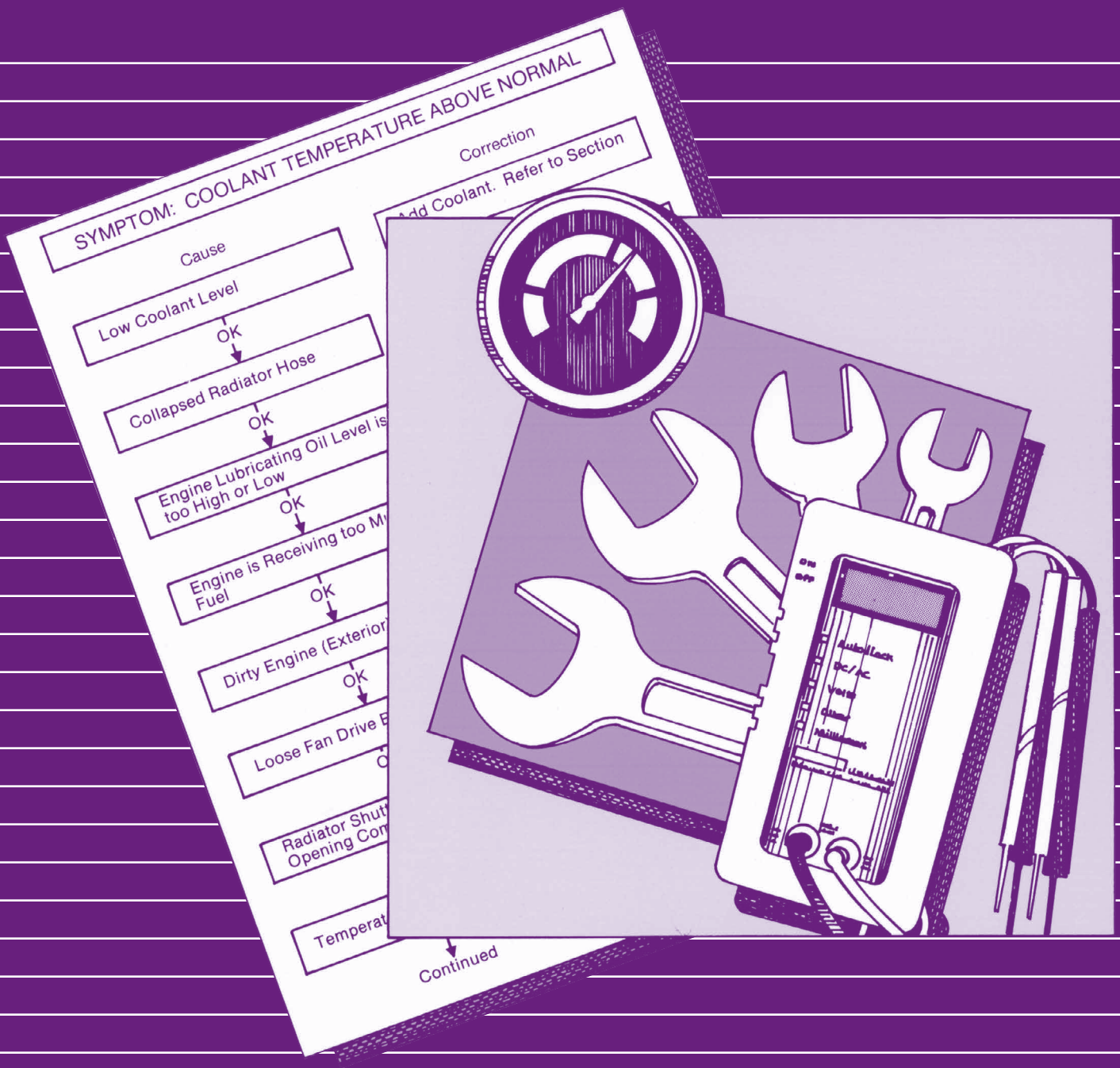
Troubleshooting and Repair Manual
ISM, ISM^{e}, and QSM11 Engines
Volume 1 - 2



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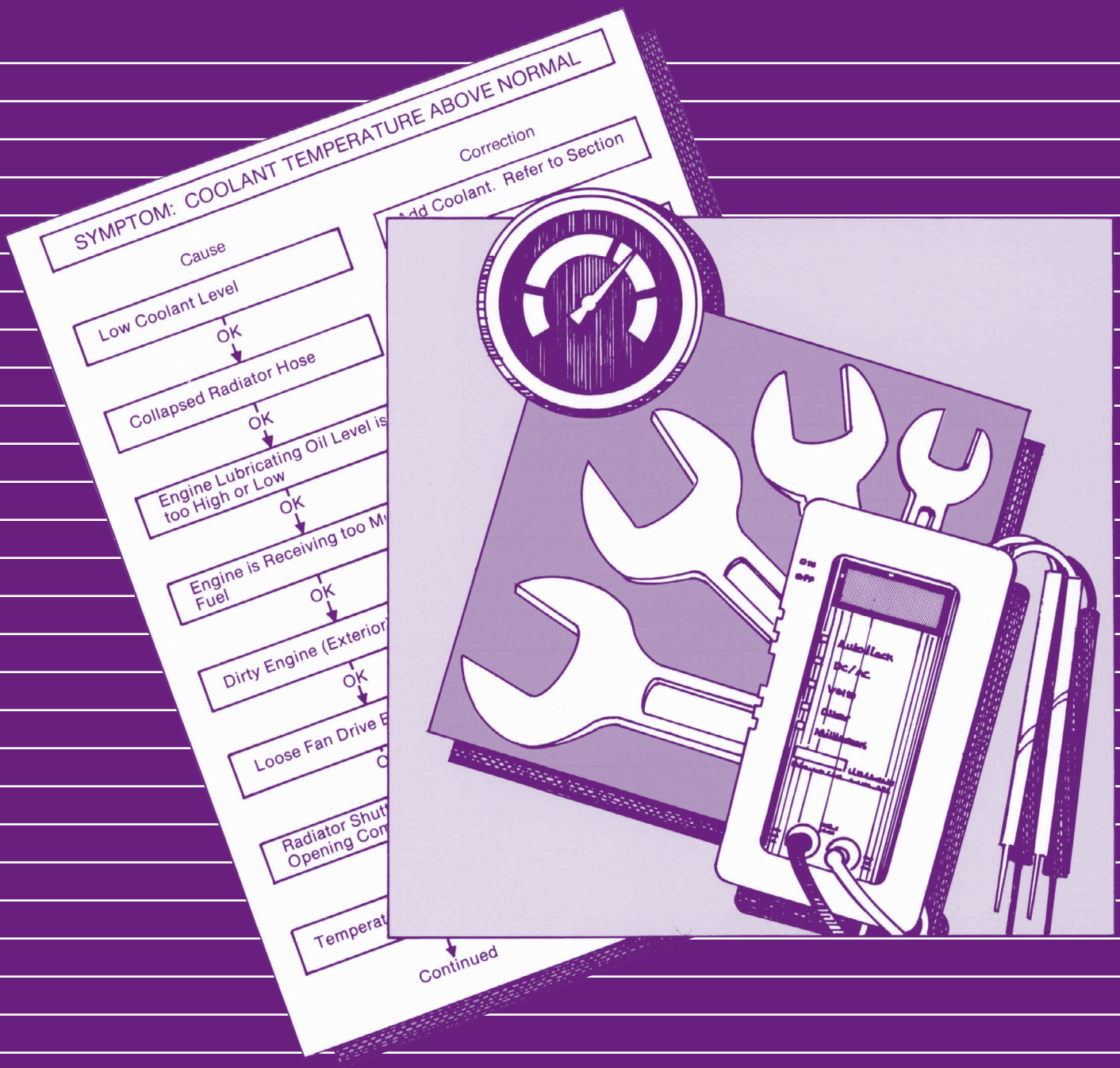

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Service Bulletin

Subject

Camshaft Reuse Guidelines for Cummins Engines with Roller Followers or Roller Tappets

Bulletin No.	Date:
3666052-02	**01-Dec-2002**

General Information

This bulletin applies specific visual inspection criteria for all Cummins engines with roller followers or roller tappets in contact with the camshaft lobe surfaces. This bulletin addresses the instances in which surface deterioration is predominately the result of galling or spalling. An additional resource for camshaft information is Technical Overview of Camshaft Durability, Bulletin 3379031. Cummins Distributors and Dealers are encouraged to use their technical expertise to implement these guidelines for low cost, high quality repair of Cummins products.

Although this bulletin applies to all Cummins engines with roller followers or roller tappets, it was revised to include knowledge gained from an injector camshaft engineering project completed on the Signature, ISX, QSX15 Heavy Duty engine. Based on the results of engineering analysis and endurance testing, the acceptable width for lobe galling damage on the injector camshaft was increased specifically for the Signature, ISX, QSX15, and ISX with CM870 controller engines. The updated lobe galling width limit applies for the surface damage indicated in Figures E and F.

Definitions

Polishing

- Normal surface condition where machining lines have been smoothed from contact between mating parts (see Figure B).

Denting

- A depression left in the surface by a piece of foreign material that is trapped between the lobe and roller. A dent has a relatively smooth, shiny bottom and does **not** have rough or sharp edges (see Figure C).

Frosted Bands

- High-density microdenting. Frosted (white) in appearance. Frosted bands are **not** detectable with a fingernail (see Figure D).

Galling

- Transfer of small pieces of material between the follower roller and the camshaft lobe surface by welding one surface to the other (see Figures E and F). Galling typically occurs when a follower roller skids on the camshaft lobe surface. This damage is detectable with a fingernail.

Pitting

- Loss of a piece of material from the lobe resulting in a hole that is visible to the naked eye. Pits typically have rough, dark bottoms and sharp edges, and usually occur in the heavily-loaded areas of the lobe (see Figure G).

Macro-Spalling

- Loss of large pieces of material from the lobe surface (see Figure H). This amount of damage will affect the operation of the engine.

Reuse Guidelines

Analysis of lobe deterioration, as represented in the photographs in Figures A through H, can be made objective by following the reuse information presented in Table 1, Figures A through D and Table 2, Figures E through H.

Camfollower Roller Inspection

Inspect and replace as necessary all camfollower rollers and pins, or assemblies. Use the criteria from this bulletin for visual inspection of the rollers. Refer to the appropriate Engine Shop Manual for other reuse guidelines.

Cummins Inc., Columbus, Indiana 47202-3005
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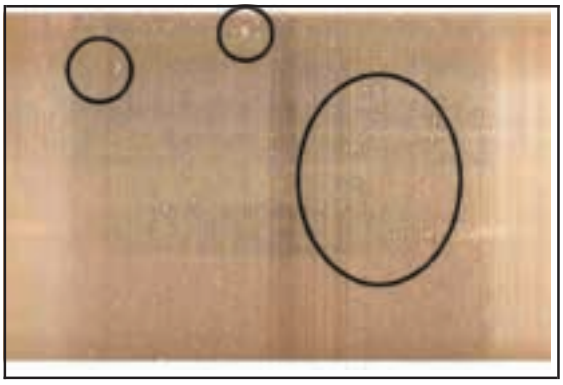
Lubricating Oil System Inspection

In the event that macrospalling is observed, inspect the lubricating oil filter for metallic debris. If metallic debris is found in the filter, inspect and replace as necessary the main and rod bearings, camshaft bushings, turbocharger, lubricating oil pump and pressure regulator, and the lubricating oil cooler. For additional detail, refer to the Camshaft Lobe Breakdown progressive damage limits published in the Cummins Warranty Administration Manual.

A. New Lobe

B. Polishing: Unconditional Reuse



C. Denting: Unconditional Reuse

D. Frosted Bands: Unconditional Reuse

Table 1: Unconditional Reuse Guidelines for Figures A, B, C, and D

Figure	Condition of Lobe	Reuse	Engines Affected
A	New	Unconditional reuse	All
B	Polish, no damage	Unconditional reuse	All
C	Denting	Unconditional reuse	All
D	Frosted bands	Unconditional reuse	All

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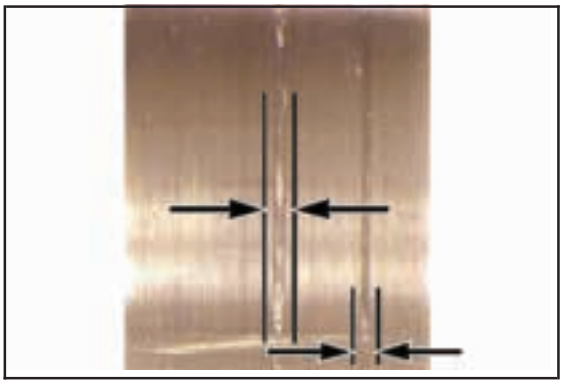
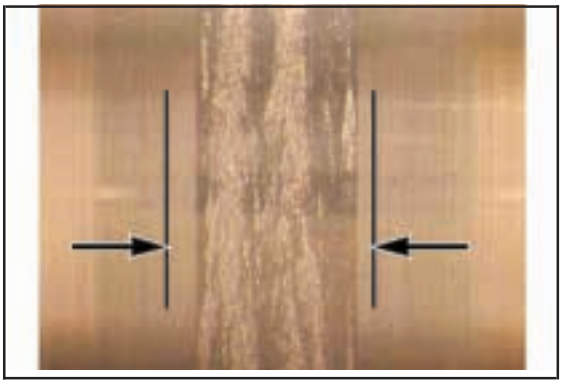


E. Galling Surface Distress: Conditional Reuse



F. Galling Surface Distress: Do Not Reuse

G. Pitting: Do Not Reuse

H. Macrospalling: Do Not Reuse

Table 2: Conditional Reuse and Replacement Guidelines for Figures E, F, G, and H			
Figure	**Condition of Lobe**	**Reuse**	**Engines Affected**
E	Galling[1] - Less than 1.5 mm [1/16 in] wide surface distress, no pits	Conditional reuse[2]	All - Except injector camshaft for ISX, Signature, QSX15 and ISX with CM870 Controller
	Galling[1] - Less than 5 mm [3/16 in] wide surface distress, no pits	Conditional reuse[3]	ISX, Signature, QSX15 and ISX with CM870 Controller - injector camshaft **only**
F	Galling[1] - More than 1.5 mm [1/16 in] wide surface distress, no pits	Replace	All - Except injector camshaft for ISX, Signature, QSX15 and ISX with CM870 Controller
	Galling[1] - More than 5 mm [3/16 in] wide surface distress, no pits	Replace	ISX, Signature, QSX15 and ISX with CM870 Controller - injector camshaft **only**
G	Pitting	Replace	All
H	Macrospalling	Replace	All

Explanation of Notes:
1. If multiple gall streaks are present but **not** connected, apply the width criteria to each streak individually.
2. Do **not** reuse the camshaft if the engine is being overhauled or if the camshaft is out of the engine.
3. Do **not** reuse the camshaft if the engine is being overhauled.

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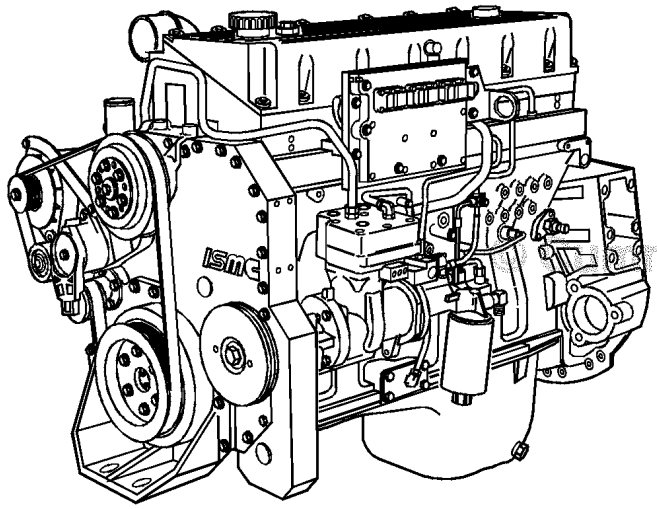

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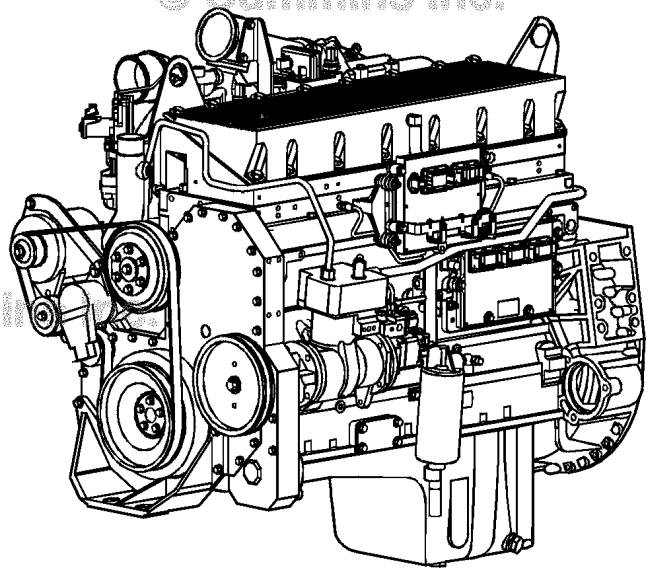

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Foreword

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

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

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

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

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

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

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

The latest technology and the highest quality components are used to manufacture Cummins engines. When replacement parts are needed, we recommend using only genuine Cummins or ReCon® exchange parts. These parts can be identified by the following trademarks:

Cummins® Cummins Inc.

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Section i - Introduction

Section Contents

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About the Manual

General Information

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

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

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

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

How to Use the Manual

General Information

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

(Step 1) Locate the symptom on the Section Contents pages of Section TS.

Reference to the page number where the Troubleshooting Symptom Tree is found is made to the right of the symptom tree title.

(Step 2) The left column of boxes in the Troubleshooting Symptom Charts indicates a probable cause of the problem, starting at the top with the simplest and easiest to repair, and continuing downward to the most difficult.

The right column of boxes provides a brief description of the corrective action with a reference number to the correct procedure used to make the repair.

(Step 3) Locate the probable cause in the left column then turn to the procedure referenced in the right column.

(Step 4) The Troubleshooting Symptom Charts are based on the following assumptions:

- The engine has been installed according to the manufacturer's specifications.
- The easiest repairs are done first.
- "Generic" solutions to cover problems with the most common applications and Original Equipment Manufacturer (OEM).

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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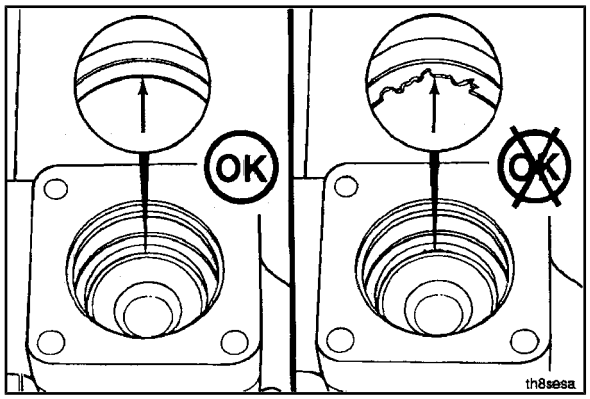
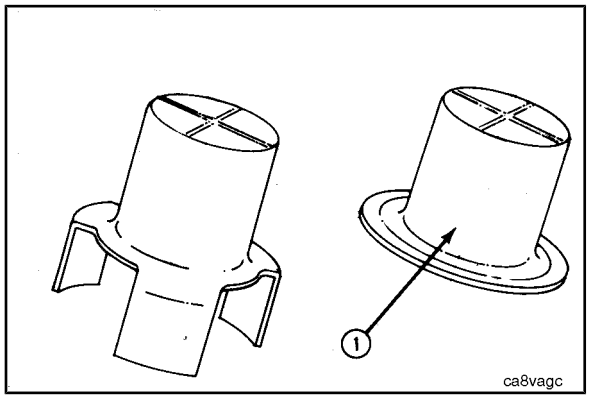


Illustrations

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, 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.
- 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.
- Liquified petroleum gas is heavier than air and can accumulate near the floor, in sumps, and low-lying areas.
- Natural gas is lighter than air and can accumulate under hood and awnings.
- To reduce the possibility of suffocation and frostbite, wear protective clothing and ONLY disconnect natural gas and liquified petroleum gas lines in a well ventilated area.
- 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.

General Repair Instructions

General Information

This engine 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.

- **Cummins Inc. does not recommend or authorize any modifications or repairs to engines or 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**

- **Follow all safety instructions noted in the procedures**
  - Follow the manufacturer's recommendations for cleaning solvents and other substances used during the repair of the engine. Some solvents and used engine oil 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 and its components **must** be kept clean during any repair. Contamination of the engine or 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 shop 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 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 or damage to the engine or components can result.

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 particulary true of lubricating oil ports and oil drilling holes, especially those located downstream of the lubricating oil filters. Plug the holes instead of trying to blow the abrasive particles and debris with compressed air because the debris is often simply blown further into the oil drilling.

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

⚠ WARNING ⚠

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

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

Gasket Surfaces

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

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

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

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

Solvent and Acid Cleaning

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

⚠ WARNING ⚠

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

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

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

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

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

Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful to **not** damage any gasket surfaces. When possible use hot high

pressure water or steam clean the parts before putting them in the cleaning tank. Removing the heaviest dirt before placing in the tank will allow the cleaner to work more effectively and the cleaning agent will last longer.

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

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

Steam Cleaning

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

⚠WARNING⚠

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

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

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

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 psd) 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.

Acronyms and Abbreviations

General Information

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

API	American Petroleum Institute
ASTM	American Society of Testing and Materials
°C	Celsius
CARB	California Air Resources Board
C.I.D.	Cubic Inch Displacement
CNG	Compressed Natural Gas
CPL	Control Parts List
cSt	Centistokes
ECM	Electronic Control Module
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
°F	Fahrenheit
FMI	Failure Mode Indentifier
GVW	Gross Vehicle Weight
LPG	Liquified Petroleum Gas
Hg	Mercury
hp	Horsepower
H_2O	Water
ICM	Ignition Control Module
km/l	Kilometers per Liter
kPa	Kilopascal
LNG	Liquid Natural Gas
LTA	Low Temperature Aftercooling
MPa	Megapascal
mph	Miles Per Hour
mpq	Miles Per Quart
N•m	Newton-meter
NG	Natural Gas
OEM	Original Equipment Manufacturer
PID	Parameter Identification Descriptions
ppm	Parts Per Million
psi	Pounds Per Square Inch
PTO	Power Takeoff
rpm	Revolutions Per Minute
SAE	Society of Automotive Engineers
SCA	Supplemental Coolant Additive
STC	Step Timing Control
SID	Subsystem Identification Descriptions
VS	Variable Speed
VSS	Vehicle Speed Sensor

Section E - Engine Identification

Section Contents

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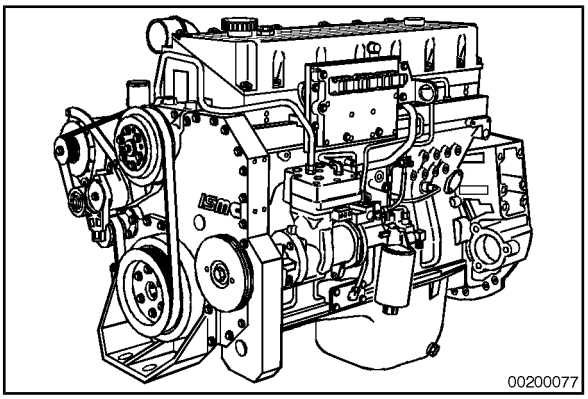
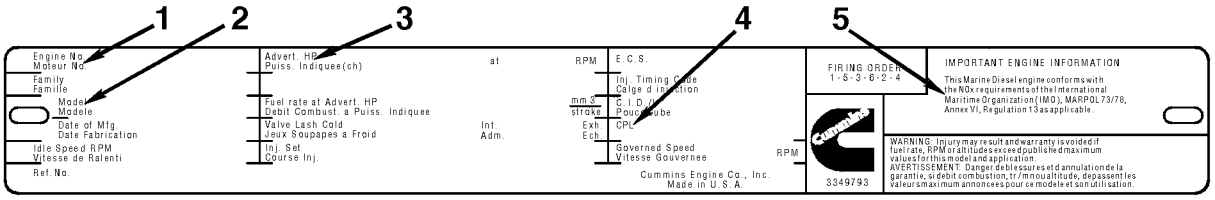
Engine Identification

Engine Dataplate

The engine dataplate shows important facts about your engine. The engine serial number and CPL provide data for ordering parts and service. The engine dataplate **must not** be changed unless approved by Cummins Inc.

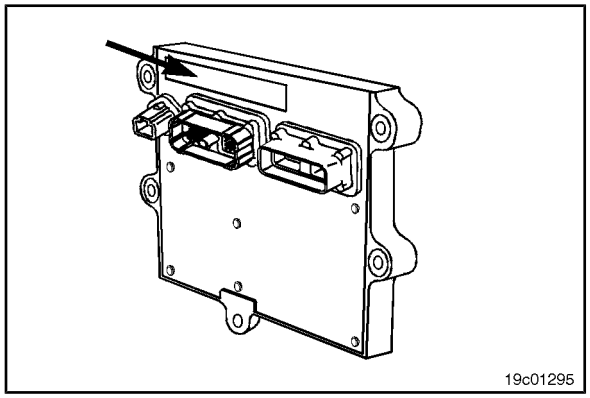
The dataplate is located on the fuel pump side of the engine, on the rocker housing. Have the following engine data available when communicating with a Cummins Authorized Repair Location. The following information on the dataplate is **mandatory** when sourcing service parts:





00200104

1. Engine serial number
2. Model
3. Horsepower and rpm rating
4. CPL
5. Emission statement (if applicable).



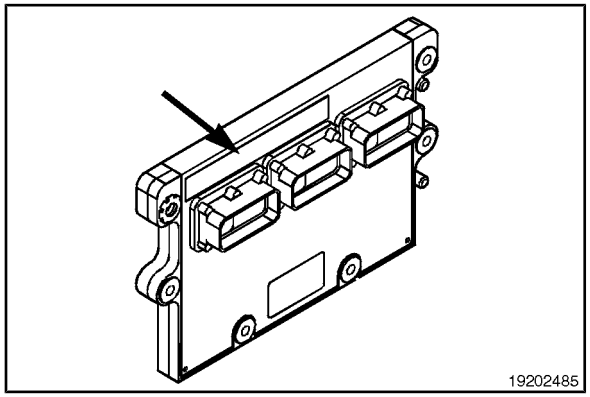
ECM Dataplate

With CM870 and CM570

The CM870 is the primary electronic control module (ECM) for the engine.

The ECM dataplate is located on the front of the ECM.

The abbreviations on the dataplate are explained as follows:

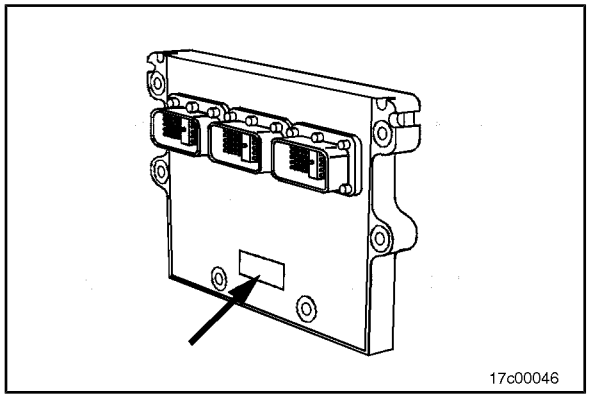


The CM570 is the fuel control module for the engine.

The fuel control module dataplate is located on the front of the fuel control module.

The abbreviations on the dataplate are explained as follows:

- P/N = part number
- S/N = serial number
- D/C = date code.



Without EGR

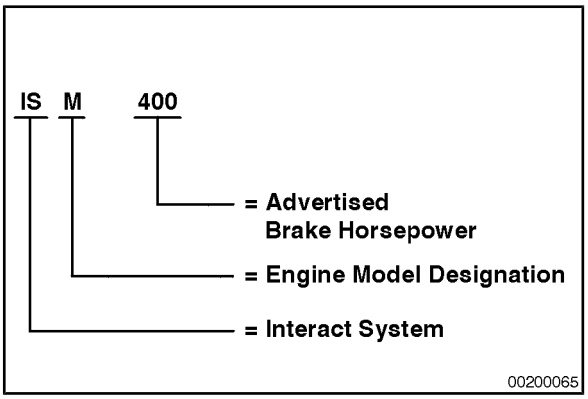
The ECM dataplate is located on the front of the ECM.

The abbreviations on the dataplate are explained as follows:

- P/N = part number
- S/N = serial number
- D/C = date code.

Cummins Engine Nomenclature

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

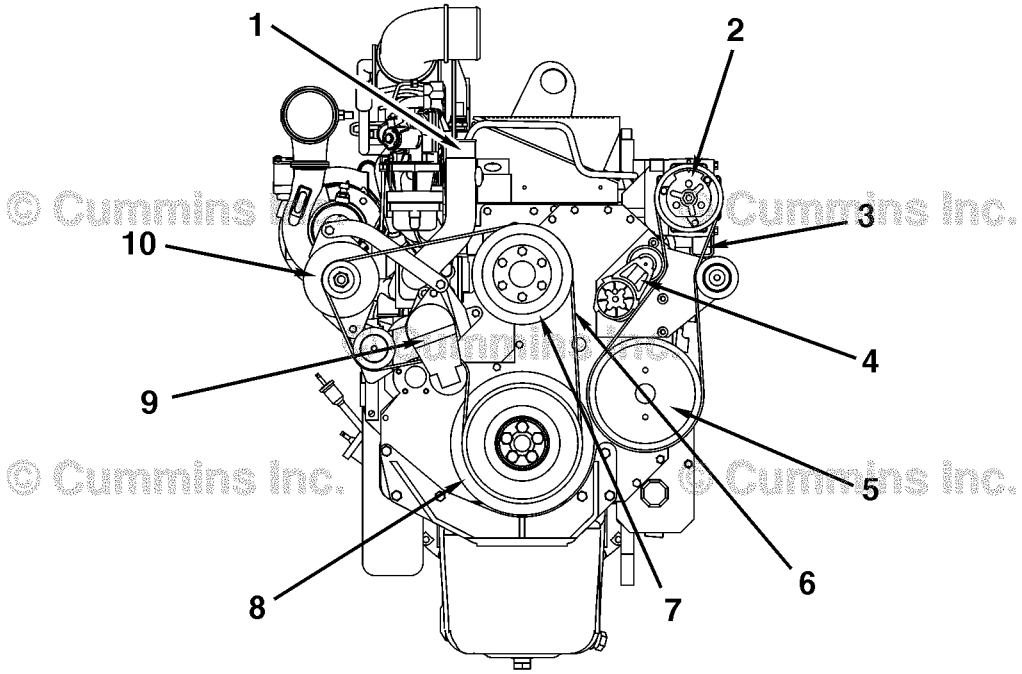


Engine Diagrams

Engine Views

The following illustrations contain information about engine components, filter locations, drain points, and access locations for instrumentation and engine controls. The information and configuration of components shown in these drawings are of a general nature. Some component locations will vary depending on applications and installations.

With CM870



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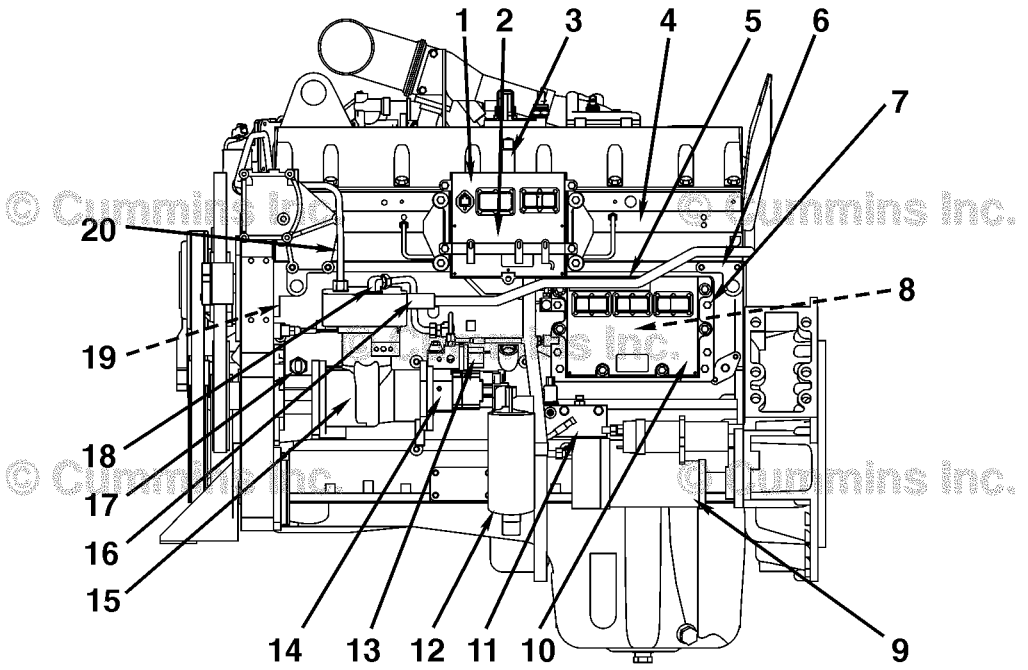
Automotive - Front View

1. Water pump outlet
2. Refrigerant compressor or alternator mounting location
3. Accessory drive belt
4. Accessory drive belt tensioner
5. Accessory drive pulley
6. Alternator drive belt
7. Fan hub
8. Vibration damper
9. Fan belt tensioner
10. Alternator.

With CM870



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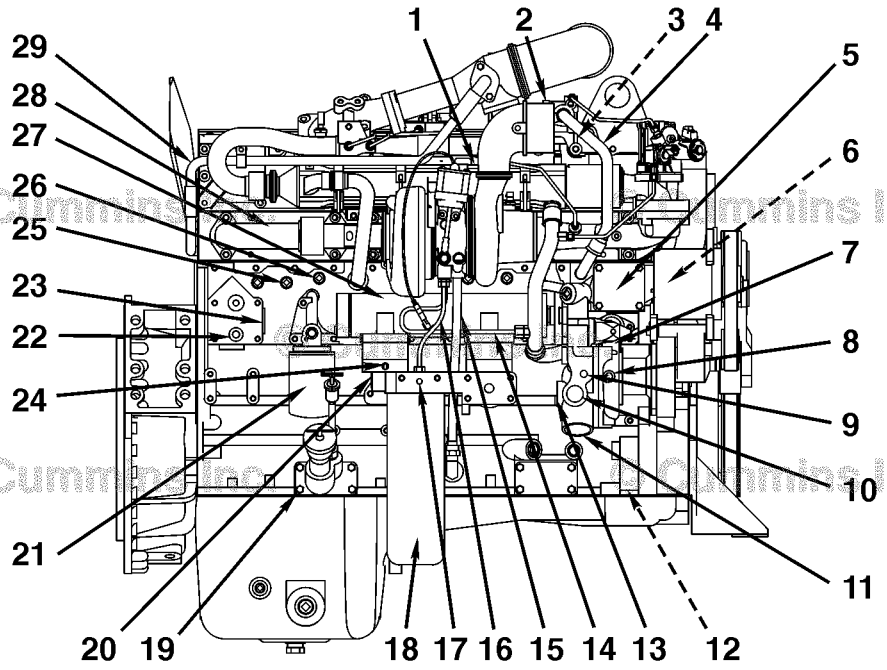
00200114

Automotive - Fuel Pump Side

1. ECM data plate
2. ECM
3. Blowby tube
4. Engine data plate
5. Fuel control module data plate
6. Engine serial number
7. Fuel control module cooling plate
8. Engine oil temperature sensor (behind fuel control module cooling plate)
9. Starter
10. Fuel control module
11. Centinel™ valve (optional)
12. Fuel filter
13. Fuel shutoff valve
14. Fuel pump
15. Air compressor
16. Air supply to air compressor
17. Engine oil pressure sensor
18. Air compressor coolant supply
19. Engine position sensor (**not** visible)
20. Air compressor coolant return.

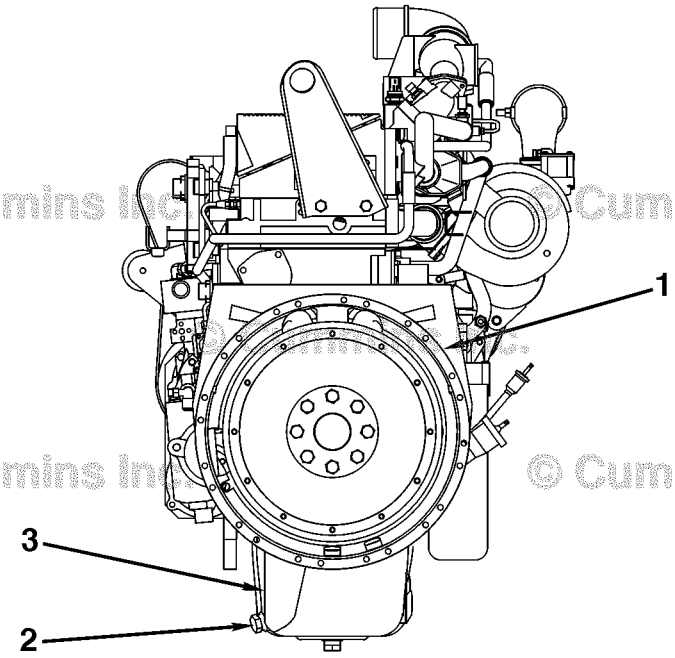
With CM870



Automotive - Exhaust Side

1. Variable geometry turbocharger coolant return line
2. Water manifold
3. Cylinder head vent line (**not** visible)
4. Water manifold return tube
5. Thermostat housing
6. Coolant temperature sensor (**not** visible)
7. Water pump
8. Water pump pressure
9. Coolant inlet pressure
10. Makeup line from radiator
11. Coolant inlet
12. Lubricating oil pump (**not** visible)
13. Heater return
14. Variable geometry turbocharger coolant supply line
15. Turbocharger oil drain tube
16. Turbocharger oil supply line
17. Lubricating oil filter out pressure
18. Lubricating oil filter
19. Lubricating oil fill/dipstick
20. Engine brake oil supply line
21. Coolant filter
22. Block coolant pressure
23. Coolant heater
24. Lubricating oil filter in pressure (lubricating pump out pressure)
25. Heater supply
26. Coolant temperature pick-up
27. Lubricating oil cooler
28. Exhaust manifold
29. Air compressor inlet tube.

With CM870



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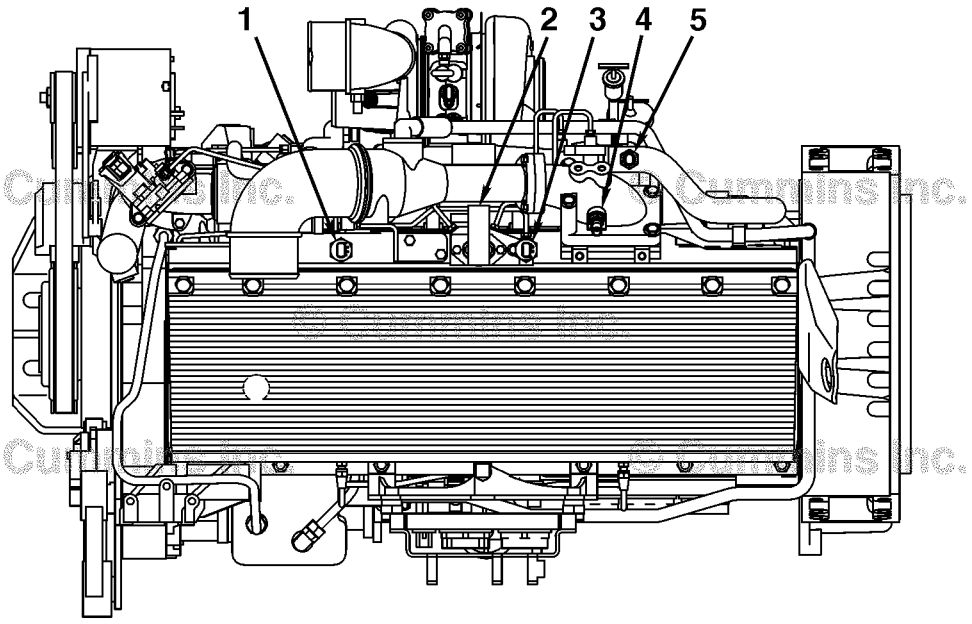
00200115

Automotive - Rear View

1. Flywheel housing
2. Lubricating oil drain
3. Lubricating oil pan.

With CM870



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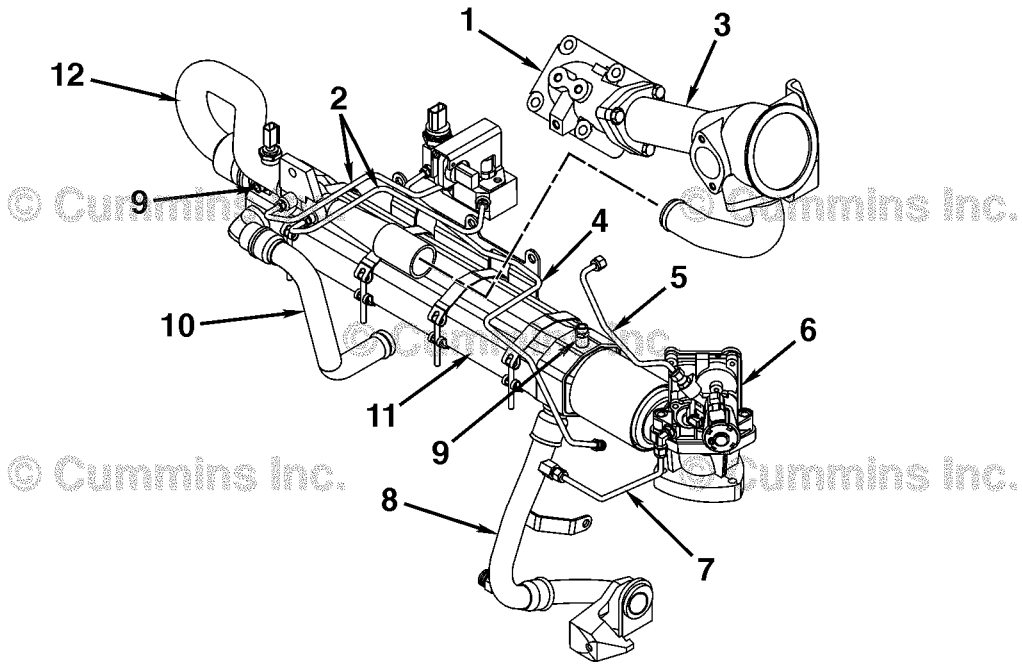
00200117

Automotive - Top View

1. Intake manifold pressure sensor
2. EGR differential pressure sensor
3. Exhaust gas pressure sensor
4. Intake manifold air temperature sensor
5. EGR temperature sensor.

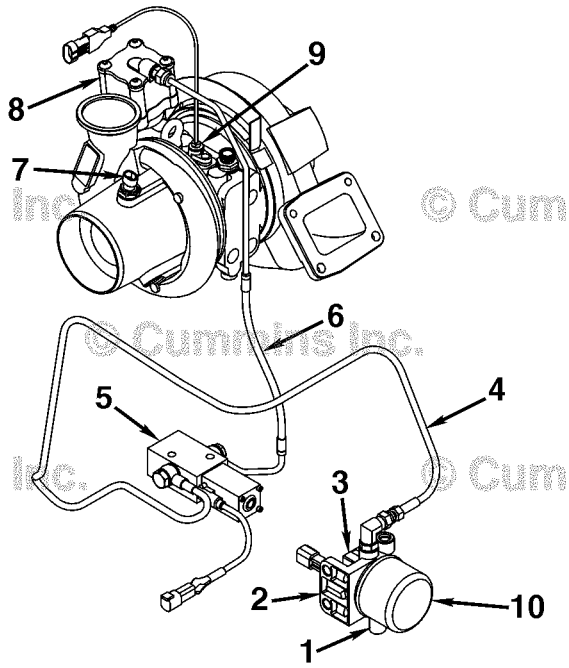
With CM870



Automotive - EGR System

1. Air intake connection
2. EGR differential pressure sensor tubes
3. EGR mixer
4. Exhaust gas pressure sensor tube
5. EGR valve coolant return tube
6. EGR valve
7. EGR valve coolant supply tube
8. EGR cooler coolant supply tube
9. EGR cooler coolant vent tubes
10. EGR cooler coolant return tube
11. EGR cooler
12. EGR cooler connection tube.

With CM870



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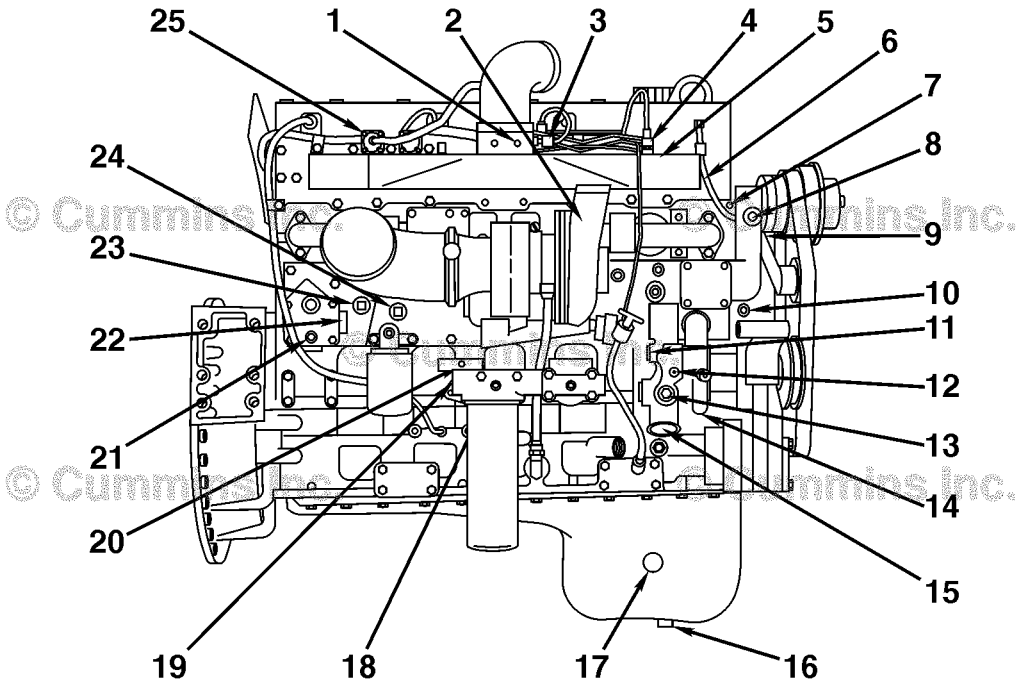
Automotive - Variable Geometry Turbocharger Control System

1. Compressed air from OEM air tank
2. Turbocharger control shutoff valve filter head
3. Turbocharger control shutoff valve
4. Compressed air from turbocharger control shutoff valve filter head
5. Turbocharger control valve
6. Compressed air from turbocharger control valve
7. Turbocharger compressor inlet air temperature sensor
8. Turbocharger actuator
9. Turbocharger speed sensor
10. Turbocharger control shutoff valve air filter.

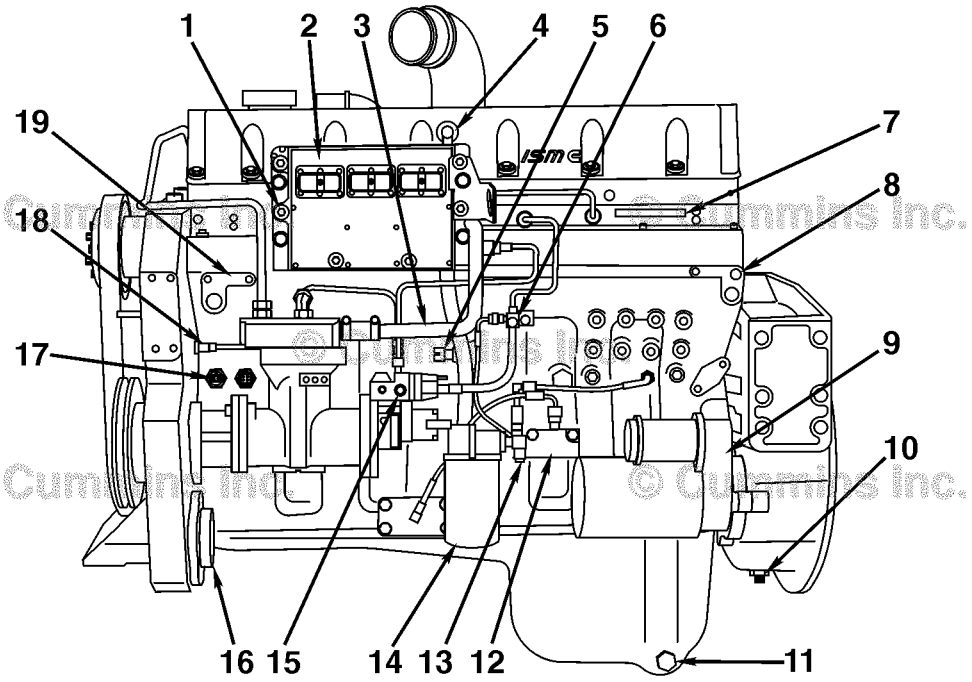
Without CM870



Automotive - Exhaust Side

1. Ether hookup
2. Before charge air cooler
3. Boost temperature sensor
4. Intake manifold pressure sensor
5. After charge air cooler
6. Shutter stat
7. Engine vent coolant
8. Shutter stat
9. Fan sensor
10. Coolant temperature sensor
11. Heater return
12. Coolant inlet pressure
13. Makeup line from radiator
14. Water pump pressure
15. Coolant inlet
16. Oil drain
17. Oil pan pump heater
18. Filter out pressure
19. Engine brake oil supply
20. Filter inlet pressure
21. Block coolant pressure
22. Coolant heater
23. Heater supply
24. Coolant temperature pickup
25. Wastegate controller.

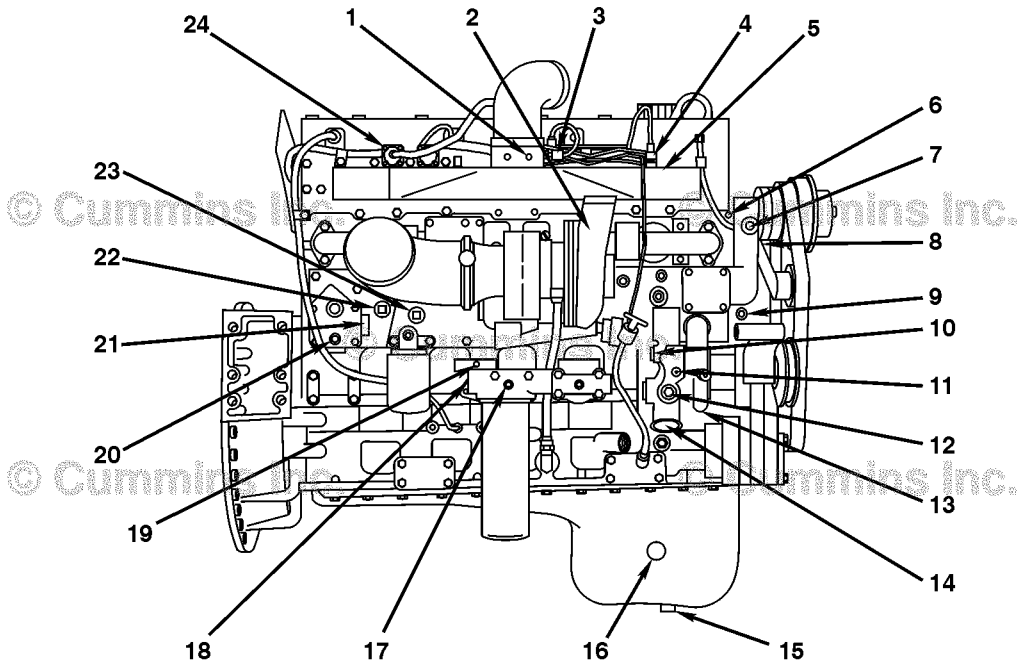
Without CM870



Automotive - Fuel Pump Side

1. ECM cooling plate
2. ECM
3. Compressor air discharge
4. Blowby measurement
5. Ambient air pressure sensor
6. Fuel return to tank
7. Engine data tag
8. Engine serial Number
9. Starter
10. Flywheel ring gear sensor
11. Side oil drain
12. Centinel™ (optional)
13. Fuel inlet to pump
14. Fuel filter
15. Rail pressure
16. Power steering pump mounting location
17. Oil pressure and temperature sensor
18. Engine position sensor
19. Freon compressor mounting location.

Industrial and Generator Drive

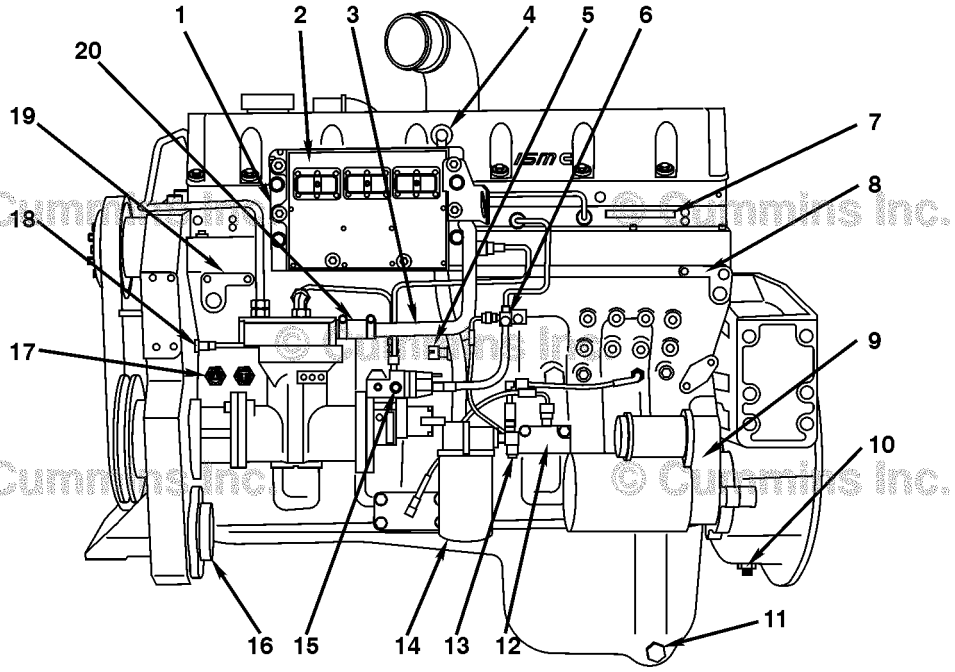


© Cummins Inc.

Industrial and Generator Drive - Exhaust Side

1. Ether hookup
2. Before charge air cooler
3. Boost temperature sensor
4. Intake manifold pressure sensor
5. After charge air cooler
6. Engine vent (coolant)
7. Shutter stat
8. Fan sensor
9. Coolant temperature sensor
10. Heater return
11. Coolant inlet pressure
12. Makeup line from radiator
13. Water pump pressure
14. Coolant inlet
15. Oil drain
16. Oil pan sump heater
17. Filter out pressure
18. Engine brake oil supply
19. Filter inlet pressure
20. Block coolant pressure
21. Coolant heater
22. Heater Supply
23. Coolant temperature pickup
24. Wastegate controller.

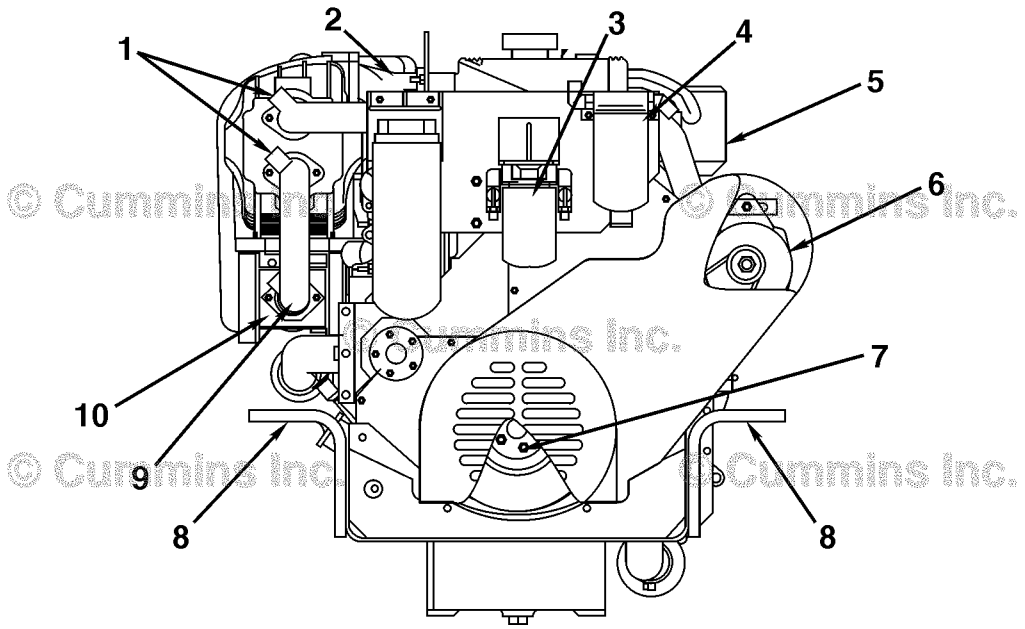
Industrial and Generator Drive



Industrial and Generator Drive - Fuel Pump Side

1. ECM cooling plate
2. ECM
3. Compressor air inlet
4. Blowby measurement
5. Ambient air pressure sensor
6. Fuel return to Tank
7. Engine data tag
8. Engine serial number
9. Starter
10. Flywheel ring gear speed sensor
11. Side oil drain
12. Centinel™ (optional)
13. Fuel inlet to pump
14. Fuel filter
15. Rail pressure
16. Power steering pump mounting location
17. Oil pressure and temperature sensor
18. Engine position sensor
19. Freon compressor mounting location.
20. Compressor air discharge.

Marine Applications



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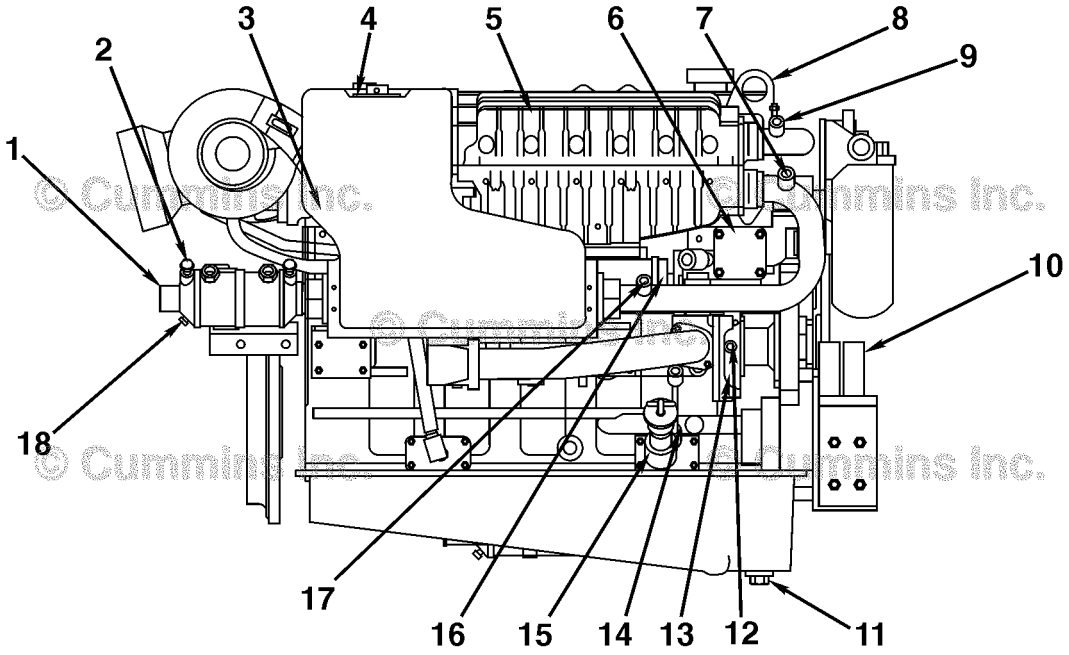
17200015

Marine - Front View

1. Zinc plugs
2. Air crossover
3. Coolant filter
4. Fuel Filter
5. Crankcase breather
6. Alternator
7. Vibration damper
8. Front engine mounts
9. Aftercooler-to-heat-exhanger pipe
10. Heat Exchanger.

Marine Applications

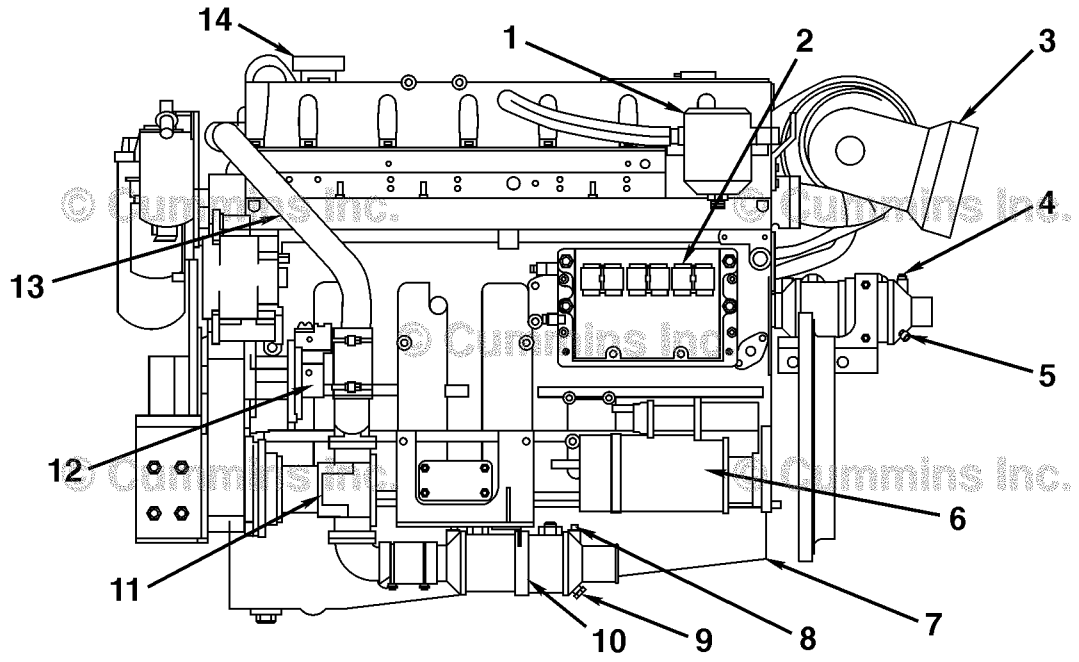


17200014

Marine - Starboard View

1. Gear oil cooler
2. Zinc plug (gear cooler)
3. Heat exchanger
4. Expansion tank
5. Aftercooler
6. Thermostat housing
7. Zinc anode
8. Engine lifting bracket
9. Zinc anode
10. Vibration damper
11. Oil pan drain plug
12. Coolant drain
13. Water pump
14. Oil dipstick
15. Oil fill
16. Engine oil cooler
17. Zinc anode
18. Gear oil cooler drain plug.

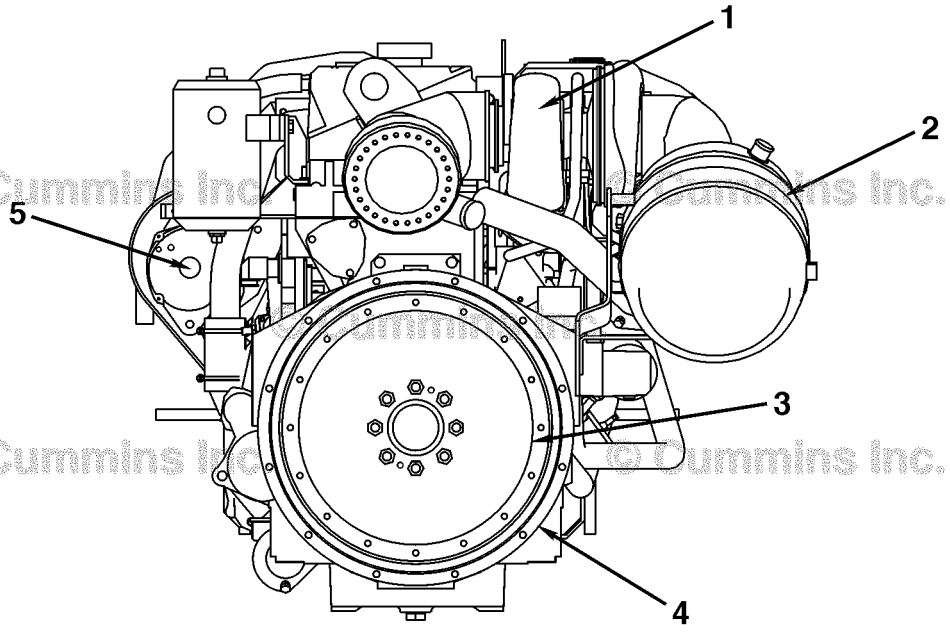
Marine Applications



Marine - Port View

1. Crankcase breather
2. ECM
3. Exhaust elbow
4. Zinc anode
5. Gear cooler drain plug
6. Starter
7. Oil pan
8. Zinc anode (fuel cooler)
9. Fuel cooler drain plug
10. Fuel cooler
11. Sea water pump
12. Fuel pump
13. Sea-water-pump-to-aftercooler pipe
14. Oil fill.

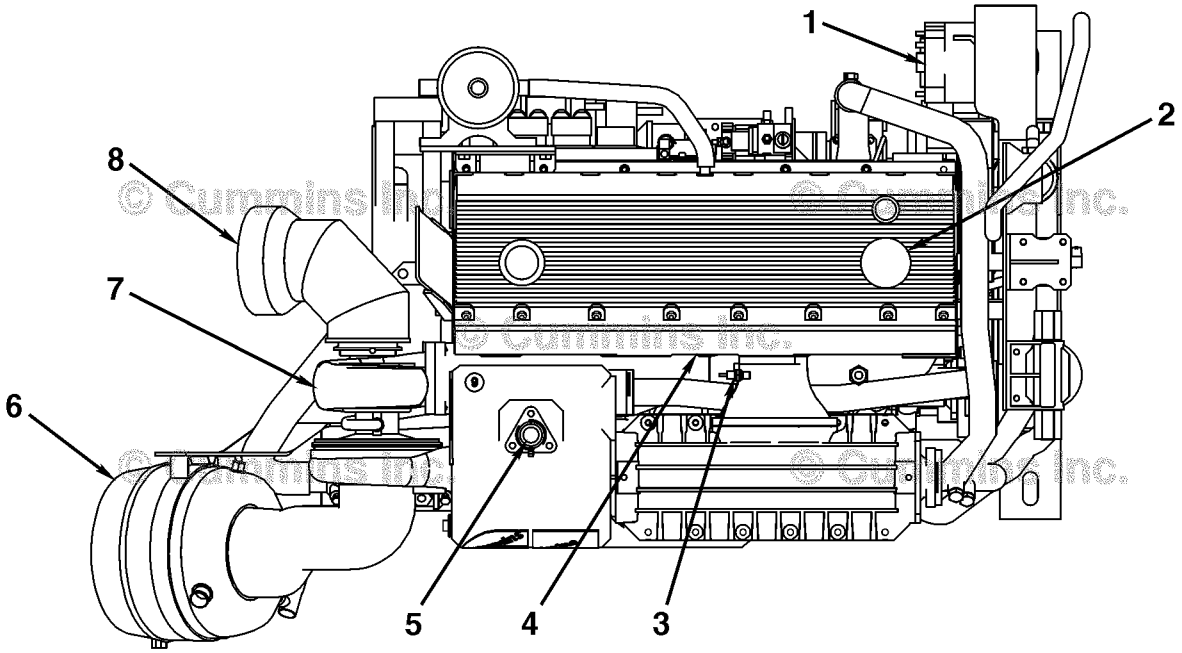
Marine Applications



Marine - Rear View

1. Turbocharger
2. Air cleaner
3. Flywheel
4. Flywheel housing
5. Alternator.

Marine Applications



Marine - Top View

1. Alternator
2. Oil fill (alternate)
3. Intake manifold temperature sensor
4. Intake manifold pressure sensor
5. Coolant fill
6. Air cleaner
7. Turbocharger
8. Exhaust elbow.

Section F - Familiarization

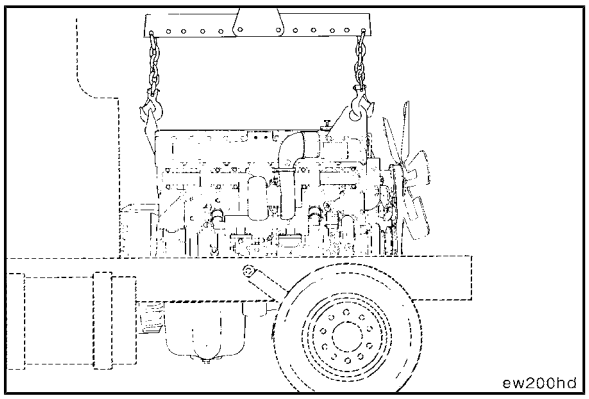
Section Contents

Complete Engine - Overview (000-999)

General Information

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

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



Cylinder Block - Overview (001-999)

General Information

⚠CAUTION⚠

Do not replace main bearing shells without performing this inspection. Engine damage is possible if the main bearing shells are replaced without performing this inspection.

Fretting is micro-motion between the main bearing cap and block that results in material loss at the joint. This motion causes a loss of crankshaft to main bearing running clearance that can lead to a spun main bearing, a spun connecting rod bearing, and/or a broken crankshaft.

There is risk when overhauling or replacing the main bearings in a block that has incurred main cap fretting. Inserting new standard main bearing shells into a joint that has sustained sufficient loss of material can lead to zero crankshaft/bearing clearance. This can cause the crankshaft to lock in place.

Recent long-hour engineering tests have shown the addition of Loctite® 518, a block stiffener plate, and increased main bearing clamp loads reduces torsional motions in the main cap/block joint. Loctite® 518 adds an additional shear strength and seals the main bearing cap/block joint from oil and debris. The stiffener plate increases block stiffness by 15 percent and the new torque-plus-angle method increases main bearing clamp load by 1588 kg [3500 lb].

NOTE: The inspection **must** be performed with the original main cap and bearing shells. During the reduction of bearing running clearance, the original main bearing develops a wear pattern, which is an indicator of main cap fretting.

Plastigage® provides a fast and accurate method to check bearing clearances. Plastigage® is a special extruded plastic thread of a definite diameter with accurately controlled crush properties. Plastigage® is packaged in calibrated envelopes, 12 envelopes per box. These envelopes **not only** protect the plastic threads but also serve directly as scales to measure the bearing clearance. Both sides of the envelope have a printed scale of graduations. One side is calibrated in inches, the other in millimeters. The numbers on the scale are the bearing clearances in thousandths of an inch or millimeter. When the width of a compressed section of Plastigage® in a bearing or journal is compared with the appropriate-numbered graduation, the bearing clearance can be read directly from the scale.

Plastigage® is available, from a local parts store, in four styles to cover different clearance ranges. Both Plastigage® thread and its matching envelope have a distinctive color for each clearance range.

Acceptance limits were developed to make sure of proper oil film thickness between the main bearings and crankshaft. The minimum acceptable clearance is 0.051 mm [.002 in] for the ISM series engines. Blocks **not** condemned can be up-fitted with the block stiffener plate.

The block meets acceptance limits if the main bearing bore passes inspection and can be reassembled with new standard bearing shells if all of the following conditions exist:

- Main cap and block mating surfaces exhibit little or no fretting
- Lower main bearing shells (2 through 6) do **not** show copper exposure or uneven wear.
- Plastigage® (if done) is equal to or greater than 0.05 mm [0.002 in]

The block main bearing bore does not pass inspection when the two following conditions exist.

- Main cap and block mating surfaces exhibit fretting.
- Plastigage® clearance on **any** main bearing (2 through 6) is less than 0.05 mm [0.002 in].

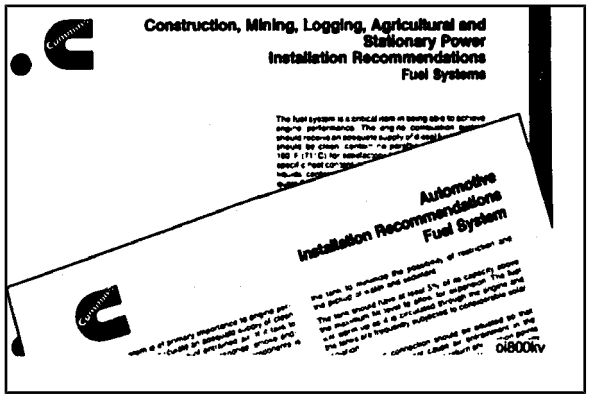
Repair options for blocks with one main journal that does not meet acceptance limits and have not spun a main bearing:

- Install an undersized main bearing kit to incrase bearing clearance.

Repair options for blocks with multiple main journals that do not meet acceptance limits or have spun a main bearing:

- Replace block with service block kit
- Replace block with ReCon® service block kit
- Replace block with ReCon® short block
- Replace engine with ReCon® engine.

NOTE: Cummins **must** approve all warrantable block repairs.



Fuel System - Overview (005-999)

Installation Recommendations

ISM

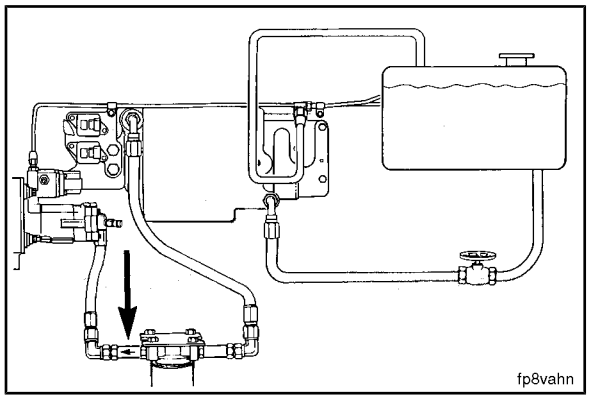
Installation Publications

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

Automotive Installation Recommendations (Fuel System), Bulletin 3382707.

Construction, Mining, Logging, and Agriculture Installation Recommendations (Fuel System), Bulletin 3382015.

Contact the nearest Cummins Authorized Repair Location for engine fuel system specifications and requirements provided on the Engine Data Sheet for your specific engine and application.

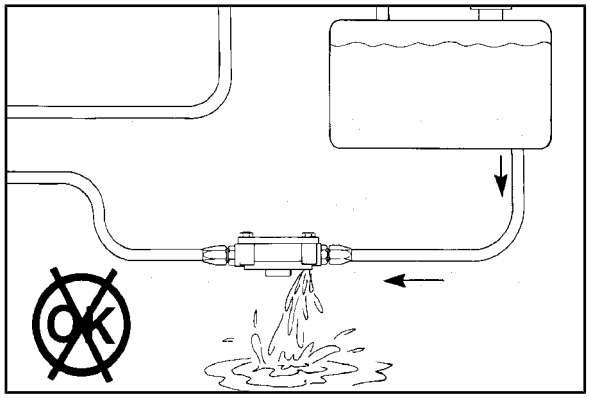


Overhead Fuel Tank Requirements

If the fuel filter is lower than the fuel pump, install a check valve in the filter outlet fuel line. Refer to the Installation Recommendations.

The check valve on the outlet side of the fuel filter prevents gear pump fuel drainback during filter removal.

Install a shutoff valve between the filter and the fuel tank.



⚠ WARNING ⚠

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

If the fuel line valve is **not** used, the overhead tank can drain when the fuel filter is changed. Spilled fuel is a fire hazard.

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