance Guidelines - Overview

General Information

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

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

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

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

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

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

Tool Requirements

General Information

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

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

Tool Part Number	Description
ST-1273	Pressure gauge
3375045	Torque wrench (0 to 175 ft-lb)
3375049	Oil filter wrench
3376807	Engine coolant and fuel filter wrench
3822524	Belt tension gauge, click type (v-belts and v-ribbed with 4 or 5 ribs)
3822525	Belt tension gauge, click type (v-ribbed with 6 to 12 ribs)
3824556	Charge air cooler (CAC) pressure kit
3824591	Engine barring gear
3824783	Torque wrench (0 to 300 in-lb)
CC-2800	Refractometer
CC-2802	Coolant test kit
3824842	M10 Compuchek® fitting

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

A computer is required to run the original equipment manufacturer (OEM) software. Contact a Cummins® Authorized Repair Location for information on hardware requirements.

Maintenance Schedule

Maintenance Check

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 .....Section 3

- Air Intake Piping - Check
- Fan, Cooling - Inspect for Reuse
- Crankcase Breather Tube - Check
- Air Tanks and Reservoirs - Drain
- Coolant Level - Check
- Fuel-Water Separator - Drain
- Lubricating Oil Level - Check
- Aftertreatment Exhaust Piping - Check
- Dust Ejection Valve - Check
- Diesel Exhaust Fluid (DEF) Level - Check

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

- Air Cleaner Restriction - Check
- Charge-Air Piping - Check
- Charge-Air Cooler - Check
- Radiator Hoses - Check
- Air Intake Piping - Check
- Radiator - Check

Maintenance Procedures at 500 Hours or 6 Months .....Section 5

- Fuel Filter (Spin-On Type) - Change[6]
- Lubricating Oil System - Change[1, 7]
- Lubricating Oil Filter (Spin-On) - Change[1]
- Supplemental Coolant Additive (SCA) and Antifreeze Concentration - Check[2]
- Coolant Filter - Change
- Batteries - Check[4]
- Battery Cables and Connections - Check[4]
- Radiator Pressure Cap - Inspect for Reuse

Maintenance Procedures at 1000 Hours or 1 Year .....Section 6

- Drive Belt, Cooling Fan - Check
- Belt Tensioner, Automatic (Water Pump) - Check

Maintenance Procedures at 2000 Hours .....Section 7

- Crankcase Breather Element - Change

Maintenance Procedures at 2000 Hours or 2 Years .....Section 8

- Cooling System - Flush[8]
- Vibration Damper, Rubber - Inspect for Reuse
- Vibration Damper, Viscous - Check[3]
- Engine Steam Cleaning - Clean

- Air Compressor Discharge Lines - Check

Maintenance Procedures at 4500 Hours or 3 Years .....Section 9

- Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter - Change

Maintenance Procedures at 5000 Hours or 4 Years .....Section 10

- Overhead Set - Adjust[5]
- Engine Brake - Adjust[4]

1 Cummins Inc. requires the use of a high quality, heavy duty engine oil. Use the following procedure for lubrication oil and recomendations. Refer to Procedure 018-003 in Section V.

2 Service interval is every oil change or 500 hours, or 6 months, whichever occurs first. Use the following procedure for coolant specifications and recommendations. Refer to Procedure 018-004 in Section V. The change interval is 2 years. Antifreeze is essential for freeze, overheat, and corrosion protection. SCA is essential for liner pitting and scaling protection.

3 The service interval is 2 years.

4 Follow the manufacturers' recommended maintenance procedures for the starter, alternator, batteries, electrical components, engine brake, exhaust brake, charge-air cooler, radiator, air compressor, air cleaner, refrigerant compressor, and fan clutch.

5 Reset valve lash, if needed, to nominal specifications. Refer to Procedure 018-015 in Section V.

6 Replace the suction side and the pressure side fuel filters at the same time.

7 For standby generator sets, the recommended change interval is 250 hours or every 12 months, whichever occurs first. For primary or continuous rated generator sets the interval is 500 hours or every 12 months, whichever occurs first.

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

Use the following procedure for fuel recommendations and specifications information. Refer to Procedure 018-002 in Section V.

Maintain the correct oil and filter change intervals. It is a vital factor in preserving the integrity of an engine. Filters **must** be changed when the oil is changed.

Maintenance Record Form

Maintenance Data

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

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

A	B	C	D	E	F

Notes

Section 3 - Maintenance Procedures at Daily Interval

Section Contents

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Daily Maintenance Procedures - Overview

General Information

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

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

System Operation Report

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

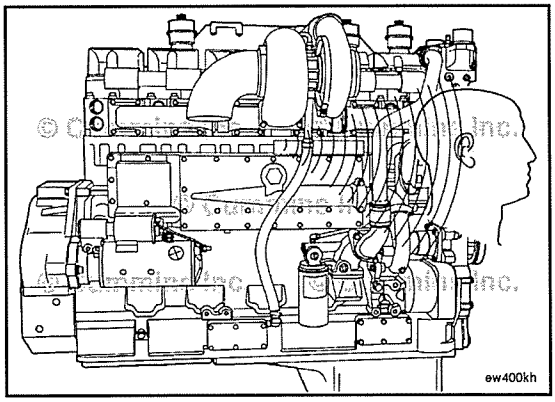
Comparison and intelligent interpretation of the daily report, along with a practical follow-up action, will eliminate most failures and emergency repairs.

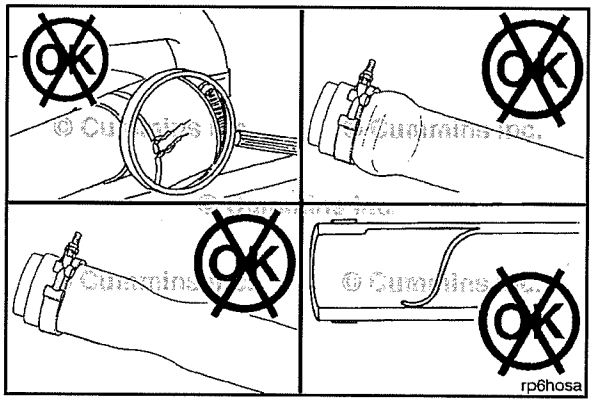
Report to the maintenance department any of the following conditions that may apply:

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

Unusual System Noise

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





Air Intake Piping

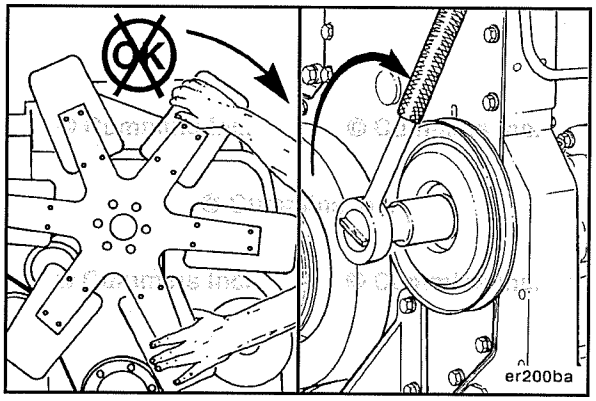
Maintenance Check

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

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

Torque Value: 8 N•m [71 in-lb]

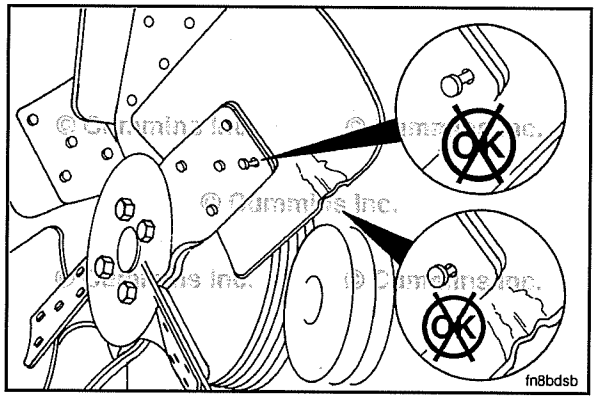
Check for corrosion under the clamps and hoses of the intake system piping. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean, as required.



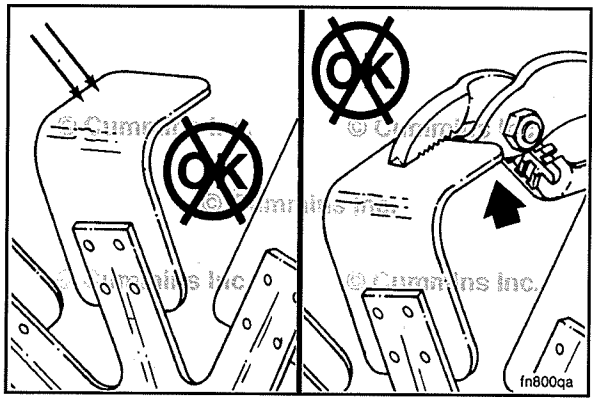
Fan, Cooling

Inspect for Reuse

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



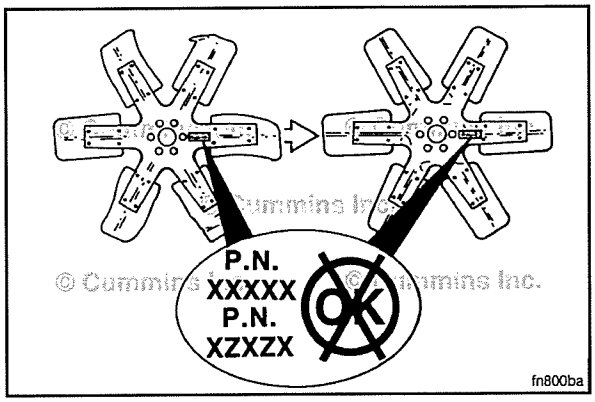
A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, and bent or loose blades. Check the fan to make sure it is securely mounted. Tighten the capscrews, if necessary.



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

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

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

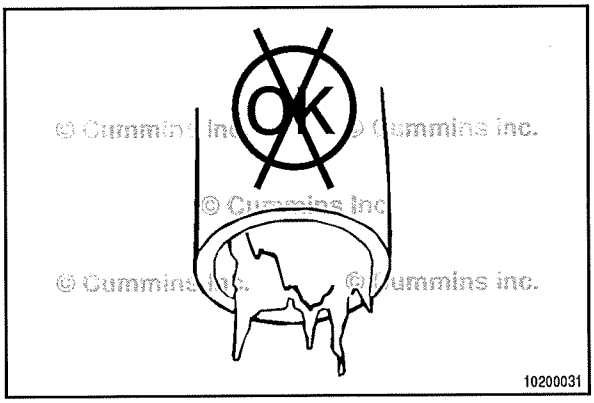


Crankcase Breather Tube

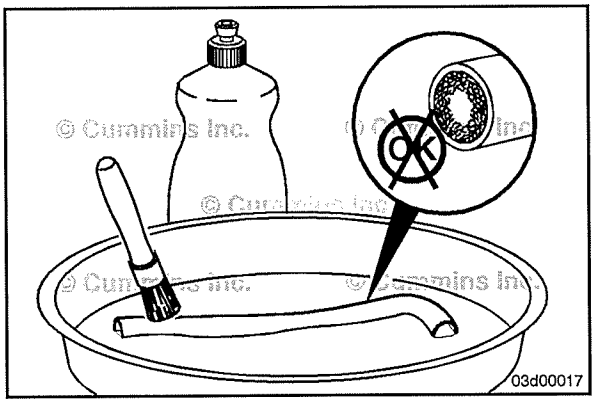
Maintenance Check

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

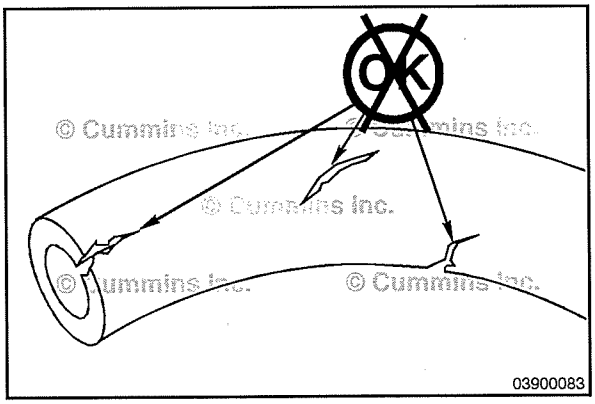
Inspect the tube more frequently in icy conditions.

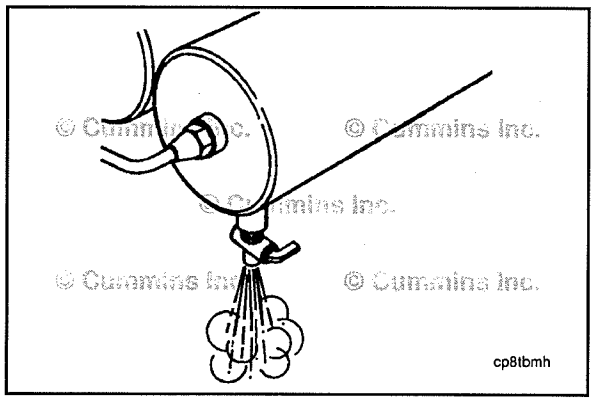


If sludge, debris, or ice is found clean the tube with detergent and warm water or a solvent. Dry the tube with compressed air.



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

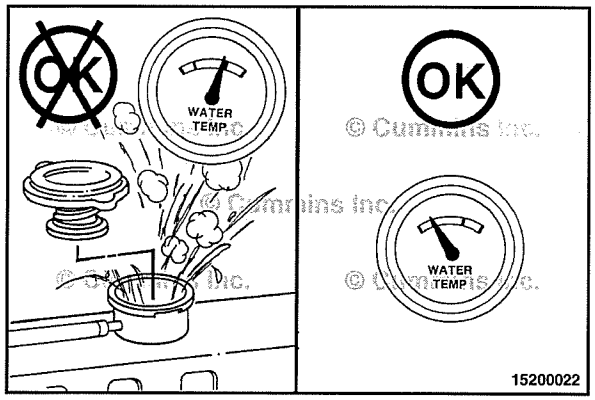




Air Tanks and Reservoirs

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.



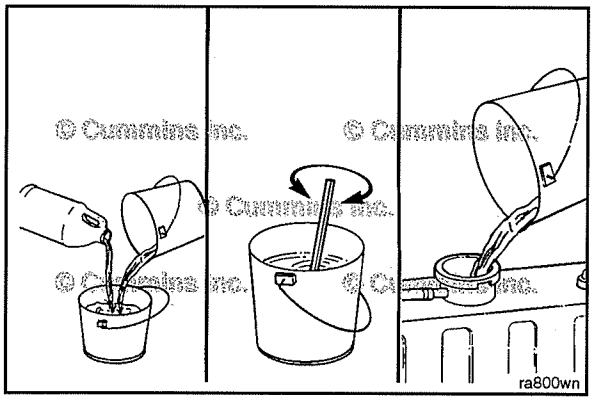
Coolant Level

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.

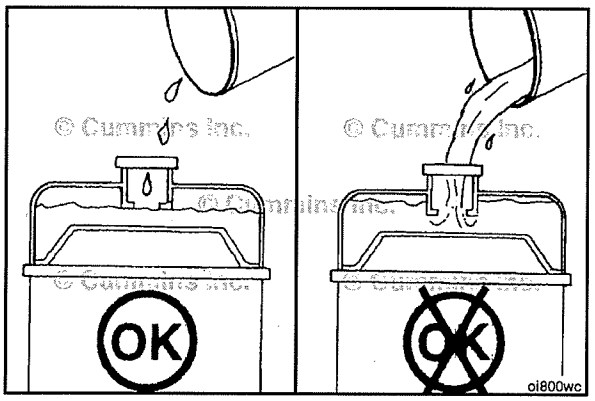
The coolant level **must** be checked daily.



△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.

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.

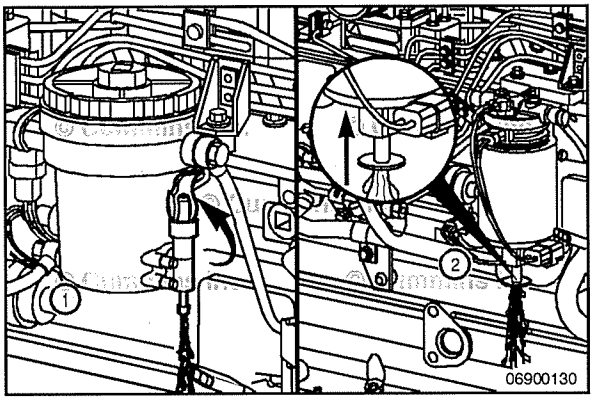
Drain the water and sediment from the separator daily.

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

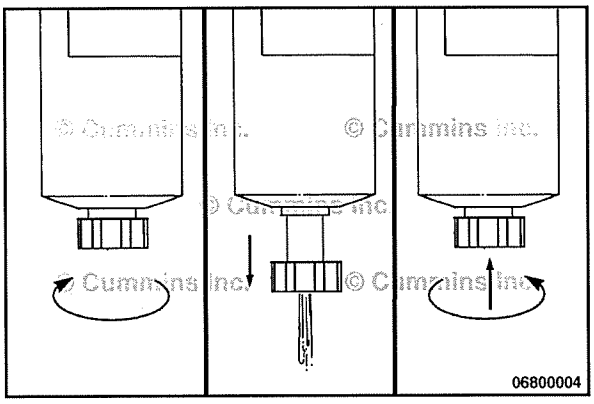
Shut off the engine.

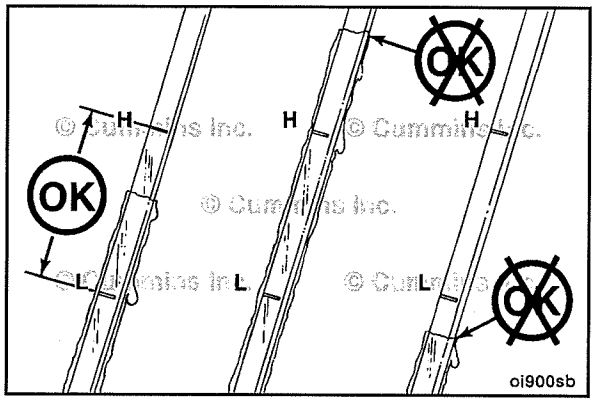
Use your hand to open the drain valve. Turn the valve **counterclockwise** approximately 3½ turns until the valve drops down 25.4mm [1 in] and draining occurs.

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).

Aftertreatment Exhaust Piping

Maintenance Check

Inspect the exhaust aspirator, if equipped, for debris. Clean if necessary.

Inspect the exhaust diffuser, if equipped, for debris. Clean if necessary.

Inspect the aftertreatment system for debris. Clean if necessary.

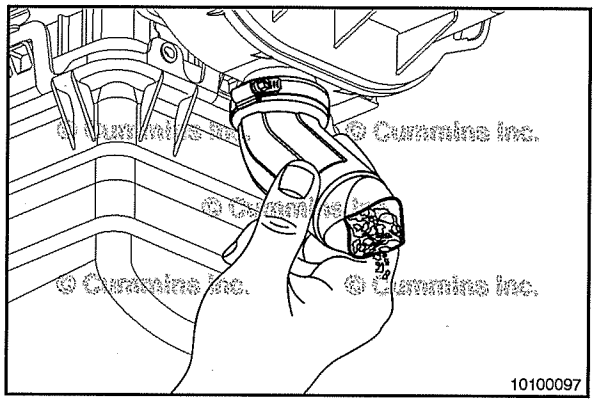
Dust Ejection Valve

General Information

The dust ejection valve is a thin flexible rubber boot located at the bottom of the pre-cleaner on the air cleaner assembly. It is used to accumulate and remove dust ejected from the pre-cleaner.

If an application is equipped with a pre-cleaner exhaust aspirator, a dust ejection valve will **not** be present, as the aspirator takes place of the dust ejection valve.

Do **not** operate the engine without a dust ejection valve or exhaust aspirator. The pre-cleaner efficiency will be greatly reduced and may result in shortened filter element life.



Clean

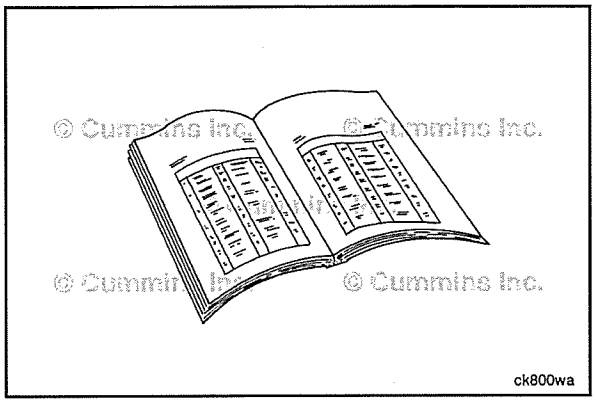
Purge the dust ejection valve of dust by squeezing the valve until it opens. This may have to be performed multiple times depending on the severity of dust or debris found in the valve.

If debris is **not** able to be purged from the valve, remove the valve and clean out by hand. See the Remove section of this procedure.

Preparatory Steps

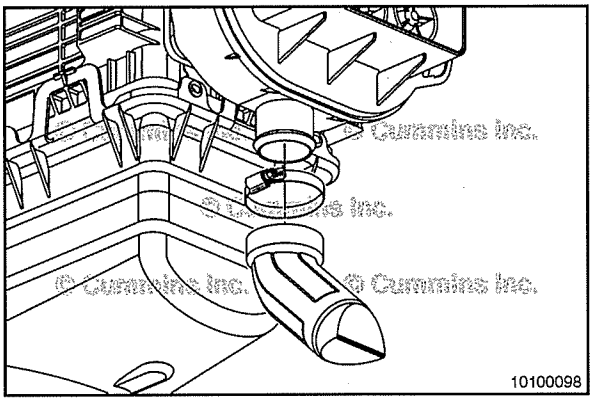
NOTE: Before servicing any intake air system component, (such as the air cleaner, pre-cleaner, hoses, ducting, etc.), clean the fittings, mounting hardware, and the area around the component to be removed.

- Shut the engine OFF.



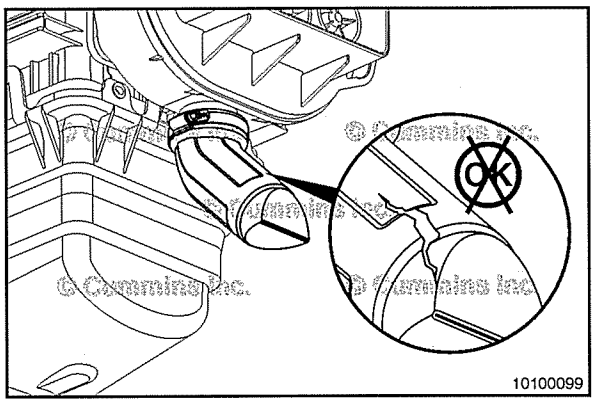
Remove

Remove the dust ejection valve from the pre-cleaner by loosening the hose clamp, if present, then rotating and pulling downward on the dust ejection tube.



Inspect for Reuse

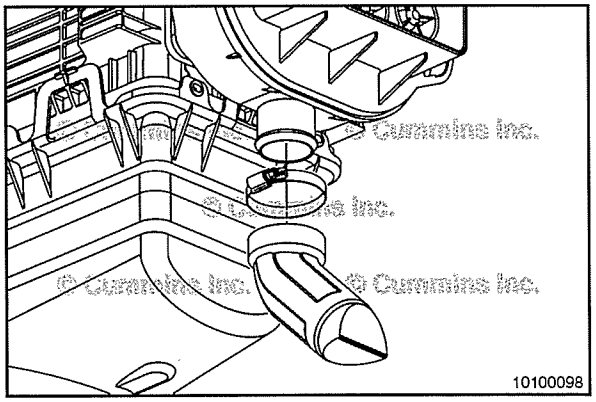
Inspect the dust ejection valve for cuts and tears. Replace the valve if damage is found.

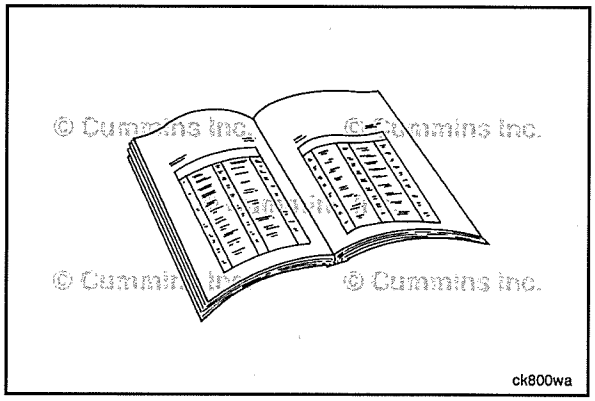


Install

Install the dust ejection valve on the pre-cleaner by attaching the hose clamp, if present. Tighten the hose clamp.

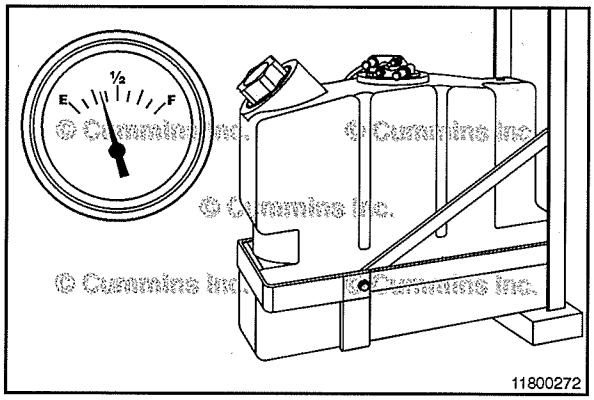
Torque Value: 5 N•m [44 in-lb]





Finishing Steps

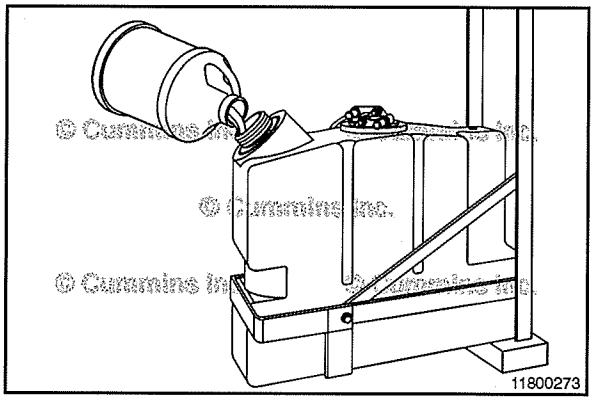
- Start the engine.
- Check for leaks.



Diesel Exhaust Fluid (DEF) Level

Maintenance Check

The Diesel Exhaust Fluid level **must** be checked daily.



⚠WARNING⚠
Do not allow Diesel Exhaust Fluid to contact the 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 Diesel Exhaust Fluid is ingested, contact a physician immediately.

△CAUTION△
It is unlawful to tamper with or remove any component of the aftertreatment system. It is also unlawful to use a catalyst solution that does not meet the specifications provided or to operate the vehicle/ equipment with no catalytic solution.

If the Diesel Exhaust Fluid level is found to be low, Diesel Exhaust Fluid **must** be added.

Refer to the OEM service manual for Diesel Exhaust Fluid level check and fill instructions.

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

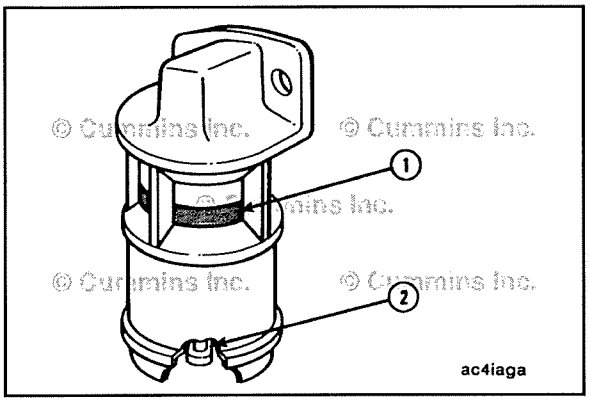
Mechanical Indicator

⚠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.

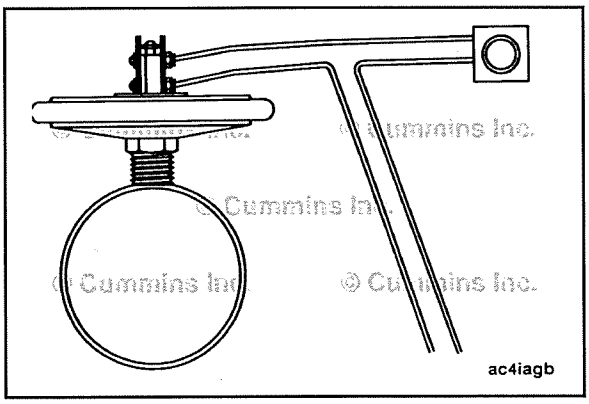
A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in the air cleaner outlet or on the instrument panel. The red flag (1) in the window gradually rises as the cartridge loads with dirt. After changing or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

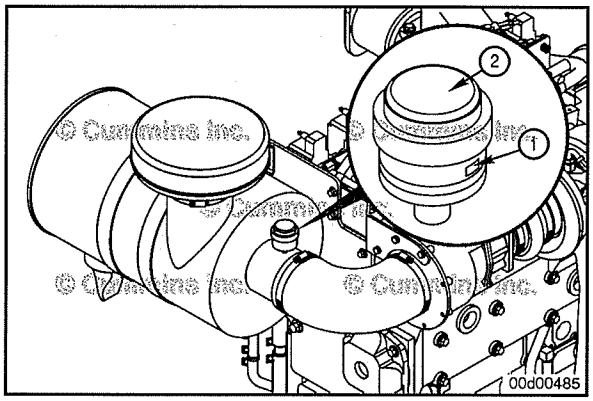
Restriction or vacuum indicators need to be installed as close as possible to the turbocharger air inlet in order to obtain a true indication of restrictions.



Vacuum Indicator

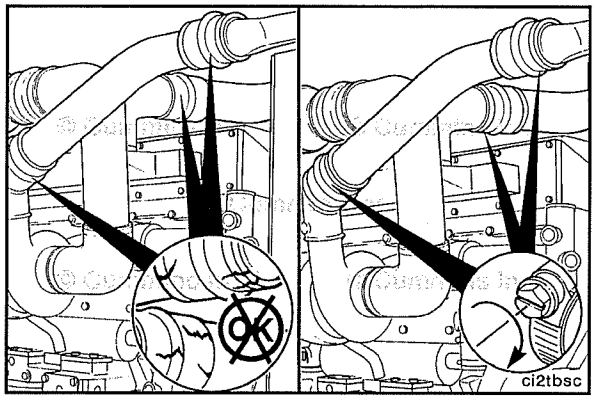
Vacuum switches actuate a warning light on the instrument panel when the air restriction becomes excessive.





Industrial Gas Mechanical Indicator

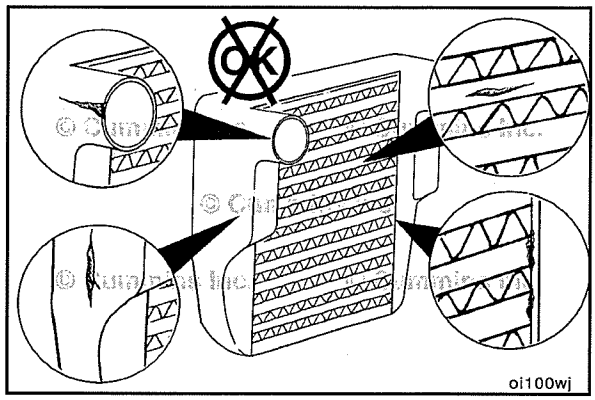
A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument is mounted in the air cleaner outlet. The red flag (1) in the window gradually rises as the cartridge loads with dirt. When air restriction is indicated the air filter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



Charge-Air Piping

Maintenance Check

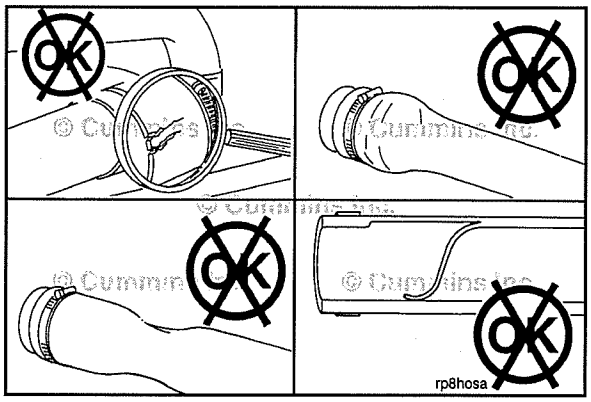
Inspect the charge-air piping and hoses for leaks, holes, cracks, or loose connections. Tighten the hose clamps if necessary. Refer to the vehicle or equipment manufacturer's specifications for the correct torque value.



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.



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

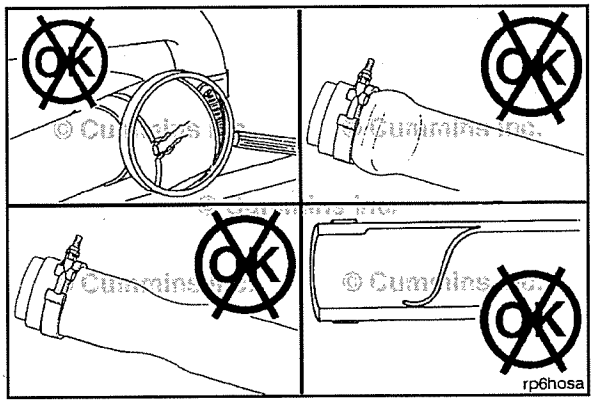
Maintenance Check

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]

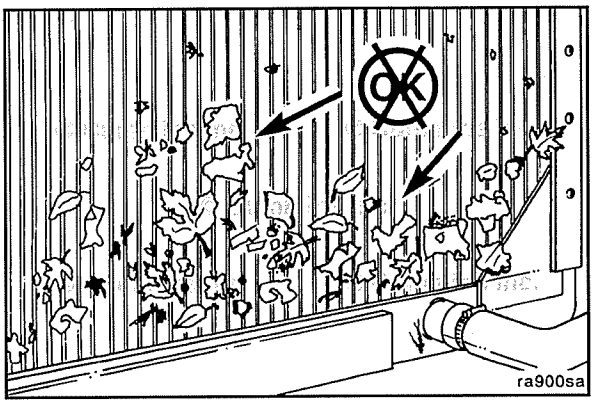
Check for corrosion under the clamps and hoses of the intake system piping. Corrosion can allow corrosive products and dirt to enter the intake system. Disassemble and clean, as required.



Radiator

General Information

Air forced through the fins of the radiator by a fan cools the coolant pumped through the radiator. Environmental debris (such as paper, straw, lint, and dust) can obstruct the fins and stop the flow of air, which will reduce the cooling effect of the radiator.



Initial Check

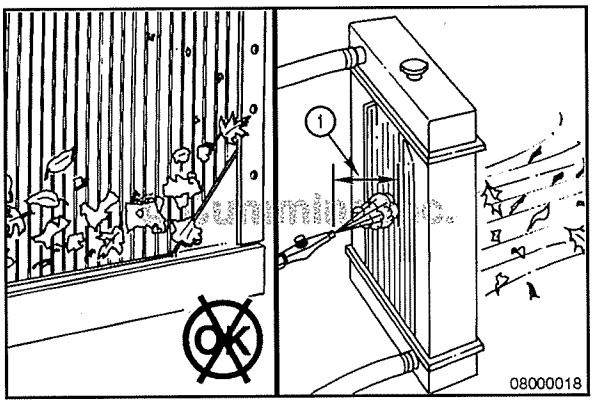
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

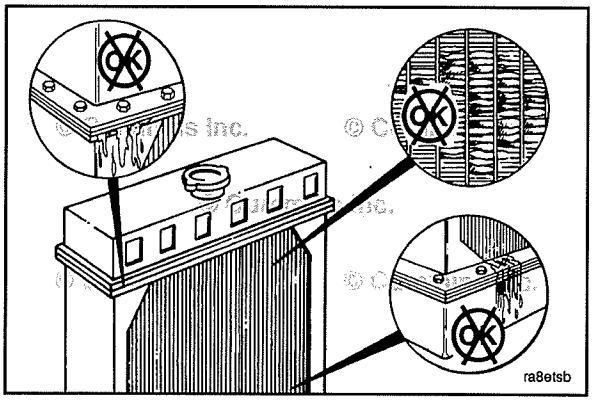
⚠CAUTION⚠
Keep the compressed air nozzle a minimum of 15cm [6 in] from the radiator core to avoid damaging the fins. See call out 1 in the illustration

Inspect for plugged radiator fins.

Use compressed air to blow out the dirt and debris.

Air Pressure: 552 kPa [80 psi]

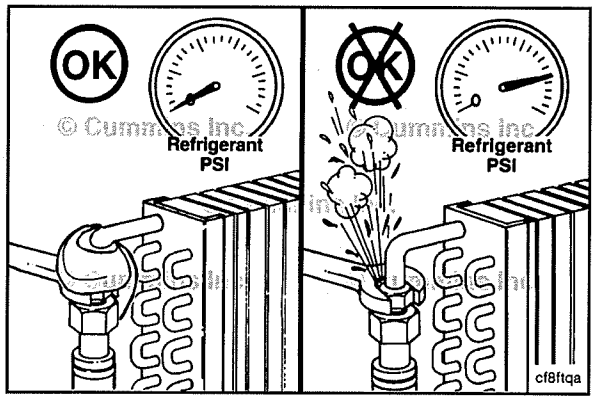




Inspect the radiator for bent or broken fins.

Inspect the radiator core and gasket for leaks.

If the radiator **must** be replaced, refer to the OEM service manual replacement procedures.



⚠WARNING⚠
If a liquid refrigerant system (air conditioning) is used, wear eye and face protection, and wrap a cloth around the fittings before removing. Liquid refrigerant can cause serious eye and skin injuries.

⚠WARNING⚠
To protect the environment, liquid refrigerant systems must be properly emptied and filled using equipment that prevents the release of refrigerant gas into the atmosphere. Federal law requires capturing and recycling the refrigerant.

Use care in removing the refrigerant system, if equipped, before removing the radiator.

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.

Fuel Filter (Spin-On Type)

General Information

The fuel system requires the use of two fuel filters. The suction-side filter **must** have the following characteristics:

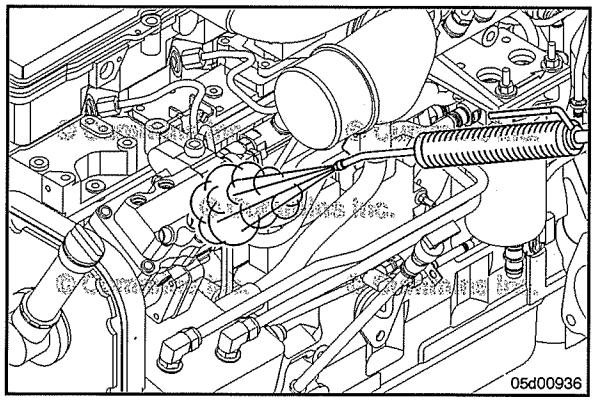
- Water-separating
- 8-micron rating
- Water-in-fuel sensor with shunt resistor
- Water-drain valve
- Engine mounted or chassis mounted.

The pressure-side filter **must** have the following characteristics:

- 5-micron rating
- Engine mounted or chassis mounted.

Use the following procedure for fuel filter recommendations. Refer to Procedure 018-024 in Section V.

If the engine has been allowed to run out of fuel or the fuel system has been serviced or repaired, it will be necessary to prime the fuel system.



Preparatory Steps

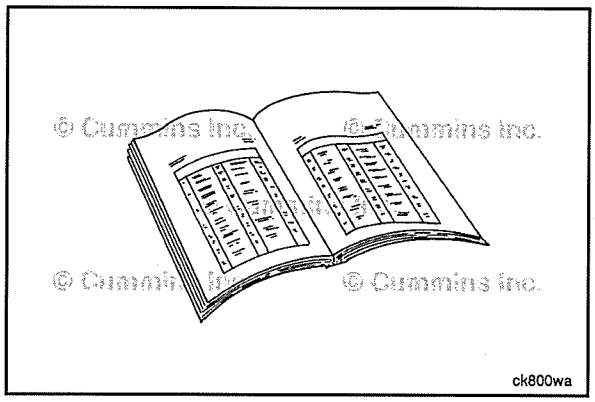
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

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

△CAUTION△
Clean all fittings before disassembly. Dirt or contaminants can damage the fuel system.

Before servicing **any** fuel system components, (such as fuel lines, fuel pump, injectors, etc.) which would expose the fuel system or internal engine component to potential contaminants prior to disassembly, clean the fittings, mounting hardware, and the area around the component to be removed. Dirt or contaminants can be introduced into the fuel system and engine if the surrounding areas are **not** cleaned, resulting in damage to the fuel system and engine.

- Clean the engine. Refer to Procedure 000-009 in Section 8. Refer to Procedure 204-008 in Section i.
- Use electrical contact cleaner, Part Number 3824510 or equivalent, to thoroughly clean all fuel lines before removal from the engine. Clean the connector fittings to remove as much debris as possible. It is very important that extra care is taken to keep the fuel connections clean during removal and installation. Refer to Procedure 204-008 in Section i.
- Make sure that debris, water, steam, or cleaning solution does **not** get inside the fuel system.



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

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

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

Remove

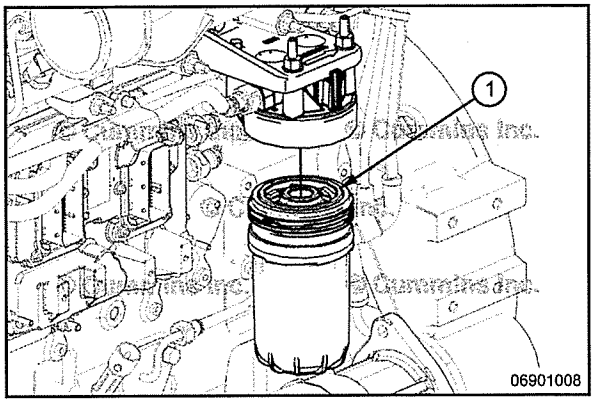
⚠WARNING⚠
Depending on the circumstance, diesel fuel is flammable. When inspecting or performing service or repairs on the fuel system, to reduce the possibility of fire and resulting severe personal injury, death, or property damage, never smoke or allow sparks or flames (such as pilot lights, electrical switches, or welding equipment) in the work area.

Disconnect the wiring harness from the water-in-fuel sensor, if equipped.

Loosen and remove the fuel filter.

Make sure the seal ring (1) does **not** stick to the filter head.

Remove the ring with an o-ring pick, if necessary.



Install

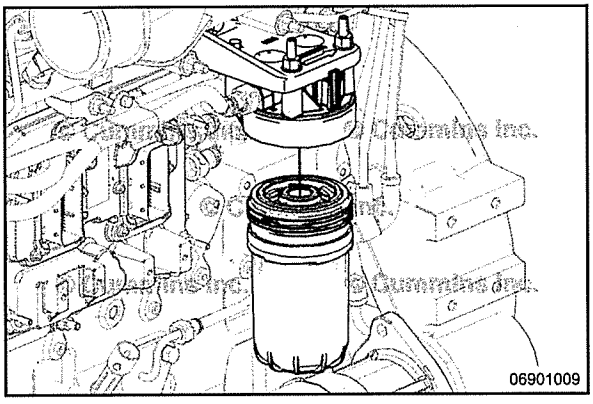
△CAUTION△
Mechanical overtightening can distort the threads as well as damage the filter element seal or filter canister.

It will be necessary to fill the 8-micron water stripping (suction-side) fuel filter with fuel.

Do **not** fill the 5-micron (pressure-side) fuel filter with fuel before installation; instead, prime the fuel system using the fuel lift pump.

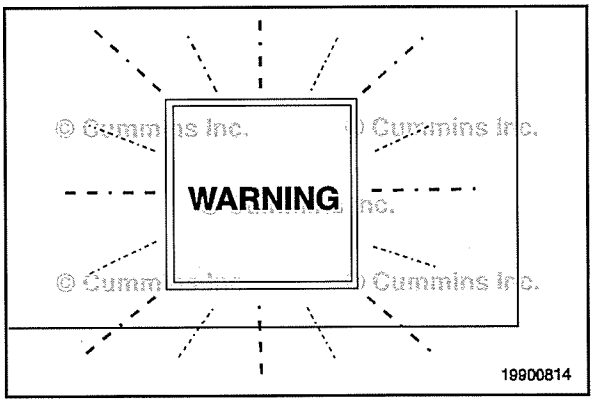
Install the filter as specified by the filter manufacturer.

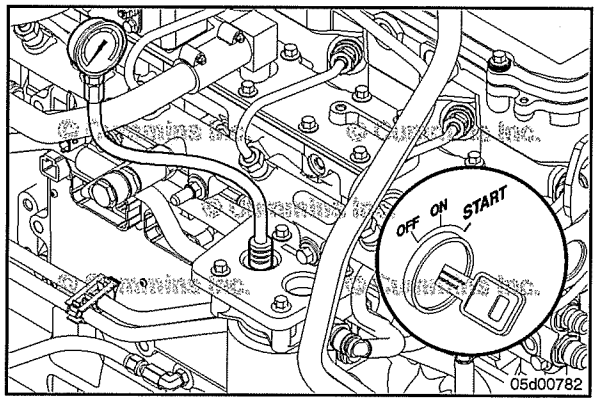
Connect the water-in-fuel sensor, if equipped.



The fuel system is capable of detecting the presence of the correct water-in-fuel sensor.

If the water-in-fuel sensor is incompatible or disconnected, the engine WARNING lamp will illuminate.





Prime

⚠WARNING⚠
When servicing the engine do not rotate engine with a high pressure fuel system joint open. Rotating the engine can create highly pressurized fuel in the fuel system. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

Install an M10 male Compuchek™ fitting, Part Number 3824842, at the on-engine fuel filter head inlet port.

To assist in fuel system priming and removing air from the fuel system, an orificed diagnostic fuel line, Part Number 3164621, can be used to bleed air from the low-pressure fuel system.

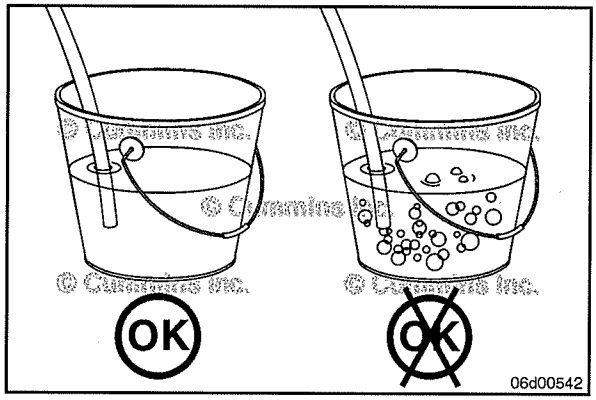
Install the orificed diagnostic fuel line to the M10 male Compuchek™ fitting at the inlet to the pressure-side fuel filter.

NOTE: If there is **not** enough clearance to install the 0.043-inch orificed diagnostic fuel line, Part Number 3164621, an adapter fitting, Part Number 3932302, and an 1/8-NPT male Compuchek™ fitting, Part Number 3377244, can be used to aid accessibility.

Turn the key to the ON position. Do **not** start the engine.

Allow the priming pump to operate and observe the orificed diagnostic fuel line. When a solid stream of fuel exits the line, the initial priming process is complete. It can be necessary to repeat this process two or three times.

Remove the diagnostic fuel line.



⚠WARNING⚠
When servicing the engine do not rotate engine with a high pressure fuel system joint open. Rotating the engine can create highly pressurized fuel in the fuel system. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

NOTE: The engine can possibly run rough for several minutes until the air is out of the system.

Start the engine and allow it to stabilize.

Attach the orificed diagnostic fuel line to the Compuchek™ fitting at the inlet to the pressure-side fuel filter. Allow engine to operate with the orificed diagnostic fuel line installed for 10 seconds.

Shut the engine OFF and observe the fuel/air exiting the orificed diagnostic fuel line.

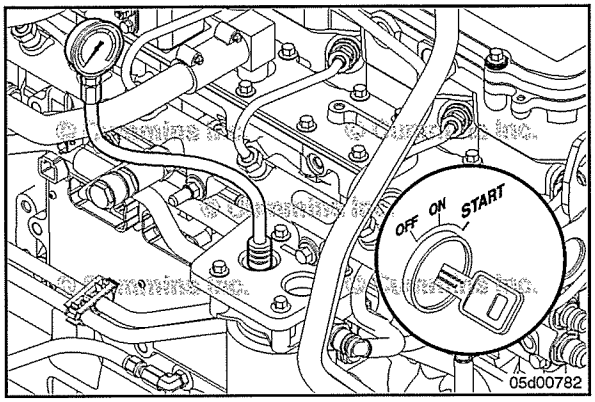
Remove the orificed diagnostic fuel line from the engine.

Repeat this process up to four times, or until air no longer exits the diagnostic fuel line after shutdown.

NOTE: Remove the orificed diagnostic fuel line before starting the engine. The engine will be difficult to start if the orificed diagnostic fuel line is installed during starting.

If air continues to exit the diagnostic fuel line after four or more repetitions, check the suction side of the fuel system for leaks.

⚠WARNING⚠
When servicing the engine do not rotate engine with a high pressure fuel system joint open. Rotating the engine can create highly pressurized fuel in the fuel system. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.



NOTE: The engine can possibly run rough for several minutes until the air is out of the system.

If the engine will **not** start, attach the diagnostic fuel line to the Compuchek™ fitting at the inlet to the pressure-side fuel filter and crank the engine for 15 seconds.

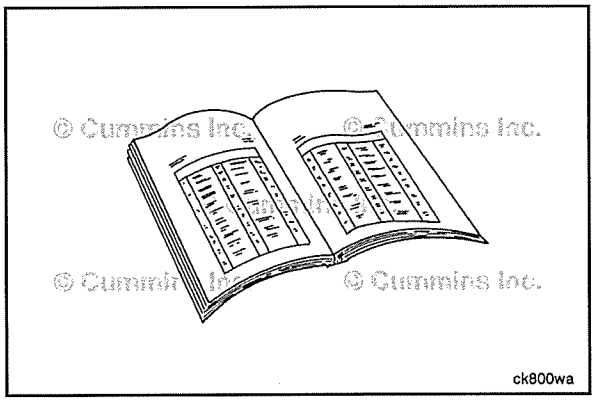
NOTE: Crank the engine in 15 second intervals with a 15 second break between cranking. This reduces the possibility of overheating the starter motor.

Stop cranking the engine and observe the orificed diagnostic fuel line. Allow the entrapped air to expand and exit through the diagnostic fuel line. Repeat this process up to four times, or until the engine starts.

If air continues to exit the orificed diagnostic fuel line after four or more repetitions, check the suction side of the fuel system for leaks.

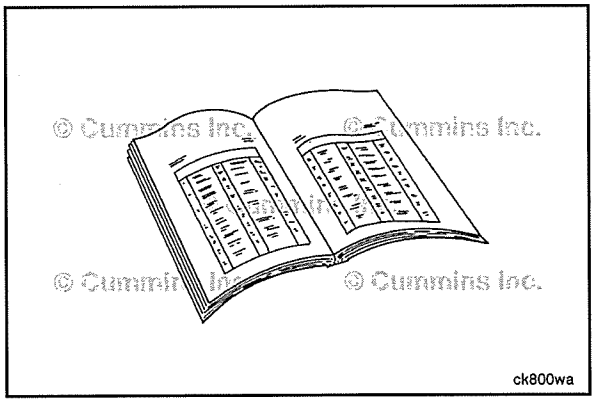
Finishing Steps

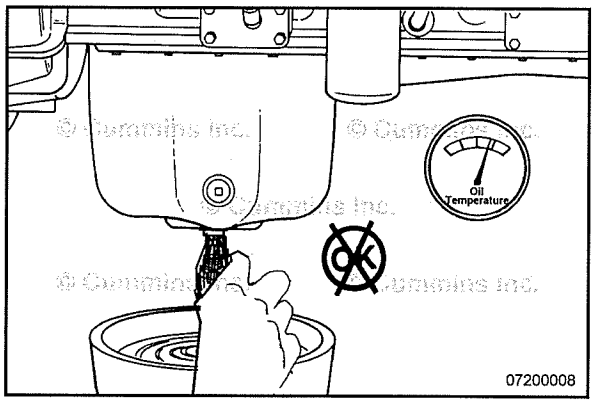
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



- Connect the battery cables. Refer to the OEM service manual.

- Operate the fuel lift pump to help prime the fuel system. Turn the keyswitch to RUN, but do **not** attempt to start the engine. This will cause the engine control module (ECM) to operate the fuel lift pump through a priming cycle which lasts at least 30 seconds. Cycle the lift pump several times by keying OFF, waiting 10 seconds, and keying ON again.
- Once the engine is started, slowly increase the engine speed while air is purged from the fuel plumbing.





Lubricating Oil System

Drain

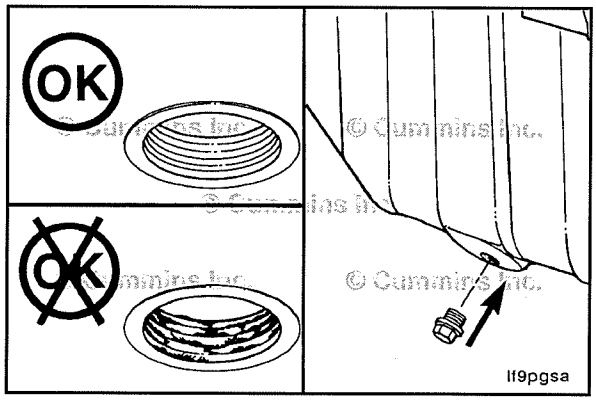
⚠WARNING⚠
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

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

NOTE: Use a container that can hold at least 28.4 liters [30 qt] of lubricating oil.

- Operate the engine until the coolant temperature reaches 60°C [140°F]. Shut the engine OFF.

  NOTE: Be sure to remove the front and rear oil drain plugs, if equipped. Failure to do so will result in incomplete draining of oil from the lubricating oil pan.
- Remove the oil drain plug.
- Drain the oil immediately to make sure all the oil and suspended contaminants are removed from the engine.



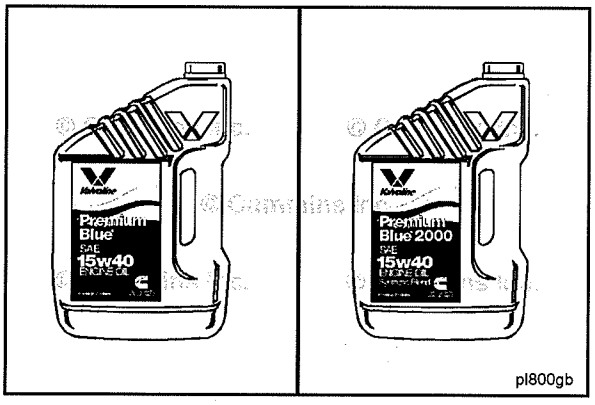
Fill

Clean and check the lubricating oil drain plug threads and sealing surface.

Install the lubricating oil pan drain plug.

Torque Value:
Steel Oil Pan 80 N•m [59 ft-lb]

Torque Value:
Cast Aluminum Oil Pan 60 N•m [44 ft-lb]

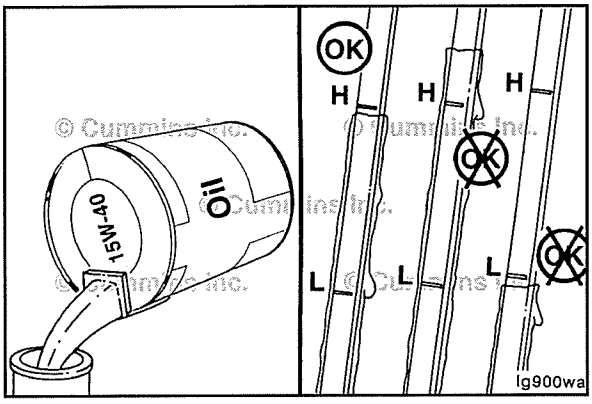


NOTE: Use a high quality 15W-40 multi-viscosity oil, such as Cummins® Premium Blue™, or equivalent, in Cummins® engines. Choose the correct oil for your operating climate as outlined in Section V.

Fill the engine with clean lubricating oil to the proper level.

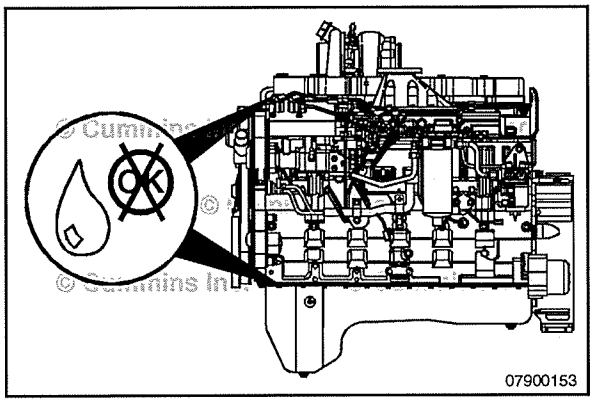
NOTE: When filling the oil pan, use the fill tube on the side of the engine rather than on top of the rocker lever cover.

Verify the lubricating oil pan capacity. Refer to Procedure 018-017 in Section V.



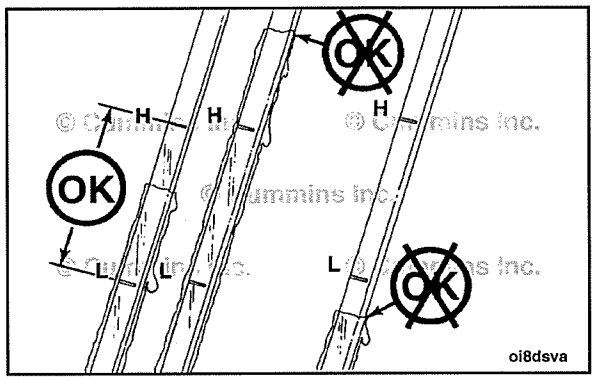
⚠CAUTION⚠
If no oil pressure is noted within 15 seconds after the engine is started, shut down the engine to reduce the possibility of internal engine damage.

Idle the engine to inspect for leaks at the drain plug.



Shut the engine OFF. Wait approximately 10 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.



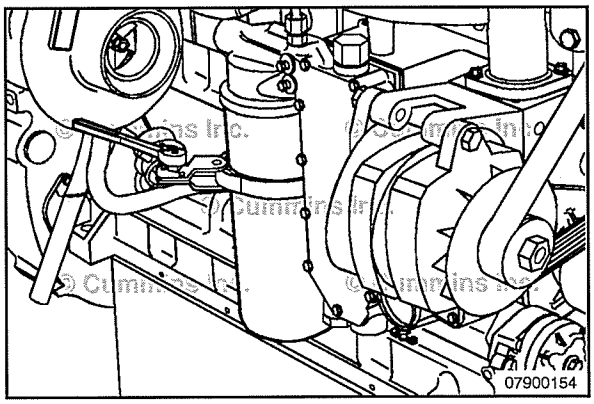
Lubricating Oil Filter (Spin-On)

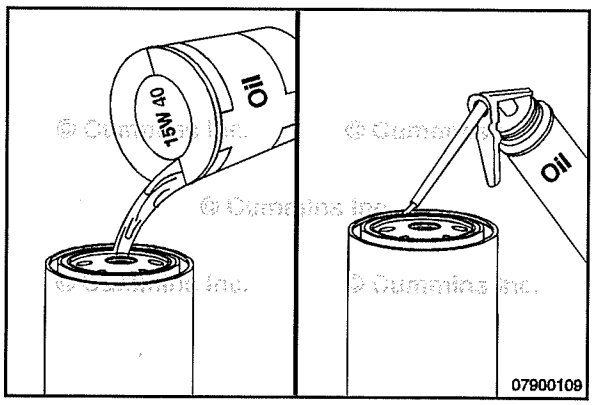
Remove

Clean the area around the lubricating oil filter head.

Use oil filter wrench, Part Number 3375049, to remove the lubricating oil filter.

Clean the gasket surface of the filter head with a clean lint-free cloth.





Install

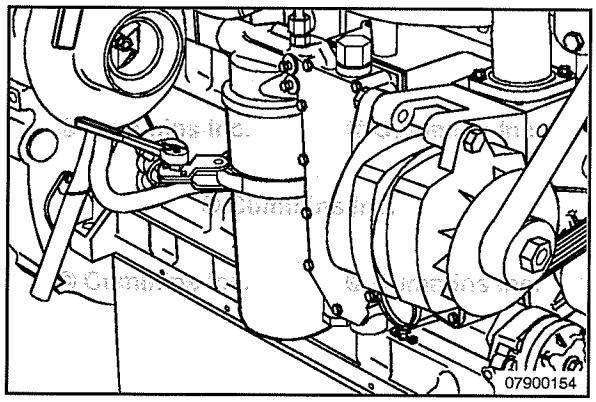
⚠CAUTION⚠

The lubricating oil filter should be full of oil at start-up to prevent engine damage.

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

Fill the filter with clean 15W-40 oil.

NOTE: Lubricating oil filters **must** have a filter bypass valve. Using a lubricating oil filter without a filter bypass valve will result in low engine oil pressure if the filter becomes plugged.

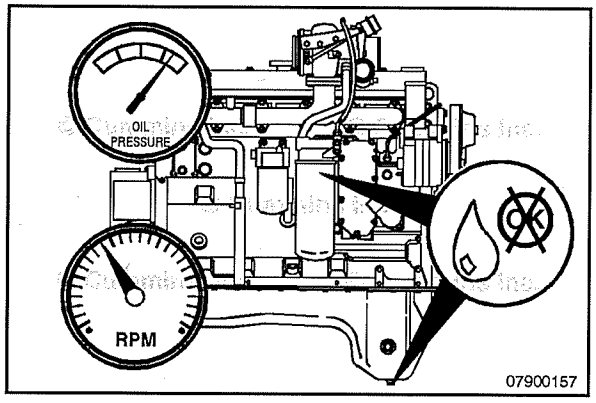


⚠CAUTION⚠

Mechanical overtightening of the 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.

Use an oil filter wrench to tighten the filter. See the filter manufacturer's instructions supplied with the filter.



⚠CAUTION⚠

If no oil pressure is noted within 15 seconds after the engine is started, shut down the engine to reduce the possibility of internal engine damage.

Operate the engine and check for leaks.

Supplemental Coolant Additive (SCA) and Antifreeze Concentration

Maintenance Check

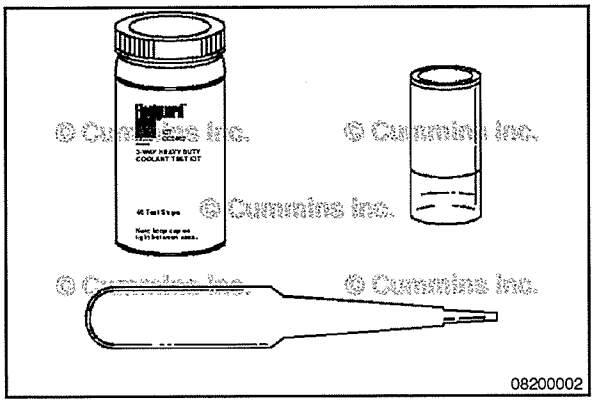
Supplemental Coolant Additive (SCA)

⚠CAUTION⚠
Failing to maintain the required SCA concentration level can cause engine damage.

Check the SCA concentration level

- At least twice a year
- At every subsequent oil drain interval if the concentration is above 3 units
- Whenever coolant is added to the cooling system between filter changes.

Use Fleetguard® coolant test kit, Part No. CC2602, to check the SCA concentration level. Instructions are included with the test kit. Use the Coolant Recommendations and Specifications in Maintenance Specifications (Section V) for the correct SCA and antifreeze level.



Antifreeze

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

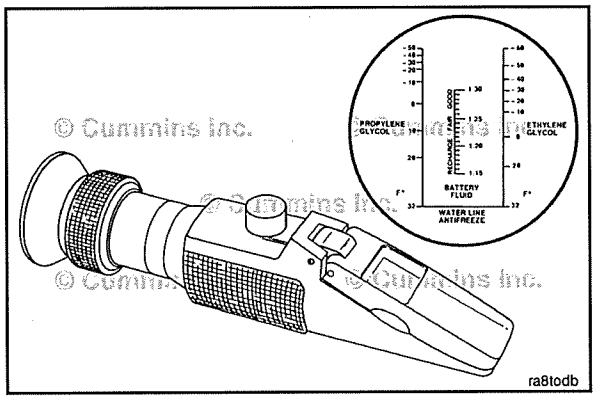
Check the antifreeze concentration. Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol-based antifreeze to protect the engine to -32°C [-26°F] year-around.

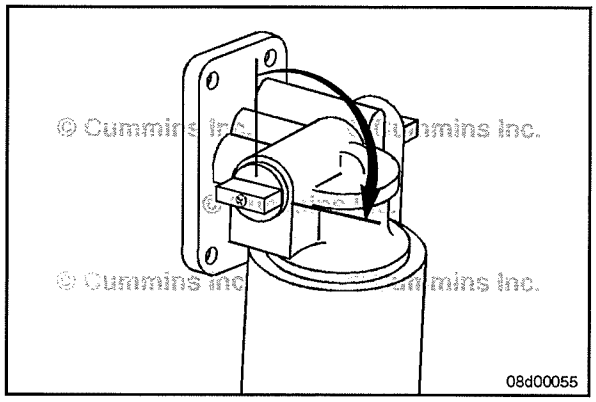
The Fleetguard® refractometer, Part Number C2800, provides a reliable, easy-to-read, and accurate measurement of freezing point protection and glycol (antifreeze) concentration.

Antifreeze is essential in every climate.

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

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





Coolant Filter

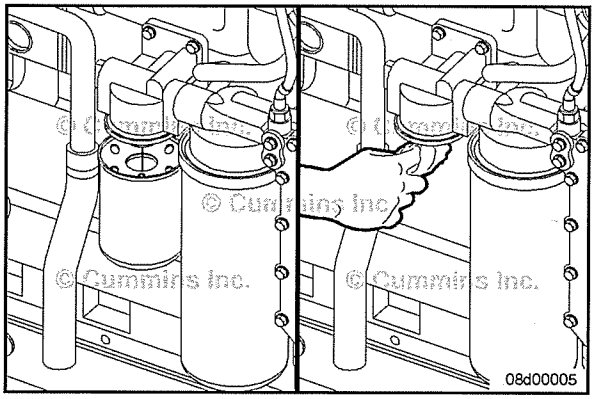
Remove

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

NOTE: Some engine models do **not** require coolant filters.

Remove the coolant system pressure cap.

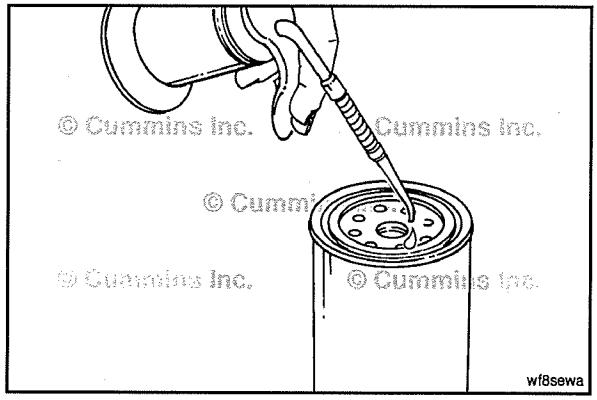
Turn the shutoff valve to the OFF position by rotating the knob from the vertical to the horizontal position, as shown.



⚠WARNING⚠
A small amount of coolant can leak when servicing the coolant filter with the shutoff valve in the OFF position. To reduce the possibility of personal injury, avoid contact with hot coolant.

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

Remove and discard the coolant filter.



Install

△CAUTION△
Do not allow oil to get into the filter. Oil will damage the DCA.

△CAUTION△
Mechanical over tightening can distort the threads or damage the filter head.

Apply a thin film of clean lubricating oil to the gasket sealing surface before installing the new coolant filter.

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

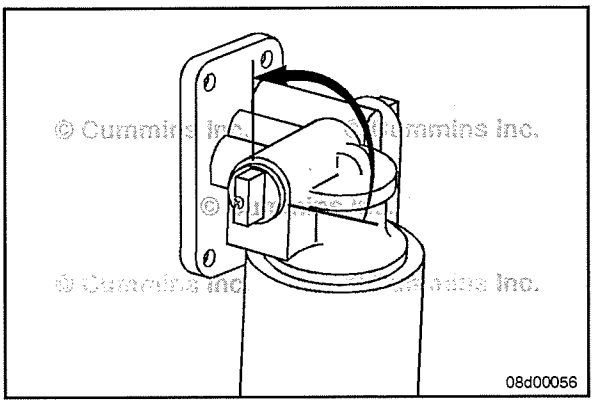
Tighten the coolant filter an additional ½ to ¾ of a turn, or as specified by the filter manufacturer.

See Section V for coolant filter recommendations.

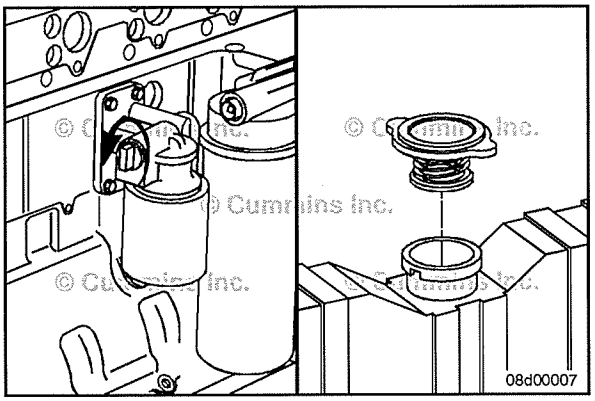
⚠CAUTION⚠

The valve must be in the ON position to prevent engine damage.

Turn the shutoff to the ON position by rotating the knob from the horizontal to the vertical position, as shown.

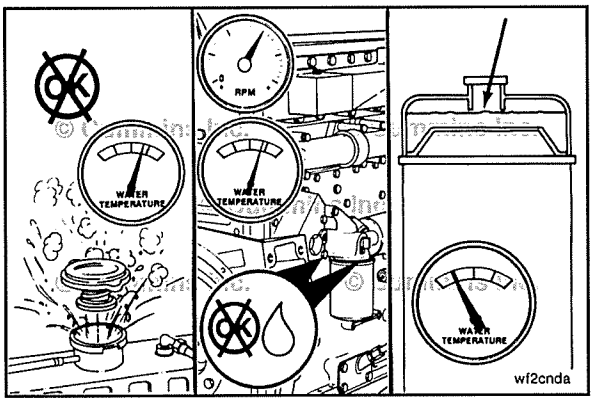


Install the coolant system pressure cap.



Operate the engine and check for coolant leaks.

Check the coolant level again after the air has been purged from the system.

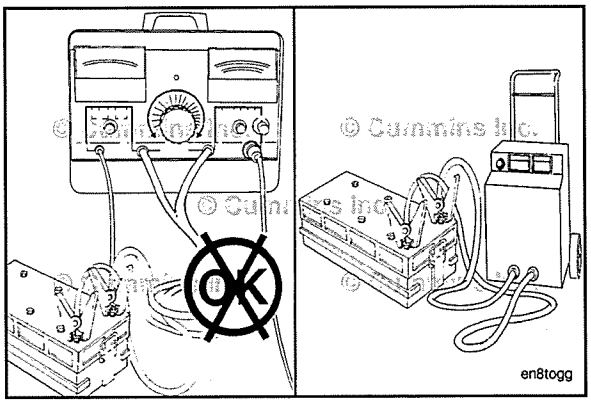


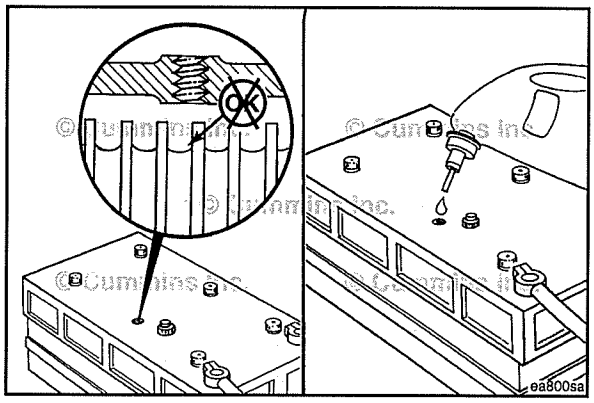
Batteries

Inspect

Use an inductive charging and cranking system analyzer to load-test the state of charge of maintenance-free batteries. If the state of charge is low, use a battery charger to charge the battery. Refer to the manufacturer's instructions.

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





If conventional batteries are used, remove the cell caps or covers and check the electrolyte (water and sulfuric acid solution) level.

⚠WARNING⚠

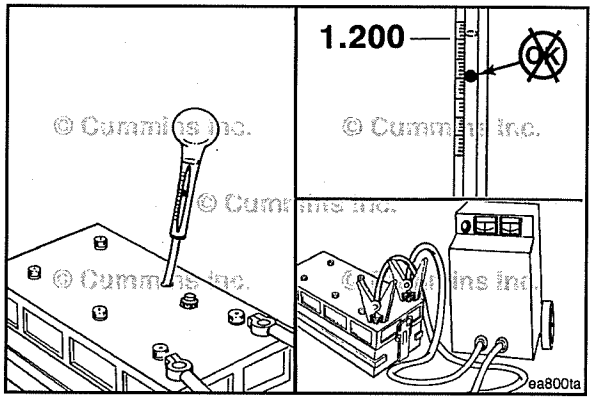
Batteries can emit explosive gas. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the battery (-) negative cable first and attach the battery negative cable last.

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

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

Refer to the accompanying table to determine the battery state of charge based on the specific-gravity readings.

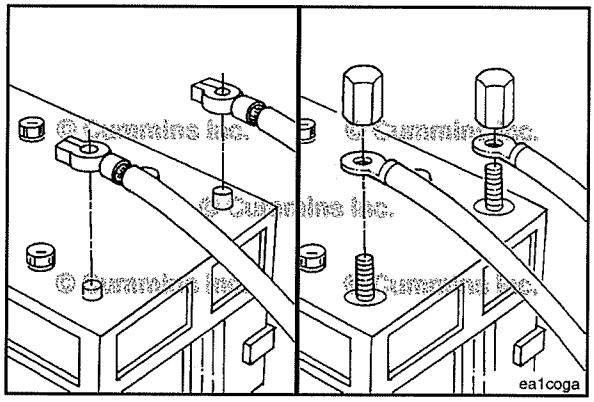
Battery State of Charge	Specific Gravity @ 27°C [80°F]
100%	1.260 to 1.280
75%	1.230 to 1.250
50%	1.200 to 1.220
25%	1.170 to 1.190
Discharged	1.110 to 1.130



Use a hydrometer to measure the specific gravity of each cell.

NOTE: If the specific gravity of any cell is below 1.200, the battery **must** be charged.

NOTE: Do **not** attempt to check the specific gravity of a battery immediately after adding water. If it is necessary to add water to allow use of the hydrometer, charge the battery several minutes at a high rate to mix the electrolyte.



Battery Cables and Connections

Initial Check

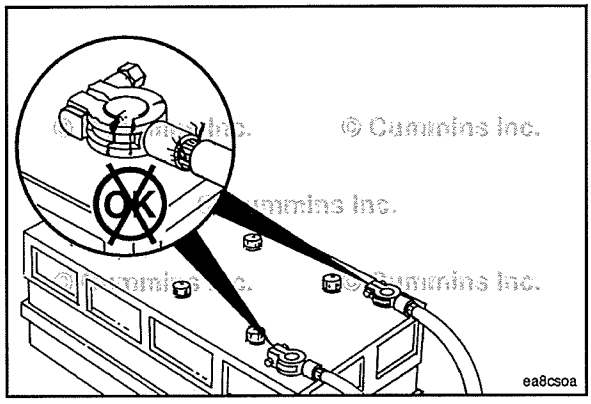
There are two possible heavy-duty battery connections:

- Battery terminal and clamp (1)
- Threaded battery terminal and nut (2).

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

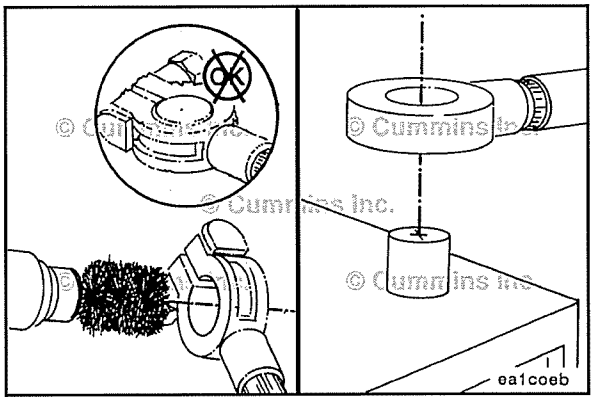
Remove and inspect the battery cables and connections for cracks or corrosion.

Replace broken terminals, connectors, or cables.



If the connections are corroded, use a battery brush or wire brush to clean the connections until shiny.

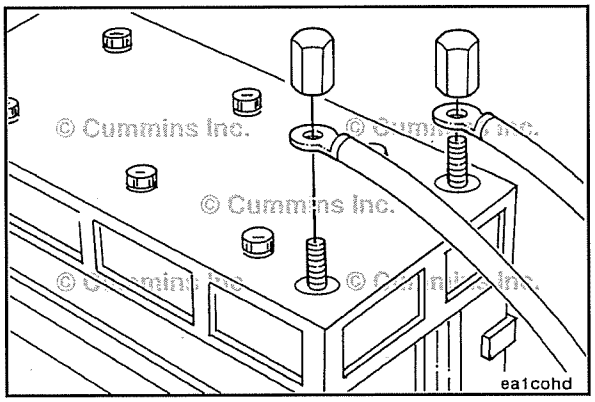
Make sure all debris is removed from the connecting surfaces.



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

Install the cables and tighten the battery connections.

Coat the terminals with grease to prevent corrosion.



Radiator Pressure Cap

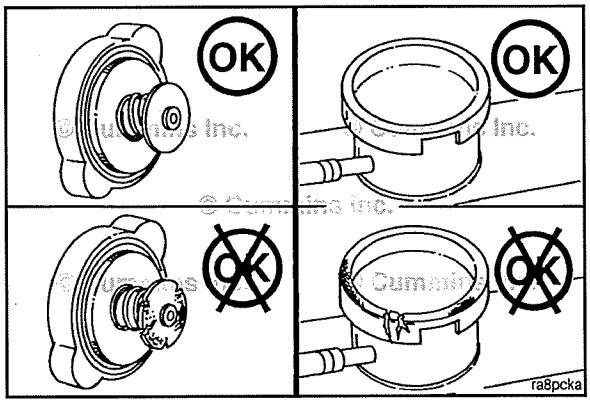
Inspect for Reuse

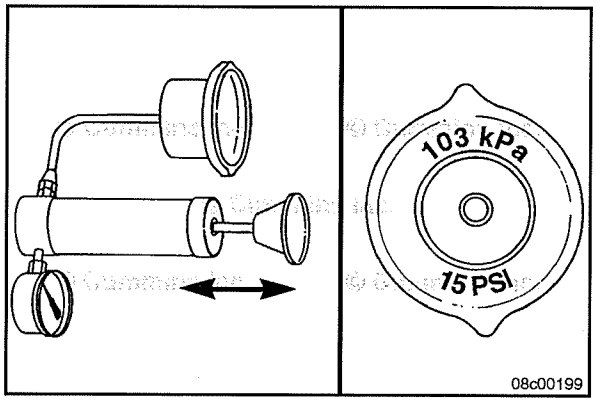
Be sure the correct radiator cap is being used. Refer to Procedure 018-018 in Section V.

Inspect the rubber seal of the pressure cap for damage.

Inspect the radiator fill neck for cracks or other damage.

Refer to the original equipment manufacturer (OEM) service manual for instructions if the fill neck is damaged.





Pressure-test the radiator cap.

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

Refer to the OEM service manual for the radiator cap test procedure.

Section 6 - Maintenance Procedures at 1000 Hours or 1 Year

Section Contents

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Maintenance Procedures - Overview

General Information

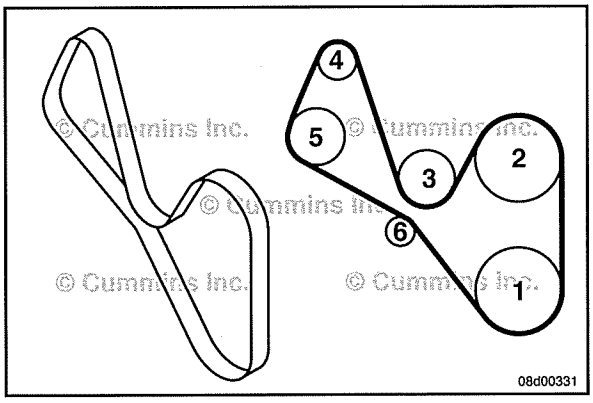
All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

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

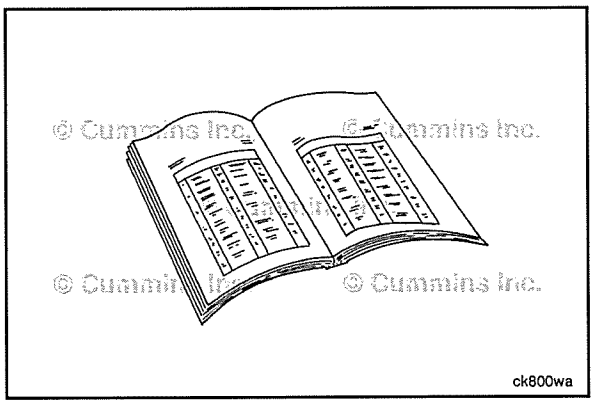
6 Tensioner idler pulley.

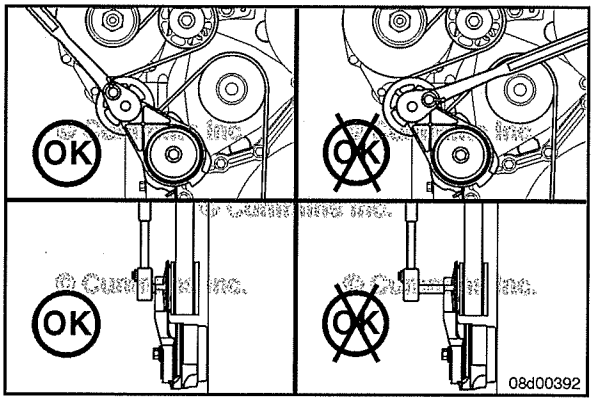
NOTE: Some engine driven belts are installed/supplied by the vehicle's original equipment manufacturer (OEM). See the OEM service manual for removal and installation instructions.

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 battery cables. Refer to the original equipment manufacturer (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.

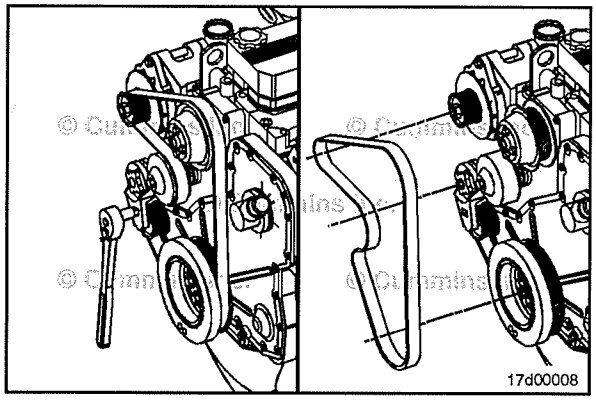
⚠CAUTION⚠
Applying excessive force in the opposite direction of windup or after the tensioner has been wound up to the positive stop can cause the tensioner arm to break.

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

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.

Lift the tensioner to remove the drive belt.

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



Install

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

⚠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.

⚠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 crack or break.

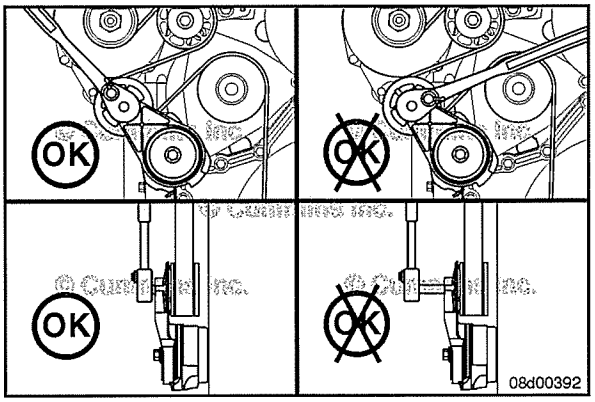
⚠CAUTION⚠
Using a socket extension is not recommended because it can cause axial twisting damage to the belt tensioner.

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 belt tensioner to apply tension to the drive belt.

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

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



Maintenance Check

Poly-Vee Belt

Inspect the belts daily. Check the belt for intersecting cracks.

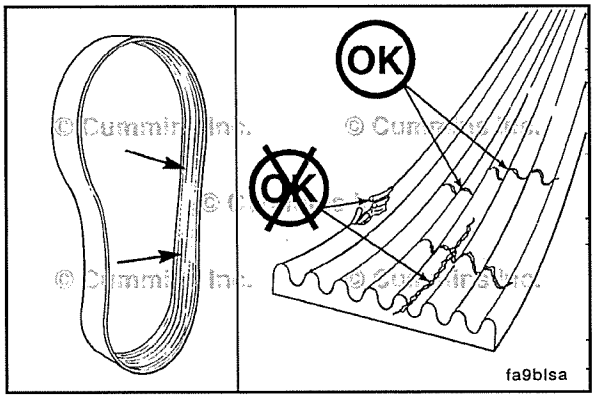
Traverse (across the belt width) cracks are acceptable.

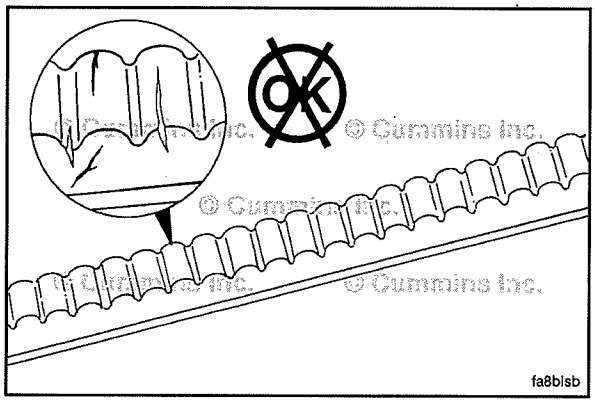
Longitudinal (direction of belt length) cracks that intersect with transverse cracks are **not** acceptable.

Replace the belt if it is frayed or has pieces of material missing. See 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 the belts.





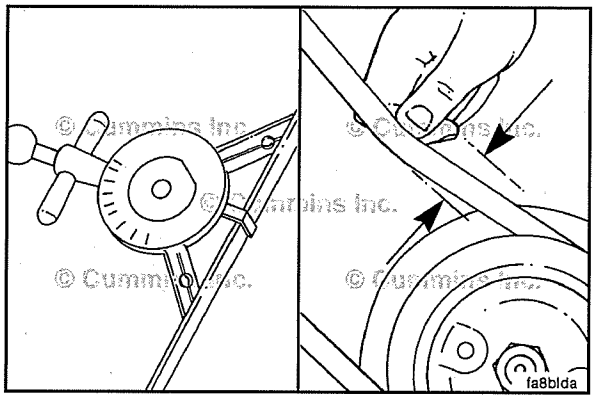
Cogged Belt

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

Adjust belts that have a glazed or shiny surface, which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear. See 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.

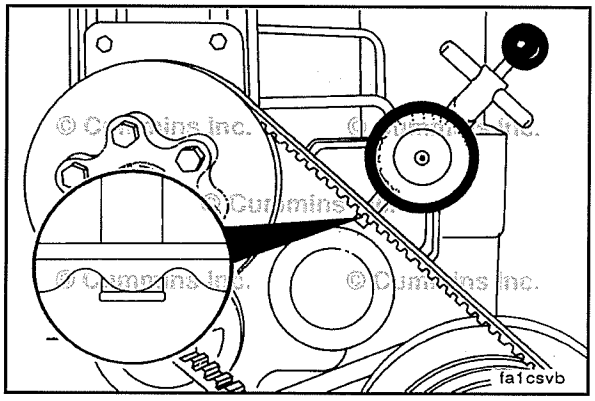


Measure the belt tension in the center span of the pulleys.

See 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] of 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.

See Section A for adjustment procedures.

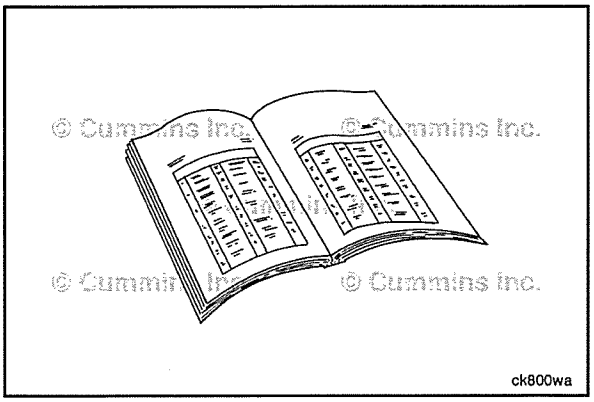


For cogged belts, **make sure** that the belt tension gauge is positioned so that the center tensioning leg is placed directly over the high point (hump) of a cog. Other positioning will result in incorrect measurement.

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 battery cables. 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.

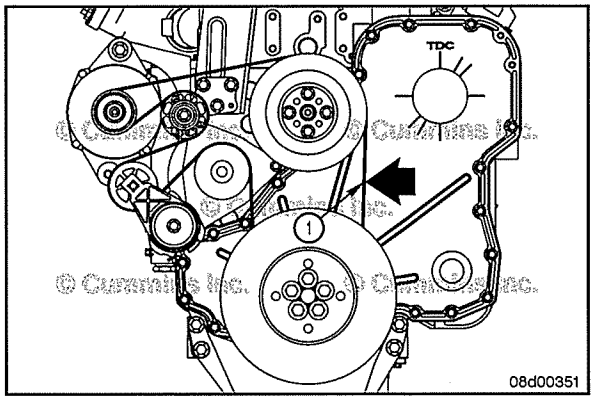


Belt Tensioner, Automatic (Water Pump)

Initial Check

Check the belt deflection at the longest span of the belt. The deflection **must** be checked at the center (1) of the span.

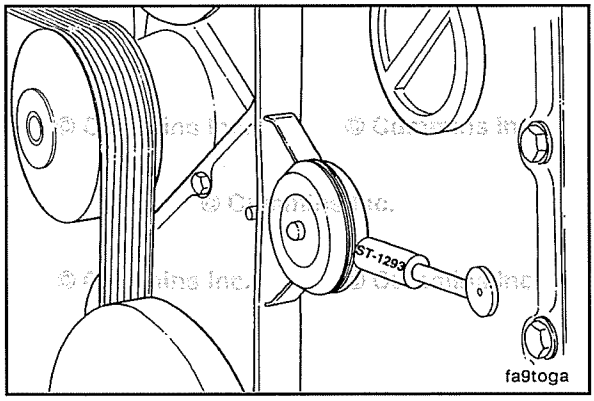
The maximum deflection allowed in the belt is 9.5 to 12.7 mm [3/8 to 1/2-in].

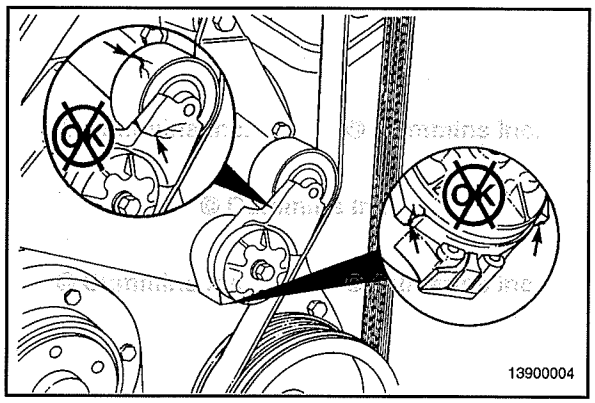


Use belt tensioner gauge, Part Number ST-1293, to measure the tension in the drive belt.

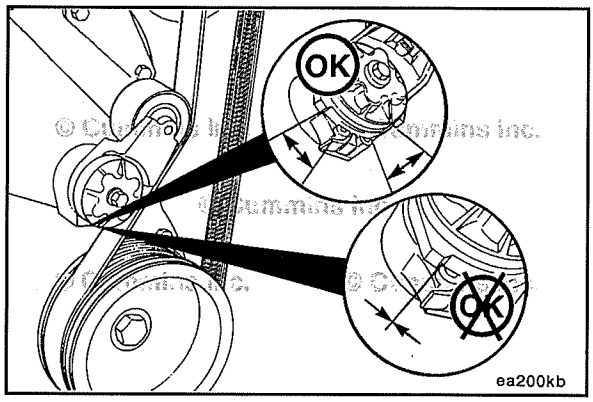
Belt Tension		
N		lbf
356	MIN	80
534	MAX	120

If the measurement is out of the specified range, replace **only** the belt and perform the tension test again. If the measurement is still outside of the specified rang after the new belt has been installed, replace the belt tensioner.



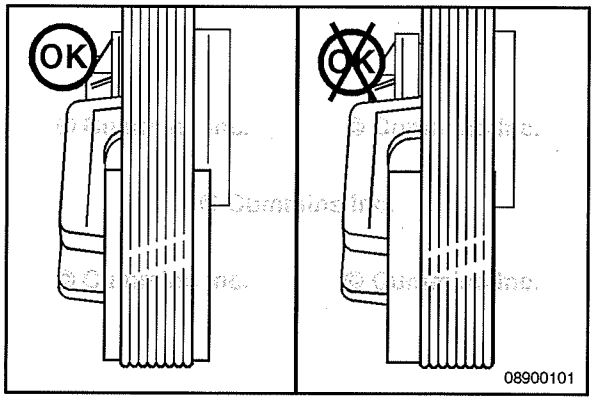


Check the tensioner arm, pulley, and stops for cracks. If any cracks are observed, the tensioner **must** be replaced.

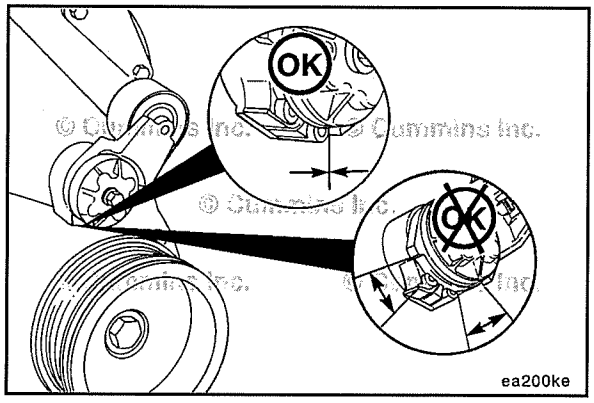


With the belt installed, verify that neither tensioner arm stop is in contact with the spring casing stop. If either stop is touching, replace the drive belt. Refer to Procedure 008-002 in Section 6.

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



Check the location of the drive belt on the belt tensioner pulley. The belt **must** 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-off failures, or increase uneven tensioner bushing wear.



Remove the drive belt. Refer to Procedure 008-002 in Section 6.

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.

Section 7 - Maintenance Procedures at 2000 Hours

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.

Crankcase Breather Element

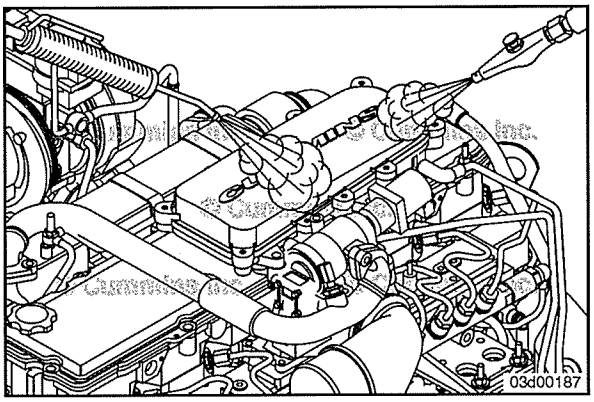
Preparatory Steps

⚠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 battery cables. Refer to the original equipment manufacturer (OEM) service manual.
- Steam clean the crankcase breather cover area.
- Dry with compressed air.



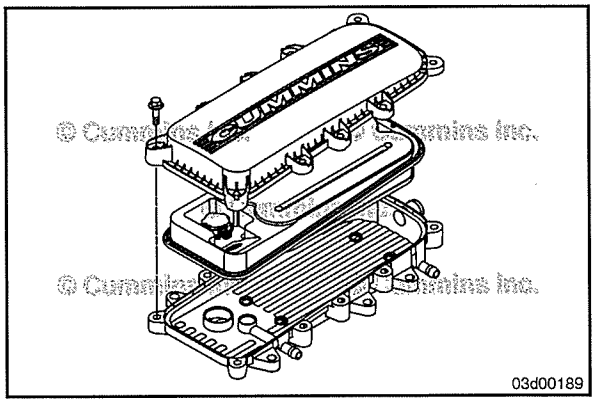
Remove

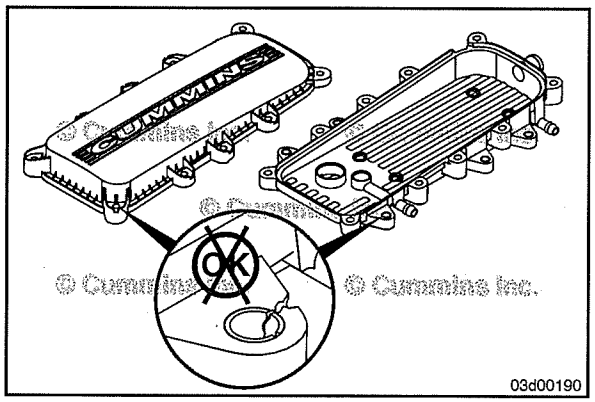
Remove the 11 crankcase breather cover capscrews.

NOTE: The six capscrews attaching the crankcase breather base to the valve cover do **not** need to be removed.

Remove the crankcase breather cover.

Remove the crankcase breather element.





Clean and Inspect for Reuse

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

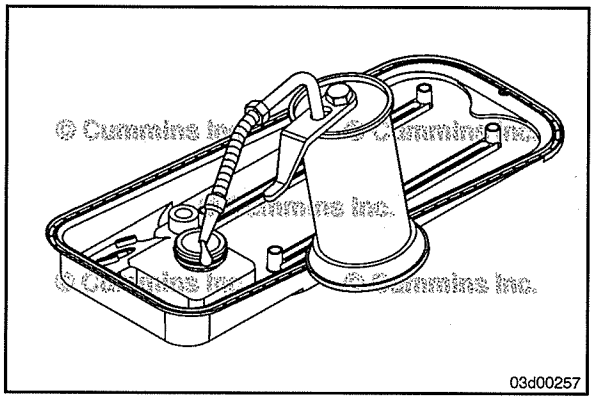
Inspect the breather cover and base for cracks or other damage.

Check for internal obstructions or sludge buildup.

Clean the crankcase breather cover with hot, soapy water and a soft brush.

Rinse the cover with clean water and dry with compressed air.

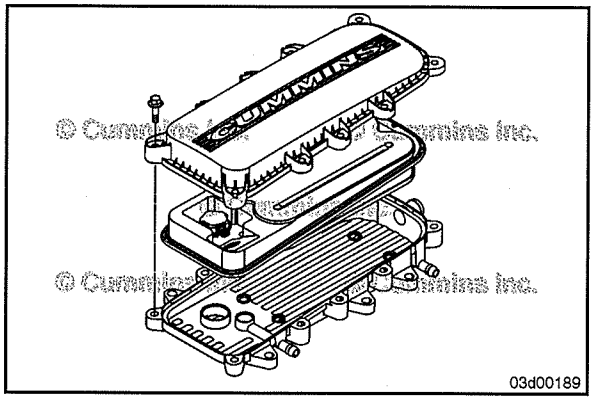
NOTE: Do **not** use soapy water to clean or rinse the breather base. Clean the base with a wet rag to prevent water from entering the crankcase.



Install

Lubricate the breather element o-ring seal with clean lubricating oil.

Use the following procedure for breather element recommendations. Refer to Procedure 018-024 in Section V.



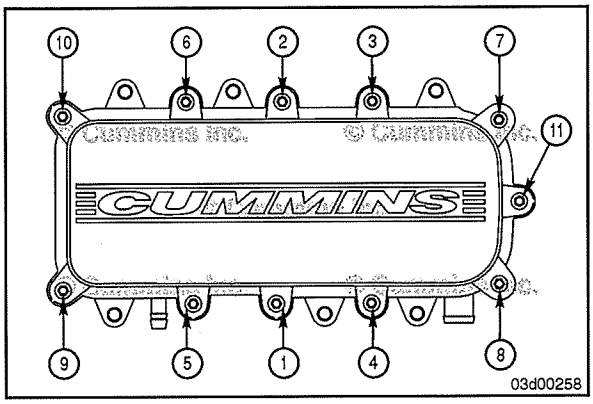
Install the new breather element onto the breather base.

Install the crankcase breather cover.

Install the eleven crankcase breather cover capscrews.

Tighten the capscrews in the sequence shown.

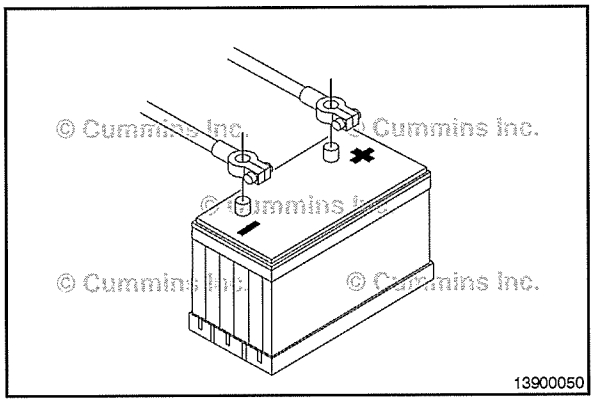
Torque Value: 10 N•m [89 in-lb]



Finishing Steps

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

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



Notes

Section 8 - 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.

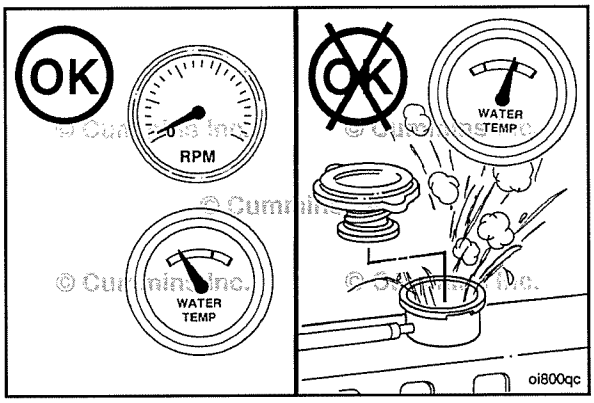
Cooling System

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.

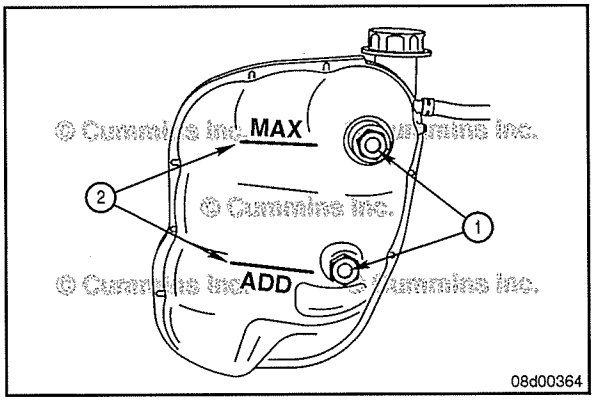


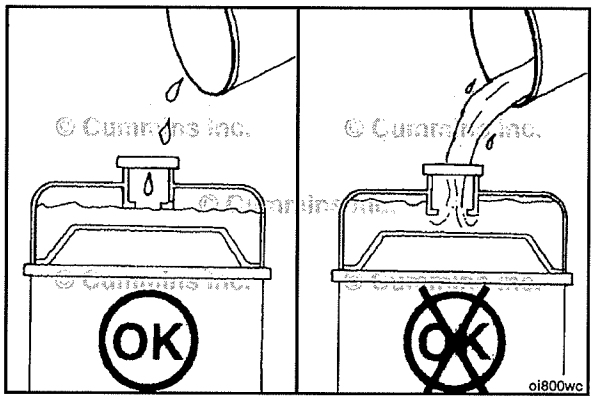
⚠CAUTION⚠
Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool below 50°C [120°F] before adding coolant.

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 "auxilary tanks", are made of a clear material (**not** shown) to aid in checking the coolant level (2) without removing the radiator cap.

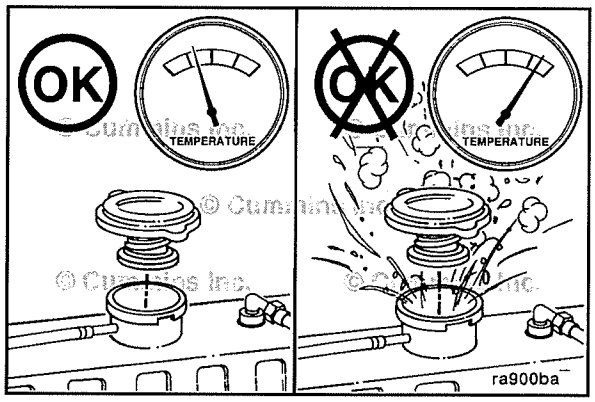
It is important to understand the impact of temperature on the expansion of the coolant. Most "top tanks" do **not** have a provision for a "FULL HOT" coolant level. Filling the "top tank" while hot will result in a low operating level once the system has cooled.





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.



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 original equipment manufacturer (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.

Refer to 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.

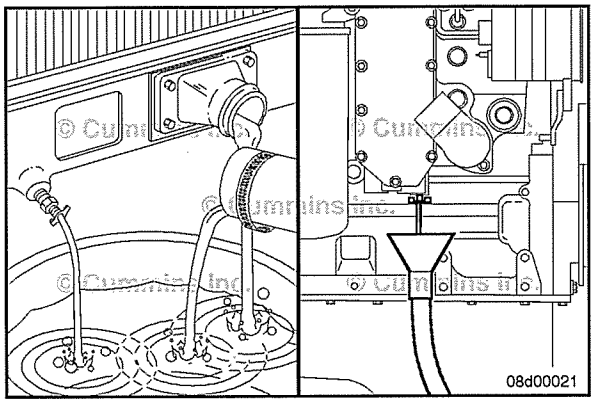
Remove all cooling system fill caps to allow the coolant to drain completely.

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

NOTE: If the coolant will be reused, drain the coolant into a clean container. Cover the container to reduce the possibility of coolant contamination after draining.

Drain the cooling system by opening the drain valve on the radiator and by 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.

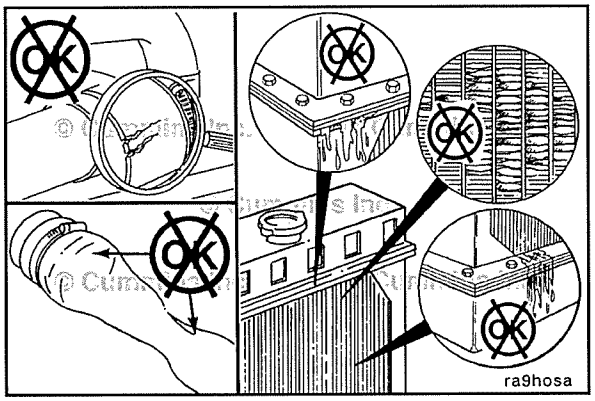
After the cooling system is completely drained, close the drain valves. Refer to the OEM service manual for complete cooling system drain information.



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

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

Clean and replace as required.



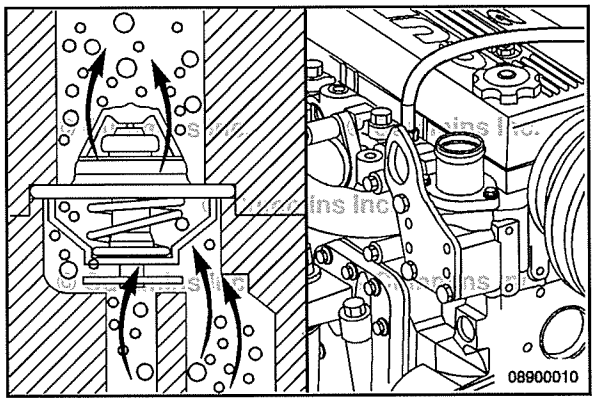
Flush

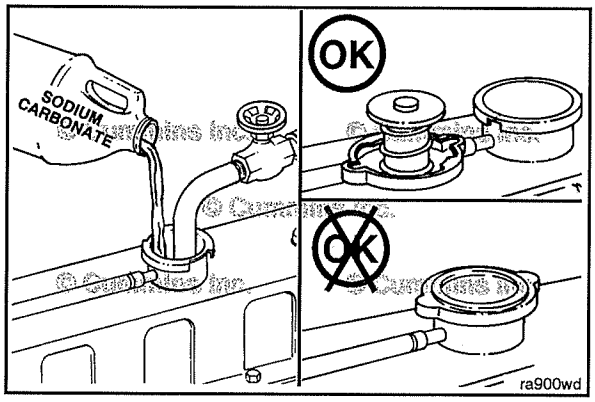
⚠CAUTION⚠
The system must be filled properly to prevent air locks or serious engine damage can result. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

To be sure air is vented during the fill process:

- Some thermostats 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 maximum 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 the surge tank or radiator while operating the engine with the pressure cap OFF. If the vehicle is equipped with fill door on the side of the surge tank, keep it closed due to coolant expansion.

⚠ CAUTION ⚠
Do not operate the engine with the pressure cap off at temperatures above 93°C [200°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. Refer to 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 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 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 2 minutes before shutting it down. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

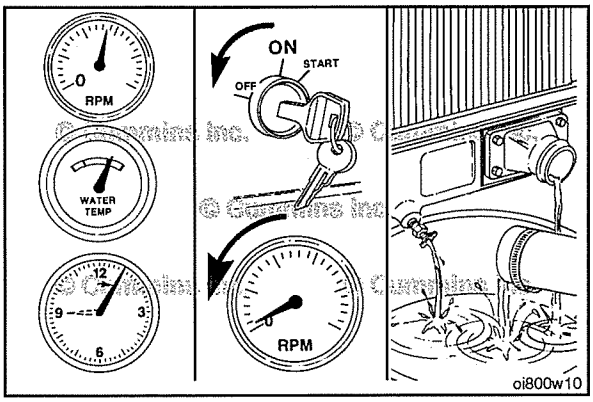
Shut the engine OFF and check the coolant level according to the OEM service manual recommendations and add coolant, if necessary, to bring it back to the FULL level.

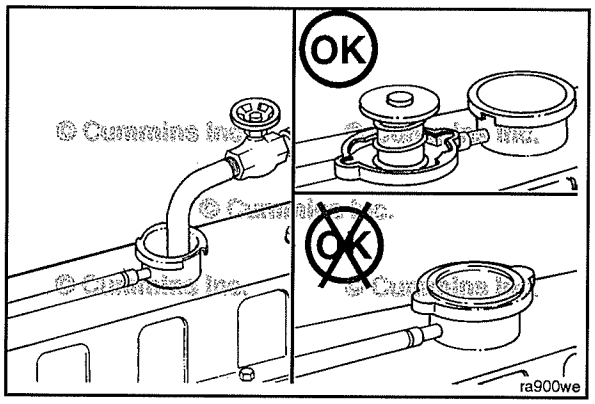
Install the cooling system fill cap.

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 engine with pressure cap off. If the vehicle is equipped with a fill door on the side of the surge tank, keep it closed due to coolant expansion.

△CAUTION△
Do not operate the engine with the pressure cap off at 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
- Shut the engine OFF and add plain water to bring the level back to FULL.

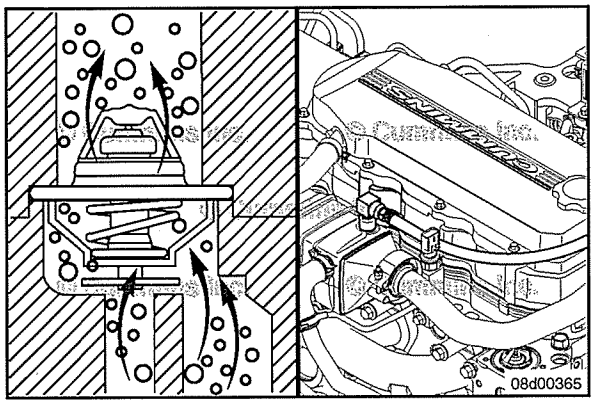
With the cooling system fill cap removed:

- 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 2 minutes before shutting it down. This allows adequate cooldown of pistons, cylinders, bearings, and turbocharger components.

Fill

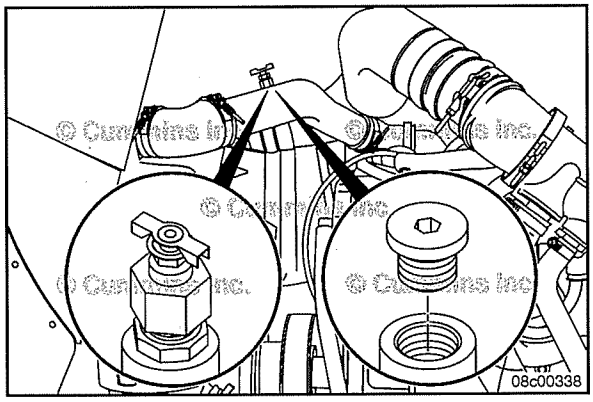


⚠CAUTION⚠
The system must be filled properly to prevent air locks or serious engine damage can result. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

Make sure air is vented during the fill process:

- Some thermostats 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.

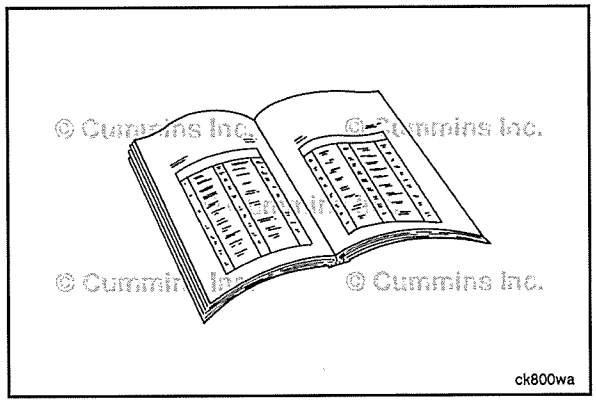
The system has a design maximum fill rate of up to 19 liters [5 gal] per minute.



NOTE: Some applications may be equipped with a manual bleed valve which is to be opened to make sure of a proper fill. The upper radiator pipe is a common location for bleed valves. The illustration is for reference **only**.

If applicable, open the manual bleed valve before filling the cooling system.

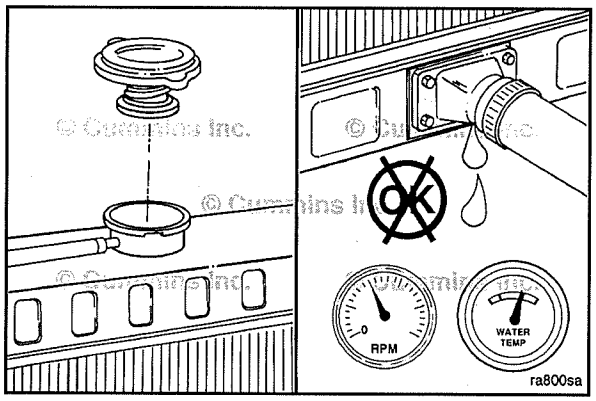
Once properly filled, make sure to close the manual bleed valve.



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

For engine coolant specifications. Refer to Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.

NOTE: If the coolant is reused, it should be inspected for signs of contamination.



⚠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 the side of the surge tank, keep it closed due to coolant expansion.

△CAUTION△
Do not operate the engine with the pressure cap off at 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 ensure 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 coolant. Closing the cooling system while hot will not allow 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.

Sequence of Events for Coolant Fill and Deaeration

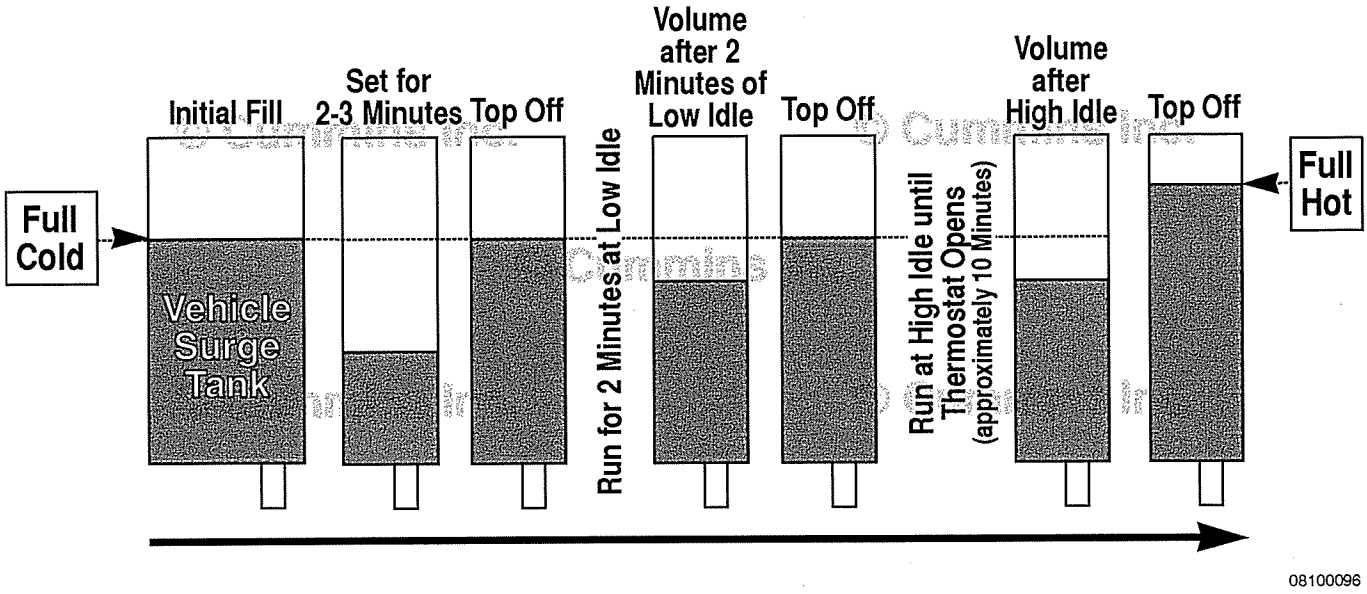


Figure 1: Sequence of Events for Coolant Fill and Deaeration.

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 coolant level to stabilize.

Add a 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 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 a 50/50 mixture.

With the radiator pressure cap off:

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.

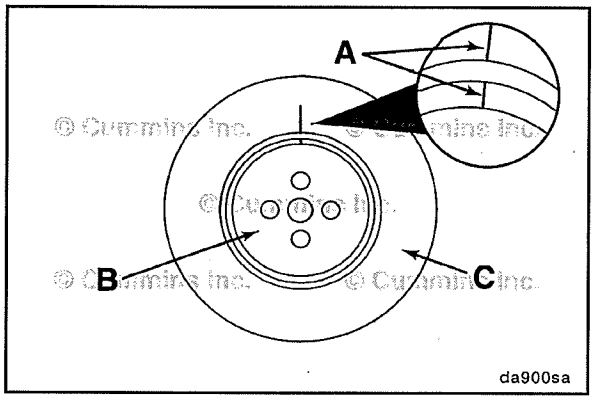
Allow the engine to idle 2 minutes before shutting it down. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

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

Allow the engine to cool to 50°C [122°F], then 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.

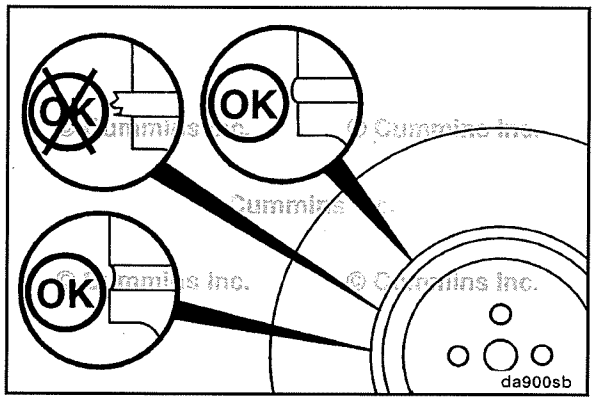


Vibration Damper, Rubber

Inspect for Reuse

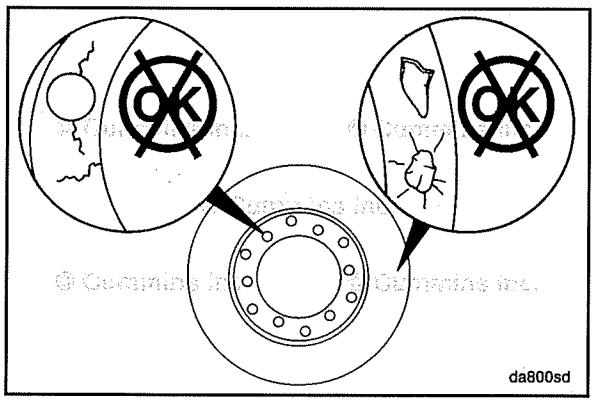
Check the index lines (A) on the damper hub (B) and the inertia member (C). If the lines are more than 1.59 mm [1/16 in] out of alignment, replace the damper.

Inspect the vibration damper hub (B) for cracks. Replace the damper if the hub is cracked.



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.

NOTE: Also look for forward movement of the damper ring on the hub. Replace the damper if any movement is detected.



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).

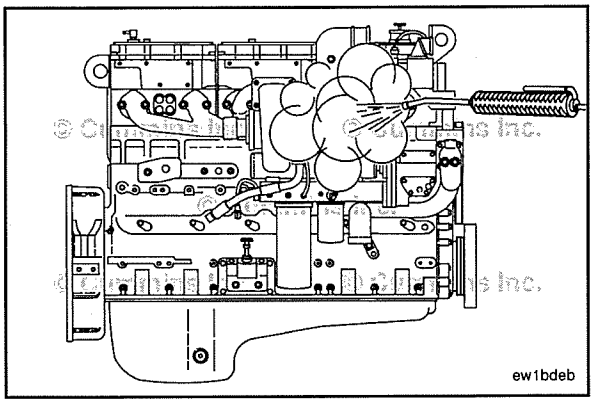
Engine Steam Cleaning

Clean

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

Steam is the best method of cleaning a dirty engine or a piece of equipment. If steam is **not** available, use a solvent to wash the engine.

Protect all electrical components, openings, and wiring from the full force of the cleaner spray nozzle.



Air Compressor Discharge Lines

General Information

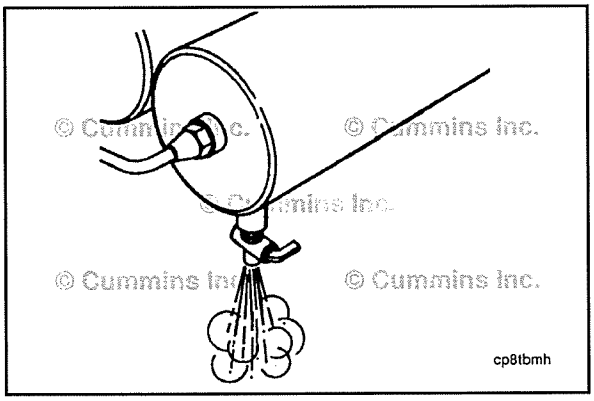
All air compressors have a small amount of lubricating oil carryover that lubricates the piston rings and moving parts. When this lubricating oil is exposed to normal air compressor operating temperatures over time, the lubricating oil will form varnish or carbon deposits. If the following maintenance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

Maintenance Check

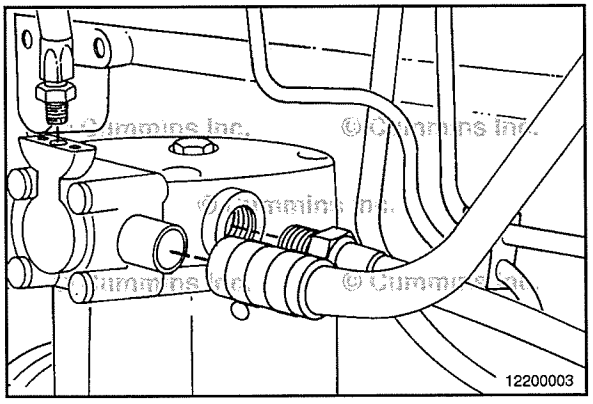
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

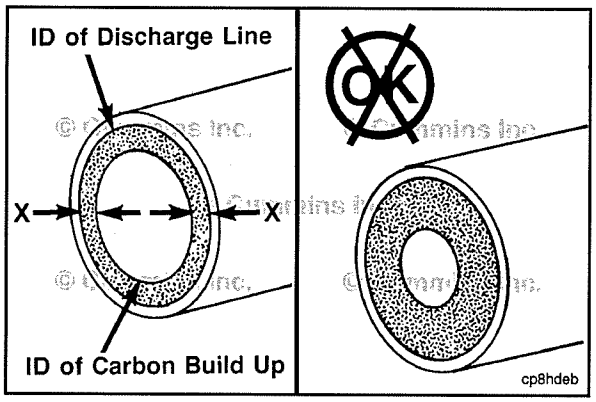
Shut off the engine.

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

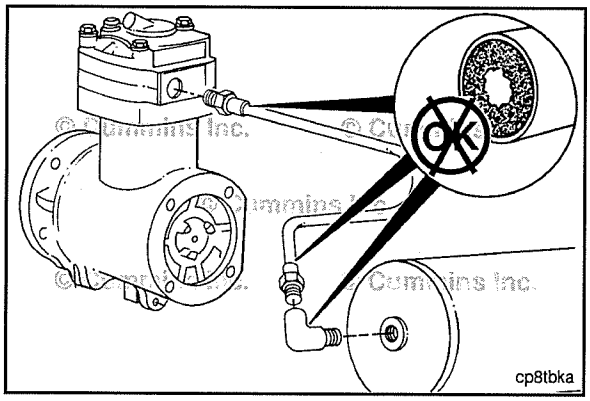


Remove the air compressor discharge line from the air compressor. Location of the air compressor discharge line can be found in Flow Diagram, Compressed Air System in System Diagrams (Section D).

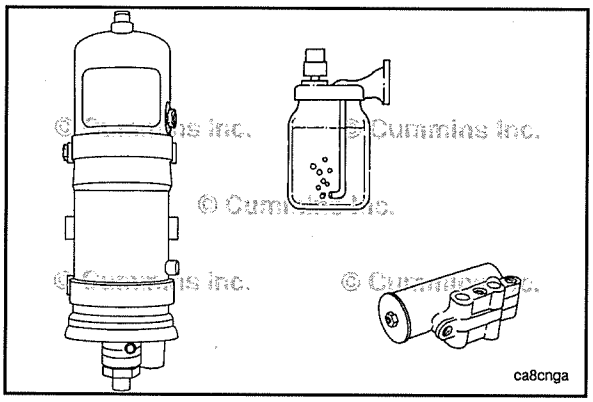




Measure the total carbon deposit thickness inside the air discharge line as shown. If the total carbon deposit (X + X) exceeds 2 mm [1/16 in], clean and inspect the cylinder head, the valve assembly, and the discharge line. Replace if necessary. Contact the Cummins Authorized Repair Location for procedures.



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.

Section 9 - Maintenance Procedures at 4500 Hours or 3 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.

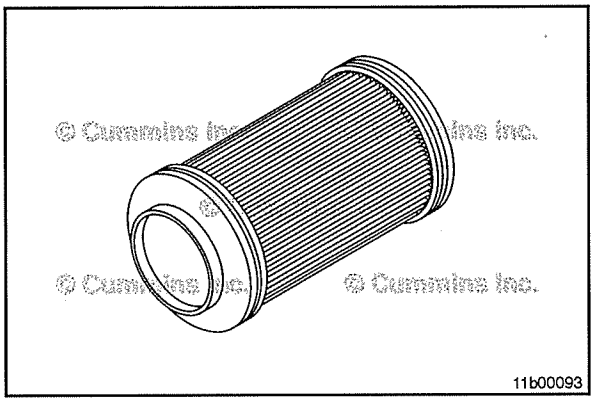
Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter

General Information

The diesel exhaust fluid (DEF) dosing unit filter is designed to prevent foreign objects that may be suspended in the DEF from entering the dosing system.

Debris can cause permanent damage and premature failure to either the aftertreatment DEF dosing unit or the aftertreatment DEF dosing valve. The aftertreatment DEF dosing unit filter is a maintenance item.

For handling incorrect or contaminated DEF, contact a Cummins® Authorized Repair Location.

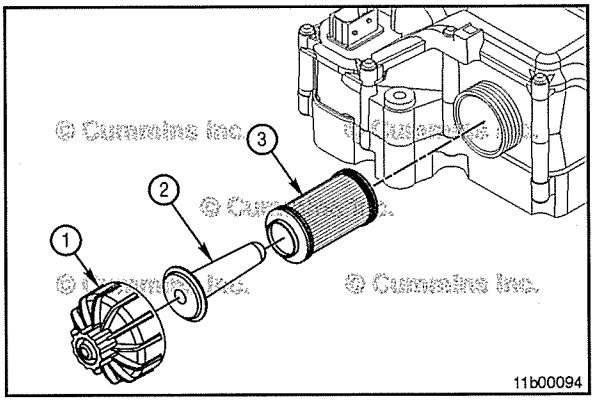


The aftertreatment DEF dosing unit filter consists of the following components:

1 Aftertreatment DEF dosing unit filter cap

2 Aftertreatment DEF dosing unit filter equalizing element

3 Aftertreatment DEF dosing unit filter element.



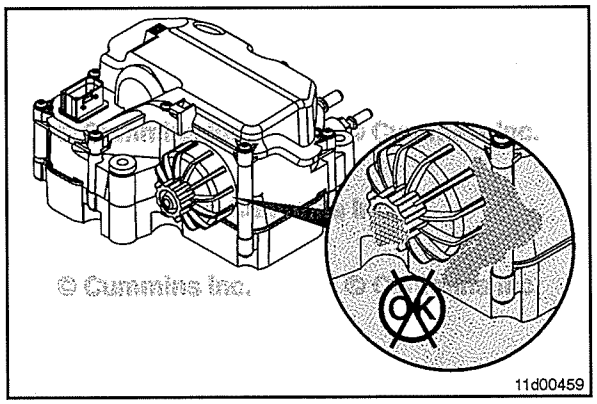
Initial Check

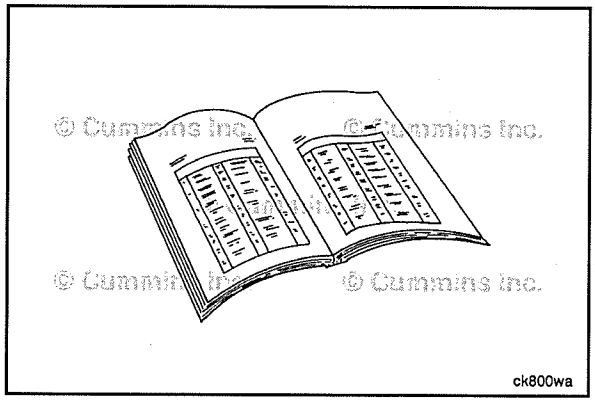
Locate the aftertreatment DEF dosing unit on the vehicle and notice the dome-shaped filter cap.

NOTE: The location of the aftertreatment DEF dosing unit varies on vehicles. Locate the DEF tank and follow the DEF lines to the aftertreatment DEF unit.

Inspect the area around the seal and vent of the aftertreatment DEF dosing unit filter cap for signs of leakage.

DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section in this procedure.





Preparatory Steps

⚠WARNING⚠
Diesel exhaust fluid (DEF) contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow. In the event the DEF is ingested, contact a physician immediately. Reference the Materials Safety Data Sheet (MSDS) for additional information.

⚠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⚠
The diesel exhaust fluid (DEF) line connecting the aftertreatment DEF dosing unit to the aftertreatment DEF dosing valve is under low pressure and should not be disconnected while the engine is running or before the system has completed the purge process after engine shutdown. Disconnecting the DEF line while under low pressure could cause DEF to spray.

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

NOTE: Do **not** disconnect the vehicle batteries until the DEF dosing system has completed the purge cycle. Before beginning to remove and/or disconnect any components, wait at least five minutes after the keyswitch is turned OFF for the aftertreatment DEF dosing system to purge the DEF from the system. The purge cycle is an automatic process and does **not** require intervention to occur. The aftertreatment DEF dosing unit will create an audible pumping noise during the purging process

NOTE: Do **not** power wash or steam clean this unit. Use compressed air to remove any loose debris.

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

Remove

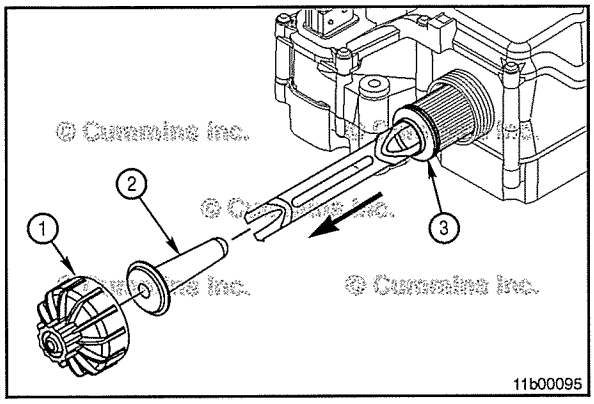
NOTE: There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

Unscrew the DEF filter cap (1). A 27 mm wrench can be used on the cap to aid in removal.

Remove the aftertreatment DEF filter equalizing element (2).

Remove the old aftertreatment DEF dosing unit filter element (3). A disposable service tool is included with the filter to aid in filter removal. Use the appropriate end of the tool, depending on the color of the plastic on the filter. When inserting the tool, a "click" sound can be heard which indicates proper engagement with the filter.

NOTE: If the filter element and equalizing element are removed from the aftertreatment DEF dosing unit, they **must** be discarded and replaced; regardless of condition.



Clean and Inspect for Reuse

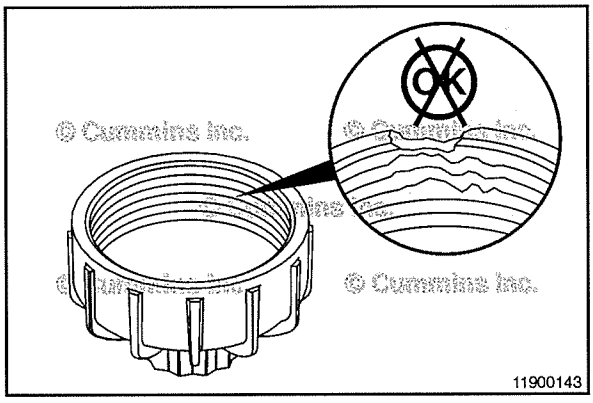
Inspect the aftertreatment DEF dosing unit filter cap for cracks or holes that could create a DEF leak path.

Check the condition of the threads on the aftertreatment DEF dosing unit cap.

If the threads are damaged, replace the aftertreatment DEF dosing unit filter cap.

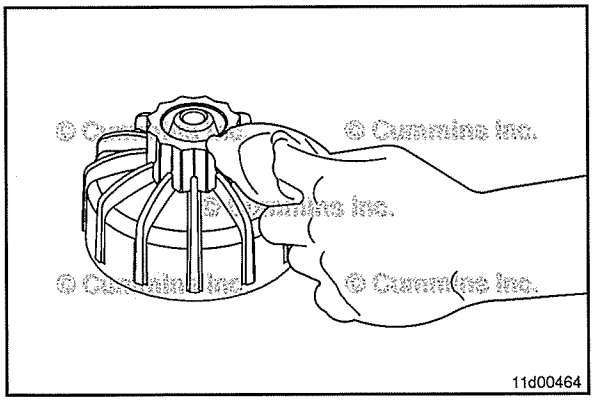
Inspect the aftertreatment DEF dosing unit threads. This is especially important if the aftertreatment DEF dosing unit cap was damaged.

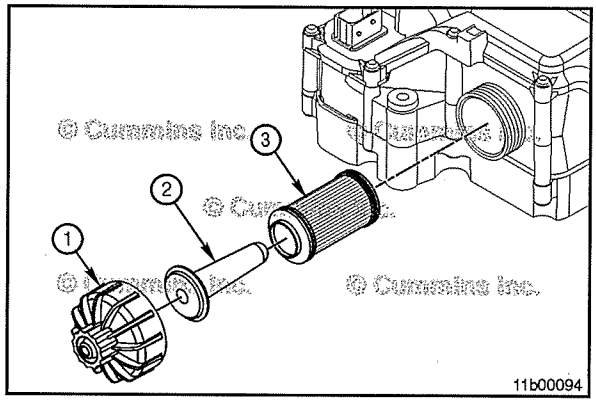
If the aftertreatment DEF dosing unit threads are damaged, replace the entire aftertreatment DEF dosing unit.



NOTE: Never operate the vehicle with the DEF cap removed.

Clean the aftertreatment DEF dosing unit cap and threads on the dosing unit with warm water and a clean cloth.





Install

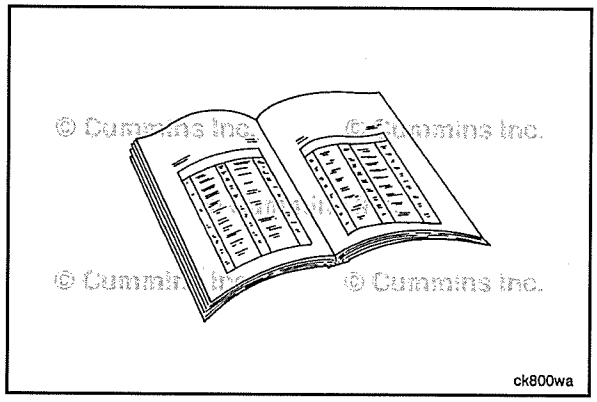
NOTE: Lubrication of the DEF filter o-rings is **not** required.

Slide the DEF filter equalizing element (2) into the DEF filter cartridge (3).

Insert the assembly into the aftertreatment DEF dosing unit.

Install and tighten the cap (1). A 27 mm wrench can be used to install and tighten the filter cap.

Torque Value: 20 N•m [177 in-lb]



Finishing Steps

⚠WARNING⚠

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

NOTE: The aftertreatment DEF dosing system will **not** prime until the correct Selective Catalytic Reduction (SCR) temperatures are reached. To verify that there are no DEF leaks, test drive the vehicle for a minimum of 15 minutes to get the SCR system up to temperature.

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

Section 10 - Maintenance Procedures at 5000 Hours or 4 Years

Section Contents

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Maintenance Procedures - Overview

General Information

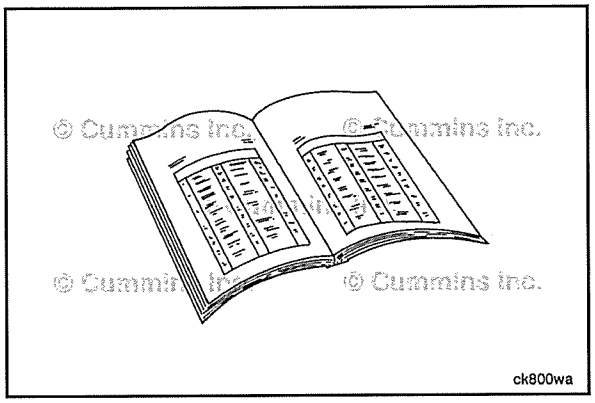
All maintenance checks and inspections listed in previous maintenance intervals **must** also be performed at this time, in addition to those listed under this maintenance interval.

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.

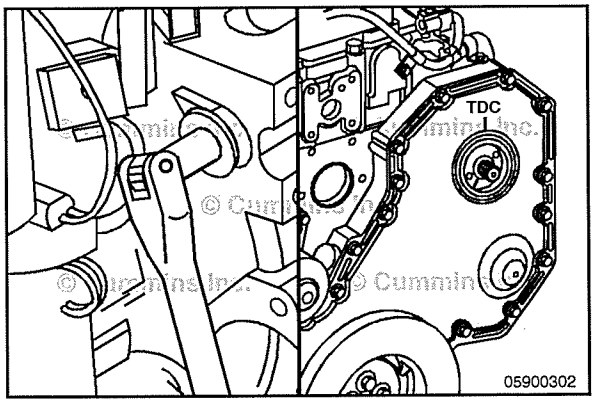
- Disconnect the battery cables. Refer to the original equipment manufacturer (OEM) service manual.
- Remove the exhaust gas recirculation (EGR) connection tube. Refer to the OEM service manual.
- Remove the plastic fuel pump drive cover located on the front of the engine.

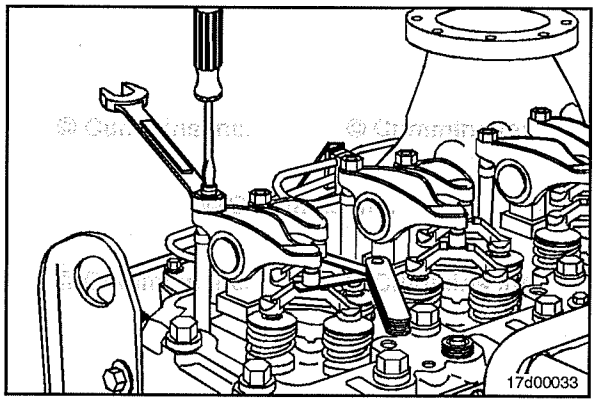


Adjust

△CAUTION△
Engine coolant temperature should be less than 60°C [140°F].

Use barring tool, Part Number 3824591 or equivalent. Rotate the crankshaft to align the top dead center marks on the gear cover and the fuel pump gear.

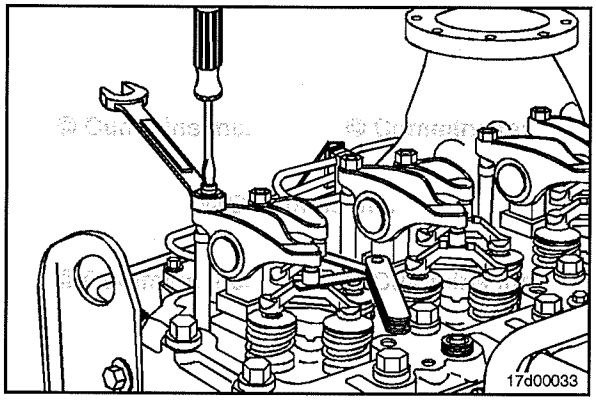




With the engine in this position, lash can be checked on the following rocker arms: 1I, 1E, 2I, 3E, 4I, and 5E.

Lash Check Limits

	mm		in
Intake	0.152	MIN	0.006
	0.559	MAX	0.022
Exhaust	0.381	MIN	0.015
	0.813	MAX	0.032



Measure lash by inserting a feeler gauge between the crosshead and the rocker lever ball insert and socket while lifting up on the end of the rocker arm. If the lash measurement is out of specification, loosen the locknut and adjust the lash to the nominal specification.

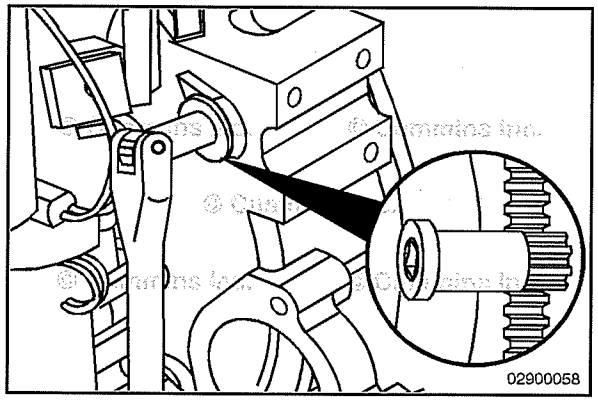
Lash Reset Specifications

	mm		in
Intake	0.305	NOM	0.012
Exhaust	0.559	NOM	0.022

NOTE: Lash resets are **only** required at the interval specified in the appropriate owner's or operation and maintenance manual when lash is measured and found out of specification, or when engine repairs cause removal of the rocker arms and/or loosening of the adjusting screws.

Tighten the locknut and measure again.

Torque Value: 24 N•m [212 in-lb]



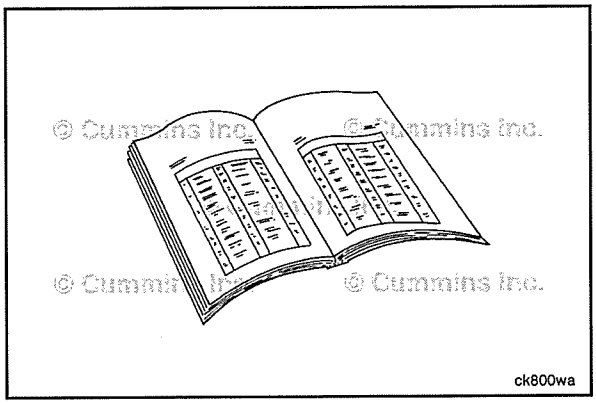
Use the barring tool, Part Number 3824591 or equivalent, and rotate the crankshaft 360 degrees and measure lash for rocker arms 2E, 3I, 4E, 5I, 6I, and 6E. Reset the lash, if out of specification.

Finishing Steps



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

- Install the EGR connection tube. Refer to the OEM service manual.
- Install the plastic fuel pump drive cover located on the front of the engine.
- Connect the battery cables. Refer to the OEM service manual.
- Operate the engine and check for leaks.



Engine Brake

Preparatory Steps

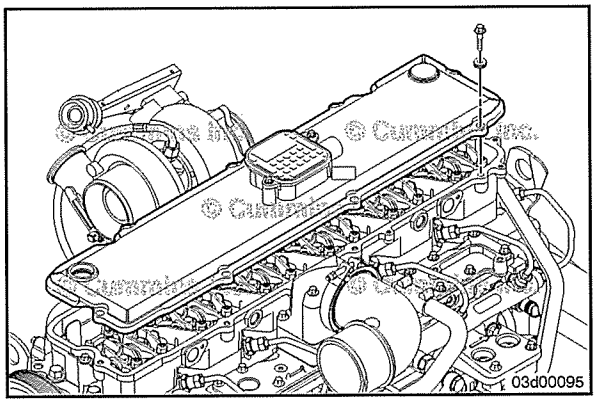
Remove the crankcase breather tube, rocker lever cover mounted breather **only.**

Remove the variable geometry turbocharger actuator air supply line, if equipped.

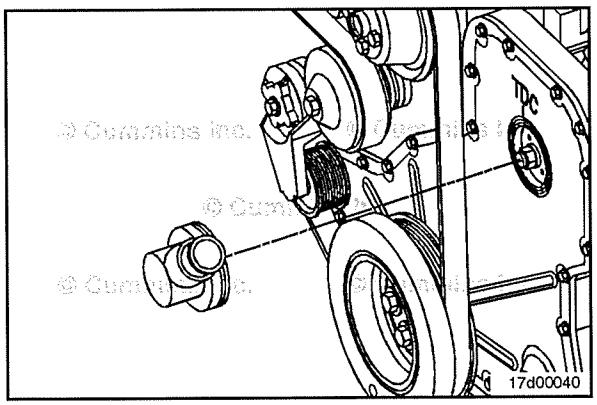
Remove the capscrews.

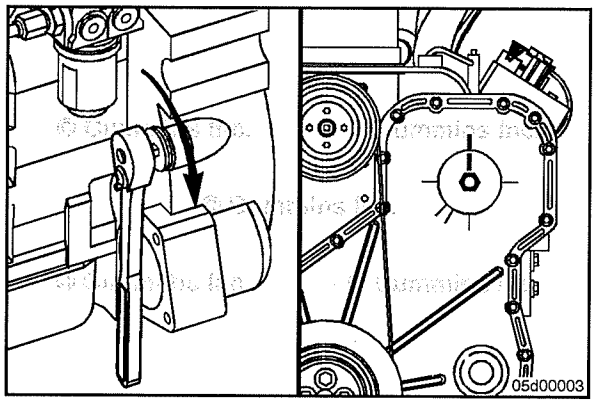
Remove the rocker lever cover and gasket.

NOTE: Rocker lever cover configurations will be different based upon if the cover is center bolted or perimeter bolted. The rocker lever cover can also be taller if the engine is equipped with engine brakes.



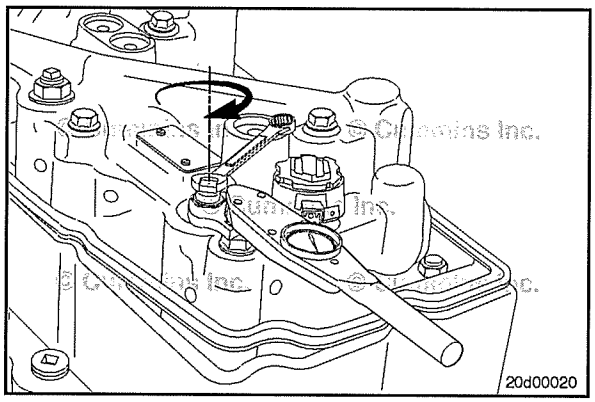
Remove the plastic fuel pump drive cover located on the front of the engine.





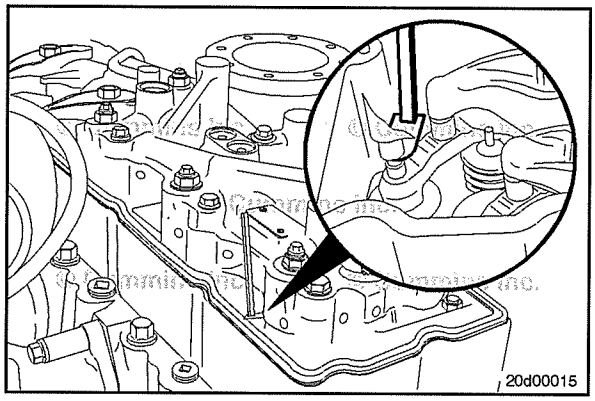
Adjust

Usie the barring tool, Part Number 3824591, to rotate the crankshaft to align the mark on the fuel pump gear with the top dead center mark on the gear cover.



When the engine is in the top dead center position, brake lash can be set on cylinders 1, 3, and 5.

Use two wrenches to hold the adjusting nut and loosen the lock nuts on the brake at cylinders 1, 3, and 5.

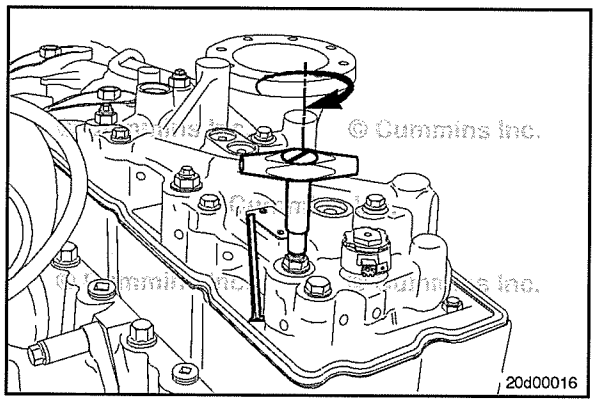


Brake Lash - Feeler Gauge Method

Insert the appropriate brake lash feeler gauge between the brake slave piston and exhaust crosshead pin on cylinder number 1.

Brake Lash - Feeler Gauge	
Tool Part Number	**Lash Specification**
3163681	2.286 mm [0.090 in]

NOTE: If the correct size feeler gauge is **not** available, there is an alternate dial indicator method for setting the brake lash following in this procedure.

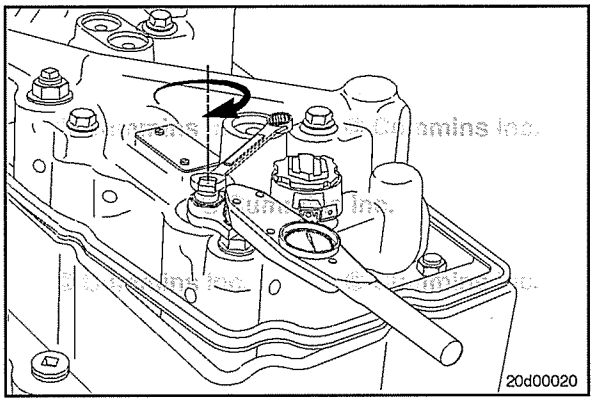


Use the 6 in-lb torque wrench, Part Number 3376592, to tighten the adjusting nut until the torque wrench clicks, or until drag is felt on the feeler gauge.

Remove the feeler gauge. Using two wrenches, hold the adjusting nut and tighten the locknut.

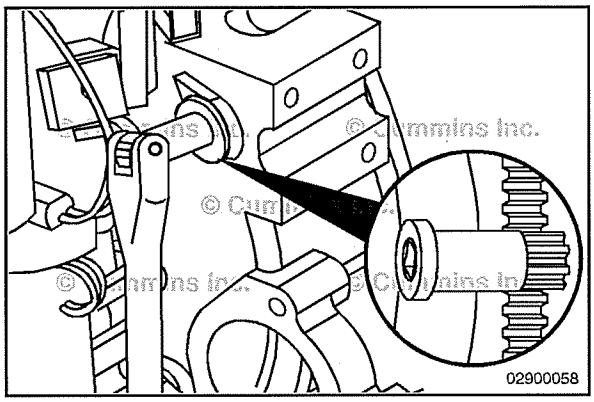
Torque Value: 35 N•m [25 ft-lb]

Repeat for cylinders 3 and 5.



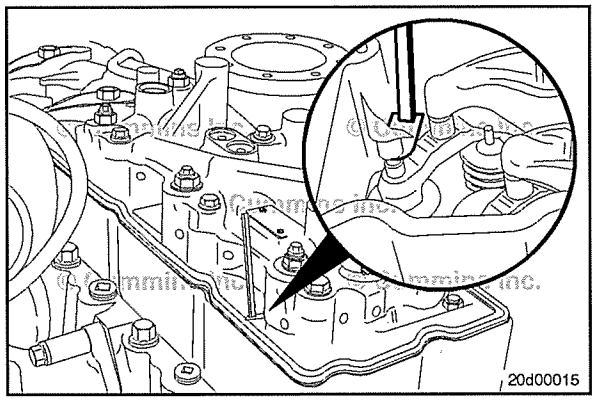
Use the engine barring tool, Part Number 3824591, to rotate the crankshaft 360 degrees to align the mark on the fuel pump gear with the mark on the gear cover that is 180 degrees away from top dead center.

When the engine is in position, brake lash can be set on cylinders 2, 4, and 6.

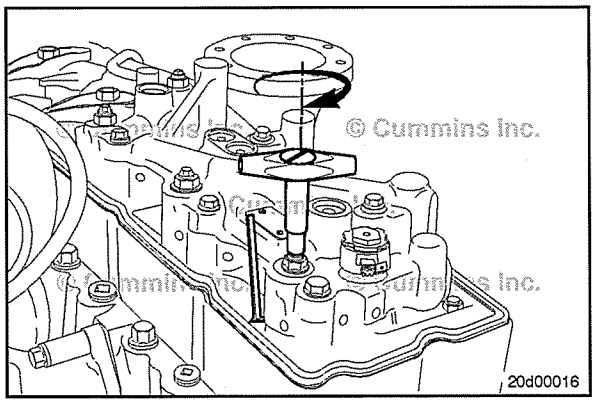


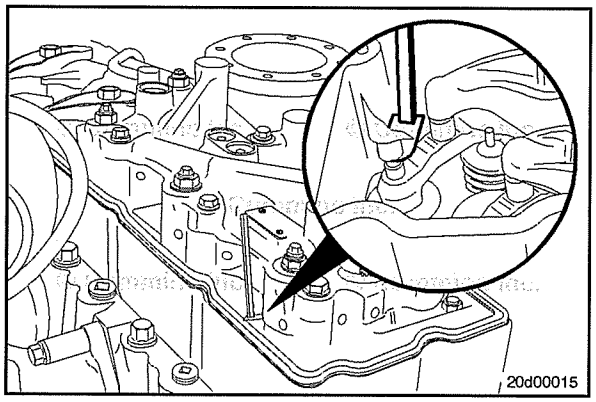
Insert the appropriate brake lash feeler gauge between the brake the brake sleeve piston and the exhaust crosshead pin on cylinder number 2.

Brake Lash - Feeler Gauge	
Tool Part Number	**Lash Specification**
3163681	2.286 mm [0.090 in]



Use the 6 in-lb torque wrench, Part Number 3376592, to tighten the adjusting nut until the torque wrench clicks, or until drag is felt on the feeler gauge.

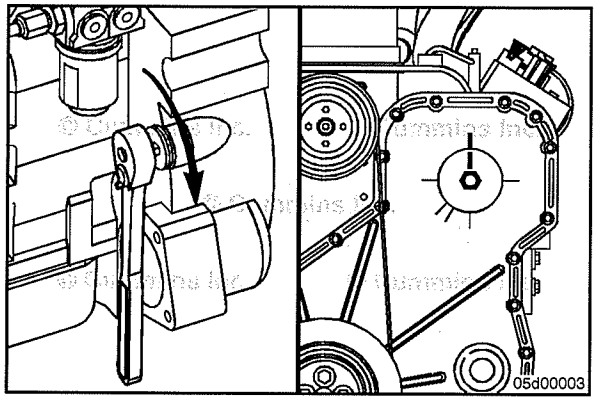




Remove the feeler gauge. Use two wrenches to hold the adjusting nut and tighten the locknut.

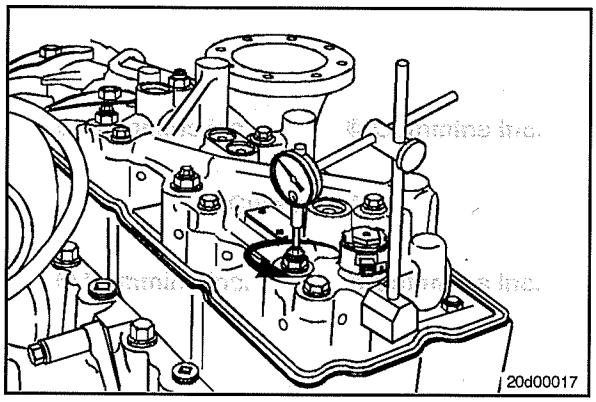
Torque Value: 35 N•m [25 ft-lb]

Repeat for cylinders 4 and 6.



The following method can be used instead of the feeler gauge method if a feeler gauge of the proper size is **not** available.

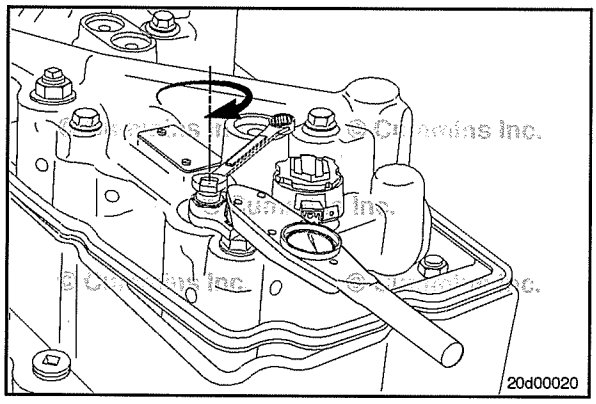
Use the barring tool, Part Number 3824591, to rotate the crankshaft to align the mark on the fuel pump gear with the top dead center mark on the gear cover.



Brake Lash - Dial Indicator

Tighten the backlash adjusting nut on cylinder 1 until resistance is felt. Place the dial indicator tip on the adjusting nut and zero the dial indicator. Turn the lash adjusting nut in a **counterclockwise** direction until the appropriate lash is reached.

Brake Lash Specification 2.286 mm [0.090 in]



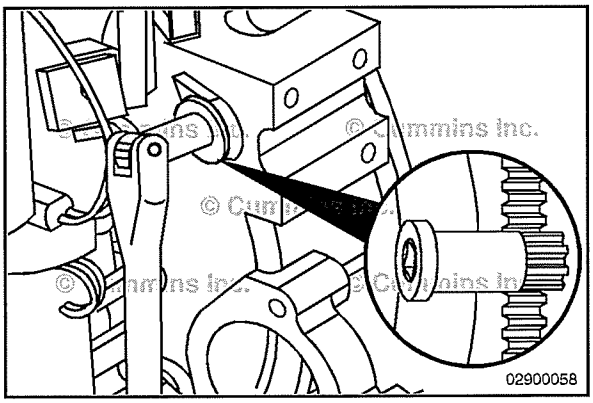
Use two wrenches to hold the adjusting nut and tighten the locknut.

Torque Value: 35 N•m [25 ft-lb]

Repeat for cylinders 3 and 5.

Use the engine barring tool, Part Number 3824591, to rotate the crankshaft 360 degrees to align the mark on the fuel pump gear with the mark on the gear cover that is 180 degrees away from top dead center.

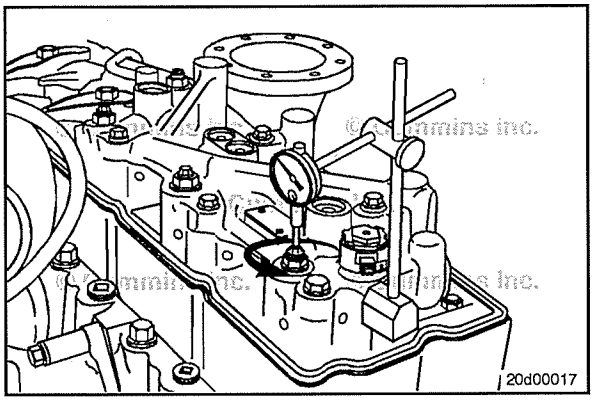
When the engine is in position, brake lash can be set on cylinders 2, 4, and 6.



Brake Lash - Dial Indicator

Tighten the backlash adjusting nut on cylinder 2 until resistance is felt. Place the dial indicator tip on the adjusting nut and zero the dial indicator. Turn the lash adjusting nut in a **counterclockwise** direction until the appropriate lash is reached.

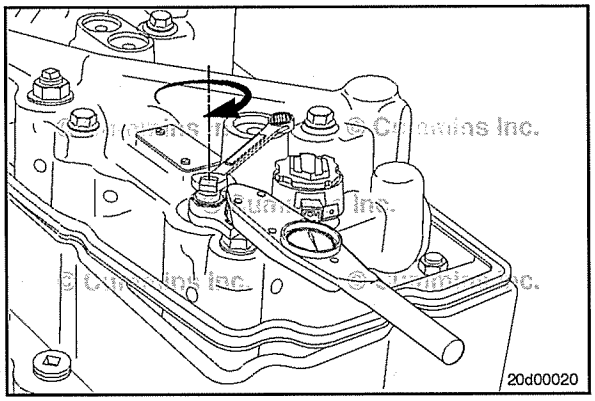
Brake Lash Specification 2.286 mm [0.090 in]



Use two wrenches to hold the adjusting nut and tighten the locknut.

Torque Value: 35 N•m [25 ft-lb]

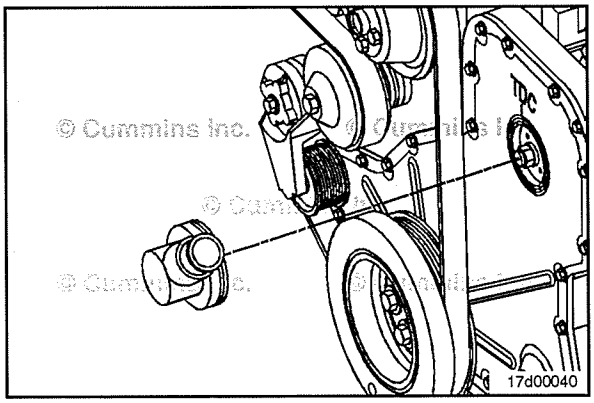
Repeat for cylinders 4 and 6.

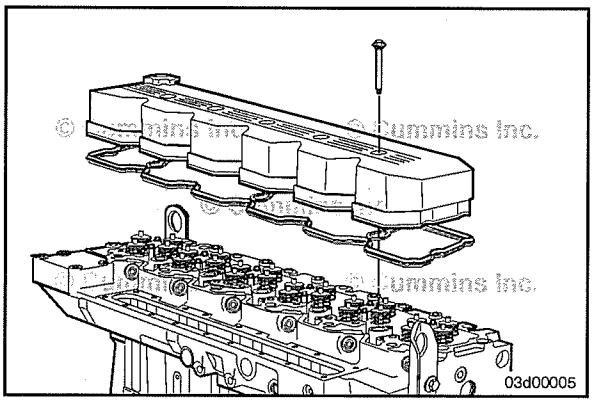


Finishing Steps

Center Bolted Rocker Lever Cover

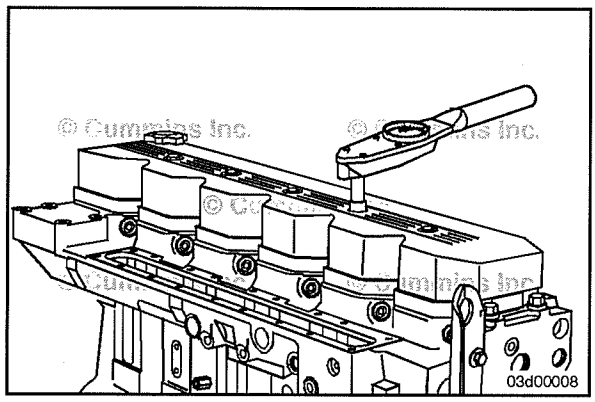
Install the plastic fuel pump drive cover located on the front of the engine





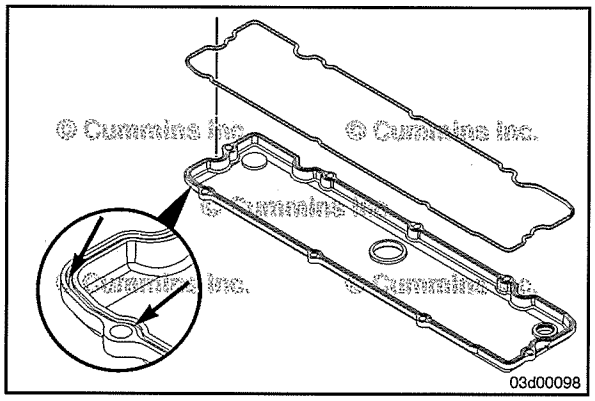
Place the gasket on the cylinder head. Be sure the gasket is properly aligned around the cylinder head capscrews.

Install the rocker lever cover and capscrews.



Tighten the capscrews.

Torque Value: 12 N•m [106 in-lb]



Perimeter Bolted Rocker Lever Cover

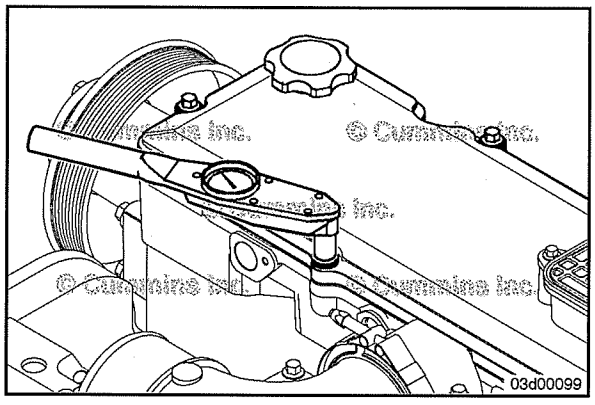
NOTE: If the gasket has been removed from the rocker lever cover, a new gasket **must** be used.

The following installation procedure **must** be used when installing the press-in gasket.

1 Press the molded gasket into the corners of the rocker lever cover.

2 Press the gasket around the capscrew mounting holes.

3 Press the remaining gasket into the rocker lever cover.



Install the rocker lever cover and capscrews.

Torque Value: 12 N•m [106 in-lb]

Install the crankcase breather tube, rocker lever cover mounted breather **only**.

Install the variable geometry turbocharger actuator air supply line, if equipped.

Section A - Adjustment, Repair, and Replacement

Section Contents

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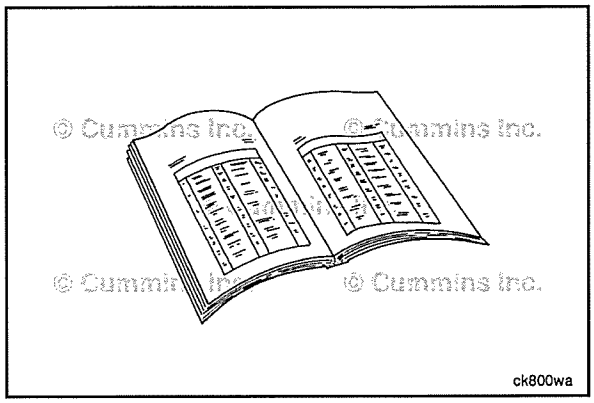
Rocker Lever Cover

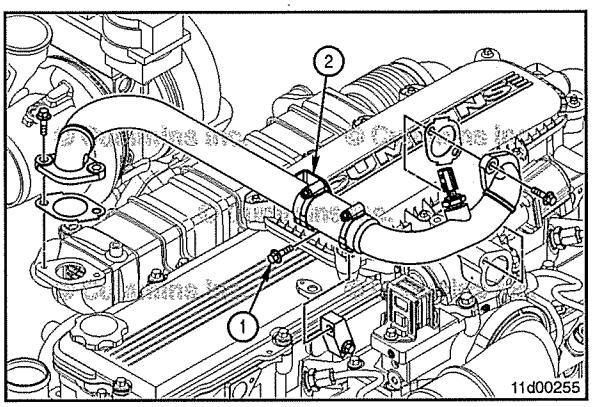
Preparatory Steps



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

Disconnect the battery cables. Refer to the original equipment manufacturer (OEM) service manual.

△CAUTION△
Do not twist or bend the EGR connection tube during removal or installation or damage to the hose can result.



Remove the capscrew (1) from the support flange of the exhaust gas recirculation (EGR) connection tube (2).

Remove the EGR connection tube by loosening the bolted flanges from both sides of the EGR connection tube.

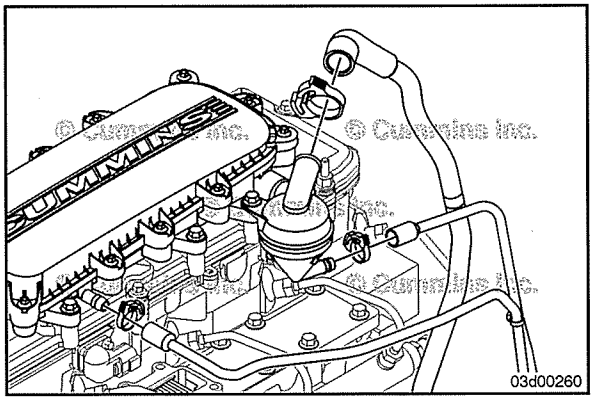
Use caution to keep debris from falling in the EGR cooler and the EGR valve when removing the EGR connection tube.

Cover all open connections with protective caps from the Air Handling Clean Care Kit, Part Number 5298776.

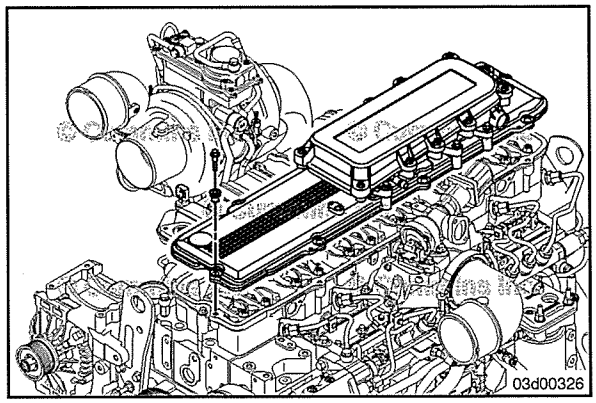
Remove the crankcase breather tube from the crankcase breather assembly.

Remove the crankcase drain lines from the crankcase breather assembly.

Remove the snapper hose clamps from the drain tube and lines.



Remove



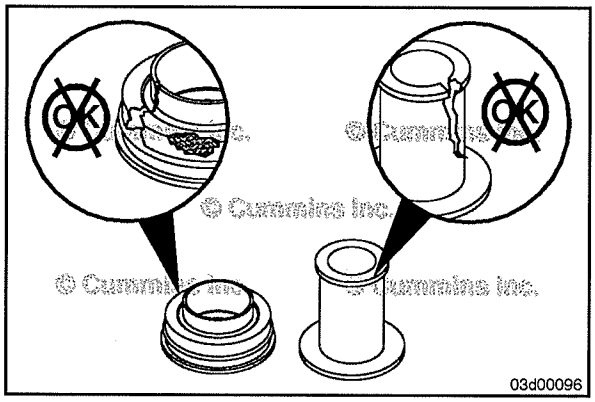
Remove the capscrews.

Remove the rocker lever cover and gasket.

NOTE: The rocker lever cover can be taller if the engine is equipped with engine brakes.

NOTE: It is **not** necessary to remove the crankcase breather in order to remove the rocker lever cover.

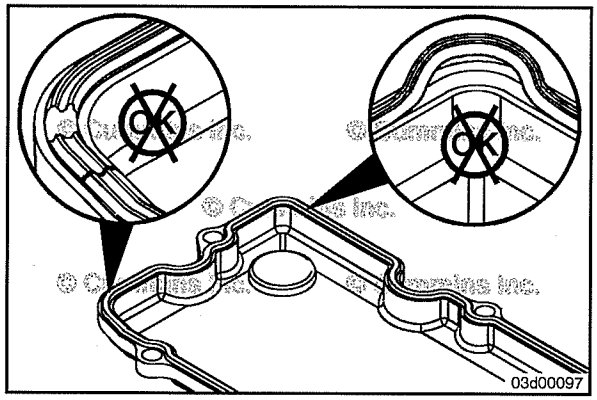
NOTE: It is **not** necessary to remove the heat shield in order to remove the rocker lever cover.



Clean and Inspect for Reuse

Check the isolators for cracks, tears, or brittleness.

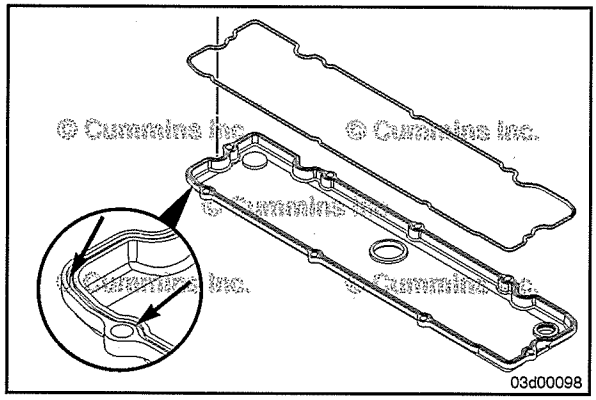
Replace the isolators if any damage is found.



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.



Install

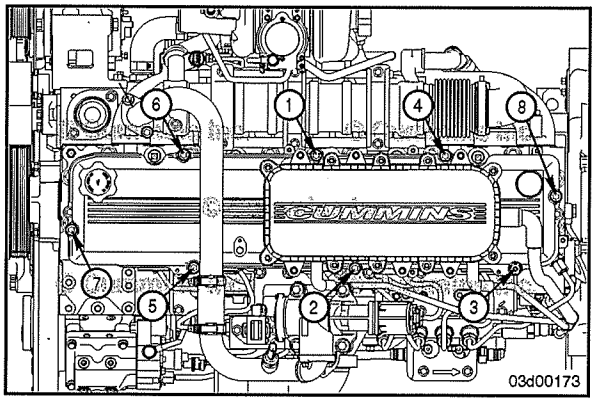
NOTE: If the gasket has been removed from the rocker lever cover, a new gasket **must** be installed.

The following installation procedure **must** be used when installing the press in gasket.

1 Press the molded gasket into the corners of the rocker lever cover.

2 Press the gasket around the capscrew mounting holes.

3 Press the remaining gasket into the rocker lever cover.



Install the rocker lever cover and capscrews.

Torque Value: 12 N•m [106 in-lb]

Tighten the capscrews in the sequence illustrated.

⚠CAUTION⚠
Do not twist or bend the EGR connection tube during removal or installation or damage to the hose can result.

Install the EGR connection tube (2) using new gaskets.

Install the capscrew and mounting capscrew (1) at the EGR cooler outlet, EGR valve inlet, and tube brace hand-tight, and check for correct alignment at all locations. Make sure the EGR crossover tube does **not** contact the rocker lever cover.

Tighten the capscrews and mounting capscrews in the following sequence:

Tighten the brace mounting capscrew.

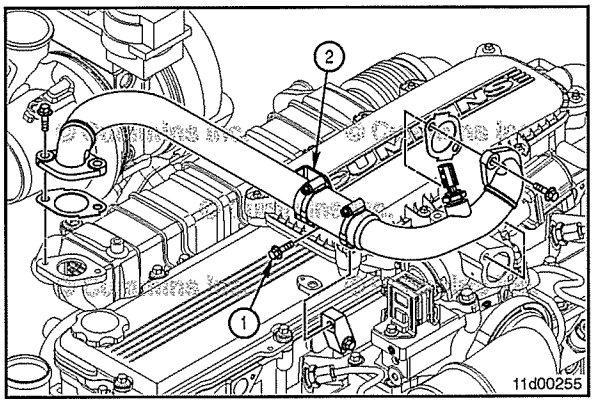
Torque Value: 24 N•m [212 in-lb]

Tighten the capscrews at the EGR cooler outlet.

Torque Value: 24 N•m [212 in-lb]

Tighten the capscrews at the EGR valve inlet.

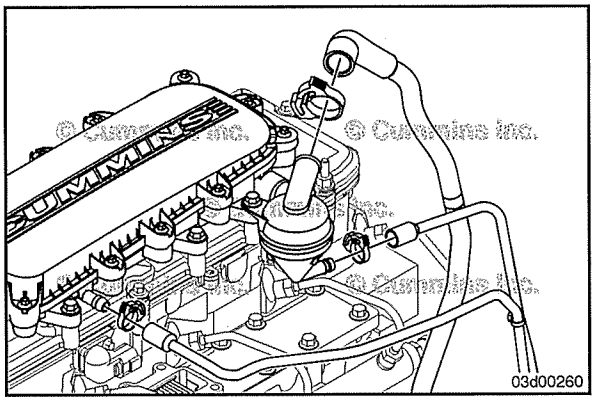
Torque Value: 24 N•m [212 in-lb]



NOTE: Make sure the crankcase breather tube or drain lines do **not** contact any high-pressure fuel lines.

Install the crankcase breather tube to the crankcase breather assembly.

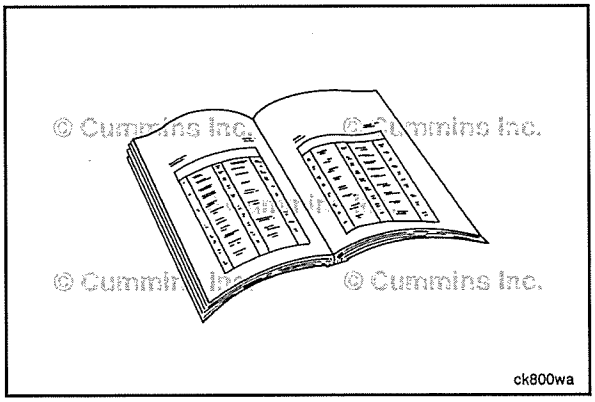
Install the crankcase drain lines to the crankcase breather assembly.

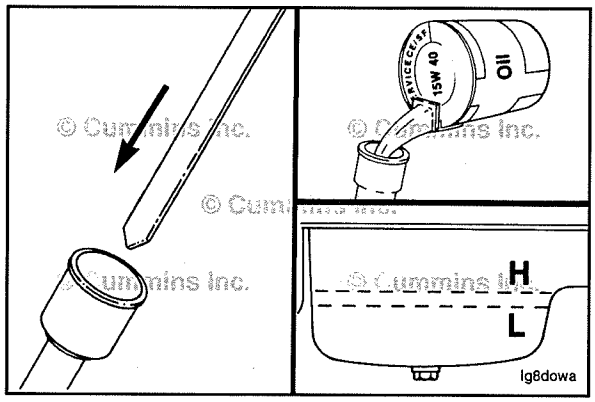


Finishing Steps

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





Lubricating Oil Dipstick

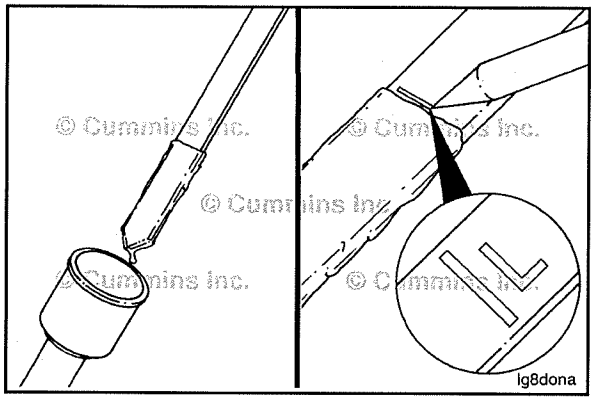
Calibrate

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

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

Install the dipstick in the dipstick tube housing.

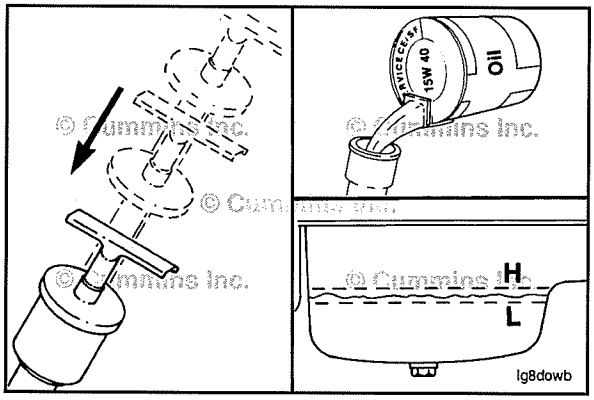
Use clean lubricating oil to fill the oil pan to the specified LOW oil level. Refer to Procedure 018-017 in Section V.



△CAUTION△
Use care when marking the dipstick. The dipstick will break if the scribe mark is too deep.

Remove the dipstick and scribe a mark across the stick at the oil level. Label the mark with an L to indicate the "LOW" oil level.

NOTE: If a new blank dipstick is being used, cut the dipstick off approximately 38 mm [1.5 in] below the LOW oil level mark.

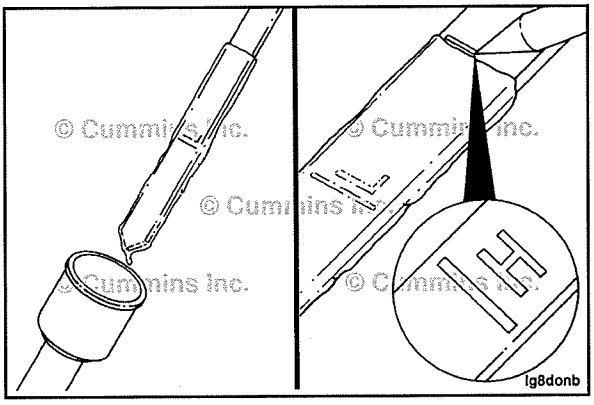


Wipe off the dipstick and install it in the dipstick tube housing.

Use clean lubricating oil to fill the oil pan to the specified HIGH oil level. Refer to Procedure 018-017 in Section V.

⚠CAUTION⚠
Use care when marking the dipstick. The dipstick will break if the scribe mark is too deep.

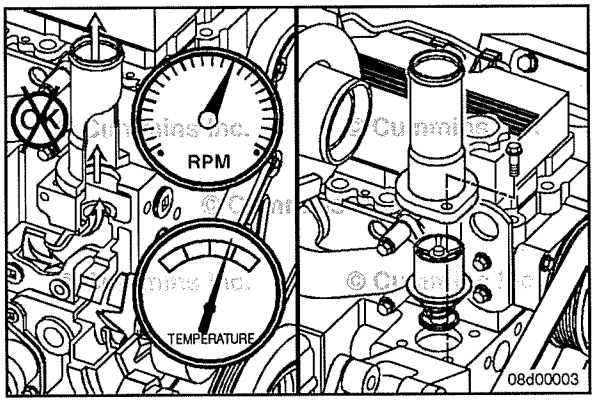
Remove the dipstick and scribe a mark across the stick at the oil level. Label the mark with an H to indicate the HIGH oil level.



Coolant Thermostat

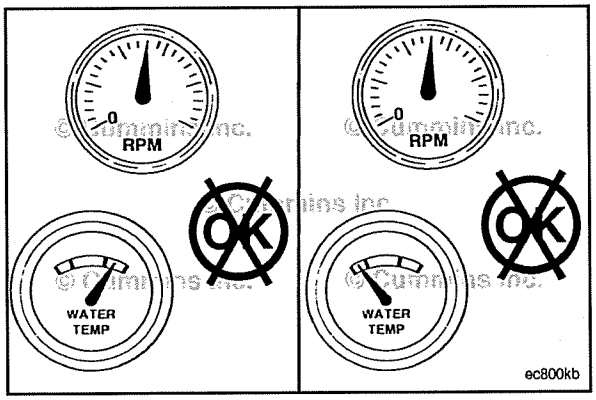
General Information

The thermostat controls the coolant temperature. When the coolant temperature is below operating temperature, coolant is bypassed to the inlet of the water pump. When the coolant temperature reaches the operating range, the thermostat opens, seals off the bypass, and forces coolant to flow to the radiator or the keel cooler on QSL9 marine engines. The thermostat begins opening at 82°C [180°F].



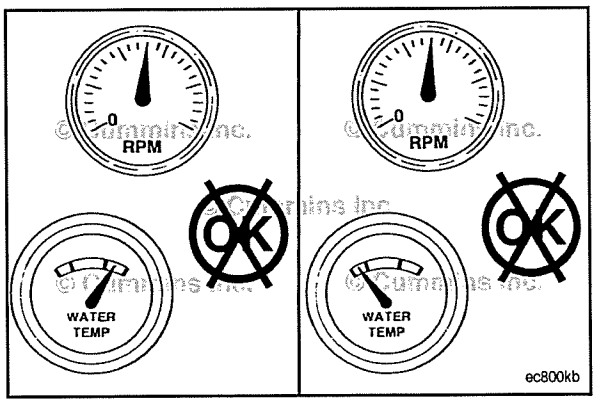
⚠CAUTION⚠
Never operate the engine without a thermostat. Without a thermostat, the path of least resistance for the coolant is through the bypass to the pump inlet. This will cause the engine to overheat.

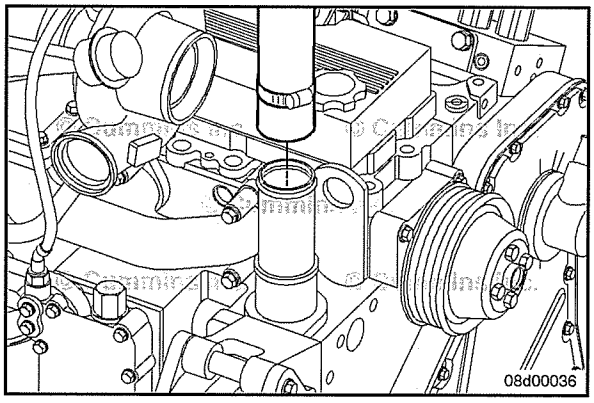
An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.



Leak Test

The engine thermostat and thermostat seal **must** operate properly in order for the engine to operate in the most efficient heat range. Overheating or overcooling will shorten engine life.





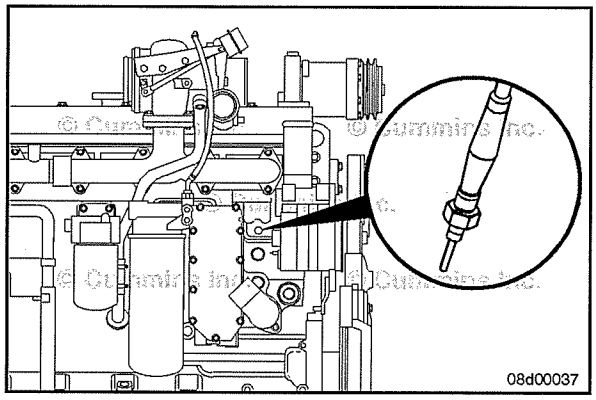
⚠WARNING⚠
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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

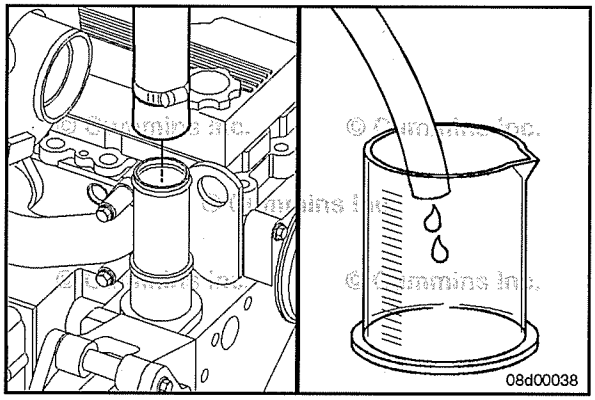
△CAUTION△
On marine engines, use caution when draining coolant that coolant is not spilled or drained into the bilge area. Do not pump the coolant overboard. If the coolant is not reused, it must be discarded in accordance with local environmental regulations.

Drain the coolant. Refer to Procedure 008-018 in Section 8.

Remove the radiator hose from the water outlet connection.



Use an electronic service tool to monitor the coolant temperature, or install a thermocouple or temperature gauge, which is known to be accurate, in the cylinder block on the engine side of the thermostat.

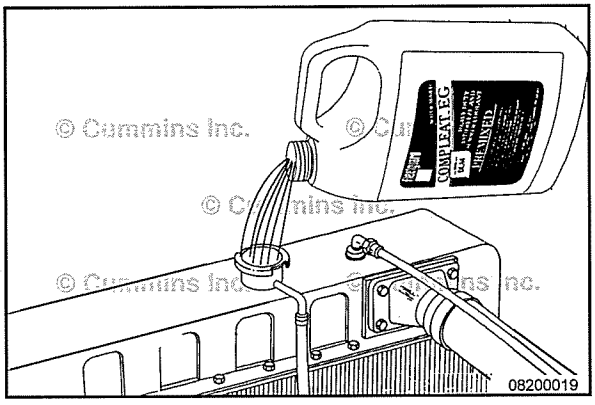


Install a hose of the same size on the water outlet connection. It must be long enough to reach a remote, dry container used to collect coolant.

Install and tighten a hose clamp on the housing outlet.

Place the other end of the hose in a dry container.

Fill the cooling system. Refer to Procedure 008-018 in Section 8.

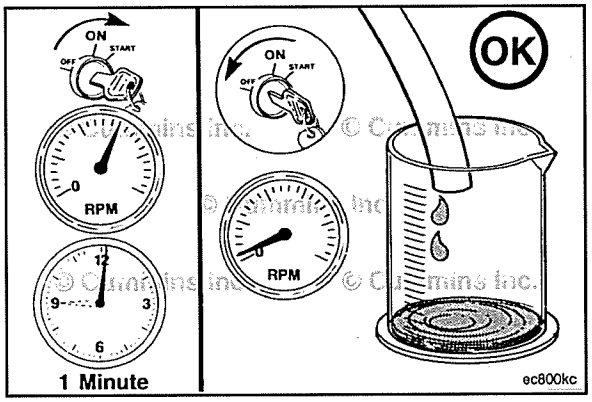


NOTE: The engine coolant temperature **must** be below the thermostat opening temperature to perform this test.

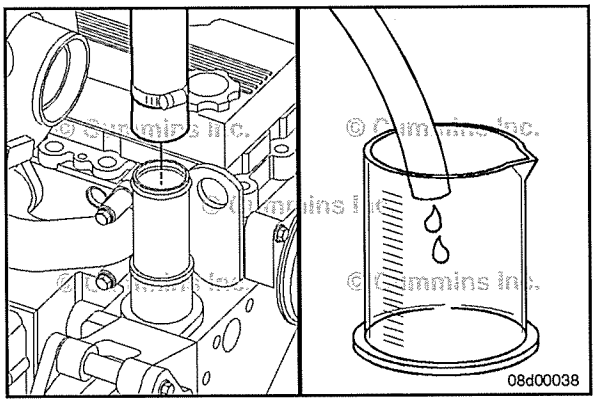
Operate the engine at rated speed for 1 minute.

Shut the engine OFF and measure the amount of coolant collected in the container.

The amount of coolant collected **must not** be more than 100 cc [3.3 fl oz].



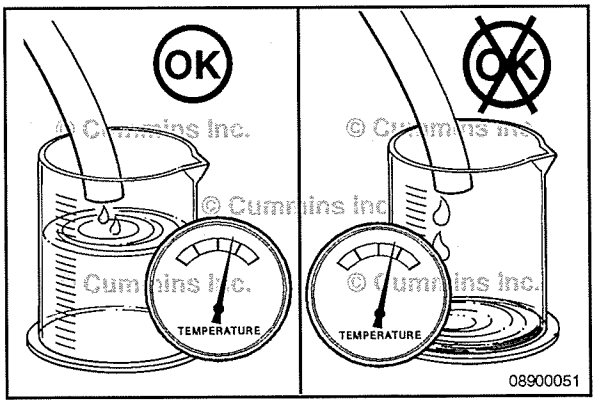
If more than 100 cc [3.3 fl oz] of coolant is collected, the thermostat is leaking and **must** be replaced.

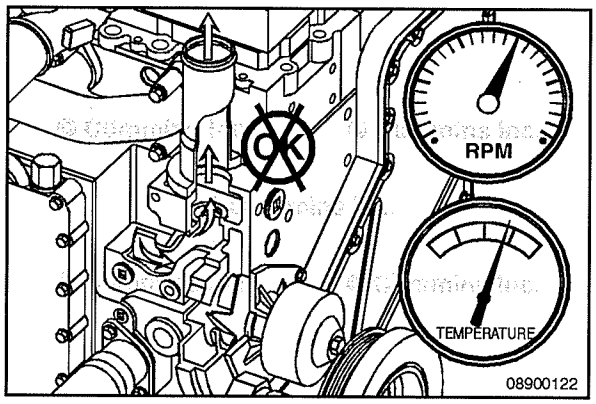


Complete the following test in-chassis to determine the thermostat opening temperature.

Start the engine and monitor the coolant temperature with INSITE™ electronic service tool or a gauge. Keep the engine speed below 1500 rpm during the test.

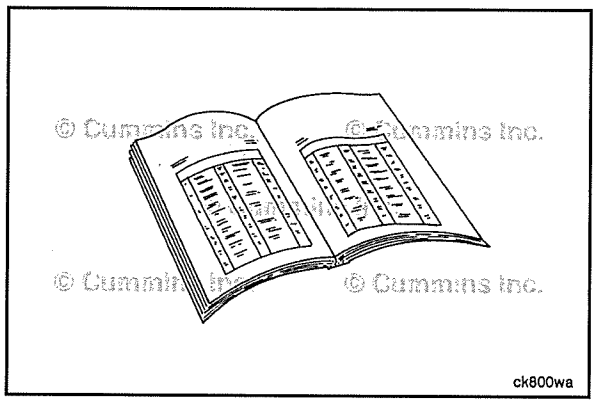
Thermostat Initial Opening Temperature		
°C		°F
79	MIN	175
83	MAX	182





Shut the engine OFF when the coolant starts to flow.

If coolant does **not** start flowing into the container during the initial opening temperature range, the thermostat **must** be replaced.



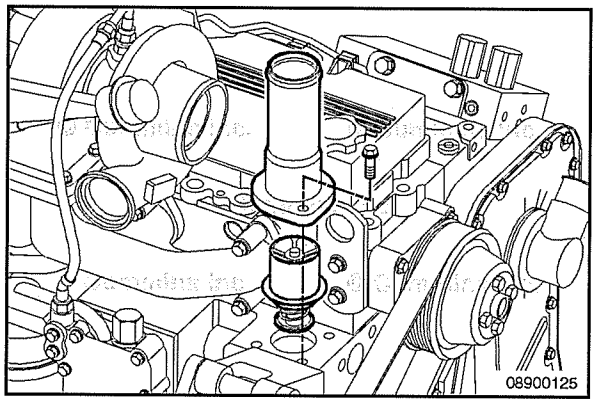
Preparatory Steps

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

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

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

- Disconnect the battery cables. Refer to the original equipment manufacturer (OEM) service manual.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the radiator hose from the water outlet connection.



Remove

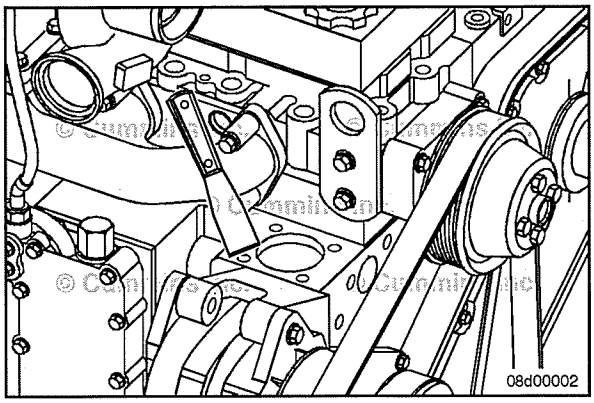
Remove the water outlet connection capscrews and water outlet connection.

Remove the thermostat.

Clean and Inspect for Reuse

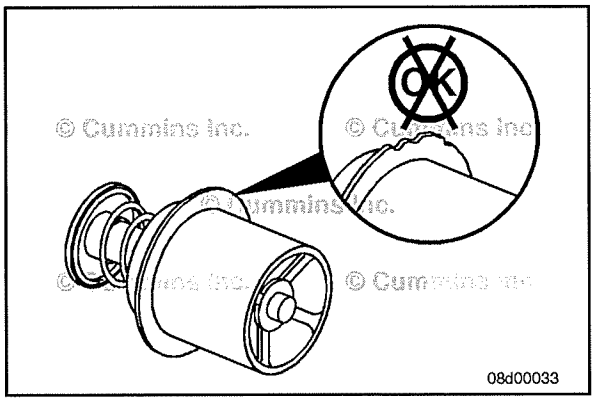
Clean all of the mating surfaces.

NOTE: Do **not** let any debris fall into the thermostat cavity when cleaning the surfaces.



Inspect the thermostat for damage.

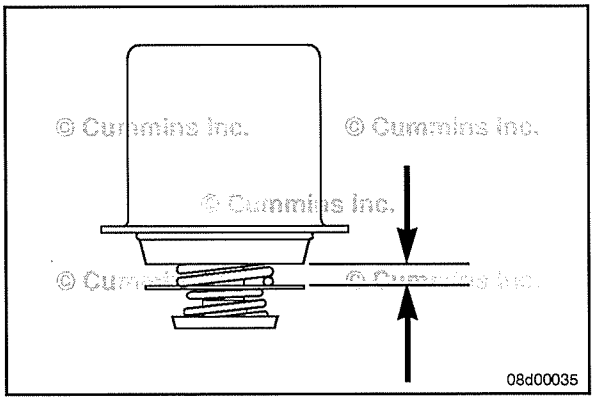
Inspect the thermostat gasket for damage. If the gasket is damaged, it **must** be replaced.



The nominal operating temperature is stamped on the thermostat. The thermostat **must** meet the following criteria:

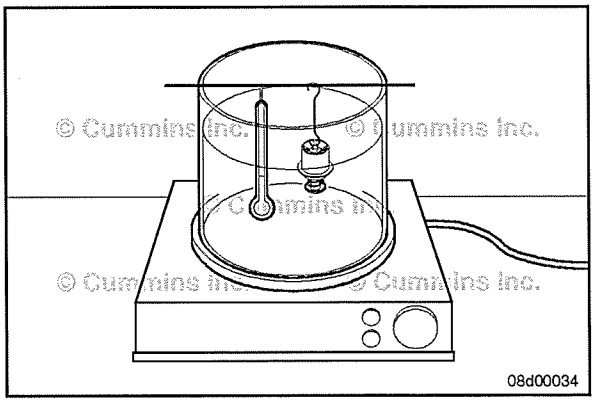
- The thermostat **must** begin to open within 1°C or 2°F of this nominal temperature.
- The thermostat **must** be fully open within 12°C or 22°F of this nominal temperature.

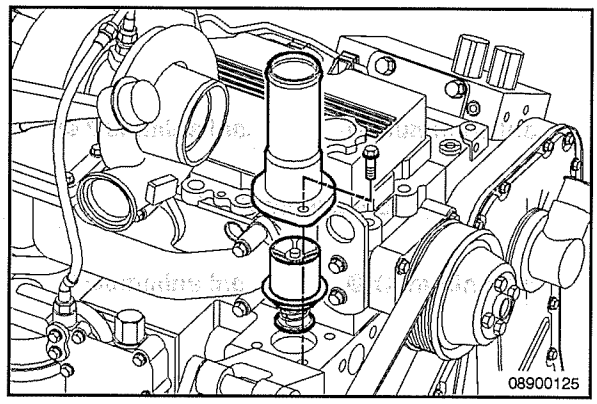
The fully open distance between the thermostat flange and housing is 10.16 mm [0.400 in].



Heat the water and check the thermostat as follows:

- Suspend the thermostat and a 100°C [212°F] thermometer in a container of water.
- Do **not** allow the thermostat or the thermometer to touch the sides of the container.





Install

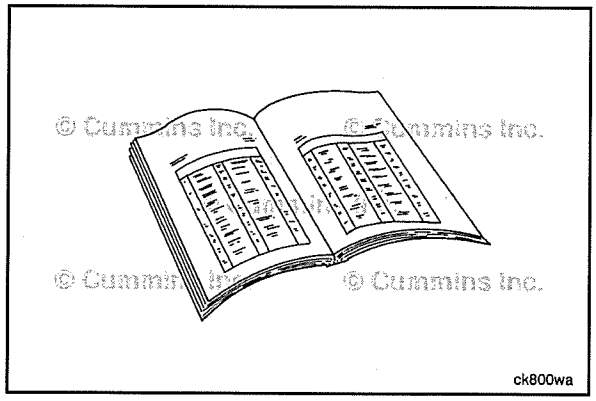
Install the new thermostat into the cylinder block.

Install a new gasket over the thermostat and onto the block.

NOTE: A new gasket **must** be installed each time the thermostat or water outline connection is removed.

Install the water outlet connection and mounting capscrews.

Torque Value: 24 N•m [212 in-lb]

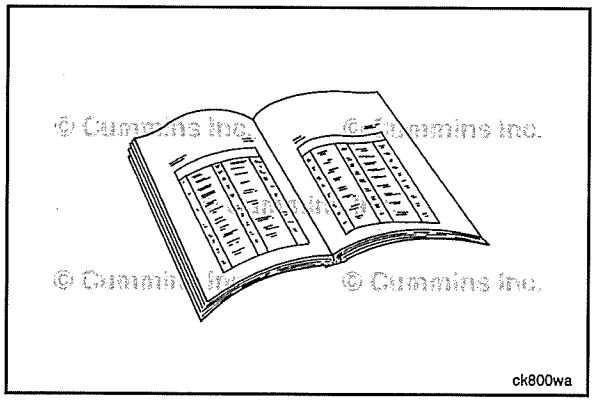


Finishing Steps

⚠WARNING⚠

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

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. Refer to the OEM service manual.
- Operate the engine and check for leaks.



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 mounting capscrews, if equipped.

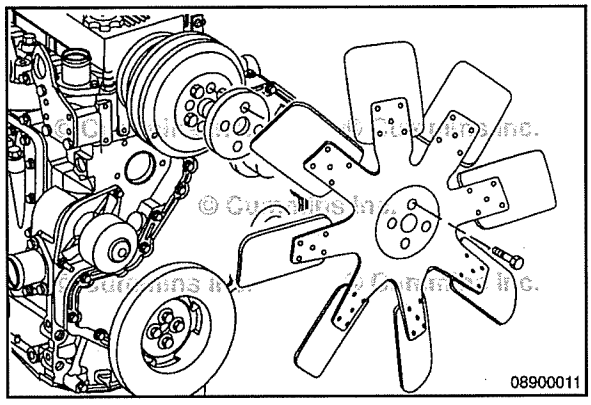
- Remove the fan drive belt. Refer to Procedure 008-002 in Section 6.

Remove

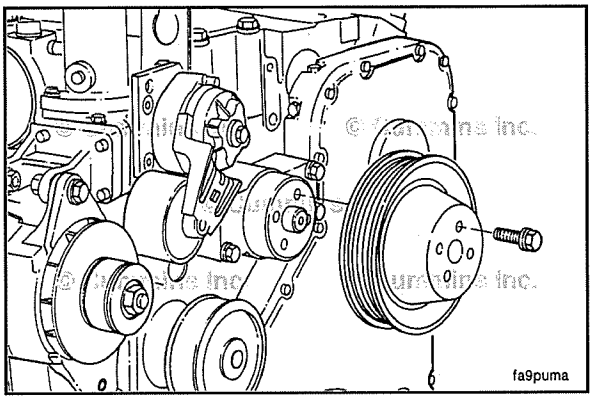
NOTE: Some applications do **not** have a cooling fan or the cooling fan is located elsewhere on the application.

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.

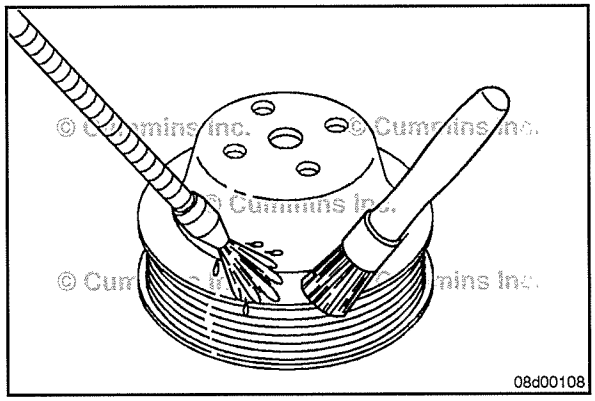


Clean and Inspect for Reuse

⚠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.

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

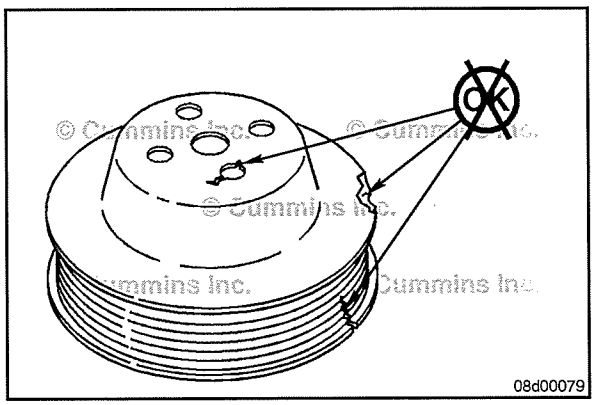
Clean the fan pulley and spacer with solvent and dry with compressed air.

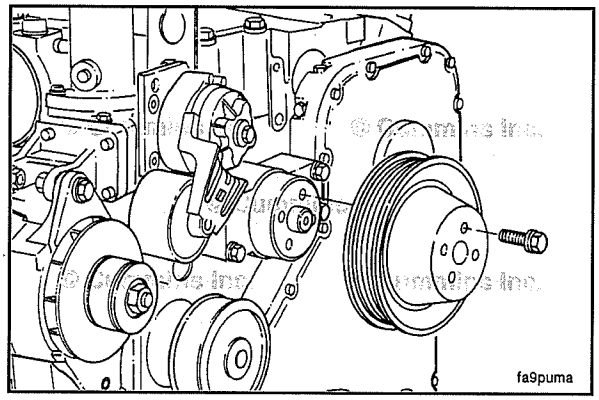


Inspect the fan pulley for cracks near the bolt holes and for damage at the drive belt contact surface.

If damage is found on the fan pulley, the fan hub **must** also be inspected.

Replace the pulley if any damage is found.





Install

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

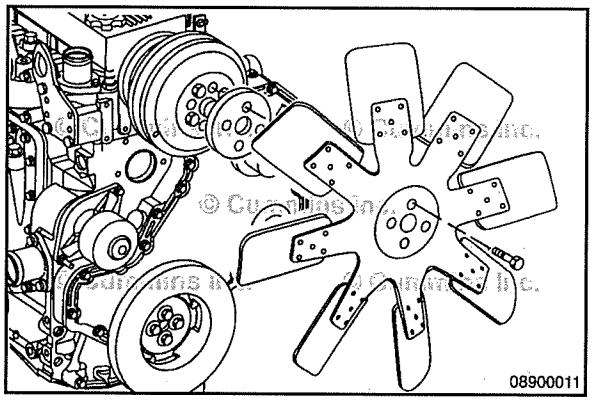
Tighten the mounting capscrews finger-tight.

Tighten the mounting capscrews to the final torque value after the drive belt is installed, using the tension of the drive belt to keep the fan pulley from rotating.

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]



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.

Tighten the mounting capscrews finger tight.

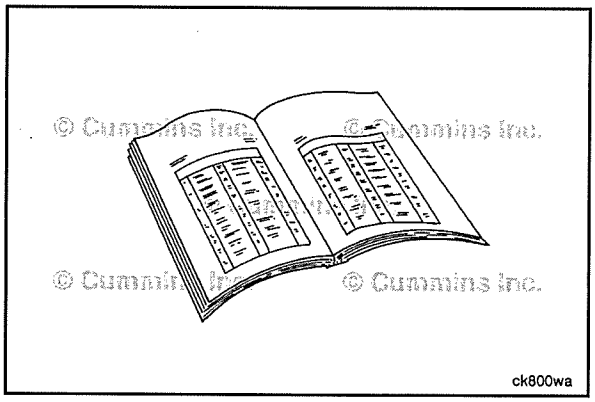
Tighten the mounting capscrews to the final torque value after the drive belt is installed, using the tension of the drive belt to keep the fan pulley from rotating.

Do **not** hold the fan blades to keep the fan pulley or cooling fan from rotating.

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.

NOTE: Tighten the fan pulley and cooling fan mounting capscrews, if equipped.

- Install the drive belt. Refer to Procedure 008-002 in Section 6.
- Operate the engine and check for proper operation.

Air Cleaner Element

General Information

⚠CAUTION⚠

Only use the approved Cummins Direct Flow® replacement filter elements to service the air cleaner. Use of improper filters can lead to engine damage.

NOTE: There are two different configurations in which the Cummins Direct Flow® air cleaners can be serviced: a front service or a side service direction. Verify the configuration by reviewing the appropriate illustrations in this manual.

The Cummins Direct Flow® air cleaner uses both a Primary and Secondary filter element for Industrial applications. The Cummins Direct Flow® air cleaner has been designed for a maximum restriction at 635 mm H_20 [25 in H_20] of water, at which point the filter element(s) is to be changed.

Measure

NOTE: The maximum restriction is reached when the vehicle is under full load. The restriction indicator will hold the maximum restriction value read during operation even after the engine is shut down.

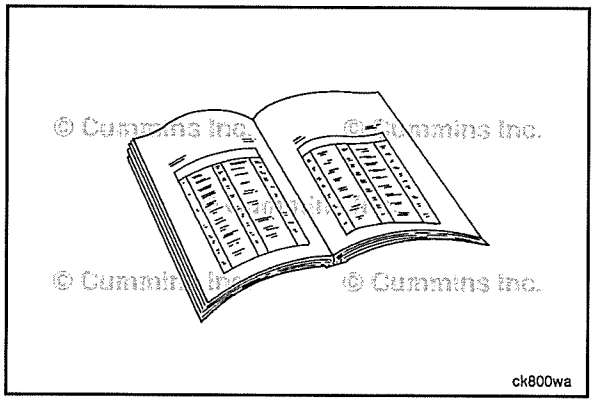
Restriction Indicator Check

Check the air cleaner restriction by the restriction indicator located on the outlet end of the air cleaner. A restriction indicator can be purchased separately if **not** present on the housing. The restriction indicator is located at the pressure tap on the outlet side of the housing.

Some restriction indicators are installed with an electronic switch that illuminates a lamp in the cab at full restriction of 635 mm H_20 [25 in H_20] of water.

Pressure/Vacuum Gauge Measure

If a restriction indicator is **not** present, attach a pressure gauge to the pressure port on the outlet side of the filter housing. Measure the vacuum during operating conditions at full load.



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

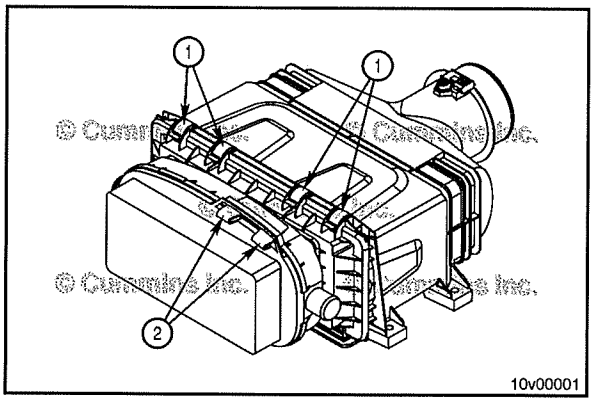
⚠WARNING⚠
Improper practices, carelessness, or ignoring the warnings can cause burns, cuts, mutilation, asphyxiation, or other personal injury or death.

△CAUTION△
Dirt or contaminants can be introduced into the system and engine if the surrounding areas are not cleaned, resulting in damage to the engine.

NOTE: It is **not** recommended to open the housing if a service event is **not** required.

NOTE: Before servicing any intake air system component, (such as the air cleaner, pre-cleaner, hoses, ducting, etc.), clean the fittings, mounting hardware, and the area around the component to be removed.

- Shut the engine OFF.
- Disconnect the battery cables. Refer to the original equipment manufacturer (OEM) service manual.



Remove

Front Service Filter Housing

Release the J-clamps to remove the pre-cleaner from the main filter housing. If present, the inlet ducting to the pre-cleaner could possibly need to be loosened or removed to remove the pre-cleaner from the housing. The pre-cleaner can be separated from the housing by sliding the mounting tabs out of the slots on the main housing.

1 Clip locations.

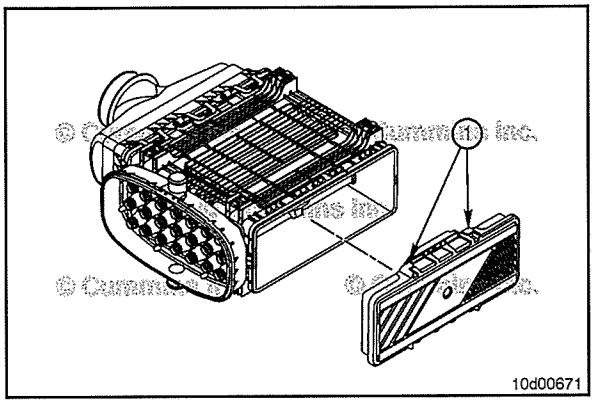
2 Tab locations.

Side Service Filter Housing

The inlet ducting does **not** need to be removed to service the filter elements. To access the filter elements, remove the service door by lifting on the plastic clips on both the top and bottom sides of the housing.

1 Service door clip (both sides).

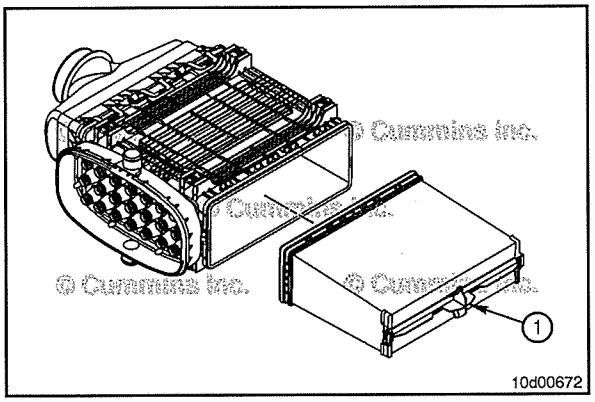
Make sure the gasket around the service door or pre-cleaner remains seated.



The Cummins Direct Flow® primary filter element has a built-in handle for easy removal. Grasp the handle in the center of the element and pull the filter element outward.

1 Primary element removal handle.

Clean the inside of the housing with a damp rag to remove all loose dirt and dust.



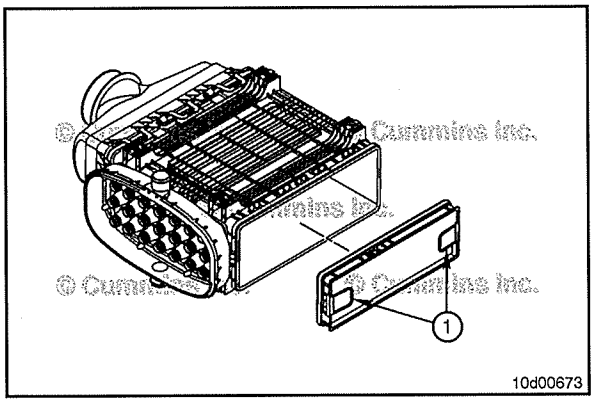
⚠CAUTION⚠
Take caution when removing the secondary element. Any loose debris can fall into the air intake plumbing leading directly to the engine. Clean the area around the secondary filter element and replace the secondary promptly to avoid engine contamination ingestion.

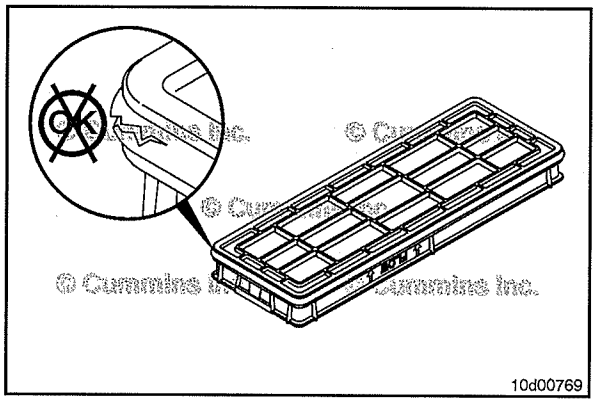
⚠CAUTION⚠
Do not attempt to clean the filter elements. Cleaning filter elements by impact or compressed air voids the warranty and can degrade or damage the filter media leading to malfunction.

NOTE: The secondary element should be replaced every-other time the primary element is replaced. Proper inspection of the secondary element should be performed and the element replaced, if necessary.

The secondary element is removed by pulling on the plastic ring tab on the inside face of the filter element.

1 Secondary element removal ring tab.

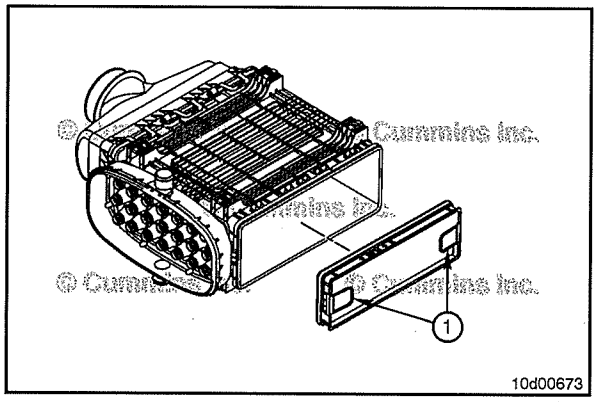




Inspect for Reuse

If the used filter element is to be installed into the filter housing, the following precautions **must** be taken:

- Inspect the gasket around the base of the filter element. If the gasket exhibits damage, replace the entire filter element assembly.
- Inspect the filter media for any tears or excessive wear. Replace the entire filter element assembly if the filter media is **not** intact. The filter media rows may **not** appear straight and exhibit some amount of a wave pattern. This appearance is normal due to standard operation and does **not** require a replacement.



Install

⚠CAUTION⚠
Only use the approved Cummins Direct Flow® replacement filter elements to service the air cleaner. Use of improper filters can lead to engine damage.

⚠CAUTION⚠
Make sure any cloth or tools used during the removal process are not left in the filter housing (before installing the filter elements) or engine damage can occur.

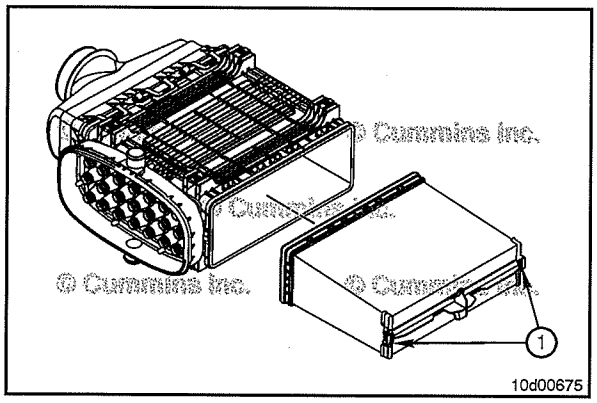
NOTE: The secondary element **must** be installed first if both the secondary and primary elements were removed.

Secondary Element

Insert the element so the orientation of the plastic removal ring is facing the inside of the housing and is accessible for the next service interval.

1 Secondary element removal ring tab should be visible.

Push the secondary element into the back of the housing so all surfaces are seated inside the housing. Apply pressure to all four corners to make sure the element is secure within the housing. The secondary filter element includes an o-ring that is glued to the filter element to provide an airtight seal.



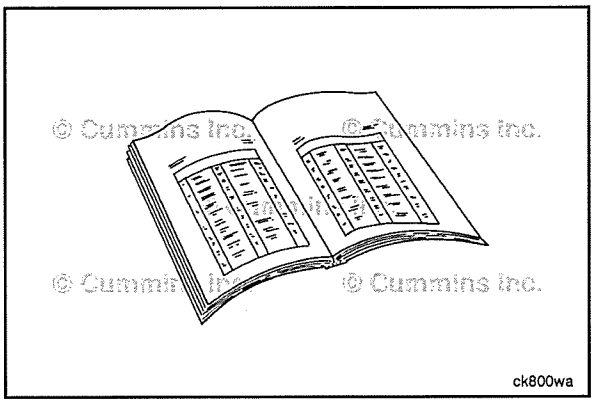
Primary Filter Element

Service Tip: Before installing a new primary filter element, use a marker to note on the element handle if a new secondary element should be installed at the next primary element service event.

Place a new primary filter element in the housing so the o-ring is toward the secondary element. Push the primary element into the housing so all surfaces are seated inside the housing. Apply pressure to the two tabs on the side of the primary element to make sure the element is secure within the housing. The tabs should seat against the center of the housing. The primary filter element also includes an o-ring that is glued to the filter element to provide an airtight seal.

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.



NOTE: The service door or pre-cleaner assembly will **not** latch if the primary filter element is **not** fully seated into the housing.

NOTE: For the 127 mm x 381 mm x 204 mm [5 in x 15 in x 8 in] version, the pre-cleaner assembly has tabs on the opposite side that will interface with slots on the housing.

NOTE: The Cummins Direct Flow® filter elements are completely disposable.

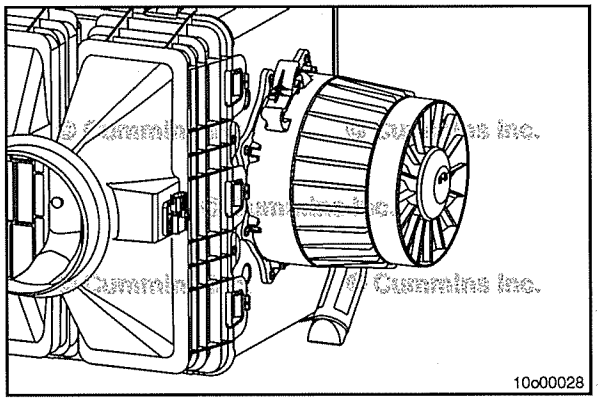
- Install the service door or pre-cleaner assembly by latching to the housing.
- Reset the restriction indicator by pushing the reset button.
- Connect the battery cables. Refer to the OEM service manual.
- Operate the engine and listen for a noise that could indicate an air leak.

Air Cleaner Precleaner

General Information

Air filtration precleaners are used to remove debris from the air stream in order to extend the life of the air filter elements. There are several types of precleaners that can be used, including, but **not** limited to:

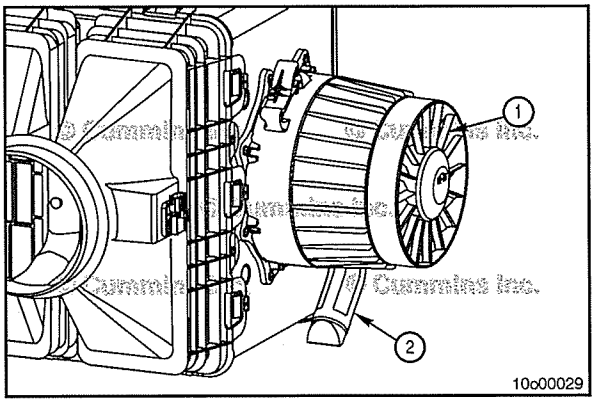
- Integrated precleaner with dust ejection valve
- Non-captive style precleaner
- Integrated precleaner with exhaust aspiration.

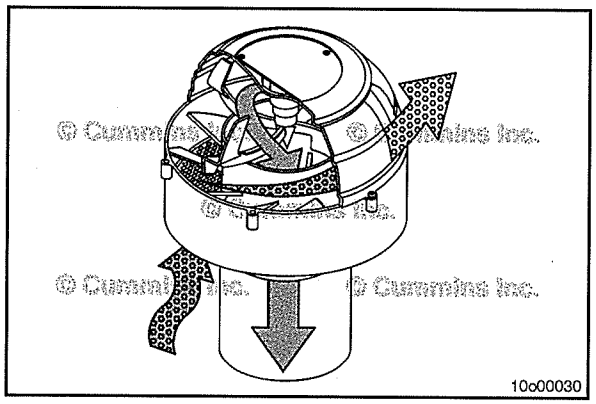


An integrated precleaner with a dust ejection valve removes debris from the intake air by using fins (1) to create centrifugal motion in the intake air stream.

The centrifugal motion causes debris to be forced to the outside of the precleaner, where it is then collected in the dust ejection valve (2).

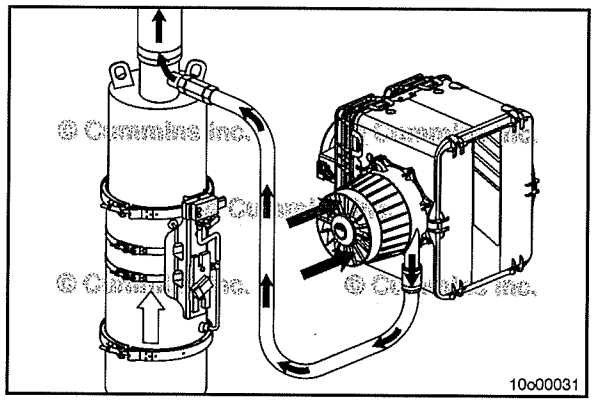
NOTE: If the dust ejection valve becomes full of debris, the precleaner will **not** function and the debris will remain in the air stream, which can lead to frequent air filter plugging or low air filter service life. Reference the following procedure. Refer to Procedure 010-146 in Section 3.





Non-captive style precleaners work similarly to integrated precleaners by using centrifugal motion to force debris to the outside of the precleaner. However, instead of being collected in the dust ejection valve, the debris is immediately expelled back into the outside air.

NOTE: These precleaners are typically more costly than the integrated precleaner with dust ejection valve and can create higher intake restriction.

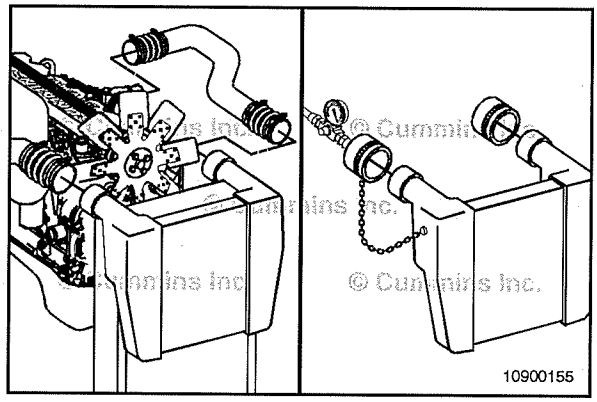


Integrated precleaning with exhaust aspiration is used for applications that are exposed to extremely dirty and dusty environments, such as agricultural equipment.

An exhaust aspirator uses exhaust flow to create suction. The suction tube from the aspirator is plumbed to the integrated precleaner and helps to separate debris out of the intake air. The debris is sucked from the precleaner through the suction tube and travels out through the exhaust

A check valve **must** be used with an exhaust aspirator to prevent exhaust gases from traveling through the air cleaner in instances when the exhaust suction force is low.

NOTE: Vacuum leaks in the exhaust aspirator piping can reduce the ability of the air cleaner precleaner to remove debris from the intake air, which can lead to frequent air filter plugging or low air filter service life.



Charge-Air Cooler

Leak Test

⚠WARNING⚠
To reduce the possibility of injury if either plug blows off during the test, secure safety chains on the test plugs to any convenient capscrew on the radiator assembly. This test must be performed with securely fastened safety chains.

To check the charge-air cooler for cracked tubes or header, remove the inlet and outlet hoses from the cooler. The charge-air cooler does **not** have to be removed from the chassis.

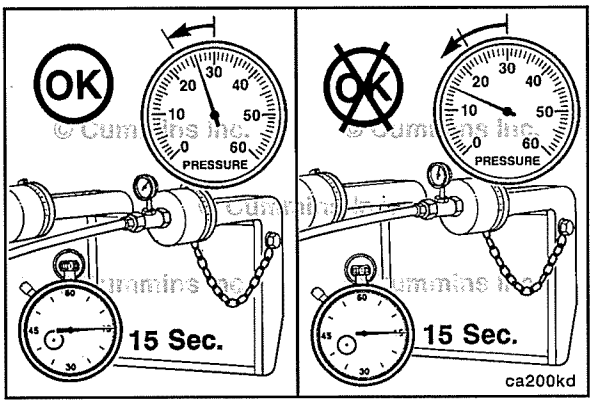
Install a plug or cap over the outlet side of the cooler. Install a pressure gauge and a regulated shop air supply line with a shutoff valve to the inlet side of the cooler.

Apply air pressure to the cooler until the pressure gauge reads a steady 207 kPa [30 psi] of air pressure.

Shut off the air flow to the cooler, and start a stopwatch at the same time. Record the leakage at 15 seconds.

If the pressure drop is 48 kPa [7 psi] or less in 15 seconds, the cooler is operational.

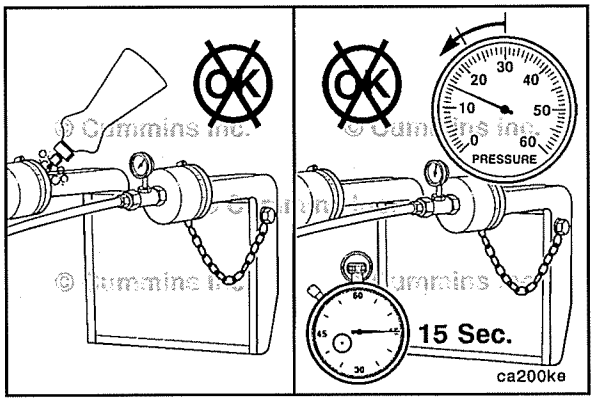
If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, check all connections again.



Determine if the pressure drop is caused by a leak in the charge-air cooler or by a leaky connection. Use a spray bottle filled with soapy water, applied to all hose connections. Watch for bubbles to appear at the location of the leak.

If the pressure drop is caused by a leaky connection, repair the connection, and repeat the test. If the leak is within the charge-air cooler, repeat the test to verify the accuracy of the pressure drop measurement. Similar pressure drop readings **must** be obtained at least three consecutive tests before the reading can be considered accurate.

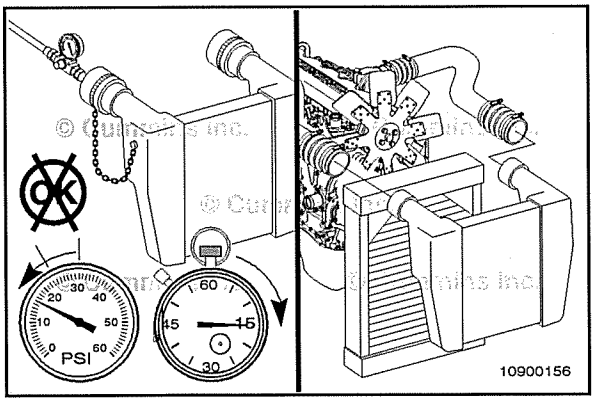
NOTE: If a charge-air cooler leak causes a pressure drop of more than 48 kPa [7 psi] in 15 seconds, it will appear as a major leak in a leak tank.



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

Refer to the OEM service manual for replacement instructions.

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

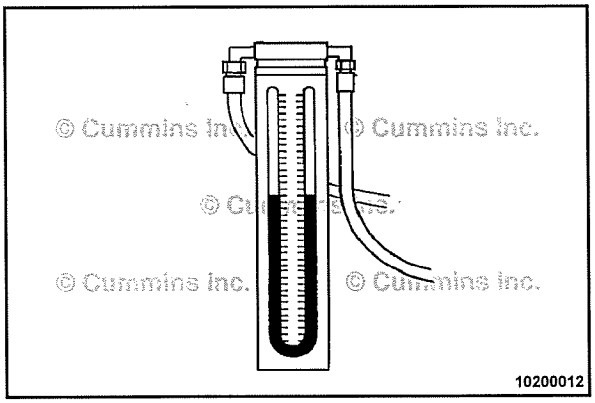


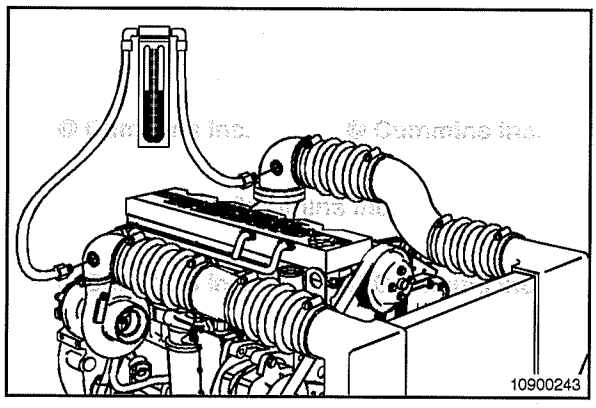
Pressure Test

Mercury Manometer, Part Number ST-1111-3

Preferred Method

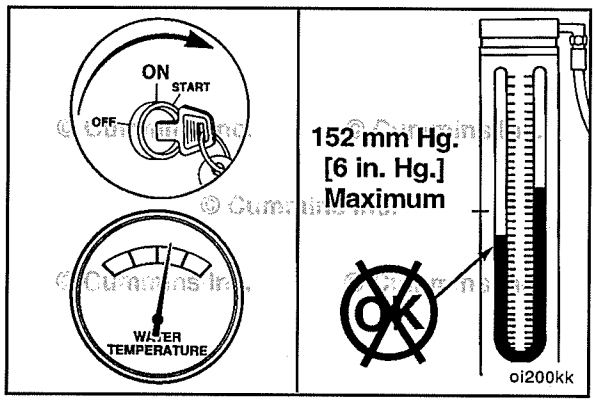
Measure the charge air cooler system pressure drop with a mercury manometer.





Install one end of a mercury manometer, Part Number ST-1111-3, in the 1/8-inch fitting in the turbocharger compressor outlet elbow.

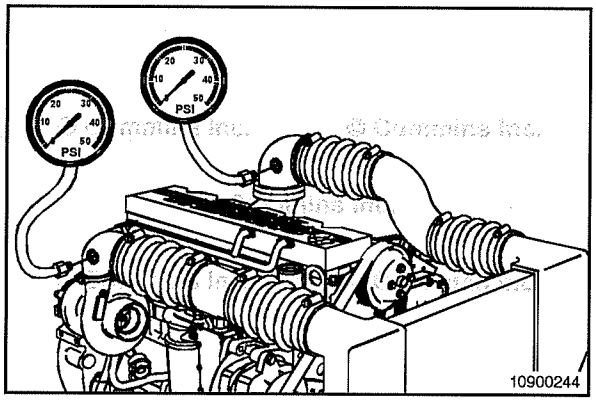
Install the other end of the mercury manometer in the intake manifold.



Operate the engine at rated rpm and load. Record the readings on the manometer.

If the differential pressure is greater than 152 mm Hg [6 in Hg], check the charge air cooler and associated piping for plugging, restrictions, or damage.

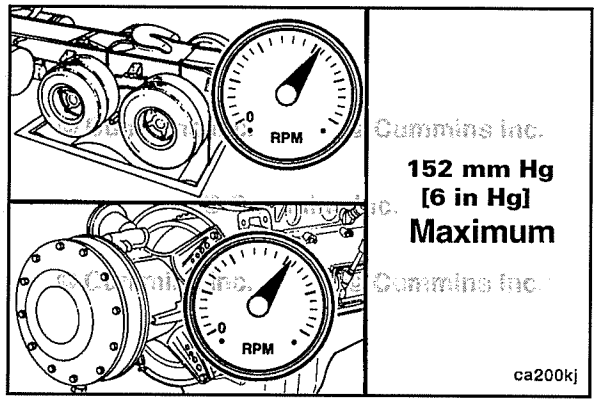
Clean or replace, if necessary.



Obtain two pressure gauges, Part Number 3823205. Check both gauges on the same pressure source at 206 kPa [30 psi] to maintain consistency.

Install one pressure gauge in the 1/8-inch fitting in the turbocharger compressor outlet elbow.

Install the other pressure gauge in the intake manifold.



Operate the engine at rated rpm and load. Record the readings on the two gauges.

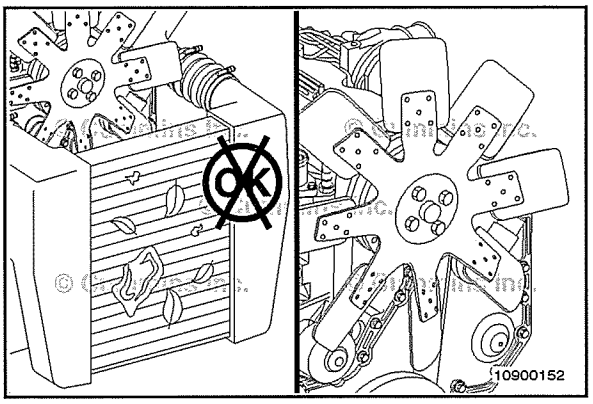
If the differential pressure is greater than 152 mm Hg [6 in Hg], check the charge air cooler and associated piping for plugging, restrictions, or damage.

Clean or replace, if necessary.

Temperature Differential Test

Inspect the charge-air cooler fins for obstructions to air flow. Remove obstructions such as a winterfront or debris. Manually lock the shutters in the OPEN position, if equipped.

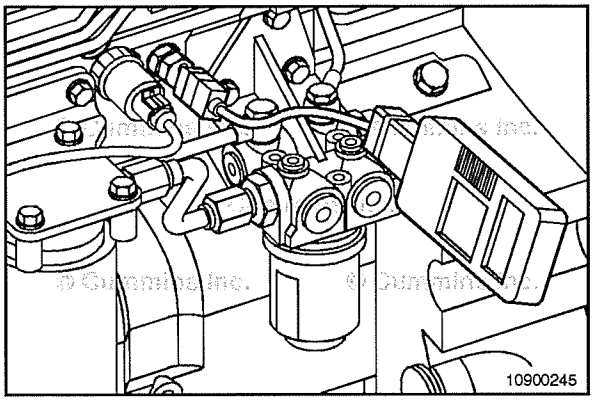
Lock the fan drive in the ON mode to prevent erratic test results. This can be done by installing a jumper wire across the temperature switch.



Install fluke digital thermometer, Part Number 3822666, into the intake manifold at the 1/8-inch NPT tap near the air horn connection with the intake manifold.

Another alternative is to use the monitor mode on the INSITE™ electronic service tool.

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

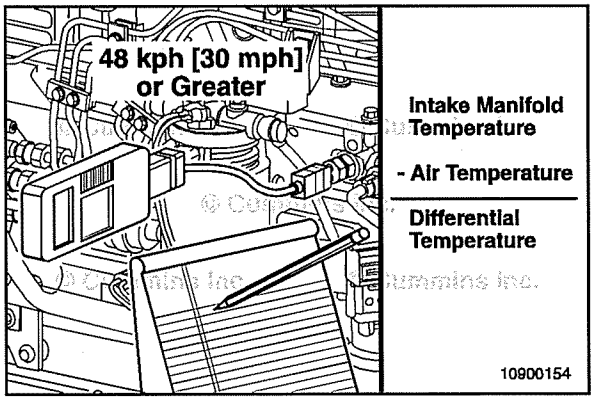


Perform a road test with the engine at peak power and a vehicle speed of 48 kph [30 mph] or greater.

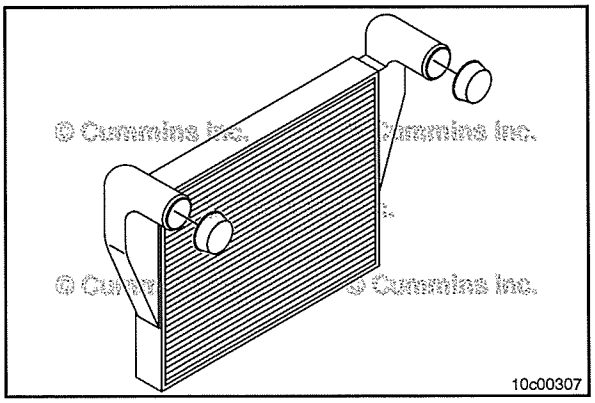
Record the intake manifold temperature and the ambient air temperature.

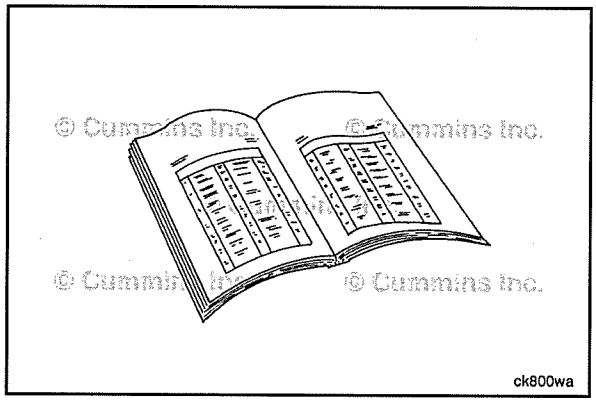
Calculate the differential temperature:

- Intake manifold temperature - ambient air temperature = differential temperature
- Maximum Differential Temperature: 21°C [38°F].



If the temperature differential is greater than the specifications, check the charge-air cooler for dirt and debris on the fins and clean as necessary. If the problem still exists, check the charge-air cooler for debris in the fins or between the charge-air cooler and radiator. Confirm full fan engagement.



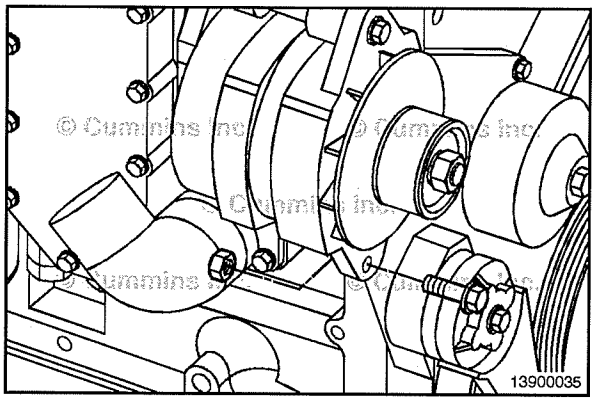


Alternator

Preparatory Steps

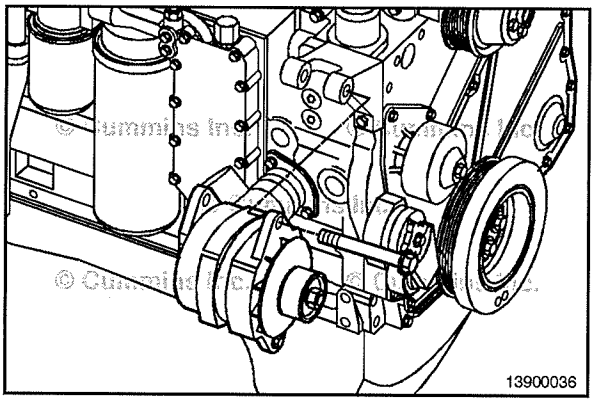
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the battery cables. Refer to the original equipment manufacturer (OEM) service manual.
- Disconnect the battery ground cable.
- Remove the belt guard, if equipped. Refer to the OEM service manual.
- Remove the drive belt. Refer to Procedure 008-002 in Section 6.
- Tag and label wires attached to the alternator.
- Remove the wires attached to the alternator.



Remove

Remove the alternator link capscrew.



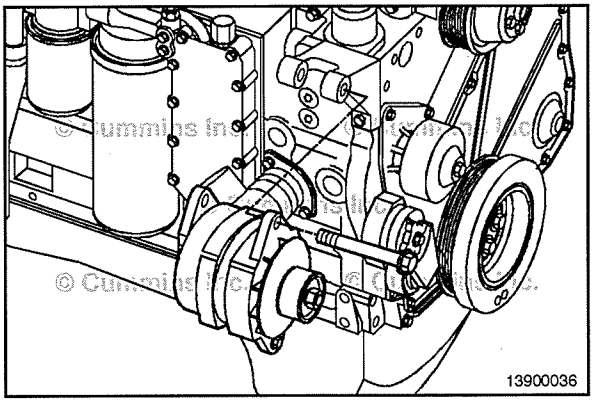
Remove the alternator mounting capscrew.

Remove the alternator.

Install

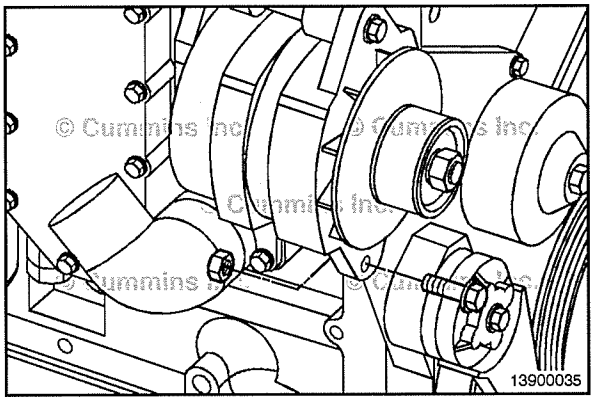
Install the alternator and alternator capscrews in the reverse order of removal.

Torque Value: 43 N•m [32 ft-lb]



Install the alternator link capscrew.

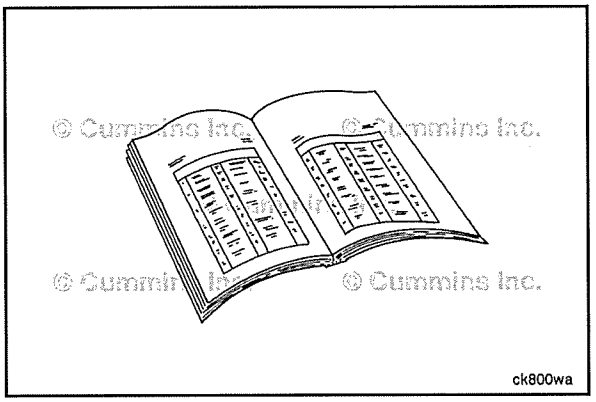
Torque Value: 24 N•m [212 in-lb]



Finishing Steps

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

- Install the drive belt. Refer to Procedure 008-002 in Section 6.
- Connect the battery cables. Refer to the OEM service manual.
- Operate the engine and verify proper alternator operation.

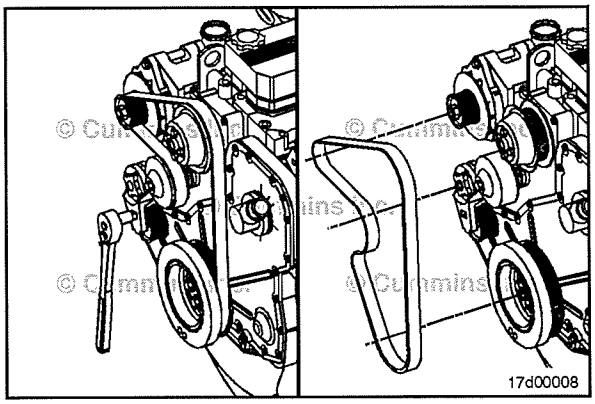


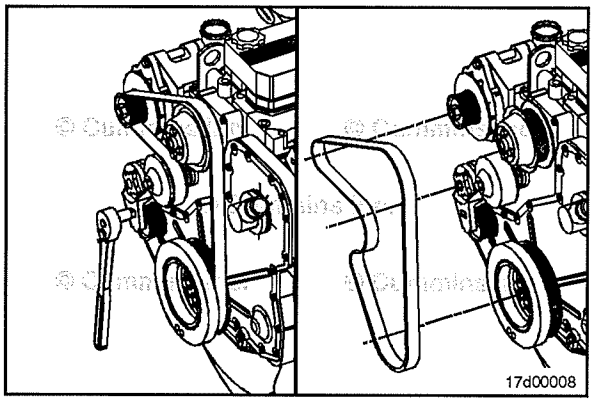
Drive Belt, Alternator

Remove

Lift the belt tensioner to relieve tension on the belt and remove the drive belt.

- Refer to Procedure 008-002 in Section 6.

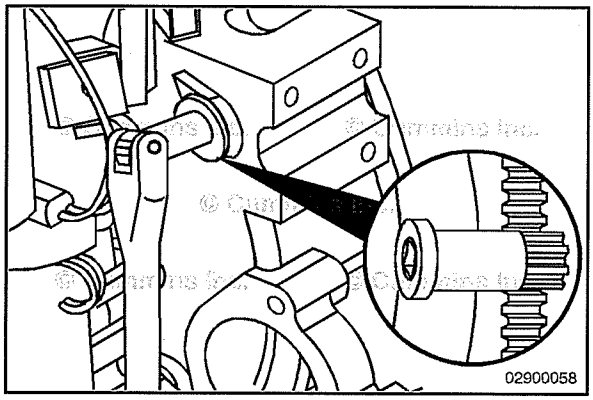




Install

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

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



Starting Motor

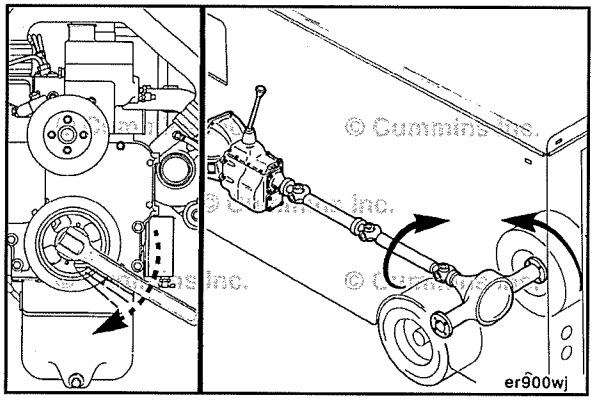
Rotation Check

If the starting motor 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 starting motor cranks the engine, check the starting motor pinion gear and flywheel ring gear for damage.

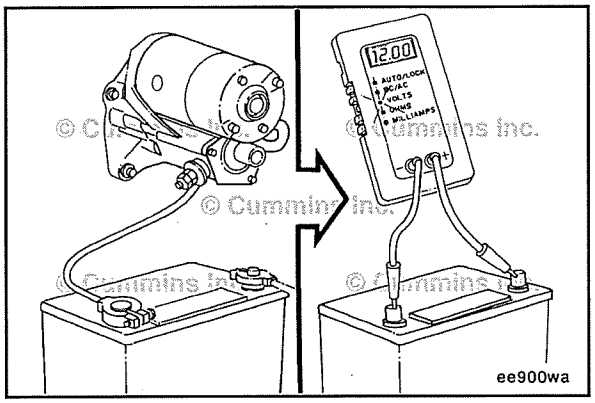
If damage to the starting motor pinion gear and/or flywheel ring gear is found when replacing the components, make sure to measure the distance from the starting motor mounting flange to the forward face of the front side of the flywheel ring gear. Follow the measure step of this procedure .



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.

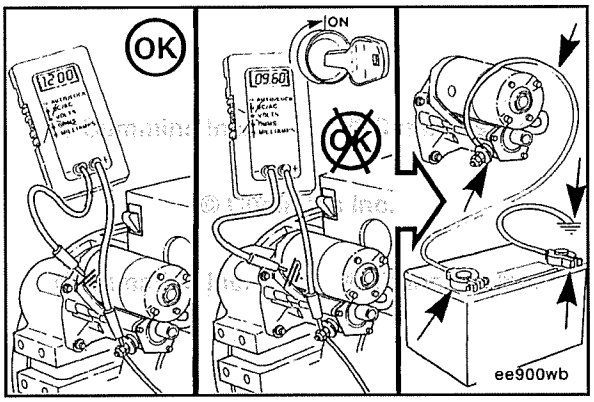
If the engine cranking speed is too slow or will **not** crank at all, and the engine rotates freely:

- Make sure the wiring connections are clean, tight, and **not** damaged
- Check the battery voltage. Refer to the original equipment manufacturer (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, or 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.



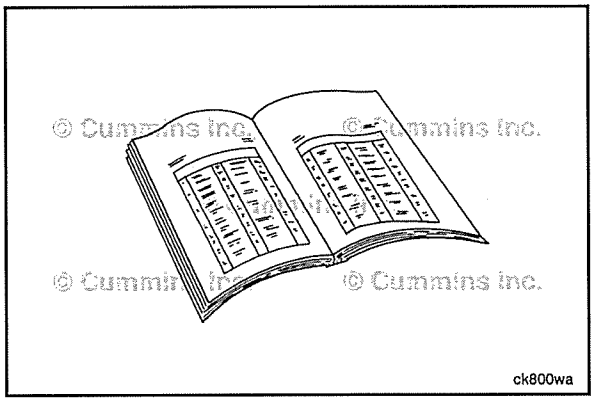
Preparatory Steps

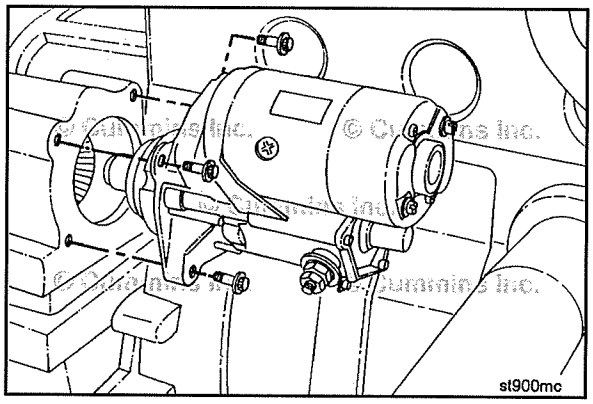
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠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 battery cables. Refer to the OEM service manual.
- Identify each wire with a tag indicating its location on the starting motor.
- Remove the electrical connections from the starting motor.
- Prior to removing the starter, use steam to clean the area around the starting motor, to prevent debris from entering the flywheel housing.
- Dry with compressed air.



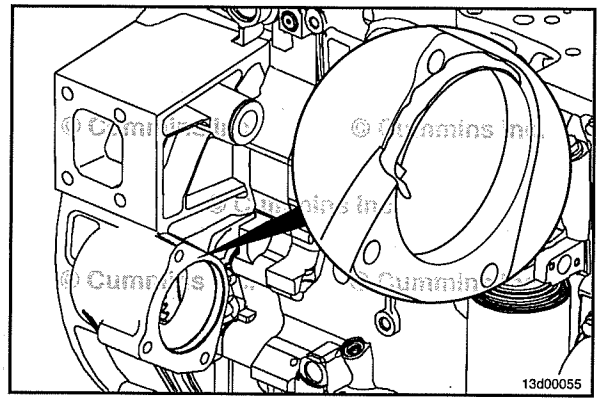


Remove

Remove the three capscrews and the starting motor.

If equipped with a System Integration Module relay, remove the relay support bracket from the starting motor mounting capscrew.

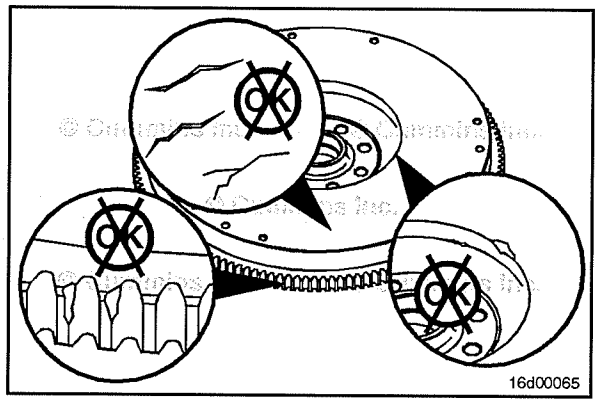
If equipped with a starting motor spacer, remove the spacer and clean all surfaces between the starting motor, starting motor spacer, and flywheel housing with a wire brush.



Clean and Inspect for Reuse

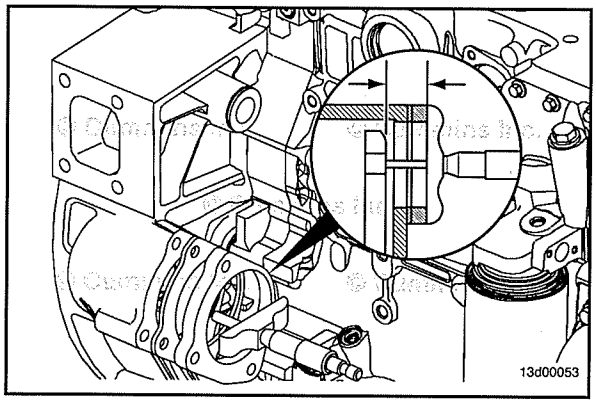
For engines that use wet flywheel housing, clean any left over sealant from the starting motor mounting flange on both the flywheel housing and starting motor.

Make sure these surfaces are clean of oil and debris.



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

If the starting motor pinion gear and/or flexplate ring gear teeth are damaged, they **must** be replaced.



Measure

Use a depth micrometer or vernier caliper to measure the distance from the starting motor mounting flange to the forward face of the front side of the flywheel ring gear.

NOTE: Include any spacers previously removed when completing the measurement.

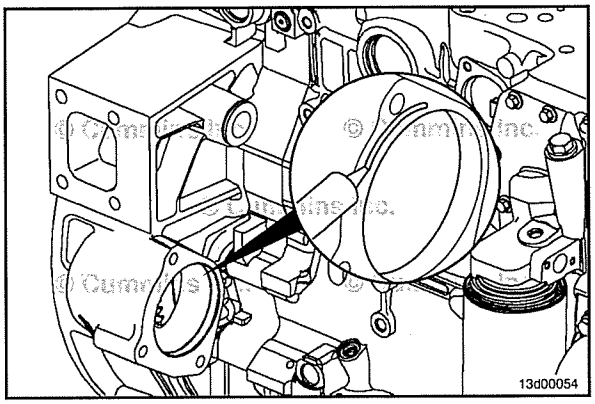
Starting Motor Spacing		
mm		**in**
49.28	MIN	1.94
52.32	MAX	2.06

Add or remove spacers as necessary to achieve the correct starting motor spacing.

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.

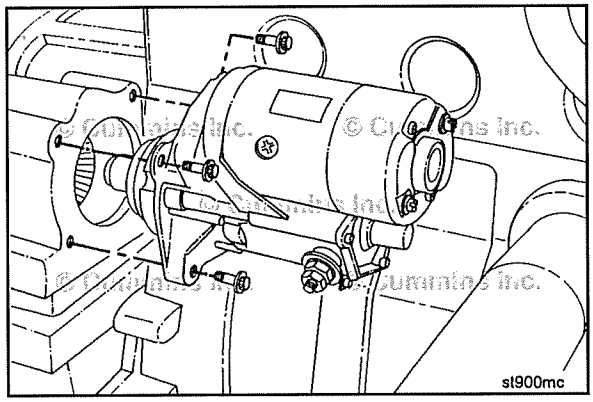
NOTE: If a starting motor spacer is required, make sure to apply sealant to the side of the spacer that contacts the starting motor.



If equipped, install the System Integration Module relay support bracket mounting capscrews.

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

Torque Value: 43 N•m [32 ft-lb]



Cummins® Branded Starters

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

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

Connect the electrical connections to the starting motor.

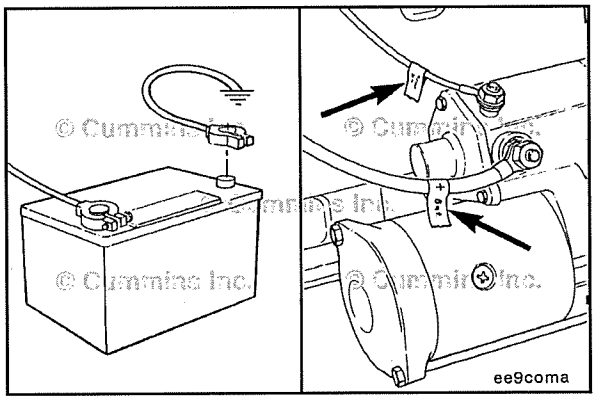
Torque Value:
M5 4 N•m [35 in-lb]

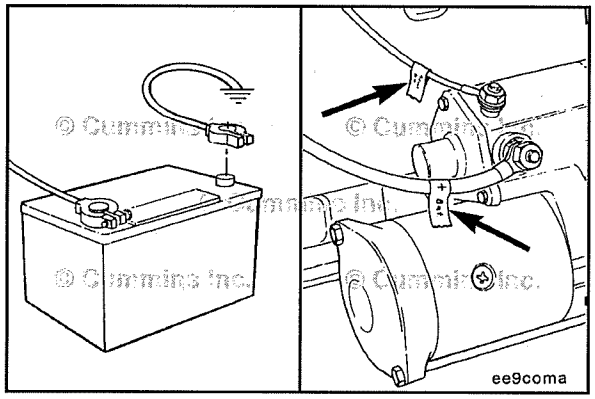
Torque Value:
M10 21 N•m [186 in-lb]

If starter came installed with the the JSP cover, install the JSP and JSP cover nut on the M terminal post.

Torque Value:
M5 4 N•m [35 in-lb]

NOTE: The JSP 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.





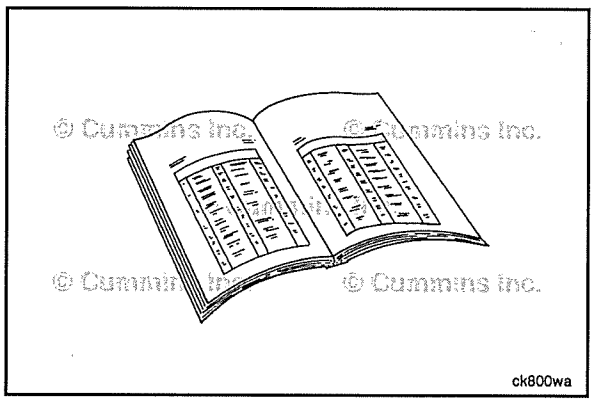
Non-Cummins® Branded Starters

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

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

Connect the electrical connections to the starting motor.

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

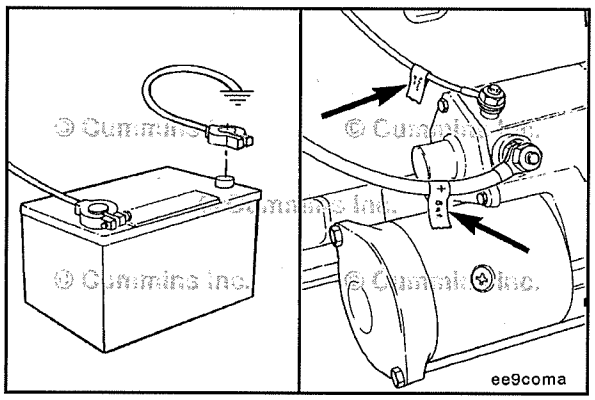


Finishing Steps

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.

- Connect the battery cables. Refer to the OEM service manual.
- Operate the starter and check for proper operation.



Non-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. Starting motor damage can result.

NOTE: Use the location tags to identify the installation location for each wire.

- Connect the electrical connections to the starting motor.
- Refer to the OEM service manual for torque specifications.
- Connect the battery cables. Refer to the OEM service manual.
- Operate the starter and check for proper operation.

Section D - System Diagrams

Section Contents

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System Diagrams - Overview

General Information

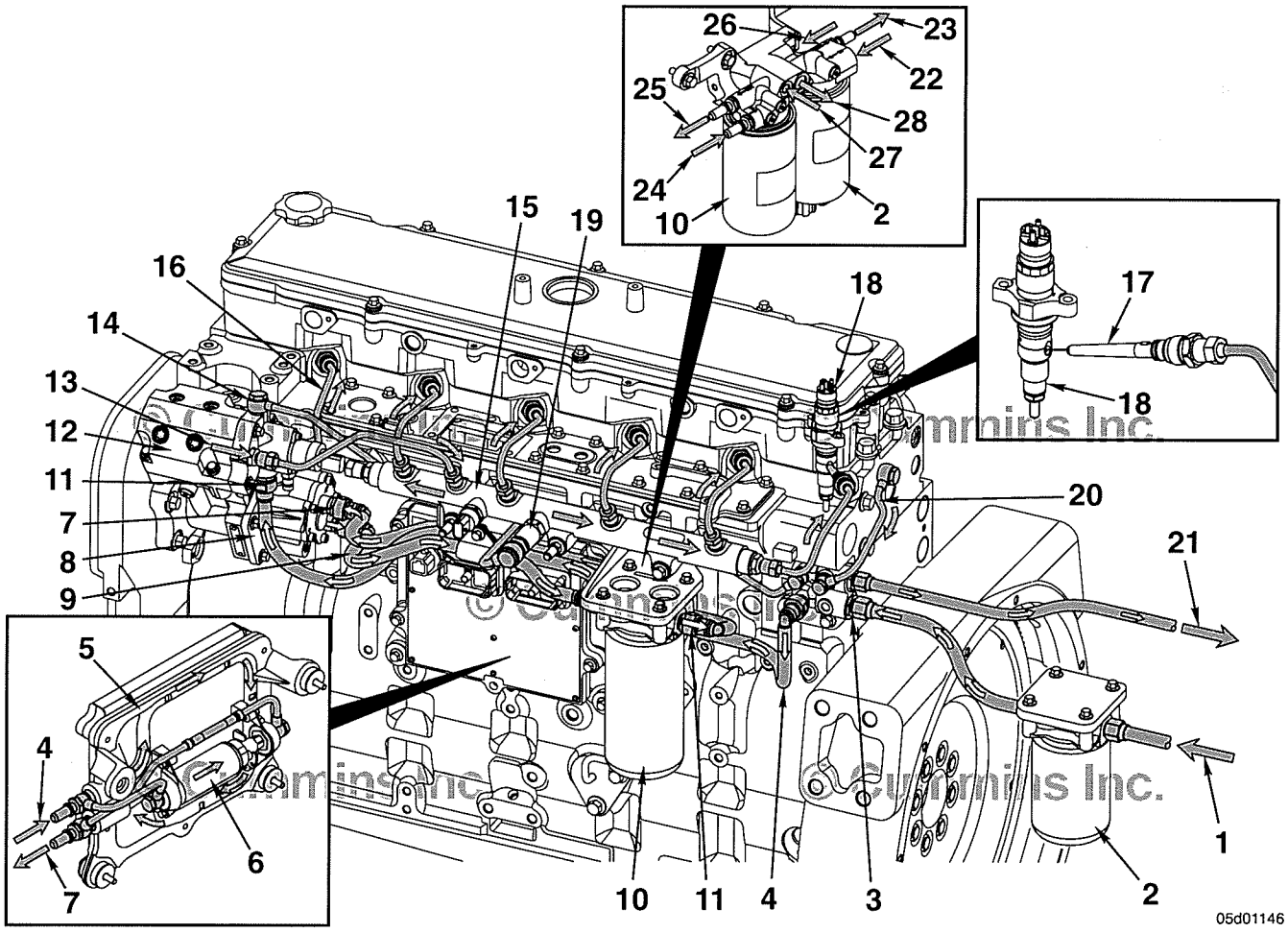
The following drawings show the flow through the engine systems. Although parts can change between different applications and installations, the flow remains the same. The systems shown are:

- 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

General Information



1 Fuel from supply tank
2 Fuel filter and water separator
3 Original equipment manufacturer (OEM) fuel supply connection
4 Fuel supply to engine control module (ECM) mounted fuel lift pump
5 ECM cooling plate
6 ECM mounted fuel lift pump
7 Fuel outlet from ECM mounted fuel lift pump/fuel to gear pump
8 Fuel gear pump
9 Fuel from gear pump to fuel filter
10 Pressure-side fuel filter
11 Fuel to fuel pump actuator
12 High-pressure fuel pump
13 Fuel outlet from high-pressure fuel pump
14 High-pressure pump drain flow connection
15 Fuel rail
16 High-pressure injector supply lines
17 High-pressure fuel connector
18 Fuel injector

19 Fuel pressure relief valve

20 Fuel injector drain flow line

21 Fuel return to supply tanks

22 Fuel supply to fuel filter and water separator*

23 Fuel supply to ECM mounted fuel lift pump*

24 Fuel supply to pressure-side fuel filter*

25 Fuel supply to high-pressure fuel pump*

26 Fuel drain from fuel rail and injector drains*

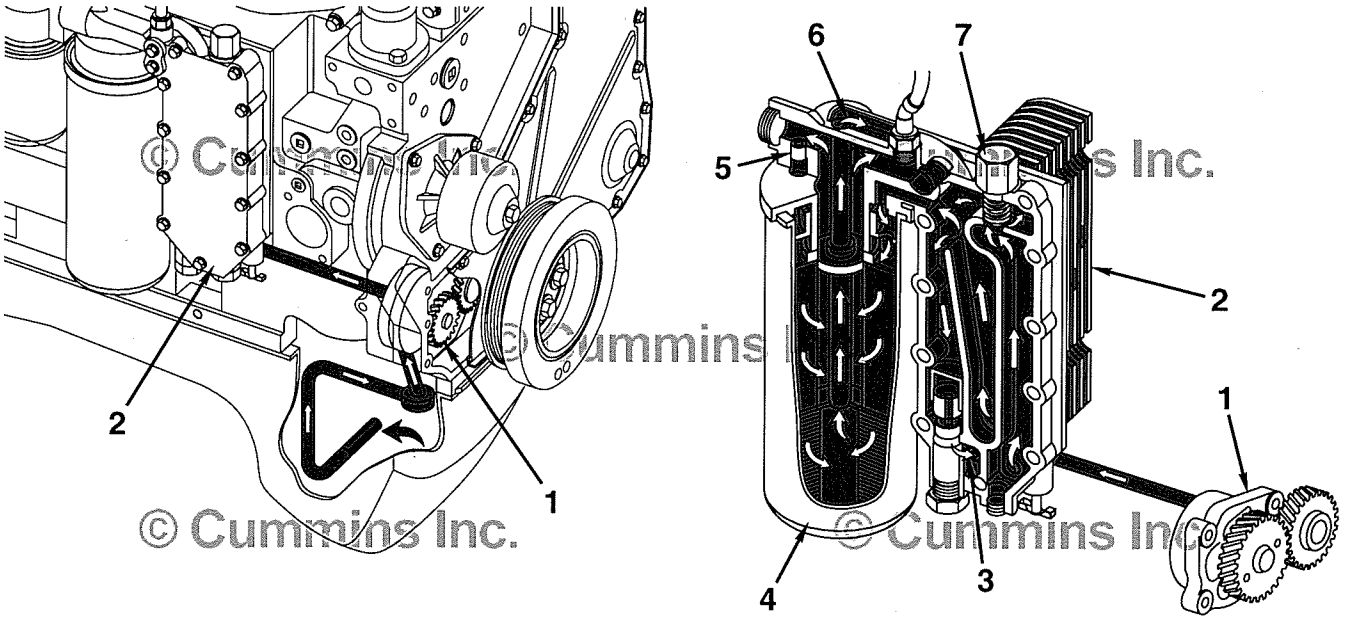
27 Fuel drain from high-pressure fuel pump*

28 Fuel return to supply tanks.*

* Some engines may have an optional dual fuel filter head which holds both the fuel filter and water separator (2) and the pressure-side fuel filter (10). The dual fuel filter head also contains a fuel drain manifold. See numbers 22 through 28 for fuel flow through the fuel filter head.

Flow Diagram, Lubricating Oil System

General Information



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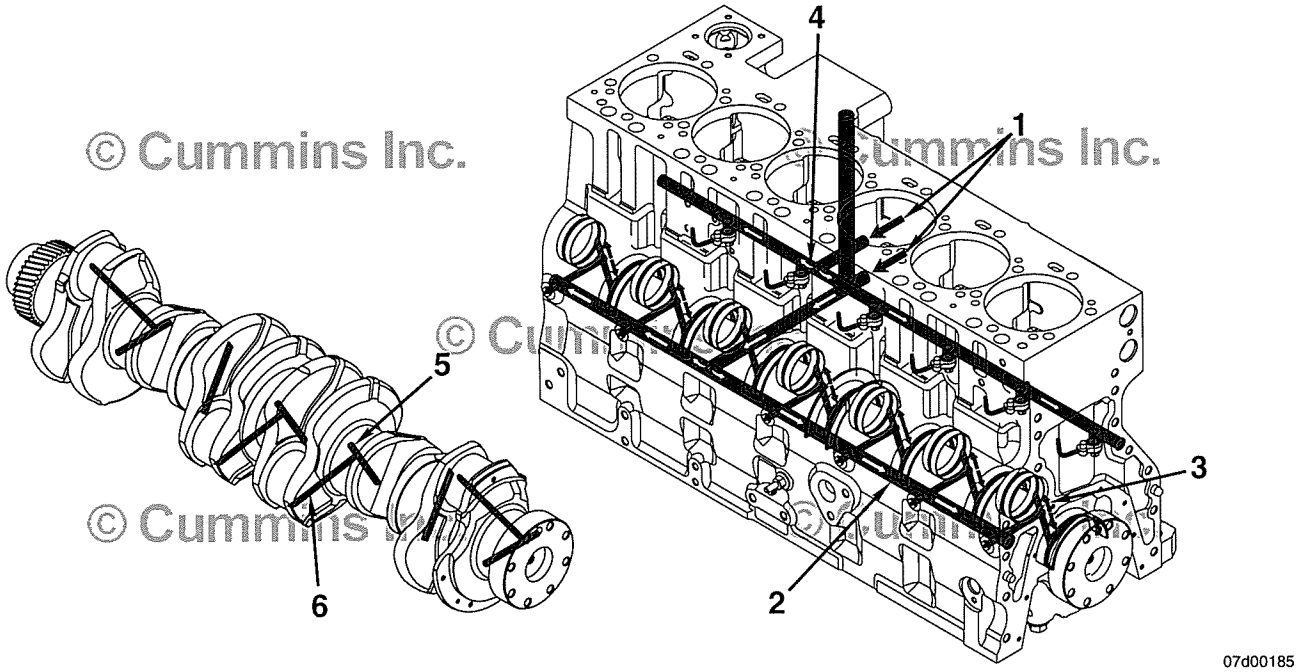
Lubricating Oil Cooler Flow

1 Gerotor lubricating oil pump
2 Lubricating oil cooler
3 Bypass oil to lubricating oil pan
4 Full flow lubricating oil filter
5 Filter bypass valve
6 From lubricating oil filter to main oil rifle
7 Oil thermostat.

Flow Diagram, Lubricating Oil System

General Information

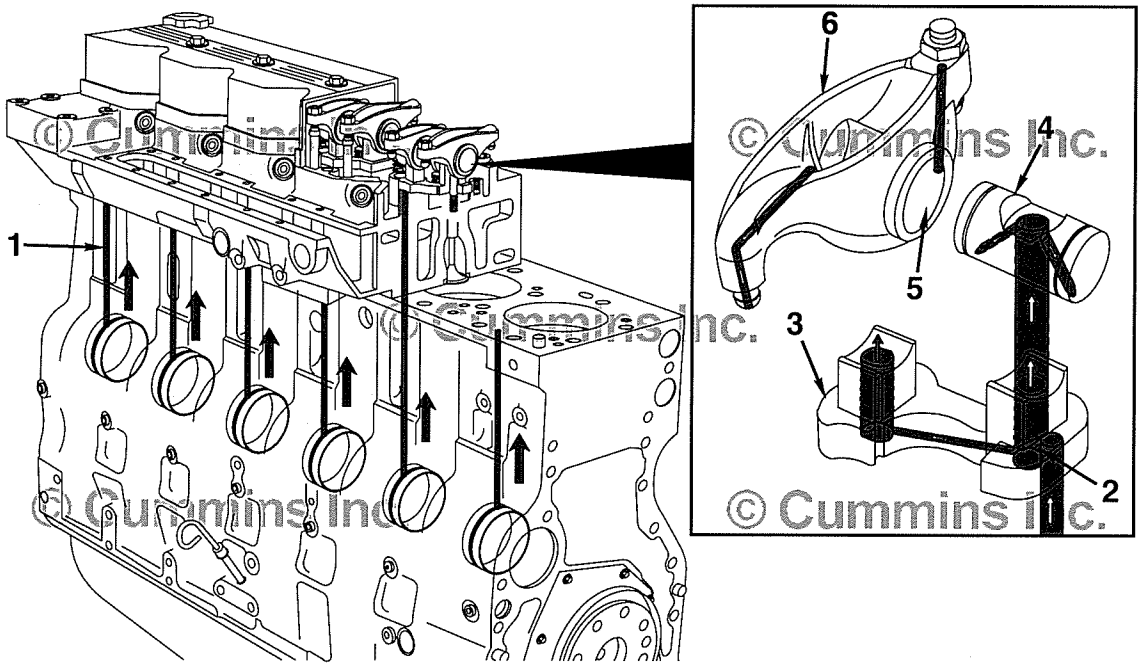


Lubrication for Power Components

1 From lubricating oil filter
2 Main lubricating oil rifle
3 To camshaft
4 To piston cooling nozzle
5 From main lubricating oil rifle
6 To connecting rod bearing.

Flow Diagram, Lubricating Oil System

General Information



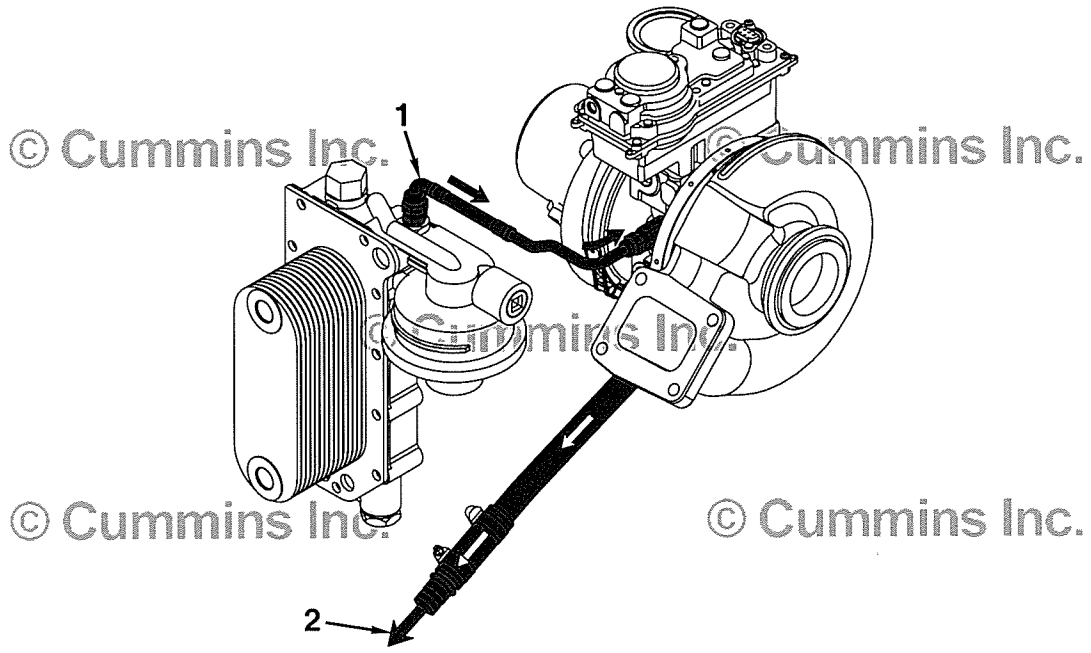
07d00002

Lubrication for the Overhead

1 From cam bushings
2 Transfer slot
3 Rocker lever support
4 Rocker lever shaft
5 Rocker lever bore
6 Rocker lever.

Flow Diagram, Lubricating Oil System

General Information



07d00228

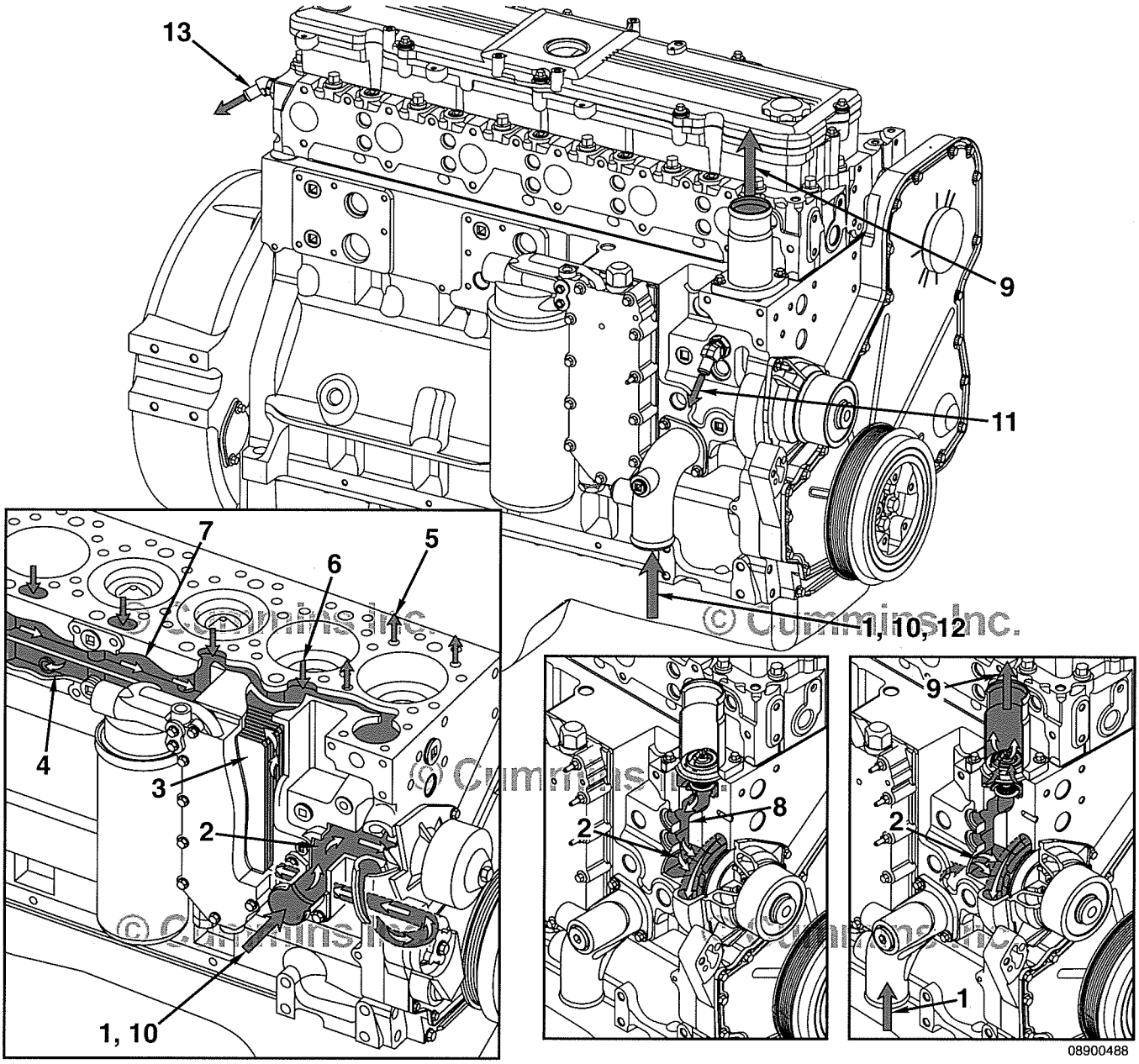
Turbocharger Oil Flow

1 Turbocharger oil supply from oil filter head

2 Turbocharger oil drain to cylinder block.

Flow Diagram, Cooling System

Flow Diagram



1 Water/coolant inlet from radiator

2 Water pump suction

3 Coolant flow through lubricating oil cooler

4 Block lower water manifold (to cylinders)

5 Coolant supply to cylinder head

6 Coolant return from cylinder head

7 Block upper water manifold

8 Thermostat bypass

9 Coolant return to radiator

10 Aftertreatment DEF valve and tank coolant return line to water/coolant inlet connection. Optional aftertreatment DEF dosing valve and tank coolant return is (1)

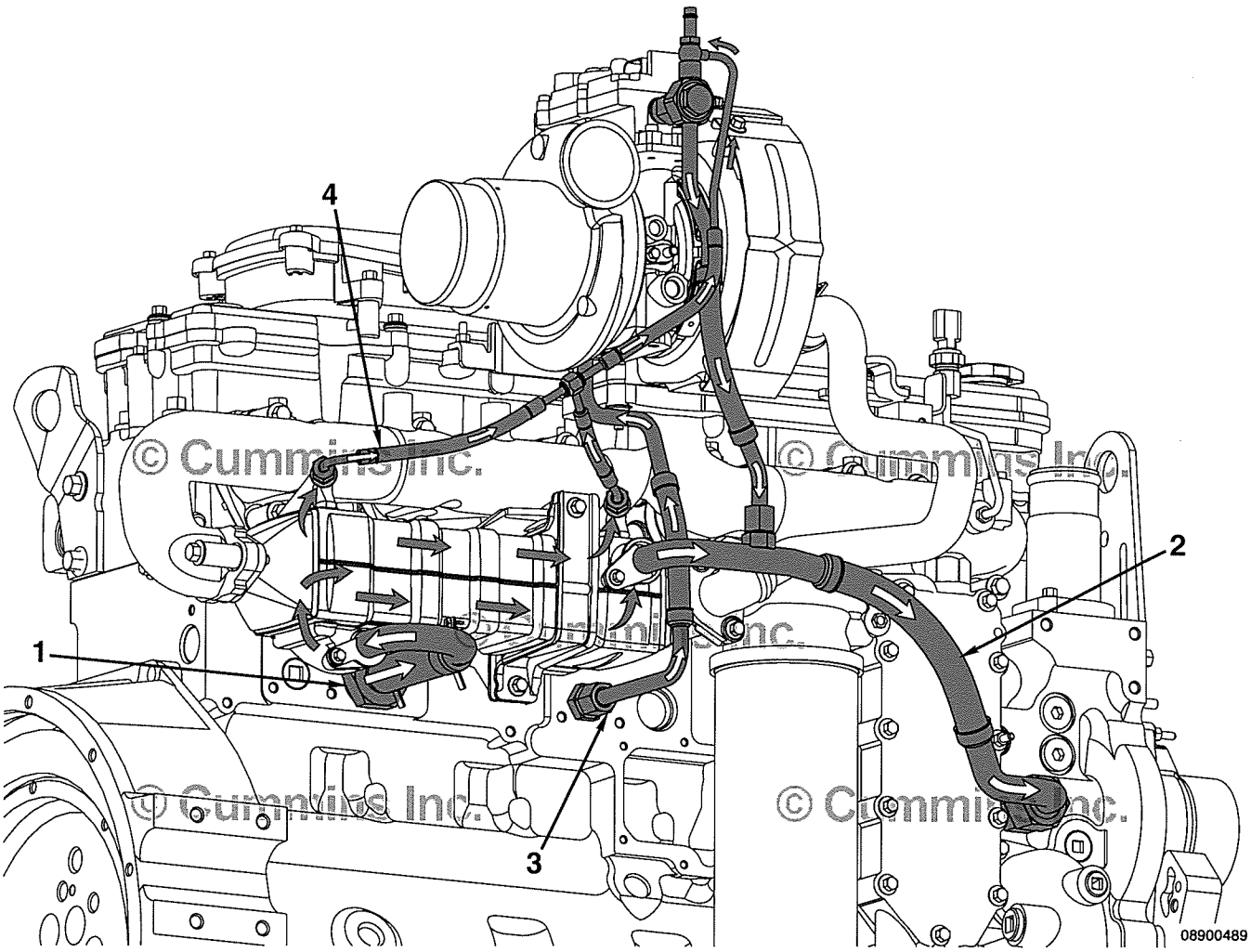
11 Optional torque converter coolant supply from cylinder block with thermostat closed

12 Optional torque converter coolant return to water/coolant inlet connection

13 Coolant supply to aftertreatment DEF fluid dosing valve and tank from cylinder head.

Flow Diagram, Cooling System

Flow Diagram



1 Coolant supply from the cylinder block to the exhaust gas recirculation (EGR) cooler

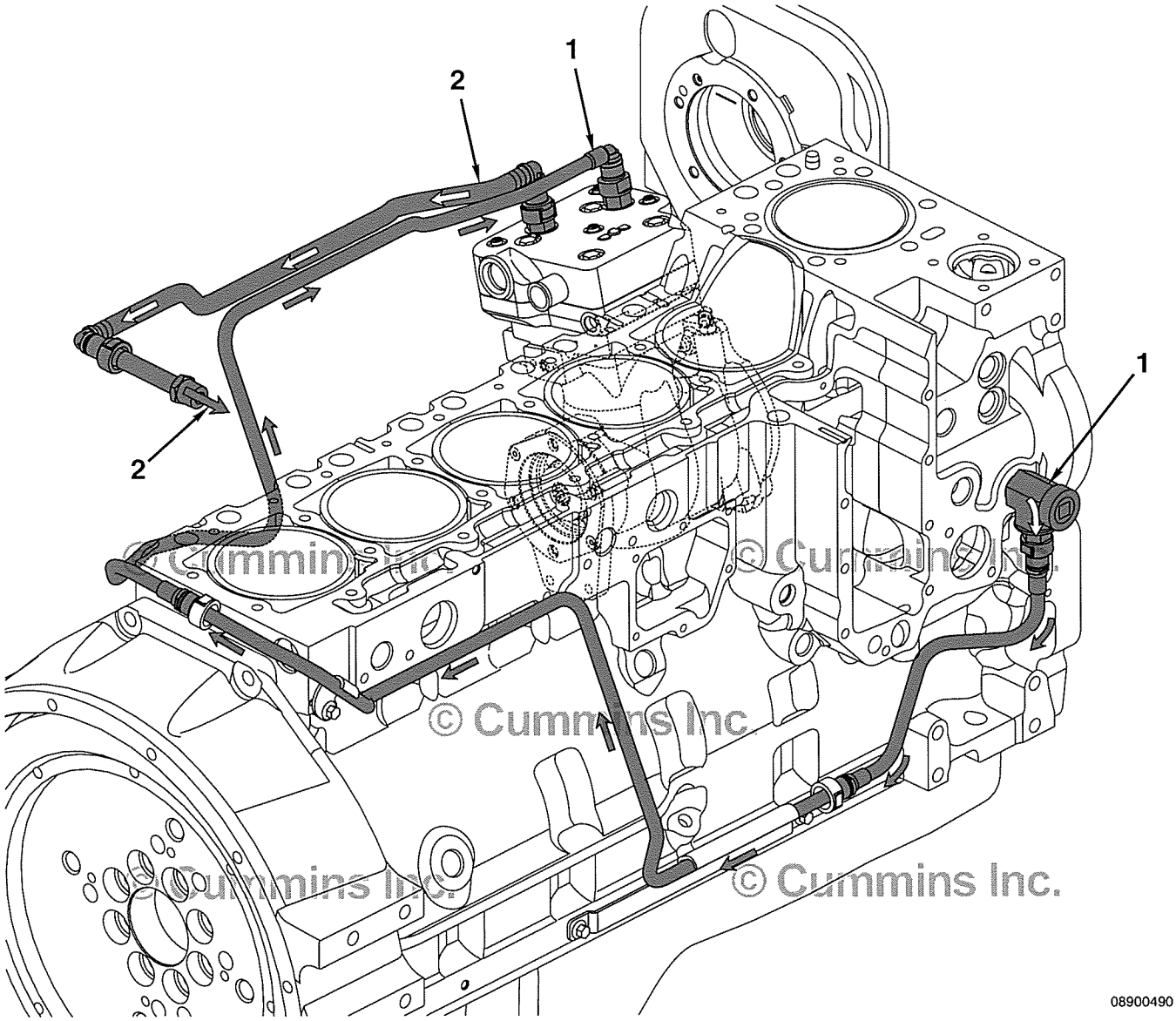
2 Coolant drain to the water pump inlet from the EGR cooler and the variable geometry turbocharger (VGT) actuator

3 Coolant supply to the VGT from the cylinder block

4 Coolant vent line to the VGT from the EGR cooler.

Flow Diagram, Cooling System

Flow Diagram



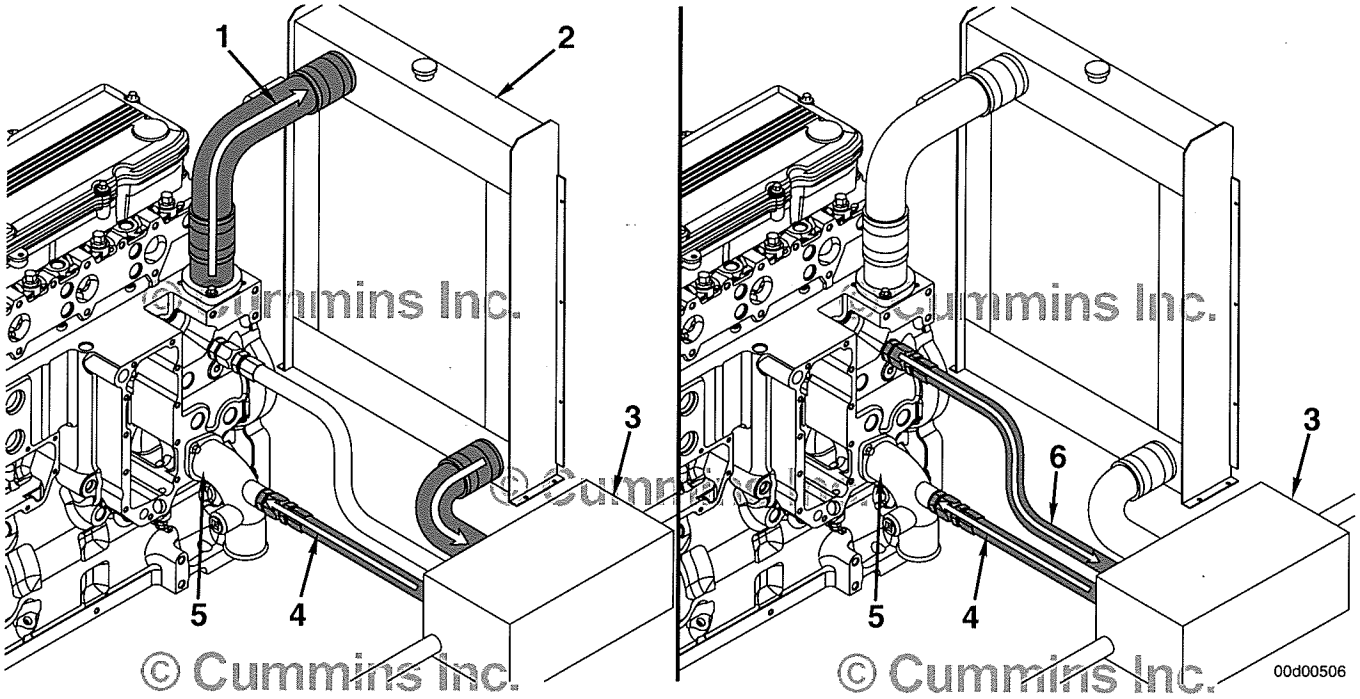
Cold Side of Engine

1 Air compressor coolant supply from cylinder block

2 Air compressor coolant return to cylinder head.

Flow Diagram, Cooling System

Flow Diagram



NOTE: For engines equipped with optional torque converter cooler option.

NOTE: Conventionally cooled engines with automatic transmissions typically use oil-to-water transmission torque converter coolers plumbed between the radiator and the engine water pump.

NOTE: A torque converter cooling system with a remote bypass allows the torque converter to receive coolant flow when the thermostat is closed (engine cold, no flow through radiator).

NOTE: For original equipment manufacturer (OEM) components, refer to the OEM service manual and literature.

1 Flow to radiator and torque converter when thermostat is open

2 Radiator

3 Torque converter cooler

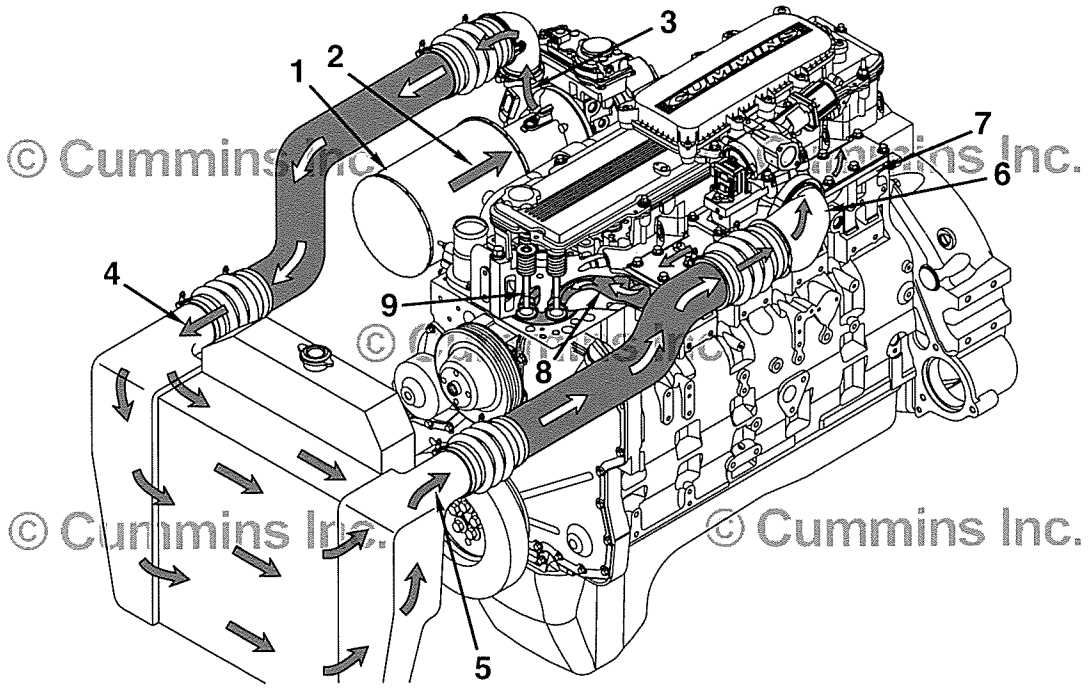
4 Coolant return to engine inlet connection from torque converter cooler.

5 Engine inlet connection

6 Flow to torque converter **only** when the thermostat is closed.

Flow Diagram, Air Intake System

General Information

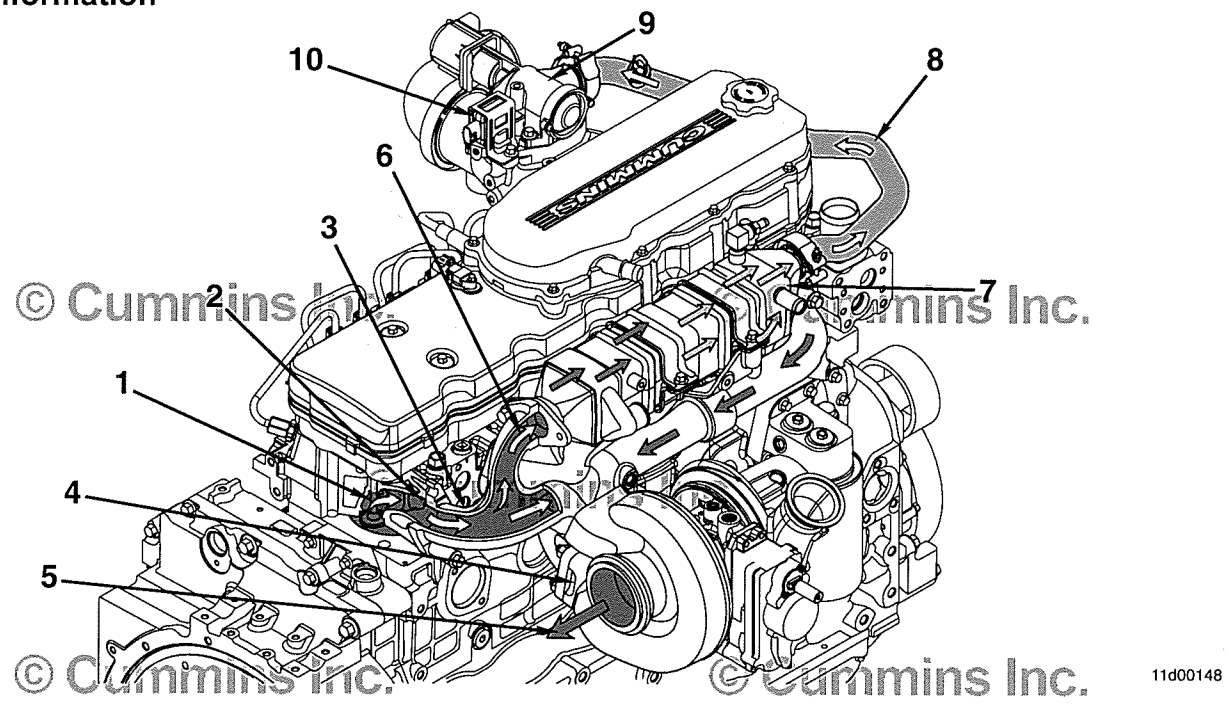


Air Intake Flow

1 Air cleaner
2 Turbocharger compressor inlet
3 Turbocharger compressor outlet
4 Charge air cooler inlet
5 Charge air cooler outlet
6 Air intake connection
7 Intake manifold (intregal part of the cylinder head)
8 Intake port
9 Intake valve.

Flow Diagram, Exhaust System

General Information

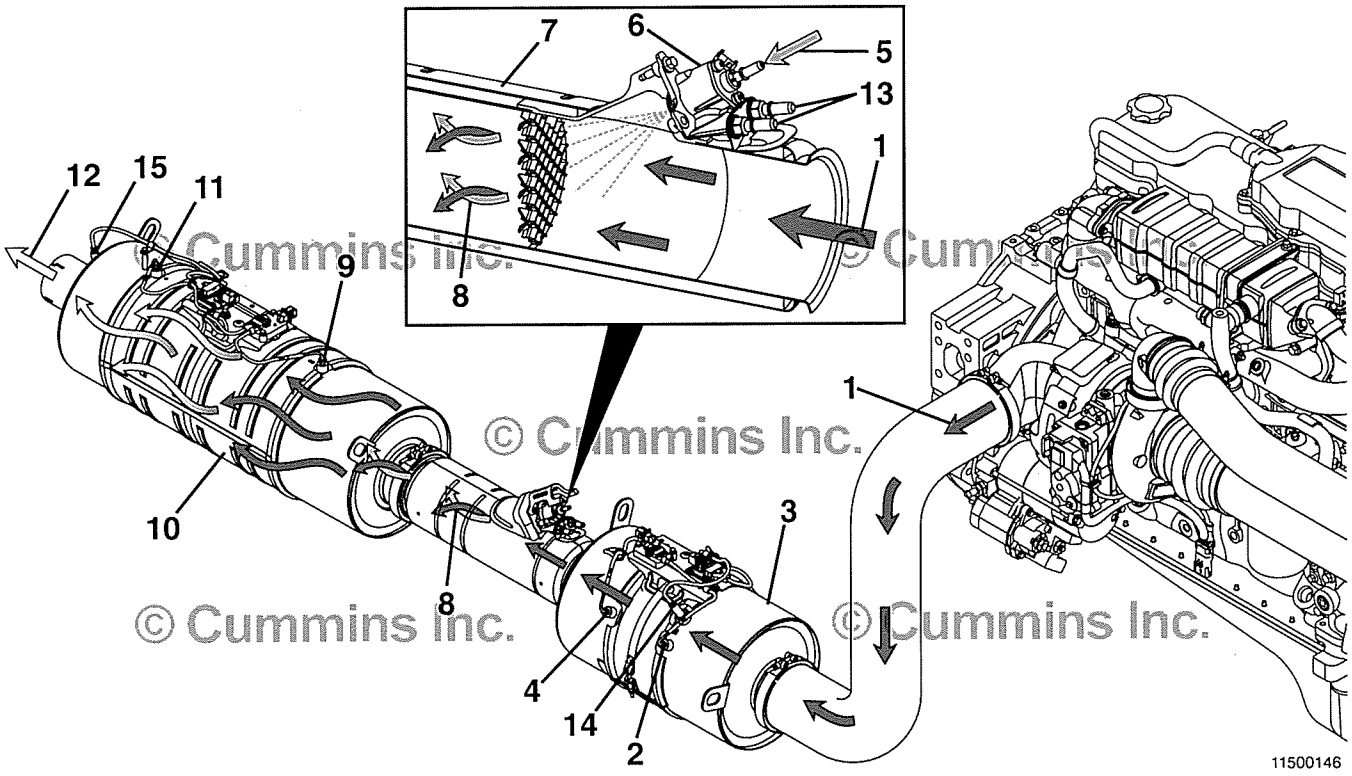


Exhaust Flow

1 Exhaust valves
2 Exhaust port
3 Exhaust manifold
4 Turbocharger
5 Turbocharger exhaust outlet
6 Exhaust inlet to exhaust gas recirculation (EGR) cooler
7 EGR cooler
8 Cooled exhaust outlet to EGR valve
9 EGR valve
10 EGR valve differential pressure sensor.

Flow Diagram, Exhaust System

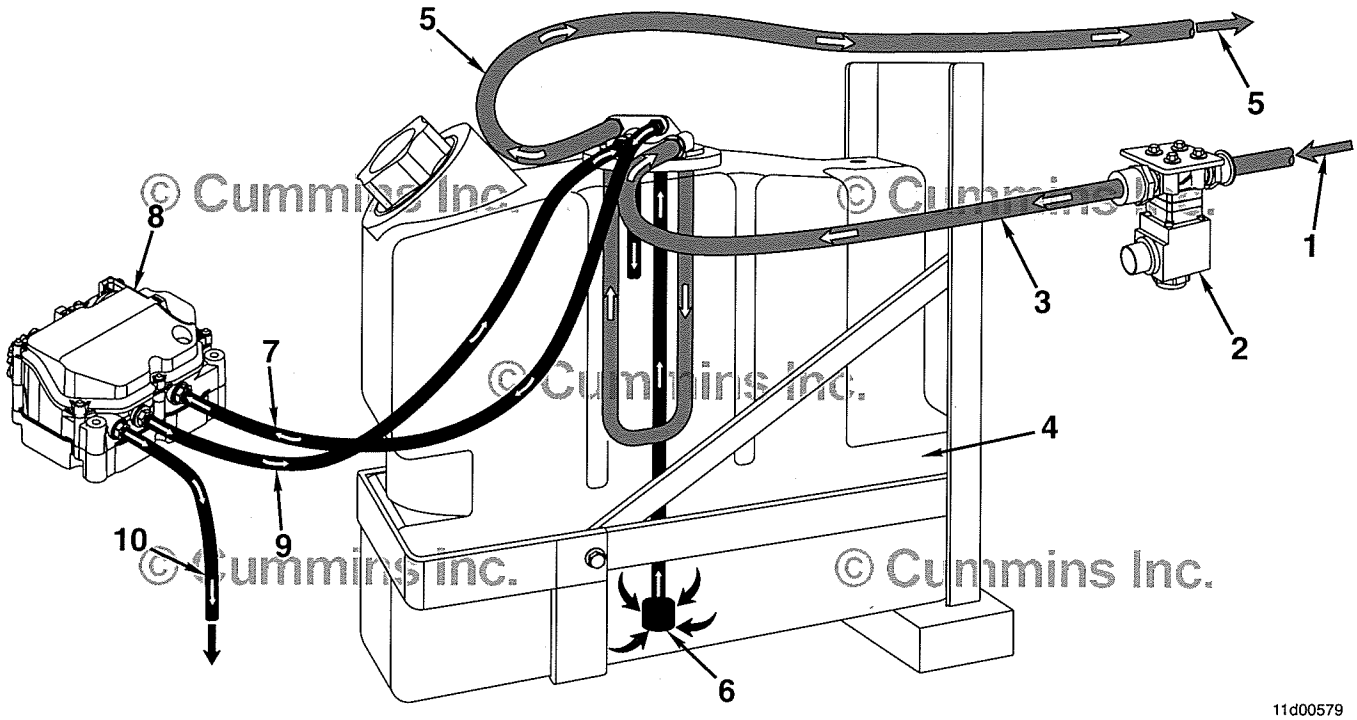
General Information



1 Exhaust from turbocharger
2 Aftertreatment diesel oxidation catalyst (DOC) intake temperature sensor probe
3 Aftertreatment DOC
4 Aftertreatment DOC outlet temperature sensor probe
5 Diesel exhaust fluid (DEF) supply to aftertreatment DEF dosing valve
6 Aftertreatment DEF dosing valve
7 Decomposition reactor
8 Exhaust and DEF mixture
9 Aftertreatment selective catalyst reduction (SCR) intake temperature sensor probe
10 Aftertreatment SCR catalyst
11 Aftertreatment SCR outlet temperature sensor probe
12 Exhaust flow exiting aftertreatment system
13 Aftertreatment DEF dosing valve coolant fittings
14 Aftertreatment inlet mono-nitrogen oxides (NOx) sensor probe
15 Aftertreatment outlet NOx sensor probe.

Flow Diagram, Exhaust System

General Information



1 Coolant flow from engine to aftertreatment DEF

2 Aftertreatment DEF tank coolant valve

3 Coolant flow to aftertreatment DEF tank (**Only** when aftertreatment DEF tank coolant valve is open)

4 Aftertreatment DEF tank

5 Coolant return to engine

6 Aftertreatment DEF supply from aftertreatment DEF tank

7 Aftertreatment DEF flow to aftertreatment DEF dosing unit

8 Aftertreatment DEF dosing unit

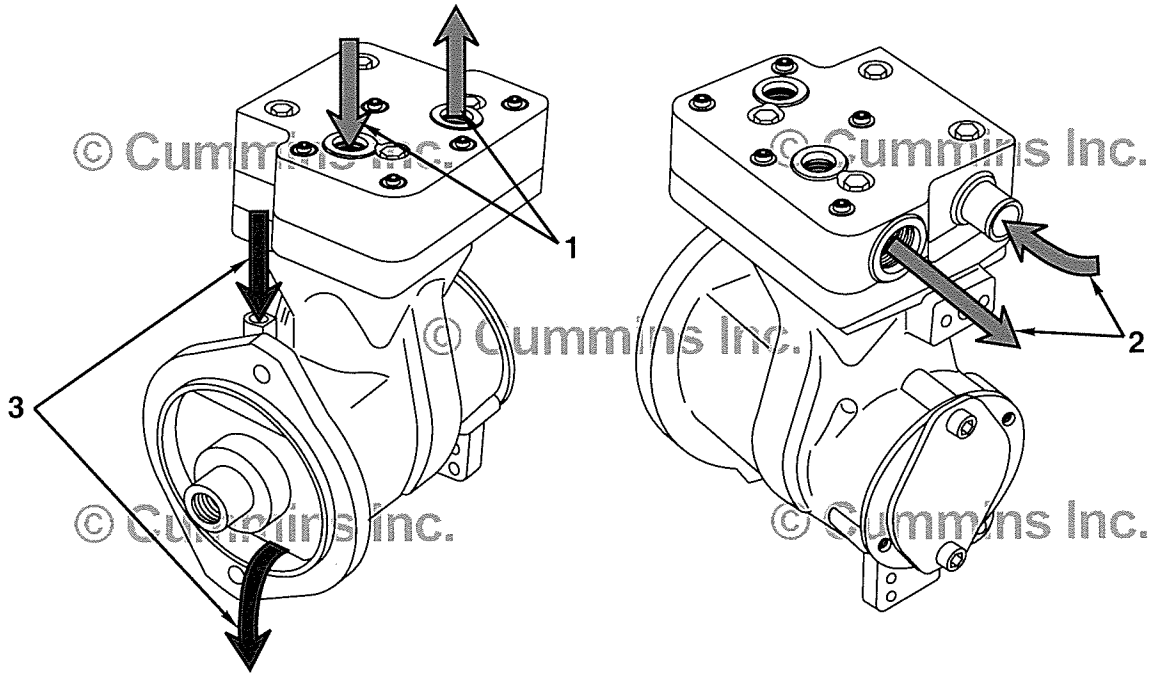
9 Aftertreatment DEF return to aftertreatment DEF tank

10 Aftertreatment DEF flow to aftertreatment DEF dosing valve.

NOTE: For additional information regarding the diesel exhaust fluid tank or coolant valve, refer to the original equipment manufacturer (OEM) service manual.

Flow Diagram, Compressed Air System

General Information



12d00033

1 Coolant
2 Air
3 Lubricant.

Notes

Cummins Service Publications Electronic Book on DVD-ROM

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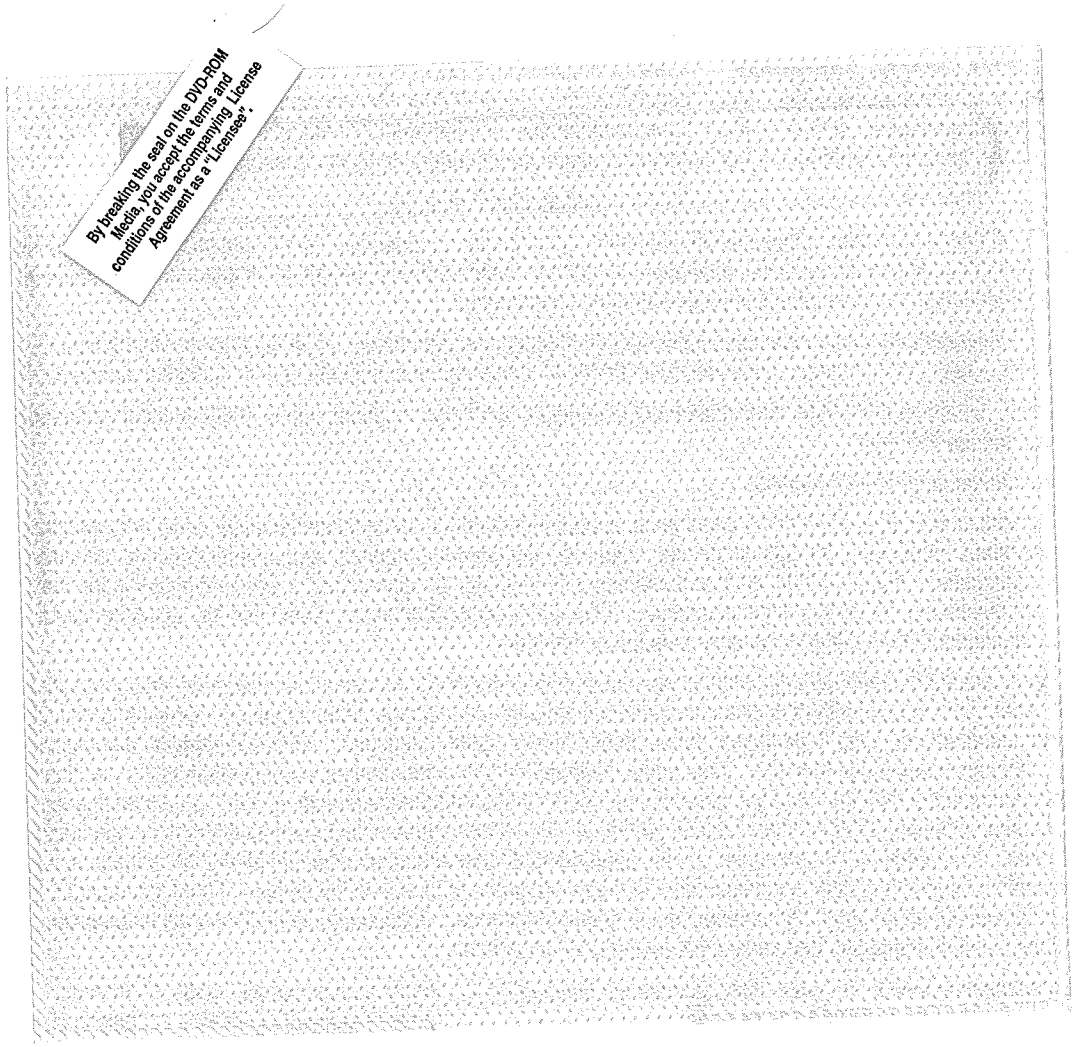

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ELECTRONIC BOOK ON DVD-ROM
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- Microsoft Windows Auto-Play must be enabled on your computer (it is enabled by default when Windows is installed)
- DVD-ROM Drive
- Color Monitor with at least 800x600 resolution graphics
- Microsoft Windows XP Professional SP3, Microsoft Windows Vista SP1, Microsoft Windows Vista x64 SP1, Microsoft Windows 7, or Microsoft Windows 7 x64. Testing has not been performed with the x64 bit versions of Vista and Windows 7, but the product is believed to be compatible. Use on other Microsoft Operating Systems may be compatible but testing has not been performed, and while it may function, it is not supported. While we try to maintain compatibility with all popular Microsoft Operating Systems, compatibility with the listed Microsoft Operating Systems is subject to change.
- Recommended memory, processor speed and available hard-disk space is in accordance with respective Microsoft Operating System Guidelines, as well as Adobe Acrobat system requirements.

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Section L - Service Literature

Section Contents

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Additional Service Literature

General Information

The following publications can be purchased.

Bulletin Number	Title or Publication
4332796	QSL9 CM2350 L102 Service Manual
4332795	QSL9 CM2350 L102 Fault Code Troubleshooting Manual
4332794	QSL9 CM2350 L102 Wiring Diagram
4332797	QSL9 CM2350 L102 Operation and Maintenance Manual
4332798	QSL9 CM2350 L102 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
3810303	Parts Reuse Guidelines
3810340	Cummins® Engine Oil and Oil Analysis Recommendations

Service Literature Ordering Location
Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at 1-800-646-5609 or Order online at www.powerstore.cummins.com
All Other Countries	Cummins Distributors or Dealers

Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contains only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number. Your name and engine model identification even appears on the catalog spine. Everybody will know that Cummins created a catalog specifically for you.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to the Cummins Electronic Parts Catalog or the Cummins Parts Microfilm System.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

North American customers can contact their Cummins Distributor or call Gannett Direct Marketing Services at 1-800-646-5609 and order by credit card. Outside North America order on-line or make an International call to Gannett at (++)502-454-6660.

Ordering On-Line

The Customized Parts Catalog can be ordered On-Line from the Cummins Powerstore by credit card.

Contact GDMS or the CUMMINS POWERSTORE for the current price; Freight may be an additional expense.

Information we need to take your Customized Parts Catalog Order. This information drives the cover content of the CPC.

- Customer Name
- Street Address
- Company Name (optional)
- Telephone no.
- Credit Card No.
- Cummins Engine Serial Number (located on the engine data plate)
- Please identify the required media: Printed Catalog, CD-ROM, or PDF File

Unfortunately not all Cummins Engines can be supported by this parts catalog. Engines older than 1984 or newer than 3 months may not have the necessary parts information to compile a catalog. We will contact you if this occurs and explain why we are unable to fill your order.

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Notes

Section S - Service Assistance

Section Contents

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Routine Service and Parts

General Information

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

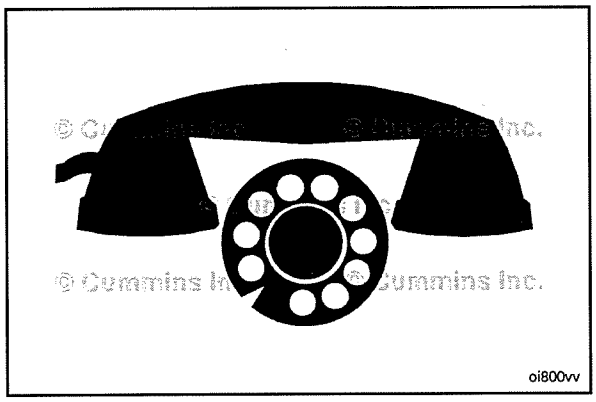
Emergency and Technical Service

General Information

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

If additional assistance is required, call Toll-Free:

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



Problem Solving

General Information

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

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

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

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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
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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,
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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,
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NETHERLANDS	**Dordrecht**	Cummins Holland B V Galvanistraat 35 Dordrecht, Zuid-Holland 3316 GHNetherlandsTelephone: (31-78) 6181200Fax: (31-78) 6176579,
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NEW GUINEA	**- See Papua New Guinea**	CumminsMacdhui StreetLaePapua New GuineaTelephone: (675) 472 3699Fax: (675) 472 3803,
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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,
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NIGERIA	**Lagos**	Scoa Power (A Division of Scoa Nigeria Plc) 15, Creek RoadApapaLagosNigeriaTelephone: (234-1) 5873623 / 5877322Fax: (234-1) 5450646,
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OMAN	**Ruwi**	Universal Engineering Services LLCPO Box 2688Ruwi 112OmanTelephone: (968) 597531 / 597537Fax: (968) 597514,
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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,
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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,
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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,
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TOGO (and BENIN)	**Lome**	TOGOMAT s.a.Zone Industrielle CNPPMELomeTogo Telephone: (228) 2272395Fax: (228) 2270310,
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VIETNAM	**Hanoi**	Diethelm & Co. Ltd., Engrg.94, Tran Quoc Toan Street,Hoan Kiem DistrictHanoiVietnam Telephone: (84-4) 9424-725Fax: (84-4) 9424-730,
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ZAMBIA	**Ndola**	Cummins Zambia LtdLufunza AvenueNdola, ZambiaZambiaTelephone: (260-2) 610 729Fax: (260-2) 612 756,
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Section ES - Engine Storage

Section Contents

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Engine Storage - Long Term

General Information

If the engine will be out of service longer than 6 months, special precautions **must** be taken. Follow the long term storage procedure in the base engine troubleshooting and repair manual or service manual or contact the nearest Cummins® Authorized Repair Location for additional information.

Notes

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 the engine air intake restriction if the air compressor air inlet is plumbed to the vehicle or equipment intake system. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 2 Air system leaks	Block the vehicle wheels and check the air system for leaks with the service brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the original equipment manufacturer (OEM) service manual. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.
OK Go To Next Step	
STEP 3 Air governor is malfunctioning or **not** set correctly	Perform an exhaust gas analysis check. If the exhaust gases are **not** within specifications, perform the Starting Procedure for New Engine or Changed Conditions. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Carbon buildup is excessive in the air discharge line, check valve, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line, if necessary. Refer to Procedure 012-015 in Section 8.
OK Go To Next Step	
STEP 5 Air system component is malfunctioning	Check the operation of check valves, alcohol evaporators, air dryers, and other OEM-installed air system components. Refer to the manufacturer's instructions.
OK Go To Next Step	
STEP 6 Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 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 the service brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the original equipment manufacturer (OEM) service manual. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.

OK
Go To Next Step

STEP 2 Air governor is malfunctioning or **not** set correctly	Perform an exhaust gas analysis check. If the exhaust gases are **not** within specifications, perform the Starting Procedure for New Engine or Changed Conditions. Refer to the OEM service manual.

OK
Go To Next Step

STEP 3 Air system component is malfunctioning	Check the operation of check valves, alcohol evaporators, air dryers, and other OEM-installed air system components. Refer to the manufacturer's instructions.

OK
Go To Next Step

STEP 4 E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the OEM service manual.

OK
Go To Next Step

STEP 5 Carbon buildup is excessive in the air discharge line, check valve, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line, if necessary. Refer to Procedure 012-015 in Section 8.

OK
Go To Next Step

STEP 6 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. Contact a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 7 Air dryer outlet check valve is sticking	Lubricate or replace the air dryer outlet check valve assembly. Refer to the manufacturer's instructions.

OK
Go To Next Step

STEP 8
Contact a Cummins® Authorized Repair Facility

Air Compressor Noise is Excessive

Cause	Correction
STEP 1 Carbon buildup is excessive in the air discharge line, check valve, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line, if necessary. Refer to Procedure 012-015 in Section 8.
OK Go To Next Step	
STEP 2 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 original equipment manufacturer (OEM) instructions.
OK Go To Next Step	
STEP 3 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 OEM instructions.
OK Go To Next Step	
STEP 4 Contact a Cummins® Authorized Repair Facility	

Air Compressor Pumping Excess Lubricating Oil into the Air System

Cause	Correction
STEP 1 Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002 in Section 2.
OK Go To Next Step	
STEP 2 Air intake system restriction to air compressor is excessive	Replace the air compressor air cleaner, if installed. Check the air intake piping. Check the engine air intake restriction if the air compressor air inlet is plumbed to the vehicle or equipment intake system. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 3 Contaminants are building up in the system reservoirs	Drain the reservoirs daily. Refer to Procedure 012-021 in Section 3. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line and the inline air filter on the air supply line to the dosing control unit for contamination.
OK Go To Next Step	
STEP 4 E-type system is **not** plumbed correctly	Install an Econ valve, a check valve, and system hoses. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 5 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. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Carbon buildup is excessive in the air discharge line, check valve, or cylinder head	Check for carbon buildup. Replace the air compressor discharge line, if necessary. Refer to Procedure 012-015 in Section 8.
OK Go To Next Step	
STEP 7 Lubricating oil pressure is above specification	Check the oil pressure. Contact a Cummins® Authorized Repair Location
OK Go To Next Step	
STEP 8 Air compressor runs hot	If coolant temperature is above normal, refer to the Coolant Temperature Above Normal - Gradual Overheat troubleshooting symptom tree in Section TS.
OK Go To Next Step	

Air Compressor Pumping Excess Lubricating Oil into the Air System

Cause	Correction
STEP 9 Air compressor pumping too high air pressure	Check the air governor for correct operation. Refer to the OEM service manual.

OK
Go To Next Step

STEP 10
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 original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Air governor is malfunctioning or not set correctly	Check the air governor for correct operation. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 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 the service brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the original equipment manufacturer (OEM) service manual. For applications fitted with selective catalytic reduction exhaust systems, check the air supply line to the dosing control unit.

OK
Go To Next Step

STEP 2 Air governor is malfunctioning or **not** set correctly	Check the air governor for correct operation. Make sure the air governor is located less than 0.6 m [2 ft] from the air compressor. Refer to the OEM service manual.

OK
Go To Next Step

STEP 3 Unloader valve is malfunctioning	Check the unloader valve and unloader body seal. Refer to the OEM service manual.

OK
Go To Next Step

STEP 4 Air governor signal line or actuator line is plugged	Inspect the signal line and actuator line. Refer to the manufacturer's instructions.

OK
Go To Next Step

STEP 5 Air system component is malfunctioning	Check the operation of check valves, alcohol evaporators, air dryers, and other OEM-installed air system components. Refer to the manufacturer's instructions.

OK
Go To Next Step

STEP 6
Contact a Cummins® Authorized Repair Facility

Alternator Not Charging or Insufficient Charging

Cause	Correction
STEP 1 Vehicle gauge is malfunctioning	Check the vehicle gauge. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Alternator belt is loose	Check the alternator belt tension. Refer to Procedure 013-001 in Section A.
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 the manufacturer's wiring diagrams.
OK Go To Next Step	
STEP 4 Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections. Refer to the OEM service manual and the manufacturer's wiring diagrams.
OK Go To Next Step	
STEP 5 Batteries have malfunctioned	Check the condition of the batteries. Replace the batteries, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 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 7 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 8 Contact a Cummins® Authorized Repair Facility	

Alternator Overcharging

Cause	Correction
STEP 1 Battery cell is damaged (open circuit)	Check the condition of the batteries. Replace the batteries, if necessary. Refer to the original equipment manufacturer (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 the OEM service manual.
OK Go To Next Step	
STEP 3 Contact a Cummins® Authorized Repair Facility	

Coolant Loss - External

Cause	Correction
STEP 1 Power system coolant level is above specification	Check the power system coolant level. Refer to Procedure 008-066 in Section 3.
OK Go To Next Step	
STEP 2 External coolant leak	Inspect the engine for coolant leaking externally from items such as coolant hoses, drain valves, coolant manifolds, expansion and pipe plugs, fittings, air compressor coolant lines, EGR cooler coolant lines, turbocharger coolant lines, transmission oil cooler or torque converter oil cooler, water pump seal, radiator core, heat exchanger, lubricating oil cooler housing, aftertreatment diesel exhaust fluid tank heater and hoses, aftertreatment diesel exhaust fluid dosing valve coolant lines, and OEM mounted components that have coolant flow. If necessary, pressure test the cooling system. Refer to Procedure 008-018 in Section 8 and the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 3 Radiator cap is **not** correct, is malfunctioning, or has low-pressure rating	Check the radiator pressure cap. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045 in Section 4.
OK Go To Next Step	
STEP 5 Coolant fill line is restricted or obstructed	Check the coolant fill line for restrictions or obstructions. Refer to Procedure 008-018 in Section 8.
OK Go To Next Step	
STEP 6 Engine is overheating	Refer to the Coolant Temperature is Above Normal - Sudden Overheat troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 7 Contact a Cummins® Authorized Repair Facility	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 1 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 384 cm2 [60 in2] or approximately 19.6 x 19.6 cm [7.5 x 7.5 in] of opening at all times. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 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 the OEM service manual.
OK Go To Next Step	
STEP 3 Coolant level is below specification	Check the coolant level. Check for an external leak. Refer to Procedure 008-066 in Section 3. Sample the lubricating oil and have a laboratory check for coolant in the oil (internal leak).
OK Go To Next Step	
STEP 4 Coolant mixture of antifreeze and water is **not** correct	Verify the concentration of antifreeze in the coolant. Add antifreeze or water to correct the concentration. Refer to Procedure 018-018 in Section V.
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, as necessary.
OK Go To Next Step	
STEP 6 Fan drive belt is broken or loose	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002 in Section 6.
OK Go To Next Step	
STEP 7 Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 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	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 9 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045 in Section 4.
OK Go To Next Step	
STEP 10 Fill line or vent lines are restricted, obstructed, or **not** routed correctly	Check the vent lines and the fill line for correct routing and for restrictions. Refer to the OEM service manual.
OK Go To Next Step	
STEP 11 Intake manifold air temperature is above specification	Refer to the Intake Manifold Air Temperature Above Specification troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 12 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-043 in Section 3.
OK Go To Next Step	
STEP 13 Thermostat is **not** correct or is malfunctioning	Check the thermostat for the correct part number and for correct operation.
OK Go To Next Step	
STEP 14 Lubricating oil is contaminated with coolant or fuel	Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 15 Water pump is malfunctioning	Check the water pump for correct operation. Replace the water pump, if necessary.
OK Go To Next Step	
STEP 16 Radiator core is internally obstructed or damaged, or the check valve or J-tube is malfunctioning	Inspect the radiator and clean, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 17 Torque converter is malfunctioning	Check the torque converter. Refer to the OEM service manual.
OK Go To Next Step	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 18 Torque converter cooler or hydraulic oil cooler is malfunctioning	Remove and inspect the cooler cores and o-rings. Refer to the OEM service manual.
OK Go To Next Step	
STEP 19 Vehicle cooling system is **not** adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM service manual.
OK Go To Next Step	
STEP 20 Engine is overfueled	Check the engine fuel rate. Refer to the Fuel Consumption Excessive troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 21 Contact a Cummins® Authorized Repair Facility	

Coolant Temperature Above Normal - Sudden Overheat

Cause	Correction
STEP 1 Coolant level is below specification	Check the coolant level. Check for an external leak. Refer to Procedure 008-066 in Section 3. Sample the lubricating oil and have a laboratory check for coolant in the oil (internal leak).
OK Go To Next Step	
STEP 2 Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Fan drive belt is broken or loose	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002 in Section 6.
OK Go To Next Step	
STEP 4 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 384 cm2 [60 in2] or approximately 19.6 x 19.6 cm [7.5 x 7.5 in] of opening at all times. Refer to Procedure 101-015 in Section 1.
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 original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 6 Charge-air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge-air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Procedure 010-027 in 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. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to Procedure 008-045 in Section 4.
OK Go To Next Step	

Coolant Temperature Above Normal - Sudden Overheat

Cause	Correction
STEP 9 Fill line or vent lines are restricted, obstructed, or **not** routed correctly	Check the vent lines and the fill line for correct routing and for restrictions. Refer to the OEM service manual.

OK
Go To Next Step

STEP 10 Thermostat is **not** correct or is malfunctioning	Check the thermostat for the correct part number and for correct operation.

OK
Go To Next Step

STEP 11
Contact a Cummins® Authorized Repair Facility

Coolant Temperature Below Normal

Cause	Correction
STEP 1 Coolant temperature gauge or sensor is malfunctioning	Test the gauge or the sensor. Repair or replace, if necessary. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Excessive coolant flow through OEM plumbing and heater cores	Close valves to heater cores. Run engine. If engine operates at normal temperature, refer to the OEM service manual.
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 the OEM service manual.
OK Go To Next Step	
STEP 4 Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Thermostat is **not** correct or is malfunctioning	Check the thermostat for the correct part number and for correct operation.
OK Go To Next Step	
STEP 6 Contact a Cummins® Authorized Repair Facility	

Cranking Fuel Pressure is Low

Cause	Correction
STEP 1 Fuel connections on the low-pressure side of the pump are loose	Tighten all fuel fittings and connections between the fuel tanks and the fuel pump.
OK Go To Next Step	
STEP 2 Fuel level is low in the tank	Fill the supply tank. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 3 Fuel suction standpipe in the fuel tank is broken	Check and repair the standpipe, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 4 Contact a Cummins® Authorized Repair Facility	

Engine Acceleration or Response Poor

Cause	Correction
STEP 1 Operator technique is **not** correct	Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 2 Fuel level is low in the tank	Fill the supply tank. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 3 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 4 Clutch is malfunctioning or is **not** correct	Compare the drivetrain specifications to Cummins Inc. 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 service manual.
OK Go To Next Step	
STEP 6 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Intake manifold air temperature is above specification	Refer to Intake Manifold Air Temperature Above Specification troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 8 Fuel supply line restriction between the fuel pump and the injectors	Check the fuel supply line from the fuel pump to the cylinder head for sharp bends that can cause restrictions. Refer to the OEM service manual.
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 Procedure 010-027 in Section 4.
OK Go To Next Step	

Engine Acceleration or Response Poor

Cause	Correction
STEP 10 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 in Section 3.
OK Go To Next Step	
STEP 11 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 12 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of known high quality fuel. Refer to Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 13 Contact a Cummins® Authorized Repair Facility	

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

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Starting aid is necessary for cold weather or starting aid is malfunctioning	Check for the correct operation of the starting aid. Refer to the OEM service manual
OK Go To Next Step	
STEP 3 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 4 Fuel heater is malfunctioning, if equipped	Check the fuel heater and replace, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Battery voltage is low	Check the batteries and the unswitched battery supply circuit. Refer to the OEM service manual and Procedure 013-009 in Section 5.
OK Go To Next Step	
STEP 6 Engine cranking speed is too slow	Check the engine cranking speed with a handheld tachometer or electronic service tool. Determine if the cranking speed is slower than 150 rpm. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 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 8 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 9 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
OK Go To Next Step	

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

Cause	Correction
STEP 10 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 4.

OK
Go To Next Step

STEP 11 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 Procedure 018-002 in Section V.

OK
Go To Next Step

STEP 12
Contact a Cummins® Authorized Repair Facility

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

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Engine indicator lamps illuminated	Refer to Procedure 101-048 in Section 1.
OK Go To Next Step	
STEP 3 Battery voltage is low	Check the batteries and the unswitched battery supply circuit. Refer to Procedure 013-007 in Section 5.
OK Go To Next Step	
STEP 4 Battery voltage supply to the engine 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 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.
OK Go To Next Step	
STEP 6 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 7 OEM engine protection system is malfunctioning	Isolate the OEM engine protection system. Follow the OEM service manual instructions to check for a malfunction.
OK Go To Next Step	
STEP 8 Engine control module (ECM) is malfunctioning	Replace the ECM. Refer to a Cummins® Authorized Repair Facility.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Engine Noise Excessive

Cause	Correction
STEP 1 Fan drive belt is loose	Check the belt tension and tighten, if necessary. Refer to Procedure 008-080 in Section A.
OK Go To Next Step	
STEP 2 Fan is loose, damaged, or **not** balanced	Check the fan. Refer to Procedure 008-040 in Section 3.
OK Go To Next Step	
STEP 3 Fan clutch, hydraulic pump, or refrigerant compressor noise is excessive	Isolate each component and check for noise. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 4 Air intake or exhaust leaks	Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-058 in Section 3.
OK Go To Next Step	
STEP 5 Air intake or exhaust piping is contacting the chassis or cab	Inspect the air piping, chassis, and cab for contact points. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-043 in Section 3.
OK Go To Next Step	
STEP 7 Lubricating oil is thin or diluted	Refer to the Lubricating Oil Contaminated troubleshooting symptom tree in Section TS. 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 8 Lubricating oil pressure is below specification	Check the oil pressure. If the pressure is low, refer to the Lubricating Oil Contaminated troubleshooting symptom tree in Section TS. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 9 Vibration damper is damaged	Inspect the vibration damper. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	

Engine Noise Excessive

Cause	Correction
STEP 10 Coolant temperature is above specification	Refer to the Coolant Temperature Above Normal - Gradual Overheat troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 11 Drivetrain noise is excessive	Disconnect the drivetrain. Check for engine noise. Refer to the OEM service manual.
OK Go To Next Step	
STEP 12 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the OEM service manual.
OK Go To Next Step	
STEP 13 Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-004 in Section 9.
OK Go To Next Step	
STEP 14 Air compressor noise is excessive	Refer to the Air Compressor Noise Excessive troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 15 Combustion noise excessive	Refer to the Engine Noise Excessive - Combustion Knocks troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 16 Contact a Cummins® Authorized Repair Facility	

Engine Noise Excessive - Combustion Knocks

Cause	Correction
STEP 1 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of known high quality fuel. Refer to Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 2 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
OK Go To Next Step	
STEP 3 Coolant temperature is above specification	Refer to the Coolant Temperature Above Normal - Gradual Overheat and Coolant Temperature Above Normal - Sudden Overheat troubleshooting symptom trees in Section TS.
OK Go To Next Step	
STEP 4 Overhead adjustments are **not** correct	Measure and adjust the overhead settings. Refer to Procedure 003-004 in Section 9.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Engine Power Output Low

Cause	Correction
STEP 1 Operator technique is **not** correct	Explain correct engine operation to the operator. Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 2 Original equipment manufacturer (OEM) machine constrained operation	OEM machine constrained operation through an OEM controller. Verify that the OEM system is configured to deliver correct power output. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Engine is operating above recommended altitude	Engine power decreases above recommended altitude. Refer to Procedure 101-008 in Section 1 or contact a Cummins® Authorized Repair Facility for specifications.
OK Go To Next Step	
STEP 4 Engine indicator lamps illuminated	Refer to Procedure 101-048 in Section 1.
OK Go To Next Step	
STEP 5 Fuel grade is **not** correct for the application or fuel quality is poor	Operate the engine with a known good fuel supply and determine if the performance symptoms are eliminated. Verify if the customer is using any fuel additives and is using the correct fuel grade. Refer to Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 6 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 7 Fuel level is low in the tank	Fill the supply tank. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 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	

Engine Power Output Low

Cause	Correction
STEP 9 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 10 Fuel tank vents are plugged or damaged	Remove and clean the tank vents. Replace the vents if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 11 Lubricating oil level is above specification	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 12 Fuel filter is plugged	Measure the fuel pressure before and after the fuel filter. Refer to Procedure 006-015 in Section 5 and contact a Cummins® Authorized Repair Facility.
OK Go To Next Step	
STEP 13 Fuel suction line restricted	Inspect for pinched, crimped, or kinked fuel lines. Refer to a Cummins® Authorized Repair Facility.
OK Go To Next Step	
STEP 14 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 3.
OK Go To Next Step	
STEP 15 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 in Section 3.
OK Go To Next Step	
STEP 16 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	

Engine Power Output Low

Cause	Correction
STEP 17 Charge-air cooler is restricted or leaking	Inspect the charge-air cooler for air restrictions or leaks. Refer to Procedure 010-027 in Section 4.

OK
Go To Next Step

STEP 18
Contact a Cummins® Authorized Repair Facility

Engine Runs Rough at Idle

Cause	Correction
STEP 1 Engine is cold	Allow the engine to warm to operating temperature. If the engine will **not** reach operating temperature, refer to the Coolant Temperature Below Normal troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 2 Electronic fault codes are active	Review instructions for reading active fault codes. Refer to a Cummins® Authorized Repair Location, if fault codes are active.
OK Go To Next Step	
STEP 3 Idle speed is set too low for accessories	Check and adjust the low-idle screw. Refer to Procedure 101-007 in Section 1 or contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Engine mounts are worn, damaged, or **not** correct	Check the engine mounts. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 5 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 6 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of known high quality fuel. Refer to Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 7 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 8 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Check the fuel suction line for restriction. Refer to Procedure 006-015 in Section 5.
OK Go To Next Step	
STEP 9 Fuel supply is **not** adequate	Check the flow through the filter to locate the source of the restriction. Refer to Procedure 006-015 in Section 5.
OK Go To Next Step	

Engine Runs Rough at Idle

Cause	Correction
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 is Below Normal troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 2 Engine indicator lamps illuminated	Refer to Procedure 101-048 in Section 1.
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.
OK Go To Next Step	
STEP 4 Fuel supply line restriction between the fuel pump and the injectors	Check the fuel supply line from the fuel pump to the cylinder head for sharp bends that can cause restrictions. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 5 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 6 Fuel quality is poor	Operate the engine from a temporary tank of known high quality number 2 diesel fuel. Clean and flush the vehicle's fuel system. Fill the fuel system with a known high quality number 2 diesel fuel.
OK Go To Next Step	
STEP 7 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 8 Contact a Cummins® Authorized Repair Facility	

Engine Shuts Off Unexpectedly or Dies During Deceleration

Cause	Correction
STEP 1 Fuel level is low in the tank	Fill the supply tank. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 3 OEM engine protection system is malfunctioning	Isolate the OEM engine protection system. Follow the OEM service manual instructions to check for a malfunction.
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 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 original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
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.
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 known high quality fuel. Refer to Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 5 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 original equipment manufacturer (OEM) service manual.

OK
Go To Next Step

STEP 2 Electronic fault codes active or high counts of inactive fault codes	Contact a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 3 Fast Idle Warm-up feature is activating	If enabled, monitor Fast Idle Warm-up status with INSITE™ electronic service tool. Refer to a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 4 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 5 Fuel inlet restriction	Check for fuel inlet restriction. Contact a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 6 Fuel filter or fuel suction inlet restriction	Check the flow through the fuel filter. Replace the fuel filter, if necessary. Refer to Procedure 006-015 in Section 5 or contact a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 7 Air in the fuel system	Check for air in the fuel system. Refer to a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 8 Engine control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Reference the calibration history spreadsheet on QuickServe™ Online internet website or the INCAL™ calibration DVD-ROM. Make sure the correct calibration is being used. If necessary, calibrate the ECM. Refer to a Cummins® Authorized Repair Location.

OK
Go To Next Step

Engine Speed Surges Under Load or in Operating Range

Cause	Correction
STEP 9 Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again, if necessary. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 10 J1939 control devices are interfering with the engine controls	Alternately disconnect all other J1939 control devices from the data link circuit until communication or functionality is restored. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 11 Gain Adjust setting is incorrect for the application (Power Generation Engines **Only**)	The Gain Adjust can be used to resolve issues with engine surge. Use the Features and Parameters menu in INSITE™ electronic service tool to determine how the Gain Adjust is set. The following options are available; the INSITE™ electronic service tool trimmable calibration, hardwired control knob, or the data link. Verify that the Gain Adjust is set correctly. If applicable, verify that the engine is able to receive messages from the data link or from the potentiometer. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 12 Accelerator pedal or lever is restricted or malfunctioning	Check the percent accelerator pedal or lever reading on an electronic service tool. Verify that it reads 100 percent with the accelerator pedal depressed and 0 percent when released. Calibrate the accelerator, if possible. Replace the accelerator pedal, if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 13 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 14 Equipment and/or engine parastics are excessive	Check the equipment for excessive loads from the engine-driven components. Refer to the OEM service manual.
OK Go To Next Step	

Engine Speed Surges Under Load or in Operating Range

Cause	Correction
STEP 15 Engine speed sensor or circuit is malfunctioning	Check the engine speed sensor for correct adjustment and for debris on the sensor. Check the engine speed sensor circuit. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 16 Engine position sensor (EPS) or circuit is malfunctioning	Check the engine position sensor and circuit. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 17 Vehicle speed sensor (VSS) or circuit is malfunctioning	Refer to the appropriate electronic service tool manual. If the monitor shows speed, check the sensor and circuit. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 18 Fuel heater is malfunctioning (if equipped)	Check the fuel heater and replace if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 19 Fuel connector is leaking fuel	Measure the drain line fuel quantity. Inspect the fuel connector and injector for nicks or damage that can cause fuel leaks. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 20 Injector sealing washer is **not** correct	Remove the injectors and verify the injector sealing washer thickness. Contact a Cummins® Authorized Repair Location
OK Go To Next Step	
STEP 21 Injector(s) are malfunctioning	Perform diagnostics to find the damaged injector(s). Replace the injector(s) as necessary. Contact a Cummins® Authorized Repair Location
OK Go To Next Step	
STEP 22 Injectors are **not** correct	Reference QuickServe™ Online to verify the injector part numbers. Replace the injector(s), if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	

Engine Speed Surges Under Load or in Operating Range

Cause	Correction
STEP 23 Clutch is malfunctioning or is **not** correct	Check the clutch for correct operation. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 24 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 Procedure 018-002 in Section V or a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 25 Turbocharger is **not** correct	Reference QuickServe Online™ to verify the turbocharger part number. Replace the turbocharger, if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 26 Turbocharger wheel clearance is out of specification	Check the radial bearing and axial clearances. Inspect the turbocharger. Repair or replace the turbocharger, if necessary. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 27 Fuel pump is malfunctioning	Check the fuel pump output pressure with INSITE™ electronic service tool. Replace the fuel pump, if necessary. Monitor fuel rail pressure commanded against that measured during engine operation. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 28 Vibration damper is damaged	Inspect the vibration damper. Refer to Procedure 001-052 in Section 8.
OK Go To Next Step	
STEP 29 Flywheel housing is **not** aligned correctly	Check the flywheel housing alignment. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 30 Transmission damaged	Problem is related specifically to the transmission. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	

Engine Speed Surges Under Load or in Operating Range

Cause

STEP 31
Internal engine damage

OK
Go To Next Step

STEP 32
Contact a Cummins® Authorized Repair Facility

Correction

Analyze the oil and inspect the filters to locate an area of probable damage. Contact a Cummins® Authorized Repair Location.

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 troubleshooting symptom tree in Section TS.
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 troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 3 Moisture in the wiring harness connectors	Dry the connectors with electrical contact cleaner, Part Number 3824510.
OK Go To Next Step	
STEP 4 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 original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Battery voltage supply to the engine control module (ECM) is low, interrupted, or open	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to Procedure 013-009 in Section 5 and the OEM service manual.
OK Go To Next Step	
STEP 3 Contact a Cummins® Authorized Repair Facility	

Engine Vibration Excessive

Cause	Correction
STEP 1 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 a Cummins® Authorized Repair Facility.
OK Go To Next Step	
STEP 2 Fan is loose, damaged, or has excessive hub bearing end play	Check the fan. Refer to Procedure 008-040 in Section 3.
OK Go To Next Step	
STEP 3 Engine is misfiring	Refer to the Engine Runs Rough or Misfires troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 4 Vibration damper is damaged	Inspect the vibration damper. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Engine Will Not Crank or Cranks Slowly (Electric Starter)

Cause	Correction
STEP 1 Battery voltage is low	Check the batteries and the unswitched battery supply circuit. Refer to Procedure 013-007 in Section 5.
OK Go To Next Step	
STEP 2 Battery cables or connections are loose, broken, or corroded (excessive resistance)	Check the battery cables and connections. Refer to Procedure 013-009 in Section 5.
OK Go To Next Step	
STEP 3 Battery capacity is below specification	Replace the batteries, if necessary. Refer to Procedure 018-021 in Section V.
OK Go To Next Step	
STEP 4 Battery cables are **not** the correct gauge or length	Replace the battery cables with larger gauge or shorter length cables. Refer to Procedure 013-009 in Section 5.
OK Go To Next Step	
STEP 5 OEM starter interlock devices engaged	Check the starter interlock devices. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 6 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. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Engine-driven units are engaged	Disengage any engine-driven units.
OK Go To Next Step	
STEP 8 Lubricating oil level is above specification	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 9 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 018-024 in Section V.
OK Go To Next Step	

Engine Will Not Crank or Cranks Slowly (Electric Starter)

Cause	Correction
STEP 10	
Contact a Cummins® Authorized Repair Facility	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
STEP 1 Vehicle parasitics are excessive	Check the vehicle for brakes dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 2 Engine power output is low	Refer to the Engine Power Output Low troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 3 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 Drivetrain components are malfunctioning or are **not** correct	Compare the drivetrain components to the engine and equipment specifications. Isolate the drivetrain components and check for vibrations. Refer to the the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 3 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 engine control module (ECM) is low, interrupted, or open	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to Procedure 013-009 in Section 5.
OK Go To Next Step	
STEP 3 Idle Shutdown or PTO Shutdown features are activated	Check the time limit on Idle Shutdown and PTO Shutdown features with an electronic service tool. Refer to the original equipment manufacturer (OEM) service manual or contact a Cummins® Authorized Repair Location.
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	Explain correct engine operation to the operator. Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 2 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 3 Hubometer or odometer is miscalibrated	Check the hubometer and odometer calibrations. Calibrate or replace the hubometer or odometer, if necessary. Calculate fuel consumption with new mileage figures.
OK Go To Next Step	
STEP 4 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 in Section 3.
OK Go To Next Step	
STEP 5 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 6 Equipment and environmental factors are affecting fuel consumption	Consider ambient temperatures, wind, tire size, axle alignment, routes, and use of aerodynamic aids when evaluating fuel consumption.
OK Go To Next Step	
STEP 7 Lubricating oil level is above specification	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Contact a Cummins® Authorized Repair Facility	

Fuel in Coolant

Cause	Correction
STEP 1 Broken valve seat insert	Check the bulk coolant supply. Drain the coolant and replace with non-contaminated coolant. Change the coolant filters. Refer to Procedure 008-006 in Section 5.

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

Fuel in the Lubricating Oil

Cause	Correction
STEP 1 Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with non-contaminated oil. Change the oil filters.
OK Go To Next Step	
STEP 2 Engine idle time is excessive	Low oil and coolant temperatures can be caused by long idle times (greater than 10 minutes). Shut the engine OFF rather than idle for long periods. If idle time is necessary, raise the idle speed. Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 3 Contact a Cummins® Authorized Repair Facility	

Intake Manifold Air Temperature Above Specification

Cause	Correction
STEP 1 Fan drive belt is broken	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002 in Section 6.
OK Go To Next Step	
STEP 2 Fan drive belt is loose	Check the belt tension and tighten, if necessary.
OK Go To Next Step	
STEP 3 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm2 [60 in2] of opening at all times. Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 4 Charge-air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge-air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Procedure 010-027 in Section 4 and the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 5 Intake manifold temperature gauge is malfunctioning, if equipped	Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again, if necessary. Refer to a Cummins® Authorized Repair Facility.
OK Go To Next Step	
STEP 7 Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Fan is **not** correct	Check the fan part number and compare it to the OEM-specified part number. Replace the fan, if necessary. Refer to the OEM service manual.
OK Go To Next Step	

Intake Manifold Air Temperature Above Specification

Cause	Correction
STEP 9 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, as necessary.
OK Go To Next Step	
STEP 10 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 11 Exhaust system leaking hot air into engine compartment	Check the exhaust plumbing for leaks or broken components. Refer to the OEM service manual.
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 service manual.
OK Go To Next Step	
STEP 13 Fan is **not** an adequate size for the application	Verify that the fan is the correct size. Refer to the OEM service manual.
OK Go To Next Step	
STEP 14 Contact a Cummins® Authorized Repair Facility	

Intake Manifold Pressure (Boost) is Below Normal

Cause	Correction
STEP 1 Air intake or exhaust leaks	Inspect the air intake and exhaust systems for air leaks. Refer to Procedure 010-058 in Section 3.
OK Go To Next Step	
STEP 2 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 3 Charge-air cooler is restricted or leaking	Inspect the charge-air cooler for air restrictions or leaks. Refer to Procedure 010-027 in Section 4.
OK Go To Next Step	
STEP 4 Engine power output is low	Refer to the Engine Power Output is Low troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 5 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Consumption Excessive

Cause	Correction
STEP 1 Verify the oil consumption rate	Check the amount of oil added versus the mileage.
OK Go To Next Step	
STEP 2 Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-018 in Section 3.
OK Go To Next Step	
STEP 4 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-037 in Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 5 Lubricating oil drain interval is excessive	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002 in Section 2.
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 Procedure 012-015 in Section 8.
OK Go To Next Step	
STEP 7 Lubricating oil level is above specification	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 8 Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 9 Lubricating oil is contaminated with coolant or fuel	Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	

Lubricating Oil Consumption Excessive

Cause	Correction
STEP 10	
Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Contaminated

Cause	Correction
STEP 1 Fuel in the lubricating oil	Refer to the Fuel in the Lubricating Oil troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 2 Internal coolant leaks	Refer to the Coolant Loss - Internal troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 3 Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with non-contaminated oil. Change the oil filters.
OK Go To Next Step	
STEP 4 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. Contact a Cummins® Authorized Repair Location.
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 Procedure 007-043 in Section 3 and Procedure 018-017 in 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 Procedure 007-037 in 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. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Engine indicator lamps illuminated	Refer to Procedure 101-048 in Section 1 for information on the engine indicator lamps.
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 Cummins® Authorized 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 Cummins® Authorized Repair Facility.
OK Go To Next Step	
STEP 8 Blowby excessive	Check for excessive blowby. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
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 troubleshooting symptom tree in Section TS.
OK Go To Next Step	

Lubricating Oil Loss

Cause	Correction
STEP 10 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Pressure High

Cause	Correction
STEP 1 Coolant temperature is below specification	Refer to the Coolant Temperature is Below Normal troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 2 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-037 in Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 3 Lubricating oil pressure switch, gauge, or sensor is malfunctioning or is **not** in the correct location.	Check the oil pressure switch, gauge, or sensor for correct operation and location. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Lubricating oil pressure sensor or circuit is malfunctioning (electronic controlled fuel system)	Check the lubricating oil pressure sensor and circuit. Refer to 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 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. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 2 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-043 in Section 3.
OK Go To Next Step	
STEP 3 Lubricating oil filter is plugged	Change the oil and filter. Refer to Section Procedure 007-037 in Section 5. Review the oil change interval. Refer to Section V.
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. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-037 in Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 6 Lubricating oil is contaminated with coolant or fuel	Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Engine angularity during operation exceeds specification	Refer to a Cummins Authorized Repair Location.
OK Go To Next Step	
STEP 8 Lubricating oil pressure sensor or circuit is malfunctioning (electronic controlled fuel system)	Check the lubricating oil pressure sensor and circuit. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Lubricating Oil Sludge in the Crankcase Excessive

Cause	Correction
STEP 1 Bulk oil supply is contaminated	Check the bulk oil supply. Drain the oil and replace with non-contaminated oil. Replace the oil filter(s). Refer to Procedure 007-037 in Section 5.
OK Go To Next Step	
STEP 2 Coolant temperature is below specification	Refer to the Coolant Temperature Below Normal troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 3 Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-018 in Section 3.
OK Go To Next Step	
STEP 4 Fuel grade is **not** correct for the application or the fuel quality is poor	Operate the engine from a tank of known high quality fuel. Refer to Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 5 Lubricating oil does **not** meet specifications for operating conditions	Change the oil and filters. Refer to Procedure 007-037 in Section 5. Use the oil recommended in Section V.
OK Go To Next Step	
STEP 6 Contact a Cummins® Authorized Repair Facility	

PTO or Cruise Control Does Not Operate

Cause	Correction
STEP 1 Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again, if necessary. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 2 Engine control module (ECM) calibration is malfunctioning	Verify that the engine control module (ECM) calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 3 Vehicle speed sensor (VSS) or circuit is malfunctioning	Check the vehicle speed sensor and circuit. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 4 Clutch switch or circuit is malfunctioning	Check the clutch switch adjustment, switch, and circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Engine brake on/off switch or circuit is malfunctioning	Check the engine brake on/off switch and circuit. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 6 Vehicle brake switch or circuit is malfunctioning	Check the vehicle brake switch and the circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Cruise Control/PTO ON/OFF switch or circuit is malfunctioning	Check the Cruise Control/PTO ON/OFF switch and the circuit. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 Cruise Control/PTO selector switch or circuit is malfunctioning	Check the Cruise Control/PTO selector switch and circuit. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Smoke, Black - Excessive

Cause	Correction
STEP 1 Engine indicator lamps illuminated	Refer to Procedure 101-048 in Section 1. If required, contact a Cummins® Authorized Repair Location.

OK
Go To Next Step

STEP 2
Contact a Cummins® Authorized Repair Facility

Smoke, White - Excessive

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 troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 2 Engine is operating at low ambient temperature	Check the winterfront, shutters, and under-the-hood air. Use under-the-hood intake air in cold weather. Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 3 Starting aid is necessary for cold weather or starting aid is malfunctioning	Check for the correct operation of the starting aid. Refer to Procedure 101-004 in Section 1
OK Go To Next Step	
STEP 4 Electronic fault codes are active	Review instructions for reading active fault codes. Refer to a Cummins® Authorized Repair Location, if fault codes are active.
OK Go To Next Step	
STEP 5 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 Procedure 018-002 in Section V.
OK Go To Next Step	
STEP 6 Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-058 in Section 3.
OK Go To Next Step	
STEP 7 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 8 Charge-air cooler is restricted or leaking	Inspect the charge-air cooler for air restrictions or leaks. Refer to Procedure 010-027 in Section 4.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Turbocharger Leaks Engine Oil or Fuel

Cause	Correction
STEP 1 Engine is operating for extended periods under light or no-load conditions (slobbering)	Review the engine operating instructions. Refer to Procedure 101-015 in Section 1.
OK Go To Next Step	
STEP 2 Air intake system restriction is above specification	Check the air intake system for restrictions. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 3 Exhaust system restriction is **not** within specification	Check the exhaust system for restrictions. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 4 Lubricating oil lines leak oil	Check all oil lines and fittings for leaks. Tighten any loose fittings and replace leaking oil lines, if necessary.
OK Go To Next Step	
STEP 5 Crankcase ventilation system is plugged	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-018 in Section 3.
OK Go To Next Step	
STEP 6 Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. Contact a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Lubricating oil or fuel is entering the turbocharger	Remove the intake and exhaust piping, and check for oil or fuel.
OK Go To Next Step	
STEP 8 White smoke is present	Refer to the Smoke, White - Excessive troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 9 Contact a Cummins® Authorized Repair Facility	

Diesel Exhaust Fluid Usage - Abnormal

Use this TS tree to troubleshoot complaints of low or high diesel exhaust fluid usage.

Cause	Correction
STEP 1 Electronic fault codes are active or high counts of inactive fault codes	Review instructions for reading active fault codes. Refer to a Cummins® Authorized Repair Location, if fault codes are active.
OK Go To Next Step	
STEP 2 Aftertreatment diesel exhaust fluid leak (external)	Inspect for external aftertreatment diesel exhaust fluids leaks near the aftertreatment diesel exhaust fluid tank, aftertreatment diesel exhaust fluid lines, and associated connections. Repair or replace parts as necessary.
OK Go To Next Step	
STEP 3 Aftertreatment diesel exhaust fluid low level or warning level not set correctly.	The vehicle manufacturer has the ability to change when the warnings for low diesel exhaust fluid level activate, which may cause the low diesel exhaust fluid level warnings to activate earlier than expected. Verify the warnings are correctly set per the OEM service manual.
OK Go To Next Step	
STEP 4 Engine control module (ECM) calibration is malfunctioning	Verify that the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. If necessary, calibrate the ECM. Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 5 Aftertreatment diesel exhaust fluid level gauge is inaccurate	Verify that the aftertreatment diesel exhaust fluid level gauge is correctly calibrated and matched to the diesel exhaust fluid tank. Refer to the original equipment manufacturer (OEM) service manual.
OK Go To Next Step	
STEP 6 Engine out NOx emissions above normal	Refer to a Cummins® Authorized Repair Location.
OK Go To Next Step	
STEP 7 Contact a Cummins® Authorized Repair Facility	

Air Filter Plugging Frequent

Cause	Correction
STEP 1 Dust ejector valve maintenance schedule not followed.	Determine if the inspection and maintenance schedules for the dust ejection valve are being followed. Refer to Procedure 102-002 in Section 2.
OK Go To Next Step	
STEP 2 Dust ejector valve plugged.	Inspect the dust ejection valve for plugging. Clean and inspect the valve for reuse. Refer to Procedure 010-146 in Section 3.
OK Go To Next Step	
STEP 3 Dust ejector valve damaged or not installed correctly.	Inspect the dust ejection valve for damage and proper installation. Clean and inspect the valve for reuse. Refer to Procedure 010-146 in Section 3.
OK Go To Next Step	
STEP 4 Aspirator damaged or not operating correctly.	If equipped, inspect the aspirator for leaks or other damage. Refer to the Aspirator Not Functioning troubleshooting symptom tree in Section TS.
OK Go To Next Step	
STEP 5 Air filter restriction indicator damaged or not operating properly.	Check the air filter restriction indicator for proper operation and damage. Refer to Procedure 010-059 in Section 4.
OK Go To Next Step	
STEP 6 Large debris blocking precleaner.	Inspect the precleaner for large debris that can disrupt the air flow.
OK Go To Next Step	
STEP 7 Precleaner damaged or **not** installed correctly.	Inspect the precleaner for damage and proper installation. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 8 Precleaner or dust ejection valve **not** oriented correctly	Inspect the precleaner for proper orientation. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	

Air Filter Plugging Frequent

Cause	Correction
STEP 9 Air filter media is excessively wet.	Inspect the air filter housing for cracks or other damage that would allow water into the housing. If equipped, inspect the rain cap and inlet piping for proper installation and damage. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 10 Incorrect air filter elements installed.	Inspect the air filter elements for correct specifications. Refer to Procedure 010-014 in Section A.
OK Go To Next Step	
STEP 11 Maintenance schedule for secondary air filter element was **not** followed.	Determine if the inspection and maintenance guidelines for secondary air filter elements are being followed. Refer to Procedure 010-014 in Section A.
OK Go To Next Step	
STEP 12 Air filter housing damaged.	Inspect the air filter housing for damage. Inspect the air filter housing cover for proper installation. Refer to Procedure 010-014 in Section A.
OK Go To Next Step	
STEP 13 Air filter inlet housing is located near the debris/ dust output of the vehicle or machine.	If the air filter air intake is ingesting contaminated air, filter replacement frequency will increase. Refer to the OEM service manual.
OK Go To Next Step	
STEP 14 Contact a Cummins® Authorized Repair Facility	

Aspirator Not Functioning

Cause	Correction
STEP 1 Aspirator hose, venturi, or check valve is plugged	Inspect the aspirator hose, venturi, and check valve for blockage. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 2 Aspirator hose is damaged or leaking	Inspect the aspirator hose for cracks, other damage, and loose connections. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 3 Precleaner is damaged or obstructed	Inspect the air filter housing precleaner for damage and proper orientation. Be sure the precleaner is **not** obstructed. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 4 Aspirator check valve is **not** functioning properly	Check the aspirator check valve for damage and proper operation. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 5 Aspirator venturi is **not** functioning properly	Check the aspirator venturi for damage and proper operation. Refer to Procedure 010-015 in Section A.
OK Go To Next Step	
STEP 6 Exhaust pipe is obstructed or back pressure is excessive	Check the exhaust pipe for obstructions and correct back pressure. Refer to the OEM service manual.
OK Go To Next Step	
STEP 7 Light engine load causing reduced aspirator efficiency	Determine the average load of the engine. Excessive idle or light duty operation can reduce the efficiency of the aspirator.
OK Go To Next Step	
STEP 8 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 the engines covered in this manual:

Horsepower.....See engine dataplate
Firing Order.....1-5-3-6-2-4
Crankshaft Rotation (viewed from front of engine)..... **Clockwise**
Displacement.....8.9 liters [543 in^3]
Bore and Stroke.....114 mm [4.49 in] x 145 mm [5.71 in]
Wet Weight.....708 kg [1561 lb]
Overhead Adjustment
Intake Valve Adjustment.....0.305 mm [0.012 in]
Exhaust Valve Adjustment.....0.559 mm [0.022 in]
Engine Brake Adjustment.....2.286 mm [0.090 in]
Maximum Overspeed Capability (15 seconds maximum).....2550 rpm
Minimum Ambient Air Temperature for Unaided Cold Start[1] .....-23°C [-10°F]
Minimum Ambient Air Temperature with Cold Starting Aid[2] .....-40°C [-40°F]
Minimum Engine Cranking Speed.....120 rpm
Engine Idle Speed.....700 to 1200 rpm
Altitude Limit Before Derate is Applied.....3658 m [12,000 ft]

1. Engines covered by this manual meeting regulations for Tier 4 Final/Stage IV **must** be equipped with an intake air grid heater. Refer to Procedure 010-029 in Section 10.

2. Available cold starting aids include a block heater and an oil pan heater.

Fuel System

Specifications

Maximum Fuel Return Line Pressure.....30 kPa [4.3 psi]
Maximum Fuel Inlet Restriction at Gear Pump Inlet (Dirty Filter, Loaded Condition).....254 mm-Hg [10 in-Hg]
Maximum Fuel Inlet Restriction at original equipment manufacturer (OEM) Connection (Dirty Filter, Loaded Condition) .....203 mm-Hg [8 in-Hg]
Minimum Gear Pump Pressure
During Cranking Condition.....105 kPa [15 psi]
During Rated Condition.....483 kPa [70 psi]
Maximum Filter Pressure Drop.....80 kPa [11.7 psi]
Minimum Lift Pump Flow.....100 ml [3.4 fl-oz] in 10 seconds
Minimum Engine Cranking Speed.....150 rpm

Lubricating Oil System

Specifications

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

Regulated Oil Pressure....517 kPa [75 psi]
Lubricating Oil Filter Capacity....3.78 liters [4 qt]

Oil Pan Capacity, Low to High (ISC)
- Standard Oil Pan....15.1 to 18.9 liters [16 to 20 qt]
- Standard Oil Pan with Cylinder Block Stiffener Plate....16.1 to 19.9 liters [17 to 21 qt]

Total System Capacity (Oil Pan and New Oil Filter) (ISC)
- Standard Oil Pan....22.7 liters [24 qt]
- Standard Oil Pan with Cylinder Block Stiffener Plate....23.7 liters [25 qt]

Oil Pan Capacity, Low to High (ISL)
- Standard Oil Pan....18.9 to 22.7 liters [20 to 24 qt]
- Standard Oil Pan with Cylinder Block Stiffener Plate....19.9 to 23.7 liters [21 to 25 qt]

Total System Capacity (Oil Pan and New Oil Filter) (ISL)
- Standard Oil Pan....26.5 liters [28 qt]
- Standard Oil Pan with Cylinder Block Stiffener Plate....27.4 liters [29 qt]

Cooling System

Specifications

Coolant Capacity (engine **only**).....12.4 liters [13.1 qt]
Standard Modulating Thermostat Range.....82 to 93°C [180 to 200°F]
Minimum Recommended Pressure Cap.....90 kPa [13 psi]
Minimum Fill Rate (without low-level alarm).....11.4 liters/min [3 gpm]
Maximum Deaeration Time.....25 minutes
Maximum Top Tank Coolant Temperature.....107°C [225°F]
Winterfronts
Minimum allowed air passage area.....774 cm^2 [120 in^2]

Air Intake System

Specifications

⚠CAUTION⚠

Engine intake air must be filtered to prevent dirt and debris from entering the engine. If the air intake piping is damaged or loose, unfiltered air will enter the engine and cause premature wear.

Maximum Intake Restriction

Clean Air Filter Element	381 mm H_2O [15 in H_2O]
Dirty Air Filter Element	635 mm H_2O [25 in H_2O]
Charge-Air Cooler Restriction (maximum)	102 mm Hg [4.0 in Hg]

Exhaust System

Specifications

Maximum Exhaust Restriction:

Exhaust System.....315 mm Hg [12.4 in Hg]

1 See the following procedure for more information. Refer to Procedure 011-009 in Section 11.

Electrical System

Batteries (Specific Gravity)

Specific Gravity at 27°C [80°F]	State of Charge
1.260 to 1.280	100 percent
1.230 to 1.250	75 percent
1.200 to 1.220	50 percent
1.170 to 1.190	25 percent
1.110 to 1.130	Discharged

Compressed Air System

Specifications

Single Cylinder

Piston Displacement.....318 cc [19.4 C.I.D.]
Bore.....85 mm [3.346 in]
Stroke.....56 mm [2.204 in]
Drive Ratio.....1:1
Cooling.....Engine coolant
Lubrication.....Engine lubricating oil

Plumbing Line Sizes

Coolant Inlet and Outlet.....3/4 x 116 STOR
Air Inlet.....25.4 mm [1 in] Nominal
Air Outlet.....M27 x 2 STOR
Unloader Port.....M10 x 1 STOR
Governor Mounting Direct.....M8 x 1.25

Height, Overall (from crankshaft centerline).....216 mm [8.50 in]
Width, Overall (Approximate).....144 mm [5.67 in]
Length, Overall (Approximate).....211 mm [8.31 in]
Weight (Approximate).....17.6 kg [38.8 lb]
Crankcase Radius (Approximate).....68.5 mm [2.70 in]

Cummins®/Fleetguard® Filter Specifications

General Information

Cummins Filtration™, which produces Fleetguard® products, is a division of Cummins Inc. Fleetguard® filters are developed through joint testing at Cummins Inc. and Cummins Filtration™ Fleetguard® filters are standard on new Cummins® engines. Cummins Inc. recommends their use.

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

Lubricating Oil Filter (1)	
Cummins® Part Number	3401544
Cummins Filtration™ Part Number	LF9009

Fuel Filter (Pressure-Side) Hex Drive Base (2) (3)	
Cummins® Part Number	5303743
Cummins Filtration™ Part Number	FF63009

Fuel Filter (Suction-Side, with Water-In-Fuel Sensor)(2)	
Cummins® Part Number	5308722
Cummins Filtration™ Part Number	FS20038

Crankcase Breather Element	
Cummins® Part Number	4939749
Cummins Filtration™ Part Number	CV5060300

Air Filter (Primary)	
127 x 381 x 203 mm [5 x 15 x 8 in]	
Cummins® Part Number	5261248
Fleetguard® Part Number	AF55005
127 x 381 x 305 mm [5 x 15 x 12 in]	
Cummins® Part Number	5261249
Fleetguard® Part Number	AF55014
254 x 254 x 305 mm [10 x 10 x 12 in]	
Cummins® Part Number	5261250
Fleetguard® Part Number	AF55015

Air Filter (Secondary)	
127 x 381 x 203 mm [5 x 15 x 8 in]	
Cummins® Part Number	5261251
Fleetguard® Part Number	AF55308
127 x 381 x 305 mm [5 x 15 x 12 in]	
Cummins® Part Number	5261251
Fleetguard® Part Number	AF55308
254 x 254 x 305 mm [10 x 10 x 12 in]	
Cummins® Part Number	5261252
Fleetguard® Part Number	AF55309

Aftertreatment Diesel Exhaust Fluid (DEF) Dosing Unit Filter	
Cummins® Part Number	5303604

(1)An LF9009 lubricating oil filter **must** be used. A venturi type lubricating oil filter **must** be used in order to benefit from the bypass filtration section of the lubricating oil filter. Do **not** use an LF3000 lubricating oil filter. Engine durability will be reduced by the use of the incorrect lubricating oil filter

(2)The fuel system requires the use of two fuel filters.

The suction-side filter must have the following characteristics:

- Water separating
- 8-micron rating
- Water-in-fuel sensor with shunt resistor
- Water drain valve
- Engine mounted or chassis mounted.

The pressure-side filter **must** have the following characteristics:

- 5-micron rating
- Engine mounted or chassis mounted.

(3)Early production pressure-side fuel filters were built with a square drive feature for installation and removal. Later built pressure-side fuel filters transitioned to a hex drive feature. The drive feature is the **only** difference between the pressure-side fuel filters.

Diesel Exhaust Fluid Recommendations and Specifications

General Information

⚠WARNING⚠

It is unlawful to tamper with or remove any component of the aftertreatment system. It is also unlawful to use a Diesel Exhaust Fluid (DEF) that does not meet the specifications provided or to operate the vehicle/ equipment with no Diesel Exhaust Fluid (DEF).

⚠WARNING⚠

Diesel Exhaust Fluid (DEF) contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow internally. In the event the diesel exhaust fluid is ingested, contact a physician immediately. Reference the Materials Safety Data Sheet (MSDS) for additional information.

⚠CAUTION⚠

Never attempt to create Diesel Exhaust Fluid by mixing agricultural grade urea with water. Agricultural grade urea does not meet the necessary specifications required and the aftertreatment system may be damaged.

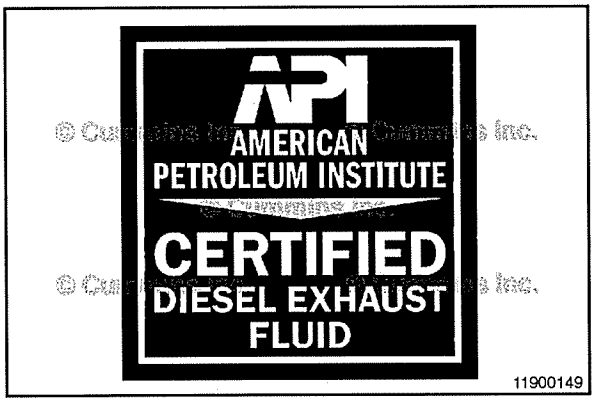
Cummins Inc. requires the use of Diesel Exhaust Fluid meeting ISO 22241-1. There is NO acceptable substitute.

NOTE: Some locations may reference the DIN 70070 standard. Diesel Exhaust Fluid specification limits of this standard are identical to ISO 22241-1.

Cummins Inc. is not responsible for failures or damage resulting from what Cummins Inc. determines to be abuse or neglect, including but not limited to: operation without correctly specified Diesel Exhaust Fluid; lack of maintenance of aftertreatment; improper storage, or shutdown practices; unauthorized modifications of the engine and aftertreatment. Cummins is also not responsible for failures caused by incorrect Diesel Exhaust Fluid or by water, dirt or other contaminants in the Diesel Exhaust Fluid

For further details and discussion of Diesel Exhaust Fluid (DEF) for Cummins® engines. Refer to the Diesel Exhaust Fluid Specifications for Cummins® Selective Catalytic Reduction Systems, Service Bulletin Number 4021566.

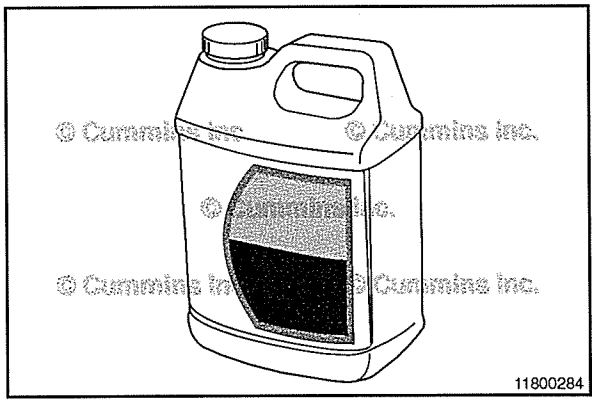
For engines using SCR operating in the United States and Canada, it is also strongly recommended that the Diesel Exhaust Fluid (DEF) used be certified by the American Petroleum Institute (API). This would be indicated by a symbol on the container/dispensing system as shown.



To ensure the correct Diesel Exhaust Fluid (DEF) is used, Cummins Inc. recommends the use of Fleetguard® Diesel Exhaust Fluid. Fleetguard® carries different quantity options from small to bulk containers.

For customers located in the United States and Canada, for assistance locating Diesel Exhaust Fluid (DEF), contact the Cummins Customer Assistance Center: 1-800 DIESELS (1-800-343-7357).

For customers outside of the United States and Canada, contact you local Cummins authorized repair location for assistance in locating Diesel Exhaust Fluid (DEF).



The following are other common names used for Diesel Exhaust Fluid (DEF):

- Urea
- AUS 32 (Aqueous Urea Solution 32)
- AdBlue
- NOx Reduction Agent
- Catalyst Solution
- DEF

Regardless of what the Diesel Exhaust Fluid is called, the Diesel Exhaust Fluid must meet the specifications as outlined in the General Information section of this procedure.

Storage

NOTE: The following information is for reference and is to be used as a guideline only. There are many factors that determine Diesel Exhaust Fluid (DEF) shelf life, with temperature and duration being two of the major determining contributors. If in doubt, check the concentration of the Diesel Exhaust Fluid (DEF), refer to the Test step of this procedure, or replace the fluid with known quality Diesel Exhaust Fluid.

Diesel Exhaust Fluid has a limited shelf life, both in the vehicle's diesel exhaust fluid tank and in storage/bulk/ transportation containers.

The following conditions are ideal for maintaining DEF quality and shelf life during prolonged transportation and storage:

- Storage temperature between 23°F and 77°F (-5°C and 25°C)
- Store in sealed containers to avoid contamination
- Avoid direct sunlight

In these conditions, DEF has a minimum expected shelf life of 18 months. If stored at higher temperatures for extended periods of time, the shelf life will be reduced by approximately 6 months for every 5°C [9°F] above the highest storage temperature listed above.

Long term storage in a vehicle (in excess of 6 months) is not recommended. If long term storage is necessary, periodic testing of the Diesel Exhaust Fluid is recommended to be performed to ensure the concentration does not fall out of specification. Follow the Test step of this procedure.

NOTE: To assist in preventing Diesel Exhaust Fluid from deteriorating when stored in the vehicles DEF tank, locate and plug the tanks venting to seal the tank exposure to the atmosphere.

Handling

Diesel Exhaust Fluid is not harmful to handle, but can be corrosive to certain materials over time. Such as carbon steels, iron, zinc, nickel, copper, aluminum and magnesium.

- Make sure to only use approved containers to transport and store Diesel Exhaust Fluid. Containers made of polyethylene and polypropylene are recommended.
- If Diesel Exhaust Fluid is spilled, rinse and clean immediately with water.
- Avoid prolonged contact with skin. In case of contact, wash with immediately with soap and water. If not washed immediately, when the diesel exhaust fluid dries, a white film will be left that can be more difficult to wash off.

NOTE: Spilled Diesel Exhaust Fluid if left to dry or wiped away with a cloth only will leave a white residue. Failure to clean the spilled Diesel Exhaust Fluid may result in an incorrectly diagnosed leak of the Diesel Exhaust Fluid Dosing system.

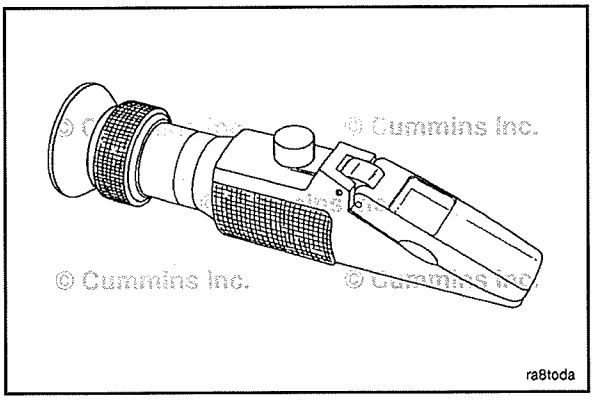
Before using containers, funnels, etc. that will be used to dispense, handle or store Diesel Exhaust Fluid, make sure to wash thoroughly to remove any contaminants and then rinse with distilled water.

NOTE: Do not use tap water to rinse components that will be used to deliver diesel exhaust fluid. Tap water will contaminate the Diesel Exhaust Fluid. If distilled water is not available, rinse with tap water and then rinse with Diesel Exhaust Fluid.

Disposal

If disposing of Diesel Exhaust Fluid (DEF), always check with the local authority regulations on proper disposing process and requirements.

Test



Having the correct concentration of Diesel Exhaust Fluid is critical to the engine and aftertreatment system performing correctly.

To test the concentration of the Diesel Exhaust Fluid, use the Cummins Diesel Exhaust Fluid Refractometer, service tool part number 4919554. Follow the instructions provided with the service tool.

Percent Urea Concentration: 32.5 +/- 1.5%

The specification listed above takes into consideration the refractometer tool tolerances, varibility, and calibration when measuring Diesel Exhaust Fluid concentration.

If the Diesel Exhaust Fluid concentration is found to be outside of this specification, drain the Diesel Exhaust Fluid tank, flush with distilled water and fill with new and/or known good Diesel Exhaust Fluid. Recheck the Diesel Exhaust Fluid concentration.

Concentration of the Diesel Exhaust Fluid should be checked when:

- The vehicle has been stored for an extended period of time.
- It is suspected that water has been added to the Diesel Exhaust Fluid tank

Contamination/Incorrect Fluid

⚠CAUTION⚠

Never add water or any other fluid besides what is specified to the Diesel Exhaust Fluid (DEF) tank. The aftertreatment system may be damaged.

In the event that the incorrect fluid is added to the Diesel Exhaust Fluid tank, such as, but not limited to:

- Water
- Diesel Fuel
- Hydraulic Fluid
- Coolant
- Windshield Washer Fluid

Contact a local Cummins Authorized Repair location to determine the appropriate repair direction.

If only water has been added to the Diesel Exhaust Fluid (DEF) tank, drain the Diesel Exhaust Fluid (DEF) tank, flush with distilled water and refill with new and/or known good Diesel Exhaust Fluid (DEF). Check the Diesel Exhaust Fluid (DEF) concentration after completing the refill, follow to the Test step of this procedure.

Freezing

⚠CAUTION⚠

Do NOT add any chemicals/additives to the Diesel Exhaust Fluid in an effort to prevent freezing. If chemicals/ additives are added to the Diesel Exhaust Fluid, the aftertreatment system may be damaged.

Diesel Exhaust Fluid will freeze around -11°C [12°F]. The diesel exhaust fluid system on the vehicle is designed to accommodate this and does not require any intervention by the vehicle operator.

The Operating the Engine (101-015) procedure in Section 1 of the Owners and Operation and Maintenance Manual will provide information on proper cold weather set up for your engine/vehicle.

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.

⚠CAUTION⚠

Do not use diesel fuel blended with lubricating oil in engines equipped with an aftertreatment system. Service intervals for aftertreatment systems will be reduced.

⚠CAUTION⚠

Ultra-low sulfur diesel fuel is required for correct operation of the aftertreatment system. If ultra-low sulfur diesel fuel is not used, the aftertreatment system could possibly be damaged.

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

The engine has been optimized for use with an exhaust aftertreatment to meet the Tier 4 interim/Stage IIIB off-highway emissions regulations. It **must** operate on ultra-low sulfur diesel (ULSD) with a maximum sulfur content of 15 ppm in the United States and 10 ppm in the European Union. Failure to do so can permanently damage engine and aftertreatment systems within a short period of time. This damage could cause the engine to become inoperable and affect the warranty coverage on the engine.

Ultra-low sulfur diesel fuel, also defined by ASTM S-15, is defined as diesel fuel **not** exceeding 0.0015 (15 ppm) mass percent sulfur content. There is no acceptable substitute.

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 types of fuels for this engine.

Acceptable Types of Fuels									
Number 1D Diesel[1] [2]	Number 2D Diesel[2]	Number 1K Kerosene	Jet-A	Jet-A1	JP-5	JP-8	Jet-B	JP-4	CITE
OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK
48-34[3]	40-24[3]	50-35[3]	51-37[3]	51-37[3]	48-36[3]	51-37[3]	57-45[3]	57-45[3]	57-45[3]

1 Any adjustment to compensate for reduced performance with a fuel system using alternate fuel is **not** warrantable.

2 Winter blend fuels, such as those found at commercial fuel dispensing outlets, are combinations of number 1D and number 2D diesel fuel, and are acceptable.

3 BTU Content/Degree API Gravity - Low API gravity fuels have a higher thermal energy content (BTU). As a general rule, there is a 3 to 5 percent decrease in BTU content for every 10 degree increase in API gravity; there is also a 0.7 degree API gravity increase with an increase in fuel temperature. This decrease in energy content equates roughly to the same percentage of power loss. Use of fuels with higher API gravity will cause higher than normal fuel consumption.

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 42 for engines that are operated at temperatures above 0°C [32°F].

NOTE: The use of diesel fuel with a 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.

NOTE: Cummins Inc. requires all permissible fuels to have adequate fuel lubricity. 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.

The equipment original equipment manufacturer (OEM) is required to display readily visible labels on the dashboard (or instrument panel) and near all fuel fill inlets that state "Use Ultra Low-Sulfur Diesel Fuel Only" or "Ultra Low-Sulfur Diesel Fuel Only"

ULSD/Biodiesel blends up to B20 (20 percent biodiesel) supplied by a BQ9000 certified supplier are acceptable.

For information on alternative fuels, such as biodiesel, and additional information for fuel recommendations and specifications, reference the Fuels for Cummins® Engines, Bulletin 3379001.

Lubricating Oil Recommendations and Specifications

General Information

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.

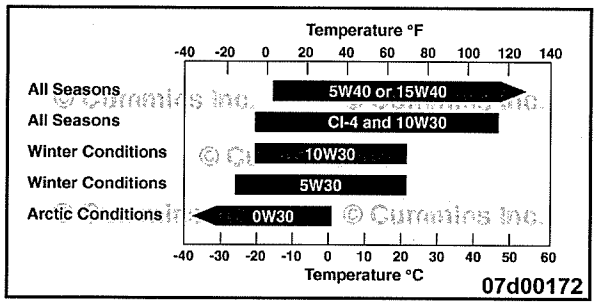
Cummins Inc. requires the use of a high-quality SAE 15W-40 heavy-duty engine oil, such as Valvoline Premium Blue™ (USA) or Valvoline Premium Blue™ Extra (International), which meets or exceeds the American Petroleum Institute (API) performance classification CJ-4.

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

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 the latest revision of 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® requirements. Only 10W-30 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. Only 10W-30 oils meeting CES 20081 (API CJ-4) can be used in the ambient temperature range similar to 15W-40 oils.

Cummins Inc. primary 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 than monograde oils, it is important to use multigrade oils, to be certain the 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 API CJ-4 and a 10W-30 viscosity grade, **must** meet a minimum high/temperature/high shear viscosity of 3.5 cP and ring wear / liner wear requirements of Cummins® and Mack™ tests. Thus, they can by used over a wider temperature range than 10W-30 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.

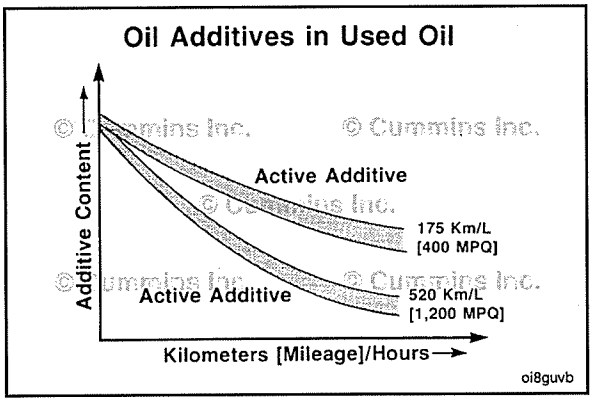
An example of the API service symbols are shown in the accompanying illustration. The upper half of the symbol displays the appropriate oil categories.

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, hours 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 the application.



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

Any warranty claims that could be oil quality related **must** be accompanied by complete service history details of the following, prior to any warranty assessment being undertaken:

- Oil type, specifications and supplier
- Oil drain intervals
- Injector, valves and engine brake lash adjustments
- Oil filter type and supplier
- Application duty cycle.

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

⚠CAUTION⚠

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

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. Use the following procedure for the maintenance schedule. Refer to Procedure 102-002 in Section 2.

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

API: American Petroleum Institute

CES: Cummins® Engineering Standard

To determine if the lubricating oil meets CES 20081, review the label on the back of the lubricating oil bottle for the CES 20081 reference. If acquiring the lubricating oil in bulk, contact the supplier for the lubricating oil specifications and confirm that the oil meets CES 20081.

Also located on the lubricating oil bottle is the API service symbol, which is 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. The table below shows how the Cummins® Engineering Standard (CES) compares to the American Petroleum Institute (API) classification.

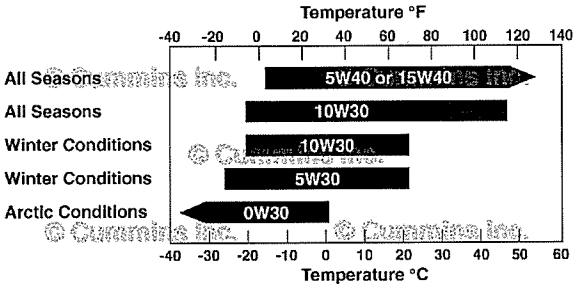
Cummins® Engine Standard Classification (CES)	American Petroleum Institute Classification (API)	Comments
CES20081	CJ-4/SL	Minimum oil classification required

NOTE: A lubricating oil that meets the American Petroleum Institute (API) performance classification CJ-4/SL may **not** meet the CES 20081 requirement. **Always** make sure the lubricating oil used meets the CES 20081 requirement, in addition to the API performance classification CJ-4/SL.

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

Use of "synthetic engine oils" (those made with API group 3 or group 4 base stocks) is permitted, subject to the same performance and viscosity limitations of petroleum (mineral) based engine oils. The same oil change intervals **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, reference Cummins® Engine Oil Recommendations, Bulletin 3810340.



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While the preferred viscosity grade is 15W-40, lower viscosity multigrade oils can be used in colder climates. See the accompanying chart. Any viscosity grade lower than15W-40 **must** still meet CES 20081.

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

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

New Engine Break-in Oils

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.engine-manufacturers.org).

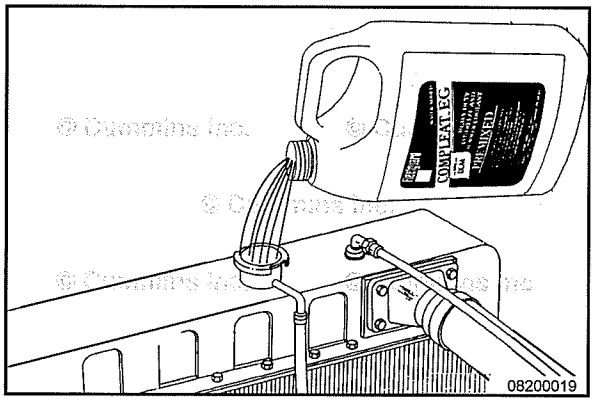
△CAUTION△

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 lubricating oil that will be used during normal operation.

AfterMarket Oil Additive Usage

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



Coolant Recommendations and Specifications

Fully Formulated Coolant/Antifreeze

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

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

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

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

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

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

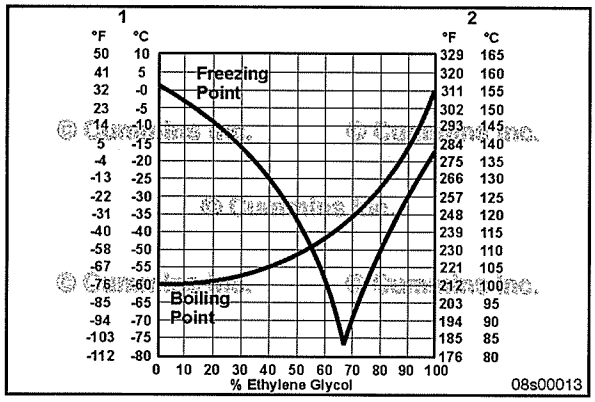
- Rocker lever housing gasket
- Lubricating oil cooler housing gasket
- Cylinder head gasket
- Thermostat housing gasket

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

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

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

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

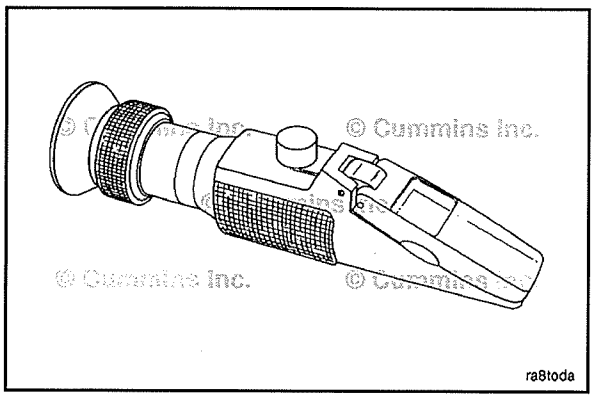


Fully formulated antifreeze **must** be mixed with good-quality water at a 50/50 ratio (40- to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-33°F] freezing point and a 108°C [226°F] boiling point, which is adequate for locations in North America. The actual lowest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

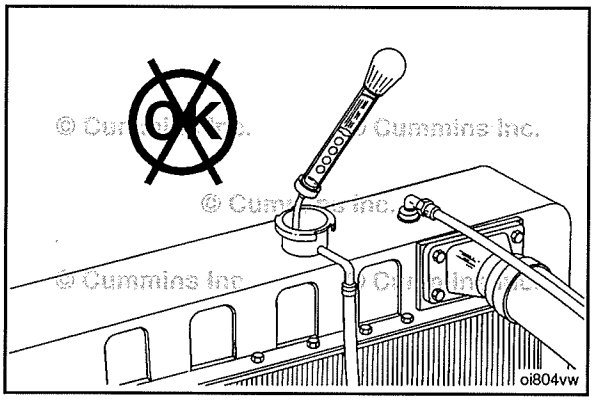
Legend

1 Freezing Point Temperature Scale

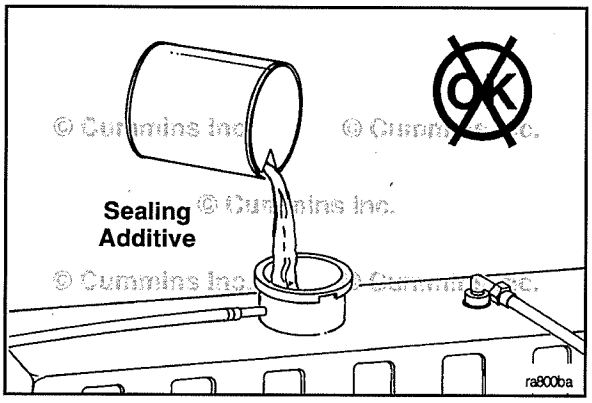
2 Boiling Point Temperature Scale



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



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



Cooling System Sealing Additives

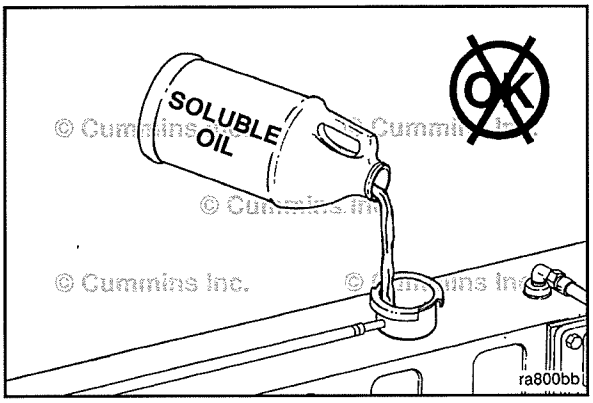
Do **not** use sealing additives in the cooling system. The use of sealing additives will:

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

Cooling System Soluble Oils

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

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



Drive Belt Tension

Tension Chart

SAE Belt Size	Belt Tension Gauge Part No.		Belt Tension New		Belt Tension Range Used*	
	Click-type	Burroughs	N	lbf	N	lbf
0.380 in	3822524		620	140	270 to 490	60 to 110
0.440 in	3822524		620	140	270 to 490	60 to 110
1/2 in	3822524	ST-1138	620	140	270 to 490	60 to 110
11/16 in	3822524	ST-1138	620	140	270 to 490	60 to 110
3/4 in	3822524	ST-1138	620	140	270 to 490	60 to 110
7/8 in	3822524	ST-1138	620	140	270 to 490	60 to 110
4 rib	3822524	ST-1138	620	140	270 to 490	60 to 110
5 rib	3822524	ST-1138	670	150	270 to 530	60 to 120
6 rib	3822525	ST-1293	710	160	290 to 580	65 to 130
8 rib	3822525	ST-1293	890	200	360 to 710	80 to 160
10 rib	3822525	3823138	1110	250	440 to 890	100 to 200
12 rib	3822525	3823138	1330	300	530 to 1070	120 to 240
12 rib K section	3822525	3823138	1330	300	890 to 1070	200 to 240
31 rib	-	3164750	1668	375	1330 to 1560	300 to 350

NOTE: This chart does not apply to automatic belt tensioners.

* A belt is considered used if it has been in service for ten minutes or longer.

* If used belt tension is less than the minimum value, tighten the belt to the maximum used belt value.

Sealants

General Information

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

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

Capscrew Markings and Torque Values

General Information

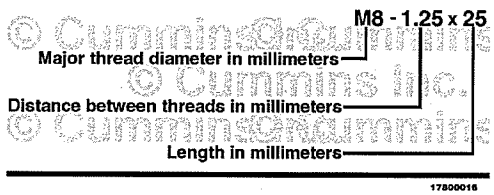
⚠CAUTION⚠

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

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

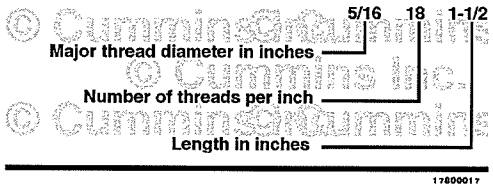
The following examples indicate how capscrews are identified:

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]



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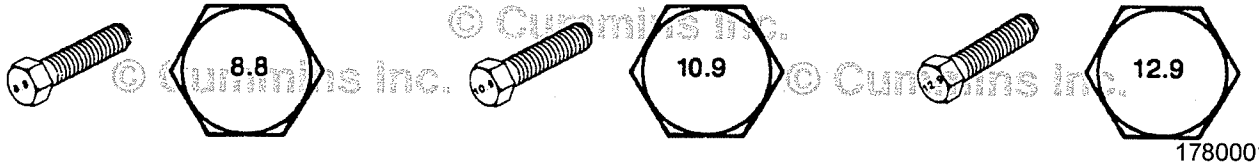
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. 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



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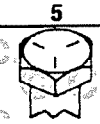
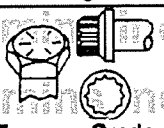
Body Size	Torque				Torque				Torque			
Diameter	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
mm	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7

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

SAE Grade Number	5	8
Capscrew Head Markings These are all SAE Grade 5 (3 line)		

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Capscrew Torque - Grade 5 Capscrew

Capscrew Torque - Grade 8 Capscrew

Capscrew Body Size	Cast Iron		Aluminium		Cast Iron		Aluminium	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1/4 - 20	9	7	8	6	15	11	8	6
1/4 - 28	12	9	9	7	18	13	9	7
5/16 - 18	20	15	16	12	30	22	16	12
5/16 - 24	23	17	19	14	33	24	19	14
3/8 - 16	40	30	25	20	55	40	25	20
3/8 - 24	40	30	35	25	60	45	35	25
7/16 - 14	60	45	45	35	90	65	45	35
7/16 - 20	65	50	55	40	95	70	55	40
1/2 - 13	95	70	75	55	130	95	75	55
1/2 - 20	100	75	80	60	150	110	80	60
9/16 - 12	135	100	110	80	190	140	110	80
9/16 - 18	150	110	115	85	210	155	115	85
5/8 - 11	180	135	150	110	255	190	150	110
5/8 - 18	210	155	160	120	290	215	160	120
3/4 - 10	325	240	255	190	460	340	255	190
3/4 - 16	365	270	285	210	515	380	285	210
7/8 - 9	490	360	380	280	745	550	380	280
7/8 - 14	530	390	420	310	825	610	420	310
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

Fraction, Decimal, Millimeter Conversions

Conversion Chart

Fraction	inch	mm	Fraction	inch	mm
1/64	0.0156	0.397	33/64	0.5156	13.097
1/32	0.0313	0.794	17/32	0.5313	13.494
3/64	0.0469	1.191	35/64	0.5469	13.891
1/16	0.0625	1.588	9/16	0.5625	14.288
5/64	0.0781	1.984	37/64	0.5781	14.684
3/32	0.0938	2.381	19/32	0.5938	15.081
7/64	0.1094	2.778	39/64	0.6094	15.478
1/8	0.1250	3.175	5/8	0.6250	15.875
9/64	0.1406	3.572	41/64	0.6406	16.272
5/32	0.1563	3.969	21/32	0.6563	16.669
11/64	0.1719	4.366	43/64	0.6719	17.066
3/16	0.1875	4.763	11/16	0.6875	17.463
13/64	0.2031	5.159	45/64	0.7031	17.859
7/32	0.2188	5.556	23/32	0.7188	18.256
15/64	0.2344	5.953	47/64	0.7344	18.653
1/4	0.2500	6.350	3/4	0.7500	19.050
17/64	0.2656	6.747	49/64	0.7656	19.447
9/32	0.2813	7.144	25/32	0.7813	19.844
19/64	0.2969	7.541	51/64	0.7969	20.241
5/16	0.3125	7.938	13/16	0.8125	20.638
21/64	0.3281	8.334	53/64	0.8281	21.034
11/32	0.3438	8.731	27/32	0.8438	21.431
23/64	0.3594	9.128	55/64	0.8594	21.828
3/8	0.3750	9.525	7/8	0.8750	22.225
25/64	0.3906	9.922	57/64	0.8906	22.622
13/32	0.4063	10.319	29/32	0.9063	23.019
27/64	0.4219	10.716	59/64	0.9219	23.416
7/16	0.4375	11.113	15/16	0.9375	23.813
29/64	0.4531	11.509	61/64	0.9531	24.209
15/32	0.4688	11.906	31/32	0.9688	24.606
31/64	0.4844	12.303	63/64	0.9844	25.003
1/2	0.5000	12.700	1	1.0000	25.400

Conversion Factor: 1 inch = 25.4 mm

Newton-Meter to Foot-Pound Conversions

Conversion Chart

N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1	9 in-lb	55	41	155	114
5	44 in-lb	60	44	160	118
6	53 in-lb	65	48	165	122
7	62 in-lb	70	52	170	125
8	71 in-lb	75	55	175	129
9	80 in-lb	80	59	180	133
10	89 in-lb	85	63	185	136
11	97 in-lb	90	66	190	140
12	106 in-lb	95	70	195	144
14	124 in-lb	100	74	200	148
15	133 in-lb	105	77	205	151
16	142 in-lb	110	81	210	155
18	159 in-lb	115	85	215	159
20	15 ft-lb	120	89	220	162
25	18	125	92	225	165
30	22	130	96	230	170
35	26	135	100	235	173
40	30	140	103	240	177
45	33	145	107	245	180
50	37	150	111	250	184
NOTE: To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.					

Pipe Plug Torque Values

Torque Table

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
in	**in**	**N•m**	**ft-lb**	**N•m**	**ft-lb**
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Tap-Drill Chart - U.S. Customary and Metric

General Information

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.

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

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

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

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

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Weights and Measures - Conversion Factors

Conversion Chart

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

Section W - Warranty

Section Contents

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

Coverage

Products Warranted

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

Base Engine Warranty

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

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

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

Additional Coverage is outlined in the Emission Warranty section.

Extended Major Components Warranty

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

Bushing and bearing failures are not covered.

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

Consumer Products

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

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

Cummins Responsibilities

During The Base Engine Warranty

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

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

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

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

During The Extended Major Components Warranty

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

Owner Responsibilities

During The Base Engine Warranty

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

During The Extended Major Components Warranty

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

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

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

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

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

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

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

Limitations

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

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

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

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

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

Cummins Compusave units are covered by a separate Warranty.

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

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

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

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

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

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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

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

Emission Warranty

Products Warranted

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

Coverage

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

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

Limitations

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

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

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

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

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

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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

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

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

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

All Engines International Industrial (Off-Highway)

Coverage

Products Warranted

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

Base Engine Warranty

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

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

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

Extended Major Components Warranty

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

Bushing and bearing failures are not covered.

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

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

Cummins Responsibilities

During The Base Engine Warranty

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

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

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

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

During The Extended Major Components Warranty

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

Owner Responsibilities

During The Base Engine Warranty

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

During The Extended Major Components Warranty

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

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

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

During The Base Engine Warranty And Extended Major Components Warranties

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

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

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

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

Limitations

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

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

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

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

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

Cummins Compusave units are covered by a separate Warranty.

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

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

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

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

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

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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

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

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

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

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

CMD Quantum Commercial Marine Propulsion (QSB5.9/QSB6.7/QSC8.3/QSL9/QSM11/SDI/TDI)

Coverage

Engines Included in this Coverage

Marine Propulsion

QSB5.9/QSB6.7/QSC8.3/QSL9/QSM11/SDI/TDI

Products Warranted

This Warranty applies to new Product sold by Cummins MerCruiser Diesel, herein after "CMD", that is branded as Cummins MerCruiser Diesel product and used in Commercial and Government Marine Propulsion applications anywhere in the world as permitted by US ITAR and Export Compliance regulations where CMD approved service is available* and delivered to the first user on or after May 1, 2011.

This Warranty covers any failures of the Product, under normal use and service, which results from a defect in CMD material or workmanship (Warrantable Failure). The (Product) includes the Engine, controls and other components other than pods or sterndrives as delivered from the CMD factory and accessories with a CMD part number that are added by a CMD approved distributor or OEM. Pods and sterndrives are covered under a separate CMD Warranty.

COMMERCIAL USE

Commercial use is defined as any work or employment related use of the product, or any use of the product which generates income, or any part of the warranty period, even if the product is only occasionally used for such purposes.

GOVERNMENT USE

Government use is defined as use by Federal, State, and Local agencies in non-revenue producing applications.

MARINE PROPULSION RATINGS

Government Service (GS) Rating

Intended for use in variable load applications where full power is limited to one hour out of every eight hours of operation.

Reduced power operation must be at or below cruise speed (rpm). Cruise speed (rpm) is dependent on the engine rated speed (rpm):

Rated Speed (rpm)	Cruise Speed (Reduction from rated speed, rpm)
2,000 to 2,800 rpm	200 rpm below rated
2,801 to 3,500 rpm	300 rpm below rated
3,501 to 4,500 rpm	400 rpm below rated

Government Service (GS)

The Government Service Rating applies to Government use in variable load applications where annual use is less than 500 hours and full power is one (1) out of every eight (8) hours of operation. Reduced power operation must be at or below cruise speed.

Light Commercial (LC)

The Light Commercial Rating applies to Commercial use in variable load applications where annual use is less than 500 hours and full power is one (1) out of every eight (8) hours of operation. Reduced power operation must be at or below cruise speed.

Intermittent Duty (ID)

This power rating is intended for intermittent use in variable load applications where full power is limited to two hours out of every eight hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 1,500 hours per year.

Medium Duty (MD)

This power rating is intended for continuous use in variable load applications where full power is limited to six hours out of every twelve hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 3,000 hours per year.

Heavy Duty (HD)

This power rating is intended for continuous use in variable load applications where full power is limited to eight hours out of every ten hours of operation. Also, reduced power must be at least 200 rpm below the maximum rated rpm. This rating is an ISO3046 Fuel Stop Power Rating and is for applications that operate less than 5,000 hours per year.

Continuous Duty (CD)

This power rating is intended for continuous use in applications requiring uninterrupted service at full power. This rating is an ISO3046 Standard Power Rating.

Base Engine Warranty

This warranty covers any failures of the Product, under normal use and service, which result from a defect in CMD material or factory workmanship (Warrantable Failure). Coverage begins with the sale of the Engine by CMD and continues for the Duration stated in the following table. The Duration commences on either the date of delivery of the Product to the first end-user, or the date the unit is first leased, rented or loaned, or when the Product has been operated for 50 hours, whichever occurs first. The Base Coverage duration ends two (2) years after the in-service date or allowed hours of total operation, whichever occurs first.

Warranty Coverage Periods				
Rating	QSB, QSC, QSL, SDI, TDI		QSM11	
	Coverage ends at whichever occurs first, months or hours of usage.		Coverage ends at whichever occurs first, months or hours of usage.	
	Months	Hours	Months	Hours
Government Service (GS)	24	1,000	24	1,000
Light Commercial (LC)	24	1,000	NA	NA
Intermittent Duty (ID)	24	3,000	24	3,000
Medium Duty (MD)	24	5,000	24	6,000
Heavy Duty (HD)	24	5,500	24	8,000
Continuous Duty (CD)	24	6,500	24	9,000

Cummins MerCruiser Diesel Responsibilities

During Engine Warranty

CMD will pay for all parts and labor needed to repair the damage to the Product resulting from a Warrantable Failure when performed during normal business hours. All labor costs will be paid in accordance with Cummins published Standard Repair Time guidelines.

When it is necessary for mechanics to make on-site warranty repairs CMD will pay reasonable travel expenses, including meals, mileage and lodging, for mechanics to travel to and from the repair dock. Labor must be performed by an authorized CMD Repair Facility.

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

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

Owner Responsibilities

During the Engine Warranty

Owner is responsible for the operation and maintenance of the Product as specified in the applicable CMD Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed. This warranty does not cover normal wear and tear of covered parts. Exceeding the operational parameters of the rating will void this Warranty. The Owner of the boat is ultimately responsible for ensuring the Engine is properly operated and maintained. The Warranty will be void on any Engines that are misapplied, not maintained properly or misused.

Before the expiration of the applicable warranty, Owner must notify a CMD service provider, distributor, authorized dealer, or other repair location approved by CMD of any Warrantable Failure and make the Engine available for repair by such facility. Locations in the United States and Canada are listed in the Cummins U.S. and Canada Sales and Service Directory; other locations are listed in the CMD International Sales and Service Directory.

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.

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.

In the event of any Product failure, Owner is responsible for the cost of towing the boat to the repair dock and for all associated docking and harbor charges.

Owner is responsible for maintaining the Engine hourmeter in good working order at all times and to ensure that the hourmeter accurately reflects the total hours of operation of the Product.

Owner is responsible for the costs to investigate complaints, unless the problem is caused by a defect in CMD material or factory workmanship.

Limitations

1. Maintenance Component Limitations
CMD will replace certain maintenance components if they fail within 90 days or less after the base coverage starts. Maintenance components include but are not limited to: sea water pump impellers, zinc plugs, oil filters, fuel filters, air filters, water filters, fuel/water separator filters, expansion tank pressure caps, belts, hoses.

2. Other Component Limitations
CMD does not warrant components that are not supplied by CMD factory.

3. CMD supplied alternators and starters limitation
Warranty coverage is limited to 2 years or 2,000 hours, whichever expires first for rating other than Government Service.

Warranty coverage is limited to 2 years or 1,000 hours, whichever expires first for the Government Service rating.

Consumer Products
The warranty on Consumer Products in the United States is a limited warranty. **CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied warranties applicable to Consumer Products 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 above limitations or exclusions may not apply to you.

CMD is not responsible for failures or damage resulting from what CMD determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of cooling, lubricating or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications to the engine; improper propping that does not allow the engine to run at its maximum rated speed; submersion, freezing temperatures, improper service, removal of parts, or running the engine out of water; water ingestion, unless caused by a Warrantable failure. CMD is also not responsible for failures caused by incorrect oil or fuel or by water, dirt or other contaminants in the fuel or oil.

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

CMD is not responsible for failures of maintenance components supplied by CMD beyond 90 days after the coverage duration start date. Maintenance components include, but are not limited to: sea water pump impellers; zinc plugs; oil filters; fuel filters; air filters; water filters; fuel/water separator filters.

Parts used in warranty repairs may be new CMD parts, CMD approved rebuilt parts, or repaired parts. CMD is not responsible for failures resulting from the use of parts not supplied by CMD.

A new CMD or CMD approved rebuilt part used to replace a Warranted Part assumes the identity of the Warranted Part it replaced and is entitled to the remaining coverage hereunder.

CMD DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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

Emission Warranty

Products Warranted
This Emission Warranty applies to new Engines certified to United States EPA 40 CFR 94 sold by CMD that are installed in vessels flagged or registered in the United States**.

Coverage
CMD warrants to the first user and each subsequent purchaser that the Engine is designed, built, and equipped so as to conform at the time of sale by CMD 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 5,000 hours of operation, whichever occurs first. The Emissions

Warranty starts from the date of delivery of the Engine to the first user, or the date the unit is first leased, rented, or loaned, or when the Engine has been operated for 50 hours, whichever occurs first, or (B) The Base Engine Warranty.

Limitations

The owner may elect to have maintenance, replacement, or repair of the emission control parts performed by a facility other than a CMD distributor, an authorized dealer or a repair location approved by CMD, and may elect to use parts other than new genuine CMD or CMD approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts and subsequent failures resulting from such service or parts will not be covered under this emission control system warranty.

Failures, except those resulting from a defect in materials, or factory workmanship, are not covered by this WARRANTY.

CMD IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

In the United States** and Canada, this warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Outside the United States** and Canada, in 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.

* Locations in the United States and Canada are listed in the Cummins United States and Canada Sales and Service Directory; other locations are listed in the Cummins International Sales and Service Directory.

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

California Emission Control System Warranty, Off-Highway

Products Warranted

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

Your Warranty Rights and Obligations

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

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

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

Manufacturer's Warranty Coverage

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

Coverage

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

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

Owner's Warranty Responsibilities

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

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

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

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

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

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

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

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

Replacement Parts

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

Cummins Responsibilities

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

Emergency Repairs

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

Warranty Limitations

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

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

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

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

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

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

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

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

Notes